EURAF2020
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European Agroforestry Federation

UNINUORO
L'UNIVERSITÀ AL CENTRO

5TH EUROPEAN AGROFORESTRY CONFERENCE

17th - 19th MAY 2021 - ITALY

BOOK OF ABSTRACTS

Agroforestry for the transition towards sustainability and bioeconomy

EURAF2020

Welcome Address

Towards a renaissance of Europe's agriculture

As we open the fifth European agroforestry conference – twice pandemic-delayed, and alas still online – we are beginning to see indications that the world is at long last beginning to take the Earth systems crisis as seriously as it deserves. The most obvious signs are the ones that make the headlines: Joe Biden, the United States' new President, has nominated a prominent diplomat, John Kerry, as his climate envoy with Cabinet rank; the world is preparing to recognize the dire state of global biodiversity at a COP in Kunming, China and do something about it; preparatory meetings for the UNFCCC's COP 26 in Glasgow are noting the alarming trends of global heating and leading countries to negotiate ever stronger emission cuts. Large powers like France drum up funding for particularly stressed regions through top-level meetings like the One Planet Summit. And while the cold war between China and the West is heating up, the one area on which both sides collaborate productively are climate change and biodiversity issues. Buttressing that are United Nations efforts to wake peoples' sense of urgency and get corporate players and civil society to commit to change, ranging from the Decade for Ecosystem Restoration to the upcoming Food System Summit.

But the most encouraging signs are the ones that are harder to discern. The cost of renewables has dropped so much that a recent paper estimates that 70% of the world's population now lives in areas where the cheapest form of energy is solar power. The oracle of the energy world, the IEA, the International Energy Agency, has systematically underestimated the speed with which renewables spread and drop in price, and has done so every year for the last 20 years. But its latest report, just out, says that PV solar is now "the cheapest form of energy in human history". Even the inchoate efforts of America's last president, Donald Trump, to preserve coal jobs did not help: under his presidency, coal lost more market share more rapidly than any previous time in American history. And today, we begin to see a similar dynamic affecting gas, as policymakers recognize that far from being a cleaner alternative than coal, the frequent leakages of methane along its production and supply chain means that it can be as bad for the climate as solid fossil fuels. Finally, there is the extraordinary speed with which China is ramping up the design, production and deployment of new, modern nuclear power plants. Yes, together the various forms of non-carbon energy still only account for a few percent of the global total, but they are on unmistakable exponential growth curves.

On the biodiversity front, a number of papers have qualified the awful news of the past few years documenting the speed of the decline of vertebrate animals. The situation is no doubt dire, but not quite as dire as we thought. There is also a growing recognition that far from being a pristine wilderness until Europeans imported their technologies, much of the world has been a productively managed garden for the last 10,000 years, seemingly for the benefit of humans and biodiversity alike. Based on this growing insight, an increasing number of bodies are recognising the management skills of indigenous and traditional groups and developing the legal and financial support required to protect them against external impacts.

And that brings us closer to our own world, agriculture. There, mentalities are beginning to change too. The tired old argument of the agrochemical industry that the only thing needed to fix the problems of industrial farming are better chemistry and better genetics are finding it ever harder to find receptive ears (which is why our salvation is now supposed to come from precision agriculture – if you can't win the argument, shift the conversation). Instead, the farming world is abuzz with the excitement of a new concept, regenerative agriculture. Still nebulous and subject to capture by private interests, this idea is a seductive one: by using farming practices that mimic natural ecosystemic processes - for example by mixing perennials and annuals, ensuring the soil is always covered with living plants, reducing or eliminating ploughing and integrating livestock management - farmers, it is said, can boost their profits by reducing their costs and broadening their suite of products, all while delivering a multitude of desirable ecosystem services too. Films like "Kiss the Ground" are hits on Netflix, and almost every copy of the magazines sent out to farmers by their associations now contain features on soil health. Consumers are beginning to understand that "organic" and "sustainable" are yesterday's promises and I looking for ways to make a difference with their spending, while certificates such as ROC, Regenerative Organic Certification, are hoping to provide a widely recognized alternative.

In this new world being born, agroforestry is an essential technology. Novel archaeological techniques suggest this most ancient form of agriculture was applied in immensely varied and complex ways over many thousands of years by people across biomes ranging from the hottest and most humid to the driest and most frigid. We are only just beginning to understand just how productive these systems could be: the population density of pre-contact Papua New Guinean Highlands was of the same order of magnitude as that of the modern-day Netherlands, and as far as we can tell has been that high for several thousand years. Vast areas of the south-western Amazon were managed as periodically flooded farmlands, again for thousands of years, and the perennial species distribution across the whole of that forest suggests that, far from being a natural environment, the growth of species useful to humans has been systemically encouraged over centuries by its inhabitants.

While usually unaware of this deep history, policymakers are beginning to understand how powerful the agroforestry tool can be to achieve big societal objectives such as carbon mitigation and biodiversity restoration. The European Union has identified it, along with peatlands management, as one of its two key climate farming interventions. It is now regularly mentioned in the context of the reform of the CAP, the common agricultural policy, is a key component of the CAP's ecoschemes, and has become the go-to solution to rural development in most overseas development programmes.

And last but not least, the world is now awash with trillion tree campaigns, billion tree campaigns and million tree campaigns, all promising to absolve us of our carbon greed by locking the resulting pollution into trees, in a mechanism some wags compare to the sale of absolutions by the mediaeval Catholic Church. The amount of money flowing from corporations into carbon offsets backed by trees is growing exponentially. Most of these campaigns have recognized that large-scale monoclonal plantations of single species are a bad idea (after all, an oil palm plantation is a "forest" too) and are seeking to encourage farmers, usually in the global south, to add trees to their fields through a mixture of financial inducements and technical support.

Nevertheless, we all know that agroforestry's spread in Europe's landscapes is much slower and far more constrained than we hoped. The reasons range from a widespread unfamiliarity with these ancestral techniques (it has been three to four generations now since trees and hedges started being grubbed up and replaced by mechanization and agrichemical inputs, long enough for cultural knowledge to disappear) to a lack of technical support, ignorance by advisory services, a farming discourse dominated by the input industry, often relayed to their members by farmers associations; and immensely complex rules and regulations that farmers have to respect to get their subsidies. When policymakers try to dictate the number of trees per hectare or limit the range of species that may be planted, and change those rules regularly, we should not be surprised that most farmers are getting cold feet.

Nevertheless, agroforestry is beginning to become recognized as a key agricultural technology to lead Europe to a Renaissance of its farmlands. The excitement is palpable and takes many forms, from a nobleman informing your president that he would not cut down his trees in order not to be damned by future generations, to the increasing evidence presented at this conference about the superb impacts of this technology and the challenges of deploying it at scale.

As you will see by scanning these abstracts, few of these issues have been ignored by our community and many have been the subject of rigourous research and impactful innovation. And while I profoundly regret that I will not be able to discuss the many fascinating insights of your research over the traditional beer (or three) in the evening, I take heart from the fact that a fully online conference can reach a broader audience and may, thus, hopefully convince more people that adding trees to farming landscapes is not some deranged hippy idea, but the future.

And it is why this book of abstract has helped convince me that, unlike Sisyphus, we will not have to keep on pushing the rock of agroforestry wisdom uphill for eternity. Soon, our labours will bear fruits.

Patrick Worms

EURAF President

Welcome Address

On behalf of the EURAF2020 Scientific and Organizing Committees, we are very pleased to introduce the rich collection of research on agroforestry illustrated in this book of abstracts and presented within the 5° European Agroforestry Conference.

Unfortunately, as we all know, the COVID-19 pandemic has forced us to meet only remotely, despite all the efforts of our local and national organizers to hold the conference in presence. We are conscious about the completely different dimension, which does not allow participants to meet, discuss and live the conference supported by an environment socially vibrant and rich of cross-cultural stimuli as the real Sardinia can offer.

Nevertheless, in accordance with the mission of the European Agroforestry Federation, EURAF, to promote agroforestry knowledge, we wish to support the sharing of data presented and solicit a fruitful scientific confrontation on agroforestry issues.

This book is the result of a long and rigorous work performed by the authors (about 230 abstracts sent from 5 continents and 37 countries) and members of the Scientific Committee. The book will be one of the tools supporting such confrontation we are glad to foster from the heart of the Mediterranean.

The Mediterranean is a "demonstration site" with a pivotal role in showing the effects of climate change on the environment, a hotspot where extreme events, water resource reduction, forest fires, soil consumption, desertification, crop productivity and ecosystem services losses are the main issues. However, it can be the place to successfully build a new model of sustainable development to strengthen resilience and reduce impacts. Today, to be aware of this transformation is an absolute priority, also in consideration of health, environmental, social, and economic crisis caused by COVID-19.

The IPCC report on Land emphasizes how urgent is to test different integrated agricultural systems to assess synergies between mitigation, adaptation, and sustainability to reach low-carbon and climate-resilient pathways for sustainable food security and ecosystem health. Agroforestry practices are coherent with such indications following a holistic approach to obtaining biophysical, socio-cultural, and economic benefits from land management systems.

A multidisciplinary approach to the organization of this conference has allowed facing the research in agroforestry from different perspectives, as shown by the studies reported in this volume.

The provision of ecosystem services, the role of agroforestry in featuring the landscapes, and driving rural development, the need for proper policy instruments to support farmers in adopting agroforestry and look towards innovation encouraging education and dissemination, all such themes represent a comprehensive context that can help understand the complexity and preserve the beauty of European agroforestry systems.

We do hope that you will find this volume and the entire conference program noteworthy and thought-provoking and a valuable opportunity to build new connections between the scientific community, institutions, enterprises, and practitioners from around the world.

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5TH EUROPEAN AGROFORESTRY CONFERENCE

17th - 19th MAY 2021 - ITALY

OVERALL PROGRAMME

Agroforestry for the transition towards sustainability and bioeconomy

PROGRAMME - 17TH MAY 2021

14.00 PLENARY SESSION - ROOM A

14.00 **Connection**

14.10 **Welcome to the 5th European Agroforestry Conference**
Francesca Camilli, *EURAF Vice-President;* **Patrick Worms**, *EURAF President*

14.20 **Plenary session I**

CHAIRS: Donatella Spano, *Department of Agricultural, University of Sassari, Italy - Sciences, and CMCC Foundation Euro-Mediterranean Center on Climate Changeo*

Protecting the Earth and Her Human Inhabitants through Multifunctional Agroforestry

Sarah Lovell, *Center for Agroforestry, UMCA, University of Missouri, USA*

18.50 *Connection with* **"Cocoa Agroforestry Conference"**

14.50 PARALLEL SESSIONS 1

1.1 CLIMATE CHANGE - ROOM A

CHAIRS: Maria Teresa Vilela Nogueira Abdo, *Polo Regional Centro Norte-APTA, Brazil;* **Alberto Mantino**, *Institute of life sciences, School of Advanced Studies Sant'Anna, Pisa, Italy*

14.50-15.00 **(O1.1_1_19) Design and potential carbon sequestration benefits of a newly - established silvopasture system in Highland Scotland**

Andrew Barbour, Seonag Barbour, Robert Barbour

15.00-15.10 **(O1.1_2_39) Looking into the future – what is suitable to be grown and what is authorised to be grown in Switzerland?**

Sonja Kay, Felix Herzog

15.10-15.20 **(O1.1_3_40) The role of watering ponds in securing water supply for livestock in Iberian dehesas in a context of climate change**

Ubaldo Marín-Comitre, Susanne Schnabel, Manuel Pulido-Fernández

15.20-15.30 **(O1.1_4_82) Does agroforestry modelling need a paradigm shift?**

Eike Luedeling, Katja Schiffers, Cory Whitney

15.30-15.40 **(O1.1_5_130) Carbon footprint and carbon sequestration comparative analysis of organic pig and cattle farms in dehesa agroforestry systems**

Andrés Horrillo, Paula Gaspar, Marta Alcalá, Francisco Mesías, Ahmed Elghannam, Miguel Escribano

15.40-16.00 **Discussion**

1.2 ENHANCING ECOSYSTEM SERVICES PROVISION BY AGROFORESTRY SYSTEMS - ROOM B

CHAIRS: Nuria Ferreiro-Dominguez, *Universidade de Santiago de Compostela, Spain;* **Antonello Franca**, *Institute for Animal Production System in Mediterranean Environment, National Research Council, CNR-ISPAAM, Italy*

14.50-15.00 **(O1.2_1_38) Land-sharing or land-sparing for trees within upland agricultural land use in Wales, what's the way forward for rebalancing ecosystem services?**

Ashley Hardaker, Tim Pagella, Mark Rayment

15.00-15.10 **(O1.2_2_49) Can temperate agroforestry systems contribute to Sustainable Intensification of agriculture?**

Felix Herzog, P.K.R. Nair

15.10-15.20 **(O1.2_3_88) Balancing demand and supply of land-based services with suitability maps for agroforestry systems**

Carmen Schwartz, Fabrizio Ungaro, Sonoko Bellingrath-Kimura, Mostafa Shaaban, Annette Piorr

15.20-15.30 **(O1.2_4_100) Assessing the influence of silvopastoral practices on the provision of ecosystem services in grazed woodlands: a Delphi survey on Spanish Mediterranean mid-mountain areas**

Antonio Lecegui, Ana Ma Olaizola, Elsa Varela

15.30-15.40 **(O1.2_5_302) The hidden land conservation benefits of olive-based (Olea europaea L.) landscapes: An agroforestry investigation in the southern Mediterranean (Calabria region, Italy)**

Elena Brunori, Mauro Maesano, Federico Valerio Moresi, Giorgio Matteucci, Rita Biasi, Giuseppe Scarascia Mugnozza

15.40-16.00 **Discussion**

1.3 AGROFORESTRY, BIODIVERSITY, AND WILDLIFE MANAGEMENT - ROOM C

CHAIRS: Michael den Herder, *European Forestry Institute, Finland* **Andrea Pisanelli**, *National Research Council, Research Institute on Terrestrial Ecosystems, CNR-IRET, Italy*

14.50-15.00 **(O1.3_1_7) Higher biodiversity and pollination service in temperate agroforestry than in monoculture**

Alexa Varah, Hannah Jones, Jo Smith, Simon Potts

15.00-15.10 **(O1.3_2_15) Characterization and management of Russian olive accessions in Gilgit-Baltistan, northern Pakistan**

Muhammad Abubakkar Azmat, Asif Ali Khan, Iqrar Ahmad Khan, Andreas Buerkert, Martin Wiehle

15.10-15.20 **(O1.3_3_36) Ecosystem services in short rotation coppice in agricultural land in Latvia**

Dagnija Lazdina, Vita Kreslina, Guntis Brumelis, Arta Bardule, Kristaps Makovskis, Andis Bardulis

15.20-15.30 **(O1.3_4_59) Woodlands and hedgerows of the Po plain: planning instruments and policies implications on biodiversity conservation**

Giovanni Trentanovi, Andrea Rizzi, Thomas Campagnaro, Edoardo Alterio, Simone Iacopino, Federico Correale, Giustino Mezzalira, Tommaso Sitzia

15.30-15.40 **(O1.3_5_99) The effects of tree species composition on soil-related biodiversity in shelterbelts**

Nóra Szigeti, Dániel Winkler

15.40-16.00 **Discussion**

1.4 AGROFORESTRY AND THE LANDSCAPE - ROOM D

CHAIRS: Norbert Lamersdorf, *Soil Science and Temperate Ecosystems, University of Gottingen;* **Antonio Brunori**, *PEFC Italy*

14.50-15.00 **(O1.4_1_61) The role of agroforestry systems in the FAO Globally Important Agricultural Heritage Systems (GIAHS) programme**

Martina Venturi, Erica Mazza, Remo Bertani, Antonio Santoro, Federica Corrieri, Mauro Agnoletti

15.00-15.10 **(O1.4_2_95) Landscape transitions as a chance for agroforestry. The case of Park Lingezegen, The Netherlands**

Suzanne van der Meulen, Derk Jan Stobbelaar, Louis Dolmans

15.10-15.20 **(O1.4_3_104) Designing urban agroforestry withpeople in mind**

John R. Taylor, Sarah T. Lovell

15.20-15.30 **(O1.4_4_159) Diversifying oil palm plantations in the Southern Pacific region in Costa Rica**

Ricardo Salazar-Díaz, Lucía Mack-Rivas, Mario Guevara-Bonilla

15.30-15.40 **(O1.4_5_173) The role of agroforestry in a multifunctional and uncertain world: a landscapes perspective**

Esther Reith, Elizabeth Gosling, Thomas Knoke, Carola Paul

15.40-16.00 **Discussion**

16.00 **Coffee break**

16.20 PARALLEL SESSIONS 2

2.1 AGROFORESTRY, QUALITY FOOD PRODUCTS AND CERTIFICATION - ROOM A

CHAIRS: Manuel Bertomeu, *Department of Agricultural and Forestry Engineering, University of Extremadura, Spain;* **Antonio Trabucco**, *Impacts on Agriculture, Forests and Ecosystem Services Division, Foundation Euro-Mediterranean Center on Climate Change (CMCC), Italy*

16.20-16.30 **(O2.1_1_193) Certification of agroforestry systems and products according to the PEFC**

Antonio Brunori, Francesca Dini, Eleonora Mariano

16.30-16.40 **(O2.1_2_207) FireFlocks: Managing wildfire risk by adding value to flocks' products**

Emma Soy-Massoni , Nuria Prat, Guilleme Canaleta , Oriol Vilalta

16.40-16.50 **(O2.1_4_255) The potential of geographical indications for labelling in Mediterranean agroforestry systems**

Lukas Flinzberger, Yves Zinngrebe, Tobias Plieninger

16.50-17.00 **(O2.1_5_303) Understanding the resilience of agroforestry systems in a changing biosphere: a review of stable isotopes in ecophysiological studies**

Marco Lauteri, Francesca Chiocchini, Marco Ciolfi, Giuseppe Russo, Claudia Consalvo, Pierluigi Paris, Andrea Pisanelli, Maria Cristina Monteverdi, Angela Augusti, Cristina Maguas

17.10-17.30 **Discussion**

2.2 POLICY - ROOM B

CHAIRS: Gerry Lawson, *European Agroforestry Federation, UK;* **Giustino Mezzalira**, *Giustino Mezzalira, Regional Agency for Agriculture, Forestry and Agri-food sectors, VenetoAgricoltura, Italy*

16.20-16.30 **(O2.2_2_185) AGROMIX – Introducing Policy Co-Development for Agroforestry and Mixed Farming**

Ulrich Schmutz, Sara Burbi, Paola Migliorini

16.30-16.40 **(O2.2_3_191) Policy lessons from fifty years of trees on farms in New Zealand**

Donald J Mead

16.40-16.50 **(O2.2_4_198) Agroforestry in the CAP: an analysis of RDP support in Italy**

Antonio Pepe, Luca Caverni, Raoul Romano, Francesco Vanni, Lorenzo Crecco, Saverio Maluccio

16.50-17.00 **(O2.2_5_203) Agroforestry Options in the next CAP**

Gerry Lawson, Patrick Worms

17.10-17.30 **Discussion**

3.2 AGROFORESTRY INNOVATIONS TOWARD INNOVATIVE AGROFORESTRY SYSTEMS - ROOM C

CHAIRS: Anastasia Pantera, *Faculty of Crop Science, Agricultural University of Athens, Greece;* **Marcello Mele**, *Center for Agro-environmental research "Enrico Avanzi", University of Pisa, Italy*

16.20-16.30 **(O3.2_1_48) Do agroforestry practices improve tree performance compared to monoculture? Case study of agroforestry plantations including fast- growing trees**

Anaïs Grosjean, Nicolas Marron, Pierrick Priault

16.30-16.40 **(O3.2_2_139) 3 years of agroforestry implementation in Brandenburg – main findings, lessons learnt, outlook**

Tobias Cremer, Ralf Bloch, Tobias Kamphoff, Elias Wodzinowski

16.40-16.50 **(O3.2_4_153) Agroforestry between tradition and innovation: redesigning organic long-term experiments in Italy through participatory approach**

Elena Testani, Danilo Ceccarelli, Stefano Canali, Mariangela Diacono, Angelo Fiore, Corrado Ciaccia

17.10-17.30 **Discussion**

3.3 MANAGING MEDITERRANEAN AGRO-SILVOPASTORAL SYSTEMS - ROOM D

CHAIRS: Maria Conceiçao Caldeira, *Instituto Superior d'Agronomia, Universidade de Lisboa, Portugal; Antonio Franca, Institute for Animal Production System in Mediterranean Environment, National Research Council, CNR-ISPAAM, Italy*

16.20-16.30 **(O3.3_1_113) What drives silvopastoral management in mid-Mediterranean mountain areas? Addressing opportunities, synergies and barriers of forest owners and livestock farmers for joint silvopastoral management**

Elsa Varela, Ana Olaizola, Isabel Blasco, Carmen Capdevila, Antonio Lecegui, Isabel Casasús, Daniel Martín-Collado, Alberto Bernués

16.30-16.40 **(O3.3_2_120) Redesign and management of Silvopastoral systems in the South of France. Insights from agroecology**

Stéphane Bellon

16.40-16.50 **(O3.3_3_160) Interaction between beef herd and olive grove in Lazio (Italy) organic farm**

Miriam Iacurto, Francesca Pisseri, Davide Bochicchio, David Meo Zilio, Anna Beatrice Federici

16.50-17.00 **(O3.3_4_208) Using quantile regression to evaluate the impact of different factors in the cork calliper of cork oak trees in montado agroforestry ecosystem**

Joana Amaral Paulo, Paulo Neves Firmino, Sónia Pacheco Faias, Margarida Tomé

17.00-17.10 **(O3.3_5_228) Assessing the long-term persistence of legume-rich mixtures sown in Mediterranean Dehesas through NDVI analysis**

Antonio Pulina, Ana Hernández-Esteban, Giovanna Seddaiu, Pier Paolo Roggero, Gerardo Moreno

17.10-17.30 **Discussion**

17.30 **Coffee break**

17:50 PARALLEL SESSION 3

1.1 CLIMATE CHANGE - ROOM A

CHAIRS: Zita Szalai, *Department of Ecological and Sustainable Production Systems, Szent Istvàn University;* **Marcello Mele**, *Center for Agro-environmental research "Enrico Avanzi", University of Pisa, Italy*

17.50-18.00 **(O1.1_6_199) Artificial shading to mimic the effects of trees on old wheat varieties for future implementation in agroforestry systems**

Anna Panozzo, Elia Tognetti, Giuseppe Barion, Manuel Ferrari, Alberto Di Stefano, Cristian Dal Cortivo, Teofilo Vamerali

18.00-18.10 **(O1.1_7_200) Grazing iberian dehesa: Carbon sequestration offset livestock emissions**

Mireia Llorente, Gerardo Moreno

18.10-18.20 **(O1.1_8_246) Assessing the adaptability of maize varieties in silvoarable systems, a case study of Galicia region, Spain**

Davide Primucci, Nuria Ferreiro-Domínguez, Antonio Rigueiro-Rodríguez, Maria Rosa Mosquera-Losada

18.30-18.50 **Discussion**

3.1 AGROFORESTRY AND WILDFIRE PREVENTION - ROOM B

CHAIRS: Bohdan Lojka, *University of Life Sciences, Prague; Czech Republic;* **Valentina Bacciu**, *Institute for the BioEconomy, National Research Council, CNR-IBE, Italy*

17.50-18.00 **(O3.1_1_20) Forest fire prevention and agroforestry: the case of the Zonza forest (South Corsica, France)**

Antonella Massaiu, Muriel Tiger

18.00-18.10 **(O3.1_2_46) Swidden Agriculture as a Sustainable Production System: a case study on soils in the Southeast Atlantic Forest of Brazil**

Anna M. Visscher, Manuela Franco de Carvalho da Silva Pereira, José Lavres Jr, Carlos, Eduardo Pellegrino Cerri, Hilton Thadeu Zarate do Couto, Ciro Abbud Righi

18.10-18.20 **(O3.1_3_57) Fire as a tool for territorial management in agroforestry contexts**

Salvatore Cabiddu, Antonio Casula, Franco Casula, Michele Chessa, Giovanni Monaci, Stefania Murranca, Maria Tiziana Pinna., Giancarlo Muntoni, Gonaria Dettori

18.20-18.30 **(O3.1_4_260) Improving silvopasture farming systems in highly biodiverse areas through the use of aerial images**

Jose Javier Santiago-Freijanes, Nuria Ferreiro-Domínguez, Francisco Javier Rodríguez-Rigueiro, Antonio Rigueiro-Rodríguez, María Rosa Mosquera-Losada

18.30.18.50.1 Discussion

3.2 - AGROFORESTRY INNOVATIONS TOWARD INNOVATIVE AGROFORESTRY SYSTEMS - ROOM C

CHAIRS: Robert Borek, *Institute of Soil Science and Plant Cultivation, Pulawy, Poland;* **Pierluigi Paris**, *Research Institute on Terrestrial Ecosystems, National Research Council, Italy*

17.50-18.00 **(O3.2_6_211) Differences in measured and modeled transmitted photosynthetically active radiation in different orchards and their impact on understory crop photosynthesis**

Adolfo Rosati, Kevin Wolz, Lora Murphy, Michael Gold

18.00-18.10 **(O3.2_7_250) From early adopters to mainstream: Facilitating the developing agroforestry community in the Netherlands**

Andrew Dawson, Donatella Gasparro, Fogelina Cuperus, Maureen Schoutsen, Isabella Seli Noren, Wijnand Sukkel

18.10-18.20 **(O3.2_8_287) Paulownia in Northern Italy and its potential use in silvoarable systems**

Giustino Mezzalira, Federico Correale, Loris Agostinetto

18.30-18.50 **Discussion**

3.3 MANAGING MEDITERRANEAN AGRO-SILVOPASTORAL SYSTEMS - ROOM D

CHAIRS: Sonja Kay, *Agroscope, Federal Department of Economic Affairs, Education and Research EAER, Switzerland;* **Giovanna Seddaiu**, *Department of Agricultural Sciences, and Desertification Research Centre, University of Sassari, Italy*

17.50-18.00 **(O3.3_6_265) Shrub encroachment combines with drought and fire to decrease Quercus suber tree resilience in silvopastoral cork oak ecosystems**

Maria C. Caldeira, Xavier Lecomte, Raquel Lobo-do-Vale, Christiane Werner, Miguel N. Bugalho

18.00-18.10 **(O3.3_7_338) Does livestock grazing affects soil properties in an oak silvopastoral system? Results from a traditional system in Western Greece**

Theodoros Notis, Andreas Papadopoulos, Stavroula Galanopoulou, Anastasia Pantera

18.10-18.20 **(O3.3_8_345) Adaptive Multi-Paddock model: a sustainable management practice for Mediterranean silvopastoral systems**

Antonio Frongia, Antonio Pulina, Marco Cuboni, M.aria Carmela Caria, Tore Pala, Daniele Nieddu, Daniele Dettori, Costantino Masala, Simonetta Bagella, Antonio Franca, Pier Paolo Roggero, Giovanna Seddaiu

18.20-18.30 **(O3.3_9_27) The agroforestry in the new Algerian forest strategy: state of art, socio-economic importance and future perspectives**

Sonia Marongiu, Mohamed Abes, Assia Azzi

18.30-18.50 **Discussion**

18.50 **Closing the first day**

PROGRAMME - 18TH MAY 2021

14.00 PLENARY SESSION - ROOM A

14.00 **Connection**

14.10 **Welcome from the EURAF board**
Judit Csikvari, *Zsork Foundation, Hungary;* **Rico Huebner,** *Chair for Strategic Landscape Planning and Management, Techncical University of Munich, Germany*

14.20 **Plenary session II**

CHAIRS: Maria Rosa Mosquera, *Crop Production and Project Engineering Department, University of Santiago de Compostela, Spain*

Agricultural heritage systems and agroforestry

Mauro Agnoletti, *CULTAB – Laboratory for Landscape and Cultural Heritage School of Agriculture, University of Florence, Italy*

14.50 **Plenary session III**

CHAIRS: Giuseppe Pulina, *Department of Agriculture Sciences, University of Sassari, Italy*

Agroforestry for sustainable animal production systems

Fabiana Villa Alves, *Ministério da Agricultura, Pecuária e Abastecimento, Brasil*

15.20 **Coffee break**

15.40 PARALLEL SESSION 4

1.1 CLIMATE CHANGE - ROOM A

CHAIRS: Paul Burgess, *Crop Ecology and Management, Cranfield Soil and Agrifood Institute, UK;* **Adolfo Rosati**, *Council for Agricultural Research and Economics (CREA), Research Centre for Olive, Fruit and Citrus Crops, Italy*

15.40-15.50 **(O1.1_10_326) Tree cover affects the soil C balance in the Mediterranean cork-oak based silvopastoral systems**

Antonio Pulina, Chiara Cappai, Sergio Campus, Roberto Lai, Lorenzo Salis, Pier Paolo Roggero, Giovanna Seddaiu

15.50-16.00 **(O1.1_11_30) Silvopasture as a best practice for achieving good animal welfare in a changing and changeable climate: a review**

Lindsay Whistance, Jo Smith

16.00-16.10 **(O1.1_13_33) Potential of agroforestry in climate change mitigation - Assessment of greenhouse gas emissions in four different beef cattle production systems in Finland**

Alice Ripamonti, Michael den Herder, Anna Sandrucci

16.10-16.20 **(O1.1_14_54) Agroforestry and climate change – can almonds be grown in northern Switzerland?**

Adrian Reutimann, Sonja Kay, Felix Herzog, Andreas Naef

16.20-16.30 **(O1.1_15_98) Ink disease threaten Castanea sativa in agroforestry systems in Sardinia (Italy): prevention and control strategies**

Bruno Scanu, Virgilio Balmas, Lucia Maddau, Vanda Prota, Salvatorica Serra, Quirico Migheli

16.30-16.50 **Discussion**

1.2 ENHANCING ECOSYSTEM SERVICES PROVISION BY AGROFORESTRY SYSTEMS - ROOM B

CHAIRS: Bert Reubens, *Institute for Agricultural, Fisheries and Food Research, Belgium;* **Marco Lauteri**, *National Research Council, Research Institute on Terrestrial Ecosystems, CNR-IRET, Italy*

15.40-15.50 **(O1.2_6_339) Plant diversity and ecosystem services of silvopastoral Mediterranean agroforestry systems**

Pier Paolo Roggero, Antonio Pulina, Giovanna Seddaiu, Maria Carmela Caria, Simonetta Bagella

15.50-16.00 **(O1.2_8_34) Distribution and nutrient content of poplar fine roots in an agroforestry crop alley in Northern Germany**

Anita Swieter, Magdalena Gara, Maren Langhof, Jörg Michael Greef, Rolf Nieder

16.00-16.10 **(O1.2_10_101) Defining research priorities in complex Agroforestry systems**

Katja Schiffers, Cory Whitney, Eike Luedeling

16.10-16.20 **(O1.2_11_111) Studies on the diversity of the bacterial community associated with symbiosis between Tuber borchii and Quercus ilex in different Sardinian forest**

Giovanni Ragaglia, Aurélie Deveau, Nicoletta Pasqualina Mangia, Marongiu Raffaele Enrico Lancellotti, Antonio Franceschini, Pietrino Deiana

16.20-16.30 **(O1.2_13_248) Study of residual effects of sewage sludge application in a silvopastoral system on soil bacterial communities using a high-throughput sequencing technology**

Vanessa Alvarez-Lopez, Alexander Lamas, Beatriz Vazquez, Maria Rosa, Mosquera-Losada

16.30-16.50 **Discussion**

1.3 AGROFORESTRY, BIODIVERSITY, AND WILDLIFE MANAGEMENT - ROOM C

CHAIRS: Andrea Vityi, *Hungary Co-operational Research Centre Nonprofit Ltd, University of Sopron, Hungary;* **Bachisio Arca**, *Institute for the BioEconomy, National Research Council, CNR-IBE, Italy*

15.40-15.50 **(O1.3_6_220) Conserving threatened beneficial insects: bees, wasps and hoverflies in UK silvoarable systems**

Tom Staton, Richard J. Walters, Jo Smith, Tom D. Breeze, Sian K. Davies, Robbie D. Girling

15.50-16.00 **(O1.3_7_283) Tree rows change the soil biodiversity abundance and repartition within the first year of plantation at an experimental agroforestry site in Ramecourt (Northern France)**

Caroline Choma, Christelle Pruvot, François Delbende, Sitraka Andrianarisoa

16.00-16.10 **(O1.3_9_257) Phytosociology of Weeds in agroforestry system managements**

Monica Helena Martins, Maria Beatriz Bernardes Soares, Ana Carolina Oliveira, Bruna Beatriz Correiar, Maria Teresa Vilela Nogueira Abdo

16.10-16.20 **(O1.3_10_297) Agroforestry as on-farm conservation strategy for Virola surinamensis, an endangered Amazonian species**

Fátima Conceição Márquez Piña-Rodrigues, Karina Martins, Ivonir Piotrowski, José Mauro Santana da Silva, Aparecida Juliana Martins Corrêa, Roselea Oliveira de Almeida, Miguel Luiz Menezes Freitas

16.20-16.30 **(O1.3_11_322) Practicing sustainable agroforestry for biodiversity conservation and sustained livelihood option for tribal in Jharkhand (India)**

Sanjeev Kumar

16.30-16.50 **Discussion**

1.4 AGROFORESTRY AND THE LANDSCAPE - ROOM D

CHAIRS: Felix Herzog, *Agricultural landscapes and biodiversity, Agroscope, Switzerland;* **Giustino Mezzalira**, *Regional Agency for Agriculture, Forestry and Agri-food sectors, VenetoAgricoltura, Italy*

15.40-15.50 **(O1.4_6_204) The Meriagos: landscape value from Sardinian agro-forestry system**

Giuseppe Pulina, Luisa Carta, Giovanni Piras, Manuela Manca, Giampiero Incollu, Antonio Melchiorre Carroni

15.50-16.00 **(O1.4_7_223) Monitoring of gypsy moth in Sardinian cork oak forests and woodlands: past, present and future implementations**

Roberto Mannu, Arturo Cocco, Pietro Luciano, Maurizio Olivieri, Giuseppino Pira, Pino Angelo Ruiu, Salvatore Seddaiu, Andrea Lentini

16.00-16.10 **(O1.4_8_71) Enhancing Terraced Landscapes for Ensuring a Sustainable Development of Traditional Agroforestry Systems. A case study in Piedmont (Italy).**

Enrico Pomatto, Paola Gullino, Marco Devecchi, Federica Larcher

16.10-16.20 **(O1.4_9_72) Spatial models as a tool to evaluate afforestation actions In agrosilvopastoral systems**

Joaquin Francisco Lavado Contador, Estela Herguido Sevillano, Susanne Schnabel, Manuel Pulido Fernández, Alavaro Gómez Gutiérrez

16.20-16.40 **Discussion**

16.40 **Coffee Break**

17.10 PARALLEL SESSION 5

4.1 EDUCATION, INFORMATION SHARING AND AWARENESS RAISING IN AGROFORESTRY - ROOM B

CHAIRS: Judit Csikvari, *Zsork Foundation, Hungary;* **Alberto Mantino**, *Institute of life sciences, School of Advanced Studies Sant'Anna, Italy*

17.10-17.20 **(O4.1_1_60) Hands-on tools for participative development of agroforestry implementation plans: the Agroforestry Planner and the Adaptive Farm Plan methodology as inspiring examples**

Bert Reubens, Marco Bijl, Tom Coussement, Eurídice Leyequíen

17.20-17.30 **(O4.1_2_64) Linking scientific and empirical knowledge: an interactive web app to design agroforestry market gardening systems**

Raphael Paut, Rodolphe Sabatier, Marc Tchamitchian

17.30-17.40 **(O4.1_3_115) Participative formats to promote agroforestry in Germany – insights, challenges, experiences and recommendations**

Rico Hübner, Wolfgang Zehlius-Eckert, Carmen Schulze, Christian Böhm

17.40-17.50 **(O4.1_4_125) Green entrepreneurship and business skills needed for micro-entrepreneurs –case of Estonia**

Marit Piirman, Heli Tooman

17.50-18.10 **Discussion**

4.2 AGROFORESTRY AND RURAL TOURISM - ROOM C

CHAIRS: Antonio Trabucco, *Impacts on Agriculture, Forests and Ecosystem Services Division, Foundation Euro-Mediterranean Center on Climate Change (CMCCItaly;* **Fabien Liagre**, *Research development department, Société coopérative et participative spécialisée en agroforesterie, France*

17.10-17.20 **(O4.2_1_65) Visual appreciation of tree-based intercropping systems by rural residents in Quebec, Canada**

Geneviève Laroche, Gérald Domon, Alain Olivier

17.20-17.30 **(O4.2_2_93) Developing garden tourism and services – case of Garden Pearls Network in Estonia and Latvia**

Marit Piirman, Tatjana Koor, Kandela Õun

17.30-17.40 **(O4.2_3_293) Agroforestry in the mountainous area of Evritania (Greece)**

Vasiliki Lappa, Anastasia Pantera, Andreas Papadopoulos

17.40-17.50 **(O4.2_4_314) Olive trees and iris flowers in Tuscany: an agroforestry system to exploit rural tourism**

Francesca Camilli, Valentina Marchi

17.50-18.10 **Discussion**

1.4 AGROFORESTRY AND THE LANDSCAPE - ROOM D

CHAIRS: Teresa Soarez David, *Instituto nacional de investigaçao agraria e veterinaria, Portugal;* **Andrea Pisanelli**, *National Research Council, Research Institute on Terrestrial Ecosystems, CNR-IRET, Italy*

17.10-17.20 **(O1.4_11_249) The decline of the cork oak growing in Sicily is accompanied by the loss of the functions proper to agroforestry systems**

Emilio Badalamenti, Giovanna Sala, Rafael da Silveira Bueno, Tommaso La Mantia

17.20-17.30 **(O1.4_12_264) Silvopastoralism and potential use in Europe**

Jose Javier Santiago-Freijanes, Francisco Javier Rodríguez-Rigueiro, Vanessa Álvarez-López, Tamara Isabel Franco-Grandas, Nuria Ferreiro-Domínguez, Antonio Rigueiro-Rodríguez, María Rosa Mosquera-Losada

17.30-17.40 **(O1.4_13_289) Innovative beef cattle grazing systems for the restoration of abandoned lands in the Alpine and Mediterranean mountains (iGRAL)**

Giampiero Lombardi, Maria Sitzia, Marcello Verdinelli, Giovanna Seddaiu, Simonetta Bagella, Michele Lonati, Marco Acciaro, Margherita Addis, Luciano Gutierrez, Lorenzo Salis, Stefano Arrizza, Maria Leonarda Fadda, Stefania Bagella, Marco Pittarello, Ginevra Nota, Maria Carmela Caria, Giovanna Piga, Giovanni Rivieccio, Marco Cuboni, Alberto Tanda, Pier Paolo Roggero

17.40-18.00 **Discussion**

18.10 PLENARY SESSION - ROOM A

18.10 **Plenary session IV**

CHAIRS: Patrick Worms, *European Agroforestry Federation, Belgium CIFOR Center for International Forestry Research - ICRAF, World Agroforestry*

Making Agroforestry Mainstream: Lessons on Communicating Agro forestry to the Private Sector

Felipe Villela, *reNature, Founder & CCO, The Netherlands*

18.20 **Closing the second day**

PROGRAMME - 19TH MAY 2021

14.00 PLENARY SESSION - ROOM A

14.00 **Connection**

14.10 **Welcome from the EURAF board**
Claire Lamarié, *European Agroforestry Federation, France;* **Manuel Bertomeu,** *Department of Agricultural and Forestry Engineering, University of Extremadura, Spain*

14.20 **Plenary session V**

CHAIRS: Christian Dupraz, *Inrae, Montpellier, France - IUAF, International Union for Agroforestry*

Biodiversity – productivity – stability relationships in agroforestry systems: from principles to processes and practices

Bart Muys, *Division of Forest, Nature and Landscape, KU Leuven, Belgium*

14.50 PARALLEL SESSION 6

1.1 CLIMATE CHANGE - ROOM A

CHAIRS: Jo Smith, *Mvarc Agroecology Research Centre, Portugal;* **Federico Correale Santacroce**, *Regional Agency for Agriculture, Forestry and Agri-food sectors, Veneto Agricoltura, Italy*

14.50-15.00 **(O1.1_19_177) Temperature regulation: how agroforestry helps climate change mitigation**

Claire Lemarié

15.00-15.10 **(O1.1_21_240) The transformation of agricultural systems into agro-forestry systems as a system of adaptation to climate and economic changes: some Sicilian case studies**

Tommaso La Mantia, Michele Russo, Paola Quatrini, Rafael da Silveira Bueno

15.10-15.20 **(O1.1_22_243) Wheat varieties established under walnut of different ages In Galicia (NW Spain)**

Nuria Ferreiro-Domínguez, Pinilopi Papadopoulus, Antonio Rigueiro-Rodíguez, Maria Rosa Mosquera-Losada

15.20-15.30 **(O1.1_23_244) Variation of soil organic matter in silvopastoral systems established under Pinus sylvsetris L. with celtic pigs in Galicia (Spain)**

Maria Rosa Mosquera-Losada, Antonio Rigueiro-Rodíguez , Antonio Iglesias-Becerra, Nuria Ferreiro-Domínguez

15.30-15.40 **(O1.1_24_259) Drought-shade interactions on winter pea induce carbon source-sink mechanisms that may lead to higher yield stability in a mature alley-cropping system**

Guillaume Blanchet, Mattia Bradley, Jean-François Bourdoncle, Lydie Dufour, Alain Sellier, Grégoire Vincent, Christian Dupraz, Marie Gosme

15.40-16.00 **Discussion**

1.2 ENHANCING ECOSYSTEM SERVICES PROVISION BY AGROFORESTRY SYSTEMS - ROOM B

CHAIRS: Giovanna Seddaiu, *Department of Agricultural Sciences, and De sertification Research Centre, University of Sassari, Italy;* **Rico Huebner**, *Chair for Strategic Landscape Planning and Management, Techncical University of Munich, Germany - German Association for Agroforestry, DEFAF, Germany*

14.50-15.00 **(O1.2_15_272) Ecosystem services assessment, financial performance evaluation, and exploration of opportunities for amplification of agroforestry: learning from a case study in Devon UK**

Rafael Pompa, Martin Lukac, Richard Tranter

15.00-15.10 **(O1.2_16_274) What agroforestry is at the service of the restoration of a Camargue riparian forest? - Case study of the Psalmody riparian forest (Gard – Occitanie)**

Stéphane Person, Laurent Limouzy

15.10-15.20 **(O1.2_17_296) FOOD FOR FOREST – Restorative Silvi-Pastoralism: the Food that Feeds the Forest**

Roberta Berretti, Simone Ravetto Enri, Marco Pittarello, Davide Barberis, Davide Ascoli, Ginevra Nota, Dino Genovese, Paolo Cornale, Giampiero Lombardi, Michele Lonati, Renzo Motta, Luca Maria Battaglini

15.20-15.30 **(O1.2_18_333) How to revitalize abandoned mountain areas? An agro forestry approach for livestock farmers in the alpine region**

Martina Re, Francesca Pisseri, Giorgia Robbiati, Stefano Carlesi, Silvia Baronti, Anita Maienza, Fabrizio Ungaro, Francesco Vaccari, Paolo Barberi

15.30-15.50 **Discussion**

4.1 EDUCATION, INFORMATION SHARING, AND AWARENESS RAISING IN AGROFORESTRY - ROOM C

CHAIRS: Patrick Worms, *European Agroforestry Federation, CIFOR Center for International Forestry Research - ICRAF, World Agroforestry, Belgium;* **Antonio Raschi**, *Institute for the BioEconomy, National Research Council, CNR-IBE, Italy*

14.50-15.00 **(O4.1_6_158) Public-private partnerships for agroforestry investment and adoption in the USA**

Kevin J Wolz, Keefe Keeley, Scott Brainard, Bill Davison

15.00-15.10 **(O4.1_7_168) The participative approach to promote innovations in agroforestry: the AFINET project in Italy**

Claudia Consalvo, Andrea Pisanelli, Giuseppe Russo, Marco Ciolfi, Marco Lauteri, Francesca Chiocchini, Pierluigi Paris

15.10-15.20 **(O4.1_8_184) Linking scientific knowledge to management practices in Agroforestry: the pivotal role of higher education**

Tommaso Anfodillo, Giustino Mezzalira, Anna Panozzo, Teofilo Vamerali

15.20-15.30 **(O4.1_10_217) Paraíba River Basin Agroforestry network: teaching methodology, participatory research and rural extension in Agroecology promotion**

Thiago Ribeiro Coutinho, Antonio Carlos Pries Devide, Maria Teresa Vilela Nogueira Abdo

15.30-15.40 **(O4.1_13_334) The network of AIAF demonstrative farms: the example of the "Casaria" farm**

Giustino Mezzalira,Teofilo Vamerali, Anna Panozzo, Mauro Sangiovanni, Federico Correale Santacroce

15.40-16.00 **Discussion**

16.00 **Coffee break**

16.20 PARALLEL SESSION 7

1.1 CLIMATE CHANGE - ROOM A

CHAIRS: Joana Amaral Paulo, *Centro de Estudos Florestais, Universidade de Lisboa, Portugal;* **Pierluigi Paris**, *Research Institute on Terrestrial Ecosystems, National Research Council, CNR-IRET, Italy*

16.20-16.30 **(O1.1_25_262) Analysis of agroforestry systems productivity compared to afforestation in a climate change context in Galicia**

Francisco Javier Rodríguez-Rigueiro, Nuria Ferreiro-Domínguez, Maria Rosa Mosquera-Losada

16.30-16.40 **(O1.1_26_278) Tree coverage in Sardinian dairy sheep systems: farm characteristics and environmental implications**

Pasquale Arca, Bachisio Arca, Alberto S. Atzori, Antonello Cannas, Salvatore Contini, Delia Cossu, Mauro Decandia, Pierpaolo Duce, Mondina F. Lunesu, Giovanni Molle, Paola Sau, Gabriella M. Serra, Domenico Usai, Enrico Vagnoni, Antonello Franca

16.40-16.50 **(O1.1_27_304) Quantitative assessment of carbon sequestration and oxygen production by oak windbreaks growing in the Forest-Steppe zone of Ukraine**

Vasyl Yukhnovskyi, Vira Moroz, Ihor Ivaniuk

16.50-17.00 **(O1.1_28_330) Variation of yield in varieties of wheat and rye under shade conditions**

Tamara Isabel Franco-Grandas, Nuria Ferreiro-Domínguez, Antonio Rigueiro-Rodríguez, Maria Rosa Mosquera-Losada

17.00-17.10 **(O1.1_29_348) Exploring the potential of coffee agroforestry systems to productivity, adaptation, and mitigation: a system typology approach**

Leonel Lara-Estrada

17.10-17.30 **Discussion**

3.3 MANAGING MEDITERRANEAN AGRO-SILVOPASTORAL SYSTEMS - ROOM B

CHAIRS: Adolfo Rosati, *Council for Agricultural Research and Economics (CREA), Research Centre for Olive, Fruit and Citrus Crops, Italy;* **Claire Lemarié**, *European Agroforestry Federation, France*

16.20-16.30 **(O3.3_10_29) Maremmana breed, woodland menvironment and cattle behaviour**

Jacopo Goracci, Francesco Tiezzi, Alessio Del Tongo

16.30-16.40 **(O3.3_11_212) Simulating the effect of light availability reduction on grass and legume swards in a Mediterranean rainfed plot trial**

Lorenzo Gabriele Tramacere, Alberto Mantino, Iride Volpi, Massimo Sbrana, Marco Mazzoncini, Alice Cappucci, Marcello Mele, Giorgio Ragaglini, Daniele Antichi

16.40-16.50 **(O3.3_12_233) Olive grove and livestock: Project on pasture management schemes for dry sheep**

Francesca Pisseri, Stefano Spinelli, Michelangelo Benza, Nicola Furlanetto, Miriam Iacurto, Virginia Altavilla

16.50-17.00 **(O3.3_14_301) Grazed orchards in France: different forms of livestock integration and their implications for fruit growers' practices**

Arnaud Dufils, Raphaël Paut

17.00-17.10 **(O3.3_15_352) Observations on a livestock cattle system in a Mediter ranean mountain pasture**

Marco Acciaro, Carla Cabboi, Gianni Battacone

17.10-17.30 **Discussion**

3.2 AGROFORESTRY INNOVATIONS TOWARD INNOVATIVE AGROFORESTRY SYSTEMS - ROOM C

CHAIRS: Judit Csikvari, *Zsork Foundation, Hungary;* **Antonio Raschi**, *Institute for the BioEconomy, National Research Council, CNR-IBE, Italy*

16.20-16.30 **(O3.2_12_41) Integrating the dynamics of soil erosion under agroforestry systems in process based dynamic crop models: challenges and the way forward**

Habib-ur-Rahman, Thomas Gaiser, Hella Ellen Ahrends

16.30-16.40 **(O3.2_13_47) Agroforestry: New perspectives for water conservation/ development and regional added value in rural economy**

Camilla Bentkamp, Zaira Ambu, Frank Wagener, Dr. Andreas Stowasser, Lars Stratmann, Tabea Gerhardt, Peter Heck

16.40-16.50 **(O3.2_16_119) Above ground dendromass of black locust (Robinia pseudoacacia L.) in alley cropping systems**

Veronika Honfy, Attila Borovics, János Rásó, Zsolt Keserű

15.20-15.30 **(O3.2_18_205) Productivity of a soybean-sorghum two-year crop rotation in an innovative poplar short rotation coppice silvoarable system**

Alberto Mantino, Giovanni Pecchioni, Iride Volpi, Simona Bosco, Federico Dragoni, Cristiano Tozzini, Fabio Taccini, Marcello Mele, Giorgio Ragaglini

16.50-17.10 **Discussion**

18.00 PLENARY SESSION - ROOM A

Round Table - ROOM A

18.00 **Agroforestry: the future of nature-based farming?**

CHAIRS: Patrick Worms, *European Agroforestry Federation, CIFOR Center for International Forestry Research - ICRAF, World Agroforestry, Belgium*
PK Nair, *University of Florida, Gainesville, USA*
Dennis Garrity, *CGIAR, EverGreen Agricolture*
Christian Dupraz, *INRA-Montpellier, France, Int. Union of Agroforestry*
Giuseppe Scarascia Mugnozza, *Silviculture and Urban Forestry, University of Tuscia, Italy*
Peter Minang, *World Agroforestry Centre (ICRAF), Kenya (to be confirmed)*

Abstract Overview

Abstract Plenary Session

PS.01 *Protecting the Earth and her human inhabitants through multifunctional agroforestry*

PS.02 *Agricoltural heritage systems ad agrtoforestry*

PS.03 *Agroforestry for sustainable animal production systems*

PS.04 *Making Agroforestry Mainstream: reNature lessons from large corporates*

PS.05 *Biodiversity – productivity - stability relationships in agroforestry systems: from principles to processes and practices*

1. AGROFORESTRY, ECOSYSTEM SERVICES, LANDSCAPE AND RURAL DEVELOPMENT

1.1 Climate Change (Adaptation and Mitigation)

ORAL

O1.1_1_19 *Design and potential carbon sequestration benefits of a newly established silvopasture system in Highland Scotland*

O1.1_2_39 *Looking into the future – what is suitable to be grown and what is authorised to be grown in Switzerland?*

O1.1_3_40 *The role of watering ponds in securing water supply for livestock in Iberian dehesas in a context of climate change*

O1.1_4_82 *Does agroforestry modelling need a paradigm shift?*

O1.1_5_130 *Carbon footprint and carbon sequestration comparative analysis of organic pig and cattle farms in dehesa agroforestry systems.*

O1.1_6_199 *Artificial shading to mimic the effects of trees on old wheat varieties for future implementation in agroforestry systems*

O1.1_7_200 *Grazing iberian dehesa: Carbon sequestration offset livestock emissions*

O1.1_8_246 *Assessing the adaptability of maize varieties in silvoarable systems, a case study of Galicia region, Spain*

O1.1_10_326 *Tree cover affects the soil C balance in Mediterranean cork-oak based silvopastoral systems*

O1.1_11_30 *Silvopasture as a best practice for achieving good animal welfare in a changing and changeable climate: a review*

O1.1_13_33 *Potential of agroforestry in climate change mitigation – Assessment of greenhouse gas emissions in four different beef cattle production systems in Finland*

O1.1_14_54 *Agroforestry and climate change – can almonds be grown in northern Switzerland?*

O1.1_15_98	*Ink disease threaten Castanea sativa in agroforestry systems in Sardinia (Italy): prevention and control strategies*
O1.1_19_177	*Temperature regulation: how agroforestry helps climate change mitigation*
O1.1_21_240	*The transformation of agricultural systems into agro-forestry systems as a mechanism of adaptation to climate and economic changes: some Sicilian case studies*
O1.1_22_243	*Wheat varieties established under walnut of different ages in Galicia (NW Spain)*
O1.1_23_244	*Variation of soil organic matter in silvopastoral systems established under Pinus sylvestris L. with celtic pigs in Galicia (Spain)*
O1.1_24_259	*Drought-shade interactions on winter pea induce carbon source-sink mechanisms that may lead to higher yield stability in a mature alley-cropping system*
O1.1_25_262	*Analysis of agroforestry systems productivity compared to afforestation in a climate change context in Galicia*
O1.1_26_278	*Tree coverage in Sardinian dairy sheep systems: farm characteristics and environmental implications*
O1.1_27_304	*Quantitative assessment of carbon sequestration and oxygen production by oak windbreaks growing in the Forest-Steppe zone of Ukraine*
O1.1_28_330	*Variation of yield in varieties of wheat and rye under shade conditions*
O1.1_29_348	*Exploring the potential of coffee agroforestry systems to productivity, adaptation, and mitigation: a system typology approach*

POSTER

P1.1_1_24	*Expansion of cashew in the post-forest zone of Côte d'Ivoire: between reconversion strategies and crop diversification in a context of land saturation and ecological change*
P1.1_3_50	*Seasonal trend of carbon fluxes under different light intensity in a Sardinian cork oak wooded pasture*
P1.1_4_51	*The potential contribution from tagasaste (Chamaecytisus proliferus var. palmensis) to Sardinian farming systems: an agroforestry approach*
P1.1_5_73	*AGROMIX – AGROforestry and MIXed farming systems – Participatory research to drive the transition to a resilient and efficient land use in Europe*
P1.1_6_75	*Agroforestry Use of Almond in Lebanon: Potential and Development*
P1.1_7_117	*Do agroforestry systems and landscape features of non-production function influence the temperature regime in the landscape? Case study Šardice (South Moravia, Czech Republic) – preliminary results*
P1.1_8_131	*Life cycle analysis in a comparative study according to the size of extensive sheep farms in dehesas agroforestry systems.*
P1.1_9_157	*Shading effect on crop yields in intercropped systems of walnut and agricultural crops*
P1.1_10_163	*Biochar and new forest plantations: winning combination for soil Carbon preservation and sequestration*
P1.1_12_247	*Organic carbon in the soil of agroforestry system, Atlantic forest remnant and other land use systems*
P1.1_13_266	*Carbon sequestration in agroforestry system under different managements.*
P1.1_14_300	*Endogenous silvicultural / fruit-growing agroforestry practices, food crops and reforestation around Togodo-sud National Park in Togo to fight against climate change*

P1.1_15_316	*The role of shrub and tree encroachment in abandoned subalpine grasslands: a case study in Aosta Valley*
P1.1_16_321	*Climate protection and production of biomass through agroforestry in Germany*
P1.1_17_331	*Mértola, Laboratory for the future – agroecological transition as a bottom-up response to climate change in Mediterranean semiarid conditions*
P1.1_18_357	*Silvipastoral systems improving beef cattle welfare*
P1.1_19_358	*Vaginal temperature as a predictor of thermoregulation on Nellore heifers under agrosilvopastoral systems*
P1.1_20_359	*Infrared thermography for microclimate measurements on agroforestry systems*
P1.1_21_501	*Potential Constraint of Rainfall Availability on the Establishment and Expansion of Agroforestry in the Joe Gqabi, Alfred Nzo and OR Tambo Districts, Eastern Cape in South Africa*
P1.1_22_514	*Crop responses to climate changes are species dependent in agroforestry systems in Northern France*
P1.1_23_517	*Development and application on ash (Fraxinus excelsior) of a methodology to measure the quantitative and qualitative intake of ruminants for heterogeneous woody fodder.*
P1.1_24_519	*Transpiration decrease in shaded hazelnuts: a green light for experimenting new orchard structures.*
P1.1_25_521	*Semi-extensive agrosilvopastoral system as low-carbon livestock strategy: a case study on beef meat in Tuscany*
P1.1_26_522	*Identification of a group of woody species having an interesting forage profile and able to develop in Auvergne over the second half of the 21st century*
P1.1_27_527	*Successional agroforestry in a temperate climate – establishment of a diverse agroforestry system for practitioners and research in Germany*
P1.1_18_146	*PASTORALP project: expected impacts of climate change on future distribution and development of alpine grasslands and wooded pastures*

1.2 Enhancing Ecosystem Services Provision by Agroforestry Systems

ORAL

O1.2_1_38	*Land sharing or land sparing for trees within upland agricultural land use in Wales, what's the way forward for rebalancing ecosystem services?*
O1.2_2_49	*Can temperate agroforestry systems contribute to Sustainable Intensification of agriculture?*
O1.2_3_88	*Balancing demand and supply of land-based services in agroforestry systems*
O1.2_4_100	*Assessing the influence of silvopastoral practices on the provision of ecosystem services in grazed woodlands: a Delphi survey on Spanish Mediterranean mid-mountain areas*
O1.2_5_302	*The hidden land conservation benefits of olive-based (Olea europaea L.) landscapes: An agroforestry investigation in the southern Mediterranean (Calabria region, Italy)*
O1.2_6_339	*Plant diversity and ecosystem services of silvopastoral Mediterranean agroforestry systems*
O1.2_8_34	*Distribution and nutrient content of poplar fine roots in an agroforestry crop alley in Northern Germany*

POSTER

P1.2_20_524 *Restoring shrub-encroached alpine grasslands using agro-silvopastoral management practices*

P1.2_21_525 *Let's get comparable – a standardized soil sampling design for agroforestry systems in Germany*

P1.2_22_526 *Crop yield, soil conditions and functional agrobiodiversity in temperate arable alley cropping fields throughout the first decade after tree establishment*

P1.2_14_267 *Spread wooded riparian buffer areas can increase significantly the phyto-depuration service*

1.3 Agroforestry, Biodiversity, and Wildlife Management

ORAL

O1.3_1_7 *Higher biodiversity and pollination service in temperate agroforestry than in monoculture*

O1.3_2_15 *Characterization and management of Russian olive accessions in Gilgit-Baltistan, northern Pakistan*

O1.3_3_36 *Ecosystem services in short rotation coppice in agricultural land in Latvia*

O1.3_4_59 *Woodlands and hedgerows of the Po plain: planning instruments and policies implications on biodiversity conservation*

O1.3_5_99 *The effects of tree species composition on soil-related biodiversity in shelterbelts*

O1.3_6_220 *Conserving threatened beneficial insects: bees, wasps and hoverflies in UK silvoarable systems*

O1.3_7_283 *Tree rows change the soil biodiversity abundance and repartition within the first year of plantation at an experimental agroforestry site in Ramecourt (Northern France)*

O1.3_9_257 *Phytosociology of Weeds in agroforestry system managements*

O1.3_10_297 *Agroforestry as on-farm conservation strategy for Virola surinamensis, an endangered Amazonian species*

O1.3_11_322 *Practicing sustainable agroforestry for biodiversity conservation and sustained livelihood option for tribal in Jharkhand (India)*

POSTER

P1.3_1_21 *Conservation of the macedonian oak (Quercus trojana) and monitoring Great Capricorn Beetle (Cerambxy cerdo) in Murgia Materana Regional Park*

P1.3_2_53 *What creatures are there in my agroforestry hedge?*

P1.3_3_263 *Weeds inventory in agroforestry system managements*

P1.3_4_279 *Analysis of phenological functional traits as a contribution for a network of Biodiversity – Ecosystem Functioning (BEF) experiments: the International Diversity Experiment Network with Trees (IDENT)*

P1.3_5_299 *Agroforestry, Market gardening of medicinal aromas and vegetables and 3U / O-3P Initiative in Benin and Togo*

P1.3_7_532 *Agroforestry practices and non-wood forest products in Northern Norway*

1.4 Agroforestry and the Landscape

ORAL

O1.4_1_61	*The role of agroforestry systems in the FAO Globally Important Agricultural Heritage Systems (GIAHS) programme*
O1.4_2_95	*Landscape transitions as a chance for agroforestry. The case of Park Lingezegen, The Netherlands*
O1.4_3_104	*Designing urban agroforestry with people in mind*
O1.4_4_159	*Diversifying oil palm plantations in the Southern Pacific region in Costa Rica.*
O1.4_5_173	*The role of agroforestry in a multifunctional and uncertain world: a landscapes perspective*
O1.4_6_204	*The Meriagos: landscape value from Sardinian agro-forestry system*
O1.4_7_223	*Monitoring of gypsy moth in Sardinian cork oak forests and woodlands: past, present and future implementations*
O1.4_8_71	*Enhancing Terraced Landscapes for Ensuring a Sustainable Development of Traditional Agroforestry Systems. A Case Study in Piedmont (Italy).*
O1.4_9_72	*Spatial models as a tool to evaluate afforestation actions in agrosilvopastoral systems*
O1.4_11_249	*The decline of the cork oak growing in Sicily is accompanied by the loss of the functions proper to agroforestry systems*
O1.4_12_264	*Silvopastoralism and potential use in Europe*
O1.4_13_289	*Innovative beef cattle grazing systems for the restoration of abandoned lands in the Alpine and Mediterranean mountains (iGRAL)*

POSTER

P1.4_1_37	*Agroforestry in vineyards as part of the agroecology approach: reviews, perspectives and insights from ECOVINEGOALS partnership*
P1.4_5_222	*Microbiological control against Lymantria dispar (L.) and Malacosoma neustrium (L.) in the cork oak forests of Sardinia (Italy)*
P1.4_6_230	*SAR and optical data comparison for detecting Trees Outside Forest in agroforestry landscapes*
P1.4_7_308	*Riparian habitat quality evaluation – development and implementation of a new methodological approach with potential use in agroforestry research*
P1.4_8_310	*Agro-Forestry and microclimate in the Pamir*
P1.4_9_232	*Agroforestry in European peri-urban areas, new landscapes for a territorial transition*

2. AGROFORESTRY AND POLICY FOR SUSTAINABLE DEVELOPMENT

2.1 Agroforestry, Quality Food Products and Certification

ORAL

O2.1_1_193	*Certification of agroforestry systems and products according to PEFC*
O2.1_2_207	*FireFlocks: Managing wildfire risk by adding value to flocks' products*
O2.1_4_255	*The potential of geographical indications for labelling in Mediterranean agroforestry systems*
O2.1_5_303	*Understanding the resilience of agroforestry systems in a changing biosphere: a review of stable isotopes in ecophysiological studies*

POSTER

P2.1_1_43	*Explore the economic opportunities and health benefits of the specialty crops in the agroforestry system*
P2.1_3_236	*Spatial-temporal models and authenticity maps to reinforce commercial value of Mediterranean high-value products: displaying REALMed first results*
P2.1_4_239	*Effects of shading orientation on soybean isoflavone concentration to predict the influence of trees in agroforestry systems*
P2.1_6_284	*Effect of season, altitude and ripening on fatty acids profile of sheep cheese*
P2.1_7_286	*Truffles and agroforestry: a binomial to be explored, planned and spread*
P2.1_8_307	*Honey, an agroforestry product featured by the territory. A characterization of locally produced honey*
P2.1_9_320	*Agroforestry in a farm in central Italy. Agroforestry project for Azienda Agricola Boccea*
P2.1_10_328	*The Edible Park: agroforestry with horticultural crops – A multifunctional farm for peri-urban areas*
P2.1_11_502	*Perceptions on Constraints to Agroforestry Competiveness: A Case*
P2.1_12_503	*Flattening the Food Insecurity Curve Through Agroforestry: A Case Study of Agrosilviculture Community Growers in Limpopo & Mpumalanga*

2.2 Policy

ORAL

O2.2_2_185	*AGROMIX – Introducing Policy Co-Development for Agroforestry and Mixed Farming*
O2.2_3_191	*Policy lessons from fifty years of trees on farms in New Zealand*
O2.2_4_198	*Agroforestry in the CAP: an analysis of RDP support in Italy*
O2.2_5_203	*Agroforestry Options in the next CAP*

POSTER

P2.2_1_25 *Measures of adaptation and mitigation in forestry and rural areas from the perspective of the Regional Strategy on Climate Change.*

P2.2_2_26 *Cooperation projects in the implementation of Measure 16 of the 2014-2020 Rural Development Plan in support of rural land and agroforestry policies.*

P2.2_3_89 *Agroforestry in the Czech Republic – history, present state and perspectives*

P2.2_4_129 *Post Nijm egen: what happened to agroforestry policy in the Netherlands after the 2018 EURAF Conference?*

P2.2_6_182 *Agroforestry in Switzerland – current research focus and policy developments*

P2.2_7_227 *Towards Net Zero Carbon: Developing High-resolution Farm-Level Carbon Inventory Maps*

P2.2_8_234 *Main foundations of the afforestation strategy in Ukraine*

P2.2_9_268 *SWOT analysis of silvopastoralism: CAP strategic plans*

P2.2_10_317 *Biodiversity and climate protection by agroforestry in Germany*

P2.2_11_353 *Trees + grapevines. Southern European traditional vineyard agroforestry landscapes and their preservation: a challenge for policies*

P2.2_12_504 *Learning and spreading lessons about agroforestry integration in*

P2.2_13_505 *Boosting agroforestry implementation in The Netherlands: moving*

P2.2_14_515 *Rural and Peri-Urban Areas Planning with the View to Improving Agroforestry and Landscape – EU Experience in Serbia*

3. AGROFORESTRY SYSTEMS AND INNOVATIONS

3.1 Agroforestry and wildfire prevention

ORAL

O3.1_1_20 *Forest fire prevention and agroforestry: the case of the Zonza forest (South Corsica, France)*

O3.1_2_46 *Swidden Agriculture as a Sustainable Production System: a case study on soils in the Southeast Atlantic Forest of Brazil*

O3.1_3_57 *Fire as a tool for territorial management in agroforestry contexts*

O3.1_4_260 *Improving silvopasture farming systems in highly biodiverse areas through the use of satellite images*

POSTER

P3.1_1_108 *Impact of wildfires burning on forest and peatland environment in Latvia*

P3.1_2_150 *Fire risk management with pastures*

P3.1_3_213 *Characterization of canopy in Quercus ilex stands by terrestrial laser scanning*

P3.1_4_254 *New Business Models for innovating the cork sector and contrasting cork oak woodland abandonment*

3.2 Agroforestry Innovations Toward Innovative Agroforestry Systems

ORAL

POSTER

P3.2_12_149	*Allelopathic and Shading Effects of Mangifera Indica L. on Germination and Early Growth of Associated Crops at Chano Mille, Arba Minch Zuria Woreda, Gamo Gofa Zone, Southern Ethiopia*
P3.2_14_164	*What light is available for understory crops in high-density and super-high-density olive orchards? Spatial and temporal patterns of transmitted PAR*
P3.2_15_190	*Aspects of the formation and management of a biodiverse agroforestry system: arrangement, organic matter contribution and food production*
P3.2_16_206	*On-farm production of woodchip for use as a soil improver: practical implementation*
P3.2_17_270	*Agroforestry innovation networks*
P3.2_18_313	*Comparing production systems -including agroforestry type – in organic vegetable growing on the basis of soil properties, and climate*
P3.2_19_343	*Testing "Greater Environmental Sustainability" poplar clones in silvoarable systems. A possible alternative to open field plantation*
P3.2_20_506	*Rapid tannin profiling of tree fodders using untargeted mid-infrared spectroscopy and partial least squares regression*
P3.2_21_507	*Augmented reality to support the design of innovative agroforestry systems*
P3.2_22_509	*How do chicken influence hazelnut production in a silvopastoral agroforestry production system?*
P3.2_23_510	*Successional Agroforestry Systems for the Mediterranean-Temperate transition: the Portuguese example*
P3.2_24_512	*Agroecological approach in soil management to sustain apple organic orchards*
P3.2_25_516	*The wonder of willow tannin-rich trees (Salix spp): A potential valuable tree fodder for ruminants*

3.3 Managing Mediterranean Agro-Silvopastoral Systems

ORAL

O3.3_1_113	*What drives silvopastoral management in mid-Mediterranean mountain areas? Addressing opportunities, synergies and barriers of forest owners and livestock farmers for joint silvopastoral management*
O3.3_2_120	*Redesign and management of Silvopastoral systems in the South of France. Insights from agroecology.*
O3.3_3_160	*Interaction between beef herd and olive grove in Lazio (Italy) organic farm*
O3.3_4_208	*Using quantile regression to evaluate the impact of different factors in the cork calliper of cork oak trees in montado agroforestry ecosystem*
O3.3_5_228	*Assessing the long-term persistence of legume-rich mixtures sown in Mediterranean Dehesas through NDVI analysis*
O3.3_6_265	*Shrub encroachment combines with drought and fire to decrease Quercus suber tree resilience in silvopastoral cork oak ecosystems*
O3.3_7_338	*Does livestock grazing affects soil properties in an oak silvopastoral system? Results from a traditional system in Western Greece*
O3.3_8_345	*Adaptive Multi-Paddock model: a sustainable management practice for Mediterranean silvopastoral systems*

O3.3_9_27	*The agroforestry in the new Algerian forest strategy: state of art, socio-economic importance and future perspectives*
O3.3_10_29	*Maremmana breed, woodland environment and cattle behaviour*
O3.3_11_212	*Simulating the effect of light availability reduction on grass and legume swards in a Mediterranean rainfed plot trial*
O3.3_12_233	*Olive grove and livestock: Project on pasture management schemes for dry sheep*
O3.3_14_301	*Grazed orchards in France: different forms of livestock integration and implications for fruit growers' practices*
O3.3_15_352	*Observations on a livestock cattle system in a Mediterranean mountain pasture*

POSTER

P3.3_1_74	*Selecting indicators for an integrative assessment of different land management in Iberian agro-silvopastoral systems*
P3.3_2_110	*Selection of acorn-Quercus ilex for reforestation of "dehesas" before climate change: experimental seeding of acorns of different procedures*
P3.3_3_112	*Seed mass and parent effects on the early response of Holm oak to different microclimatic tree shelters*
P3.3_5_216	*FOR[m]AGE, BEES & FRUITS: bee-fruit synergies with forage farming systems in rainfed Mediterranean environment*
P3.3_7_291	*Attractiveness of salt placement to cattle in the Mediterranean mountain areas*
P3.3_8_295	*Evaluation of remote sensing indices for characterizing insect defoliation in a Mediterranean agroforestry system*

4. AGROFORESTRY, EDUCATION, DISSEMINATION

4.1 Education, Information Sharing, and Awareness Raising in Agroforestry

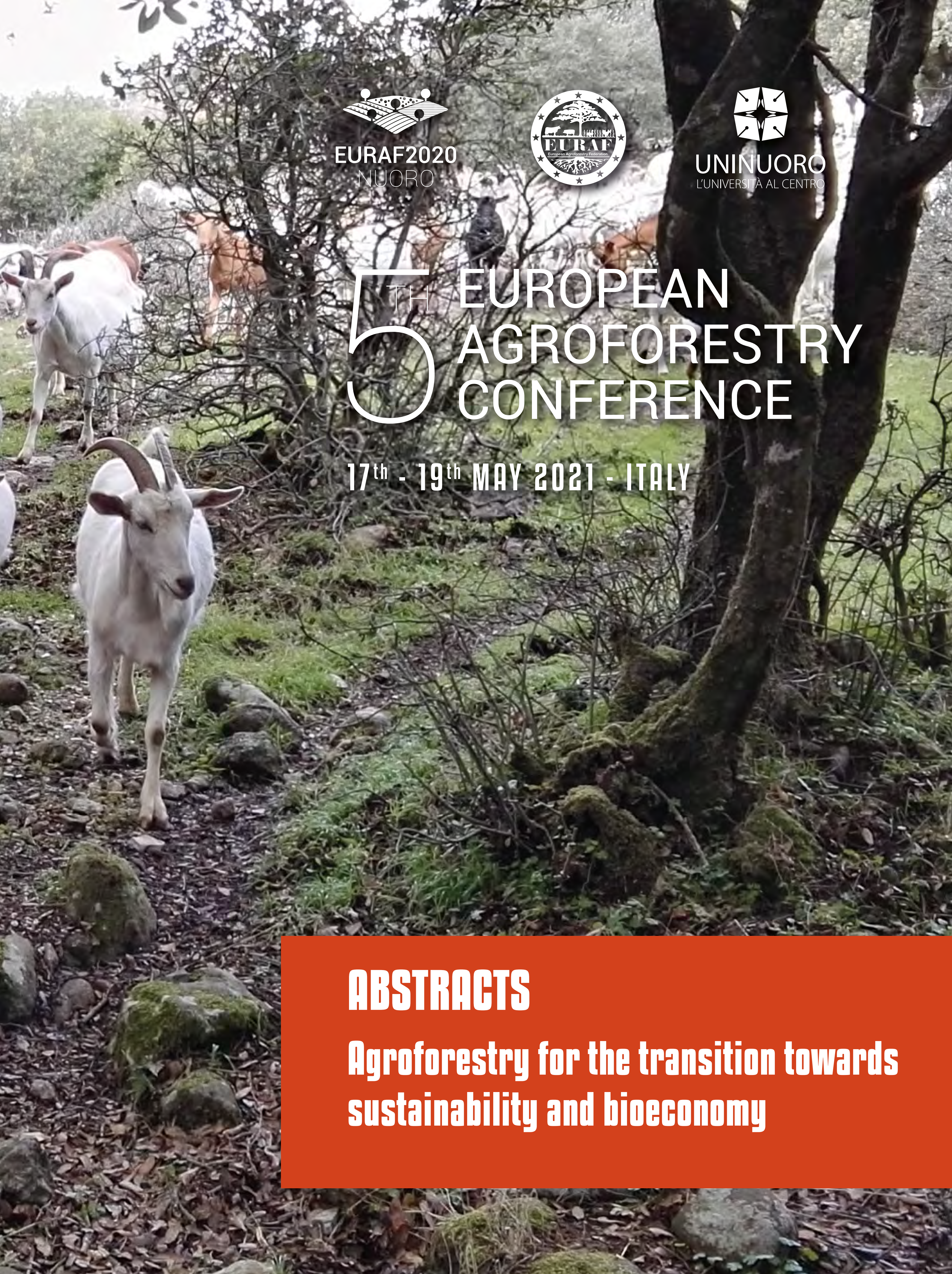
ORAL

O4.1_1_60	*Hands-on tools for participative development of agroforestry implementation plans: the Agroforestry Planner and the Adaptive Farm Plan methodology as inspiring examples*
O4.1_2_64	*Linking scientific and empirical knowledge: an interactive web app to design agroforestry market gardening systems*
O4.1_3_115	*Participative formats to promote agroforestry in Germany – insights, challenges, experiences and recommendations*
O4.1_4_125	*Green entrepreneurship and business skills needed for micro-entrepreneurs – case of Estonia*
O4.1_6_158	*Public-private partnerships for agroforestry investment and adoption in the USA*
O4.1_7_168	*The participative approach to promote innovations in agroforestry: the AFINET project in Italy*

POSTER

4.2 Agroforestry and Rural Tourism

ORAL



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UNINUORO L'UNIVERSITÀ AL CENTRO

5TH EUROPEAN AGROFORESTRY CONFERENCE

17th - 19th MAY 2021 - ITALY

ABSTRACTS

Agroforestry for the transition towards sustainability and bioeconomy

Invited Speaker

Protecting the Earth and her human inhabitants through multifunctional agroforestry

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Keywords: Multifunctional landscapes, perennial agriculture, resilience, community health

Multifunctional agroforestry can be considered as a transformative landscape solution for the health of the earth and her human inhabitants. We currently face unprecedented challenges to feed a growing population, protect our limited resources, and adapt to extreme climate conditions. The health of our own human species is in decline as a result of poor diets and sedentary lifestyles that cause the cluster of conditions we now refer to as "metabolic syndrome". Exposure to toxins, extreme temperatures, floods, and other environmental hazards will further threaten our species into the future. Evidence suggests that these issues disproportionately impact marginalized communities, which in turn has implications for social justice. This presentation explores methods and applications in agroforestry that seek to improve ecosystem health by considering humans as "indicator species". The physical, psychological, and social health of human individuals and populations can serve as a guide for designing and planning the landscape to integrate agroforestry elements that are most likely to offer positive outcomes. An ecosystem approach recognizes that humans are an integral component of the system, so their health and cultural diversity are recognized. Integrating human needs into the conversation on environmental stewardship might allow agroforestry to reach broader audiences, gaining public support that could drive new markets and policy changes.

The urban environment is an appropriate place to consider such an ecosystem approach for agroforestry, as dense populations necessitate an interaction between the green spaces and nearby residents. Urban food forests have the potential to address a broad range of environmental and cultural issues. Food-producing trees sequester carbon in their woody biomass and offer habitat and nutritional resources for urban wildlife. Their contributions to human health and well-being might be even more compelling in the urban context. The shade from trees can moderate the microclimate and mitigate the urban heat island effect, impacting comfort of urban residents and in extreme situations even decreasing the incidence of heat-related conditions and fatalities. Settings with trees are typically preferred from a visual quality perspective, which can boost the restorative power of this form of "nature". The foods produced by trees and shrubs in the urban environment include some of the most nutrient-dense alternatives available. At the same time, however, potential risks such as those associated with growing edible species in contaminated soils, must be considered in a human-oriented ecosystem approach.

An interesting opportunity for agroforestry has emerged with the spread of COVID-19, as multiple vulnerabilities in our food system have been exposed. Disruptions in the processing and distribution of food occurred as a result of wide-spread disease in some facilities. These situations highlighted the need to have local food sources, ideally including healthy items that can be stored for long periods of time. The worst outcomes of the COVID-19 disease itself were correlated with diet-related factors including hypertension, diabetes, and cardiovascular disease. Food products from agroforestry, such as black walnut and elderberry, could play an important role in reducing those conditions. A community orchard project demonstrates the potential for agroforestry to contribute to human health and wellbeing at a time when these topics are taking center stage. The Osage Orchard serves as an example of agroforestry established in response to the pandemic, but with long-term potential to contribute to food security, community health, and cultural learning for many years to come.

Agricoltural heritage systems ad agrtoforestry

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Today, the world is facing numerous challenges in front of changes in almost every sphere of life. This clearly seems to be a transition period in the economic, social, ethical, cultural, technological fields, and this is added to modifications in weather conditions and cycles of nature, caused by a harsh and sudden climate change occurring in our planet. According to scientists, the impact of these changes is stronger due to the effect of unsustainable practices carried out by human activities. Examples of these practices are the incorrect, imbalanced and unsustainable use of natural resources, as well as untenable development models, which do not consider long term impacts or "side effects" of activities conducted. As one of the human activities which has a direct relationship with nature and environment, agriculture is considered as one of the main drivers of the negative trend that is being followed. In fact, unsustainable farming practices result in land conversion, habitat loss, inefficient use of water, soil erosion and degradation, pollution, genetic erosion, among many other negative impacts on wild and human life. Simultaneously, agriculture is suffering from climate change and natural resource loss, being a direct user of soil, water and biodiversity. Nevertheless, when agriculture is practiced in a sustainable way, it can preserve and restore habitats, protect watersheds, and improve soil health and water quality. The use of sustainable and ecological practices is the key feature distinguishing traditional agriculture and agroforestry, which was developed over decades or centuries, based on traditional experience and proven traditions. This kind of farming does not provide enormous production, but ensures sustainable yield over time, thanks to time-tested technologies and traditional know-hows, being more sustainable and less polluting than industrial techniques. Based on this idea, in 2002, FAO launched the idea of Globally Important Agricultural Heritage Systems (GIAHS), to identify and safeguard agricultural sites which have survived using traditional techniques and are still providing many services to the ecosystem, while maintaining landscapes, wild and agricultural biodiversity, ancestral knowledge transmitted through generations, and strong cultural and social values. From 2015, based on the outcome of the 39th FAO Conference, GIAHS has become an FAO corporate programme, today listing more than 66 sites. In several countries there are national lists from where potential sites can apply to the FAO program, in Italy we have the National Register of Historical Rural Landscapes, with 22 registered sites and 17 waiting to be nominated.

Agroforestry for sustainable animal production systems

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Keywords: climate change, livestock production, shade, sustainable systems

Abstract

Grass fed beef has unique organoleptic characteristics that make it appreciated by consumers. However, in tropical areas, as in Brazil, extensive grazing production is challenged by heat stress imposed by the rough environment, compromising animal performance and welfare. Under unfavorable conditions like this, agricultural systems capable of providing shade, such as agroforestry systems, are able to improve several aspects of the surrounding environment, with positive effects on animals. This work has investigated the effect of agroforestry systems to assist sustainable animal production. Results show that according to season and weather, the presence of native or cultivated trees integrated into pastures, can promote air temperature reductions from 2 °C to 9 °C throughout the day. This leads to reduction of up to 28% in thermal radiation load and up to 4.5 percentage points increase in relative humidity, followed by reductions between 1.0 and 4.2 °C in infrared radiation emissions between tree canopy and the forage. With a reduction of up to 3.7 % in Temperature Humidity Index and 10.2 % in Black Globe Humidity Index in shade, there is a change in behavioral patterns of cattle, when they show longer time spent in shade (53.7%) and preference for grazing in the sun in the morning and grazing under shade in the afternoon. Other daily activities, such as rumination and idleness, are preferably performed under shade. Even Nellore cattle, a thermotolerant breed, kept in pastures with natural shade available in adequate quantity and quality have body temperature, on average, 0.5 °C lower than those without access to shade. Finally, total weight gains showed to be up to 30 kg LW higher under agroforestry systems, proving that thermal comfort can indeed reflect on cattle performance.

Introduction

Discussions on thermal comfort and animal welfare in agriculture are heightened along with other concerns about the impacts caused by climate change and global warming. Especially in the tropical and subtropical Brazilian regions, where cattle ranching occurs almost exclusively on pastures, the high incidence of solar radiation with consequent heating of the environment greatly influences the thermal stress of animals (Oliveira et al., 2019; Karvatte Jr et al., 2021). Despite the fact that beef on pasture is considered a qualitative differential, mainly for the international market, given the basic availability of more natural conditions of survival, in these regions, the shade in adequate quantities helps to improve animal welfare for both European breeds and Zebu with their crosses.

Thus, in recent years, agroforestry systems, although initially designed for the recovery of degraded soils and pastures, have also stood out for improving microclimate conditions and contributing to sustainability in cattle ranching. The combination of trees in different densities and spatial arrangements affects the thermal environment with a variety of processes and feedbacks, highly dynamic and correlated in space and time (Karvatte Jr et al., 2021). By intercepting direct solar radiation, trees reduce the heat load below the forest canopy, providing a cooler environment through evapotranspiration and shading (Oliveira et al., 2017; Karvatte Jr et al., 2020). For forage production, i.e. food for animals, the reflexes caused include greater availability of water in the soil, nutrient cycling between the components involved and pastures with better nutritional values and structural quality (Glatzle et al., 2021), which guarantee better animal performance and gains by area (Oliveira et al., 2014; Pereira et al., 2021).

In this context, national public policies have been developed with a view to consolidating a national agriculture based on sustainable, resilient and productive systems. Prioritizing actions at a territorial level, recently the Brazilian Government, led by the Ministry of Agriculture, Livestock and Food Supply (MAPA), laid the foundations for the development of a global strategy for the Adaptation Plan to Climate Change and Low Carbon Emission in Agriculture, called ABC + Operational Plan, to be carried out from 2020 to 2030, which considers the stimulus to technological innovation as a driving factor for food production. The plan aims to maintain agroforestry systems and their modalities as a strategy to encourage the adoption and maintenance of conservationist and sustainable agricultural production systems, to increase productivity and income, resilience and control of greenhouse gas emissions. It contributes, thus, for the fulfillment of the goals established by the 17 Sustainable Development Goals (SDGs) (Brasil, 2021).

The objective of this work is to address the main effects of agroforestry systems within the context of more sustainable animal production.

Shade effect on pasture availability and animal performance

Introduction trees in production systems based on pastures, contributes significantly to reducing risks arising from climate change. Cultivating trees in rows, characterize a condition of canopy unevenness throughout its establishment, which may influence solar radiation transfer (reducing incidence) and radiation reflection through the tree canopies, through shading, in addition to modify the corrugation of the soil surface and, thus, change the scattering of radiation in the environment (Alves and Karvatte Jr., 2019). However, it is noteworthy that solar radiation affecting the undergrowth varies depending on the daily solar elevation, season and distance between tree rows. This shows that shade projection is not static during the day, nor throughout seasons, allowing the entire system to benefit from a portion of solar radiation, to a greater or lesser extent, throughout the production cycle (Oliveira et al., 2017; Karvatte Jr., 2021).

Looking at effects on forage, the configuration of tree rows preserves high transmission of photosynthetically active radiation, essential for its development. In this sense, initially, animal production in agroforestry systems can be considered as an environmental challenge. When the intensity of radiation that affects the understory changes, both in quantity and in quality, the forage plants prioritize the aerial part growth to the detriment of the root system and the beginning of flowering, presenting important effects on the morphogenesis of grasses (Oliveira et al., 2014; Almeida et al., 2019; Pereira et al., 2021). Paciullo et al. (2011), demonstrated that the tiller density at 9.1 m away from the tree line was 37 % higher than that established below the tree canopies, as a consequence, greater production of forage mass (kg MS.ha-1) was observed in more distant locations of tree rows or that offered less radiation interception. However, when shaded, grasses tend to have better nutritional value, with a higher crude protein content, less fiber content and better dry matter digestibility (Oliveira et al., 2014), favored also by the gradient of moisture accumulation in the different layers of the soil (Glatzle et al., 2021).

Looking at the effects on animals, when they feed on grasses with better nutritional quality, there is a reduction in heat production for maintenance needs and less need for thermal dissipation with the environment, making it metabolically more efficient (Martello et al., 2016). As a result, better performance in total weight gain is expected. In fact, Pacciulo et al. (2011), identified a difference of up to 17.9 % in the weight gain of dairy heifers reared in silvopastoral system (0.628 g.animal-1) in comparison to open pasture (0.515 g.animal-1). In beef cattle production, Luz (2019) evaluating Nellore steers identified greater average daily weight gain (0.484 vs. 0.394 kg.day-1) and final live weight (455.23 vs. 443.18 kg) in agroforestry systems compared to open pasture. However, it is also important to note that in tropical countries, such as Brazil, the seasonality of production, defined by periods of higher rainfall and forage availability, also influences the variation in weight gain of finishing animals (i.e., Nellore steers) in pasture systems with and without trees (Aranha et al., 2019).

Shade effect on thermal comfort, behaviour and animal welfare

Although it is not directly related to air temperature, several studies prove that shading in pastures plays an essential role in altering the microclimate. In shaded pastures with different tree densities, Karvatte Jr et al. (2016) found a reduction of 2 to 9 °C in air temperature and an increase of 4.5 percentage points in air relative humidity, in relation to full sun. In these systems, infrared radiation emissions from tree canopies and pasture is also limited to a narrow temperature range (below 23 °C, moment of stomatal inactivity), avoiding an accumulation of thermal load by radiation and favoring increases of relative humidity, in the understory (Barreto et al., 2020; Karvatte Jr. et al., 2020). Occurrence of winds in agroforestry systems is also altered, with formation of vortices derived from temperature difference between shaded and non-shaded areas, which result in a decrease in wind speed (wind break effect) from 26 % to 61 %, in winter and summer, respectively (Alves and Karvatte Jr., 2019). However, it is important to note that in systems with less spacing between tree rows, reduced circulation of winds can become a factor of animal stress, due to the heat accumulated during the day. On the other hand, the daily thermal amplitude is also favored in agroforestry systems by conserving a milder microclimate at night and favoring animal thermal comfort, especially in regions with cold climates (Alves and Karvatte Jr., 2019).

In this sense, in milder microclimate conditions, the degree of environmental thermal comfort is also changed. This leads to a reduction of up to 28 % in radiation thermal load, followed by a reduction of up to 3.7 % in Temperature and Humidity Index (THI) and 10.2% in Black Globe Temperature and Humidity Index (BGHI) in the shade (Karvatte Jr et al., 2016). In fact, Magalhães et al. (2020) observed that silvopastoral systems with single tree rows spaced at 37 m and triple rows spaced at 30 m provided shadow zones with values of BGHI, during the four seasons of the year, lower than those obtained in a conventional pasture system. During the Spring and Summer, zones of better thermal comfort were found close to the North face of tree rows with projected shade close to tree trunks. In Autumn and Winter, South face, with a greater area of projected shade in the space between tree rows, due to the difference in solar elevation between the seasons (Karvatte Jr et al., 2021). However, microclimate changes are not limited to the shadow cast area only. The changes that occur in the air temperature gradients can be seen in a radius of up to 50 m away from the trees, even in full sun (Abreu and Labaki, 2010).

Reflections of a production environment with better conditions of thermal comfort are also observed in the physiological animal responses. Under favorable thermal conditions, animals adjust themselves physiologically, behaviorally and immunologically, to minimize the adverse effects of thermal stress. In silvopastoral systems, if correctly handled, the presence of shade favors thermal dissipation to the benefit of body thermoregulation, which can reduce the skin's surface temperature by an average of up to 0.5 °C. An example of this was reported by Oliveira et al. (2019), over a period of 24 hours, these authors identified a delay of two to four hours in the maximum peak of vaginal temperature of Nellore heifers in response to the maximum peak temperature of black globe in the environment (obtained at times close to noon). These results suggest that under high temperature conditions, animals store a portion of the heat from the production environment. However, they demonstrate the establishment of a nocturnal thermal environment favorable to the dissipation of the thermal surplus accumulated during the day. In this sense, being able to adjust to the environment more easily, reproductive responses are also benefited, an example of which was demonstrated by Silva et al. (2020) who obtained a blastocyst rate of Nellore heifers 54.7 % higher in the shade, when compared to a system without trees.

Still in this sense, in environments with adequate shading, where animals are not directly exposed to solar radiation, water consumption tends to be up to 35% lower than traditional systems without shade (Giro et al., 2019; Pereira et al., 2019), demonstrating that water losses due to sweating, due to thermoregulation, are reduced in a more suitable thermal environment. The time spent on grazing activity is also affected, with a longer stay in the shade (53.7%) and preference for grazing in sunny areas in the morning and in the shaded areas in the afternoon, reserving the hottest times of the day (between 12 p.m. and 4 p.m.) for idleness and rumination activities, which are also preferably carried out in the shade (Giro et al., 2019; Vieira Jr et al., 2019). In addition, animals with access to shade are more interested in interacting with the environment, in exploratory behavioral activities and social behavior.

Conclusions

Agroforestry systems are a viable alternative from a technical, environmental and socioeconomic point of view to traditional models of livestock production in the tropics, with an improvement in the productive capacity of the land and optimizing use of available resources. In these systems, the tree component has strong influence on the local environment, through the mitigation of climatic effects, boosting animal performance through pastures with better plant structure and nutritional value and providing better conditions of thermal comfort and animal welfare.

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Making Agroforestry Mainstream: reNature lessons from large corporates

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Theme: How to engage the private sector and large corporates to adopt Agroforestry inside their supply-chain and create a long-term relationship agreement to meet its sustainability targets. Lessons from reNature work with Agroforestry on building trust across the market.

Keywords: Private investment, commercial supply chain, commodity production, regenerative agriculture, agroforestry, corporates, impact investing, ESG & inspirational.

Oral Presentation: Lessons from Developing Agroforestry Projects with Large Corporates - how to grow your own Agroforestry business

Food & Agricultural industry sectors play a key role in defining global agricultural practice. Burgeoning private-sector excitement for "regenerative agriculture", "agroforestry" approaches is an opportunity to channel unprecedented resources into the development of commercially-viable agroforestry practices at large scales. For example, companies such as Nespresso, General Mills, Danone, VF Corporation and Patagonia are all putting themselves forward as frontrunners in a new wave of regenerative big business.

Yet most commercial agroforestry initiatives are still only occurring on small scales and amongst relatively few companies. Therefore this emerging opportunity for agroforestry remains largely under-exploited. A key challenge is that agroforestry "solutions" are complex and case-specific, taking a number of years and specialised knowledge to put in place. This complexity and timescale presents a communication & business challenge. For agroforestry to achieve its "potential" on a large scale it is essential for the scientific agroforestry community to find effective means to develop new business cases with the private sector.

This presentation discusses approaches for presenting Agroforestry to corporates and the commercial potential of agroforestry to private sector actors. Over the past two years reNature has built deep knowledge of effective methods for communicating agroforestry to a wide audience. Our goal is to connect world-leading knowledge and practice with the massive resource potential of private sector investment.

Our experiences from the past three years can offer a number of key insights. Firstly, although agroforestry practices and farmer transition processes are complex and often challenging, it does not always have to be communicated as such. The possibility for win-win-win outcomes for companies, communities and the environment is a powerful message for driving commercial enthusiasm. On this basis companies see the potential for improving their image not only towards consumers and the wider public, but also towards their own staff, who increasingly want to know that they are "doing good" for the planet.

Secondly, agroforestry's potential for improving yields, quality or long-term stability of key commodities is also a powerful communication tool. It helps to drive an understanding of agroforestry as more than a conservation or social welfare tool, allowing companies to justify investment because of direct benefits to their core resource base. This form of inspirational engagement can open the door for the science of agroforestry to be more widely applied.

And finally, effective digital communication methods have the potential to rapidly increase the pool of dedicated agroforestry practitioners across the globe. While scientific and practical understandings of agroforestry are increasingly refined, cutting-edge knowledge and techniques are still relatively "centralised" amongst an elite community. Widespread engagement of younger generations who increasingly prioritise "meaningful" careers is an opportunity to create a worldwide network of practitioners applying the best agroforestry knowledge to their own local contexts.

The current challenge is to create a story about agroforestry's potential that is engaging enough that leading agroforestry experts have the opportunity to apply their knowledge in commercial supply chains. Direct, simple and positive messaging is a key tool for driving private sector investment and making agroforestry mainstream.

Biodiversity – productivity – stability relationships in agroforestry systems: from principles to processes and practices

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The hypothesis that ecosystem productivity increases with increasing diversity was first formulated by Charles Darwin in 1859. It took another century, until 1958, for the hypothesis that higher stability is obtained in more diverse ecosystems to be postulated by Evans. Yet, much earlier, humans had developed, through trial and error, ingenious agricultural systems where both productivity and yield stability had been increased by harnessing biodiversity function. In regions with light or water limitations, typically crop rotation systems developed, such as the four crop system (sequential cropping of wheat, a pest controlling mustard family representative, barley, and a nitrogen-fixing pulse) which originated in Flanders in the 16th century and powered the British agricultural revolution of the 18th century. In regions with nutrient limitations, typically multi-layered agroforestry systems developed, such as the Itteri system developed in Tamil Nadu since time immemorial, which combines the cultivation of trees, shrubs and herbs in small patches or linear landscape elements.

One of the basic assumptions of agroforestry systems is the occurrence of complementarity and facilitation. This means that the increased diversity of the system provides advantages compared to monocultures that go beyond a mere sampling effect, which is the probabilistic effect of having a greater chance of encountering a well-performing species in a mixture. Complementarity occurs when trees and crops exploit more of the factors limiting growth, when grown together than when grown apart. The most common mechanism for this is the temporal sharing of resources. For example, Faidherbia albida trees shed their leaves during the rainy season, so have reduced water demand when the understorey crop develops, yet, through a deep taproot, they take up water in the dry season, thus increasing resource use over the year. In any multi-layered system, crops such as coffee, vanilla or cocoa inhabit the understorey and can make use of the filtered light of a mixed tree canopy. Facilitation is a modification of the environment by one species that inadvertently benefits the other. For example, upper-canopy trees reduce dew formation on crops under their canopy and this can reduce leafspot diseases. Shade from the trees also can reduce weed competition, particularly of grasses. This presentation will give a state of affairs of what we know in terms of diversity effects and their mechanisms in agroforestry systems to date.

But curiously, even though agroforestry is built on these premises, the evidence of such biodiversity effects and the quantititative assessment of the biodiversity function mechanisms at play are lagging behind, in comparison to research output in other production systems such as grasslands, forests or aquatic systems. There is therefore a need for more well-designed agroforestry experiments, where confounding factors of climate, soil and other management practices are carefully controlled for, and where biomass production, crop yield and economic gain, and their stability over time, are meticulously assessed as a function of the diversity level used. In comparison with forestry or grassland experiments, agroforestry experiments are more complex to design. In addition to levels of species diversity and functional diversity, there is a need to assess levels of structural diversity. The presentation will do some recommendations for boosting biodiversity function research, as a basis for designing more effective and resilient agroforestry systems.

1

Agroforestry, ecosystem services, landscape and rural development

1.1

Climate change (adaptation and mitigation)

Design and potential carbon sequestration benefits of a newly-established silvopasture system in Highland Scotland

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: silvopasture, carbon sequestration, uplands, Scotland

Abstract

The design and use of a new wood pasture system (established in 2009) will be described on an upland Scottish farm with discussion on future woodland management approaches, wider applicability within the Scottish upland farmed landscape, carbon sequestration and practical benefits for livestock and the enterprise.

The Mains of Fincastle is a 540 ha upland livestock farm in Highland Scotland. A 50 suckler cow herd and 400 commercial sheep flock are run by A&S Barbour in an organic, extensively run system. In 2009, two silvo-pastoral blocks were established at 280 m a.s.l. on brown earth soils, covering 5 ha and 1 ha respectively. The objectives were to grow oak for on further sale/farm use for milling and firewood, whilst providing shelter and early spring grass for livestock. It was also anticipated that carbon values would prove useful for the farm business.

An alley design was adopted on two sites (5 ha and 1 ha), with 3 rows in eight left unplanted (see figure 1). The 5 planted rows consisted of a central core of oak (Q. p.) with outer rows of rowan, birch, alder and ash. Overall tree density was 1600 ha^{-1}, but the planted rows were effectively established at 2500 stems/ha. Tree species were primarily chosen as site suitable native species which have the ability to coppice, with oak being the main crop species. Trees were established without ground preparation by direct planting and protected using easy wrap 60 cm sleeves with supporting canes. Livestock was excluded with stock fences during the early establishment period. The sites chosen were agricultural fields with a history of agricultural improvement but were adjacent to former oak sites, grown in the 18th and early 19 centuries, subsequently put under grass.

Oak are growing at yield class 6 and are showing predominantly good form. Pruning of lower branches has been partially achieved using sheep stock, introduced at year 5 and cattle at year 9, with some selected hand pruning. It is anticipated that a thinning will be taken at 20 to 25 years, based on former Forestry Commission general yield class models. The target density of final crop trees will be brought down to 60 trees ha^{-1} which will then be grown 'free' to maximise growth rate. It is anticipated that another 60 trees ha^{-1} will be cut as pollards but there is a variety of management options, given the ability of most of the species to regenerate through coppice/pollarding.

Carbon values of this proposed management approach will be presented, using Forestry Commission published values (Cannell, 1999). This is compared with carbon outputs from the farm currently (using 2017 real figures) as calculated using Agrecalc carbon calculator, conducted by the Scottish Agricultural College.

Finally, these results will be discussed based on choice of methane metrics, using GWP100 and GWP*(Allen et al, 2018). The implications of these two metrics will be outlined on this farm and discussed in the context of UK and Scottish Government policy objectives. The potential in the Scottish uplands of a wider uptake of this approach will be summarised and barriers to uptake outlined.

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Figure 1. photo of described silvopasture system

Looking into the future – what is suitable to be grown and what is authorised to be grown in Switzerland?

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: agroforestry, climate, adaption, legal framework

Abstract

In Switzerland - as in many other European countries - Agroforestry systems are long-term investments for farmers. The woody component provides income earliest after 5 years from a continuous fruit or energy production and latest after 30 or 100 years when timber is harvested in Europe. To guarantee a sustainable and resilient production over this whole period requires bold and farsighted decisions considering legal framework and markets as well as changing climate conditions. While the markets are almost unpredictable, and changes occur rapidly; climate can be modelled and projected. For example, the Swiss National Centre for Climate Services (CH2018 2018) predicts temperature rise in summer of 2.5 to 4.5 °C and a decrease of precipitation of 10 % to 25 %. The growing season will be prolonged, but it will become drier. While these conditions will restrict the present agricultural production, they will also allow new crops and tree species to flourish.

Based on previous studies (e.g. den Herder et al., 2017; Kay et al., 2019) listing existing and optional European agroforestry practices, we evaluated the future suitability of agroforestry candidates for the Swiss plateau region. This region spreads out from Lake Geneva to Lake Constance within an altitude below 600 m. Around half of the areas is used by agriculture, mainly arable land, which offers good conditions to establish agroforestry practices.

Against this background, we first checked the suitability of the "existing European agroforestry practices" (Kay et al. 2019) for Swiss future climate conditions. Although there are several future possibilities, not all of them are feasible and legally authorised. Therefore, we evaluated in a second step the conformity of the first selection within the current Swiss legal framework.

From the 64 agroforestry candidates proposed by Kay et al. (2019) for Europe, we selected 12 silvoarable systems that are not currently grown in Switzerland, but only in the Atlantic, Mediterranean and Steppic regions and evaluated their potential for growing under current and future climate conditions as well as the conformity to Swiss legal framework (Table 1).

Three candidates are recommended for a growing and testing phase in the Swiss plateau. Five practices are classified as "constricted" as either temperature or water supply might not adequately fit the growing requirements. For these propositions an individual check of the local conditions is recommended. Four candidates are inadvisable; three if them are not conform to the Swiss legal framework.

We crosschecked our results with farmers, local stakeholders, and horticultural specialists. They confirmed that almonds and olives could already be grown in (home) gardens and parks in Switzerland. Besides that, they pointed out that farmers, mainly due to legal limitations, do not yet use hedges (or fodder trees).

Table 1. Potential new agroforestry systems for Switzerland

ID	Agroforestry practices / Management	Growing conditions	Suitable under current climate conditions	Suitable under future climate conditions	Conformity to Swiss legal framework	Remarks	Recommen-dation
1	Hedges / Bocage Wide range of species composition	Variable according to species requirements	+ +	+ +	Installation: ++ Harvest: - +	Hedges are subject of the Swiss nature conservation, max. 1/3 can be used at once	Constricted
2	SRC Poplar (Populus ssp) and Willow (Salix ssp.)	Adequate water supply	+ +	+ -	+ +	Current policy goals promote food rather than energy production	Constricted
3	SRC Black locust (Robinia pseudoacacia)		++	++	- -	Classified as invasive alien species (Wittenberg 2006)	Inadvisable
4	SRC Pawlonia (Paulownia tomentosa)	Adequate water supply or irrigation	+ -	- +	- -	Classified as invasive alien species (Wittenberg 2006)	Inadvisable
5	High stem trees Pawlonia (Paulownia tomentosa)	Adequate water supply or irrigation	+ -	- +	- -	Classified as invasive alien species (Wittenberg 2006)	Inadvisable
6	High stem trees Olive (olea europaea)	Sensible to frost and freezing; high drought tolerance, preference for long dry summer	- -	- +	+ +		Constricted
7	High stem trees Almond (Prunus dulcis)	Sensible to frost and freezing	+ -	+ +	+ +	Interesting market opportunities for fruits	Viable
8	Mixed high stem trees e.g. Hackberry (Celtis australis)	Sensible to frost, tolerate drought, nutritionally poor soils	- +	+ -	+ +	High quality timber (elastic); fruits for pastries	Viable
9	Intercrop cork oak plantation (Quercus suber)	Evergreen tree, tolerant to drought and heavy rain, preference for mild winters	- -	- -			Inadvisable
10	Mixed high stem trees with Black walnut (Juglans nigra)	Fast growing, high water requirements	+ +	- +	+ +		Constricted
11	Intercropped fruit plantations with Pistachio (Pistacia vera)	Young Pistachio trees with low frost tolerance, but high drought tolerance	- -	- +	+ +	Interesting market opportunities for fruits	Constricted
12	Mixed high stem trees with e.g. Grayish oak (Quercus pedunculiflora)	Grayish oak is medium-sized tree, high drought and flood tolerance	- -	+ -	+ -		Viable

In conclusion, forward-looking agricultural management builds on a collection of multiple information and (hopefully) results in a diversity of suitable opportunities. Our list presents a first idea of additional propositions for Swiss farmers to established climate resilient agroforestry – already at present.

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The role of watering ponds in securing water supply for livestock in Iberian dehesas in a context of climate change.

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation) / Managing Mediterranean agro-silvopastoral systems

Keywords: Watering ponds; livestock watering; dehesa; hydrology; reliability; climate change

Abstract

Dehesas are agro-silvo-pastoral systems characterised by the presence of a savannah-like open tree layer (mainly holm oaks and cork oaks). These systems dominate the landscape of the southwestern (SW) Iberian Peninsula and are considered High Nature Value farmland systems in Europe, due to the wide range of ecosystem services they provide (Garrido et al. 2017). At present, livestock rearing in extensive farms is the dominant land use in dehesas.

In these farms, water is an essential and often scarce resource. Regular water stress in summertime is accompanied by a high interannual rainfall variability due to the existence of occasional long dry periods. Under these circumstances, ensuring a continuous supply of drinking water for an increasing livestock population is already a challenge for ranchers, presumably will be aggravated in the future by climate change. In the Mediterranean region, projections show that temperatures and rainfall variability will rise and droughts will occur more frequently, which will negatively affect both the quantity and quality of pastures and the availability of water resources for livestock (IPCC 2018). At the same time, an increase in the demand for water by livestock is expected as a result of prolonged exposure to higher air temperatures. All this will lead livestock systems in this region to experience greater water stress.

Water storage is a way to cope with variability in water availability and is often considered to be an adaptation strategy to climate change. In particular, the collection and storage of rainwater (rainwater harvesting) through the construction of small reservoirs has been a technique utilized by farmers for thousands of years to enhance the resilience of their water systems to climate variability and there is currently a renewed recognition for the development of this kind of infrastructures led by its multiple benefits (van der Zaag and Gupta 2008).

Ponds for livestock watering are an example of such infrastructures. In the Iberian Peninsula, the construction of watering ponds has been an increasing phenomenon in the last decades and, at present, they have become habitual elements of the landscape in dehesas. Most of these ponds consist of small earth dams which collect surface runoff from intermittent streams, with pond sizes rarely exceeding 1 ha. The hydrological functioning of these infrastructures must be understood in order to be located, designed and managed properly. Very few studies have addressed the hydrological dynamics of this specific type of water bodies and, up to our knowledge, none has been carried out in Mediterranean areas yet.

In this study, we have investigated the temporal patterns of the water regime of a sample of representative livestock watering ponds in the SW Iberian Peninsula, trying to answer questions such as: how does the temporal rainfall variability influence the water availability in the ponds? Are these ponds able to provide water to livestock during the regular dry seasons and during frequent droughts? What size of pond and catchment area would be necessary for ranchers to be able to cope with these periods of water scarcity with certain guarantees?

For this study, two private farms, representative of the dehesa land use system, were selected, in which a total of 17 watering ponds were identified. The temporal patterns of the water regime of the ponds were analysed by using high resolution aerial images (orthophotos). All images available online for the two farms and taken during the last 20 years, were gathered (21 images in total). In each of them, the flooded area (A) of each pond was digitized and quantified. In addition, the flooded area corresponding to the maximum capacity of each pond (A_{max}) was identified in the images and quantified. As representative variable of the water availability in the ponds, the A/A_{max} ratio was used.

The influence of temporal rainfall variability on water availability in the ponds was analysed by simple linear regression analysis between the observed A/A_{max} ratios and antecedent rainfall. For these analyses, we included 12 different periods for calculating the rainfall accumulated prior to the observation dates: from 1 to 12 months, i.e. a total number of 12 linear regressions were conducted for each pond. Rainfall data were taken from several meteorological stations located in the vicinity of the study farms.

The high correlation coefficients obtained in those regressions evidence the dominant role played by rainfall in the hydrological dynamics of livestock watering ponds in the study area. The accumulation periods of antecedent rainfall (AP) that best explained the hydrological response of the ponds depended largely on pond size. While water availability in the smaller ponds (<2000 m^2) was greatly influenced by AP between 2 and 5 months, in the larger ones (>2000 m^2), the best correlations were obtained for AP greater than 6 months. These results highlight the important role of the size of the ponds in their capability to hold water during the dry periods. Since the dry season in the study area usually lasts for more than 3-4 months, it is expected that the smaller ponds will reach very low water levels (or dry out) at the end of the summer, regardless of rainfall occurring in the previous months. Instead, the larger ponds could remain operational throughout the dry season, if it rains enough during the wet season and if their catchment area is large enough to allow a sufficiently high filling level to be reached at the end of the wet season. In this regard, the analysis of annual rainfall and discharge data recorded since 1991 in two experimental catchments, representative of the Iberian dehesas, led us to propose, for the study area, a minimum value of the catchment-area/pond-capacity ratio of approximately 100.

Moreover, an analysis of water availability in ponds in the images taken in a context of drought (i.e., with antecedent rainfall amounts substantially lower than normal for the corresponding time of year) revealed that almost all these ponds had filling levels below 20%. This vulnerability to drought observed in most ponds, together with the frequent occurrence of these events in the SW Iberian Peninsula, questions the use of ponds as the only source of water supply in the farms, particularly in the context of climate change, with an expected increase of drought frequency in this area (CEDEX 2017). As climate change becomes a greater threat to livestock systems, diversification of the types of water supply systems used will provide an important adaptation mechanism.

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Does agroforestry modelling need a paradigm shift?

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Modelling, uncertainty, complexity, decision analysis, value of information

Abstract

Agroforestry systems are complex. The intricate ways in which trees and annual crops, animals and other system components interact have presented major challenges for agroforestry modellers. Some progress has been made in modelling agroforestry systems (Luedeling et al. 2016), but the resulting tools have remained very difficult to use. Data requirements have been immense and simulations have usually relied on extensive field studies – or on bold assumptions. This may be acceptable wherever the goal is to predict the performance of well-established agroforestry systems, but it is not helpful for assessing agroforestry's performance in new places, or innovative agroforestry options. In such settings, collecting data is impossible, placing stifling constraints on the use of established agroforestry models for decision support. Even where datasets are available, models are often unable to produce decision-relevant information, because they do not adequately represent the inevitable uncertainty that accompanies all projections on systems that are not perfectly understood.

Agroforestry models have also struggled to address the full scope of benefits tree-based agricultural systems can produce. Obvious benefits, in particular the yield of annual crops, are usually considered, but agroforestry systems produce a wide range of somewhat more complex benefits, such as soil protection, erosion control, water cycle regulation, biodiversity conservation, microclimatic improvement, additional marketable products and intangible cultural benefits such as the aesthetic appeal of agro-forested landscapes (Fig. 1). These important factors have proven difficult to model, but omitting them can lead to erroneous recommendations when models are used to support land use decisions. Agroforestry systems are likely to produce greater benefits in most respects with the possible exception of annual crop yields. Models that do not account for the full scope of system impacts risk systematically underappreciating the true benefits of adopting agroforestry practices.

Capturing the complex interactions in agroforestry systems, as well as the full scope of their impacts, has been a challenge for agroforestry modellers. In our view, the main reason for this is that researchers often have the unrealistic ambition to achieve precise understanding of all system interactions. Models are usually built through an approach that attempts to assemble all of a system's constituent parts. For each of these parts, precise relationships between system parameters and variables are defined, and the overall construct of many such pieces is then applied to simulate the performance of the overall system. This concept may work fine for relatively simple, highly predictable systems. However, it becomes problematic for complex systems like agroforestry, where outcomes of important processes cannot be predicted with precision, where variables cannot be precisely quantified or where complex outcome dimensions defy precise modelling altogether.

We propose a new paradigm for agroforestry modelling that is based on the principles of decision analysis (Luedeling and Shepherd 2016). A guiding maxim of decision analysis is that a model that is intended to

support a particular decision does not need to consider all details of the target system. Instead, it needs to account for only those aspects of the system that are decision-relevant. For each of these aspects, the state of knowledge should be captured and fully considered in generating model outputs. Possible tools to implement such computations are Monte Carlo simulations (Kuyah et al. 2019) and Bayesian Networks (Yet et al. 2016). The focus of such models is the provision of decision support, which is often achievable by collating existing information, without the need for collecting additional data beyond what is already known. Additional measurements are necessary only where model outputs based on the current state of knowledge are inconclusive. We present a framework for achieving such analyses and discuss the potential of this innovative approach to emerge as a new pragmatic paradigm for agroforestry modelling that addresses both the need for decision-relevant guidance and the prerogative of adequately reflecting the complexity and diversity of agroforestry settings.

Figure 1. Agroforestry systems such as this Acacia-tef system in Ethiopia deliver a wide range of provisioning, regulating and cultural services in addition to annual crop yields. In providing model-based support to decisions related to agroforestry adoption, such services should be considered, but common modelling approaches struggle to achieve this feat.

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Carbon footprint and carbon sequestration comparative analysis of organic pig and cattle farms in dehesa agroforestry systems.

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: organic livestock; extensive management; carbon footprint; life cycle assessment; carbon sequestration; dehesa.

Abstract

Dehesa, situated in the Southwest of the Iberian Peninsula, is one of the largest managed agroecosystems in Europe. In Spain in particular, it contributes approximately 5.5 million hectares (den Herder et al. 2017). The intrinsic characteristics of this ecosystem make it possible to collect a great variety of farming systems, which benefit from and take advantage of natural resources by means of different types of farms, according to the productive orientation and management of the different zootechnical species.

These conditions mean that extensive livestock farming is one of the main agricultural and economic activities that take advantage of these ecosystems, and that optimum use of dehesas is based on extensive grazing of ruminants (beef cattle, sheep and/or goats) and extensive rearing of Iberian pigs, with the use of acorn as the main resource. (Espejo and Espejo 2006). However, livestock activity in these ecosystems, where the conservation of their soils, water and biodiversity are under severe pressure, present an alarming current environmental situation. In spite of this, livestock and agriculture make a very important contribution to their conservation, but if management is not adequate it can also be the cause of their accelerated decline.

In the search for more sustainable animal production systems, several authors present the ecological production model as an option, as these have advantages over conventional production due to: (i) its lower environmental impact on ecosystems (Tuomisto et al. 2012); (ii) increased biodiversity (Phalan et al. 2011); mitigation of desertification (Thomas 2008); lower energy dependence (Lee et al. 2008); its potential to contribute to development and the local economy (O'Hara and Parsons 2012).

The fight against climate change has become a current main concern and measuring the impact of agricultural and livestock activities on extensive ecological systems, and in particular on dehesas, is an important objective, as we can differentiate these systems from others that are more intensified and that use fewer natural resources and more food inputs.

In this sense, this case study determines the carbon footprint of four cattle farms in the pasture, two of which are beef cattle and two Iberian pigs in the extensive area. The methodology used to calculate the greenhouse gas (GHG) emissions balance was the Life Cycle Assessment (LCA). In this methodology, in addition to calculating system emissions, soil carbon sequestration is also included (Petersen et al. 2013), which is of great interest within a legislative framework.

The results include the GHG emissions of the four systems analysed and the carbon sequestration, expressed in kg CO2eq per functional unit (FU), the FU was the kg live weight. As shown in Figure 1, beef cattle (calves) have the highest carbon footprint (16.27 kg carbon dioxide equivalent (CO2eq) / kg live

weight), and the farm with the lowest carbon footprint is the Iberian pig montanera fattering 2.94 kg CO2eq / kg live weight. Enteric fermentation represents 56.4% and 51.7% of total emissions in ruminant farms. In contrast, in pig farms, the highest percentage of emissions comes from manure management (36.5%-43%) and feed inputs (31%-37.7%). The final result in terms of carbon sequestration reveals that an amount of between 5,18 y 6,52 Kg de CO2 eq/FU, which goes to prove the importance of extensive farming, where pastures and animals (their dung) play a key role in the agricultural systems. The high capacity of carbon sequestration of the soil in these farming systems of dehesas derives from the large areas of land, which to a great extent compensates for the livestock emissions. In the case of beef cattle farms, emissions are compensated between 35 and 49.6% and, in the case of Iberian pigs, carbon sequestration not only offsets, but is higher than emissions. Given these results, particularly highlighting the extensive livestock management system of these ecosystems, we could conclude that organic livestock farming is an adequate strategy for the mitigation of GHG and the deceleration of climate change. Although, in despite this reflection, it should be pointed out that these systems cannot be compared in product units with other more intensive ones, therefore, the carbon footprint in the ecological dehesa systems must refer to the territory.

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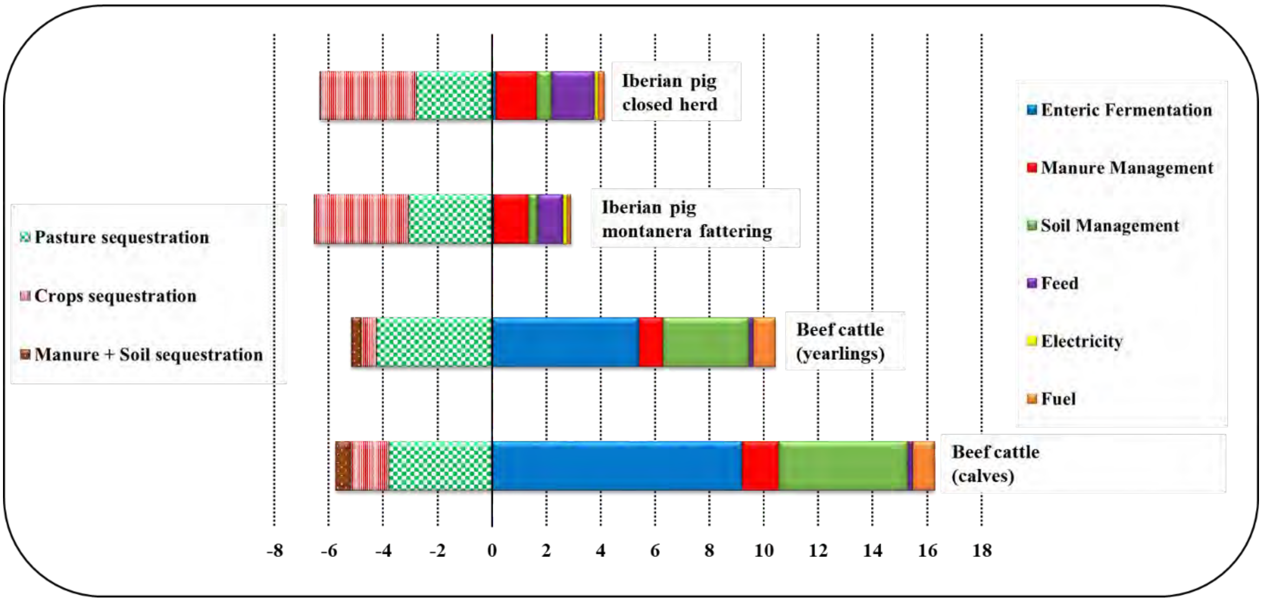

Figure 1. Compensated CF per functional unit (kg of CO2 eq per FU); (From: prepared by the authors)

Artificial shading to mimic the effects of trees on old wheat varieties for future implementation in agroforestry systems

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: shade level, wheat phenology, old varieties, grain protein

Abstract

Introduction Agroforestry systems (AFS) are receiving renewed attention in temperate regions, as agricultural systems able to enhance crop resilience towards climate scenarios of increasing mean temperatures and shifting rainfall patterns. The shortening of crop growing cycle and the reduction of grain ripening duration are the main effects of climate change which leads to yield and quality impairments in cereal production (Ren et al., 2019). In silvoarable AFS, among the main factors affecting the development and yield of the cultivated intercrops there are the design and management of the system, which strongly influence the availability of resources such as light, nutrients and water, and the adaptability of the crop to the specific growing conditions (Pardon et al., 2018). Considering that actual quantitative data in temperate AFS is limited, especially with a mature tree component, artificial shading is an interesting experimental tool to mimic the effect of tree rows on the intercrop in order to investigate different shading intensity and dynamics on a limited space, and to isolate the light factor from other potential interactions between the two components of the AF system (Artru et al., 2017). In this study we investigated the effect of artificial shading with two levels of light reduction on the growth and yield of three varieties of common wheat: two old varieties originated in the NE of Italy, compared with a reference modern variety, in order to evaluate their future implementation in alley cropping AFS.

Materials and methods The experiment was conducted at the experimental farm of the University of Padova (Legnaro – NE Italy) during the 2018-2019 growing season on three wheat varieties (*Triticum aestivum* L.): the modern var. Bologna (SIS, Bologna, Italy) and two old wheat varieties preserved at the "N. Strampelli" Institute of Genetic and Agricultural Research in Lonigo (Vicenza, NE Italy), Terminillo and Piave. Sowing took place on 25 October 2018, with a density of 350 (Bologna) and 220 (Terminillo and Piave) seeds m^{-2}, and 12.5 cm row apart; harvest occurred on 26 June 2019. Artificial shading was implemented by covering wheat plants with white nets from the 19th of April to mimic the beginning of foliage development of poplar trees in NE of Italy, and kept constantly until harvest. Each variety underwent two shading levels, -30% and -50% of photosynthetic active radiation (PAR) availability, obtained with different mesh size of the nets, compared with a control under full sun conditions (C). Nets were supported by a metallic squared structure 2 m high placed over a 4-m^2 area. An equal surface without shading was considered as control area. In this area, 3 plots/replicates of 1 m^2 were defined for each variety × treatment, to perform statistical analysis. The phenological development and leaf vegetational indexes such as SPAD and NDVI were monitored periodically during the rest of the crop cycle. At harvest, yield, the thousand grain weight (TGW), grain protein content (Kjeldahl method) and the concentration of Ca, P an Mg in the grains (by ICP-OES) were determined. A factorial discriminant analysis and principal component analysis were carried out with MS Excel XLSTAT to describe the changes of growth and yield parameters according to variety choice and the treatment.

Results During the growing cycle rainfall was 608 mm, half of which occurring during April and May, and temperatures were similar to the historical 10-year average (except during May: -2°C). All varieties showed a significant delay of phenological development under artificial shading, completing heading and flowering (BBCH= 59 and 69, respectively) about one week later compared to full sun. Similarly, the longer maintenance of canopy greenness and the delay of leaf senescence were supported by higher values of NDVI and SPAD under shading. Grain yield was significantly reduced by shading in old varieties (-60% and -20% for Piave and Terminillo, respectively), while slightly increased in var. Bologna under the less severe shading (-30% PAR: +8% of yield vs C, not significant). The grain protein content was generally improved with both shading levels in all varieties, on average by 10%, and significantly for var. Bologna with -50% PAR: 15.7% s.s. vs. 14% of C. An increase of the mineral concentration (Ca, Mg and P) in grains was also observed in the old varieties, but not in the var. Bologna. Both shading levels, however, improved grain quality of var. Bologna, with a significant higher percentage of gluten and the Zeleny index (NIRS analysis). All the parameters investigated were informative to explain the variability between varieties and treatments (Fig. 1).

Conclusions Moderate shading level (-30% PAR) can positively delay leaf senescence and improve grain quality with no yield impairments in a reference modern wheat variety such as Bologna. Implementation in real AF systems will be fundamental to evaluate this result, since significant wheat yield reductions were reported in temperate AF systems with a similar PAR reduction (Dufour et al., 2013). The old tall varieties, that were damaged by abundant rainfall in spring and lodging, seem less suitable to shaded conditions, however the multiple potential interaction with trees in alley cropping AFS might reduce the impact of adverse climate on growth and yield. Further investigations with drier climate and variable shading levels should be studied for designing appropriately the AF systems.

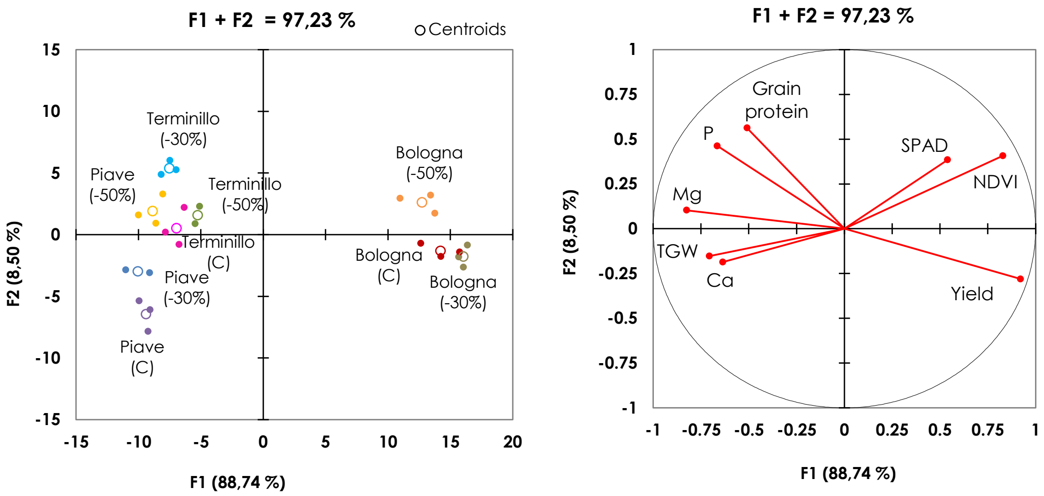

Figure 1. Principal component analysis (PCA, right) with variable loadings and discriminant analysis (DA; left) for the three wheat varieties and shading levels.

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Grazing iberian dehesa: Carbon sequestration offset livestock emissions

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development. Climate change (adaptation and mitigation)

Keywords: climate change, carbon footprint, soil carbon, tree growth, National Forest Inventory

Abstract The Iberian Dehesa is a good example of agroforestry system with great natural value, which, together with high levels of biodiversity and a fixed population in rural areas, produces food with low carbon emissions, and could even have net carbon fixation.

Grazing land occupies more than two thirds of world agricultural land, with a great share of silvopastoral systems. And there is still few data on how much carbon sequestration in both plant biomass and soil organic matter of grasslands can compensate the emissions of extensive livestock.

Here, we have measured current carbon stocks and its rate of change in soil and woody vegetation at 110 points of the Iberian dehesa. At those points we re-sampled precisely georeferenced soils that had been analyzed over a mean period of 22 years before. Aboveground biomass stock changes of trees were also measured by comparison of successive National Forest Inventories done on a decadal base.

We have estimated that these soils (0-30 cm depth) have an average carbon sequestration rate of about 0.83 Ton of C / ha / year, a rate that seems enhanced by the presence of livestock grazing (Figure 1a). That amount represents an annual C storage in pasture soils of around 11 ‰ of the current stocks, well above the levels set by the "4 per thousand Initiative: Soils for Food Security and Climate" promoted by the Paris Climate Conference (COP21), that stablish that an annual growth rate of 0.4‰ in the soil carbon stocks per year, in the first 30-40 cm of soil, would play a crucial role in reduce the atmospheric CO_2 concentration.

Following the "soil saturation" concept (e.g. Stewart et al, 2008), which establishes that soils have a limited carbon storage capacity, we find that the soils of pastures initially poor in organic matter tend to have higher C sequestration rates than those of soils initially richer in organic matter. Figure 1b shows that the potential C storage capacity of the pastures is around 2.8%, considerably greater than the current average content of 1.7%. This difference between the current content and the estimated potential content indicates that the pasture's ability to capture and store C in its soils can be maintained for many years.

Tree biomass stocks, both above and below ground, and their change rates, were also measured using the National Forest Inventory (IFN) as a source of information (n= 3823 stands). The rate of C sequestration for trees in pastures is 0.08 Ton of C / ha / year. The National Emissions Inventory of Spain (MAPAMA, 2017) establishes that when land use is maintained or specific soil conservation practices are not carried out, the organic carbon content in it remains unchanged. Our study offers grounds for thinking that this should be considered in another way, since it is rare to find ecosystems whose C stocks are in equilibrium. Their conservation, therefore, could be an interesting C sink that should be inventoried, among other things, because that would imply enhancing the role of these ecosystems as mitigators of Climate Change.

In summary, the main C sinks of soils and trees of Iberian dehesas, together sequester an average of 0.91 Ton of C / ha / year, equivalent to 3.3 Ton of CO_2-eq / ha / year. Field data and a great collection of surveys to the farmers, allowed us to calculate the Carbon Footprint of some of the principal livestock products (meat, wool and milk) linked to the dehesa agroforestry systems. According to other studies about livestock systems linked to the pasture (e.i. Eldesouky et al., 2018), estimated emissions ranged from 1.0 to 1.8 Ton of CO2-eq / ha / year depending on farm size, livestock management and intensification degree. We can conclude, therefore, that foods derived from extensive livestock farming linked to pasture agroecosystems can be considered as a potentially neutral emission foods or even emission mitigating foods.

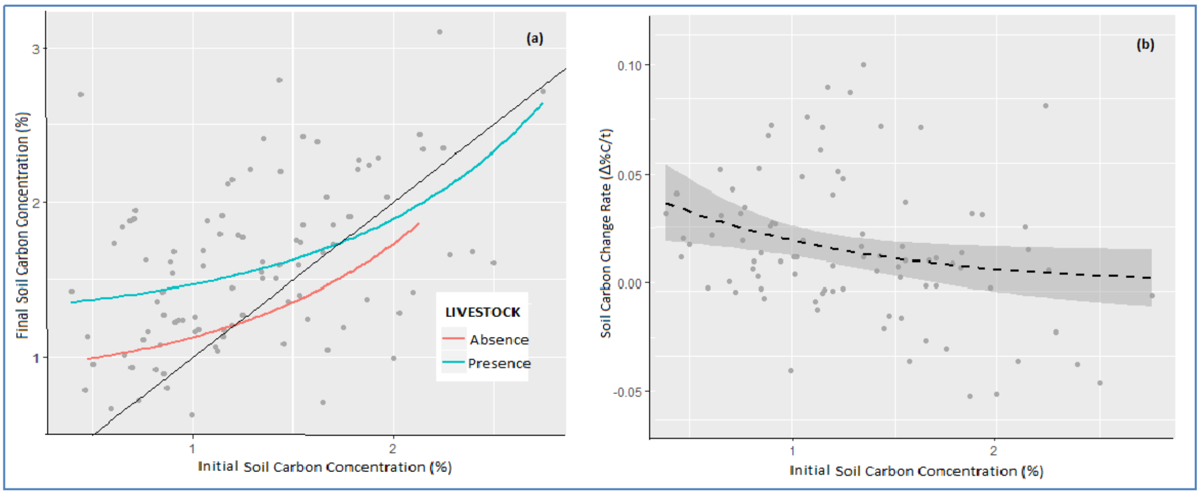

Figure 1. (a) Representation of soil C% in soils at the beginning and end of the study; (b) Representation of the sequestration rate of C in the soil with respect to its initial C content.

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Assessing the adaptability of maize varieties in silvoarable systems, a case study of Galicia region, Spain

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: climate change, adaptation, walnut, shade

Abstract

Promoting agroforestry would benefit the integration of the mitigation and adaptation targets for agriculture within the overall EU climate strategy (Hernández-Morcillo et al., 2017). In terms of adaptation, agroforestry can reduce the negative impacts of climate change and enhance the resilience of European farmers, for example by reducing the effects of extreme weather events. In silvoarable practices the partial shade could offer protection from the more frequently occurring spring heat waves that are damaging cereal crops in Mediterranean countries (Arenas-Corraliza et al. 2016). However cereal varieties on the market haven't been established to be grown specifically in silvoarable system. To address this gap, the aim of this experiment was to evaluate the production of three forage maize varieties in silvoarable system established with hybrid walnut with different ages (3, 8 and 14 years-old) compared with conventional arable system in Galicia (NW Spain).
Before the field tests, 10 varieties of forage maize they were sown and cultivated in controlled environment in the experimental greenhouse of the Crop Production Department at the University of Santiago de Compostela in Lugo (Galicia, NW Spain). Four very early, three early and three medium varieties of maize were chosen among the typically cultivated in the geographical area of the experimental sites. The plants were cultivated by simulating the different shading conditions that they could have encountered in the field based on the different stages of tree canopy development. The following year the three best varieties (Simpatico (sold by KWS), Huxxtor (RAGT), DS 0747 (PROCASE)) in terms of yield and quality were sown in the field. The experiments were established in Boimorto (A Coruña, Galicia, NW Spain) with a mean annual temperature of 12.6 °C and 1898 mm of mean annual precipitation. The plantation densities of hybrid walnut (*Juglans major* MJ 209 x *Juglans regia*) were 6 m x 5 m, equivalent to 333 trees ha^{-1}. The trees were planted in 2004, 2007 and 2015. Therefore, the treatments consisted of three shadow conditions. In May 2018, after soil preparation, three different varieties of forage maize were sown with conventional farm machinery following a randomized block design with three replicates. Maize was sown in 4 m alleys, leaving 1 m of distance between the alley at the base of the tree row. The distance between maize plants rows was 0.75 m and the distance between plants within a row was 0.15 m. Each experimental plot had an area of 20 x 12 m. Sowing was carried out in one of the alleys, whilst the other alley remained uncropped to allow access for machinery for annual pruning and phytosanitary application to the trees. Control treatments plots of 3 x 3 m for each maize variety were also established in tree-less areas. It should be noted that before establishing the experiment, the soil chemical and physical properties were generally similar in all plots included in the study. In October 2018 ten plants of maize were collected in each plot. Then in the laboratory, the plants were fractionated into the following components: grains, cobs without grains, aborted cobs, stems, and leaves. These components were dried and weighed to estimate the dry matter production (60 °C x 48 hours). Maize production per hectare was calculated considering the plant density and assuming that the maize was sown in all alleys of the plot. Maize yield (Mg ha^{-1}) was calculated by summing the production of the different components. Data were analysed using ANOVA.
Figure 1 shows that in plots with trees established in 2015 and 2007 the higher yield was observed in the SIMPATICO variety compared with the other varieties which indicate that the SIMPATICO variety can

growth under a partial shade. When the effect of the shade generated by the trees was compared in each maize variety it was also observed that the yield of the SIMPATICO variety was similar in the tree-less plots than in the plots with trees established in 2015. However, the yield of DS 0747 and HUXXTOR was higher in the tree-less plots than in the plots with trees. Therefore, it seems that these maize varieties were not adapted to growth under shade conditions. In any case, it is important to be account that the experiment was carried out in a forest plantation, hence with a high plantation density. Tree management activities such as pruning or thinning could favour the growth of DS 0747 and HUXXTOR varieties intercropped with walnut. We can say that in the case of the maize there is an important genetic variability that must be progressing evaluated and that can allow the farmers, after adequate selection and use, a better adaptation to climate change and therefore increase the resilience of their farms.

Acknowledgements

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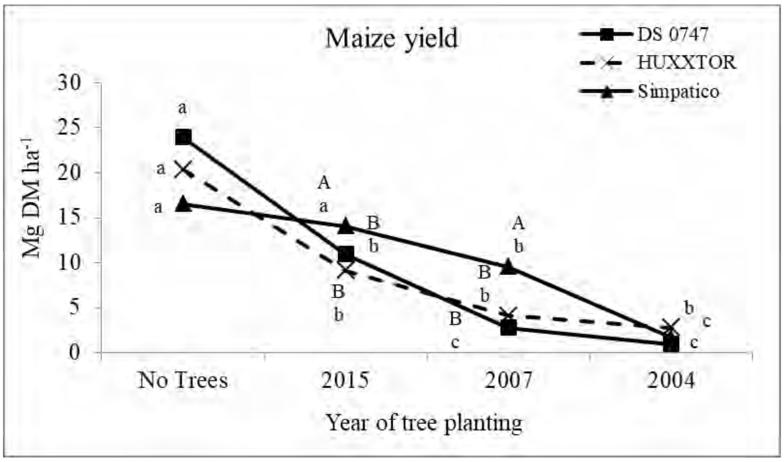

Figure 1. Yield of maize varieties (DS0747, HUXXTOR and SIMPATICO) in silvoarable systems carried out in walnut plantations established in Galicia (NW Spain) in 2015, 2007 and 2004 (different years represent different shade conditions). Capital letters indicate the differences between varieties in the same year. Lowercase letters indicate the differences between years within the same variety.

Tree cover affects the soil C balance in Mediterranean cork-oak based silvopastoral systems

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: C sequestration, Ecosystem services, Wooded grasslands

Abstract

Agroforestry systems based on silvopastoral activities maintaining grassland and scattered trees are recognized to play a crucial role in ecosystem services provision, such as forage provision and soil carbon sequestration (Seddaiu et al. 2018). Mediterranean *Quercus*-based silvopastoral systems are recognized as priority by the "Habitats" Directive 92/43/EEC (type 6310 ''Dehesas with evergreen *Quercus* spp"). These systems have been shaped by centuries of traditional agro-silvo-pastoral activities, and the maintenance of the typical scattered-trees vegetation structure is generated by the combination of extensive livestock farming and forestry activities such as cork oak extraction, with the associated ecosystem services. The role of trees in enhancing the soil C storage with respect to open pasture areas is widely recognized, as well as the role of management practices in affecting soil fertility and hence the C sequestration (Howlett et al. 2011; Seddaiu et al. 2013; 2018). However, a lack of scientific evidence emerges from the analyses of the literature on the effect of the tree cover in influencing soil C sequestration, and hence in determining the climate change mitigation potential of these agroecosystems. The aim of this work is to assess, in Mediterranean *Quercus* based wooded grasslands, how the proportion of tree-covered area and the tree aggregation with respect to the tree crown projection can affect the yearly soil C balance in a three-year study.

The study site was located in the Long Term Observatory of Berchidda-Monti (NE Sardinia, Italy), which is representative of Mediterranean wooded grassland-based semi-extensive livestock systems (Caballero et al. 2009). The site is characterized by Mediterranean climate (average annual rainfall 632 mm, temperature 14.5 °C and aridity index 0.53), sandy-loam soils derived from granitic substratum, and potential vegetation referable to *Violo dehnhardtii-Quercetum suberis* association, mainly represented by *Quercus suber* L. forests (Bagella and Caria 2011). The research activities were carried out from autumn 2012 to spring 2015, at six wooded grassland fields, within private farms, ranging from 16% to 41% of tree cover. According to both tree cover and the spatial distribution pattern (Uniform Angle Index, W) (Zhao et al. 2014), fields were classified as high-covered with a regular tree distribution (high) and low-covered with a random tree distribution (low) (n=3). The experimental layout was a three-level nested design, with tree cover (high *vs* low) as main factor, position (below the tree crown, BT and out the tree crown, OT) nested within tree cover level, and year (n=3) as random factor. At each plot, a subset of three isolated cork oaks was randomly selected in order to collect data to calculate the C balance in BT area. The same number of replications was selected for OT area. The soil C balance was, within year, calculated as the difference between the soil C inputs and the soil C-CO_2 losses, as cumulated heterotrophic respiration (Rh) sampled isolating plots with 40 cm diameter PVC collars inserted in soil at 20 cm depth (Pulina et al. 2018a). The soil C balance was calculated adapting the framework proposed by Pulina et al. (2018b) to the local experimental conditions, i.e. including the tree contribution. In particular, the soil C input at the end of summer was measured considering the contributions of herbaceous pasture plants, grazing animal excretions and trees.

The soil C input (P<0.001), the soil C output (P<0.001) and the soil C balance (P<0.01) were significantly affected by the position (BT *vs* OT) within the tree cover (Figure 1). The soil C input was significantly higher in BT areas at both cover levels than in the OT areas. Within OT areas, the C input was higher in low tree-cover than in high tree-cover areas (Figure 1A). The soil C output in BT area was higher in the low cover than in the high cover, while C-losses in OT where significantly lower than BT areas independently of the tree cover level (Figure 1B). The C balance was therefore significantly higher in high cover BT area than low cover BT area and was similar in the OT and BT at low tree cover. The C balance was not significantly different to zero for OT with high cover, and significantly lower than the C balance observed OT with low cover.

These results confirm the hypothesis that the soil C balance is affected by the tree cover and aggregation with respect to the tree crown projection. The absence of differences between OT and BT under low cover and random tree distribution is in contrast with the differences between OT and BT under high cover and regular distribution. These evidences suggest that at field scale soil C sequestration could be favoured by a well balanced presence of trees and open areas, ensuring an higher contribution of the primary productivity of herbaceous plants on soil C balance. The identification of management options that can ensure this equilibrium could be crucial in determine the climate change mitigation potential of Mediterranean silvopastoral systems.

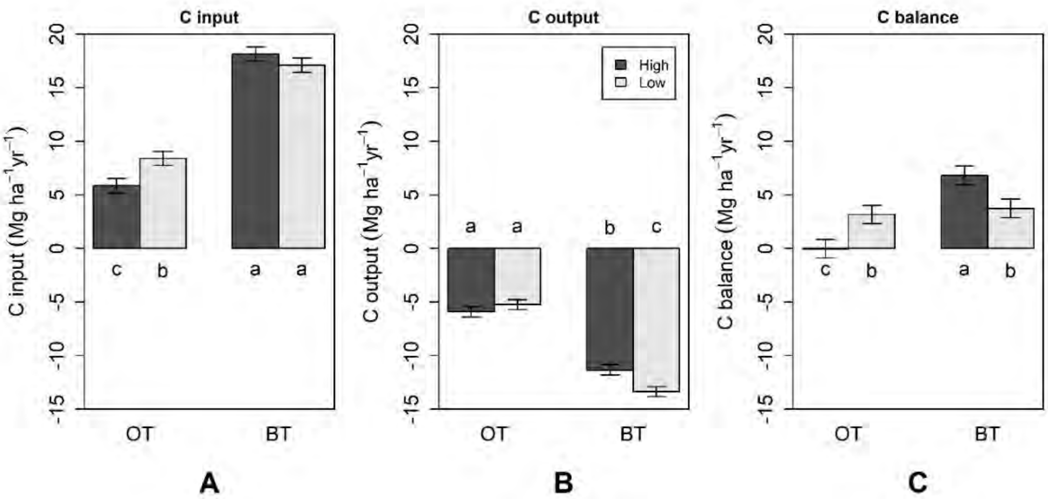

Figure 1. Average yearly values of soil C input (A), soil C output (B) and soil C balance (C) (Mg ha^{-1} yr^{-1} of C) in high (dark grey) and low (light grey) tree-covered areas, outside (OT) and below (BT) the tree crown. Different letters indicate mean significantly different according with the Student-Newman-Keuls test (P<0.05). Bars indicate the standard error of the mean (n=9).

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Silvopasture as a best practice for achieving good animal welfare in a changing and changeable climate: a review

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Animal behaviour, welfare, health, silvopasture

Introduction

As the effects of climate change become more apparent with increasingly erratic weather patterns including drought and flooding events (e.g., Najibi & Devineni, 2018), the buffering effect of trees in the landscape is increasingly relevant for both plants and animals alike. Much of an animal's daily behavioural choices are directed towards maintaining homeostasis and health, and trees can act as a buffer in both climatic and social interactions as well as offering sources of food and medicine. Furthermore, minimal learning is required to gain benefits and crucially, utilise an animal's natural behaviour patterns to help maintain good individual and group welfare (Escribano et al., 2019).

Social behaviour and body maintenance

In silvopastoral systems, the social relations of animals improve when compared to open pasture, including human-animal relationships. For example, cattle stay closer together and social licking (a behaviour that promotes social cohesion and stability) constitutes 78% of all social interactions compared to 41% on open pasture (Améndola et al., 2013). A healthy coat and skin is a first-line defence against disease, and animals spend a portion of each day in body maintenance, using available trees and shrubs as rubbing posts. Through rubbing, external parasites can be dislodged along with seeds that can penetrate the skin (Mooring & Samuel, 1998). Dead hair and skin can also be rubbed off which becomes increasingly important at moulting time as well as helping animals to better regulate body temperature.

Shade and shelter

In cold weather, ground temperatures are up to 6°C higher under trees than on open land (Percival et al., 1994) enabling animals to seek some thermal comfort. Canopies offer protection against cold and rain, and hedges and shelterbelts provide shelter from cold winds and their negative effects on ambient temperature. For example, a wind speed of 24 kph can reduce an air temperature of 2°C to -7°C. For healthy beef cattle with dry coats, the lower critical temperature is about 0°C and for every 1°C drop there is a 2% increase in energy requirements for maintenance. Research from Canada shows that beef cattle use windbreaks as part of a behavioural trade-off between optimising energy gain and minimising energy loss (Olson & Wallander, 2002). Exposure to cold is a major cause of death and poor welfare in youngstock. When appropriate shelter is provided, ewes both lamb and remain for longer in sheltered areas and lamb losses are typically reduced by 30% (e.g., Broster et al., 2012).

The most important benefit that trees bring to animals, at a global level, is shade in hot weather and all domestic animals under heat stress show shade seeking behaviour. Stress caused by heat has traditionally been measured, and underestimated, using the simple Temperature-Humidity Index (THI). An alternative model, ETIC (equivalent temperature index for cattle), incorporating further environmental and physiological factors, indicates that for dairy cows, mild heat stress can already occur at 18°C with moderate stress between 20-25°C (Wang et al., 2019). Heat stress triggers an inflammation cascade and research in Italy has shown a positive correlation between THI and somatic cell counts (Bertocchi et al., 2014). On silvopasture, Karki and Goodman (2009) recorded a 58% reduction in solar radiation compared to open pasture and skin temperature under trees is lower by several degrees (e.g., Betteridge et al., 2012). Under these more benign conditions, animals maintain normal behaviour patterns including grazing and browsing activity, where loafing becomes the dominant behaviour on open pasture.

Trees as a source of feed and medicine

All farm animals browse and proportions in the diet can be up to 0.55, 0.76 and 0.93 for cattle, sheep and goats respectively (Dicko & Sickena, 1992). Nutritional content of tree fodder is comparable to grasses grown in the same environment and mineral content is high, representing a valuable and regenerative resource (Smith et al., 2017). Additionally, the presence of condensed tannins can help to manage internal parasites. Sheep and goats with high worm burdens preferentially select high tannin feeds, reducing burdens by 50% (Min & Hart, 2003). There is increasing evidence of self-medication in farm animals (Villalba & Provenza, 2007) with sheep preferentially selecting willows high in salicylic acid, a pain suppressant with anti-inflammatory, antibacterial and fungicidal properties. Acquiring 'nutritional wisdom' requires animals having access to diverse plants, and trees play an important role.

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Potential of agroforestry in climate change mitigation - Assessment of greenhouse gas emissions in four different beef cattle production systems in Finland

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Climate change, Silvopastoral system, Beef cattle, Life Cycle Assessment, Carbon sequestration

Abstract

Greenhouse gas (GHG) emissions from the livestock sector are a big concern as they represent from 12% to 18% of all human induced GHG emissions, and ruminants are responsible for 80% of these emissions. GHG emissions from the ruminant sector include CO_2 and non-CO_2 emissions. The main non-CO_2 emissions are methane (CH_4) emission from enteric fermentation due to the presence of fibre in the diet and nitrous oxide (N_2O) emission from soil and manure management. One of the most important direct CO_2 loss is caused by the conversion of forest or grassland into arable land for the cultivation of feed crops. Emissions related to cultivation and transportation phases of feed also contribute to emissions from livestock production. Despite their impact on our environment, ruminants are a valuable resource for mankind since they are important for food security thanks to their ability in converting roughages and by-products into edible food products rich in high nutritional value proteins and other essential components. Moreover, ruminants can thrive well on poor productive land areas unsuitable for crop cultivation and they generate an important source of income for farmers. Therefore, reducing the number of animals is not the only solution, but other sustainable strategies must be adopted in order to reduce GHG emissions from the ruminant sector. Over the last couple of years, silvopastoral systems received increasing attention. A silvopastoral system is an agroforestry system where shrub and trees species are integrated in the pasture. Perennial species provides a large number of ecosystem services besides being a feed source for animals. Silvopastoral systems have traditionally been an important element of rural landscapes, and new studies suggest that silvopastures have potential for sustainable intensification that allow to mitigate GHG emission from livestock through both carbon sequestration by trees in the system and avoided emissions from feed production and transportation. Moreover, silvopasatures do not pose any conflict between food and feed production. At the same time, these systems diversify agricultural production and create possibilities to have different sources of income. For the evaluation of environmental impact of products, one of the most utilized approach is the Life Cycle Assessment (LCA) methodology which is suitable to evaluate different aspects of environmental impact along production chains of different products, including animal products. The main advantage of using an LCA approach is that it is possible to standardize the assessment of a productive process by following four phases: (1) Goal and scope definition, (2) Inventory analysis, (3) Environmental impact evaluation, (4) Result interpretation. In the analysis, we focussed on the production of beef cattle in Finland where silvopastoral systems have traditionally been an important element of rural landscapes but in the last decades, they have been abandoned or converted to arable land. The aim of the study was to compare four different beef cattle production systems in Finland (forest pasture, wood pasture, pasture and indoor systems) in order to determinate if silvopastoral systems can help to mitigate the GHG release during the fattening stage of beef cattle production. In the assessment only the fattening stage was considered and the feed ration

was assumed as composed only from barley and grass-silage entirely self-produced at the farm. Moreover, it was assumed that in the outdoor systems cattle graze for 4 months in a year and during grazing period, no feed was given in addition to pasture. The data used in the assessment were taken from statistics and from existing literature about silvopastoral systems and beef cattle production systems in Northern Europe. Calculations were made for carbon sequestration, methane emission from enteric fermentation and manure management, nitrous dioxide emission from soil and manure management and emission related to feed production (IPCC 2006; Schulp et al. 2008; Fernández-Núñez et al. 2010). Finally, all the result where converted in CO_2 equivalent by using IPCC coefficients. The final results were express as kg CO_2eq per kg Carcass Weight (CW). Emissions from enteric fermentation, significantly contribute to the total GHG emissions, especially in the forest pasture system due to the large amount of low digestible roughages, such as forest understory, eaten by the animals (Figure 1). Emissions from feed production are also important; they can be partly avoided in the silvopastoral systems. In forest pasture, wood pasture and conventional pasture systems the component of carbon sequestration is able to compensate most of the emissions generated from the beef cattle production, especially in the systems where trees are present. These results are in line with other studies from the literature and suggest the potential for sustainable and carbon neutral meat production. In the scientific literature exist a lot of studies on the climate mitigation potential of agroforestry, but studies in Finland on this topic are so far completely lacking. The assessment can be improved by using direct measurements and by considering larger system boundaries including the whole lifecycle of beef cattle production. Farmers might be sceptical to implement silvopastoral systems because animal performance may decrease due to the lower feed digestibility compared with the conventional systems and further studies about the best management practices are required to help the implementation of these system. However, silvopastoral system can allow a diversification of income because other products, such as wood, can be sold. Moreover, in the near future, selling carbon credits on the carbon market may become a possible source of income. In conclusion silvopastoral system seems to be a good strategy to mitigate the impact of beef cattle production in Finland.

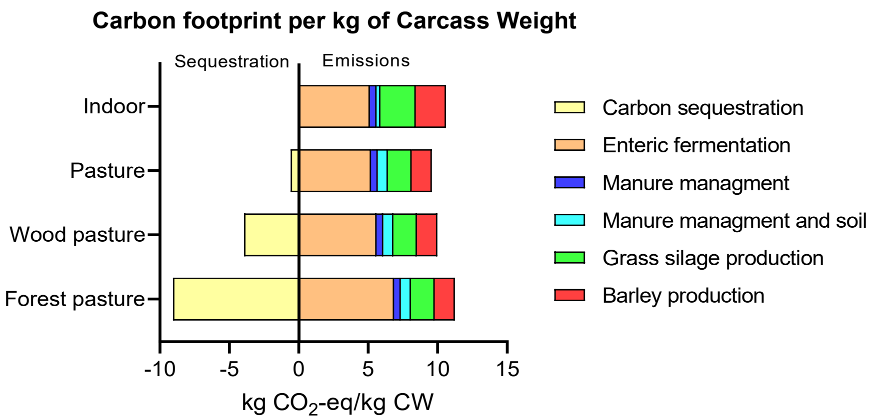

Figure 1. Carbon footprint per kg of carcass weight (CW) in four beef cattle production systems in Finland: forest pasture, wood pasture, open pasture and indoor production.

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Agroforestry and climate change – can almonds be grown in northern Switzerland?

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Almonds, orchards, Switzerland, stakeholder approach, resilient agriculture

Abstract

Standard size cherry trees with high stems are a major element of traditional agroforestry systems in northern Switzerland. Nowadays the cultivation of standard fruit trees with cherries is under pressure in this area. High harvest and crop management costs combined with declining income make the cultivation of high stem trees in combination with grazed grasslands unattractive. In addition, there are high consumer quality requirements, pest pressure from *Drosophila suzukii* and volatile yields. Moreover, full-time farmers consider trees that are not regularly pruned as a source for pests and diseases. They argue that these trees should be removed.

However, these orchards offer – on top of food and fodder production - many environmental benefits, e.g. foraging resource for insects, habitats for flora and fauna and touristic elements. Biodiversity and humans benefit directly from them.

Ideas for profitable alternatives to traditional cherry orchards, from which both humans and especially fruit growers as well as nature can benefit, are in demand. Corresponding efforts have already been made, exploring options for alternative tree species that would allow to maintain the traditional agroforestry landscape scenery. One option that has not yet been examined could be the change of tree species towards almond trees. The almond tree is mainly known in Mediterranean regions, but has also been cultivated in Germany (Pfalz) for over 800 years. The blossom resembles the cherry blossom and the flowering period is between March and April.

The goal of the project is to answer the question: Does almonds (*Prunus dulcis*) offer an alternative to (standard tree) cherries within traditional agroforestry systems and contribute to the product and risk diversification of fruit producers? Would it be possible to grow almonds in northern Switzerland, also accounting for climate change and opportunities for breeding adapted varieties?

We did a literature review and stakeholder interviews in Switzerland and the surrounding countries. In total, we contacted over 70 experts and organizations such as farmers, tree nurseries, breeders, researchers, agroforestry experts, administrators, extension officers, associations or potential buyers.

Our results show that innovative Swiss farmers have been experimenting for several years and have successfully cultivated individual almond trees. We found over 220 almond trees on 14 Swiss farms. Varieties such as 'Ferraduel', 'Tuono', 'Keilmandel' or 'Papierski' were mentioned to be suitable for

Switzerland. Late frost during the almond flowering that was stated as problem in literature was not an issue. Apart from that, several Swiss growers mentioned problems with *Monilia* disease and pointed out that trees grown on well-drained soils could prevent fungal diseases. Cultivars less susceptible to *Monilia* are e.g. 'Ferraduel'. Other problems were gummosis, leaf curl or European stone fruit yellows (ESFY). The integration of almonds trees in an agroforestry systems and especially the combination with pastureland for grazing was not tested yet in Switzerland.

Depending on the variety, almond fruits can serve several markets such as direct consumption, chocolate production or almond milk. The Swiss market might be a challenge because almonds are not protected by custom duties in Switzerland, in contrast to other fruits as cherries or apples. Nevertheless, we found buyers, which are interested in Swiss almonds. Regarding the processing of almond fruits in line with market standard, crack and peeling machines already exist for walnuts and hazelnuts and could partly be used for almonds.

Our investigations show that almond cultivation has started to develop through farmer initiatives and experimentation. They now need support from research with respect to the selection (or even breeding) of adapted varieties, the evaluation of appropriate locations (soil, topography, micro-climate) and tree management. In the future, almond trees could gradually complement or even replace traditional cherry tree orchards and help to maintain the ecosystem services they provide and the familiar agroforestry landscape scenery.

Ink disease threaten *Castanea sativa* in agroforestry systems in Sardinia (Italy): prevention and control strategies

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: disease management, epidemic, forest dieback, invasive pathogens, *Phytophthora*

Abstract

In Italy chestnut stands evolution has been historically and strictly linked to both ecological and socioeconomic factors. Agroforestry with sweet chestnut (*Castanea sativa* Mill.) is a traditional land use system in the Gennargentu Mountain, in Sardinia (Italy), providing several ecosystems services to local inhabitants, including relevant pastoral uses, a wide variety of products, such as chestnut, timber and firewood. These agroforestry systems are usually considered to have played a multifunctional role in the traditional way of life of the inhabitants of the region. However, on present times, chestnut woodlands have restricted distribution ranges and severe declining trends due to rural abandonment, climate change, pest and diseases. Amongst the phytosanitary problems, ink disease caused by *Phytophthora* spp. still represents a serious threat to sweet chestnut throughout its distribution area (Jung et al. 2018). *Phytophthora ×cambivora* has been the main species associated with ink disease in Sardinia (Scanu et al. 2010), while *P. cinnamomi* seems to be limited to nursery, perhaps due to its intolerance to low temperatures. Several other *Phytophthora* species of minor impact were also found associated with declining chestnuts in Sardinia, including the recently described *P. castanetorum* (Jung et al. 2017). Ink disease incidence is strictly related to climatic and site condition as well as human activities. Heavy or continuous rain during the vegetative season, soil compaction and disturbance by tillage practices, physical restrictions to root expansion, poor soil fertility, vehicle movement along roads, and human recreational activities in forests are the main predisposing and contributing factors for disease development. Planting of infested nursery stock and movement of contaminated substrates are the main pathways of short and long-distance inoculum dispersal (Jung et al. 2016). Amongst control strategies, new perspectives have been offered by the use of potassium phosphite, a fertilizer that indirectly control Phytophthora diseases by acting on host physiology and on host-pathogen interactions. In this study, we tested *in planta* the efficacy of trunk injection with potassium phosphite against seven different *Phytophthora* species associated with ink disease. A total of 216 resprouts (2-year-old) were selected from 18 sweet chestnut coppices for the treatments. Injections were applied with Chemjet tree injectors (Chemjet Trading, Queensland, Australia) each containing 10 ml of the phosphonate formulation (Kalex - 70% of K_2HPO_3) at two concentrations of 140 g/l and 280 g/l. After two days, *Phytophthora* isolates were inoculated under bark of the main stem of treated and control resprouts as described by Scanu & Webber (2016). Four weeks after inoculation, the outer bark was removed and the extent of the necrotic lesions measured. For two of the seven species, *P. cinnamomi* and *P. ×cambivora*, the treatments were repeated at two different environmental conditions (mean temperature 15°C vs 25°C) and tree phenology. The results obtained demonstrated that potassium phosphite was overall able to contain the development of Phytophthora infections in phloem tissues, however its efficacy varied based on the concentration applied and the *Phytophthora* species tested. The concentration of 280 g/l of potassium phosphite (40% of the commercial product Kalex) was the most effective and in some cases, callus formation around the necrotic lesion was detected.

Interestingly, at higher temperature the ability of *P. cinnamomi* to colonize the phloem tissues increased significantly in non-treated controls, highlighting the potential for *P. cinnamomi*, under current climate change projections, to invade and cause huge damage to sweet chestnut ecosystems on a large scale. The results obtained in this research have highlighted, as the use of endotherapic treatments with potassium phosphite can be an important component of an integrated management approach of chestnut ink disease for the enhancement of this important forest resource.

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Ink disease symptoms on *Castanea sativa* caused by *Phytophthora* spp. (left) and trunk injection with potassium phosphite (right)

Temperature regulation: how agroforestry helps climate change mitigation

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Climate change, temperature regulation, agroforestry, breeding

Abstract

In Pays-de-la-Loire (West of France), the climate is temperate with a maximum temperature higher than 25°C and a minimum lower than -1°C for an average annual temperature between 11 and 13°C. In the future, climate will change with an increase of temperatures and extreme weather phenomena. It will impact animal breeding.

1. Each animal has a comfort temperature which is around 12°C for cattle and 24°C for poultry. Most of the breeders notice the impact of extreme temperatures on animal well-being and productivity. Some producer groups and cooperatives are aware of the economic issues of this subject. They are looking for technical solutions like agroforestry, since trees tend to favour a microclimate. [i]

2. For instance, at Congé-sur-Orne (Pays-de-la-Loire), probes to measure the temperature has been installed in different locations of an agroforestry poultry system. Records, throughout the summer 2020, show three main results. Firstly, average temperatures are inadequate to work with because of a smoothing effect. Secondly, two contrasting locations (full sun/ shade of trees) reveal a significant difference between extreme temperatures and between temperatures range, and in summer animal comfort temperatures can be far exceeded. Thirdly, the buffering effect varies with the species (ex: cherry tree or apple tree) and design of trees (ex: isolated trees or hedges). [ii]

3. Furthermore, the impact of extreme weather phenomena on productivity has a double effect: a direct and an indirect. Indeed, in the very short term there are effective losses such as dead animals and decrease of milk and eggs production. But in the medium term, there are losses due to the amount of time needed to restore the previous productivity rates. Since economic loss can be important on a farmer's scale, these results could lead to comparisons at the European level. [iii]

The results show that a well-designed agroforestry system can be a solution to mitigate extreme temperatures which impact breeding productivity. Moreover, one could wonder whether climate change impacts product's quality and what could be the role of agroforestry in this context.

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[i] Technical knowledge, specialist animal production advisors, Chambre d'agriculture des Pays-de-la-Loire
[ii] « MicroClim'Arbres » project, Claire Lemarié, Chambre d'agriculture des Pays-de-la-Loire
iii Analysis of the extreme weather phenomena impact on productivity by specialist animal production advisors, Chambre d'agriculture des Pays-de-la-Loire

previous C4 based corn system to support land use history data (Oelbermann & Varoney 2007). A physical slaking test determined particulate, adsorbed and occluded organic carbon (PAO-C) qualified the relative stability of the C in the soil according to aggregate size. Combined grams of C/kg soil were aggregated from the POM and MIN fractions of each sample, and multiplied by a Bulk Density factor to calculate total C stocks (kg).

Data was evaluated using analysis of variance and multiple analysis of variance to establish correlations between related variables of soil C and aggregate size for each of the systems by age and depth. (Baker & Murray 2012). The authors hypothesized that older *Corylus* and *Castanea* cropping systems would show more cumulative stable C sequestration than new stands, un-managed pasture land and conventional corn cropping, with a saturating effect as stand age increases. Increased N inputs in stands inter-planted with N-fixing trees, were thought likely to result in higher soil C concentrations, on a significant but lesser scale than in the chronosequence. The authors expected to see a positive relationship between abundance of soil C levels, soil aggregate stability, and contribution of C3 carbon, and that conventional corn production would compare less favorably than the nut-tree agroforestry systems in terms of carbon intensity, a metric that links yield and C fluxes over area.

Initial data analysis did not confirm that soil C increased with stand age, nor was there substantial difference in soil C stocks across different sites. Though a substantial number of original samples were recovered from the site, the samples analysed did not comprise all of those collected. Additional complications arising from the circumstances preclude the authors from drawing any definite conclusions from the data. On-farm treatments at the initial project site have since changed soil C conditions and therefore prevented re-sampling.

In the 8 years since Jonah initially conceived this research, the fields of soil science and agroforestry have advanced substantially. New methods in sampling and analysis, together with improved understandings of soil carbon sequestration dynamics have considerably influenced the way the scientific community understands the role that temperate agroforests can play in climate change mitigation. Exploring and updating Jonah's original experiment in step with these developments produced key insights on the development of the field overall. Meanwhile, concurrent studies have since elucidated the carbon sequestration potential of *corlyus-* and *castanea-* based agroforestry systems specifically. This review summarizes key developments in soil carbon sequestration studies, systematically condenses the literature on climate mitigation vis-à-vis *corylus* and *castanea* agroforestry, and celebrates Jonah's life and vision with a forward-thinking conclusion on new directions for climate resilience through diversified agricultural production in temperate, rural areas.

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The transformation of agricultural systems into agro-forestry systems as a system of adaptation to climate and economic changes: some Sicilian case studies

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: climate change, desertification, diversification, resilience

Abstract

Many traditional agricultural systems show different limits both in ecological and economic terms. These limits are exacerbated by the increasingly extreme climatic conditions which in the southern regions are manifested essentially in a concentration of rainfall and in increasingly intense dry periods. As part of the LIFE (Desert Adapt) project, some companies involved in the project are modifying their cultivation systems without changing the land use destination. This appears possible by introducing elements of diversification which make the system more resilient as a whole but which guarantees safer economic resources. In particular, in the case of a "classic" agricultural company Caltagirone (Sicily, Ct) (prickly pear and fruit orchard), the farmer accepted spread of woody forest species for the production of firewood. Furthermore, the spread of brambles and asparagus allows you to have supplementary productions of great commercial value because the fruits are collected and sold. Generally these plants are eliminated during the normal operations of managing the prickly pear. The company is also spreading Bamboo, which is increasingly appreciated today as a “wood”.
More complex are the interventions to be implemented in the cereal-zootechnical farms where the practice of burning stubble has led to the total elimination of arboreal and shrub vegetation (Fig. 1). In this case there is also a cultural problem related to the fact that shepherds do not adequately consider the advantages deriving from the presence of wood species. The projects, which will be implemented within the Rural Development Plan of the Sicilian Region but with the support of the LIFE Desert Adapt in the dissemination phase, foresee a total paradigm shift. In fact, the creation of arboreal bands presupposes that these are defended from the action of the animals in the early stages of growth and subsequently actively from fires. The latter, as already mentioned, are hanged to eliminate residual straw and this guarantees an immediate but ephemeral advantage in terms of soil fertility. The adequate management of the residues allows, in the long run, to increase the content of organic substance in the soil and therefore to achieve lasting advantages in terms of fertility. Also for these companies one of the main objectives remains to diversify production. This goal is not easy to achieve because often these companies have soils with pedological limits (excess clay) which reduces the possibility of choice. However, choices are being made that are already determining advantages including, for example, the breeding of bees and the creation of multifunctional riparian vegetation.
The presence of riparian vegetation or lines of vegetation or small woods also reduces the effects of erosion and loss of surface soil. In the future, the possibility of using the trees (Popolus, Salix) for the production of wood will be evaluated.

The spread of vegetation along the margins has no impact on animal species (especially birds and plants) linked to open systems. These plants and animals are those at greatest risk at European level due to the intensification of crops. In both cases, however, organic farming techniques that reduce the impacts of agrochemicals will be used.

Figure 1. Many cereal-zootechnical farm are like those illustrated in this photo: totally devoid of woody vegetation and with strong erosive phenomena. The project involves the creation of strips of arboreal-shrub vegetation along streams and roads and the creation of small groves useful also for animals both for shelter from atmospheric events but also for feeding.

Wheat varieties established under walnut of different ages in Galicia (NW Spain)

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Theme: Climate change (adaptation and mitigation)

Keywords: silvoarable, tree canopy cover, Ingenio, Tocayo, weeds

Abstract

Climate change is one of the most important current environmental problems which affect the whole planet. One of the most visible consequences of climate change is the increase in the intensity and frequency of extreme weather events which can decrease the crops yield. Therefore, farmers need strategies for adaptation to climate change. In recent years, agroforestry and its different practices as the silvoarable practices have been recognised as an excellent strategy for climate change adaptation (MosqueraLosada et al. 2018). In the silvoarable practices, it is key to know which is the best crop and crop variety to use in an environment that at the end will have less light due to the tree cover. Moreover, tree species and its age are also key factors because tree canopy cover modifies the light and the available nutrients for the understory crops. To provide insight on crops and trees in silvoarable systems, a coordinated project (AFCLIMA) funded by the Spanish Ministry (Retos 2016) is being carried out in three regions of Spain (Galicia, Extremadura and Catalonia). In this project silvoarable practices established with different varieties of cereals (wheat, barley, triticale, maize and rye) and tree species of different ages (chestnut, walnut and oak) were evaluated in the Spanish Atlantic region (Galicia) and Mediterranean (Extremadura and Catalonia). The Galician experiment consisted of the evaluation of twelve varieties of rye, maize and wheat under simulated shading in greenhouse conditions. The crop varieties that better performed were sown in the field under different tree species (walnut and chestnut) with different canopy covers. This paper shows the results obtained in silvoarable systems established in the field with two varieties of wheat (CCB Ingenio and RGT Tocayo) under walnut with different ages (3, 11 and 14 years-old). The experiment was established in Boimorto (A Coruña, Galicia, NW Spain) on three plantations of *Juglans major* MJ 209 x *Juglans regia* (*Juglans* MJ 209xRa) managed by the Bosques Naturales company. The plantations of walnut were carried out in 2004, 2007 and 2015, being the distance between trees rows 6 m and the distance between trees within a row 5 m (333 trees ha^{-1}). In February 2018, when the tree canopy cover was 15, 45 and 65% for the trees established in 2015, 2007 and 2004, respectively, the wheat varieties (CCB Ingenio and RGT Tocayo) were sown (sowing by volley) in the alleys between two trees rows. Wheat varieties were sown in 6 m alleys, leaving 1 m of the distance between the alley at the base of the trees (1 m both sides of the tree row). Each experimental plot had an area of 20 x 12 m^2 (5 trees separated by 5 m (4 x 5 m) x 3 rows of trees (2 x 6 m)). Sowing was carried out in one of the alleys, whilst the other alley remained uncropped to allow access for machinery for annual pruning and phytosanitary application to the trees. Control treatments were also established in which the two wheat varieties were sown in tree-less areas. In total 36 plots were established following a randomized block design with three replicates. The production of the wheat (leaves + spikes with grains) and weeds was determined by randomly collecting one sample (1 m × 1 m) in each plot in September 2018. The samples were dried and weighed to estimate the dry matter production (60ºC x 48 hours). The wheat and weeds production per hectare was calculated

considering the area occupied by the trees and assuming that the wheat was sown in all alleys of the plot. Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. The statistical software package SAS (2001) was used for all analyses. The results of this study showed that when the tree canopy cover was medium (45%) the wheat production increased in the Ingenio variety compared with the Tocayo variety ($p<0.001$) (Figure 1). This result indicates that the Ingenio variety is better adapted to shade conditions generated by the trees in the understorey that the Tocayo variety. Therefore, the Ingenio variety could be used in silvoarable systems established with trees with similar morphophysiological characteristics to walnut. On the other hand, the production of both wheat varieties was generally lower in the tree-less plots (0%) compared with the plots with a low tree canopy cover (15%) in the case of the Tocayo variety and the plots with a medium tree canopy cover (45%) in the case of the Ingenio variety ($p<0.001$). This result could be explained by the higher production of weed in the tree-less plots than in the plots with trees, independently of the tree canopy cover, because weeds can compete with the wheat for light, nutrients, water and root space, mainly during the seedling stages, thus reducing the wheat production. The lower weeds production in the plots with trees than in the tree-less plots could be due to the lower light amount in the understorey of the plots with trees because annual weeds generally require a high light amount for the germination of their seeds (Juroszek and Gerhards 2004). Therefore, the silvoarable systems could favor the wheat production, mainly in the case of the Ingenio variety, when the tree canopy cover is low or medium because the shade generated by the trees can decrease the weed production which implies a use pesticides reduction in the farms.

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Acknowledgements

This work was supported by Ministerio de Economía y Competitividad (CTM2016-80176-C2-1-R) "Sistemas agroforestales para la producción de cereal como estrategia de adaptación y mitigación al cambio climático en el ámbito de la península ibérica" (AFCLIMA) and Xunta de Galicia, Consellería de Educación, Universidade e Formación Profesional (Programa de axudas á etapa posdoutoral modalide B DOG nº 213, 08/11/2019 p.48018, exp: ED481D 2019/009).

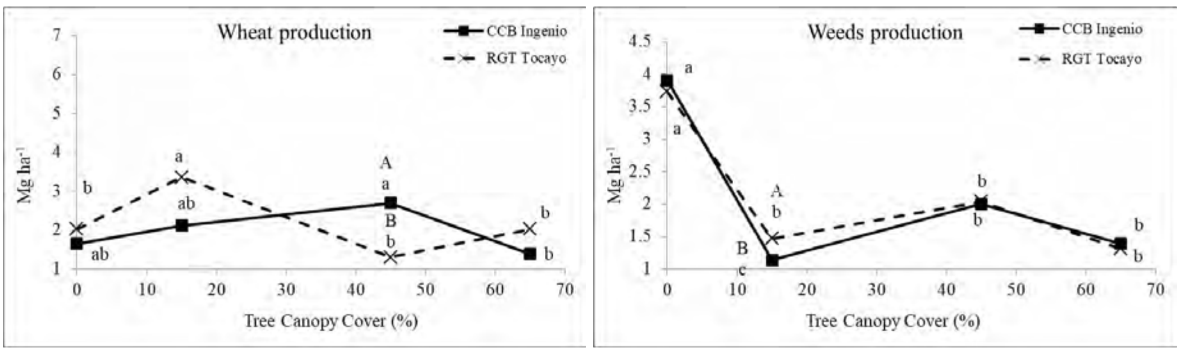

Figure 1. Production of different wheat varieties (CCB Ingenio and RGT Tocayo) and weeds (Mg ha^{-1}) in tree-less plots (0%)and in silvoarable systems established in walnut plantations with different tree canopy cover (15, 45 and 65%) in Galicia (NW Spain). Different lowercase letters indicate significant differences between tree canopy covers within the same wheat variety. Different capital letters indicate significant differences between wheat varieties within the same tree canopy cover.

Variation of soil organic matter in silvopastoral systems established under *Pinus sylvsetris* L. with celtic pigs in Galicia (Spain)

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: autochthonous breeds, grazing, soil properties, fire risk

Abstract

Galicia (NW Spain) is one of the most fire-prone areas of Europe, accounting for approximately 35% of the area of Spain affected by forest fires in 2017. This data is very relevant if we consider that Galicia represents 8% of the total forest area of Spain. Therefore, nowadays finding ecological and low-cost methods with which reduce the fire risk is emerging as a major society goal in regions as Galicia. In this context, silvopastoral systems are recognised as a tool for fire risk prevention at the same time that nutrient recycling, control soil erosion, biodiversity or soil carbon sequestration are improved (Ferreiro-Domínguez et al. 2014). In some Atlantic areas as Galicia, silvopastoral systems are being established with autochthonous breeds such as the celtic pigs due to their perfect adaptation to the conditions of the native Galician forests. Moreover, an adequate stocking rate of celtic pigs eliminates the forest fire risk. However, the grazing with this type of animals can modify the physical and chemical soil properties. The aim of this study was to evaluate the effect of grazing with celtic pigs on the variation of soil organic matter in a silvopastoral system established under *Pinus sylvsetris* L. in Galicia. In 2018, a silvopastoral system was established in a plantation of *Pinus sylvsetris* L. (400 trees ha^{-1}) in the communal forest “Monte de Carballo” (Friol, Lugo, Galicia). In this plantation a plot of 50 ha was established with an electrified mobile fence. During one year, this plot was grazed with 60 celtic pigs which were also fed with an automatic system at fixed points of the plot every days. At the beginning of the experiment (June 2018) and in April 2019, before moving the electrified fence to establish a new plot, composite soil samples were randomly taken at a soil depth of 1 m and at three distances from the fixed feed points (near, medium and far). In the field, soil samples were divided taking into account the soil profiles. Soil profiles were identified taking into account the color change of the soil. In the laboratory, soil samples were analysed in a LECO C.N.H.S. Elemental Analyzer (LECO, St. Joseph, MI) for C percentage. The percentage of soil organic matter was calculated by multiplying the total C content of the soil by the de Van Bemmelen factor (1.724). Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. The statistical software package SAS (2001) was used for all analyses. The results of this study showed that the soil organic matter tended to be higher in 2019 than in 2018 probably due to the grazing with celtic pigs which could have implied an addition of organic matter to the soil from animal excreta. Moreover, the urine supply of celtic pigs could have also favored the incorporation of the soil organic matter to the soil. Similar results were previously described in silvopastoral systems established with sheep under *Prunus avium* L. in Galicia (Ferreiro-Domínguez et al. 2016). Moreover, in 2018 in the profile 2 and profile 3, it was observed that the soil organic matter increased in the areas far from the feeding points compared with the nearby areas ($p<0.001$). However, in 2019 in the soil profile 3, the higher percentage of soil organic matter was found in the medium areas compared with the areas near the feeding points. These results indicate that the grazing with celtic pigs modifies the soil organic matter, finding negative effect of the grazing on the soil organic matter in the areas near the feeding points where the animals are most of their time looking for

feed. Therefore, in regions as Galicia, the establishment of silvopastoral systems with celtic pigs increases the soil organic matter over time but an adequate animal management is necessary to avoid a decrease of soil organic matter in the areas most frequented by the animals. Water and feed points should be moved to increase a most sustainable use of land.

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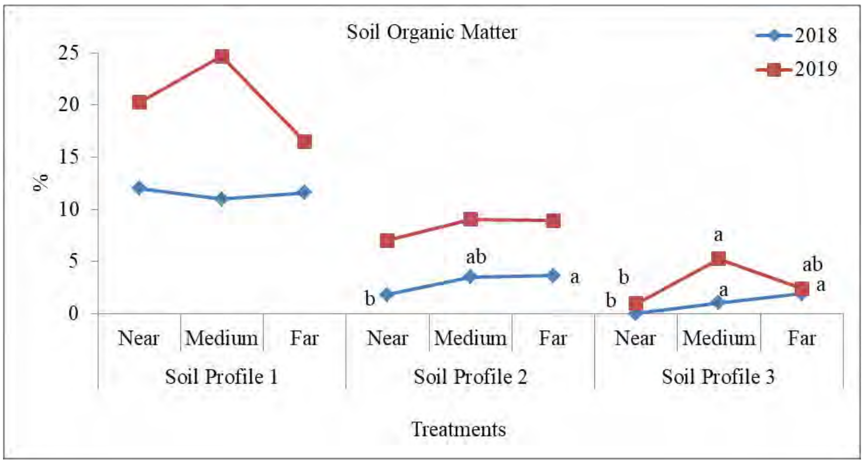

Figure 1. Variation of soil organic matter (%) at three distances from the fixed feed points (near, medium and far) in a silvopastoral system established in a plantation of *Pinus sylvsetris* L. with celtic pigs in Galicia (NW Spain). Different letters indicate significant differences between distances within the same year and soil profile.

Drought-shade interactions on winter pea induce carbon source-sink mechanisms that may lead to higher yield stability in a mature alley-cropping system

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: rainout shelters, interactive factors, light, water, yield loss

Abstract

In the context of climate change, many regions will be more prone to erratic and longer dry spells. If such climate hazard is not sufficiently anticipated, local consequences for farming systems may be important. Therefore, seeking for cropping systems that improve (i) overall water use efficiency and (ii) yield stability rather than yield productivity might represent a viable option for many farmers in an ever more unpredictable climate. Agroforestry systems, though still not widespread in temperate regions, may represent a good adaptation strategy. But knowledge regarding their whole functioning in the face of drought events remains scarce, potentially hindering in turn farmer's acceptance.

In order to gather insights regarding the potential of alley cropping systems as an adaptation strategy to drought hazards, we performed a rainfall manipulation experiment in South of France, at the Restinclières Farm Estate (15 km North of Montpellier). On the same parcel, winter pea was cultivated either as pure crop (PC) or intercropped in a mature alley cropping system (24 year-old hybrid walnut with tree rows orientated East-West) (AF). 20 rainout shelters were layout in a pseudo split-plot design covering both cropping systems in 2018-2019 (Blanchet et al. 2019). Rainfall exclusions started just before the flowering period (early April) and were performed until its end (mid-May). In total, 135 mm were excluded, impacting soil moisture content until at least 50 cm depth.

We hypothesized that crop yield would be impacted by the presence of trees (mostly through competition for light) but that, in case of drought, yield stability would be improved in understory conditions as the result of an overall improvement of biomass elaboration. As a first analysis, we proposed to analyse the result according to a simplified framework derived from Wery (2005). Three situations were compared and considered as representative of a gradient of tree-crop interactions: (1) pure crop (PC) ; (2) South of trees (AF-S) ; (3) North of trees (AF-N).

Experimental conditions led to contrasted crop growth dynamics, especially in terms of phenology, LAI and biomass. At harvest, crop yield was decreased in all agroforestry modalities (- 35 % overall), but a significant drought-shade interaction effect was reported on both yield and total biomass (see figure 1). In case of drought, biomass gap decreased along the shade gradient while harvest index improved. Consequently, yield losses were significantly reduced in AF modalities. The analysis of yield components revealed significant interaction effects on the number of fertile pods per plant and the thousand kernel weight. Those results are perfectly in line with the observations of Verghis et al. (1995), who studied the impact of both drought and shade on chickpea yield. We explained those results by i) a limited competition between tree and crop for soil water-resource in our system and ii) C-source-sink mechanisms altered by light competition during the flowering period. We advocate for further on-farm studies on the

effects of drought-shade interaction and their implication in terms of source-sink mechanisms as a strategic lever for climate change adaption.

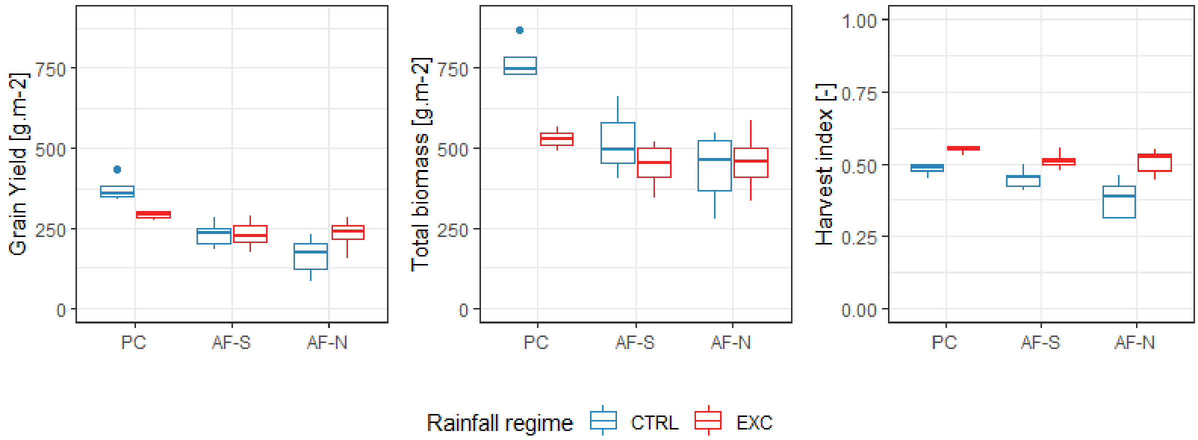

Figure 1. Boxplots of crop yield (a), total aboveground biomass (b) and harvest index (c) of winter pea along a gradient of tree-crop interactions: pure crop (PC), south of trees (AF-S), north of trees (AF-N). Two rainfall regimes were experimented: control (CTL) and rainfall exclusion (EXC)

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Analysis of agroforestry systems productivity compared to afforestation in a climate change context in Galicia

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Model, pinus, timber, adaptation, tree density.

Abstract

Temperatures increase over land related to climate change conditions has occurred at a faster rate in recent years, modifying also precipitations patterns (Masson-Delmotte et al. 2019). Agroforestry is widely recognised as a land-use system that contributes to climate change mitigation and adaptation (IPCC 2019) and turn also managed forests into a key tool (FAO 2008). Galicia region produces yearly around 47 % of timber in Spain occupying just 5.8 % of land extension (Picos 2018). *Pinus radiata* D. Don is the second coniferous species in Galicia, representing almost a quarter of coniferous and 7% of total tree mass (IV IFN 2011), being one of the tree species more expanded in recent years due to industry requirements and private land ownership (Xunta de Galicia 2018). The objective of the present study is to predict and compare potential productivity on 30+30 (2020-2081) years of a *Pinus radiata* D. don afforested land compared to an agroforestry system (AFS) with grass-clover as understory production in Galicia.

Tree densities of 1667 trees ha^{-1} and 100 trees ha^{-1} were selected for the afforestation and the AFS respectively. Afforestation tree density mirror a traditional plantation frame in the area (Mosquera-Losada et al. 2015), while the AFS one enables land eligibility for CAP support (EU 2014). Thinning in years 18 and 25 reduces afforestation tree density to 100 trees ha^{-1}. Yield-SAFE, as a dynamic model on agroforestry systems, allows studying potential production considering climate change parameters (Palma et al. 2016). Climatic data were obtained through the CliPick online tool, produced by the University of Lisbon.

Results reflect a higher productivity of the AFS for both timber volume of stand and volume per tree parameters at year 30. A bigger timber volume of the stand for afforestation was found before thinnings due to the high initial tree density, dropping-off in more than an 85% as tree density reduces and leading to a final volume of stand around 200 m^3 ha^{-1}. Therefore, AFS timber volume of stand more than double afforestation volume when tree density is evened out, reaching more than 500 m^3 ha^{-1} at year 30. Volume per tree is clearly superior when linked to AFS since its value above 5 m^3 at year 30 overtake the afforestation volume in more than two and a half times. The aforementioned higher afforestation timber volume of the stand before thinnings match with an intensive land-use system, which is more vulnerable to extreme events linked to climate change, pests and forest fires than AF systems. On the opposite, AFS diversifies production providing yearly revenues consequence of the interaction of the different agroforestry components (Fernández-Núñez and Castro 2016) and a higher resilience within a climate change conditions frame. In addition, AFS delivers ecosystem services such as nitrogen fixation, increasing land fertility and productivity. Volume per tree, as an indicator of timber quality considering industries

requirements in Galicia, may contribute to increasing AFS profitability over afforestation timber production.

In conclusion, it can be stated that agroforestry systems productivity would be higher than afforestation productivity in a climate change context in which AFS resilience and quality stand out as key strengths to enhance positive outcomes and system profitability.

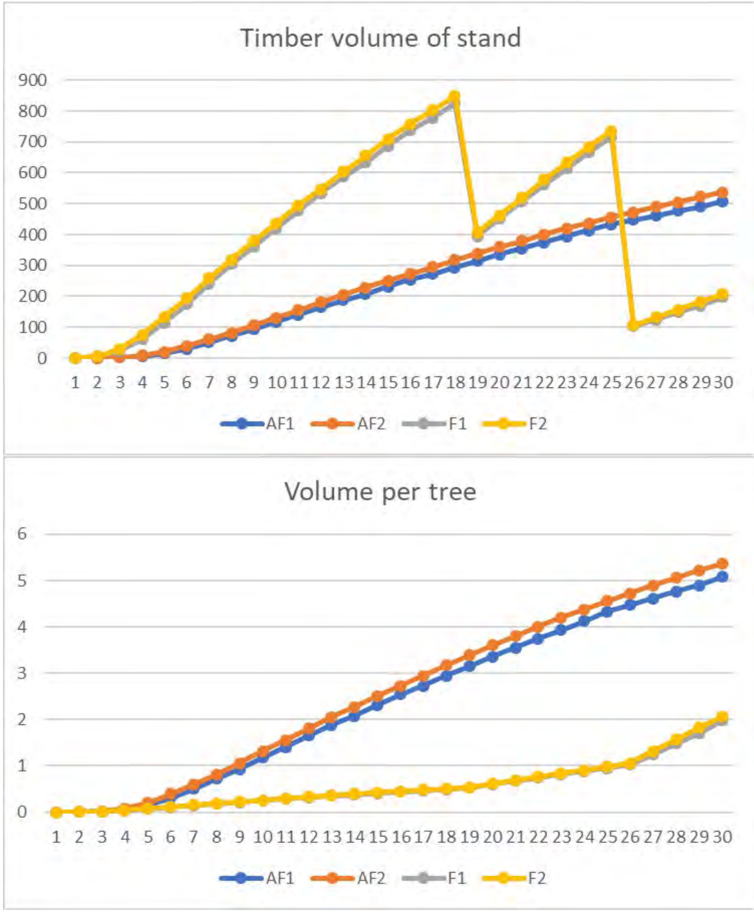

Figure 1. Agroforestry (AF) and afforested (F) predicted timber volume of stand production (m^3/ha) (upper) and volume per tree in m^3 (bottom) considering two different 30 years temporary spaces; 2020-2050 (AF and F) and 2050-2080 (AF2 and F2).

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Tree coverage in Sardinian dairy sheep systems: farm characteristics and environmental implications

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Global Warming Potential, land use, silvopastoral sistems.

Abstract

Considering the relevance of silvopastoral systems in Sardinian rural areas, the objective of this work is to analyse the relationships between tree coverage and main productive and environmental performances of Sardinian dairy sheep farms. A survey on twenty-six farms provided productive and environmental indicators. Land cover of the farm paddocks were classified in nine different land uses from remote-sensed images and two categories of farms were identified, with 0-50% or 50-100% of the farmland area occupied by tree-covered paddocks. Livestock activities and Global Warming Potential per hectare of dairy sheep farms were significantly higher in farms with 0-50% tree coverage than in farms with 50-100% (217 vs. 141 kg of normalized milk/ewes and 4,618 vs 3,350 kg CO_2-eq/ha, respectively). It suggests that production specialization of Sardinian sheep farms can be affected by land resources and ecosystem services should be considered in sustainability assessments.

Introduction

Many of the High Natural Value farms in Europe are represented by silvopastoral systems where extensively-managed livestock graze on lands that include both grasslands and trees. In Italy, about 1,300,000 ha of land (10% of the utilised agricultural area, UAA) include trees with livestock production, ranging from grazed forests to scattered trees in permanent grasslands (Paris, 2019). In Sardinia, silvopastoral systems are principally grazed by sheep and cattle (Rossetti and Bagella, 2014) and have an important socio-economic role providing rural employment and a wide range of ecosystem services (Seddaiu et al., 2013). The objective of this work is to analyse the relationship between tree coverage level and main productive and environmental performances of Sardinian dairy sheep farms.

Materials & Methods

A farm inventory database was compiled using data from twenty-six dairy sheep farms regarding their technical and productive characteristics. The paddocks of the farmland area were classified in nine different land uses by analysing remote-sensed images: i) temporary grassland (TG); ii) permanent grassland (PG); iii) permanent grassland with isolated trees (<20% of tree coverage - PGI); iv) permanent grassland with scattered trees (20 - 60% of tree coverage - PGS); v) permanent grassland with dense trees (>60% of tree coverage - PGD); iv) temporary grassland with isolated trees (<20% of tree coverage - TGI); vii) temporary grassland with scattered trees (20 - 60% of tree coverage - TGS); viii) temporary grassland with dense trees (>60% of tree coverage - TGD) and ix) other tree coverage (tree hedges and Mediterranean maquis – OTC). Data gathered from farms were used to calculate productive and environmental indicators. In order to describe the characteristics of farms with different woodland availability, farms were then classified in two groups based on the percentage of farmland area occupied by tree-covered paddocks: 0-50% (G1) and 50-100% (G2). Farm specific data was collected in order to determine the Global Warming Potential (GWP), expressed as kg CO_2-eq/ha UAA, according to Fazio et al. (2018). The soil C sequestration was not included in the calculation. A one-way ANOVA was applied to farm variables to test statistical differences among the groups.

Results and Discussion

On average, treeless grasslands occupy 50% (TGI) and 4% (PGI) of the farmland area (Fig.1). G1 farms are essentially treeless, with only 15% of farm surface occupied by tree-covered paddock and predominance of TG (83%). G2 farms are silvopastoral, with less than 45% of arable soils (TG, TGI, TGS and TGD) and about 50% of permanent grasslands covered by trees (PGI, PGS and PGD). G1 farms show flock size significantly greater than G2 farms, in terms of total mature ewes, replacement females and rams. Also, milk production level is significantly higher in G1 than in G2 (Tab.1). Finally, the GWP per hectare of UAA of the sheep farms with less tree coverage is significantly higher than that of the farms with more tree coverage, since higher amount of livestock activities are concentrated in these areas.

Conclusions

Sardinian dairy sheep systems characterized by a relevant incidence of tree coverage have significant low intense livestock activities and low GWP per ha than farms with less tree coverage. This clearly indicates that systems with different production characteristics coexist within the Sardinian sheep milk sector, despite the fact that almost all milk production is destined for cheese making. Indeed, sustainability assessment of Sardinian sheep farms should involve a full set of indicators quantifying the ecosystems services provided by the sheep farms, such as carbon sequestration, labor, ecological services or food, and needing further studies.

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and Forage4Climate LIFE15 CCM/IT/000039.

Figure 1. Land uses in respect to tree coverage of farmland area.
TG: temporary grassland;
PG: permanent grassland;
PGI: permanent grassland with isolated trees;
PGS: permanent grassland with scattered trees;
PGD: permanent grassland with dense trees;
TGI: temporary grassland with isolated trees;
TGS: temporary grassland with scattered trees;
TGD: temporary grassland with dense trees;
OTC: other tree coverage.

Percentage of farm land with tree coverage	G1 (0-50%)	G2 (50-100%)
Farms, N.	13	13
Ewes, N.	662[a]	351[b]
Replacement females, N.	168[a]	76[b]
Rams, N.	15[a]	8[b]
Utilized agricultural area (UAA), ha	100	88
Stocking rate, ewes/ha	6.4	4.6
Milk yield, kg FPCM/yr per present ewe	217[a]	141[b]
Global Warming Potential, kg of CO_2-eq/ha of UAA	4,618[a]	3,350[b]

Table 1. Dairy sheep farm characteristics and environmental impact in respect to tree coverage of farmland area. Within rows different letters indicate significant differences at P<0.05.

Quantitative assessment of carbon sequestration and oxygen production by oak windbreaks growing in the Forest-Steppe zone of Ukraine

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Abstract
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Theme: Climate change (adaptation and mitigation) [WG Agroforestry, ecosystem services, landscape and rural development]

Keywords: Common oak, phytomass, transfer coefficients, stock

Abstract

Windbreaks in the Forest-Steppe zone of Ukraine occupy about 79 thousand hectares of agricultural land. Mostly, windbreaks are represented by pure oak plantations or with a small admixture of related species - linden, maple, ash. According to the latest accounting of windbreaks, the average plantation age in the regions is 59 years, and the average plantation stock is 280 m^3/ha [1].

The purpose of the study was to determine the structure of the phytomass of oak trees and windbreaks by its components and the amount of carbon accumulated in them and oxygen production.

According to the forest-biometric methods [2, 3], based on the analysis of 71 trial plots and 118 model trees, mathematical models of the dynamics of the components of the above-ground biomass of trees and windbreaks were calculated.

Studies have shown that much of the aboveground phytomass of the oak tree in a windbreak accounts for the crown, which is dominated by the phytomass of the branches. For a single tree with a diameter at breast height of 36 cm, height of 24 m the proportion of phytomass trunk in a massive stand exceeds, and for the crown is less than in a windbreak by 6% . With increasing of porosity in the upper part of a windbreak, the phytomass of the crown of a single tree increases. Studies confirm the hypothesis that with age, the proportion of components of the tree crown and, accordingly, carbon in them increases, and the proportion of stem part in the total phytomass decreases.

The content of carbon in the components of biomass was determined according to the coefficients established by G. Matthhews [1], which make up 0,50 for the biomass of wood and bark, and 0,45 for leaves. It's established that windbreaks, in comparison with massive plantations, have certain advantages in terms of accumulation of carbon in wood, bark, branches and leaves by 28, 54, 4 and 33% respectively.

Comparative characteristics of carbon absorption, in the same area and stock of plantations, between oak massive stands and windbreaks indicate that windbreaks accumulate far more phytomass and absorb carbon per hectare (Fig. 1).

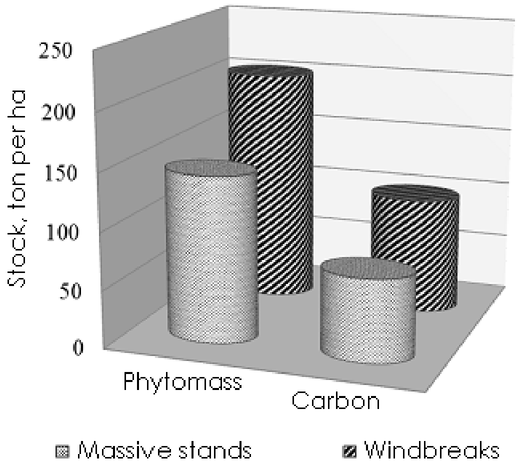

Fig. 1. Phytomass and carbon stock in the windbreaks and massive stands of the regions

This difference is due to the conditions of growth of common oak trees. Due to the fact that oak trees in windbreaks have a larger feeding area and a more powerful crown than trees growing in massive stands, their photosynthetic ability is greater.

The oak windbreaks of the regions annually absorb 60-70 thousand tons of carbon from the air, which is approximately 4.5-5.7% of the annual carbon emissions into the atmosphere by industry.

Due to the transfer coefficients [4] the oxygen production capacity of oak windbreaks per 1 ha has been calculated. Figure 2 shows the results of the data obtained on the amount of carbon deposited and the amount of oxygen released by the windbreaks into the atmosphere during 2010–2017.

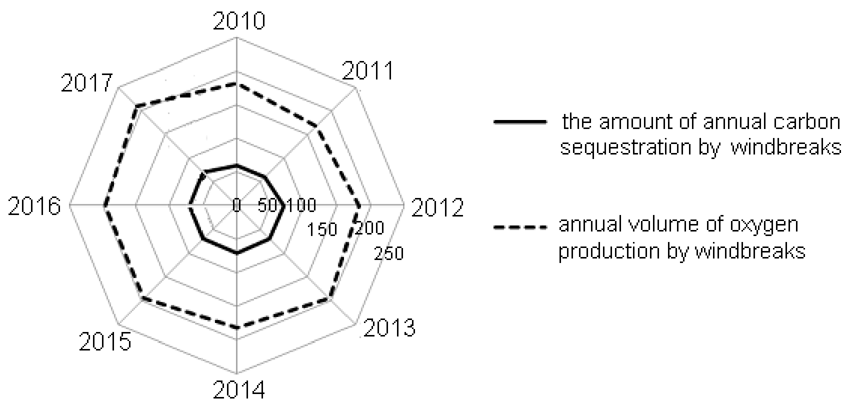

Fig. 2. Dynamics of annual carbon sequestration and oxygen production in the Forest-Steppe zone of Ukraine during 2010-2017, thousand tons

The total amount of oxygen produced by the oak windbreaks in the Forest-Steppe zone of Ukraine in the period 2010–2017 was 1.5 million tones, which is three times more than the carbon deposition during the same period.

Consequently, the windbreaks in 30% more accumulate aboveground phytomass and absorb carbon than massive forest stands. The windbreaks annually absorb about 67.5 thousand tons of carbon and emit 190 thousand tons of oxygen, indicating the significant ecological role of windbreaks and the need to increase them to improve the climate.

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Variation of yield in varieties of wheat and rye under shade conditions

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Abstract
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Theme: Climate change (adaptation and mitigation)
Keywords: Shadow, rye, wheat, Silvoarable Systems, crop yield, weight grain, air biomass.

Abstract

Silvoarable systems can benefit crop yields by reducing the adverse effects of climate change. Trees help to regulate conditions below them by reducing the effects of extreme temperatures. In addition, trees act as windbreaks and reduce evaporation from the soil surface by preventing drought episodes. However, in silvoarable systems the phenology of the crops, and/or the rate of evapotranspiration can be significantly modified. There are many studies in temperate and Mediterranean areas that have shown that interactions between trees and crops can be competitive (Dufour et al., 2013), not only because of access to resources, such as water and mineral nutrients (Cannell et al., 1996; Jose et al. 2000a; Livesley et al. 2004), but also because of light. Under the tree canopy there is a regime of sunshine, which can vary in a short interval of time (seconds, minutes), due to the fluctuations in position that the leaves of the trees suffer when they are shaken by the wind. Therefore, it is necessary to understand how shade influences the development and yield of crops that are part of the food base for humans and animals, such as cereals. In this context, a greenhouse experiment was set up in 2018 at the University of Santiago de Compostela (Galicia, NW Spain) to assess how light stress influences cereals. The study was carried out with 17 varieties of wheat and 11 varieties of rye, planted in December 2017, in 15x15x30 cm pots filled with 58% peat substrate and 42% perlite. To carry out this trial, a complete block design was made at random with eight replicates per variety and the light radiation treatment used.
Three levels of irradiation were established for synthetic photoactive radiation (PAR): control, corresponding to open field conditions (100% light); second treatment with a mean light reduction (30% light reduction) and a third treatment under conditions of maximum radiation reduction (50% reduction of light radiation). To achieve a total and uniform reduction of light radiation in each block and depending on the treatment applied, each culture table was covered with a shade mesh. The mesh sizes were 0.0075 cm^2 and 0.0026 cm^2 for 30% and 50% respectively. The mesh was installed in mid-May, imitating the chestnut tree foliage.

In 2018, the parameters studied were the different components that determine the yield of each of the varieties of the species under study: weight grains per spike, total above-ground biomass and number of spikes per m^2. Other potential variables influencing grain yield have also been analysed: genotype and precocity. The results obtained in both statistical models were treated by variance analysis (ANOVA) with Tukey's post hoc tests ($p < 0.05$), using the SAS statistical package (2019).

In Figure 1 it can be seen how a decrease in biomass per unit area occurred in rye varieties as the reduction of light radiation increased, ($p<0.0001$). In open field conditions it was observed that the biomass per spike represented 32.37% of the total biomass and in conditions of light reduction of 30% it represented 16.77%. This fact was accentuated as the light stress increased where the spike biomass represented 13.25% of the total biomass, which was 42.8% lower than in open field conditions. The reduction in height probably was due to the reduction in the rate of CO_2 assimilation. As the light stress was higher, plant height growth and the biomass allocation pattern could have been affected. This result could be due to the allocation of more biomass designated to the roots and to a lesser extent to the stem and leaves, which implies a decrease in the number of grains per spike. A significant effect was observed between the biomass yield and the phenotypic characteristics of each variety ($p < 0.05$).

In addition, it has been seen in some varieties such as Gattano (p <0.001) (Figure 1), high performance has been maintained before different types of light stress, and others such as Daniello, did not reach the spike.

On the other hand, it has also been seen that some varieties, such as Nikko, decrease their yield in biomass under conditions of maximum light reduction, a difference from what was observed under 30% light reduction conditions where the biomass of the spike represents 32.22% of the total aerial biomass. This variety together with Brandie and Gattano appear to be the varieties that under conditions of maximum luminous reduction have a higher biomass yield per unit area.

Under light stress conditions, the varieties with the highest wheat production were medium-precocity varieties. This is partly since wheat, like a good heliophile plant, under light stress conditions can be morphologically transformed by lengthening the stem (stem phase) and spike causing an increase in total biomass. In addition, a weight gain of dry spike per unit surface has been observed in some varieties of wheat such as Sy Alteo and Candelo, leading to an increase in the number of grains, as well as an increase in biomass.

Therefore, this study allows not only to determine which species are most suitable under shade conditions in silvoarable systems, but also to obstruct the behaviour of varieties under luminous reduction conditions, and thus select those that they can perform better.

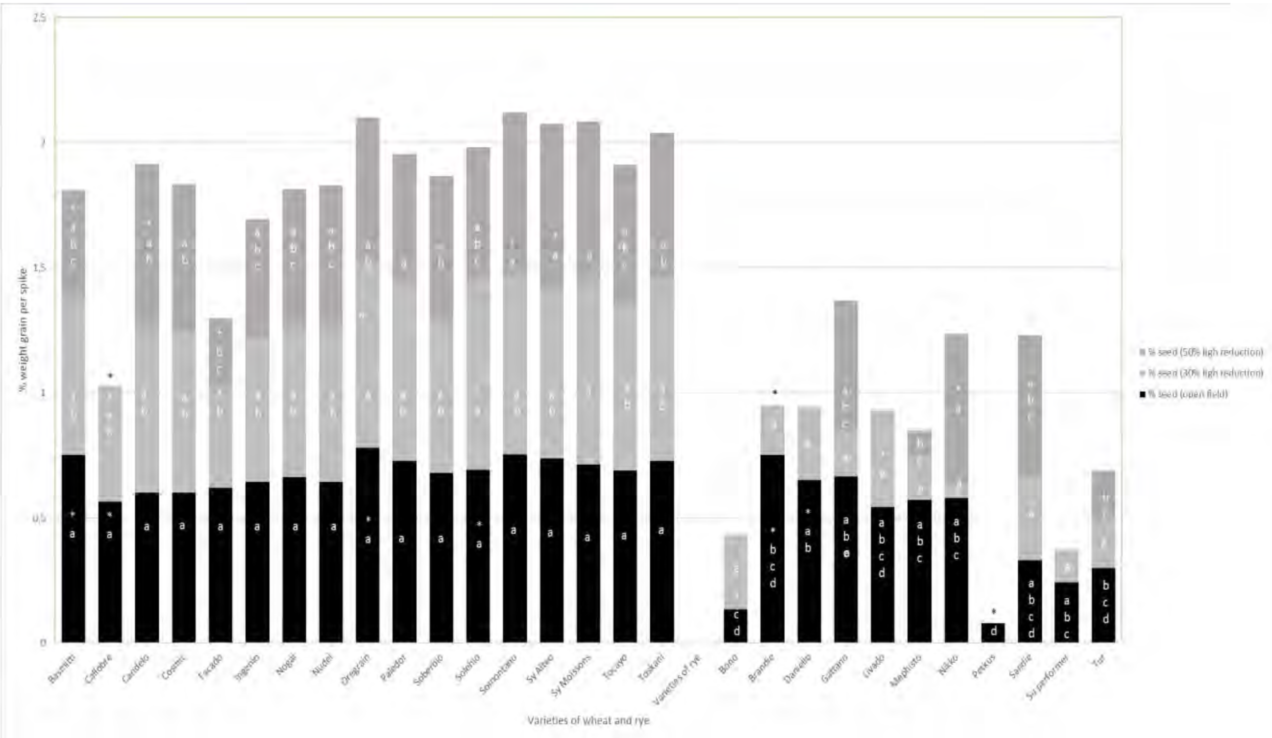

Figure 1. Variation % weight grain per spike under different light treatments.

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Exploring the potential of coffee agroforestry systems to productivity, adaptation, and mitigation: a system typology approach.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: coffee agroforestry typologies, tradeoffs, synergies, shade of trees, climate change

Abstract

The inclusion of trees in coffee plantations generates goods and services to the crop, farmers, and environment. The provision of organic matter, microclimate regulation, fruits, timber, and carbon sequestration is relevant for land and crop productivity and for adaption or mitigation to climate change. The presence and intensity of these benefits depend on the species and number of trees, farming intensification level, and biophysical conditions of the land. Farming typologies have been used widely to characterize farm systems and facilitate the implementation of policies and programs by decision-makers. The objective of current coffee agroforestry typologies is describing the intensification level [e.g. low, high inputs], or type of production [convencional, organic] or the structure and composition [e.g. multistrata, mono strata] of the shade trees. In this sense, promote or describe agroforestry systems in terms of their potential for [crop/land] productivity, and adaptation and mitigation to climate change would be favored by a typology than embed such objectives. Therefore, a new coffee agroforestry system typology was created to identify the potential of current coffee agroforestry systems considering productivity, adaptation and mitigation objectives.

A coffee survey from Nicaragua was used to create the typology; the survey includes data on farming practices, type and species of shade trees, shade level, yields, and labor. The net income from coffee and musaceas and carbon stock above and below ground were calculated using equations from literature. The shade trees were divided into woody trees and musaceas to capture the difference in the carbon sequestration potential. Five variables were selected to define the typology; coffee yields [kg ha^{-1}] and annual maintenance costs [US$ ha^{-1}] were used to represent productivity; the shade level [%] for adaptation; and the density of woody trees [trees ha^{-1}] and musaceas [stems ha^{-1}] for mitigation. A principal component, cluster and variance analyses were implemented to identify the typologies.

The three first principal components explained 90.3% of the variability. From the cluster and variance analyses, five typologies were defined and named based on the intensification and shade level, and shade trees dominance [woody, musaceas], the typologies are IMW = Intensive management under Medium-dense shading of Woody trees; MDW = Medium-intensive management under Dense shading of Woody trees; LMM = Low-intensive management under Medium-slight shading of Musaceas; ISM = Intensive management under Slight shading of Musaceas; LMW = Low-intensive management under Medium-slight shading of Woody trees. The typologies were described considering the maintenance cost, net income, shade levels, carbon stocks, and altitude. The IMW has the highest potential for productivity, adaptation and mitigation objectives at medium altitudes, and the ISM the highest potential for productivity and adaptation only at high altitudes. MDW has medium potential for the three objectives. The potential of the coffee agroforestry system is correlated to the level of shading required given the altitude, and therefore, some coffee regions have a higher potential for productivity, adaptation, and mitigation. Given the expected rise in the air temperature under climate change, increment in the current shade levels and more woody threes usage may occur that would provoke an increment in the carbon stock and reduction of coffee yields.

Expansion of cashew in the post-forest zone of Côte d'Ivoire: between reconversion strategies and crop diversification in a context of land saturation and ecological change

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations towards innovative agroforestry systems

Keywords: Deforestation, land saturation, seasonal instability, cashew, reconversion, diversification, post-forestry zone

Title: Expansion of *Anacardium occidentale* L. in the post-forest zone of Côte d'Ivoire: between reconversion and crop diversification strategies in a context of land saturation and ecological change.

Abstract

Before independence, Côte d'Ivoire focused its economic development on agriculture, mainly coffee, then cocoa. After independence, public policies contributed to farmers' preference for cocoa, which became the main source of agricultural income for both the Ivorian population and the state. The development of cocoa has been at the expense of the forest, which has shrunk from 12 million hectares in 1960 to less than 2 million hectares today. Faced with a decline in productivity due, among other things, to aging plantations, declining soil fertility and seasonal instability, difficulties in renewing farms are observed in the various cocoa loops (Assiri, 2007). Thus, we are witnessing the reconversion or diversification of these former coffee and cocoa orchards towards other perennial crops, particularly cashew.

This study aims to identify strategies based on the adoption of cashew nuts by farmers in a context of land saturation and ecological change. To serve this objective, the authors mobilize two (02) case studies in the Center-West of the country, the first one on the periphery of the classified forest of Haut-Sassandra subject to strong land pressure, the second one between Gagnoa and Sinfra, where cocoa farms are strongly affected by the swollen shoot disease. Socio-economic surveys were conducted in 21 localities to identify the strategies developed by farmers to deal with land saturation and climate change. Data collection was carried out through individual and semi-structured interviews using a questionnaire. The questions asked were related to the farmers' settlement period, the age of cultivation, the cultural precedent of the crops, the adaptation strategies, and the species associated with the main crops. A total of 464 farmers were interviewed. The results of the analyses showed that cashew nut cultivation appeared in the first study area between 2001 and 2005 with a settlement rate of 3%. Between 2011 and today, the rate of expansion is about 90%. Half of the cashew plantations have as their main cultural precedent old cocoa and coffee plantations (age > 30 years). In the second study area, the progression is staggered, starting in 2010/11, but accelerated by the progression of the swollen shoot. In 2019, almost 100% of farmers have cashew trees.

Finally, the introduction of cashew, which is a savannah crop in cocoa and coffee producing areas, follows three strategies. The first is that cashew tree stands provide shade for juvenile cocoa trees and also restore impoverished land. Indeed, farmers use the humus provided by the decomposition of the dry leaves of the cashew tree to enrich the soil. The second strategy is the reconversion of old cocoa and

coffee plantations. Indeed, this second strategy consists in gradually replacing unproductive cocoa and/or coffee tree stems with cashew nuts. Finally, despite the price collapse in 2018, the introduction of cashew nuts on cocoa and coffee farms is a strategy to diversify farmers' sources of income. In addition to cashew nuts, farmers associate to their plantation exotic species (*Mangifera indica, Persea americana, citrus sp*...) and forest species (*Ricinodendron heudelotii, Irvingia gabonensis, Milicia excelsa, Garcinia Kola, Elaeis guineensis*...). The products from these species are mainly used for food, medicinal care, fodder, timber. These agroforestry strategies based on the introduction of cashew trees and woody species in plantations deserve to be improved and disseminated in areas subject to strong land pressure, in a context of land saturation and climate variability.

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Seasonal trend of carbon fluxes under different light intensity in a Sardinian cork oak wooded pasture

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Soil CO_2 emission, shade and no shade conditions, Silvopastoral systems

Abstract

Evergreen oak species (*Quercus suber* L. and *Quercus ilex* L.) dominate the wood vegetation in Sardinia land where cork oak areas cover about 140000 ha^{-1} (90% of Italian cork oak areas), which are exploited combining silvopastoral systems and cork trade. Conservation of that ecosystem model depends not only on the market demands for cork products but also on the peaceful coexistence between extensive cattle production and semi-natural ecosystems. Global climate change caused by rising levels of carbon dioxide (CO_2) and other greenhouse gases (GHGs) is recognized as a serious environmental issue, requiring the increase of the carbon storage capacity of terrestrial ecosystems (Kumar and Ramachandran Nair, 2011). Climate projections show that the arid climate type is likely to expand into Euro-Mediterranean areas during the 21st century. However, changes are already being noticed particularly in the Mediterranean basin, experiencing an increase in the interannual variability in precipitation and temperature, as well as in the occurrence of extreme climatic events (Aguilera et al., 2020). In the framework of FP7 Agforward project, a research has been started in 2015 to investigate seasonal values of CO_2 soil effluxes and to measure their variations in contrasting microenvironments. The present work reports measurements of CO_2 soil effluxes in evergreen cork oak under a silvopastoral systems typical of northern Sardinia (Italy) and semi-arid areas of the Mediterranean basin. The research was carried out between 2015 and 2019 in a private farm in Buddusò (SS) (40°37′99″N, 9°15′33″ E, elevation 700 m a.s.l.). The climate is Mediterranean with hot dry summers. Long-term rainfall is 840 mm year^{-1} and the average annual temperature is 12.7 °C. Main land use is represented by traditional cattle farming (1 LU ha^{-1}) with pasture as primary feeding source. Open areas with full sunlight exposition (FS) and areas with partial shade (PS) under tree canopy at 450 trees ha^{-1}, were carefully identified. Light levels of photosynthetically active radiation were measured using a SunScan canopy analysis system (Delta-T Devices, Cambridge, UK). For both FS and PS areas understory was an unsown native pasture with 60% legume composition and a predominance of *Trifolium subterraneum* L. Other legumes were *Trifolium* spp. *Ornithopus compressus* L. and non-legume species, mainly represented by *Lolium* and *Avena* spp., *Asphodelus macrocarpus* Parl., *Hyoseris radiata* L., *Carlina corymbosa* L., *Sonchus oleraceus* L., *Plantago lanceolata* L., *Raphanus raphanistrum* L., *Rumex* spp, *Daucus carota* L., *Echium plantagineum* L. and *Thapsia garganica* L. In both FS and PS pastures, the soil CO_2 efflux due to soil respiration (SR) was measured *in situ* using a portable, closed chamber soil respiration system (EGM-4

with SRC-1, PP-Systems, Hitchin, UK) with a measurement time of 124 s. The measurements were carried out fortnightly from November 2015 to July 2019. The soil CO_2 efflux was measured by fitting the closed chamber to PVC collars (10-cm inner diameter and 10-cm long, with perforated walls in the first 5 cm) previously inserted into soil at 9 cm depth (Two collars per plot). The average value of the two SR measurements per plot in each sampling date was used for data analysis. SR was monitored on 44 different dates, with 12 measurements for each sampling date. The measurements were performed between 8:30 and 12:00 am so that the data collected were representative of the daily means (Almagro et al., 2009). Higher Soil Organic Carbon (SOC) values was found under PS than FS, + 21%, + 34% and + 19%, respectively at the 0-20, 20-40 and 40–60 cm of soil layers. Soil Water Content (SWC) at 10 cm depth was in the range 3.1-32.4% and 3.4-36.3% in PS and FS, respectively. On average, FS soil was wetter than PS (14.5% vs 15.1%). Soil temperature at 10 cm depth ranged from 5.3 °C to 28.8°C and 3.1 °C to 31.1°C, in FS and PS, respectively and soil water content was negatively correlated with soil temperature during the whole period of observation (data not shown). In the study period, CO_2 soil respiration rate, ranged from 0.442 µmol m^{-2} s^{-1} to 9.760 µmol m^{-2} s^{-1} in PS and from 0.778 µmol m^{-2} s^{-1} to 10.328 µmol m^{-2} s^{-1} FS. The polynomial regression analysis of the dependency of CO_2 fluxes on soil temperature and soil water content showed that the CO_2 flux was affected by both soil temperature (only in PS) and soil water content (in PS and FS). The temperature and water dependency of soil CO_2 fluxes in PS condition, could be describe by a polynomial regression analysis (R^2= 0.22, P≤ 0.004 for temperature and SWC). On the other hand, in FS condition the regression coefficients were significantly only for soil temperature (R^2= 0.14, P≤ 0,006). Our results highlight that under tree canopy condition of PS, despite the higher root density than FS, the root activity and organic matter decomposition led to a reduction of CO_2 fluxes and an enrichment of SOC, due to the mitigating actions on microclimate,

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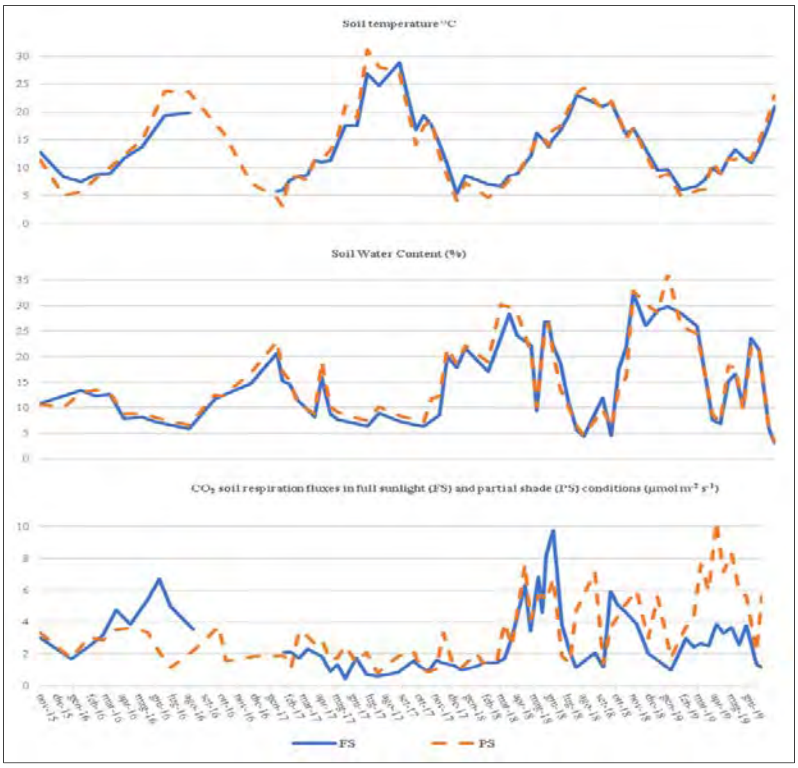

Fig. 1 Soil Temperature, Soil Water Content and CO_2 soil respiration in Full sunlight and Partial Shade conditions.

The potential contribution from tagasaste (*Chamaecytisus proliferus var. palmensis*) to Sardinian farming systems: an agroforestry approach

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: tree lucerne, rainfed, Mediterranean, forage quality, phenolics, flavonoids

Abstract

Shrubs and cultivated multipurpose fodder trees are indispensable sources of animal feed in Southern Europe, Eastern Mediterranean region and African savannas, for alleviating feed shortages during the long and dry summer period and mid-winter (Papanastasis et al. 2008). Tagasaste (*Chamaecytisus proliferus* (L. fit.) Link var. *palmensis* (Christ) Hansen and Sunding is a perennial fodder shrub native to Balearic islands and cultivated as a legume fodder tree around the world due to its valuable forage traits (Sulas et al., 2016). In fact, this shrub species has the ability to retain evergreen leaves and hence maintain a relatively high nutritive value during the dry season as well as to be drought-resistant (Assefa et al., 2012).

A research was started to evaluate adaptation and performances of tagasaste grown under Mediterranean conditions of Sardinia (Italy). This study presents novel information regarding qualitative traits of tagasaste and discusses its possible contribution to existing forage farming systems according to an agroforestry approach. Field experiments were conducted during 2013-2014 in Southern Sardinia (39° 31' N, 8° 51' E), where the climate is Mediterranean with mild winter. The area has a long-term average annual rainfall of 446 mm received mainly in the autumn and winter months, and a mean annual air temperature of 17.6 °C. Tagasaste plants have been grown on experimental plots of the Council for Agricultural Research and Economics, each spaced 2.5 m between rows and 2 m apart within rows, under a randomised block design with three replicates.

At bi-monthly intervals, three undisturbed plants per plot were pruned at a cut height of 50 cm. Plant aerial biomass was separated into branches, lignified stems and edible biomass, which was then subdivided in leaves and twigs. Concurrently, herbaceous forage sources available at the site, namely native pasture, triticale (x Tricosecale Wittmack), sulla (Sulla coronaria [L. Medik)]) and cocksfoot (Dactlys glomerata L.) were also cut on 3 sampling areas of 0.5 m^2 each. Tagasaste leaves and herbaceous samples were oven dried at 65 °C for 48 h, then ground to 1 mm screen to be analysed for quality traits. Total N was determined using the Kjeldahl method and crude protein (CP) was calculated by multiplying the N content by 6.25. Neutral and acid detergent fibres (NDF and ADF) and acid detergent lignin (ADL) were determined by using the procedure of Van Soest et al. (1991) and ether extract (EE) using Soxhlet extraction. Results showed that tagasaste was the only fodder plant able to supply green leaves with an

overall high nutritional value during the whole year, and in particular from summer to late autumn, when seasonal feed shortages, associated to drought season typically occurs. Wide seasonal differences for bromatological composition were recorded among species (Fig. 1). Based on the comparison with the abovementioned herbaceous forage sources, which represent, taken together, the most valuable forage options at that site, tagasaste biomass represents a high quality feed supply (in terms of CP and NDF). Additionally, the low NDF level of tagasaste, associated with the high ruminal degradability compared to the others forage species, confirm the interest on this feedstuff for livestock system in the Mediterranean basin. From late summer to winter (time between sowing of annual forage crops and seedling development and/or plant re-establishment allowing a first grazing) tagasaste might result the only source of high quality green forage, which is available in field under rainfed regime. Therefore, results suggest that tagasaste is suitable for complementing in time and space traditional herbaceous fodder resources of rainfed, mainly located on plain and hill arable land and based on the cultivation of cereals and forage crops. Other than strategic fodder to cover ruminant requirements, the introduction of tagasaste offers additional benefits and ecosystems services such as N-fixation ability, soil erosion control, windbreak, biomass and honey production, ecological infrastructures, etc. With the inclusion of tagasaste, the existing farming systems could be easily turned into agroforestry, with advantages in terms of system diversification and resilience to climatic variability.

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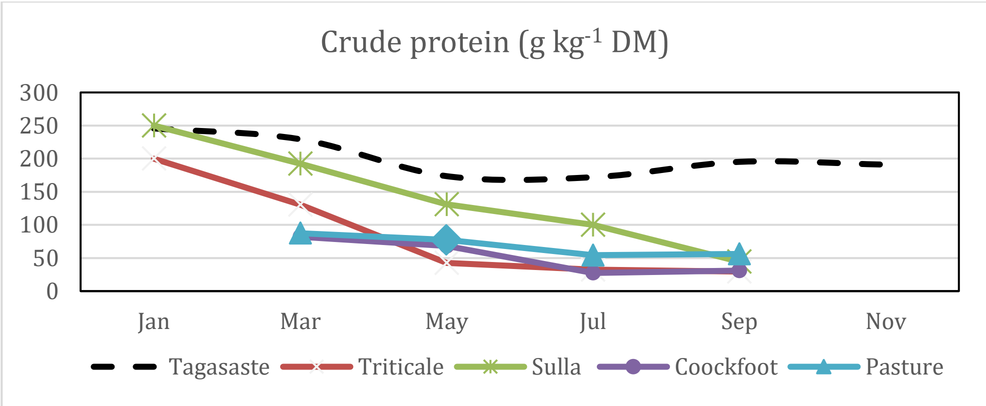

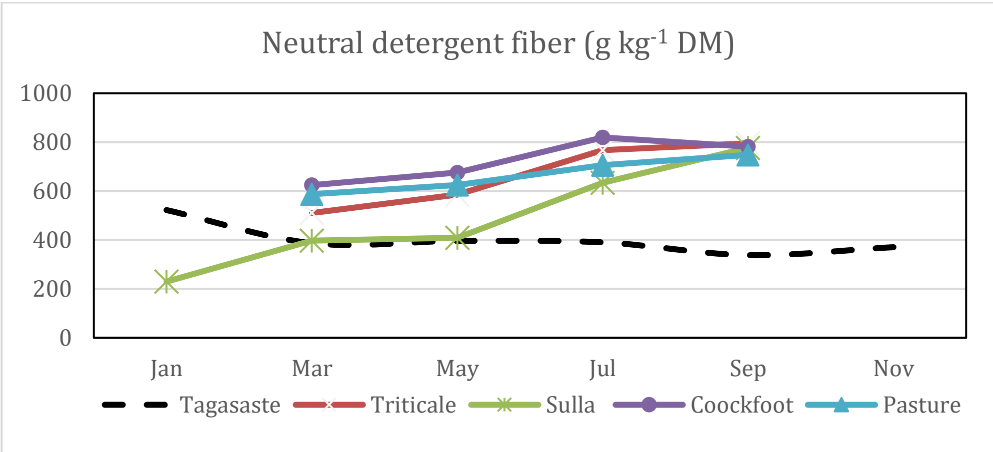

Figure 1. Seasonal trends of crude protein (CP) and neutral detergent fibre (NDF) contents in tagasaste leaves compared to different forage sources.

AGROMIX - AGROforestry and MIXed farming systems - Participatory research to drive the transition to a resilient and efficient land use in Europe

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: resilience, holistic evaluation, efficient land use, participatory co-design, transition

Abstract

The AGROMIX project aims to deliver participatory research to drive the transition to a resilient and efficient land use in Europe. It focuses on practical agroecological solutions for farm and land management and related value chains. AGROMIX makes use of a network of 83 sites with Mixed Farming (MF), AgroForestry (AF) or value chain stakeholder networks, which are used to measure, design, model, test and improve these systems. A nested approach will be used to conduct 12 co-design pilots across Europe. In addition, 6 replicated long-term trial sites are used for detailed analysis (crops and livestock).

AGROMIX has six specific objectives: (**1**) Unlock the full potential of synergies in MF/AF systems. (**2**) Develop and promote value chains and infrastructure for MF/AF produce. (**3**) Develop the MIX-A toolkit to co-design and manage MF/AF systems in practice. (**4**) Identify and model transition scenarios. (**5**) Develop policy recommendations and action plans for a successful transition. (**6**) Maximise the impact and legacy of the project for building low-carbon climate-resilient farming systems.

AGROMIX uses a transdisciplinary multi-actor research approach with 10 universities, 7 research institutes and 11 multi-actor partners. It will use Reflexive Interactive Design methodology to include stakeholders in participatory co-design and implementation of MF/AF systems. The research starts with a work package (WP1) on context, co-creating a resilience framework. WP2 on systems design and synergies is at the heart of project. WP3 on indicators and scenarios will refine the greenhouse gas inventories for MF/AF systems and model transition scenarios. WP4 develops and tests the MIX application/ serious game. Further WPs are on economics and value chains, and on policy co-development, action plans and dissemination delivering impact and exploitation through practical innovations on farms, in value chains, policy levels and through communication and knowledge hubs across Europe.

By adopting a multi-actor, transdisciplinary, participatory approach, AGROMIX will generate and share knowledge to support farmers and key-actors in the transition from specialised to MF/AF systems across Europe. Solutions will consider systems complexity and diversity and as a result AGROMIX can achieve impact in both the conventional and organic sector and its different supply chains across Europe. Impacts include:

- Reduce the environmental impact of farming and contribute towards mitigation and adaptation to climate change.
- Provide ecosystem services through integrated and small-scale land management.

- Foster synergies between agricultural production, climate change mitigation and adaptation.
- Deliver effective solutions for ensuring the highest level of implementation in heterogeneous landscapes.
- Unlock and improve viability and replicability and propose different transition scenarios.
- Strengthen social cohesion and consumer understanding of mixed farming and agroforestry.
- Facilitate the emergence of new businesses in the farming sector and exploitation of novel supply chains for MF/AF systems, e.g. dynamic agrovoltaism.
- Increase the efficiency and competitiveness of the farming sector.
- Develop market niches focusing on MF/AF value chain products.
- Develop renewable energy markets from MF/AF value chain products.

Proposed innovations include:

Participatory Design of MF/AF systems and Knowledge Exchange Hubs: AGROMIX will build on the Reflexive Interactive Design methodology to engage with 12 co-design pilots across Europe (WP2). The Participative Design Platform will not only test co-design of MF and AF systems with the farmers themselves, but it will showcase how real and effective change can be co-created and achieved in the sector. This approach will serve as stakeholder demonstration and it has the aim to achieve greater impact across the sector. The Knowledge Exchange Hubs (WP7) will provide a common space for AGROMIX partners and external stakeholders where they will access to up-to-date information and tools available to achieve climate-smart and resilient mixed farming and/or agroforestry.

Environmental Performance: AGROMIX activities in WP3 will advance knowledge on best practices and land uses that unlock the synergies in MF and AF systems to achieve higher environmental performance. Key indicators will be measured to assess productivity, environmental resilience and the role of above- and below-ground biodiversity. AGROMIX will fill the key knowledge gaps in these areas. This will bring a more comprehensive understanding of how to maintain and enhance the efficiency of MF and AF systems contributing to climate change mitigation and adaptation strategies. AGROMIX will also explore future scenarios for efficient and resilient land uses in Europe to provide evidence for environmental policy.

Gamification Platform for Immersive Learning and Innovation: Serious Games are particularly effective to drive innovation through the use an immersive learning environment. AGROMIX will adopt this approach and transform stakeholder engagement events into informal learning environments where AGROMIX will engage with a wide range of stakeholders (e.g. farmers, policy makers, retailers, academics, NGOs, local authorities). AGROMIX will develop the MIX-App Serious Game Prototype (WP4) as an open-source gamification platform to enable non-expert end-users from diverse contexts to create their own problem-solving Serious Game. This approach has never been specifically adopted in the context of MF and AF systems. The MIX-App will combine existing and newly generated knowledge and understanding of MF and AF systems with the use of problem-based learning as an active learning process that uses critical and logical thinking and reflections. AGROMIX specific approach will enable end-users to tailor their experience and it will facilitate real farm management transition for climate-smart farming.

Economic Performance and Value Chains: While key gaps exist in the understanding of environmental performance of MF and AF systems, greater uncertainty is found in the economic performance of such complex systems and how value chains and networks can be re-designed and improved for MF/AF systems. AGROMIX will integrate socio-economic and financial performance data from several datasets with stakeholders and consumers surveys. AGROMIX will advance the understanding of socio-economic performance of MF/AF systems and subsequent MF/AF-adapted value chains. AGROMIX will address the economic uncertainty that could hinder uptake of MF/AF systems and implementation of climate-smart farming.

LULUCF Reporting for Policy Development: Emissions reporting from agriculture is complex, in part due to the range of contexts and land uses adopted. Land uses categorisation and emissions reporting for MF/AF systems do not accurately reflect the real impact of these complex systems. AGROMIX will improve the current Land Use and Land Use Changes for Forestry (LULUCF) reporting and contribute to IPCC reporting and policy development at national, European and international level. This will bring more clarity to the context-related real and projected impact of MF/AF systems and their potential as carbon sinks.

Agroforestry Use of Almond in Lebanon: Potential and Development

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Agroforestry, Almond, Climate change, Land Suitability, GIS.

Abstract

Land is already under increasing pressure from human activities, and climate change (CC) is intensifying these stresses. On the other hand, only by reducing greenhouse gas (GHG) emissions in all sectors, including land and food systems, global warming would be well below 2 °C (IPCC 2019). Developing countries will suffer the consequences of CC, and they are the ones who are going to withstand the worst of its negative impacts.

Almond (*Prunus dulcis* or *Amygdalus communis*) is an important nut crop, which ranks first in world nut production, with 1.07 million tons of kernels. *Prunus dulcis* is an economically significant crop tree grown primarily in Mediterranean climates. The almond tree is a native species to Lebanon well known in its resiliency and its economic importance. Native species are adapted to the local environment and hence may be less susceptible to stress, severe disease, and pest damage. Local people are more popularized with their native plants and have more uses for them.

In this context and due to its high adaptability to the semi-arid conditions and its economic value, considerable attention is being given to almond culture in Lebanon.

Almond trees need adequate winter chill to deliver yields that are economically profitable. During the cold season, trees develop a period of dormancy in order to prevent frost damage of vulnerable tissue. Endodormancy is broken after a certain period of cold conditions (chilling), and the tree is ready to start spring growth. On the other hand, almonds flower buds are very sensitive to frost, which could be lethal. Temperature is supposed to rise in many parts of the world with minimum temperature increasing most rapidly. Global warming is expected to affect the biophysical requirements of the tree by reducing the available winter chill, so, it may have a major impact on the growth, the geographical distribution of plant species and crop yields.

One of the GHG mitigation strategies is Agroforestry (AF). This discipline is renowned around the world as an integrated approach to sustainable land use since it supports the economic, social and environmental values of the territory, promoting resistance and resilience towards ongoing CC.

In this study, the main objective is to develop a GIS-based approach for land-use suitability evaluation which will help the land managers to identify areas with physical constraints by analyzing the main limiting factors for almond production and to assist decision-makers to exploit crop managements adept to improve the land productivity.

GIS has been used to classify the suitability for almonds based on the biophysical requirements of the tree and the land characteristics (Physico-chemical and climatic). Diverse land parameters such as edaphic parameters (Soil Texture/Soil Type, Soil Depth, and soil pH), topographic parameters (aspect, exposure (slope), elevation, and distance from the Sea) and climatic parameters (temperature, rainfall, frost, relative humidity) are evaluated. Then all of them are combined and integrated into the ArcGIS 10.6 platform to elaborate land suitability and capability maps elucidating the suitability degrees for identifying AF target regions for the Almond tree.

The classification of land in terms of suitability is based on FAO 1976 guidelines for land evaluation.

Overall, this work highlighted the potential of the almond tree to mitigate CC and its capacity to grow in marginal conditions under different combinations (alley cropping, silvopasture). This is expected to reduce vulnerability to the CC through all the benefits that AF systems may offer such as ensuring habitat for plants and animals, buffering microclimates, storing carbon, modulating water flows, providing food to people and increasing their income.

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Do agroforestry systems and landscape features of non-production function influence the temperature regime in the landscape? Case study Šardice (South Moravia, Czech Republic) – preliminary results.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: agroforestry, temperature regime, microclimate, climate adaptation and mitigation

Abstract

This study aims to describe basic trends in temperature regimes in degraded landscape of the Kyjovsko region (South Moravia, Czech Republic). This region encompasses mostly very fertile soils (Chernozems, with very thick organic chernic horizon), which are however very often eroded (eroded Chernozems). This phenomenon is mainly due to merging of field blocks together during collectivization, which was the agricultural politicy in the period after the World War II. The resulting fields of as much as hundreds of ha have remained until present days. Such landscape is (aside from erosion hazard) of near-desert nature, especially in very hot and dry seasons, which happened in the last two years. The non-productive landscape features and agroforestry systems have been established in the area to eliminate such negative effects.

To study the effectiveness of these measures, two study plots were established at two localities near the Šardice village and named after their owners/founders: The "Marada Plot" (12 ha)comprises non-production landscape features enhancing biodiversity and acting as a protection against erosion and a climate mitigation measure. The "Dumbrovsky Plot" (73 ha) consists of strips of woody vegetation (orchards) with agricultural intercrop (peas, lucerne), i.e. a productive system with expected important environmental benefits (agroforestry).

At each of the plots, sensors for temperature and soil moisture monitoring were installed (TMS, see: https://tomst.com/web/en/systems/tms/). The TMS sensors once installed in the soil, collect 3x temperature (in 20-cm depth, on the soil surface, and 10 cm above the soil surface). Measurement of soil moisture is based on electro-conductivity and gives dimensionless number, which is a subject for calibration (Wild et al. 2019). At the "Marada Plot", the TMS dataloggers were placed along a transect, from the conventional arable land (peas), through the "biobelt" (a belt of mixture of various grass species), to the "biocentre" (non-productive grassland with woody (shrub) vegetation). A fourth datalogger is situated at a hedgerow, right in the heart of "biocentre". At the "Dumbrovsky Plot", TMS datallogers are set up at a similar pattern – arable field (peas) and orchard (mostly plums)". Together it is 6 sensors, collecting data every 15 minutes starting from 31.7.2019. In this study, a period of 2 months (VIII-IX) was analysed in more detail.

Because of a limited number of thermometers, both areas were flown over on 4.9.2019 by an unmanned aerial vehicle (UAV), "a drone" type Trinity F9, equipped with RGB and multispectral cameras. The spectral

bands: red, green, blue, red-edge, near-infra red, LWR (thermal); spatial resolution: first 5 bands max. 9,13 cm, LWR: max. 117,8 cm; flight altitude 190 m. Further technical parameters of MicaSense Altum camera – see https://www.micasense.com/altum. After georeferencing of the images, the data processing resulted in the thermal map of both study plots (in °C) and layer of NDVI (Normalized Difference Vegetation Index). The former enabled to assess trends in temperatures at the landscape level within defined vegetation classes (described above). For each class the subarea of app. constant size was delimited and basic statistics were calculated.

The results obtained from dataloggers show significant decreasing trend in soil surface temperature along the transect of arable field (barley) – biobelt – biocentre during the whole monitoring period (the average difference between field and biocentre is app. 2,5 °C). Values of biobelts shifted during the time, being near to those of arable field in August and decreasing toward those of biocentre during September. This points at the significant role of trees and woody vegetation in landscape (which are only in biocentre). The temperature values read from dataloggers during the UAV flight match well with the temperatures derived from the appropriate pixel (R^2=0,85). It is a good relationship, despite the exact point character of dataloggers values and values averaged within 1m^2 pixel of UAV thermal band. Basic statistics computed for particular subplots on 4.9.2019 within flight period are: mean 22,9 °C (± SD1,9) for arable field, 21,1 (± 2,3) for biobelt and 18,7 (± 2,5) for biocentre. Naturally, the biocentre itself and buffer of biobelt show much higher NDVI values than the surrounding conventional fields.

The conditions at the Dumbrovsky Plot are more heterogeneous. Based on photointerpretation of RGB, thermal and NDVI layers one can conclude that the presence of (more) vegetation cover (including dense agricultural crop!) lowers the surface temperature. Also, the temperatures 10 cm above ground surface correlate better here with the thermal band of UAV than the temperatures from the ground surface itself. Further, the strong negative correlation between temperatures (derived from camera) and NDVI (R^2= - 0,85) suggests the important role of vegetation in this respect. The second key factor is the organic matter content in case the naked soil emerges at places that are temporarily without vegetation cover. The values of surface temperatures between the variants (arable field – peas and orchards) do not differ in such an extent as at the Marada Plot (28,1 °C ± 2,2 and 28,3 °C ± 1,7, respectively). This is probably due to more complex conditions and factors as suggested above based on the fact, that the Dumbrovsky Plot is a productive agroforestry system in essence and hereby managed. However, the average temperatures during the whole summer period were in every moment equal or (more often) lower in orchards than in the open areas.

Despite its limitations, this preliminary study show importance of tree vegetation in thermal regime of landscape. The standard explanation is that trees creates specific microclimate (Kanzler et al. 2019; Quinkenstein et al. 2009) and transform the solar energy into the process of photosynthesis and (evapo)transpiration with parallel cooling effect (Ellison et al. 2017). This is a good presumption together with carbon sequestration potential to be efficient tool in climate adaptation and mitigation. The limits of this study are the number of sensors (in fact without any replications) and only one single UAV image. We plan to deal with these disadvantages in the next year (2020) by installing more datallogers (also in deeper soil horizons and in the air) and by obtaining time series of UAV images during the season. We will also focus on integrated assessment of the temperature and humidity regimes.

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Life cycle analysis in a comparative study according to the size of extensive sheep farms in dehesas agroforestry systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Keywords: sheep farms, extensive management; carbon footprint; life cycle assessment; carbon sequestration; dehesa.

Abstract

Reducing greenhouse gas emissions and climate change represent one of the greatest global environmental challenges. The livestock sector contributes significantly to global GHG emissions (12% of GHG emissions (Havlík et al. 2014), but it can also help mitigate them. Therefore, the implementation of mitigation strategies by livestock is of vital importance (Gerber et al. 2013). Livestock is the only sector that emits low CO2 compared to other greenhouse gases such as N2O and CH4, which are the main responsible of global warming. This is a difference compared to other agricultural sectors. In addition, livestock production based on grazing have sink capacity, so it is also the only sector that emits GHGs and fixes CO2 (Domingo et al. 2013).

An example of proper ecosystem management is the pastureland of south-western Spain, characterized by semi-arid and often marginal conditions, poor soils and consequently low and irregular rainfall, adequate management of the stocking density that reduces animal pressure on the soil is crucial for soil conservation. The basis of this management are grazing systems, important resources for feeding small ruminants, especially in areas where grasslands are part of the landscape and provide natural resources (Hörtenhuber et al. 2010). These grasslands can act as a carbon sink of approximately 1 tonne of kg CO2eq/ha/year (Janssens et al. 2004). For that reason, it is not only important to calculate GHGs from agricultural systems, it has also to be considered the carbon sequestration capacity of soil resulting from the carbon contribution of crop residues or manure (Batalla et al. 2015).

This study is based on the analysis of twelve sheep-for-meat farms in extensive conditions. The farms are located in pasturelands of the region of Extremadura (SW Iberian Peninsula). Most of the feeding resources used for sheep breeders is based on the use of natural pastures. In addition, the twelve farms have been classified into three categories according to the size of the farm: measured in ha of pasture; thus 5 farms have less than 150 ha of pasture; 4 farms occupy a range of 150 and 350 ha and 3 farms have an area of more than 350 ha.

Among the various methodologies available to estimate the GHG emissions, Life Cycle Assessment (LCA) is an internationally accepted, standardised method used to identify and quantify the environmental impact of a product (Buratti et al. 2017), and it has therefore been selected for this piece of research. The carbon footprint (CF) has been calculated according to the 2006 IPCC guidelines for national GHG inventories (IPCC 2006).

In this work, the functional unit (FU) is the reference unit with which all the produced emissions of the system will be associated. In sheep meat systems, the defined FU is the kilogram of live weight of the product, i.e. the kilogram of live weight of lambs. Table 1 shows the results obtained when calculating GHG emissions, carbon sequestration and the total compensated footprint. The total CF of sheep-for-meat farms ranges from 13.89 and 15.86 kg CO2eq/FU. The amount of carbon sequestered per year

ranges from 216.52 to 369.78 kg CO2eq/ha. In the analysis of agricultural inputs, medium-sized farms emit the most GHGs (26.71%), then the largest (25.41%) and finally the smallest (19.50%). In this study these emissions ranged from 18.28% in the largest farms to 24.05% in medium farms. In addition, the results of this work show that enteric fermentation is responsible for most of the emissions in the analyzed sheep farms, followed by animal feed. Other emissions have less influence. To conclude, the results (table 1) reflect that the pasture system has the capacity to act as carbon sinks through pastures, organic fertilizers and animal grazing (urine and manure). It is therefore important to include soil carbon sequestration in LCA because it has the capacity to mitigate emissions and reduce CF.

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	>150 ha		150-350		>350		Total	
GHG Emissions	**kg CO_2eq/kg product**	**%**	**kg CO_2eq/kg product**	**%**	**kg CO_2eq/kg product**	**%**	**kg CO_2eq/kg product**	**%**
Enteric fermentation CH_4	9,92	65,35	8,31	59,83	9,67	60,97	9,32	62,55
Total manure management	0,82	5,40	0,64	4,61	0,73	4,60	0,74	4,97
Total soil management	1,45	9,55	1,22	8,78	1,42	8,95	1,37	9,19
Total On-Farm Emissions	12,20	80,37	10,17	73,22	11,81	74,46	11,43	76,71
Total Feeding	2,90	19,10	3,34	24,05	2,90	18,28	3,05	20,47
Total fertilisers	-	-	0,19	0,37	0,66	4,16	0,23	1,54
Total seeds	-	-	0,05	0,36	0,05	0,32	0,03	0,20
Electricity	-	-	-	0,00	0,003	0,02	0,001	0,01
Total Fuel	0,06	0,40	0,13	0,94	0,41	2,59	0,17	1,14
Total Off-farm Emissions	2,96	19,50	3,71	26,71	4,03	25,41	3,48	23,26
TOTAL CF kg CO_2eq/FU	15,18	100	13,89	100	15,86	100	14.90	100
Total Kg CO_2eq/ ha	1140,52	-	975,86	-	1045,63	-	1061,91	-
CO_2 stored	**>150 ha**		**150-350**		**>350**		**Total**	
Total Kg CO_2eq pasture	194834,07		360755,08		1094956,55		475171,69	
Total kg CO_2eq manure-soil[a]	25444,87		55285,89		112942,39		57266,26	
Total kg CO_2eq manure-soil/ha	413,81		287,31		302,97		343,93	
Total kg CO_2eq/ha	3697,78		2165,15		2848,46		2974,57	
Total CO_2 sequestration (kg CO_2eq ha/year)[b]	369,78		216,52		284,85		297,46	
Total CO_2 sequestration (kg CO_2eq FU/year)[b]	5,83		3,95		6,71		5,42	

[a] The conversion factor for N to C is 13/4 and 44/12 for C to CO2

[b] Annual C sequestration of 10% is considered

Figure 1. Technical indicators, GHG emissions per FU and Carbon sequestration (kg CO2eq/year) of the studied farms. (from: prepared by the authors)

Shading effect on crop yields in intercropped systems of walnut and agricultural crops

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: buckwheat, tree canopy, solar radiation, yield, wheat

Abstract

Introduction

More frequent decision of farmers to switch from crop production to fruit production (such as walnuts), brought out the question: can we still grow crops within the alleys while waiting for fruit yields? And what would be the shading effect from walnut canopy on crop yields? Although we can expect lower crop yields several ecological beneficial aspects can be observed by intercropping in walnut orchards. Combining permanent woody species with agricultural crops can positively influence the microclimate conditions, which can improve the plant resistance to stress conditions such as more recent climatic extremes (drought, flooding), better use of the production area, positive influence on soil fertility, diversity of production in one vegetation, protection against plant disease, pests and weeds, better use of nutrients and water in soil as well as increased biodiversity (Quinkenstein et al., 2009). The aim of the research is to investigate the shading effect in intercropped systems of walnut orchard and agricultural crops and its effect on crop yields.

Materials and methods

The field trial was set up in eastern Croatia (city of Đakovo) in an 11-yr old walnut orchard where walnut alleys are 8 meter wide. The field trial consisted of three plots - control plot of wheat without walnuts, walnut orchards with intercropped wheat and a walnut orchard without intercropped wheat. Within the alleys a 6m strip was sown with winter wheat in October 2017 and buckwheat in end of May 2019. During the vegetation period during 2018 and 2019 climatic conditions were observed on a stationary meteorological station (temperature, humidity, precipitation, solar radiation, wind speed and direction) at the same time on several occasion (November 2018, April 2019, June 2019, July 2019, September 2019, November 2019) the solar radiation was measured in canopy shade and direct sunlight (middle of the alley) during the clear days without clouds. Crop yields were determined at the harvest (wheat beginning of July 2018 and buckwheat beginning of September 2019).

Results and discussion

There is a significant difference in solar radiation throughout a vegetation period, in canopy shade as well as in direct sunlight. In direct sunlight, middle of the row, the highest solar radiation was measured during the summer months (June and July) when the solar radiation was in range of 100000 - 120000lux on a clear day. In canopy shade highest solar radiation was measured during the month without the leaf (November) when solar radiation was in range of 17000 – 42000 lux. In relative numbers, in November, 85% of solar radiation passes through the canopy, In April 30%, in October 20% and in summer months (June and July) in range of 6 – 8 %. Although only 6% of solar radiation passes through the canopy shade it is still amount of light that is above minimum requirement for wheat. Furthermore by

that time (June), winter crop such as winter wheat is already fully developed and need for light is not of such importance anymore and the shade reduces evapotranspiration during these humid months. On the other hand, buckwheat at that time (June and July) is in its development stage. Buckwheat vegetation is around three months, so from June till September.

The yield results of both crops (winter wheat and buckwheat) have shown statistically lower yields in intercropped orchard compared to control plot. However, the winter wheat, whose vegetation period does not overlap with the walnut vegetation period, had only 11% reduction in yield while buckwheat whose vegetation was overlapping with walnut had 28% yield reduction in intercropped walnut orchard. Such findings confirm the importance of light (Dufour et al., 2013; Talbot et al. 2014). Although, the yields are statistically lower, the reduction in yields is not that severe and further investigation of other parameters that might be influencing crop yields is necessary.

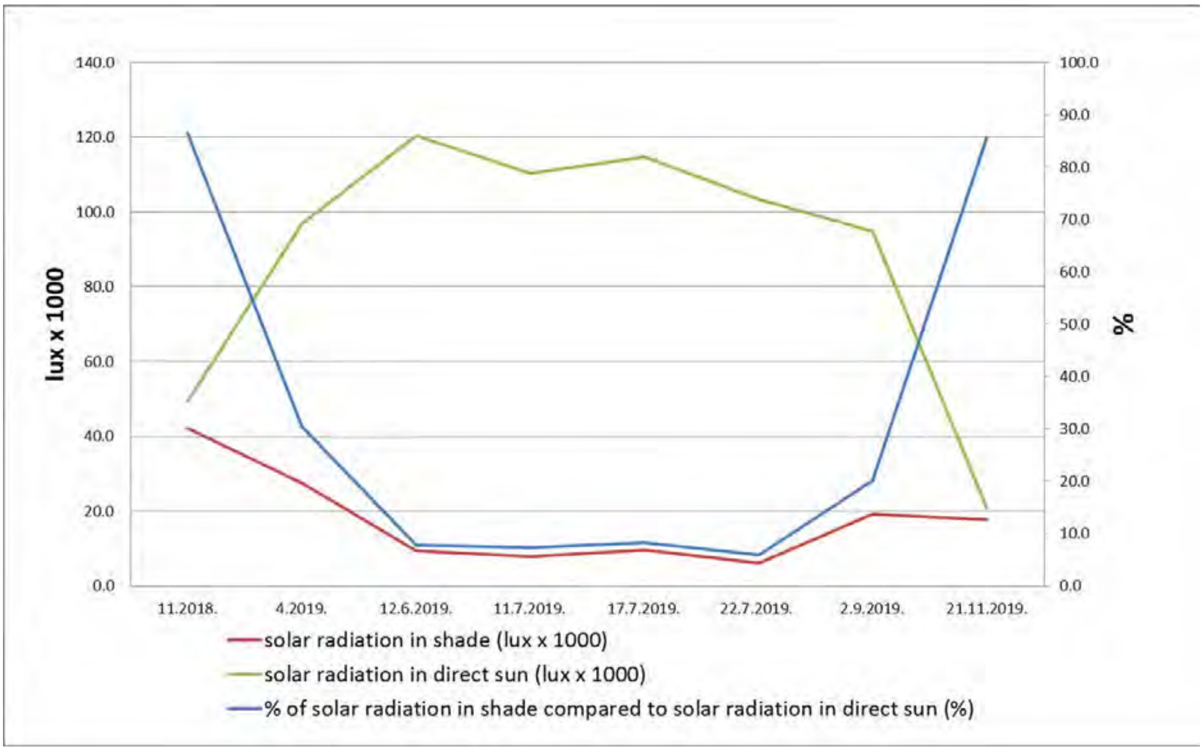

Figure 1. Solar radiation in walnut orchard

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Biochar and new forest plantations: winning combination for soil Carbon preservation and sequestration.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Arboricolture, poplar, MSA clones, Biochar, sustainability

Abstract

Thanks to Rural Development Programme (RDP) of Veneto Region in Italy an Operational Group was created to increase the plantations with poplar trees and other species on agricultural soils and to increase the level of carbon in the soil. In fact, the sub-Measure 16.2 play a role mainly in the agriculture and forestry sectors improving their competitiveness and their impact on environment and climate change, particularly on the Focus Area 5E "Fostering Carbon conservation and sequestration in agriculture and forestry".

In Italy forest plantations with poplars decreased from about 150,000 hectares in the Seventies to 46,000 in the 2017. This amount is 50% ca of total area of wood arboriculture, but it represents almost the total production of Italian industrial wood coming from arboriculture, equal to one third from the domestic forest utilisation. Specialized poplar cultivation is concentrated in the Northern plains of Italy. The demand of poplar roundwood by Italian industry are mainly associated with panel sector, particularly plywood (Castro et al. 2014). Versus an annual demand of poplar wood more than two million cubic meters, the internal supply does not reach one million. This deficit, inducing remarkable import of round and semi-processed wood from other European countries, could be filled by an increase of Italian poplar cultivation till about 115,000 hectares. In recent years poplar clones with improved environmental sustainability - so called "MSA" clones - are available for the cultivation and farmers can take advantage of PSR contributions for the plantation if they include a percentage of "MSA" clones.

Soils contain large quantities of Carbon: Earth's soils contain around 2,500 gigatonnes (Gt) of Carbon, four times more than vegetation (Kane, 2014). Through soil degradation, much of the natural soil Carbon stocks have been lost. It has been estimated that the Carbon sink capacity of the world's agricultural and degraded soils is 50 to 60% of the historical Carbon loss namely 42 to 78 Gt of Carbon (Lugato et al. 2015). Among the recommended management practices, soil organic carbon (SOC) sequestration had been considered a win–win strategy for mitigating climate change while sustaining food productivity through sustainable organic matter management (Paustian et al. 2016; Tubiello et al. 2015). Biochar was produced upon pyrolysis (Hamedani et al. 2019) of organic residues produced in agriculture (Colantoni et al., 2016) and had been recommended for enhancing stable organic carbon storage with various ecosystem benefits (Lehmann and Joseph 2015). Some field studies also indicated that there was no simulative effect

of biochar on soil respiration (Liu, Zheng et al. 2016). Given these, biochar amendment has been regarded as a hopeful measure to mitigate climate change contributed by its favorable ability in SOC sequestration and N2O emission reduction effects under soil amendment (Sohi et al. 2009; Woolf et al. 2010).

The Operational Group consists of a Lead (Confagricoltura Veneto - a confederation of farmers), 13 farms, 3 research institutions (CREA, University of Tuscia, CNR) and the Italian body of the certification system Programme for Endorsement of Forest Certification schemes (PEFC-Italia).

The object of the activity is to realize new plantation with poplar using a higher percentage of "MSA" clones than that required by the RDP, to plant new agroforestry systems with poplar and/or other species and to use of wood from pruning to produce biochar and the use of biochar as an organic fertilizer in the soil. Ten farms will plant 64 hectares of poplar plantation with 15 % of "MSA" clones, other three will realize 18 hectares with agroforestry systems with poplar or/and other species with medium-long rotation.

A prototype of a mobile furnace for biochar production will be designed and built, aiming at a low energy input production process and minimizing its negative externalities. The effects of the biochar introduced into the soil on the contribution of Carbon sink balance and the economic evaluation of the production process will be assessed. Soil Carbon sequestration and the Carbon balance of cultivations will be calculated, particularly on "MSA" poplar clones; the Carbon sequestration of poplar will be related to the water use to identify the best clones. The effects of the project will be assessed through an economic evaluation of the plantations with MSA clones, also applying sustainable management techniques.

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Organic carbon in the soil of agroforestry system, Atlantic forest remnant and other land use systems

EURAF 2020

Agroforestry for the transition towards sustainability and bioeconomy

Abstract

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Theme: Climate change (adaptation and mitigation)

Keywords: climate change, carbon sequestration, tropical soils, Atlantic forest

Abstract

The integration of trees, shrubs, crops and animals in a single area, simultaneous or sequentially as in Agroforestry systems (AFS) can aggregate factors and resources in the area to optimize production, economic, social, cultural and environmental values as an alternative to a sustainable model of land use and management (SILVEIRA, 2005). Soil quality represents its ability to sustain biological activity and species growth (DORAN & PARKIN, 1994). Organic matter is used as a source of energy by soil microorganisms, as well as being part of nutrient cycling, aggregate formation and stabilization, density reduction and cation exchange increase (ALTIERI, 2002). The soil organic matter properties are very important as a source of energy for the microbial mass and nutrients for plants. In tropical and subtropical soils, organic matter is helpful in fertility, increasing cation exchange capacity and improving chemical, physical and biological characteristics, and maintaining sustainability. Therefore, management practices that conserve and increase organic matter contents are fundamental to improve soil qualityas well as its productive potential. In natural ecosystems the source of organic carbon in the soil originates from native vegetation residues, while in agricultural systems most of the soil carbon comes from native vegetation and the decomposition of plant residues from introduced crops (BERNOUX et al. 1999). AFS are efficient systems of production for soil preservation and recovery since they have tree and shrub species that contribute to the increase of soil organic matter and environmental gains, contribute to erosion control with intense and stratified ground cover. So AFS can be considered as one of the most sustainable land use systems when compared to other systems such as monoculture, pasture or short cycle agriculture. Anthropogenic soil changes can have positive or negative impacts, improving their condition oraccelerating their degradation, depending on soil and vegetation management in the area (PORTUGAL et al., 2010). In the present work, different land use systems such as AFS, pasture, reforestation and regeneration area wereevaluated and compared to a tropical native forest remnant in Pindorama-SP, Brazil to verify total organic carbon (TOC) and soil organic matter contents of the areas. Nine years after the implementation of the agroforestry system, the study of the area's soil is important sowe can evaluate how this system contributed to its improvement compared to other land use systems. The studied area is located in the city of Pindorama, State of São Paulo,Brazil, APTA REGIONAL - Centro Norte. The soil is predominantly composed of sandstones and classified as medium / abrupt sandy texture Ultisol (ABDO et al., 2012), According to the Köppen classification, the climate of the AREA is humid tropical with rainy season in summer and dry in winter, average annual precipitation 1258 mm, average temperature summer is 23.8 ° C and winter is 19.3 ° C, the native vegetation of the area is representativeof the Atlantic Forest biome, semideciduous seasonal tropical broadleaved forest (ABDO et al., 2012). The AFS was planted as a revegetation plan in 2011 after a stabilization process of a gully erosion. The treatments were different implantation management on soil turnover and weed control in four pounds edge with 28 native tropical forest species planted with 3 productive species. The pioneer species were: *Guazuma crinita, Joannesia princeps, Anadenanthera macrocarpa, Psidium acutangulum, Schinus terebinthifolia, Myrrciaria dubia, Peltrophorum dubium, Mabea fistulifera, Croton floribundus, Cecropia pachystachya, Albizia haslerrii, Guajava pynifera, Inga edulis, Inga laurina, Syzygium malaccense, Jaracatia spinosa,*

Dilodendron bipinnarum, Acacia polyphylla, Ceiba Samauma, Chorisia glaziovii, Gallesia integrifolia, Caesalpinia ferrea, Triplaris americana, Rapanea guianesis The climax species planted were: *Gustavia augusta, Hymenaea courbaril, Cariniana legalis, Casearia gossypiosperma, Tabebuia heptaphylla, Cariniana estrellensis*. The productive species were:(*Malpighia emarginata*), rubber tree (*Hevea brasiliensis*) and annatto (*Bixa Orellana*). The treatments with 4 repetitions each were identified by the soil management and weed control: AFS1: weed control using a brushcutter, 3m x 2 m spacing between tree rows, no plantation between rows and without no soil turnover; AFS2: weed chemical control, 3.5m x 2m spacing between rows, maize cultivation between rows under no tillage management; AFS3: control of weeds with plow and harrow, use of furrows for furrowing, 3.5m x 2m spacing between trees rows, maize planting under conventional system; AFS4: control of weeds with plow and harrow, furrows for furrowing, 3.5m x 2 m spacing between trees rows, no culture plantation between trees(ABDO et al. 2012). For this work soil samples were collected in seven different land use, the following treatments wereconsidered according to land use in the area: Treatment 1- AFS 1; Treatment 2- AFS 2; Treatment 3- AFS3 i; Treatment 4- AFS4; Treatment 5-Regeneration in isolated area for 21 years; 6-Pasture area for over 20 years; Treatment7- Reforestation implanted (21 years) and Treatment 8- Native forest. For the evaluations two soil depths were considered: 0-20cm and 20-40cm. For each soil depth of each of the 8 treatments, 4 replications were collected. The results of soil analysis can be seen in table 1

Table 1: Total Organic Carbon (TOC), Organic matter (OM) pH, phosphorus (P)and V% in two depths:

0-20 cm depth						**20-40 cm depth**				
Variance analysis	**TOC**	**OM**	**Ph**	**P**	**V%**	**TOC**	**OM**	**Ph**	**P**	**V%**
DF Res	24	24	24	24	24	24	24	24	24	24
F treatment	2.95 *	2.95 *	5.25 **	1.36	7.18**	2.95*	2.95 *	5,25 **	1.36	7.18**
General mean	11.22	19.28	5.09	6.53	61.37	1.22	19.28	5,09	6.53	61.37
S D	4.62	7.94	0.42	2.68	9.43	4.62	7.94	0,42	2.68	9.43
MSD (5%)	10.82	18.61	0.99	6.27	22.08	10.82	18.61	0,99	6.27	22.08
VC (%)	41.20	41.20	8.29	40.96	15.36	41.20	41.20	8,29	40.96	15.36
Atlantic Forest	14.10 ab	24.25 ab	5.75 ab	7.00 a	78.55a	4.10 ab	24.25 ab	5.75 ab	7.00 a	78.55a
Regeneration	19.22 a	33.00 a	5.03 abc	7.75 a	50.93 b	19.22 a	33.00 a	5.03 abc	7.75 a	50.93 b
Pasture	11.75 ab	20.25 ab	5.23 abc	8.25 a	67.40 ab	11.75 ab	20.25 ab	5.23 abc	8.25 a	67.40 ab
Reforestation	8.45 ab	14.50 ab	4.93 abc	4.75 a	59.50 ab	8.45 ab	14.50 ab	4.93 abc	4.75 a	59.50 ab
AFS 1	10.48 ab	18.00 ab	4.65 c	8.25 a	48.15 b	10.48 ab	18.00 ab	4.65 c	8.25 a	48.15 b
AFS 2	10.33 ab	17.75 ab	5.83 a	6.50 a	80.05 a	10.33 ab	17.75 ab	5.83 a	6.50 a	80.05 a
AFS 3	6.28 b	10.75 b	4.83 bc	4.25 a	55.85 b	6.28 b	10.75 b	4.83 bc	4.25 a	55.85 b
AFS 4	9.15 ab	15.75 ab	4.50 c	5.50 a	50.53 b	9.15 ab	15.75 ab	4.50 c	5.50 a	50.53 b

Level of significancy **1% * 5%

The agroforestry system can be used to recover degraded areas soils and in the evaluated area, under conservative management (AFS 1 and AFS 2 recovered soil organic matter and showed carbon contents similar to native Atlantic Forest remnants in 0-20 cm and 20-40 depth. The AFS management that revolved the soil(AFS3) presented lower values of carbon in soil after nine years. The regeneration area had higher values for carbon probably due to humidity that preserved the organic matter and did nor decompose it compared to other treatments.

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Carbon sequestration in agroforestry system under different managements.

EURAF 2020

Agroforestry for the transition towards sustainability and bioeconomy

Abstract

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Theme: Climate change (adaptation and mitigation)

Keywords: climate change, carbon sequestration, tropical soils, Atlantic forest

Abstract

An agroforestry system (AFS) intercropping native tropical forest species with rubber tree *(Hevea brasiliensis*) and annatto (*Bixa orellana)* was planted after a gully erosion process stabilization in order to restore the vegetation, promote biodiversity and sustainability. The area also received a maize plantation interlines in the first years and what expected was that combining tree species and crops in the area would increase biodiversity, contribute to soil nutrient recycling, and restore essential functions for sustainability and also provide farmers with additional income and livelihoods. This area has been evaluated since its plantation in 2011. This work measured carbon sequestration by the trees from the agroforestry system, which was planted in the Regional APTA (São Paulo State Agribusiness Agency), Pindorama-SP, Brazil. To stablish a gully erosion process four dams were built to reduce the water flow in the area which resulted in the formation of four uneven reservoirs. The experiment was installed in 2011 on the banks of the four dams with the AFS implantation adopting different management starting from the lowest interference in the soil (Dam 1- T1) and ending with a very intensive cultivation, without vegetation protection (Dam 4- T4) according to figure 1 below:

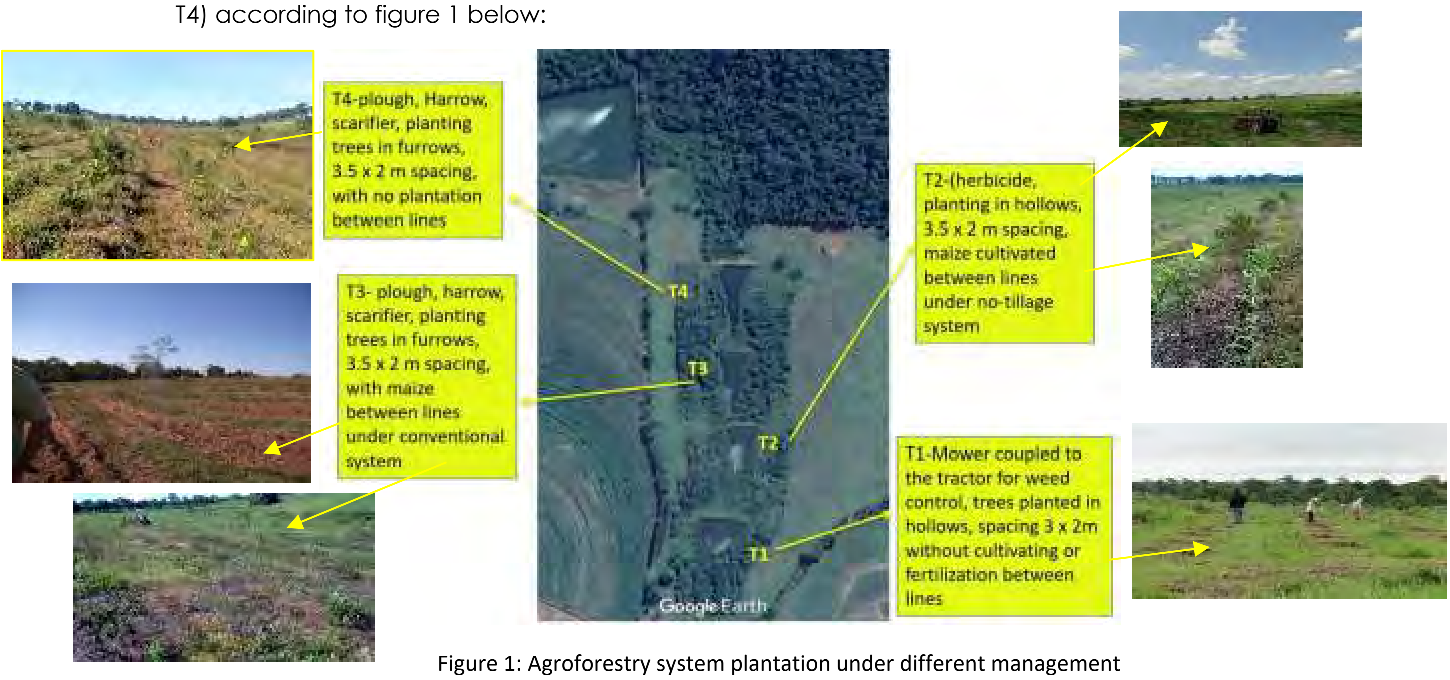

Figure 1: Agroforestry system plantation under different management

The agroforestry system was composed by 32 plots , 8 plot in each weir (4 plots in the right side an 4 the left side). Each plot had 10 lines with 28 plants from 33 native species (24 pioneer species and 6 climax species) planted in lines alternating three commercial species: Acerola (Malpighia emarginata L.), rubber tree (*Hevea brasiliensis* Muell. Arg) and annatto (*Bixa orellana* L.). The distance between lines was 3.5 m and between plants 2.5m. In T1 and T2 maize was planted in the first year. The hypothesis raised was if different management interfered on trees growth and so in trees carbon sequestration. Trees from left side of the weirs, 4 plots per treatment evaluated were inventoried from 2015 to 2020 and carbon sequestration under different managements of the agroforestry system was determined. The trees were evaluated according to the height and breast height (CAP) The diameter at breast height (DBH) was calculated by the formula: DBH = CAP / 3.1416. Tree biomass was estimated by the indirect method developed by ICRAF (AREVALO et al., 2002) where it is carried out from an evaluation and applying the following methodology with results obtained in tons of carbon per hectare (TC / ha). To estimate the carbon stored in the biomass of all living trees, data from trees with DBH greater than 2.5 centimeters at breast height were considered. The results of carbon sequestration over the years of AFS are in Figure 2.

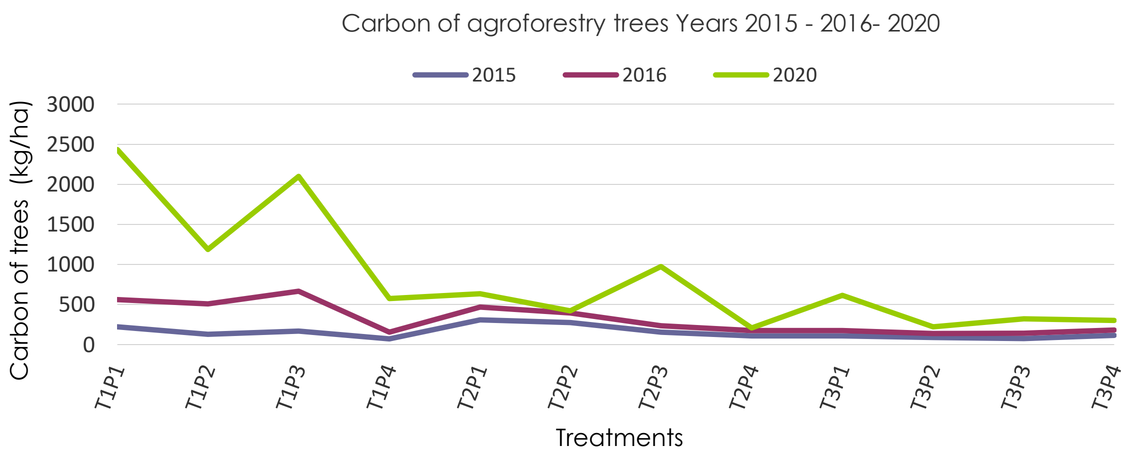

Figure 2 : Carbon sequestration by the trees of an Agroforestry under different managements (Years 2015-2016 and 2020) under different managements T1, T2, T3 and T4 (Plots 1,2,3 and 4)

Over the years the Treatment 1 was significantly the most efficient for tree carbon sequestration comparing to other managements. The growth of the trees increased from 2015 to 2020 in all treatments. In all years the agroforestry under management T1 had greater values of growth and was statistically different from others treatments.

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Endogenous silvicultural / fruit-growing agroforestry practices, food crops and reforestation around Togodo-sud National Park in Togo to fight against climate change

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Endogenous agroforestry, forestry, fruit plants, food crops, reforestation, climate change.

Abstract

In Togo, the association of agroforestry with food crops is poorly developed. Population growth, the need for cultivable land, timber and energy are often a source of intense anthropogenic pressure on national reserves and parks in sub-Saharan Africa. To spare the Togodo-Sud National Park (PNTS) located in the south-east of Togo from this scourge, the NGO " GASD / SADDA-Togo " lobbied to have the populations of the neighboring cantons retrocede to PNTS, 3000 ha of cultivable land. During the development of these lands by the farmers, the NGO sensitized the populations to opt for what it calls "Endogenous Sylvicultural and Fruit-growing Agroforestry Practice in association with Food Crops to promote Reforestation" (PAESF / CV / Ref). This practice consists in not shaving the new land during clearing but to keep some trees or introduce others to the point that they do not encroach on food crops. This study presents the results of ten years of implementation of the PAESF / CV / Ref by the operators of the canton of Tométy Kondji.

Survey and geospacialization of the operators and exploited surfaces, counting and taking of images of the preserved and / or planted species, were the study methods.
On a surface area of 33.0546 ha valued by a sample of 31 farmers, 58 forestry and fruit species have been identified in association with food crops. Corn, cassava, beans, yams and pigeon peas were the most important food crops grown in association with *Kahya gradifiliola* (Fig 1), *Ceiba patrenda* (Fig 2), *Agnogeisus leocarpus* (Fig 3), *Adansonia digitata* (Fig 4)), *Manguifera indica* (Fig 5) and *Citrus aurantium* (Fig 6). Brought back to 449.1844 ha of cultivated land by the 339 farmers in this canton, estimates indicate the preservation of 7882 plants by endogenous Agroforestry is (PAESF / CV / Ref) on going. These results prove that PAESF / CV / Ref is a reliable agroforestry method that can be tried everywhere else. This assessment is in the process of being extended to all the cultivated areas of the 3000 ha retroceded.

Figure 1: *Kahya grandifoliola* in farm of *Manihot glasiovii* farm

Figure 2: *Ceiba pentandra* in a farm of *Cajanus cajan*

Figure 3: *Agnoseisus leocarpus* at the boarder of a farm

Figure 4: *Adansonia digitate* in a farm

Figure 5 : *Mangifera indica* in a farm of *Abelmoschus esculentus*

Figure 6: *Citrus aurantium* with *Zea maize* and *Cajanus caian*

The role of shrub and tree encroachment in abandoned subalpine grasslands: a case study in Aosta Valley

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Climate change (adaptation and mitigation)

Keywords: Encroachment; Alps; abandoned pastures; decomposition; biogeochemical cycles; soil properties; FT-IR

Abstract

Shrub encroachment is a common phenomenon occurring at a considerable number of grasslands in the Alps, with both negative and positive consequences for ecosystem services (Tappeiner et al. 2003). In the last decades, socio-economic transformations in the Alps have led to the decline of livestock farming, and consequently to land abandonment, the main driver of shrub and tree colonization in montane and subalpine grasslands (Krauchi et al. 2000). Therefore, the monitoring of plant community modification in these habitats is of great interest for regional and national carbon inventories. However, many uncertainties exist about the best management practices to optimize the trade-off between socio-economical activities such as pastoralism, and climate natural solutions, such as carbon sequestration, in this mixed situation. Previous studies highlighted a slowdown of the biogeochemical cycles (Urbina et al. 2019) in encroached areas. At the same time, the impact on Net Ecosystem Production (NEP) is complex and not universally uniform (Eldridge 2011), with some studies reporting decrease, yet other increase, of the carbon sequestration potential. Shrub encroachment has been traditionally associated with ecosystem degradation, mainly because it has been referred to a reduction of the pastoral value. Nevertheless, deeper investigations are needed to explore the role of woody species invasion into grasslands in view of its contribution to climate change mitigation and resilience to climate variability. In this study, we use a combination of experimental and remote sensing-based approaches to estimate the rate of shrub and tree encroachment, and its impacts on the ecosystem functioning of a subalpine pasture following abandonment. The study site (Fig. 1) is an abandoned pasture located at 2100 m asl in the Aosta Valley occupied by a species-rich Nardus grassland, a priority habitat (6230) listed in the Habitat Directive (92/43/CEE). With this project we aim at answering the following questions: (1) What is the rate of shrub and tree encroachment in the grassland after grazing exclusion? (2) What is the spatial pattern of the encroachment? (3) Which are the consequences of this process on ecosystem processes, such as soil nutrient composition, decomposition rate and ecosystem respiration.

1

To address questions 1 and 2 we carried out vegetation surveys in the field during 2015 and 2018. Moreover, since 2012, aerial images of the area have been acquired by drone. To answer the last question we monitored soil temperature and investigated decomposition rate trough litterbags, we

measured, C stock, available N and P, microbial C and N, Dissolved Organic Nitrogen (DON) and Carbon (DOC). Finally, variations in the ecosystem CO2 fluxes were evaluated by means of the eddy covariance data available since 2008 (Galvagno et al. 2013).

Our results showed an increase of shrub and tree cover over grassland area (Figure 1) of 6.5% from 2012 to 2018, whereas 6.7% of the colonised area already observed in 2012 remained constant. These results led to a general increase of shrub and tree cover of 13.2% in ten years, from land abandonment in 2008 to 2018 (Oddi et al. in preparation). In the encroached area, a higher decomposition rate was observed compared to the grassland, mainly due to microclimatic conditions occurring under shrubs. Finally, we observed a progressive reduction in CO2 exchanges between the ecosystem and the atmosphere, both in term of net CO2 uptake and respiration revealing a change in the functioning of this ecosystem. However, further investigations are needed to disentangle the impact of climate extremes compared to encroachment in determining this contraction of CO2 fluxes. We hypothesize that the abandonment of the grazing activity opened the way to the progress of woody species, but that the velocity of this process may have been influenced by climate extremes, which could lead to unfavourable conditions for grass species but well tolerated by the more xeric Juniperus communis, Larix decidua.

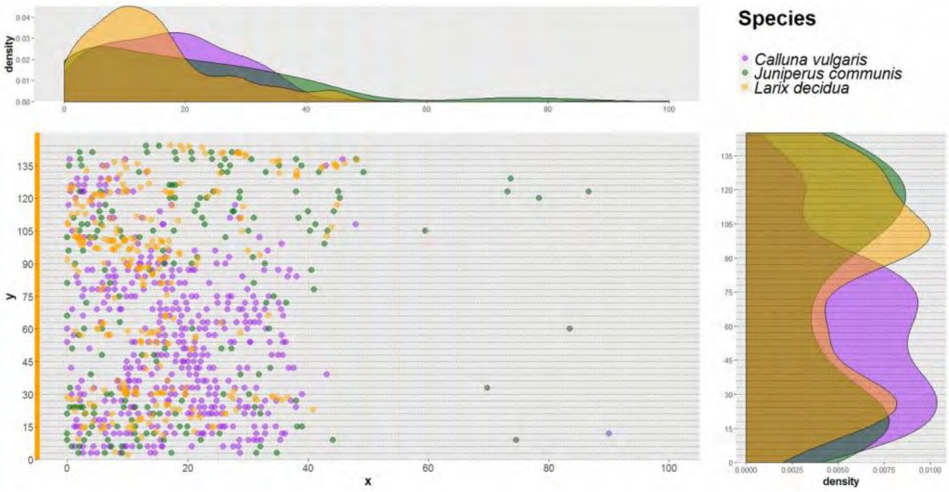

Figure 1. Distribution pattern of shrub and tree species into the grassland area. The dots represent the observed plants during the field survey (2015), the x and y axis represent the longitudinal and latitudinal directions (meters).

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Climate protection and production of biomass through agroforestry in Germany

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation); Policy

Keywords: Climate change, Policy, Climate protection, biomass, Foundation

Abstract

Agroforestry integrates trees into the agricultural area (arable / pasture land). The closer designed to nature, the more external regulation effort drops (industrial fertilizers, pesticides, energy, CO_2-emissions). Agroforestry landscapes are getting more attractive which leads to numerous ecological and economic advantages, such as

• Promotion of biodiversity through landscape structures, similar to a park with species both of forest and open land

• Climate protection through carbon binding in the tree trunks as well as through increasing humus rates (binding- and substitution-potential)
• Adaptation to climate change through wind brakes with moisture and soil protection
• Water protection through reception of nutrients by deep growing tree roots

• Stronger economic stability of farms through higher diversity of products
• Increasing yield up to 120 % of monoculture (in middle-Europe)
• Esthetic enhancement of landscape

But until now, the German federal states ("Bundesländer") do not co-finance the European grants for establishing agroforestry systems for the first time. Therefore, Germany stucks in an uncomfortable situation in relation to agroforestry. Unfortuately, everything is missing, like before starting the "German Energiewende" in former times.

Thus, in this project funded by the German Veolia Foundation
1. interested farmers are advised and accompanied free of charge establishing agroforestry (a long expression of interest list has been prioritized and is now being worked through)
2. first federal states are sensitized to this topic with the aim of activating the co-financing for existing EU funding
3. work on information and public relations is done.

Since starting in the middle of 2019, the advice German farmers ask for is increasing rapidly, of course starting at a low level. We hope that shortly Brandenburg in the north-eastern part of Germany will be the first federal state co-financing the EU-Funds. And we won`t rest until Germany`s agriculture adopt divers systems integrating trees.

Figure 1. New agroforestry system near Heidelberg, Germany (www.vrd-stiftung.org)

Mértola, Laboratory for the future – agroecological transition as a bottom-up response to climate change in Mediterranean semiarid conditions

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract

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Theme: Climate change (adaptation and mitigation)

Keywords: Agroecological transition, semiarid, local action, climate change

Abstract

Mértola is a municipality in the south-east of Alentejo (Portugal), with a semi-arid climate and a high vulnerability to desertification and climate change. In fact, it is a dry climate region (average of about 558mm per year in 2010, with fast decrease on the last decade and scenario of 288mm in 2100 (ClimaAdapt Project, data, for RCP8.5)), with high summer temperatures and one of the regions most affected by drought throughout Europe, an aspect severely aggravated by all climate scenarios. Under these conditions, it is not surprising that Mértola is among the regions in Europe most susceptible to desertification.

The vulnerability described above leads to severe limitations not only on agricultural activity, but also on other economic activities, such as tourism, affected by climate comfort, leading to high economic weakness that accelerates migration and depopulation. The population density is 4.8 hab/Km2 and the ageing rate is 376.5, making Mértola one of the most critical municipalities in terms of depopulation and limiting the capacity for innovation and search for alternative solutions.

This vicious circle of resource degradation and depopulation is difficult to counter. Physical limitations (climate and soil) condition the economy, but also the community's self-esteem and ability to change these extremely limiting situations.

However, despite all these limitations or perhaps because of its existence, Mértola is also a territory of resilience, creativity and social capital that needs to be capitalised, exponentially and monitored. It is possible to transform these weaknesses into strengths and make this territory a territory of experience for solutions. Mértola, as a semi-arid region, can be constituted as a "Laboratory of the Future" for climate change and for the agroecological transition in the food system.

The initiative to be presented as been launched by a local partnership, inspired by concepts as the “transition movement”, “regeneration by use” and “successional agroforestry”. It aims to foster the agroecological transition, in a logic of partnership between the local community and as a response that connects the food system and the local challenges of desertification, climate change and depopulation. This is an ambitious project, since it is broad in its objectives and activities, but is in this strategic diversity, which brings together different local actors already committed to the ongoing process, that the guarantee of success and resilience of the ongoing transition process is woven. The objectives of the project are:

- To encourage agroecological and regenerative practices (as successional agroforestry or syntropic farming) that counteract soil degradation (desertification) and promote adaptation to climate change;
- Raise community awareness of the need to change patterns of production and consumption;
- Contribute to the acquisition of innovative professional skills and appropriate to the extreme climate situation;
- Establish a pilot project, with potential for replication, at the level of food challenges, in situations of scarcity of resources, which can influence public policies;
- Support the settlement of young people through the regeneration of abandoned agricultural areas in order to provide a local agri-food system;
- Create a local food network based on direct collaborative relationships and short circuits.

The transitional project it's a bottom-up initiative, promoted by civil society, demonstrates that, even in the most unlikely places and with severe resource limitations (human, financial, biophysical), there are alternative solutions, where agroecological practices and the agriculture-forest-food trinomial, can be applied at the local scale, with replication capacity and with relevant socio-economic impacts.

Silvipastoral systems improving beef cattle welfare

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Ambience, beef cattle, crop-livestock-forestry systems, eucalyptus, BGHI, thermal comfort

Animal thermal comfort is influenced by the combined action of some environmental factors such as air temperature and humidity, wind speed and solar radiation, and it is an important factor for grazing cattle production in the tropics (Alves, Porfírio-da-Silva e Karvatte Jr et al., 2019). Under such conditions, the provision of natural shade is one of the cheapest and most effective ways to mitigate thermal stress. In fact, adding trees to pastures, under systematic arrangements (silvopastoral or forestry-livestock integration) enhances shade availability and improves animal welfare. One way to quantify and describe effects of the physical environment on animals is through thermal comfort indexes, such as the Black Globe Temperature and Humidity Index (BGHI), to allow an estimate of combined effects of radiant energy from the surrounding environment, air temperature and wind speed, being the most recommended for tropical conditions (Martello et al., 2004). Thus, goal of this work was to compare two production systems (silvopastoral and no-tree pasture) regarding cattle thermal comfort in Central Brazil. The trial was carried out at an Embrapa's Technological Reference Unit (TRU) in a commercial farm in Ribas do Rio Pardo-MS. Regarding the trial itself, both 4.01 ha plots used (silvopastoral and single pasture) have Piatã grass (*Brachiaria brizantha* cv. BRS Piatã). The silvopastoral system had single lines of eucalyptus planted at 28 m between rows and 2 m between trees in the row with eucalyptus (*Urograndis* (I 144)). Experimental design was randomized blocks, with two treatments and two repetitions. Experimental period was from January to March 2019. Readings were carried out daily and simultaneously in two paddocks, one for each system, throughout the whole experiment, from 00h00 to 23h00, in one-hour intervals. For data analysis, the following experimental periods were considered: dawn (00h00-05h00), morning (06h00-11h00), afternoon (12h00-17h00) and night (18h00-23h00) (GWM -04:00). For the microclimate characterization, black globe temperatures (Tbg, °C) and dew point temperatures (Tdp, °C), were recorded using a thermo-hygrometer with datalogger. In the silvopastoral system, readings were made at 2m from trees (A) and at the central of the paddock (B). In the plain pasture, reading point was at paddock center (C). In both treatments, equipment was set 1.5 m above ground level, in correspondence to center of mass of adult cattle. The Black Globe Temperature and Humidity Index (BGHI) was calculated using the Buffington (1981) equation. For classification of thermal stress risk, the National Weather Service (2012) scale was adopted, in which, BGHI up to 74, comfort situation; between 75 and 78, alert status; 79 to 84, danger; and above 84, critical situation. The data set was subject to statistical analysis, with means compared by the Tukey test at 5% probability, and results analyzed by the statistical package R (2018). Although silvopastoral systems are always associated to a greater degree of animal welfare, characteristics such as tree arrangement, density, species and height influence quantity and quality of shade available, and, as a consequence, the ability of thermal stress mitigation of such a system. Under conditions of this study, thermal comfort indexes presented different outcomes between the two systems evaluated for the periods considered. That is: danger and critical comfort, when the entire period was considered (Tables 1). Significant differences were found for Tbg (mean 24-hour variation of 28.9 ± 8.7 °C) and BGHI (mean 24-hour variation of 78.5 ± 9.5) depending on the experimental conditions (P > 0.001; Table 1). As expected, the largest mean variations were found during periods of higher incidence of solar radiation (morning and afternoon). However, significant interactions between

periods vs. systems revealed higher averages (Tgb = 37.7 ° C and BGHI = 88) during the afternoon, in the plain pasture system (B), followed by the silvopastoral system (2m from trees – A, and central of the paddock - B). These results demonstrate the importance of integrating trees and their ability to promote environmental changes in favor of animal welfare. Carvalho et al. (2011) also reported better climatic conditions in pastures with trees when compared to pastures without trees. Thus, the pasture without trees showed the highest level of thermal discomfort. The presence of trees, in sistematic arrangements, enhanced thermal comfort indexes. With tree growth, this effect tends to be more expressive. Provision of shade to animals kept on pastures is essential for mitigating thermal stress from climatic conditions at hot zones.

Table 01. Microclimate values, black globe temperature (Tbg) and Black Globe Temperature and Humidity Index (BGHI), considering 24 hours, from January to March, in two cattle grazing systems, with and without trees.

Periods	System	Points	Tbg (°C)	BGHI
Dawn	Silvopastoral	A	22,4de	71de
	Silvopastoral	B	22.8d	72cd
	Plain pasture	C	21.4e	70e
Morning	Silvopastoral	A	34.2b	85b
	Silvopastoral	B	34.0b	85b
	Plain pasture	C	34.7b	85b
Afternoon	Silvopastoral	A	34.8b	85b
	Silvopastoral	B	34.6b	85b
	Plain pasture	C	37.7a	88a
Night	Silvopastoral	A	24.2c	73c
	Silvopastoral	B	23.6cd	72cd
	Plain pasture	C	23.2cd	71cd

*Lowercase letters in the column do not differ statistically at the 5% probability level by t test. A - 2m from trees; B - central of the paddock; C – plain pasture.

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Vaginal temperature as a predictor of thermoregulation on Nellore heifers under agrosilvopastoral systems

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Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: adaptability, *Bos indicus,* thermoregulation

Abstract

Beef cattle production under grazing agrosilvopastoral systems able to provide improved animal welfare, especially regarding ambience/thermal comfort is very important in tropical areas. These systems help animals to achieve homoeothermic status, consequently improving performance and yields (Alves et al., 2019). There are several publications addressing the ability of trees to regulate microclimate on silvopastoral and agrosilvopastoral systems. However, the extent of local environment influence over animal behavior and performance is uncertain, since precise methods for such assessments under high complex systems are still incomplete. For instance, monitoring homoeothermic control on animals foresees “on-animal” readings of heartbeats, breathing and body temperature (Azevedo et al., 2005). However, grazing animals are scattered over open areas, with no daily management like feeding, making such readings rather challenging, add to it the usually less docile temperament of zebu breeds. Therefore, methods allowing easy capture of physiologic parameters would greatly help to establish a cause-effect relationship from climate-animal interactions. This would support establishing criteria for grading animals according to their ability to better adapt to heat or cold as well as help to propose novel animal thermal comfort indexes based on easier to obtain environmental and microclimate parameters. In this context, goal of this work was to evaluate easiness of capture for body temperature data through vaginal temperature from free ranging cows under full sun (CON) and under two agrosilvopastoral systems with 356 trees/ha (ASPS-1) and 227 trees/ha (ASPS-2). A trial was carried out over one year in an experimental area located at 20°27'S and 54°37'W and 530 m altitude, in Central-Brazil. We used 24 Nelore females with initial average age and live weight, of 16 months e 264.8 kg. Experimental design was random blocks in split-plots, where the parcels corresponded to type of production system; sub-parcel the season and the sub-sub-parcel time of the day. To characterize microclimate, we collected data on air temperature (Ta, °C) and black-globe temperature (BGT, °C), relative air humidity (RH, %) and we calculated Black Globe Temperature and Humidity Index (BGHI) following the method proposed by Karvatte Jr. et al. (2016). Vaginal temperature (Tvag) was read through button type thermos-recorders (ibutton, model DS1922L, Maxim Integrated TM®) with 17.35 mm circumference, 5.89 diameter and 3.3 g with a digital thermometer (reading resolution of 0.5°C within the range 30 to 70°C, having embodied real time clock (RTC); timer with ± 2 minutes and records in coated memory, all built into an adapted intravaginal device as proposed by Burdick et al. (2012). Before use, the intravaginal devices went through an asepsis protocol, intercalating periods soaking and rinsing every six hours for two days using (Extran®, Merck) detergent followed by autoclave sterilizing. Sampling frequency and temperature recording through the ibutton was predefined at one- hour intervals for 28 days in July (winter) and December (Summer) in 2015. When animals were handled for weighting, we implanted the ibuttom devices. After the sampling phase, the devices were extracted and data was downloaded for analysis using the software OneWireViewer. We observed no clinic inflammatory signs that could influence values obtained regarding vaginal temperature. Data were processed through regression analysis 9 PROC REG) using SAS®. Results showed that BGT was the climate variable that explained most of the Tvag. For each unit of increase in BGT, in

the range between 0 and 8°C, we observed and increase of 0.03°C in Tvag. For BGT between 9 and 25°C, increase on Tvag was 0.02°C and 0.01°C between 26 and 41°C for each unit of increase in BGT. The variables Tvag and BGT show similar patterns of variation throughout the day. However, there is a delay in the increase of Tvag in relation to BGT (Figure 01). We observed and increase on Tvag about two hours after the first record of BGT elevation in Winter, and, one hour in Summer. When we observe the maximum peak of BGT, Tvag response presented an even larger interval, with maximum values for Tvag found from two to four hours after the record of maximum BGT. This latency for Tvag to respond to environmental variation can be explained by the dependency on thermal gradient existing between animal and environment.

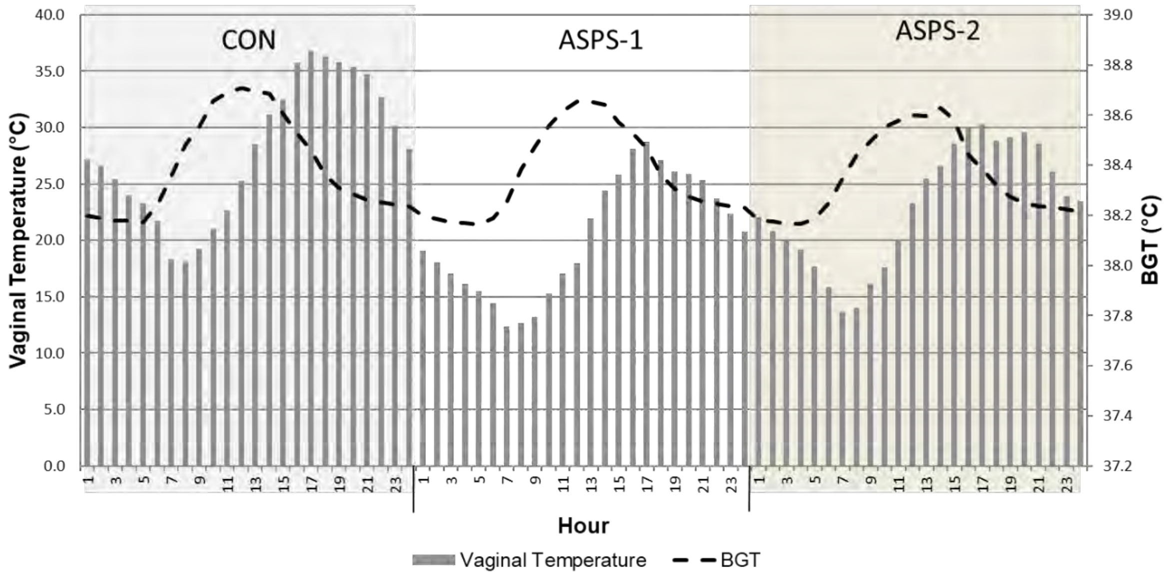

Figure 1. Average vaginal temperature in Nelore heifers and black globe temperature (BGT) in husbandry systems under full sun (CON) and under agrosilvopastoral systems (ASPS-1 e ASPS-2).

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Infrared thermography for microclimate measurements on agroforestry systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: livestock precision, microclimate, production systems, thermal imagers

Abstract

Agroforestry systems are widely recognized for promoting microclimate changes favorable to animal welfare (Karvatte Junior et al., 2016). When forest canopy intercepts solar radiation, photosynthesis on tree and forage leaves reduces air temperature, leading to increase in relative humidity in the understory. However, when reaching maximum values, water stress promotes the closure of stomata and a gradual increase in leaf temperature, with consequent thermal emission of infrared radiation to the environment (Kim et al., 2016). In recent years, studies focusing on ambience and meteorology have made use of different analog sensors - mainly thermo-hygrometers - to characterize microclimate in livestock production systems (Karvatte Junior et al., 2016; Oliveira et al., 2017; Giro et al., 2019). Knowing that the greater the complexity of elements in a system, the harder is to obtain accurate data, agroforestry systems pose a challenge to such studies, where trees cause a mosaic of shade over the grazing area (Oliveira et al., 2017). Infrared thermography (TIR) has stood out as a microclimate assessment tool for urban environments, since it is able to provide a quick and accurate diagnosis of thermal variations. In agriculture its use is focused on protected crops and livestock systems. Thus, goal of this study was to use TIR as a tool for microclimate monitoring in agroforestry systems. A trial was carried out on Embrapa beef cattle, in Brazil (20 ° 27'S, 54 ° 37'W, 530m of altitude and Cfa-Aw bioclimate zone), from June 2015 to February 2016, corresponding to the rainy (summer) and dry seasons (winter), in a 12 ha experimental area, with two arrangements of agroforestry systems (AS), being four *Brachiaria brizantha* cv BRS Piatã paddocks of 1.5 ha each: (AS-1) with *Eucalyptus grandis* x *E. urophylla*, clone H13 with 227 trees.ha^{-1} (22x2m) and (AS-2) with large native trees from the Brazilian Cerrado (5 trees.ha^{-1}) (Figure 1). Readings were carried out simultaneously in one paddock of each system per day, for four consecutive days every month of the experiment, every round hour between 08:00 and 16:00. The microclimate variables (air temperature, black globe temperature, dew point temperature and air relative humidity) were evaluated according to the methodology proposed by Karvatte Junior et al. (2016), using digital thermo-hygrometers with datalogger. Concomitantly, thermal images of the AS were captured using a professional thermographic camera (Testo®, model 875 2i) with a resolution of 360 × 240 pxls (number of pixels: 76,800), lens with a 7.5 mm focal length (32°x23° field of view; f/0.84) and emissivity equal to 0.97, approximately 10 m away from the trees, between tree alleys in the AS-1, and in front of the trees in the AS- 2. The equipment was positioned at reader's eye height (approximately 1.70 m). Images were analyzed through IRSoft® program, to obtain values of temperature and humidity of pasture and tree canopies, in shade and sun (Figure 1). Pearson's correlation and simple regression analysis were performed. Subsequently, the data were subjected to analysis of variance and Tukey test ($p < 0.05$), using the SAS software (version 9.2). Strong associations were found among canopy temperature (Tc) and air

temperature (Ta) (r = 0.72; Tc = 4.13+0.8923*Ta-0.0051*Ta², R^2 = 0.88) and black globe temperature (Tbg) (r = 0.62; Tc = 0.68+1.2013*Tbg-0.0124*Tbg², R^2 = 0.68), as well as a strong association between canopy humidity (Hc) and air relative humidity (RH) (r = 0.70; Hc = 19.697+0.6057*RH +0.0002*RH², R^2 = 0.99). Likewise, strong associations were identified between pasture temperature (Tp) and air temperature (r = 0.78; Tp = 8.9731+0.5272*Ta +0.005*Ta², R^2 = 0.92) and black globe temperature (r = 0.77; Tp = 5.0138+0.8766*Tbg-0.0041*Tbg², R^2 = 0.92) and pasture humidity (Hp) and air relative humidity (r = 0.73, Hp = 10.528 +0.5573*UR+0.0013*UR², R^2 = 0.95). These results support the study's hypothesis and reveal the existence of relationship between TIR and microclimatic parameters for microclimate measuring in agroforestry systems. Similar results were reported by Kim et al. (2016) who found strong correlations among TIR and air temperature, air relative humidity and solar radiation (r ≥ 0.6 or r ≤ −0.6) when evaluating surface temperature variations of a pine forest canopy in Oregon. Similar variations in hourly averages of TIR were observed among seasons. However, significant interactions between the two seasons and time of the readings show significant differences, with higher values of temperature and humidity on canopy (average difference between seasons of 2.7 ± 0.5°C and 12.9 ± 1.6 pp., respectively) and pasture (average difference between seasons of 2.6 ± 0.8°C and 15.6 ± 2.0 pp., respectively), during the rainy season, between 11:00 and 14:00 (interval of sun peak). According to Kim et al. (2016), these daily temperature deviations of both canopies are positively related to long-wave radiation that reaches the canopy layers, promoting an increase in leaf temperature and a decrease in moisture content, with direct effects on forest microclimate. In view of these findings, the TIR is useful for evaluating thermal variations on canopy and pasture, which can be used as a tool for microclimate measurements in agroforestry systems.

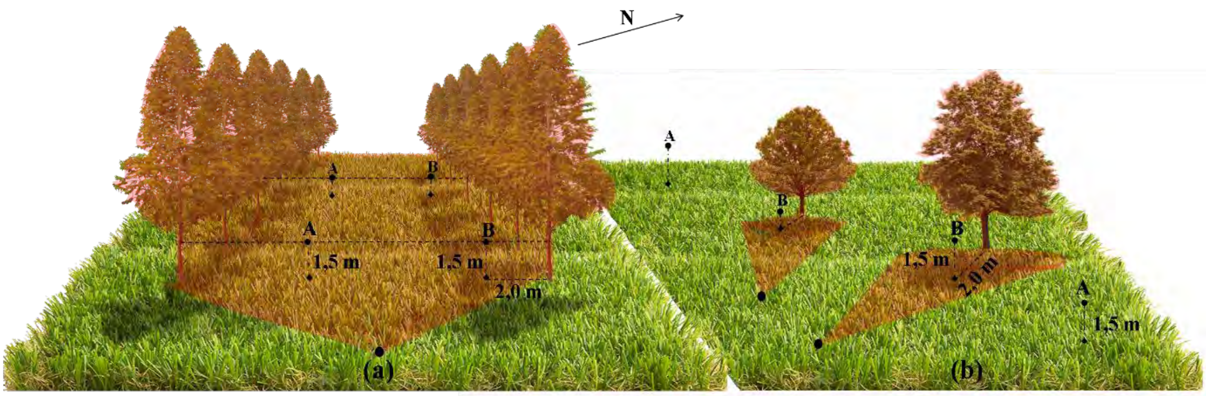

Figure 1. Illustration of equipment positioning for thermal imagery acquisition (red shading) and microclimate readings using thermo-hygrometers (dot lines) at open sun (A) and under tree shade (B), on two agroforestry systems AS-1 (a) and AS-2 (b).

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Potential Constraint of Rainfall Availability on the Establishment and Expansion of Agroforestry in the Joe Gqabi, Alfred Nzo and OR Tambo Districts, Eastern Cape in South Africa.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development

Keywords: Agrosilviculture Community Growers, Agroforestry, Rainfall Availability, Eastern Cape Province and South Africa.

Abstract

Agroforestry is a land use system that includes the use of woody perennial and agricultural crops and animals in combination to achieve beneficial ecological and economical interactions for food, fiber and livestock production. South Africa is considered a semi – arid country vulnerable to water stress, particularly drought. The threshold for rainfall agriculture is averaged at 250mm annually and in terms of forestry, rainfall needs to be higher than 750mm per annum to sustain commercial forestry. According to ARC (2020), O.R. Tambo district receives a median annual rainfall that ranges mostly between 800 and more than 1000 mm. Climatically the area is thus well suited to rainfed arable agriculture where slopes and soils permit. A moderate summer peak in rainfall is evident. Summer rains start in September and the wettest months are November and December, and the driest, May to August. Similar to O.R. Tambo, the Alfred Nzo district receives a median annual rainfall that ranges mostly between 800 and more than 1000 mm. Climatically the area is thus well suited to rainfed arable agriculture where slopes and soils permit. A moderately strong summer peak in rainfall is evident. Summer rains start in September. The wettest months are November and December, and the driest, May to August. Furthermore, Joe Gqabi district is vastly agricultural and it provides an ideal investment opportunity for agro-forestry. Hence, the objective of the study was to determine the potential constraint of rainwater on the establishment and expansion of agroforestry in the Joe Gqabi, Alfred Nzo and OR Tambo Districts, Eastern Cape. A purposive sampling technique was used to select five agroforestry sites namely (1) Sinawo Forestry Enterprise (2) Mkambathi Forestry Enterprise (3) Izinini Forestry Enterprise (4) Gqukunqa Forestry Enterprise (5) Sixhotyeni Forestry Enterprise (6) Lusikisiki Forestry Enterprise. Coordinates were received from the Department of Environment, Forestry and Fisheries (DEFF) to plot the climate maps. The following approach was used to determine average monthly rainfall (Malherbe and Tackrah, 2003): Decadal (ten day period) 1km x1km surfaces were created from rainfall data (1920 – 1999) downloaded from the AgroMet databank at the Agricultural Research Council- Soil, Climate and Water (ARC-SCW) (South African Weather Service and SCW weather stations) from stations with a recording period of 10 years or more. Regression analysis and spatial modelling were utilized taking into account topographic indices such as altitude, aspect, slope and distance to the sea during the development of the surface. The September 2020 rainfall results indicated that there was generally good rainfall (75 - 100mm) in the agroforestry sites as compared to the agricultural open field areas. The October 2020 rainfall situation improved with an increase in rainfall (101 - 150mm). During November and December 2020, increasing rainfall was experienced at 125 – 175 mm and 125 - 175mm, respectively. The future annual rainfall is estimated at 801 to +1000mm, 901 to +1000mm & +1000mm across 33rd, 50th & 66th percentiles respectively. This rainfall situation is well above the Eastern Cape Districts annual average rainfall, agriculture and forestry thresholds. These interesting results are in line with the similar studies conducted

in the agroforestry sites in Limpopo and Mpumalanga Provinces (Maponya et al., 2018; Maponya et al., 2019 Maponya et al., 2020 and Maponya et al., 2021). It can thus be concluded that rainwater is not a constraint in the study area for the establishment and expansion of agroforestry. The monthly average rainfall results confirms that rainwater is not a constraint for agroforestry establishment and expansion in the agroforestry sites. The rainfall belt is also more evident in the agroforestry sites as seen in Figures 1. Currently the profitable commodities were recommended to the Department of Environment, Fisheries and Forestry (DEFF) for agroforestry integration. The study recommends that the establishment and expansion of agroforestry be carried out in the identified suitable areas and in line with the Department of Agriculture, Forestry and Fisheries Agroforestry 2017 Implementation strategy.

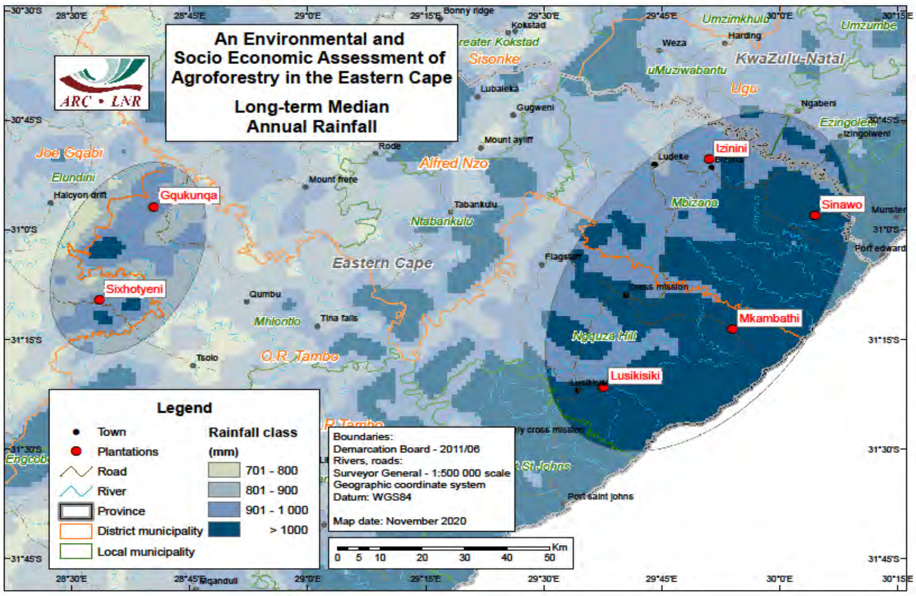

Figure 1: 50th Percentile Annual Rainfall

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Crop responses to climate changes are species dependent in agroforestry systems in Northern France

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Alley-cropping agroforestry, mitigation, climate change, sugar beet farming, modelling

Abstract

Agroforestry systems represent promising alternatives to tackle climate change challenges in agroecosystems through carbon (C) sequestration in soil and trees biomass and micro-climate buffering provided by trees. The aim of this exploratory study was to assess productivity and responses to climate changes of alley-cropping agroforestry systems within sugar beet farming in northern France.

The Hi-sAFe model (Dupraz et al., 2019) was used to simulate growth and productivity on a daily scale from 2020 to 2050 of a pure crop control (PC) and an alley-cropping agroforestry system (AF), with a 3-years crop rotation on both PC and AF: sugar beet/winter wheat/winter barley following conventional agricultural practices. Plots are located in Dequidt farm at the agroforestry experimental site of Ramecourt, on a deep (2 m) luvic cambisol developed on flint clay and jurassic limestone. In AF plot, hybrid walnut trees (*Juglans nigra x regia*) were planted with a density of 34 trees.ha-1. Both modalities were run under 3 different climatic projections: Current climate (historical data from 1972 to 2002) and two concentration scenarios (RCP4.5 and RCP8.5) for future time frame 2020-2050. All three scenarios were generated with the climate model KNMI-RACMO22E (van Meijgaard et al., 2012), accessible through Clipick database (Palma, 2017), for coordinates 50°22'N, 2°17'E.

Over a 30-years simulation with the current climate in PC, the average dry biomass production for sugar beet, winter wheat and winter barley were 19.7, 16.5 and 10.8 Mg ha-1 respectively. In AF, the trees reached 12 m and 27 cm in height and diameter respectively (i.e. an annual height growth of 0.4 m yr-1). From the 7.4 Mg C. ha-1 sequestered by trees over 30 years, 31% was found as belowground biomass. While future climate conditions under both scenarios (RCP4.5 and RCP8.5) increased the biomass production of winter wheat (+4% and +5% respectively) and sugar beet (+15% and +5% respectively), these penalized instead growth of winter barley (-6% and -7% respectively) (figure 1) and trees (-15% and -10% respectively). We observed that trees allocated more C into belowground parts (57% and 53% for RCP4.5 and RCP8.5 respectively, compared to 31% in current climate).

The presence of trees in agroforestry systems significantly decreased the sugar beet biomass by -12% (for current climate and RCP4.5) and 10% (for RCP8.5) whereas it had a smaller impact on wheat (-3% for RCP8.5), and winter barley biomass (-2% for current climate and RCP4.5).

Our results showed that the rise of temperature by about 1°C in RCP4.5 and RCP8.5 (30 years average) favoured the growth and development of sugar beet and winter wheat, as temperature is the main driver for crops' growth and no water and nutrient stresses were observed. The presence of trees reduced crop biomass regardless of the climate or crop type, as also reported by Arthur et al. (2018) for sugar beet growing under shade. However, this decrease should be balanced by trees biomass production at plot scale, which also contributes to climate change mitigation. In AF, low tree C sequestration values may be attributed to the low tree planting density. In RCP4.5 and RCP8.5, trees

allocated more C in roots to better explore soil resources such as water and nutrient. Finally, our results showed that climate change scenarios improved crop growth, except for winter barley. This latter seemed more sensitive to increasing temperature. In perspective, these results need to be confirmed with observed data.

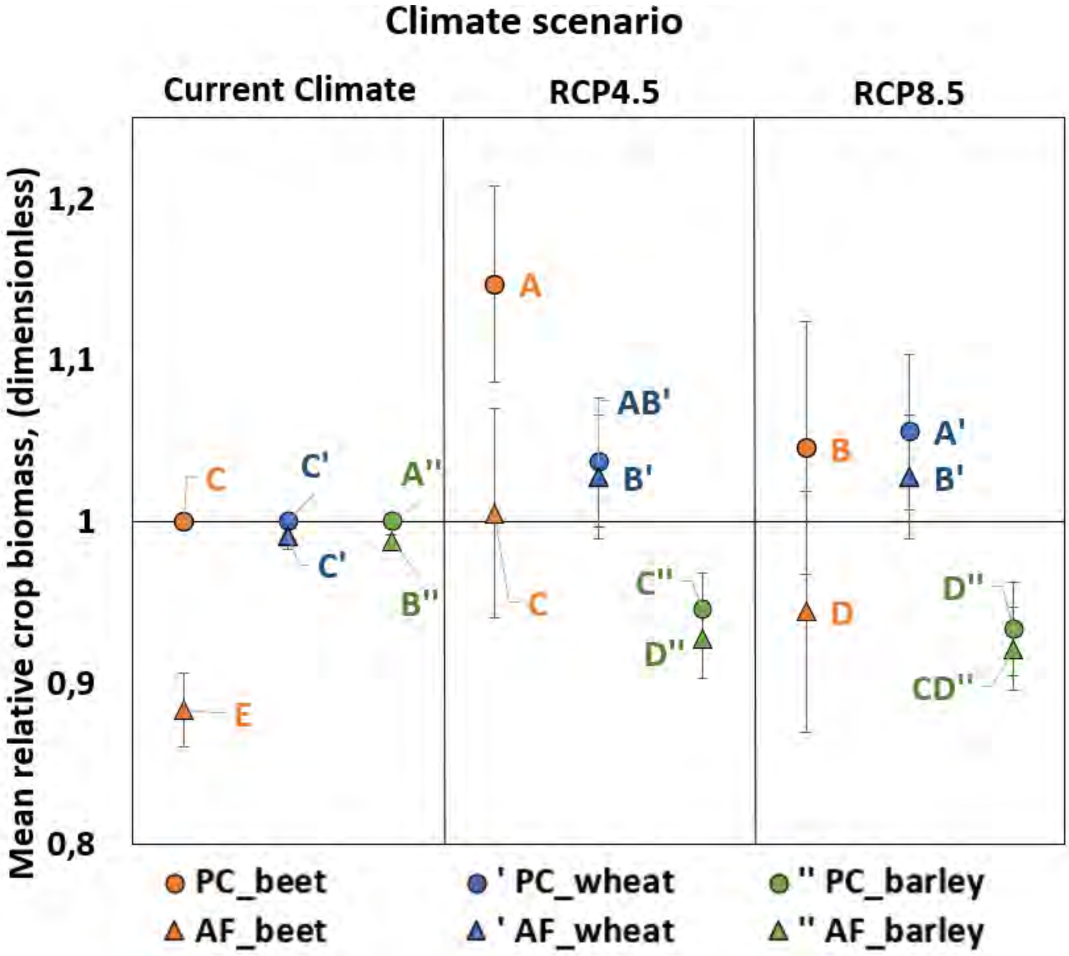

Figure 1. Variation of the mean relative biomass of sugar beet, winter wheat and winter barley after 30-years simulation in PC (pure crop control plot) and AF (agroforestry plot) systems under Current climate, RCP4.5 and RCP8.5 scenarios (for 2020-2050 time frame). Values are means, and bars are standard deviations. Relative values for each crop are in respect to crop yield in pure crop control plot simulated with the current climate for the given crop. Letters are results from ANOVA analysis followed by Tukey's post Hoc test (p<0,05) for comparison of crop biomass in each modality (combination of plot and climate type) for a given crop. Means with same letters are not significantly different.

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Development and application on ash (Fraxinus excelsior) of a methodology to measure the quantitative and qualitative intake of ruminants for heterogeneous woody fodder.

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Abstract
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Theme: Climate change

Keywords: further fodder, ruminants, ingestion, twigs, common ash tree, global warming

Abstract

Introduction In the coming years, with the multiplication and the intensification of the effects of climate change, the Auvergne, French and European livestock farming systems will have to adapt and gain in resilience if they want to maintain their production. Concretely, in Auvergne, a mid-mountain region, livestock farming, largely dependent on grass production, will be subject to longer and more frequent periods of drought (Moreau 2015). The reinforcement of the place of woody species in the systems is highlighted in the scientific literature as a possible lever to secure agricultural production. Trees have several advantages, in particular that of being an additional source of fodder, especially in summer, when grassland growth is slowed down (Emile and al. 2017; Papachristou and Papanastasis 1994). This notion of fodder trees has several scientific gaps, including the fact that the fodder value of woody species has been established on the chemical composition of the leaves, without taking into consideration the global fodder resource, phenomena of intake and digestibility of ruminants, as well as farmers' practices (Emile and al. 2017; Bernard and al. 2020). Following on the Parasol research project, in which sheep's intake of ash and white mulberry (*Morus alba*) leaves was measured (Bernard et al. 2020), this study aims to evaluate how the entire woody twigs can be included in the ruminant ration, considering the frequency of forage distribution.

Materials and methods During the summer 2020, at the experimental unit Herbipôle (INRAE), 6 castrated male texel sheep (24 months, 64 kg ± 1 kg) were housed in individual pens and fed with fresh ash twigs. The fodder was harvested twice a week, packed in 6 kg bundles and stored at +4°C in a cold room until distribution. During 9 days, the animals were gradually accustomed to their boxes and to woody fodder, whose proportion in their ration gradually increased to the detriment of hay, to reach distribution ad libitum. The experimental design was a repeated 3x3 Latin square, where the 6 sheep were fed with a daily ration of 12 kg of fresh fodder distributed according to three modalities: every day, every two days and every three days. Each modality was repeated 4 times per animal, with a duration of 4, 8 and 12 days respectively, for a total experimental duration of 24 days. The ration of each animal was weighed each day to estimate their daily quantitative consumption. Associated with the ration of each animal, a reference bundle was placed in the barn and was collected every day in comparison in order to establish a representative sub-sample of the daily consumption of the animals. Each sample was analysed for Mineral matter (MM), Digestible crude protein (DCP), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL). All these analyses enabled us to estimate the quality of the animals' intake. The water loss kinetics of the reference bundles also allowed us to estimate the evolution of the Dry Matter (DM) content of the animals' ration in relation to a reference content measured at the fodder harvesting. The statistical treatment of the data was based on mean homogeneity tests carried out according to mixed ANOVA (parametric [fixed variables: feed and quality intake, random variable: animal]) or Kruskal-Wallis tests (non-parametric [variables: feed and quality intake]).

Results Overall, the animals ate in quantity (2.08 kg DM/day; P=0.53) and quality (content of MM [8 g/kg DM, P=0.11], DCP [120 g/kg DM, P=0.61] and NDF [340 g/kg DM, P=0.27]) equivalent independently of the three distribution modalities. However, if each day of each modality is considered as an independent regime, quantitative and qualitative differences in consumption exist. Quantitatively, for the modalities where the forage

is fed for two or three days, the animals will have a lower consumption on the last day (P=2.62e-06) (-0,4 and -0,55 kg DM/day, respectively, compared to day 1). This phenomenon is explained by the composition of the animals' diet, which varies over time. On the last days of the multi-day regimes, the animals' diet is richer in young stems, in contrast to the first days where it is richer in leaves (Figure 1). In fact, from the twigs that compose the ration, the animals will consume two types of organs: leaves and stems of the year. The latter are known to have a less interesting chemical composition (Masson et al. 1980), with in particular a higher fibre content. Thus, the more a sheep eats young stems, the harder its overall diet will be to digest, with a ration fill higher, a residence time in the rumen longer and therefore a reduced voluntary feed intake.

In relation to the chemical composition of these two types of organs, the evolution of the proportion of leaves in the diet of animals also influences the quality of the ingested food, which decreases between days of multi-day modalities. For example, when forage is fed every three days, the DCP content of the ingested feed decreases from 145 g/kg DM on day one, to 119 g/kg DM on day two, and to 80 g/kg DM on day three (P=4.52e-09).

Finally, for each day of each modality, dietary intake parameters could be calculated (DM intake, DCP intake, organic matter intake and NDF intake) and were compared with those of studies where the same animals were fed with reference forages: permanent pasture hay, fresh English ray-grass and fresh chicory. Overall, during the first days of each modality, the rations consumed by the animals are of very good quality, close to an English ray-grass or chicory, and are suitable for feeding animals in production. Those of the last days are of a quality close to permanent pasture hay and are adequate for maintenance animals. Therefore, the distribution of ash twigs should be adapted according to the physiological state of the animals.

Conclusion In 2020, measurements of twig consumption were carried out on ash and the objective for the next few years will be to extend these measurements to other species with interesting in vitro fodder potential. In the future, the experimental design could be simplified in order to facilitate its implementation, without significantly impacting the statistical power. Finally, in addition to intake measurements, it would be interesting to carry out digestibility measurements to quantify the assimilation of nutrients from these forages to enhance our understanding of how this resource is valued by the animals.

This work was funded by the ISite project 16-IDEX-0001 (CAP 20-25). The authors thank all the people who participated in the realization of this study.

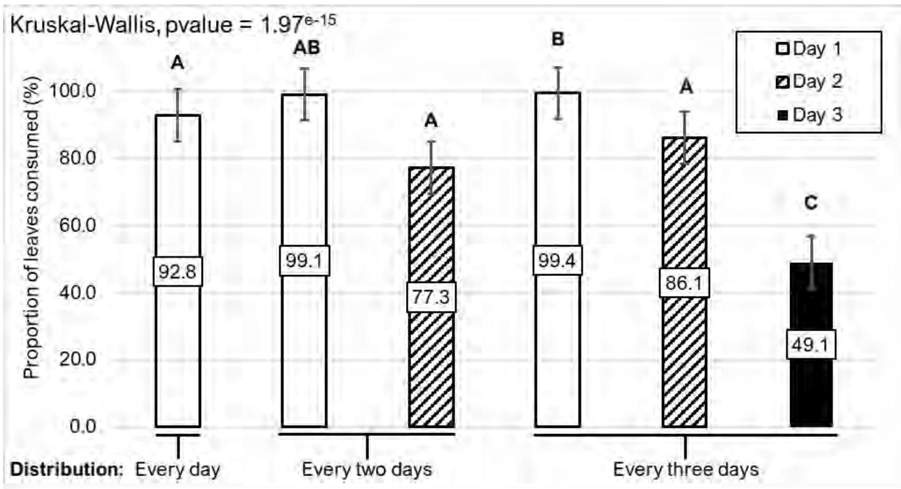

Figure 1. Evolution of the proportion of leaves consumed by sheep between the days of each modality
Source: INRAE

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Transpiration decrease in shaded hazelnuts: a green light for experimenting new orchard structures.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: *Corylus avellana*, vapour pressure deficit, shade-tolerance, canopy conductance

Abstract

Global yields of cereals and fruit trees are projected to decrease as a consequence of the increasing air vapour pressure deficit (VPD) (Hsiao et al. 2019). VPD synthesize the effect of relative humidity and temperature of the air, which is unceasingly increasing due to anthropogenic global warming since 30 years of 0.2°C (IPCC 2018). Mediterranean regions are among the most affected areas by this change. At the same time, VPD is one of the most significant parameter affecting plant physiology because it controls stomata aperture and carbon inflow into leaves. Long term exposure to high VPD leads to reduced growth (Sanginés de Cárcer et al. 2018) and tree mortality even more than just high temperature rise (Eamus et al. 2013). Still, some food trees are more sensitive to high VPD than others are. Hazelnut (*Corylus avellana* L.) is one of these. Although it is a temperate forest species, it is cultivated since centuries for the nut production in the whole Europe. In recent years, its cultivated surface is rising significantly. Italy plans to reach 20.000 hectares of hazelnut orchards at national level. In the last years, the research on hazelnut eco-physiology highlighted the sensitivity of the species to VPD rise. Hazelnut resulted shade-tolerant, it barely stands wind (Baldwin et al. 2003), stomata closure occurs above 10hPa VPD thus reducing carbon assimilation.

This leads to the hypothesis that decoupling hazelnut trees from the atmosphere prevents water loss in case of VPD rise. During summer 2019, we set an experimental study in the University of Padova (45°20'55''N, 11°56'59''E, 5 m a.s.l.) hazelnut orchard, located in Legnaro (PD), Italy. Three 12 years old hazelnuts were covered with a polypropylene net in mid-June, while three other net-free individuals served as a control. Trees were rain-fed for the entire growing season. In each treatment, we measured carbon assimilation (*An*), stomatal conductance (*gs*) and light saturation curve at leaf level with a porometer from DOY 203 to 262. In parallel, we installed in all trees TDP probes to measure the sap flow. Sap flow measurements, together with meteorological parameters and soil water content were recorded by a datalogger with a 15 minutes record frequency. Diurnal sap flow data and VPD were used to calculate the canopy conductance G in the two treatments with G = k*E_L/VPD (mm s^{-1}), where k=115.8+0.4226*T°C (m3kPa°C kg-1), E_L= transpiration per unit of LAI (g m-2s-1) as described in Tang et al. (2006).

At the leaf level, the light saturation curve showed that 48% of the CO_2 assimilation was reached already at 100 µmol $m^{-2}s^{-1}$ of PAR and remained stable for PAR > 500 µmol $m^{-2}s^{-1}$, close to what found by Tombesi et al. (2015). The shading net did not change the response to light. Daily *An* resulted slightly higher in control respect to shaded treatment, especially between 7 and 8AM and between 3 and 5PM. The shading net provided 10% decrease in mean daily VPD compared to the control. This caused a decrease in the canopy transpiration per unit of leaf area (E_L) of 13.9% (max 30.5%) in shaded compared to control treatment (0.024 and 0.028 g $m^{-2}s^{-1}$ respectively). The whole tree canopy conductance (i.e. gas exchange capacity) between the two treatments was 8% higher in control respect to shaded trees (0.16

and 0.14 mol $m^{-2}s^{-1}$ respectively). The cover net shifted the maximum G from 6 to 10hPa, but the response of G to VPD remained similar in the two treatments (Wilcoxon test, $p>0.05$).

Even if the leaf carbon assimilation is negatively affected by shade only in the early morning and some afternoon hours, the relative gain in whole tree conductance remained lower in control respect to the amount of water saved by shading the trees. Indeed, it is possible to design agroforestry systems where hazelnut grows with other non-shade tolerant species (e.g. *Populus* spp.) as dominant trees. These partner trees can benefit from the water saved from the new hazelnut orchard layout, and on its turn, provide shelter from wind, heat waves or VPD increase in the long term. Still, more research is needed to include the effect of shade on nut yield, which is though difficult in hazelnut due to its alternate bearing of fruits. Still, this work suggests that hazelnut can tolerate the coexistence of dominant trees with water savings that might compensate carbon assimilation losses.

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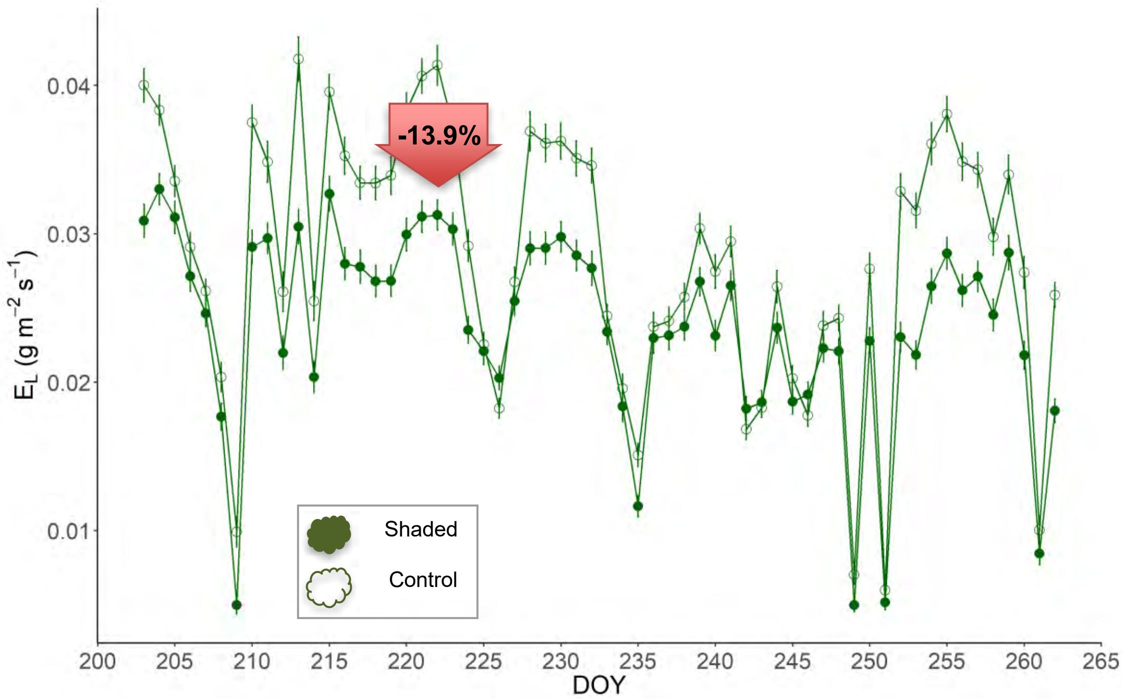

Figure 1. Mean daily canopy tanspiration per leaf area (E_L) in shaded trees and control treatment during the days of the year (DOY from 203 to 262). The red arrow shows the average decrease in EL in shaded respect to control treatment over the study period.

Semi-extensive agrosilvopastoral system as low-carbon livestock strategy: a case study on beef meat in Tuscany

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Climate change (adaptation and mitigation)

Keywords: Mediterranean, Emissions, GHG, LCA, enteric fermentation

Abstract

Livestock is one of the main sectors of agriculture, creating employment and sustaining livelihoods in Europe. Since world population is projected to reach 9.8 billion in 2050, and 11.2 billion in 2100, the global demands for livestock products will increase facing natural resource scarcity and major challenges posed by climate change. Cattle are the main contributor to the livestock sector's emissions with about 4.6 gigatonnes CO_2-eq, depicting 65 % of total livestock emissions. Beef cattle and dairy cattle generate similar amounts of GHG emissions (Gerber et al., 2013). The goal of the "Low-carbon livestock strategy" (LCLS) is to produce healthy food in a way that minimizes the overall output of GHGs into the atmosphere, by the understanding of the diversity and complexity of livestock agrifood systems (FAO 2019). Recently, Latawiec et al. (2014) reported that agrosilvopastoral systems can increase productivity and sustainability of animal products. In fact, these systems are able to provide several benefits such as, mitigation of greenhouse gas emission from livestock sector, increment of the adaptability of livestock to the climate change effects, and improvement of the nutritional quality of animal derived food. Currently in southern Tuscany, Maremmana breed rearing is still conducted by the utilization of the understory forage production. Moreover, the improving of microclimatic conditions under the tree canopy are able to improve the thermal comfort of cattle, especially during summer (heat stress) and winter (thermal excursion). The purpose of this study was to estimate the environmental impact of Maremmana beef cattle reared on an agrosilvopastoral production system and to assess whether CO_2 sequestration by forest ecosystems involved in such production were a valid mitigation option to LCLS.

The study was conducted at the "Tenuta di Paganico" organic farm, Paganico, Italy (42.954N, 11.238E) in an area characterized by Mediterranean climate conditions with mean annual temperature of 15°C and an average annual rainfall of about 800 mm (2003-2014). The beef cattle production is conducted according to semi-extensive cow-calf operations and pasture-based fattening. The reference year was 2018. The study is a cradle-to-farm gate farm-based life cycle assessment (LCA), meaning that all relevant data are primary and all relevant pre-slaughterhouse activities are taken into consideration: from feed production (machinery, seeds, irrigation, etc.) to grain milling, electricity and fuel consumption. All feeds are produced on farm and the cattle are allowed to graze freely all year round, depositing urine and dung on the soil (there is no manure management system nor manure spreading). The impact of on-farm transportation of feeds and off-farm transportation of external inputs were also taken into consideration.

Cows and heifers (n=47) with calves (n=33) and one bull, and steers with heifers (n=27) were able to graze under the canopy of a high forest (mainly *Quercus cerris* L.) that covered an area of 570 ha. Therefore, this woodland surface was included in the LCA. Carbon (C) removals and fuel use owing to harvest operations of wood products were also included, while to account the C sink, the average forest growth rate of *oaks* was derived from the Tuscany Regional Forest Inventory *(www.regione.toscana.it)*. Indeed, forests within the farm are managed according to a pluriannual silvicultural management plan. Moreover, the entire herd was allowed to graze on 50 ha of temporary grassland but C sink activity of pasture was not included. Grassland do have a strong potential to partly mitigate the GHG balance of ruminant production systems but soil C sequestration is both reversible and vulnerable to disturbance (Soussana et al., 2010), and there is still great uncertainty about the size, distribution and activity of this sink (Gerber et al., 2013). The software used was OpenLCA (GreenDelta, Berlin - Germany), while for life cycle inventory (LCI) background data, a combination of LCI databases was used, namely Ecoinvent (version 3.7.1), Agri-footprint (version 5), and Agribalyse (version 3.0.1). One kilogram of live body weight sold (LBW) was used as the functional unit and in order to conduct the life cycle impact assessment the EPD® method (2018) was used.

The assessment of the global warming potential (GWP) of organic Maremmana beef meat produced in a semi-extensive agrosilvopastoral system in Tuscany was 8.05 kg CO_2 eq per kg of LBW. Our study highlighted that without taking into account the mitigation effect of the C sink of woodlands grazed by cattle, the GWP was 22.44 kg CO_2 eq per kg of LBW. In the investigated livestock system, C sequestration by grazed woodland allowed to mitigate a large portion of the overall GHGs emitted by meat production. As reported in Fig. 1, the largest contributor to GWP was enteric fermentation followed by manure management, and crop cultivation. Aiming to cope with climate change, the woodland ecosystem positively acted mitigating 64% of the GHGs emitted by a semi-extensive meat production system. However, further research and a standardized methodology will be necessary to include grassland ecosystems in such calculations and to assess the other environmental benefits of agrosilvopastoral systems towards low-carbon livestock productions.

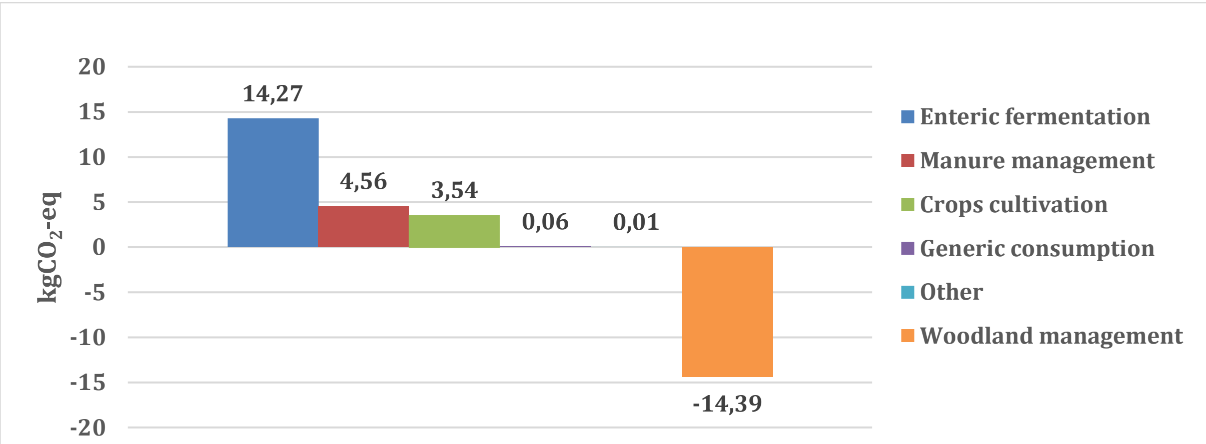

Figure 1. Global warming potential contributor sectors of organic Maremmana beef cattle in a semi-extensive agrosilvopastoral system in 2018, Italy. One kilogram of live body weight sold was used as functional unit.

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Identification of a group of woody species having an interesting forage profile and able to develop in Auvergne over the second half of the 21st century

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change

Keywords: climate change, fodder trees, forage profile, ecological characteristics, Auvergne

Abstract

Introduction Auvergne is one of the French regions with higher variability of climatic parameters due to the influence of continental, Mediterranean, mountain and oceanic climates. Even if the continental influence remains predominant, this diversity reinforces the uncertainty of the future climate of this region. The coming years are expected to be, on average, warmer and drier with a multiplication of drought risks (ORCAE 2019). This evolution is likely to put the livestock systems under pressure, as they largely depend on grass production in this region. If they want to become more resilient, new sources of forage have to be found. Fodder trees could be one possible solution (Papachristou and Papanastasis 1994). However, the potential fodder species from Auvergne should be more documented, both in terms of basic chemical composition of leaves and ecological requirements for proper productivity. First, we gathered data about the chemical composition from bibliography for as much woody species as possible, including trees and shrubs. Secondly, after having identified the species with forage potential, we retrieved their main ecological characteristics to assess their ability to develop in Auvergne's climate as forecasted for the next fifty years.

Materials and methods Based on a thorough bibliographical review, the leaf chemical compositions of the woody species found in different scientific articles were compiled in a unique database. Then, through a principal component analysis followed by a hierarchical ascending classification, we were able to classify the different species identified based on their Organic Matter (OM), Digestible Crude Protein (DCP) and Neutral Detergent Fiber (NDF) content. The different classes created were compared by carrying out homogeneity tests of mean according to Anova (parametric) or a permutation analysis of variance (non-parametric). In parallel, the future climate of Auvergne was characterized by collecting data from the RCP 8.5 model of the DRIAS - CNRM2014 project (DRIAS 2020). Relying on this modelling, average temperatures and cumulative precipitations were calculated for the four departments of Auvergne, per month, for three periods: 1950-2005 (reference), 2050-2060 (near future), 2070-2080 (far future). Finally, we used three autoecological diagrams for 54 European woody species, developing the observed presence of the specie according to 6 climatic criteria (annual precipitation, mean annual temperatures, potential solar radiation in spring and summer, mean temperature of the coldest month, ratio of variability of monthly precipitation and sum of precipitation of the driest month; San-Miguel-Ayanz et al. 2016). By projecting Auvergne climate data from the RCP 8.5 model (DRIAS 2020) onto the three autoecological diagrams (San-Miguel-Ayanz et al. 2016), it is possible to estimate the potential presence of these 54 species in the 4 Auvergne departments for each time periods (Figure 1). Thus, the studied species will be identified as either widely present in the context studied (all the projected points are in the dense part of the point clusters of the 3 diagrams), present in a limited way (at least one projected point is in the periphery, but none is outside the point clusters), or not present or barely present (at least one projected point is outside the point clusters).

Results Among 115 woody species whose chemical composition has been identified, 84 have been classified. Three classes were created. Class 1 includes 20 species with a lower OM content than the average (870 g/kg DM, $P<2e-06$) and intermediate DCP and NDF contents (150 and 310 g/kg DM respectively). Class 2 includes 38 species with average OM and NDF (930 and 350 g/kg DM respectively) and higher DCP (170 g/kg DM, $P=1.51e-14$). Finally, class 3 includes 26 species with an average OM content (940 kg/kg DM), a lower DCP content (110 g/kg DM, $P=1.51e-14$) and a higher NDF content (450 g/kg DM, $P=0.001$). As a result, the 38 species in class 2 have the best nutritional characteristics (higher DCP, average OM and NDF content), especially compared to the species in class 3 (lower DCP and higher NDF content). Class 1 species are also interesting because a lower OM content theoretically results in less energy available, but also in a higher mineral matter content. According to RCP 8.5 modelling, overall, the climate in Auvergne should be warmer (average annual temperatures increase of 4°C) and

drier (-84 mm of annual precipitation) in the next 50 years. These phenomena will be even more marked in summer where the average temperature of the hottest month would increase by 6.1°C while the rainfall of the driest month would decrease by 23 mm. This decrease in rainfall will be even more significant in the Cantal and Puy-de-Dôme departments. This change in climate will directly impact the woody flora in a more or less significant way in the 4 departments of Auvergne. Finally, among the 84 classified species, 24 species are documented through autoecological diagrams, and 23 of them will be able, according to the projections made, to develop in at least one of the Auvergnat departments in the 2070-2080 decade. Moreover, 16 species belong to class 2 and 2 species to class 1. These are the woody species of fodder interest because of the chemical composition of their leaves and which could potentially develop in Auvergne in 2070. We find for example *Acer campestre*, *Carpinus betulus*, *Fraxinus excelsior*, *Quercus robur*, *Robinia pseudoacacia*, or *Tilia platyphyllos* from class 2 or *Cornus sanguinera* from class 1.

Conclusion Despite the inherent limitations of this study (RCP 8.5 model, the limited number of variables for the chemical composition, or discarding the seasonal variability of compositions, Luske and Van Eekeren 2018), this list represents a significant step by proposing twenty woody species that have a forage potential and that could develop in the future Auvergne climate context. This potential remains theoretical and must be validated by in vivo ruminant consumption and productivity measurements, as well as species acclimation to forthcoming climate.

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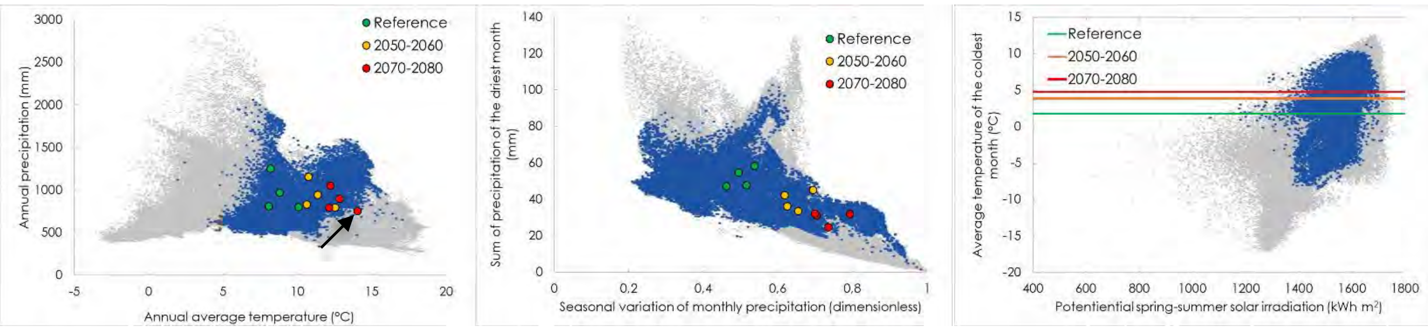

Figure 1: climatic projections of the 4 Auvergne departments at 3 periods of time on *Quercus robur*'s autoecological diagrams
Source: INRAE ; San-Miguel-Ayanz et al. 2016 ; DRIAS 2020

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Successional agroforestry in a temperate climate – establishment of a diverse agroforestry system for practitioners and research in Germany

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Climate change (adaptation and mitigation)

Keywords: Silvoarable Agroforestry, Temperate climate, Erosion control, Soil sampling, Water infiltration

Abstract

Soil erosion, periods of drought, nutrient leaching and a constant loss of biodiversity are challenges that agriculture is facing to an ever increasing extent. With their far reaching ecosystem services, agroforestry systems have a great potential to counteract these challenges. Perennial vegetation and land structured by agroforestry elements have been shown to positively influence microclimate, soil erosion and water availability of soils, as well as biodiversity of flora, fauna and fungi above- and belowground.

As part of the project "Agroforestry Systems Hesse", a diverse silvoarable agroforestry system was established on a 3.5 ha erosion-prone arable field in February 2020. The site is at the teaching and experimental farm of the Justus-Liebig-University Giessen, Gladbacherhof in Hesse, Germany. In six rows of trees, 3 m wide each, eight perennial species amounting to a total of about 800 valuable timber trees, fruit trees, poplars and shrubs were planted in 2020. Inspiration for the design of the system comes from the work of Ernst Goetsch in tropical regions (Goetsch 1992). Our system is one of the first larger attempts to adapt this specific agroforestry approach to a central European context. Tree species selection was based on considerations about the use of the tree biomass (valuable timber or wood chips for mulch, composting, charcoal or litter) and fruit (for fruit juice for the university's canteens), besides the desired ecosystem services. A legume-grass mixture was sown as an understory or buffer strip to the annual arable crop. The 18 m wide strips of arable land between the rows of trees are managed organically in an 8-year crop rotation. The silvoarable system is a scientific long-term field trial and serves as a practical example for interested land managers, and others. The accompanying scientific research comprises investigations of management factors and ecological services, including biodiversity, soil fertility and water availability, and the development of recommendations for the agricultural subsidization of agroforestry systems in Germany.

This contribution presents the design of the agroforestry system as well as the accompanying research. In addition, we report on our initial experiences with planning and establishing the agroforestry system and on the results from an extensive inventory sampling of the area using percussion core probing and water infiltration measurements.

Figure 1. Successional silvoarable agroforestry system at Gladbacherhof of the Justus-Liebig-University Giessen in Hesse, Germany. Six tree rows representing three mixed species rows (valuable timber trees, fruit trees, poplars and shrubs) and three mono-species rows (poplar or apple trees or valuable timer trees).

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1.2

Enhancing ecosystem services provision by agroforestry systems

Land-sharing or land-sparing for trees within upland agricultural land use in Wales, what's the way forward for rebalancing ecosystem services?

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem service provision by agroforestry systems

Keywords: Agriculture, Tree Cover, Land-Sparing/Sharing, Ecosystem Service Assessment, Economic Valuation

Abstract

Increasing tree cover on agricultural land is recognised as a potential mechanism to enhance ecosystem service provision. The economic value of ecosystem services from existing tree cover in the UK is quite well evidenced (Eftec 2010; Europe Economics 2017; Saraev et al. 2017; Willis et al. 2003), however quantifying the potential for new tree cover to enhance this is less clear. Economic evaluation of the impacts to ecosystem services of increasing tree cover in agricultural landscapes is a current topic of relevant research interest, with some previous studies evaluating agroforestry systems (Kay et al. 2019), higher density tree planting such as afforestation (Cosby et al. 2019) and comparing agroforestry and afforestation (Crous-Duran et al. 2020). In this case study, we added to this evidence base by undertaking a spatially explicit economic valuation to assess and map the impact of a range of land-sparing and land-sharing strategies on ecosystem services and dis-services from grassland and arable land in the Welsh uplands. We also simulated the potential impact of widespread adoption of these strategies on the total basket of ecosystem services and dis-services from the Welsh uplands as a whole. The land-sparing strategies describe either a) no increase in canopy coverage where tree cover does not replace agricultural production (*Business as usual* option) or b) complete canopy coverage where tree cover completely replaces agricultural production is displaced (*Full afforestation – conifer/broadleaf* options). The land-sharing strategies describe either a) trees being intimately integrated with agricultural production (*Agroforestry – in field trees/shelterbelts* options) or b) trees being coarsely integrated alongside agricultural production (*Farm woodland – conifer/broadleaf* options). For the monetary valuation of ecosystem service benefits and dis-service costs over the 120-year assessment period we followed a benefit transfer approach using land cover proxies. To estimate economic values, we used areas of ecosystem service and dis-service supply (derived from land cover data) combined with biophysical quantities (derived from simple mathematical models or existing country specific data) and economic unit values. The economic value of ecosystem service benefits comprises livestock production, arable crops, timber production, carbon sequestration, local flood risk mitigation, livestock shelter and shade and employment. The economic value of ecosystem dis-service costs includes GHG emissions and reduction of potable water quality. The GIS outputs showing the inter-option comparison of the economic value of net ecosystem service benefits (value of ecosystem service benefits less dis-service costs) is shown in Figure 1. Our results suggest that compared to the business as usual option, widespread adoption of land-sharing strategies—particularly agroforestry options—could lead to the greatest potential increase in the economic value of ecosystem service benefits (+£2,616.92 million for the agroforestry - in field trees option). Such land-sharing strategies deliver a basket of ecosystem services primarily focused on *private* provisioning benefits, with modest increases in *public* regulation and maintenance benefits. In contrast, widespread adoption of land-sparing strategies—particularly full afforestation options—could deliver the highest level of *public* benefits (£7,601.92 million) through significant increases in regulation and

maintenance benefits, but at a significant cost to provisioning benefits (-£17,127.11 million). Overall the land-sharing strategies (agroforestry options) where trees are intimately integrated with agricultural production provide the highest level of in-situ ecosystem service benefits are likely to represent the most suitable ways of increasing tree cover on agricultural land in the Welsh uplands. Land-sparing strategies (full afforestation options) where trees replace agricultural production and primarily provide ex-situ ecosystem service benefits are likely to require significant livelihood shifts for private landowners and occupants and strong incentivization to promote adoption.

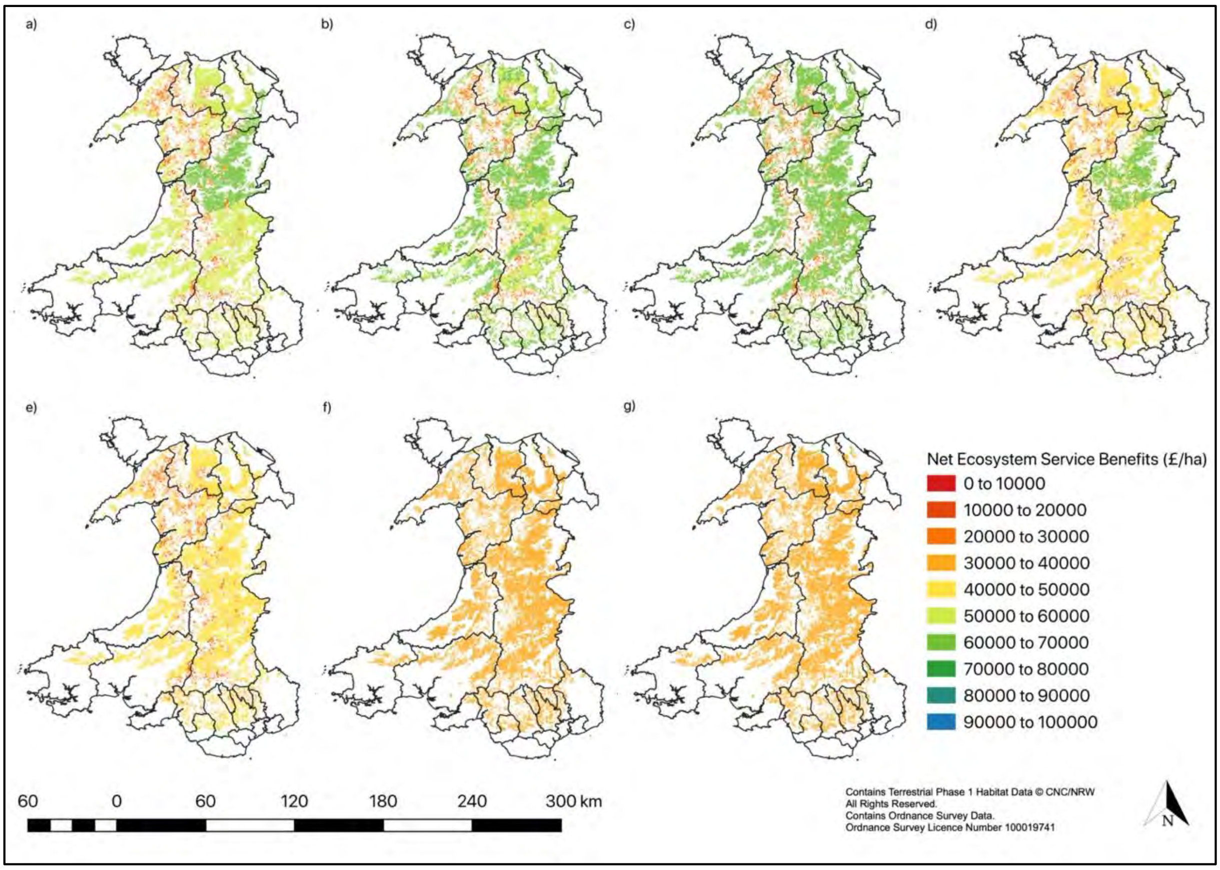

Figure 1. economic value ha^{-1} of net ecosystem service benefits from grassland and arable land in the Welsh uplands under the a) Business as usual, b) Agroforestry – in field trees, c) Agroforestry – shelterbelts, d) Farm woodland – conifer, e) Farm woodland – broadleaf, f) Full afforestation – conifer and g) full afforestation – broadleaf options. The economic value of net ecosystem service benefits comprises ecosystem service benefits less ecosystem dis-service costs. The economic values are based on 2018 market and shadow prices and calculated over 120 years at a discount rate of 3%.

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Can temperate agroforestry systems contribute to Sustainable Intensification of agriculture?

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry

Keywords: Food production, biomass production, land equivalent ratio, farmer uptake

Abstract

Two major targets of the Sustainable Development Goals of the United Nations (https://sustainabledevelopment.un.org/) are the attainment of "Zero Hunger" and "Life on Land" by 2030. While "Zero Hunger" refers to the end of hunger and achievement of food security and improved nutrition through the practice of sustainable agriculture, Life on Land implies the protection, restoration, and promotion of sustainable use of terrestrial ecosystems, and arresting biodiversity loss. It is recognized that the efforts to attain these targets need to be designed with due consideration of the steady increase in human population on earth (Gerland et al. 2014) on the one hand and the likelihood of escalating adverse effects of climate change in the coming decade already (Blanco et al. 2017) on the other. Pursuing both goals simultaneously is a formidable challenge for agriculture. Farmers are under pressure to produce more and at the same time reduce their impact on the environment.

This is an apparent contradiction. In the past, yield increases usually went along with increased burdens on the environment such as higher inputs of chemical fertilizers and pesticides leading to degradation of soil- and water quality, loss of farmland biodiversity and destruction of (semi-)natural habitats (e.g. Pingali 2012). Based on these experiences, there is a clear trade-off between increased agricultural production and ecosystem integrity. Sustainable Intensification is an approach to overcoming this trade-off by "producing more with less".

This promise of science – that it should be realistically possible to produce more with less – has become a prominent development paradigm and has been enthusiastically embraced by policy makers. Today, Sustainable Intensification is supported and promoted by several national governments and international institutions. A growing body of scientific literature has also become available (Weltin et al. 2018). Conceptually, Sustainable Intensification is to be reached by maintaining intact agro-ecosystems, fostering ecosystem services, and creating and taking advantages of synergies (e.g. Foley et al. 2011). Yet, while those concepts are promising and appealing, it is largely unclear how Sustainable Intensification is actually to be achieved on the ground, what the concrete measures are that farmers and administrators can implement now and in the near future to actually increase agricultural production and reduce its environmental burden at the same time.

Agroforestry systems are among the few concrete measures that are available and recognized as capable of steering the agricultural sector towards Sustainable Intensification. The declaration that emanated from the 4th World Congress on Agroforestry (Montpellier, France; 20-22 May 2019) attended by 1,300 participants from more than 100 countries stated that "Agroforestry is capable of maintaining or enhancing yields while mitigating carbon emissions, adapting to the increasingly frequent droughts and floods that climate change brings, restoring degraded soils and maximizing the overall productivity of

landscapes for humanity and nature alike." (https://agroforestry2019.cirad.fr/). This declaration is in line with the paradigm of Sustainable Intensification. In fact, agroforestry systems have been shown in many situations to achieve higher overall production per area through attainment of higher land-equivalent ratios (LER) (Graves et al. 2010, Sereke et al. 2015) and at the same time to generate higher ecosystem services such as soil conservation, reduced nutrient leaching, carbon sequestration, and biodiversity (Kay et al 2019). Thus, agroforestry systems are considered a technique of "Ecological intensification" (Klejin et al. 2019).

So far, agroforestry systems have been viewed primarily as applicable to tropical situations. This situation is changing rapidly. Significant gains have been made in promoting agroforestry in the temperate regions, too, especially during the past two decades. Some questions remain open, however, regarding the potential contribution of modern temperate agroforestry systems to Sustainable Intensification:

1. Even if the total biomass production of agroforestry exceeds that of monocropping, there will still be a reduction of agricultural crop yield. Is this in line with the goals of Sustainable Intensification?
2. Should agroforestry be promoted in all regions and among all farmers, or does it make more sense to differentiate the recommendations according to regions and to farmers?

In recent years, several research projects and reports investigated specific aspects of the above mentioned questions in the context of Sustainable Intensification for temperate regions. This paper will review those results and the state-of-the-art regarding the above issues will be summarized.

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Balancing demand and supply of land-based services with suitability maps for agroforestry systems

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing Ecosystem Services provision by agroforestry systems / Agroforestry on a landscape scale

Keywords: demand and supply, participatory research, landscape scale, nature's benefits to people

Abstract

Agroforestry systems have shown the integration of yield with important regulating ecosystem services such as the increase of soil organic matter (Seitz and al. 2018), carbon sequestration (Hernandez-Morcillo et al. 2017) and biological pest management (ibid.) across different scales, places and time. However, land-use designs imply trade-offs, both spatial and temporal, between actors and between services. In continental Europe, the above and below ground competition between trees and crops, especially for sunlight and water, is one of the most-mentioned trade-offs (Klapwijk et al. 2014). Economic uncertainty prevails as a main reason for the reluctant implementation (Böhm 2017). In my research I suggest the integration of both land-user preferences and feasible service supply analyses in the creation of suitability maps for agroforestry systems. To achieve these results, the research focuses on (I) DEMAND FOR LAND-BASED SERVICES and (I) INCREASE OF LAND-BASED SERVICE SUPPLY IN AGROFORESTRY SYSTEMS.

In step (I), the Participatory GIS tool "Maptionnaire" was used to conduct an assessment of the demand for ecosystem services by five stakeholder groups (Agriculture, Forestry, Tourism, Nature Conservation, Consumers and Inhabitants) in Brandenburg, Germany. The survey allowed for the mapping of rural areas and the assessment of the current and desired state of five ecosystem services (ES) – erosion control, water availability, yield, carbon sequestration and biodiversity.

In step (II), land-based services in the regions of interest were identified by using biophysical indicators to display the current state of the respective ES. The dataset provides a spatially explicit standardized set of relevant indicators for ecosystem service supply on an agricultural landscape scale. The ES chosen are mainly regulating services that can increase in well-managed agroforestry systems. In combination with the demand assessment, it allows for the creation of different land use scenarios that reflect perceived trade-offs and demand - supply mismatches of ecosystem services.

In an online-stakeholder workshop, the usability of the combination of participatory and biophysical data was discussed, and guidelines for the integration of participatory elements

such as mapping exercises in land use planning were developed. In a next step, site-specific and site-independent driving factors of land-based services by different types of agroforestry systems will be identified. The analysis encompasses location analyses of the natural and political/regulatory context as well as management analyses regarding the design and maintenance of the productive system.

The overall results will feed into the creation of suitability maps, showing areas that indicate a high suitability for ES-enhancing agroforestry systems by participatory and biophysical analysis.

<u>(Expected) Results</u>

The study displays different land-use preferences of different actors within the same regions. The PGIS exercise showed that demand for land-based services exceeded the perceived supply for all ES throughout all stakeholder groups. There is a relationship between areas mapped by the participants and the biophysical maps, indicating an awareness for ES hot- and cold spots. In the last part, the management of these areas with landscape-scale agroforestry systems will be discussed in the form of suitability maps.

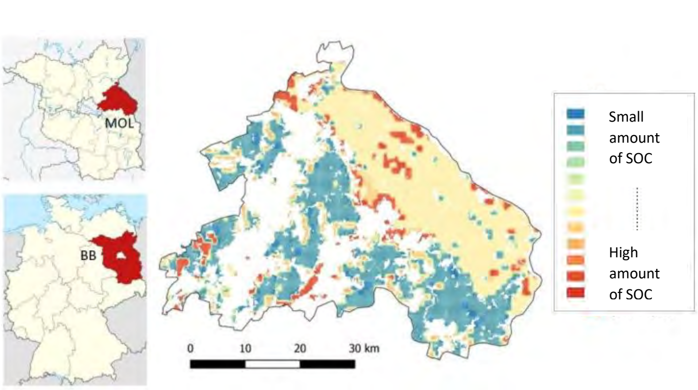

Figure 1: carbon stock in Maerkisch-Oderland (Ungaro et al. 2020)

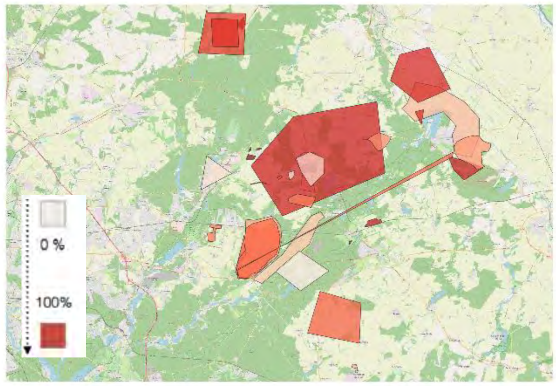

Figure 2: Discrepancy between desired and perceived state of carbon sequestration in Maerkisch-Oderland

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Assessing the influence of silvopastoral practices on the provision of ecosystem services in grazed woodlands: a Delphi survey on Spanish Mediterranean mid-mountain areas

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Delphi method, ecosystem services, silvopastoral practices, grazed woodlands, Mediterranean mid-mountain.

Abstract

Silvopastoral systems integrate woodland and livestock farming allowing for the diversification of marketable local products and the provision of regulating, supporting and cultural services. Livestock grazing, browsing and trampling together with sustainable forest management provides reduced wildfire risk, erosion control, habitat for biodiversity, climate regulation (through CO2 sequestration) and cultural heritage as increased opportunities for leisure and recreation (Casals et al., 2008; Moreno et al., 2018). The generation of these Ecosystem Services (ES) depends on vegetation structure and composition, which varies with spontaneous biological and environmental processes and ultimately, with land management. Different trade-off dynamics seem to drive the supply of bundles of ES, especially between provisioning and regulating or supporting ones (Torralba et al., 2016).

Quantifying the role of management practices in the provision of ES is a task of great complexity and much uncertainty still exists on how practices and their intensity may affect the different ES and which are the trade-offs that may arise (Filyushkina et al., 2018). This study aims to determine the influence of a set of silvopastoral practices on the provision of different ES in grazed woodlands in Spanish Mediterranean mid-mountain areas through expert consultation employing the Delphi method.

The Delphi technique is a well-established qualitative methodology for assessing uncertain outcomes resulting from the application of a given policy or management regime on a number of different dimensions. Delphi application consists of an iterative process where through an anonymous survey a well-established group of experts is consulted on a series of rounds to arrive to a consensus response on the issues raised. This technique has been previously applied on ES assessment (i.e. Rodríguez-Ortega, Olaizola and Bernués, 2018).

ES to assess have been selected according to the scientific literature review conducted as those most relevant for agroforestry systems in Europe, with special focus on Mediterranean mid-mountain areas. Provisionally, we consider 6 ES which has been grouped in 2 provisioning (production of livestock and timber products), 4 of regulation and maintenance (soil erosion control, wildfire prevention, habitat for biodiversity, sequestration of carbon) and 1 cultural (opportunities for hunting). We followed the standardisation of the Common International Classification of Ecosystem Service (CICES V5.1; Haines-Young and Potschin, 2018).

The set of management practices whose influence on ES provision will be evaluated has been chosen based on the literature review and also on the direct input gather through face to face interviews with

forest owners and livestock farmers in Catalonia and Aragon regions in Spain. Practices address interventions and actions related to the silvopastoral management carried out in these representative areas of the Spanish Mediterranean mid-mountain. Provisionally, 25 practices regarding herbaceous, scrubland, woodland and livestock management criteria are included.

The Delphi questionnaire is designed so as to allow the evaluation of the incidence of each practice over each ES in a qualitative way through a Likert scale. Finally, we can estimate the overall contribution of practices raised in the generation of ES. Steps followed in the application of the Delphi method can be summarize in 5 phases (**Figure 1**). Surveys with experts are to be conducted in January and February 2020. A group of 50 experts has been pre-selected with diverse backgrounds and expertise on the different components of silvopastoral systems while looking for a well-spread geographically represented sample.

Expected results can complement empirical data in quantifying the effect of management practices on ES supply while shedding light in ES trade-off dynamics and contribute to identify knowledge gaps (typically characterized by lacks of consensus in experts' opinions) where more research is needed. Furthermore, our results can support decision-making processes for articulation of land use-polices based on Payments for Environmental Services incentives in silvopastoral systems that enhance the provision of the ES bundle more suited to each situation.

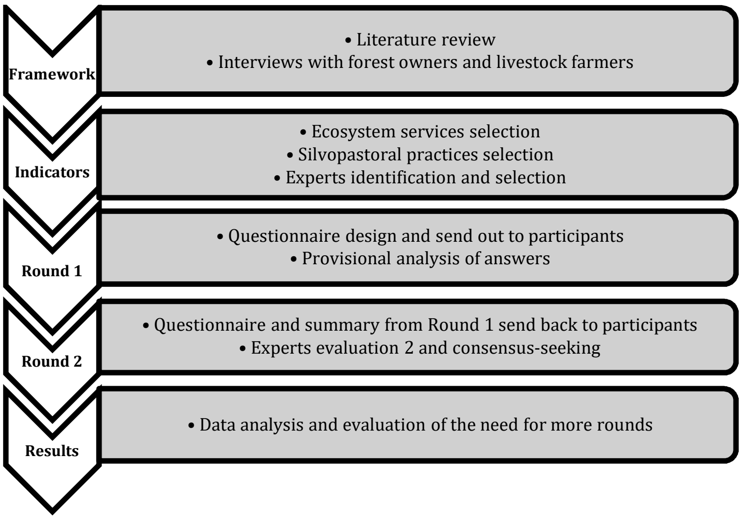

Figure 1. Delphi process scheme applied in this study.

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The hidden land conservation benefits of olive-based (Olea europaea L.) landscapes: An agroforestry investigation in the southern Mediterranean (Calabria region, Italy)

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: agricultural landscape resilience, multifunctional agriculture, polycultural permanent crops, sloping land, soil organic carbon

Abstract

The Mediterranean region is a system with many different landscapes as the result of the complex, long-lasting interactions among its peculiar geographies, its heterogeneous biotic and abiotic environments, and its human societies. Olive groves are identity-associated agroecosystems in the Mediterranean area; they combine the rural landscape with a multiplicity of assets, from traditional agroforestry systems to specialized tree crops. Agroforestry systems are widespread throughout all of Europe, primarily in the Mediterranean basin, and they represent a characteristic element of the Italian landscape. Agroforestry systems are traditional land uses, and they are highly multifunctional, combining agriculture, silvo-pastoral activities, and the conservation of consistent elements of natural capital from grassland to shrubs, and tree species.

In Italy, agroforestry systems cover approximately 106,000 ha, representing 0.4% of the total territorial area, most of which (approximately 90,300 ha) is based on permanent tree crops such as fruit trees, tree nuts, and olives. In this context, olive-based agroforestry systems are characterized by traditional structural traits such as their low planting density (<250 plants ha−1), low yield, and low agronomic input requirements (an absence of irrigation and a low degree of mechanization owing to manual harvest). Olive-based agroforestry systems are typical of Italian land. They are characterized by low tree spacing and include other crops such as cereals, citrus, grapevine, and so forth and the presence of ancient, tall (up to 30–35 m) olive trees. Italian olive groves contribute to 26% of all EU olive production (EU, 2016) and make up 51% of total olive growing areas in marginal and disadvantaged zones (mountainous and hilly steep slope areas and inner lands). Southern Italy exhibits a multifaceted olive landscape, with Olea europaea being one of the most characteristic species and crops of the Mediterranean basin. Southern Italian regions produce almost 88% of all olive oil production of the country, 33% of which comes from the Calabria Region (the extreme southern peninsula). Moreover, thirty percent of Italian olive groves are in areas with difficult orographic conditions such as steep slopes, while most of these olive orchards are located in Southern regions, particularly Calabria.

The research aims to describe the environmental functions of traditional olive agro-forestry systems in this southern Italian region, Calabria. The study area can be considered as a model zone for semi-arid Mediterranean land studies. In this context, through a Geographic Information System (GIS)-based

approach, the thematic layers of land degradation factors (i.e., landslides, fire occurrence, and land use changes) were analysed at the municipality level to (a) identify the land use dynamics over a 20-year time interval (1990–2012) and (b) quantify the ecological functions of traditional olive grove assets in comparison with the modern ones at the landscape and soil levels.

Therefore, Calabria region can be considered as a model area for studying the role of Olea europaea in preserving Mediterranean territory, soils, and landscapes. This land exhibits great variability in its physiographic traits, such as climate, geology, and orography, showing a highly heterogeneous agricultural landscape as the result of the environmental transformation wrought by farmers for productive purposes.

To quantify the environmental benefits of traditional olive grove systems in marginal study area, namely olive-based agroforestry systems, thematic maps have been used at the regional level to analyse land use changes, soil consumption, landslide susceptibility with respect to the slope gradient, wildfire occurrence, and the soil organic carbon in the topsoil layer.

In this typical Mediterranean context, the land change survey showed that the most significant land-use surface increment occurred towards the re-naturalization of olive groves after agricultural abandonment, with an increase of transitional woodland/shrubs, agro-forestry olive systems. At the same time, the expansion of artificial areas (urban sprawl) was observed, supporting the evidence for a bi-faceted erosion process of olive groves, that is, urban expansion, from one side, and the agricultural extensification towards agro-forestry olive agro-ecosystems, as also found in other traditional Italian olive growing areas such as Tuscany. Meanwhile, intensive, and super-intensive olive tree cultivation presently represents less than one-fourth of the total olive agrosystems. In addition, the maintenance of agricultural management on steeper slopes contributes to the preservation of the landscape quality, particularly in hilly and low mountain areas. The results of the land metric analysis show that olive-based poly-cultural landscapes are characterized by high complexity and lower fragmentation (low patch density value) in comparison with specialized olive landscapes (high patch density value).

In this territory, in the inner sensitive and marginal areas (steep slopes, higher elevations), olive-based poly-cultural systems are prevalent and resilient. In both specialized and polycultural olive agrosystems, fragmentation showed an increasing trend at higher slopes, where agricultural abandonment is more diffused, and for lower elevations, where soil consumption related to urban expansion can be widespread. For mid elevations, that is, around 300 m a.s.l., and moderate slopes, that is, 20%, the patch density values were the same for any kind of olive agrosystem, indicating that this type of land management had the greatest agro-ecological resilience.

Traditional olive landscapes based on traditional cultural practices, such as agroforestry, which represents key agro-ecosystems for counteracting land degradation and preserving environmental quality, particularly when managed systematically. This investigation showed that these systems could prevent critical land degradation phenomena, particularly in the most vulnerable areas such as the steeper slopes, while safeguarding soil health by assuring the resilience of a high-quality landscape that is rich in natural capital.

Therefore, traditional olive-based agrosystems require special attention from European and national legislation because they provide many hidden environmental benefits or ecosystem services including supporting, provisioning, regulating, and cultural services. They can therefore be considered as crucial cropping systems in marginal and sensitive Mediterranean areas.

Plant diversity and ecosystem services of silvopastoral Mediterranean agroforestry systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Biodiversity, Carbon stock, cork oak, Wooded grasslands, Pastoral Value, Plant richness

Abstract

The biodiversity and ecosystem services of Mediterranean agroforestry systems emerge from the interaction between forestry, pastoral and agricultural activities and natural ecological processes. The Savannah-type wooded grasslands such as Dehesas in Spain or Montados in Portugal are generated from large scale grazing systems with an even distribution of adult trees scattered in grasslands or cereal crops. This habitat is listed in the habitat directive of the European Union and is threatened by the lack of tree regeneration (Rossetti and Bagella 2014). In other Mediterranean regions, agroforestry landscapes are a mosaic of woodlands (WL), wooded grasslands (WG) and open grasslands (OG) or other crops (e.g. vineyards), in a fragmented land ownership that is now evolving towards intensification or abandonment.

The hypothesis of this research is that biodiversity and ecosystem services of Mediterranean agroforestry systems based on silvopastoral activities, can be enhanced shifting from the even distribution of the scattered tree layer to a patchy pattern generated by different land use intensities. We synthesize here the results of a decade of integrated assessment of plant biodiversity and ecosystem services and compare different land use scenarios in a diversified agroforestry landscape. We also provide evidences to support biodiversity conservation resulting into multiple ecosystem services.

The study area is the long-term observatory of Berchidda-Monti (NE Sardinia, Italy) at 250-350 m a.s.l. with an average annual rainfall of 632 mm (70% between October and March), a mean annual temperature of 14.2 °C and sandy soils of granit origin (Typic Dystroxerept). The area is characterized by a mosaic of grazed OG or WG with scattered cork oak trees, cork oak WL and vineyards. The potential vegetation is relatively homogeneous and framed within the *Violo dehnhardtii-Quercetum suberis association* (Bagella and Caria 2011). OG are grazed by dairy sheep and beef cattle (0.2 – 1.5 livestock units ha^{-1}): OG and WG are managed with shallow ploughing, fertilization and seeding of annual hay-crops at 2 to 10 years intervals depending on land use potential, tree cover and the dynamics of the semi-natural vegetation between two subsequent seeding. Biodiversity and ecosystem services were assessed across a land use intensity gradient: WL including cork oak forest (WLu) and clearings (WLo) with a total of 89% tree cover; WG including grasslands (WGo) and scattered cork oak trees (WGu) with 27% tree cover; OG represented by grazed grasslands without tree cover. The three land uses were assessed on large sampling areas (>3 ha) to prevent interferences from edge effects, so that the data collected in each land use can be used as the basis for constructing different spatial land use scenarios. Plant diversity data were collected on a total of five sampling positions (WLu, WLo, WGu, WGo, OG) and nine replicates per sampling position. In each sampling area, data on species richness, species unique to a single position, α, β and γ plant diversity was assessed on 2 m x 2 m to 10 m x 10 m quadrats depending on vegetation types. The Pastoral Value (PV, Daget and Poissonet 1971), the cover of

excellent and very good forage species (Bagella et al. 2013), the legume species cover, the hemicryptophytes cover, the vegetation nectariferous value (Bagella et al. 2014) and the C stock in soil and live trees were assessed in the five sampling areas as proxies of a wide range of provisioning, regulating and supporting ecosystem services. The collected data were used to compare different scenarios that may arise either from abandonment (WL) or intensification (OG) or from the conservation of the current tree cover arranged as an even savannah-type ecosystem (WG), the net separation of WL and OG ("Specialized") or a mix of different land use intensity ("Combined") in the same area (50% WG, 36.5% OG and 13.5% WL). To facilitate the multidimensional comparison, variables were standardized and expressed in standard deviation units.

The "combined" and "specialized" scenarios showed higher plant diversity indices than savannah-type WG or OG ecosystems. The provisioning services based on PV and the cover of excellent and good forage species were highest in the OG. The supporting services based on nectariferous species were highest in the WL, but those based on legume species cover was highest in the OG. The regulating services based on hemicryptophytes cover and organic C stock were highest in the WL. The "combined" scenario showed a maximum of plant diversity (γ diversity and number of species unique to a position) and a balanced between biodiversity and ecosystem services. The plant diversity and ecosystem services of the WG ecosystem, whose resilience is related to a combination of conservation and pastoral activities, was on average lower than that of a "specialized" scenario, which is considered a best option when the priority is to develop extensive grazing systems. The "combined" scenario would be a best option in the perspective of enhancing plant biodiversity and supporting or regulating services. These results proved that biodiversity and ecosystem services can be enhanced at landscape scale with respect to the WG with an even distribution of scattered trees, by combining a patchy pattern of specialized land uses.

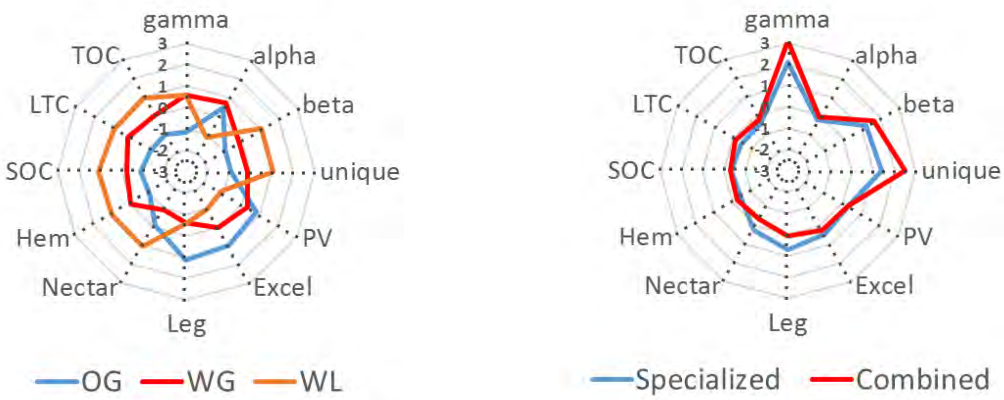

Figure 1. Biodiversity (γ, α and β diversity; unique = no. species unique to a position) and ecosystem services indicators (PV = pastoral value, Excel = cover of excellent forage species; Leg = legume species cover; Nectar = nectariferous species cover; Hem = hemicryptophytes; SOC = soil organic carbon; LTC = Living tree carbon; TOC = total organic carbon) of the three land uses (OG = open grasslands, WG = wooded grasslands; WL = woodlands) and the two scenarios (Specialized: 27% WL + 73% OG; Combined; 13,5% WL; 36.5% OG; 50% WG). Values expressed in units of standard deviation.

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Distribution and nutrient content of poplar fine roots in an agroforestry crop alley in Northern Germany

(Style: Title abstract)

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Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems (Style: please select the conference theme)

Keywords: Fine roots, poplar, short rotation, crop alley, nutrients (Style: keywords)

Abstract (STYLE: Heading Abstract)

In the transition zone between tree strip and crop alley of short rotation alley cropping agroforestry systems (ACS), trees and cultivated plants are interacting with each other in a diverse manner (Smith et al. 2012). Above all, below-ground processes in this zone could have a decisive impact on complementarity and competition in the whole agroforestry system (Noordwijk et al. 1996). The interactions between roots of the fast-growing trees and the cultivated plants as well as root-soil interactions are important processes in ACS. In general, coarse roots differ from fine roots: Coarse roots are long-lasting and responsible for the stability of the tree, whereas fine roots are important for the uptake of soil nutrients and water (Lukac 2012). Due to their short life-time and fast decomposition, fine roots play an important role for nutrient cycling in ACS. In this study, we assessed the horizontal and vertical distribution of the poplar fine roots in a crop alley of an ACS in Northern Germany. Furthermore, we analysed the nutrient composition of the poplar fine roots and calculated the potential nutrient input into the soil of the crop alley.

Our study was conducted at a 10-year old ACS, located near Braunschweig. It consists of 9 tree strips (12 x 225 meters) of fast-growing poplars, 5 narrow (48 x 225 meters) and 3 wide (96 x 225 meters) crop alleys. Our study was carried out at one of the wide crop alleys, where winter wheat was grown during soil sampling. In June 2018, fine roots of the poplars were sampled using drill cores with diameters of 8 cm. Three replicates each were taken at a distance of 0, 1, 2, 3, 4 and 7 m from the tree strip and up to a soil depth of 160 cm. In the laboratory, the drill cores were divided into 10 cm sections. Poplar fine roots with a diameter of ≤2 mm were separated manually, washed with distilled water and dried at 60 °C. After two days, the mass of the poplar fine roots was determined. To quantify their nutrient composition, the fine roots from all distances and replications were combined into a mixed sample and ground in a mortar. The analysis of the nitrogen content of fine roots was carried out with Elementar Vario Max Cube (Elementar, Hanau, Germany). Calcium, potassium, magnesium and phosphorus were determined by ICP-OES (Thermo Fisher Scientific, Waltham, USA).

Generally, biomass of poplar fine roots decreased with increasing distance from the tree strip and soil depth (figure 1). About three quarters of the poplar fine roots were found close to the tree strip at a distance of 0 m. From a distance of 4 m, no tree fine roots were found in any of the drill cores. Close to the tree strip at a distance of 0 m, most poplar fine roots were found in the uppermost section (0-10 cm), whereas at 1 m from the tree strip, a higher mass of the poplar fine roots was determined at depths 20-30 cm, 40-50 cm and 140-150 cm than in the uppermost section. According to these results, the potential nutrient input through the poplar fine roots also decreased with increasing distance from the tree strip

and soil depth. Among the analysed nutrients, the calcium content in the roots was highest (2.08%), followed by potassium (0.70%), nitrogen (0.65%), magnesium (0.24%) and phosphorus (0.16%).

As poplar fine roots were detected mainly close to the tree strip, we do not expect any substantial nutrient input to the crop plants. Furthermore, competition for water and nutrients between crops and trees might be low. However, for the trees themselves that do not receive any fertilizer, poplar fine roots can be an important nutrient source and part of the nutrient cycle within the tree strip.

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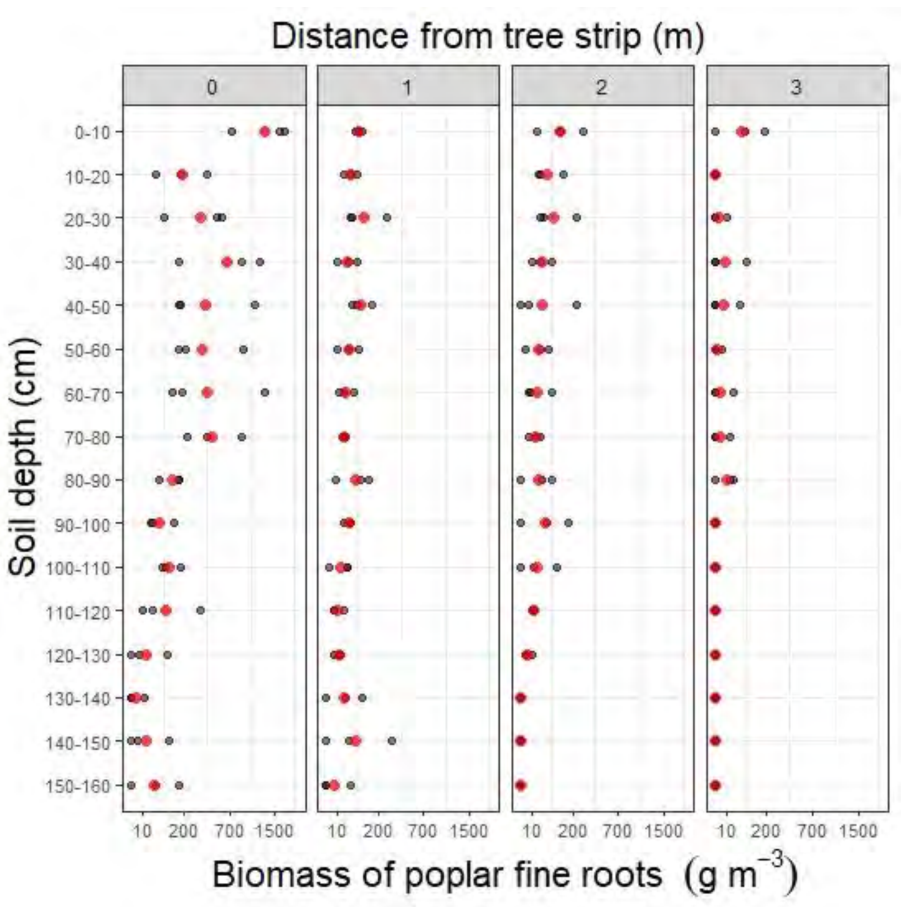

Figure 1. Biomass of poplar fine roots at different soil depths and distances from tree strip in the investigated crop alley. Grey dots denote single biomass values of three replications, whereas red dots denote average biomass values at the respective distance from the tree strip and at the respective soil depth.
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Defining research priorities in complex Agroforestry systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: decision analysis, value of information, EVPI, uncertainty

Abstract

Agroforestry systems are notoriously complex and interventions to them are fraught with uncertainties. In our work we apply decision models to simulate intervention outcomes (Luedeling et al. 2019). One useful output of this decision analysis approach is the calculation of the Expected Value of Perfect Information (EVPI), which can be useful for defining research priorities (Hubbard 2014). EVPI quantifies the potential gain in the units of an output variable of a projection model given accurate knowledge on the value a tested input variable will take. EVPI can help identify those variables for which more information would maximize the model output (Lanzanova et al. 2019). When the output variable is monetary, the EVPI can be interpreted as the highest price that decision makers should be willing to pay for perfect information (Hubbard 2014).

EVPI is calculated as the difference between the expected value of the outcome variable (EV) given accurate knowledge on the value the tested input variable will take (perfect information; PI) and the expected maximum value (EMV) of the outcome variable given only knowledge about the probability distribution of the input variable (imperfect knowledge) (Strong et al. 2014): ***EVPI = EV|PI - EMV***

To calculate EVPI with discrete probability distributions we provide an example of investment in the stock market vs. deposits (bonds) in Figure 1 (left):

The expected value of deposit investment *Expdeposit* is calculated as the probability of different states of the economy (x-axis) times the expected loss or gain in each condition (y-axis): ***Expdeposit: 0.2 · 500 + 0.3 · 500 + 0.5 · 500 = 500***

Likewise, the expected value of stock investment Expstock is the probability of each possible state of the economy (x-axis) times the expected losses or gains (y-axis): ***Expstock: 0.2 · -800 + 0.3 · 600 + 0.5 · 1500 = 680***

Because Expstock is the more likely decision to result in a gain it is referred to as the Expected Maximum Value EMV.

The expected value of the decision given perfect information EV|PI prior to the decision is calculated as the sum of all the best options (always making the more gainful choice) multiplied by the respective probabilities: ***EV|PI: 0.2 · 500 + 0.3 · 600 + 0.5 · 1500 = 1030***

The Expected Value of Perfect Information (EVPI) is then calculated as the difference between the decision given perfect information *EV|PI* and the Expected Maximum Value EMV: ***EVPI: 1030 – 680 = 350***

Knowing the direction the market will go (having perfect information) before making our decision would help us take the best decision here. We should be willing to pay up to 350€ for perfect information on the future state of the economy.

To calculate EVPI with continuous probability distributions we provide an example of an agricultural decision to apply fertilizer In Figure 1 (right). We assume that the nutrient content of the soil will follow a normal distribution and that the additional gain in yield under the decision not to apply fertilizer will remain constant (green line). Therefore the expected gain for the decision to not apply fertilizer is simply zero. When applying fertilizer the effect on additional gain is negatively correlated with the nutrient content of the soil and at a certain level causes losses in yield due to toxic effects (dashed red line).

To calculate the expected gain in yield when applying fertilizer, we multiply the dashed red line with the normal density distribution (analog to multiplying the gains and losses with the probability of the market going in the respective directions in the previous example). For the resulting weighted response (red line) we add up the areas under the curve: A-B. As the positive part A is greater than the negative part B, the expected value of applying fertilizer has a small positive value. Therefore, applying fertilizer is the decision with the expected maximum value EMV under imperfect knowledge.

The expected value given perfect information EV|PI is equal to A, because up to the nutrient content, where the line intersects zero, the best decision is to apply fertilizer, but for higher nutrient contents no fertilizer should be added. The EVPI is then again calculated as the difference between EV|PI and EMV.:
EVPI: A – (A-B) = B

The empirical_EVPI() function in R's decisionSupport library (Luedeling et al. 2019) calculates EVPI for a simple model with continuous data like the one above. The multi_EVPI() function does the same with more complex models with multiple variables.

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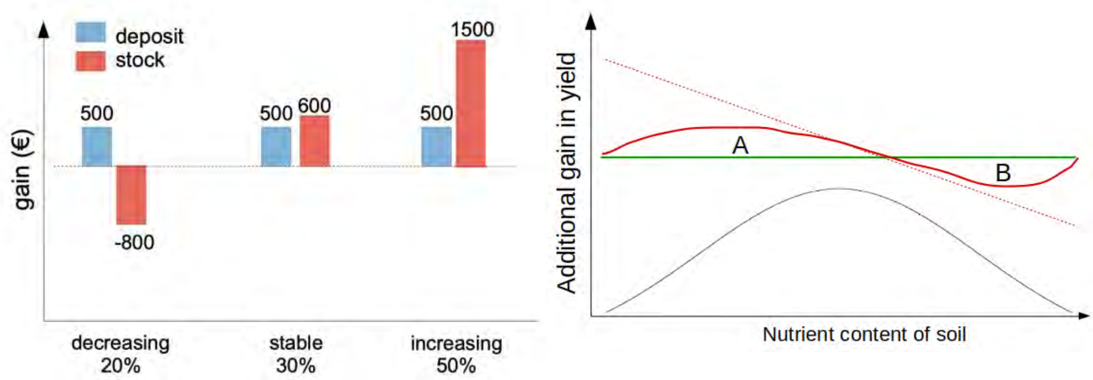

Figure 1. Example of EVPI calculated for investment in the stock market vs. deposits (left) and an agricultural decision to apply fertilizer (right).

Studies on the diversity of the bacterial community associated with symbiosis between *Tuber borchii* and *Quercus ilex* in different Sardinian forest

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Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: T. borchii, microbial communities, soil microbiology

Abstract

In agroforestry, ectomycorrhizal complexes are particularly important since they establish mutual relationships that are often essential for the survival of one, or both, symbionts. The symbiosis results in beneficial effects for the fungus, mainly the immediate availability of energy, that allows it to complete the biological cycle; while, on the other hand, the plant reinforces its resistance to abiotic and biotic stresses, in the short and medium term. As a result, the plant maintains an optimal physiological, vegetative and sanitary state, even in the presence of adverse environmental conditions. Recent studies on mycorrhizal symbiosis have revealed an ecological relationship (direct or indirect) between mycorrhizal symbiosis and other terrestrial microorganisms, such that it allows to hypothesizing a co-evolution among fungus, plant and bacteria, the three main elements of this symbiosis, being regarded as tripartite (Desirò et al. 2015). This study provides a characterization of the physical-chemical and microbiological differences of two *Tuber borchii* truffle grounds, in two holm oak woods, which have very similar climate and vegetation characteristics, but grow on soils having a different rock matrix. The two sites were respectively named SAG for the forest located in the northern part of the island on granite substrate, and LSF for the one located in the middle of Sardinia on a dolomitic substrate. The following samples were taken in: Granitic Soil Bulk (GSB), Granitic Soil Ascocarp (GSA), Granitic Ascocarp Peridium (GAP), Granitic Ascocarp Gleba (GAG), Calcareous Soil Bulk (CSB), Calcareous Soil Ascocarp (CSA), Calcareous Ascocarp Peridium (CAP) and Calcareous Ascocarp Gleba (CAG). The chemical-physical analysis of the two bulk soils were performed. The microbial communities of the two soils have been characterized through the Ecoplates™ Biolog®, assessing the community level physiological profiling (CLPP). To evaluate possible quantitative/qualitative differences between the bacterial cultivable component of the sampling sites, different studies were conducted. The microbial community of soil samples was taxonomically estimated by sequencing the rRNA of the 16S region (184 bacterial isolates). The ascocarps microbial community was evaluated via GEN III™ Biolog® system, running a phenotypic identification based on the metabolic profile of the bacterial isolate (36 isolates). The results obtained from physical-chemical analyses of the soil samples highlighted a major difference between the two truffle grounds. As a matter of fact, the soil of the SAG site showed a sandy-silty texture with a sub-acid reaction (pH 5.7 ± 0.23). On the contrary, the LFS area showed limestone soils with a basic reaction (pH 8.03 ± 0.27). Furthermore, statistically significant differences were found for all the chemical parameters, except the quantity and type of organic substance. This confirms the high adaptability of the *Tuber borchii,* that grows in a large variety of soils (Raglione and Owczarek, 2005). The total values of the microbial count showed no substantial difference in the forest soil samples of the two sites (≈10^7 cfu/g) after 96 hours of incubation. Despite the major pedological differences, the two microbial communities have a very similar metabolic footprint. Indeed, no index calculated on the Ecoplates™ data showed significant differences. However, from the bacterial isolate identifications, a

wide biodiversity was observed in both colonies, with considerable differences in the taxonomic composition. In particular, the cultivable isolates detected at the SAG site belonged to the following classes: Bacilli (41.38%), *Betaproteobacteria* (20.69%), *Alphaproteobacteria* (10.34%), *Flavobacteriia* (10.34%), *Gammaproteobacteria* (6,90%), *and others (10.35%)*. On the other hand, identification of the cultivable isolates from the LSF site gave the following results: *Bacilli* (34.38%), *Actinobacteria* (18.75%), *Alphaproteobacteria* (15.63%), *Betaproteobacteria* (15.63%), *and others (15.63%)*. The study showed that the two microbial communities extracted from SAG and LSF soils, differ both in quantity and taxonomic composition, even if they show an undistinguishable metabolic profile and an equal functional biodiversity. Compositional differences were found also in the samples of ascomic soil. The identifications of GSA isolates display a dominance of *Gammaproteobacteria* (51.72%), followed by *Sphingobacteriia* (20.69%), *Betaproteobacteria* (17.24%), and others (10.35%). On the other hand, the isolates derived from CSA belong to *Alphaproteobacteria* (23.08%), *Gammaproteobacteria* (20.51%), *Bacilli* (17.95%), *Actinobacteria* (12.82%), *Betaproteobacteria* (12.82%), *Flavobacteriia* (7.69%) classes. Surprisingly in GSA no bacteria belonging to the *Alphaproteobacteria* were found, even if abundantly present in the relative forest soil, while in CSA, the *Sphingobacteriia* were not detected in the forest soil of the same site. Regarding ascomas, the total count values detected ($\approx 10^6$ cfu/g) is compliant with what is traditionally reported in the literature for *T. borchii* (Barbieri et al., 2005), and similar to other *Tuber* species (Gryndler et al., 2013; Rivera et al., 2010). However, the values detected in the peridium sampled in both sites have a higher microbial load (10^8 cfu/g). In accordance with the literature (Sbrana et al., 2002), the dominance of *Gammaproteobacteria* is observed and the *Pseudomonadaceae* family predominates in the peridium of all ascocarps. From a taxonomic point of view the following differences in the bacterial community were observed: among the soil samples of the two sites, between ascoma and ascomic soil and between ascomic and forest soil. The above-mentioned results confirm that every micro-environment detected in this study is an ecological niche that selects specific bacterial communities (Antony-Babu et al., 2014). Furthermore, PGPR (*Serratia plymuthica*, *Variovorax paradoxus*), saprophytes e mushroom pathogens (*Collimonas fungivorans*, *Pseudomonas tolaasii*) and human pathogens (*Inquilinus limosus* B, *Serratia plymuthica*, *Stenotrophomonas maltophilia*) were detected among the bacteria detected in the various ascomas. Additional studies are required to properly evaluate the ecological interactions between symbiotic partners.

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Study of residual effects of sewage sludge application in a silvopastoral system on soil bacterial communities using a high-throughput sequencing technology

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Ion-Touch, organic matter, pH, $CaCO_3$, Methanotrophic bacteria

Abstract

Agroforestry systems (AFSs) are considered sustainable forms of land management, but their impact on soil microbial biodiversity remains poorly understood. Soil microbes, particularly bacteria, are ubiquitous in forest ecosystems, where they play a critical role in ecosystem functions, such as the biogeochemical cycle and nutrient transformation for plant growth. Thus, a deeper understanding of how bacterial communities respond to AFSs, especially to different management regimes and edaphic gradients, is necessary for evaluating such ecosystem processes. Moreover, bacterial communities are known to quickly and strongly respond to changes in the environment and therefore are useful as bioindicators.

In this study, we describe the soil bacterial community in a silvopastoral system which was fertilised 16 years ago with different doses of sewage sludge (during for consecutive years: 2000-2004). The objectives were (i) to describe the community dominating the silvopastoral system and (ii) to describe the residual effects of organic fertilisation on those communities.

Soil samples were collected at the site of Parga, where different fertilisation regimes were applied in the year 2000 (during four consecutive years) in a silvopastoral system (*Pinus radiata* D. Don plantation combined with pasture production): two doses of sewage sludge (SS50 and SS100 corresponding to 50 or 100 kg N ha^{-1} respectively) were applied in March 2000 to six plots each. A second treatment was carried out to apply $CaCO_3$ at a rate of (2.5 Mg $CaCO_3$ ha^{-1}) to half of plots (SS50-$CaCO_3$ and SS100-$CaCO_3$). In October 2019, two replicate soil samples were collected at a depth of 25 cm at each plot. Samples of Non-fertilised plots (NF) were also collected. Soils were kept at 5°C until DNA extraction. DNA was extracted from 0.25 g of soil using a commercial extraction kit and sequencing of the V2-4-8 and V3-6, 7-9 domains of 16S rRNA genes was performed on Ion-Touch platform.

Regarding soil bacterial analysis, among 163,143 and 45,728 bacterial sequences were obtained after high-throughput sequencing. From these, among 27 to 47% of sequences were effectively assigned to a family level and among 3 to 13% were successfully assigned to a genus level. A total number of 23 phyla, 171 families and 151 genera were identified. Figure 1a shows the distribution of the most abundant phyla (%) among the treatments. The phyla Proteobacteria and Actinobacteria were shared among all

treatments (from 49 to 54% and from 19 to 22% respectively). A heatmap was carried out to observe the distribution of soil treatments according their composition at a genus level (using the most abundant bacterial genera (>0.5%) (Figure 1b). Although the three most abundant identified genera (*Burkholderia, Bradyrhizobium* and *Acidipila*) were equally distributed among the fertilisation treatments, bacterial structure at the genera level was influenced by soil treatments: NF were clustered separately from the fertilised soils. Moreover, both treatments including only organic matter application (SS50 and SS100) or organic matter together with $CaCO_3$ amendment (SS50-$CaCO_3$ and SS100-$CaCO_3$) were grouped separately among them. *Methylosinus* was found among the most abundant genera. This genus belongs to the family Methylocystaceae whose members are able to oxidise CH_4. Moreover, this genus seemed to correlate positively with soil pH, indicating that the soil treatments which increase pH can positively affect he abundance of these microorganisms. This result is in agreement with literature which shows that the optimum pH for methanotrophic bacteria is from neutral to slightly acidic, and more specifically, Benstead and King (2001) found that the maximum CH_4 uptake was at pH above 4.8. Finally, analysis of functional groups of organic matter are also currently being carried out and will also be included in the discussion of the data.

Soil diversity is key for maintaining soil functioning. In order to protect this diversity, it is important both, to describe the communities established in the different ecosystems, regions, etc (to be able to encompass the natural heterogeneity of these communities) and to study the effects of external changes (such as application of fertilisers) in these communities. According these results, the addition of organic matter combined with $CaCO_3$ seemed to be the most long-term effective treatment (either due to the stabilisation effect of $CaCO_3$ in the organic matter over time or due to the nutrient cycling between trees and soil). Finally, unravelling the parameters which can improve the presence of methanotrophs is important for the best practices recommendations in the establishment of these silvopastoral systems.

Acknowledgments. This study has been supported by the Strategic Researcher Cluster BioReDeS funded by the Regional Government Xunta de Galicia under the project no. ED431E 2018/09 and the Consolidation funds (2019-2022) of Xunta de Galicia. Vanessa Álvarez-López is grateful for the postdoctoral 'Juan de la Cierva-formación' fellowship (ref: FJCI-2017-32852) financed by the "Ministerio de Ciencia Innovacion y Universidades" (Spain)

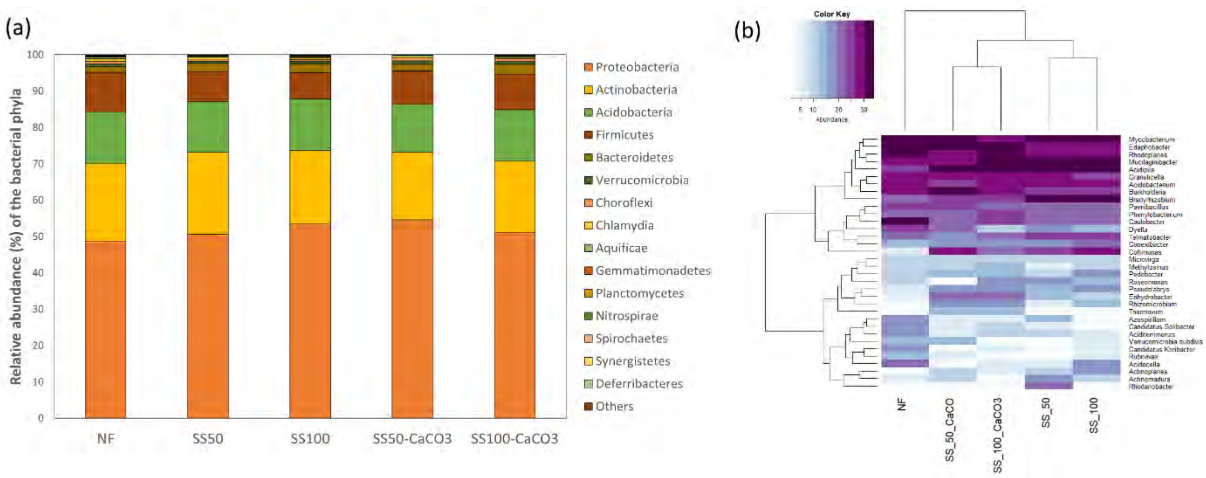

Figure 1. Composition of the bacterial phyla (a) and heatmap of the treatments distribution according their composition of the most abundant bacterial genera (b). NF (Non-fertilised soil), SS50 (Fertilisation with sewage sludge at a rate of 50 kg N ha^{-1}), SS100 (Fertilisation with sewage sludge at a rate of 100 kg N ha^{-1}), SS50_CaCO3 (Fertilisation with sewage sludge at a rate of 50 kg N ha^{-1}+ $CaCO_3$), SS100_CaCO3 (Fertilisation with sewage sludge at a rate of 100 kg N ha^{-1}+ $CaCO_3$)

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Ecosystem services assessment, financial performance evaluation, and exploration of opportunities for amplification of agroforestry: learning from a case study in Devon UK

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development

Keywords: Ecosystem services, soil organic carbon, economy, barriers, adoption

Abstract

Agroforestry is an old land-use system that combines trees or other woody perennials with agricultural production, whether is arable, pasture or both. Agroforestry increases and diversify agroecosystems productivity delivering ecosystem services (ESS) such as biodiversity habitat creation, carbon capture, and soil erosion control. Despite its multiple benefits, the number of farmers practicing this activity remains low, especially in the UK (Burgess, 2019). Several studies have documented the barriers and perceptions of farmers to adopt agroforestry (García de Jalón et al., 2018; Lovrić et al., 2018; Rois-Díaz et al., 2018) but there is a perceived lack of information that documents the adoption process itself for the specific case of agroforestry in temperate climates (Jara-Rojas et al., 2020; Ruppert et al., 2020). The Dartington Trust in Devon has pioneered the implementation of agroforestry systems under an integrated landscape management strategy that conciliates biodiversity conservation and food production needs. Seven agroforestry systems have been set up under different modalities going from multistrata systems, to silvoarable and silvopasture systems at different scale (Figure 1). This arrangement represents a unique opportunity to evaluate the effects of integrating trees in farms over the provision of ecosystem services and document the adoption process at landscape scale. Methods. A mixed research methodology is being used to evaluate the environmental and financial advantages of the practice and its impact in the adoption process. The research is divided in three sections, 1) the biophysical aspect of the project is aimed to document the carbon content in soil as a response to the introduction of trees in farms, 2) the financial section is aimed to calculate the Land Equivalence Ratio of agroforestry. Bot sections use a comparison between agroforestry and conventional agriculture to evaluate environmental and financial benefits of practicing agroforestry. The 3) social section is designed to understand the role of ecosystem services provision in supporting the adoption process for agroforestry. Soil samples have been collected in one of the agroforestry plots, at different distances and depths from the trees to evaluate soil carbon content as an indication of the provision of ecosystem services, and total yields for the agroforestry and conventional farming plots are being recorded to calculate the LER. To identify the drivers for adoption and the impact of the variables mentioned before, semi-structured questionnaires are being applied to document the agroforestry adoption process amongst practitioners in the region, and at national scale. The results of the questionnaires will be compared at different regions to evaluate the drivers that influence adoption in different contexts. Preliminary results shown that soil parameters are not

significantly different between distances nor depths in the silvoarable plots, but soil compaction is lower in the agroforestry plot when compared with the conventional arable fields, particularly nearer the trees where existing understory strips are present and soil disturbance is minimised. Comparison between agroforestry and conventional total yields have not shown significant differences in the first year which can be explained by the low yield of young trees after the initial tree establishment in the agroforestry field. These results show the need to collect additional data to quantify LER in the medium term, and long-term soil carbon stocks.

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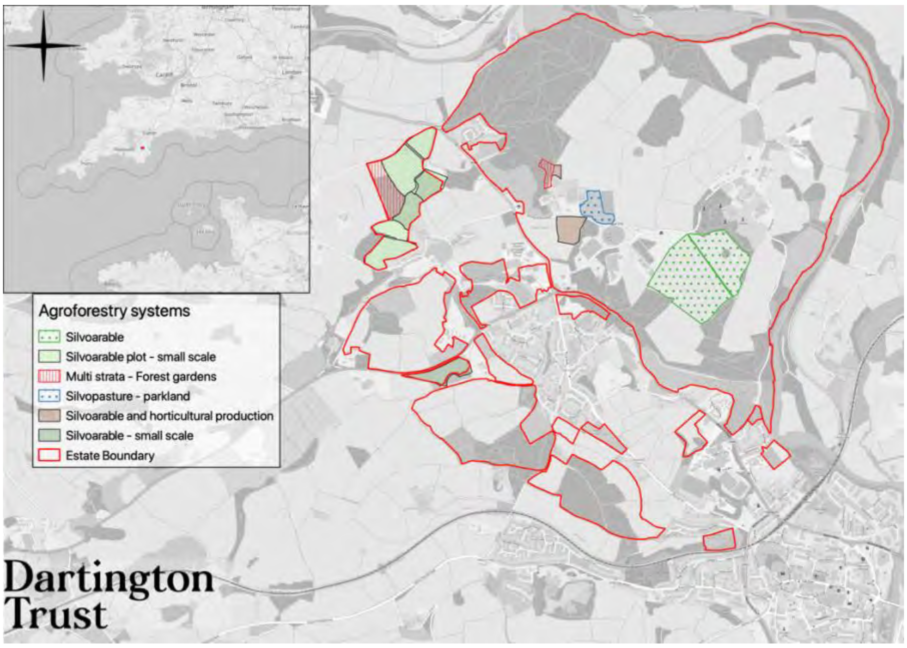

Figure 1. Agroforesty systems at the Dartington Estate, Devon UK.

What agroforestry is at the service of the restoration of a Camargue riparian forest? - Case study of the Psalmody riparian forest (Gard - Occitanie)

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: riparian forest, Camargue, ecological engineering, ecological connectivity

Abstract :

Title : What agroforestry is at the service of the restoration of a Camargue riparian forest ? - Case study of the Psalmody riparian forest (Gard - Occitanie)

Introduction
The restoration and preservation of the strategic ecotones that constitute the edge of watercourses with regard to the different ecosystem services rendered is a fundamental issue for different actors sharing these spaces. The article looks at the strengths and different contributions that the agroforestry approach can represent, both as possible complements to traditional ecological engineering.
The Camargue region is crossed by a large network of rivers and irrigation canals near which intensive cultivation is practised (rice cultivation, viticulture, arboriculture…) having very significant impacts on these sensitive areas (degradation of biodiversity, water pollution, development of invasive plants, etc.). Agroforestry can constitute another tool for the restoration of these ecosystems, available to the various riparian users of these spaces.

Since 2016, an experimentation area (Psalmody - Gard) has been entrusted and managed by a design office specializing in ecological engineering. The area stretches for about 2,500 km in length along a bank of the Vistre canal bordered by various agricultural plots (viticulture rice, cereal crops, pasture and cattle farming..). There are various signs of ecosystem degradation: very discontinuous wooded cordon, low specific diversity, in particular very limited tree cover, presence of invasive plants, water pollution etc.

Methodology: A review of the selected existing documentation was carried out, as well as studies already carried out on similar areas, on the site and managerial experience on pilot sites,

Results:
The challenges of restoration:
- **Fight against invasive species**: manual uprooting is the only way to mitigate Uruguat primrose willow (*Ludwigia grandiflora*): a very abundant invasive plant in this area, threatening the ecosystem, depriving the aquatic flora and fauna of sunlight and oxygen. The installation of a wooded cord with the development of a large root network partially can limit its installation in a sustainable and cheaper way.

- **Improve local biodiversity:** many riparian forest's species are scarce or not present. The fragmentation of the environment limits the presence of characteristic and subservient animal species. The establishment of agroforestry systems can promote ecological continuity between the riparian part and agricultural areas and helping to maintain a significant local and specific bird life (Blondel, 2003).

- **Limit contamination of the watercourse:** Canal water is contaminated by different sources of pollution (domestic and agricultural) : significant rate of sediment after rainy episodes brought by water erosion, high nitrate concentrations in the canal waters, heavy metals detected by recent analyzes.

With which agroforestry systems?
The choice must take into account different criteria, both agronomic and ecological. The diversity of activities and profiles of operators leaves a certain breadth in terms of proposals that can be adopted. It must take into account different climatic and agroecological limit: shallow brackish and salt water bevel (between 3 and 5 m deep) and a

deeper sheet of fresh water (between 20 and 25 m), recurrent risks of flooding, significant wind exposure, frequent drought episodes.

On the banks

- Replanting and reforestation: For the moment, this is the only intervention carried out in the area. The cost of interventions is a determining factor.

- Supporting natural regeneration: Letting regeneration dynamics develop, with natural seedlings of ash trees and other species present for example, could be another option. It can be accompanied by additional plantings, in particular shrubs to densify and stratify the afforestation.

On agricultural plots

- Multifunctional hedges: with several functions and not only ecosystem (micro climate, anti-erosion.), producing fodder (with local forage species such as ash) fuel wood, and biomass.

- Short or very short rotation infill coppice: The use of native species and also differentiated management (by age) limiting clearcutting could improve the ecological interest of this agroforestry system.

- Alley cropping with wood species : possibly implemented on cereal plots and arboriculture. Attractive yields with suitable species and hybrids selected for their growth speed could be expected with favorable agro-pedological conditions..

- Sylvopastoralism: The regeneration of small wooded areas could significantly improve ecological connectivity. However the cost of an artificial regeneration can be dissuasive for the breeders. Defending natural regeneration zones or establishment of N / S oriented fodder tree rows could also be considered.

Arguments favouring adoption by farmers:

- Improve local climatic conditions: to compensate for the area's sensitivity to climate change and extreme phenomena, drought, heat wave, wind, etc.

- Promote water continuity over the surface horizons: recent episodes of heat waves and drought reinforce the importance of maintaining a certain humidity in the surface soil horizons for annual crops.

- Encourage culture auxiliars : Local avifauna play a big role in the predation of pests, especially with regard to arboriculture (Ctifl, 2000), insectivorous and raptor passerines. The presence of diverse habitats plays an essential role. Other crop auxiliaries can be favoured.

- Diversify production: these different agroforestry proposals can diversify current production, in addition to the ecosystem services rendered: mainly biomass energy and timber production.

Discussion and conclusion

- Towards the development of a selection matrix: a decision matrix for the choice of agroforestry systems could be developed to guide discussions and consultation with the farmers.

- Monitoring and evaluation tools: For each of the predefined selection criteria, we will identify a series of indicators and a monitoring and data acquisition protocol that can be implemented in the near future

- Numerous and important perspectives: given the extent of the network of canals and rivers, and the ecological importance of these environments, the search for complementary solutions to restoration by ecological engineering, accessible and adoptable by farmers has a major stake

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FOOD FOR FOREST – Restorative Silvi-Pastoralism: the Food that Feeds the Forest

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry system

Keywords: Degraded forests, grazing, pigs, swine, temperate hill forests

Abstract

Silvi-pastoralism is a well-known practice for the exploitation of managed ecosystems encompassing woodlands, shrublands, and grasslands (see for instance Mosquera-Losada et al., 2009). Particularly, it can be proficiently used for an effective restoration of marginal and degraded pastures and forests, by enhancing the related ecosystem services (i.e. forage and wood provision, biodiversity, carbon storage, erosion control, fire hazard reduction, and landscape and recreation) while maintaining or improving the economic returns for farmers (Torralba et al. 2016; Moreno et al. 2018). Among livestock species farmed in silvi-pastoral systems, pigs are widely spread in many Mediterranean regions of Europe (Caballero et al. 2011). Indeed, their grazing behaviour is particularly suitable for an optimal exploitation of the understory of Mediterranean and temperate forests, where they can feed on tree (especially Fagaceae) fruits, green leaves of coarse plants (like wild-bramble), plant underground organs, etc. (Ferraz de Oliveira et al. 2013).
'Food For Forest' is a pilot project founded by the Rural Development Program (operation 16.2) of Piedmont Region (NW Italy) aiming to evaluate the effectiveness of semi-free range grazing pigs in forestlands as a pastoral and silvicultural tool for the restoration and valorisation of degraded temperate forests. This general aim includes different specific objectives. First, the mitigation of the effects of land fragmentation through the creation of land consolidation associations (according to the regional law in force, L.R. 21/2016), and the involvement of local public and private landowners. Second, the restoration of some degraded woodlands, through coarse plants and wild-bramble control using grazing pigs, thus encouraging the return to an active silviculture. Third, the enhancement of forest biodiversity, which benefits of an improved fertility due to livestock dung and urine deposition, and the reduction of alien and invasive species due to pig feeding selection. Last, the growth and fattening of pigs through a low-cost feeding resource.
The study has been established in two semi-abandoned hill stands, for a total of 18.5 ha, characterised by a poor provision of their ordinary ecosystem services. Two land consolidation associations were created, as to ensure continuity after the project. In each of them, 20 barrows (Nero di Parma) exploited the stands with rotational grazing system from April to December. From the beginning of the project, in 2017, the following activities have been carried out: i) evaluation of feeding selection of grazing pigs on herbaceous, shrub, and woody vegetation; ii) monitoring of swine health and performances; iii) involvement of public

and private owners in land consolidation associations; iv) evaluation of economic sustainability of the pilot project; and v) creation of local supply chains for swine and woody derived products.

Pig feeding selection was assessed during 12 surveying dates through direct observations. For each monitored pig, a complete list of both available and grazed plant species was recorded at three-minutes intervals. A total of 840 surveys was carried out and the 33 most common plants were classified as either preferred, indifferently consumed or avoided species, according to Manly et al. (2002) preference index. The analysis revealed four preferred (namely, *Corylus avellana, Hedera helix, Robinia pseudoacacia,* and *Rubus* spp.), 13 indifferently consumed (*Acer campestre, A. pseudoplatanus, Castanea sativa, Clematis vitalba, Cornus sanguinea, Fraxinus excelsior, Humulus lupulus, Molinia arundinacea, Parietaria officinalis, Prunus avium, Sambucus nigra, Tamus communis,* and *Ulmus minor*), and 16 avoided (*Asphodelus albus, Carex sylvatica, Crataegus monogyna, Euonymus europaeus, F ornus, Ligustrum vulgare, Lonicera caprifolium, Physospermum cornubiense, Quercus cerris, Q. pubescens, Q. robur, Ruscus aculeatus, Solidago gigantea, Viburnum lantana, Vinca minor,* and *Viola riviniana*) species.

A silvicultural renovation cut was carried out, removing 64.4 m^2 ha^{-1} (35.9% on the total available stock). The effects of feeding selection on post-cut tree resprouting were monitored on 99 stumps mainly belonging to the following species: *C. sativa*, *C. avellana*, *F. ornus*, *P. avium*, and *R. pseudoacacia*. A total of 1045 sprouts were monitored through time (seven recording dates) to assess the effect of swine feeding on plant health (signs of grazing on buds and leaves) and growth (height measurements). The evidence of the grazing pressure increased through time. In early spring, 10% of sprouts showed grazing signs, while in late summer 45% of sprouts were damaged. Initially, grazing affected selectively the buds, in particular of *C. sativa* and *C. avellana*, while later pigs fed on both buds and leaves. *F. ornus* and *R. pseudoacacia* were less affected than other species and at the end of survey only 4% and 20% of the shoots of these two species displayed grazing signs, respectively. Sprout height growth was remarkably conditioned by grazing since the average stump height of most species remained unvaried from May to August and below 20 cm. A progressive growth through time was observed only in *F. ornus* (average height of 54 cm in late summer) and *R. pseudoacacia* (average height of 188 cm in late summer) resprouts, highlighting a reduced grazing pressure on the stumps of these two species in comparison to the others.

During the grazing period (240 days) the pigs grew from 60 to 157 kg weight (10 to 18 months age), on average. The swine growing performances was compared with similar management systems and a difference ranging between -60% and -25% (beginning and ending of the grazing period, respectively) in weight increase was observed. This variability of the live weight gains was likely related to the adaptation needing and the different seasonal fodder availability, since pigs received a limited feed supplementation (approximately 2 kg pig^{-1} day^{-1}), unvaried during the whole grazing period. Nevertheless, the economic sustainability for farmers of this multifunctional grazing regime is expected due to the reduced use of feed supplements and the higher value of sold meat, even though a thorough evaluation is still in progress.

These first promising results highlight the possibility to replicate the silvi-pastoral management approach proposed by 'Food For Forest' in similar environmental and administrative conditions, while considering the benefits attainable by local stakeholders from grazing pigs.

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How to revitalize abandoned mountain areas? An agroforestry approach for livestock farmers in the alpine region

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Forest grazing, 'dynamic grazing', village abandonment, mountain livestock farming and welfare

Abstract

Introduction

In the Alpine regions, cattle breeding was originally based on small herds of local breeds adapted to the local environment. Animals were reared in high pasture during summer and kept in stables during winter, fed with local hay. During the last decades, mountain areas have been slowly abandoned. Between 1980 and 2000, mountain farms decreased in number of the 40% and traditional husbandry gave way to more intensive and less resilient husbandry systems (Battaglini et al. 2014) leading to a decrease in the provisioning of ecosystems services. In the Giudicarie valley (TN), there has been a reduction of small-scale farms that used to safeguard and preserve the mountain areas; meanwhile the intensification of livestock has led to an increase of the herds size, together with the selection of highly productive breeds. Farms are now highly dependent on external sources for feed; there has been a reduction in the energy efficiency within production processes and an increase in pressure on the environment, accompanied by the abandonment of marginal areas and the loss of biodiversity. In 2016 a pool of five mountain livestock farms of this area, felt the need to restore the link between the territory and the farming activity, giving rise to the INVERSION project.

The project

The INVERSION (Agroecological innovations to increase the resilience and sustainability of mountain livestock farms) EIP-Agri project aims at developing an innovative mountain breeding model in order to support small scale farms in improving animal welfare; adopt agroecological practices; provide ecosystem services; regenerate marginal areas and enhance economic sustainability.

Five farms, run by young farmers, located in the Giudicarie area have been involved in a three years project (2017-2020), financed by the Autonomous Province of Trento. Each farm is adopting different solutions to meet the objectives mentioned above.

The aim of this work is to present the agroecological experience of Athabaska farm, which acted as innovation broker to boost the bottom-up approach project through the implementation of an agroforestry system for livestock farming.

The case study, Agriturismo Fattoria Athabaska

Agriturismo Fattoria Athabaska is a multifunctional farm located in an area that was abandoned and subsequently regenerated. The farm pastures are located between 450 and 700 m a.s.l., the area is characterised by very scattered land plots, populated by sub-alpine vegetation. Highland and Rendena cattle breed, pigs, lama and alpaca and sled dogs are reared on the farm, animals are both functional to production (grass fed meat) and to didactic purposes, fostering rural tourism. Animals are reared outdoor all year long both day and night, therefore the interaction human-animal plays a key role in facilitating the herd management. Bull mating, hierarchy among the herd and horn maintenance, are just few of the practices adopted by the breeder, Maurizio Cattafesta for managing his herd. The large part of the feed ration comes from pasture and forest, therefore grazing management and wood management are essential for handling the herd. To do so 'dynamic grazing'(Figure1.) has been introduced as a new way of grazing, which takes into account livestock load, in order to better exploit and regenerate marginal areas together with the integration of the cattle's ration provided by the wood and limiting the use of concentrates. The total area regenerated at Le Moline is about 0,9 Ha and a total of 5,2 Ha are grazed at Bondai (Fig1.) Through the turning of animals, different species graze on the same area, thus favouring forest management and preventing hydrogeological instability.

Besides ecosystem services, forest grazing enhances animal welfare: the natural behaviour of animal is encouraged. An ethology study has been introduced in order to detect and analyse animals' interactions in the herd and in the environment. The breeder has been taking notes of animal behaviour, a GPS (Global Positioning System) tracker has been introduced in the herd management to better monitor animals.

Conclusions

The implementation of agroforestry and silvo-pastoral practices resulted as beneficial to the animal (**animal welfare**) through the provision of feed and shelter. Forest provides wood, biodiversity, wildlife habitats and clean undergrowth reduces the possibility of large wildfire. It gives quality products (milk, meat), wood from cleaning of pastures (**provisioning services**) but also services for the community, as the recovery of marginal areas to grassland, requalification of the landscape with grazing animals, didactic activities, transhumance (**cultural services**), the reduction of soil erosion and of GHG emissions with permanent covering of the soil (**regulation services**).

The Inversion project is based on a participatory approach that aims to accomplish the above-mentioned objectives, while disseminating good practices and scientific knowledge among farmers.

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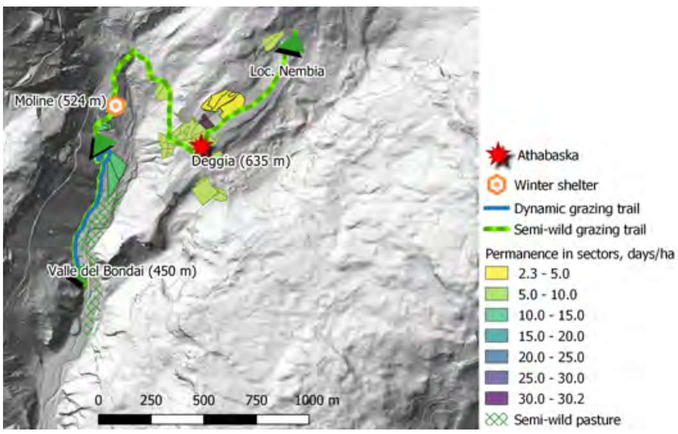

Figure 1. Cattle grazing path

The use of biochar in agroforestry soil management strengthens the retention of water and nutrients in the semiarid valleys of the Bolivian Andes

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: biochar, soil management, drought, semiarid valleys, implementation, plantation

Abstract

The agriculture of the semiarid valleys in the Bolivian Andes faces severe challenges concerning actual soil conditions and climate alterations in the future. These oblige adjustments in the use of the basic resources water and soil plus adaptations of the agricultural practice in general. The present study examines whether the incorporation of biochar into soils can improve the local soil conditions and prevent degradation processes. Besides its great potential of carbon sequestration and thus climate change mitigation, biochar is discussed to promote soil quality, especially under extreme edaphic conditions. The biochar was based on three different wood types (*Dodonea viscosa, Polylepis besseri* and *Pinus radiata*) from local agroforestry systems and produced in a charcoal stove type "Kon Tiki" (appr. 700 °C, < 1 hour of pyrolysis). The measurements took place between March and July of 2019 in an agroforestry parcel, which was implemented for the scientific purpose of this study in the research centre Mollesnejta in Cochabamba, Bolivia. This parcel of 1000 m^2 was designed to represent the typical agroforestry fruit tree systems of the Andean semiarid valleys. These are characterised by a diversity of tree species, including both native Andean (*Annona cherimola* or *Inga feuillei*) and exotic (*Ficus carica, Morus nigra* or *Prunus persica*) fruit trees. The space in between the woody species is used for pasture or horticulture mainly dedicated to subsistence farming. Due to the heterogenous, rocky surface, these systems often differ from the well-known geometric design of fruit tree production. Each of the 30 fruit trees was planted in a plantation cavity of 360 litres filled with homogenized experimental substrates. These were divided into three groups of each 10 replications with identical soil-dung-biochar mixtures. The control group did not contain any biochar, while group 1 had a dosage of 25.8 kg biochar per m^3. The biochar amendment of group 2 was the double (51.6 kg m^{-3}) replacing one part of the initial soil and keeping constant the ovine dung concentration. Soil humidity, total nitrogen content, pH and potential cation exchange capacity were chosen as indicators for possible effects of the biochar application.

In comparison to the control, both biochar groups showed positive effects due to the biochar amendments on soil conditions: The biochar application increased soil pH, potential cation exchange capacity, soil moisture and total nitrogen content. The effect on the two last-mentioned parameter was significant ($p < 0.05$) resulting in an average increase of both parameters by 150 percent (comparing group 2 with the control). Furthermore in the case of the biochar effect on soil water content the results were highly significant ($p < 0.001$). In both the raining and the dry season the water content was very elevated in the presence of biochar. It was monitored that this effect increases with the drying of the soils during the natural transition towards the dry season in the semiarid valleys. This observation makes the use of biochar even more interesting for the Andean agroforestry concerning the predicted reduction of precipitation and irrigation water. The overall positive results showed clearly can be

explained by the peculiar structural properties of biochar, primarily its high specific surface area and the diversity of functional groups on its surfaces. The last mentioned interact with both water and nutrients, resulting in a reversible adsorption which supresses the leaching of nutrients and the percolation of water. This means that the soil-dung-biochar substrates create optimal conditions for microbial life in aerated, moist and nutrient rich soils. The fact that these resources are kept inside the agricultural system does not necessarily mean that they are accessible at any time to the agroforestry plants. Because of the experimental limitations it was not possible to investigate the accessibility of water and nitrogen or other nutrients, but an overview of the recently published literature about biochar helps to understand the mechanisms that most likely signify an increase of the accessible concentrations of nutrients and water in the long-term as well. Apart from this topic, which still requires more investigation, it is crucial to concentrate in future studies on possible obstacles that could block the implementation of biochar production and usage in agroforestry practice.

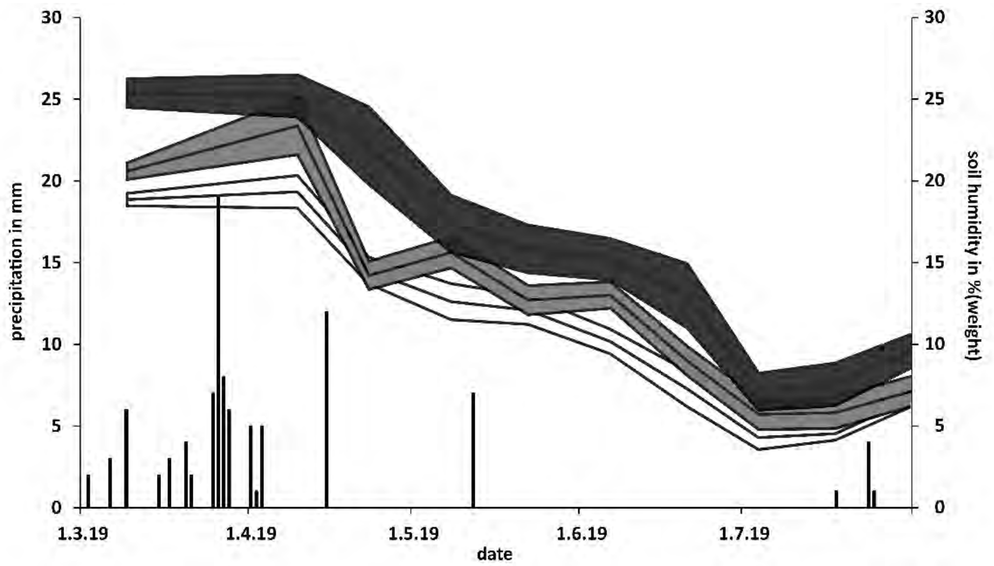

Figure 3. Covariance of climate (columns = precipitation) and soil humidity during the 5 months of the experimental period (1st of March until 31st of July). The coloured bands indicate the show the following values of the three experimental groups: The inner line indicates the mean water content (n = 10) of each group at the ten measurements, while the divergences represent the ± standard error. Colours and dosages: white (group 0): control without biochar addition; light grey (group 1): 25,8 kg BC m^{-3}; dark grey (group 2): 51,6 kg BC m^{-3}.

Regenerating Villa Fortuna (RVF) - An experimental Mediterranean complex agroforestry system

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem service provision through agroforestry systems

Keywords: Agroecology; successional agroforestry; ecosystem services; temperate climate; environmental-socio-economical balance.

Abstract

"Syntropic agroforestry", also known as "Successional Agroforestry" (SA), is a well-known approach in agroforestry. Developed in Latin America, it imitates the natural succession and stratification of the ecosystem. In this complex system, crops and trees are planted in "consortia" communities that cover the whole sequence of natural successional steps (from pioneer species to primary forest species), and which become increasingly harmonious over time. Despite the growing interest among practitioners and scientists, in Europe and Latin America, there is a lack of data and large-scale research on such complex agroforestry systems.

In this respect, RVF (Regenerating Villa Fortuna) represents a great opportunity, as an experimental system focusing on SA in San Salvatore Monferrato (province of Alessandria, Piedmont, Italy). The RVF research aims to monitor the SA processes starting from day 0 of the regeneration of approx' 20 ha of abandoned, previously cultivated, land (Figure 1), and continuing the experiment long-term (min 10 yrs).

The research aims to study how successful SA is as an eco-efficient farming system in the Mediterranean area. The main goals are to recover the local biodiversity and to provide more ecosystem services. RVF will investigate the environmental, social and economic aspects of this farming approach, and compare the results with other agroecosystems in the study area.

The research will start by selecting the plant communities to be cultivated, imitating the natural succession in the Mediterranean area, and then will move on to monitoring the biodiversity, the physiological status of the plants, yield, and the socio-economic impacts, in order to arrive at an integrated environmental socio-economic report of the whole approach.

The parameters and indicators that have been chosen are very diverse, due to the huge number of desired variables; these include: traditional soil Physico-chemical parameters, flora, the stress tolerances of the cultivated plants, nutrient efficiency, the frequency of the presence of pollinator insects, and yield in terms of quantity and quality. Moreover, a molecular approach will be implemented through the application of DNA metabarcoding on the soil environmental DNA, in order to study the progressive development of the soil communities and their interactions (Bacteria, Fungi and Metazoans).

In addition, raw materials will be used efficiently in order to assess the energy consumed and the input-output balance of the system; for this step, life-cycle assessment analysis will be applied to the whole system.

RVF aims to establish a pioneer case study in a temperate climate, that could be used as a model for the application of SA best practice.

As a first step, an area of about 3.5 ha called the "Valletta area" is going to be cultivated using this complex system, focusing on a high density of productive trees (Cherries, Apples and Pears), within a Consortia of trees, shrubs, and herbaceous plants, on different levels, which are capable of providing different ecosystem services. One aim of the development of this system, is to establish a random plot design in the initial area; including 15 experimental plots with a random distribution of the main productive trees. There will be 3 different types of plot and each plot type will be replicated 5 times. Each plot will consist of 3 cultivated rows, 30m in length, surrounded by a buffer zone to separate the plots; the buffer zone will have the same plant distribution as the plot it surrounds (Figure 1).

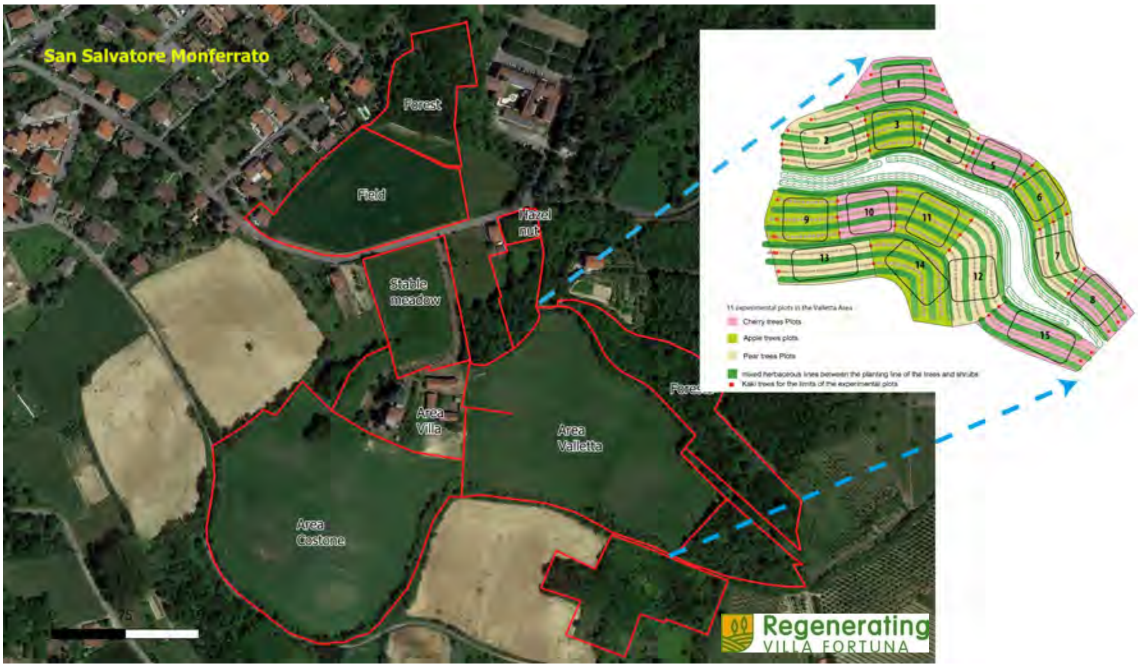

Figure 1. The total area of RVF (Regenerating Villa Fortuna) and the experimental plots in the "Valletta Area" with the random distribution of the three types of productive trees

Assessing natural pest regulation in forest gardens, a path to sustainability

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Forest gardens, beneficials, pests, natural pest control, sentinel prey

Abstract

The Intergovernmental Panel on Climate Change (IPCC) called in its last report for "sustainable intensification" of agriculture to limit the effects of climate change (de Coninck *et al*., 2018). This is expected from agroforestry systems among other services: they are supposed to produce more on the same surface (Land Equivalent Ratio >1), while preventing biodiversity loss. Forest gardens are agroforestry systems associating vegetables with fruit trees, which are also expected to better regulate crop pests.

This study is the initial phase of EMPUSA, a six-year project which aims to evaluate the multi-performances (technical, economic, environmental) of fruit agroforestry systems. EMPUSA emphasizes especially the comprehension of natural regulation mechanisms, together with the performance of the system (yield, pest pressure, workload, etc.) to start drawing reliable conclusions on their capacity to reduce dependence on plant protection products.

We targeted the dynamics of functional biodiversity between the trees and the annual crops. We characterized the control of pests by predators by comparing their regulation in three systems: forest garden, orchard control, and market gardening control. We also evaluated the regulation according to the distance to the trees in forest gardens. There are at the moment few studies on the subject in a temperate context because this type of agroforestry system remains poorly documented.

Birkhofer *et al*. (2017) suggested a decision-making process which allowed us to define the most suitable method for this study. We were interested in a community of generalist predators and specific prey. The most relevant tool was sentinel prey. The regulation was measured thanks to two types of sentinel prey, that had never been used in forest gardens before:

- predation cards with frozen brown marmorated stink bug eggs *(Halyomorpha halys,* Stål, 1855*)*, an invasive species that is slowly spreading in France for several years. Remaining eggs were kept for parasitoid survey by INRAE.
- caterpillar lures made of plasticine.

The data collection method was principally based on elements reported by Lövei and Ferrante (2017). Five exposure sessions of each sentinel prey type were carried out at regular intervals between April 19 and July 30, 2019. The experiments were carried out on three forest gardens and three control sites (two orchard controls, one market gardening control).

We were able to get the information from 689 predation cards out of 733 exposed cards, and from 417 caterpillar lures group out of 565.

The first results showed that there is no significant difference of *H. Halys'* regulation between orchard and forest garden trees (33.33% and 26.47% of predation respectively).

In contrast, *H. halys'* regulation is significantly higher in forest garden vegetables than in market gardening (28.72% and 8.00% of predation respectively). There are also more parasites genus of this insect in forest gardens (none in market gardening control, one in orchard control, four in forest gardens). However, we were not able to do any statistical comparison given the low number of parasitoid emergencies.

The trees would thus host beneficials that are interested in *H. halys*, and this study now needs to be continued to better know which fruit trees are susceptible to host them. This invasive species can indeed be very damaging in a lot of vegetable and fruit species. In the coming years of the project, emphasis will also be given to identification of the predators and the parasites, to see if they are generalist or specific beneficials.

The caterpillar lures did not show any significant difference between systems, neither for predation in vegetables nor in trees. We have been a little bit skeptical concerning the use of this method in the vegetables, as there could be technical limits such as irrigation or ant activity. However, it is a very interesting method to evaluate predation by birds. In our case, only 14,81% of the predation events were caused by birds.

The distance to the trees had no significant effect on the regulation, whatever the method. But if we consider that the market gardening control is a forest garden where the trees are very far from the vegetables, we could extrapolate the difference of *H. halys'* regulation to an impact of the distance to the trees. It would then be necessary to evaluate intermediate distances, to see in what extent.

This ongoing project will now also focus on identifying involved predators, while continuing to measure the predation rates in the three systems to confirm this year's results.

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The use of cork in the thermoregulation of the hive: an innovation attempt to enhance non-wood products and beekeeping in Mediterranean forests

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: EURAF 2020, cork beehives, thermal insulation, thermoregulation, forest product

Abstract

Hive thermoregulation is fundamental for the normal development of bee colonies and, consequently, hive productivity and bee health. External conditions substantially affect the walls of the hive. Therefore, construction materials and thermal conductivity features of hives can influence its thermoregulation efficiency. Historical findings on traditional apiculture indicate a widespread use of cork for the construction of rustic hives in the Mediterranean area in the past (Crane 1999). Some attempts of adoption of this material were made in the initial forms of semi-rational or rational beekeeping (Floris and Satta 2009). Cork is the main product of the agro-silvo-pastoral system. However, the fact that this natural material was replaced by other types of materials led to a decline in cork oak forests in sub-western Europe(Bugalho et al. 2011). For this reason, a greater use of cork in the green building sector could have a positive economic and environmental impact on cork oak systems. It is important to highlight that the production of panels for the construction of cork hives does not require raw material of a particular quality and a different management of cork forests. Even more, the cork material used in bee hives, which is called "granulated", is obtained from secondary products of the cork industry. For this reason, the exploitation of this "waste resource" is a considerable advantage of this model of beehive, which can be considered an eco-friendly hive. Another advantage of cork is that it is lighter and more resistant to mould compared to wood. In addition, the use of this hive model is associated with the sustainable use of Mediterranean agroforestry systems, thus contributing to their conservation. Because of the interesting characteristics of cork, the traditional use of cork in hive construction, and the economic interest in this non-wood forest product(Satta and Floris 2004), we tested the insulating properties of cork as construction material of modern hives and its impact on thermoregulation of Italian bee (*Apis mellifera ligustica*) colonies, in comparison to traditional beehives made of firwood. The study was performed in an experimental apiary in Northwerstern Sardinia (Italy) from December 2016 to April 2017 at the experimental farm of the Department of Agricultural Sciences of the University of Sassari (latitude 40°46’23”, longitude 8°29’34”). The experimental modified cork hives (modified

Dadant-Blatt of 10 frames) consisted of common conventional beehives modified by replacing the wooden walls with cork walls (pressed cork as thermal insulator), whereas the conventional hives (standard Dadant Blatt of 10 frames), used as control, were made entirely with firwood (Fig. 1). Two experimental groups (cork-wooden hives and conventional wooden hives) of four hives each were used in the experiment. The colonies placed into each hive contained about the same amount of adult bees, brood and food store, monitored using the method of Marchetti (1985). Environmental parameters, especially temperature inside the nest (brood chamber) and outside the hive, were assessed periodically by using ibutton mini-sensors (model DS 1923-F5#). The internal daily temperature pattern of cork-modified beehives was more regular than that of control beehives (Fig. 2). In addition, bees had a more efficient winter thermoregulation in cork-modified beehives compared with control hives. In conclusion, although further studies on a larger number of hives and during a longer time are required, our study demonstrates the effectiveness of cork in the thermal insulation of bee hives and, consequently, in their thermoregulation. Based on our results, the use of cork in the construction of modern hives appears promising and could be an interesting synergy between apiculture and woodland or forestry management. Finally, this new beehive model provides a new possibility for enhancing a non-wood product like cork, not only in the forest context but also in the bee management system, by improving the performance of bee hives.

Fig. 1 – Experimental modified beehive model (cork-wooden beehive, on the left), with walls made by cork, and standard Dadant-Blatt beehive (wooden beehive, on the right), with walls made by firwood, used as control hive.

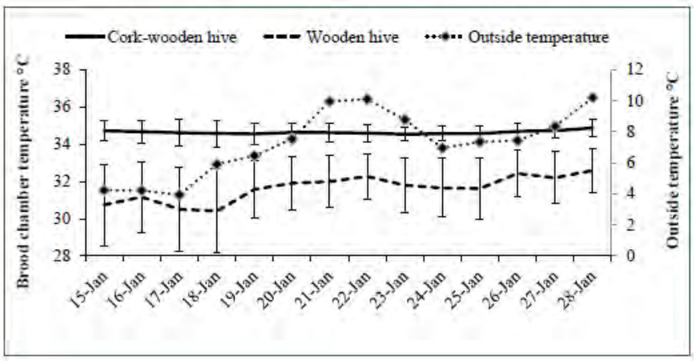

Fig. 2 – Trend of brood chamber temperature (mean ± SE) in cork-wooden and wooden beehives (main y axis) and outside temperature (secondary y axis) during two weeks in January (winter).

Evaluation of urban impact and river self-purification processes in rural areas by discriminant analysis. The case study of Scano di Montiferro: annual monitoring of the main chemical and microbiological parameters

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: pollution, river water, microbiological monitoring, environmental microbiology

Abstract

Water is an indispensable part of the lives of ecosystems and a fundamental component of the life of our planet. It is a limited resource, enclosed in a continuous cycle among atmosphere, earth and living organisms. The continuity of this cycle is threatened by human activities, pollution and climate change (Corcoran et al., 2010). This study aims at monitoring the microbiological and chemical quality of the river waters of the hydrological basin of Scano di Montiferro, to assess the resilience of a mountain stream to the anthropic impact of a town. As a matter of fact, in this area urban wastewater is poured into the river, after the purification process (Everard and Powell 2002; González, et al., 2014). The monitoring lasted overall one year. It was performed with a two-month 9-point instant sampling: 5 upstream and 4 downstream of the town (Figure 1). Sampling points are progressively numbered from upstream to downstream. In particular, points 1, 2, 3, 4 are set on three tributaries of the main river rod, fall into an area which is scarcely populated and covered with hardwood forests. Point 5 collects the same waters as point 4 and is located in the wide valley which hosts many olive groves and vegetable gardens. Point 6, downstream of the village, catches all the water flowing from the town, including the wastewater from the purification plant. Points 7, 8 and 9, also downstream, are progressively identified at increasingly greater distances. To assess the urban water pollution two types of parameters are selected: microbiological and chemical. Among the first one there are: total microbial counts at 22 °C and 36 °C, *Pseudomonas*, total coliforms, faecal coliforms, *Escherichia coli*, faecal streptococci, *Clostridium* spores and sulphite reducers; while the chemical are: pH and conductivity, oxygenation, 5 days biological oxygen demand (BOD_5), total nitrogen, ammoniac nitrogen, nitrites, nitrates, phosphorus and orthophosphates. The presence of the psychrophilic microorganisms of the environmental microflora, and of the mesophilic microorganisms, including human and/or animal enteric microbes, show a constant trend at all the sites and for all the samplings, except for point 6. In proximity of the purification system, the bacterial charge is higher than all the other sampling points, and varies between 10^6 and 10^8 cfu/ml. Also, the others microbiological parameters show a trend similar to the total microbial counts. Point 6 always shows high values of faecal pollutants, coliforms and streptococci in particular. Furthermore, all the sampling points downstream of the purification system show a high degree of *clostridium* spores and sulphite-reducer. Chemical analysis detects strong water pollution in point 6. In particular, an anoxicity of the water is observed, high values of BOD_5, high concentrations of nitrogen (in all analysed forms), phosphorus and orthophosphates. However, for many parameters, both chemical and microbiological, there is a significant reduction as the distance downstream from the discharge point increases. A discriminant analysis was performed. It is multivariate

statistical analysis that aims at discriminating between categories of the dependent variable in a perfect way. It allows to examine whether there are significant differences between the groups, in terms of predictive variables, also evaluating the accuracy of the classification (Hastie et al., 1995). The chosen dependent variable is the distance between the sampling points and the source of pollution; while the independent variables are the selected microbiological and chemical parameters. The analysis was performed on three groups of data: 1) all the parameters; 2) chemical parameters only 3) microbiological parameters only. The first one does not show any statistically significant difference. The same result was achieved by the second one. Although a reduction in chemical pollutants is observed, such pollutants remain in the water for a longer duration; this is the case of the three forms of nitrogen. The third includes some reassignments. In a database of 63 samplings, 35 upstream and 28 downstream, only the samples downstream of the purification system are reassigned, in particular those related to the sites at a greater distance from the spill point of the wastewater. Point 9 obtains a reassignment percentage of 57.14%; it is located at the distance of 2150 m from the discharge point of purification plant. Point 8 and point 7 are reassigned in the order of 48.86% and 28.57%; they are at a distance of respectively 1350 m and 1140 m. In conclusion, the progression of the reassignments shows that the river cleans itself based on the distance from the source of microbial pollution. Furthermore, no statistical difference was observed between sites with natural vegetation cover (deciduous oak woods and pastures), and those for agricultural use (olive groves and vegetable crops). Nevertheless, further analyses are necessary to prove the influence of river characteristics on the described self-purification process and to create a descriptive model.

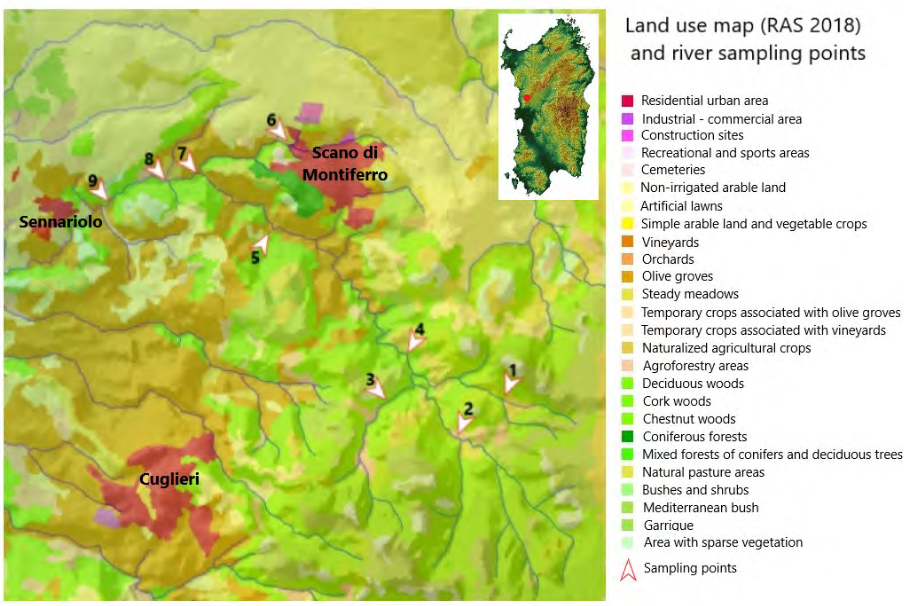

Figure 1. Land use map (from RAS, 2018) and river sampling site

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Transformation of a farm into agroforestry system

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: alley cropping, hedgerows, agroforestry system

Introduction

In Romania, the agricultural area is about 14,6 ha (61.3% of the country's surface), of which about 9.4 million hectares represent arable land. The arable land is concentrated, generally, in the plains and low hills of the west, south and east of the country, which are also climatically vulnerable areas and with low percentage of forest vegetation. Alley cropping and hedgerows were installed on a farm in the southern area of the country.

Material and methods

In order to establish the technical solutions for the realization of the agroforestry system (of introducing the forest vegetation in the existing crops), it was necessary to analyze the ecological forest site conditions. Thus, the soil type was established, the climatic conditions were characterized and the existing vegetation in the area was analyzed. The soil type was established by performing a soil profile. The characterization of the climatic conditions was made after consulting specialized works and interpreting the climatic data from the Urziceni weather station, the closest to the Ogoru Farm.

Results and discussion

The Ogoru Farm, from Călărași county, has an area of about 55 ha being composed of two plots of land, the first of about 38 ha, being the object of transformation from agricultural system to agroforestry system.

It is located in the Bărăgan Plain, in relief conditions specific to the plain silvosteppe, in the area of spread of the chernozem. This area is characterized by very hot and dry summers, cold and dry winters, with an average annual temperature of 10.6 ° C, with an average annual rainfall of 476 mm and an de Martonne aridity index of 23.1. The prevailing winds blowing from the north-east and south-west, have a detrimental influence on the development of vegetation, because the dry and very hot winds during the summer lead to lower humidity in the air and soil and increase in evapotranspiration.
In order to characterize the edaphic conditions, physical and chemical analyzes of the collected soil samples were performed. The analyzed soil falls in the type of chernozem, the limestone subtype.

The area is characterized by the presence of agricultural crops on large areas and to a very small extent by the presence of forest vegetation. In the county of Calarasi, on the territory of which the farm is located, the area occupied by the forest covers a percentage of 4.32% of the total area of the county. Therefore, the predominant vegetation in this area is given by various agricultural crops (cereals, rape, soy). Regarding the forest vegetation, in the analyzed area, the species meet are: greyish oak, Turkey oak, silver lime, ash, Siberian elm, maple, acacia, shrubs.

Within the farm are installed several crops: cereal crops (corn, wheat), which predominates, cherry orchard (about 4.7 ha), strawberry greenhouses (about 4.5 ha), fruit bushes (blueberries, raspberry) (below 0.5 ha).
From the assortment of forest species mentioned above, which could have been included in the agroforestry system, were chosen for species that do not cause harm to the cherry trees in the orchard or agricultural crops. The orchard, recently installed, already provides high yields of cherries on the farm, or combating possible pests that have as host the forest species can create complications. Given these considerations were chosen Siberian elm (*Ulmus pumila*), honey locust (*Gleditsia triacanthos*) and hazelnut tree (*Corylus avellana*) species.
The analyzed surface is completely fenced with hedgerows consisting of one Siberian elm row, with a length of 881 m and the age of 4 years, respectively one honey locust row with a length of 1,700 m and the age of 1 year.
For the design and installation of alley cropping, five rows of trees were installed at varying distances, in the fall of 2019. The distance between the rows was 90 m, 100 m, 120 m, 125 m and 136 m. The distance between seedlings per row was 8 m between Siberian elm species and 4 m between hazelnut tree. In order to avoid possible injuries caused by wild animals, but especially to stimulate the growth in the height of the seedlings, protection and growth tubes with a height of 1.20 m and a diameter of 8 and 10 cm were used.

Conclusion
The installation of these agroforestry system was made to improve the microclimatic conditions (high average annual temperature, low precipitation and frequent, dry and hot winds). Also, these agroforestry systems have experimental character being installed for the first time in Romania.

Acknowledgements
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The potential of economically successful innovative food and non-food systems in limiting soil erosion by wind across EU regions

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: wind erosion, soil degradation, integration of food- and non-food production

Abstract

Integration of food- and non-food production (IFNS) is not an easy task at the landscape scale. The questions arise, whether integrated systems systems, including agroforestry (AF) practices enhance biodiversity and ecosystem services relative to conventional agriculture and what is their general impact at the local scale in terms of climate change complexities. Here we explore the potential of different kind of AF systems (both modern type combining food and SRC wood production as well as traditional models producing bioenergy/bioproducts by smallholders in silvo-arable or silvo-pastoral systems) in delivering environmental benefits, focusing on preserving soil fertility and limiting soil degradation. One of the least visible degradation factors of soil cover is wind erosion. Wind erosion is a complex geomorphic process governed by a large number of variables. Field-scale models such as the Wind Erosion Prediction System employ numerous parameters to predict soil loss. A preliminary pan-European assessment of land susceptibility to wind erosion was created by the team at JRC in 2014 (Borelli et all, 2014). Agroforestry remains one of the most promising food production systems in terms of limiting wind erosion by lowering wind speed and increasing soil cover. In the studies, a network of representative integrated food and non-food systems (IFNS) were identified in different socio-economic and environmental settings in Northern, Eastern and Southern Europe across countries and bio-geographical zones. The network of six IFNS comprised both traditional and innovative systems in which trees, crops and livestock are integrated in different ways and at different spatial scales (table 1).

Analyzing the wind erosion threat index in NUTS3 regions, it is apparent the wider adoption of given IFNS that proved themselves to be economically successful in particular NUTS3 regions would potentially limit wind erosion rates, especially for systems with arable component.

The IFNS and their regions differ considerable in each of wind erosion threat index, British IFNS (1.616 Mg/ha/yr) and Danish IFNS (0.486 Mg/ha/yr) to a lesser extent being highly at risk of soil superficial erosion due to the location in highly wind conditions and soil susceptible to wind erosion.

The potential of regional agroforestry practices (within each IFNS category and for each land use cover – EEA 2018) was estimated to mitigate considered risk for particular NUT in terms of financial investments needed to transform the land into agroforestry practice.

The highest potential for limiting the area of strong wind erosion by an IFNS existing in a particular NUTS is observed in Romania, where 531km^2 might be protected effectively with silvopastoral system, while applied in a longer term on non-pastoral land cover classes it could provide effective protection for another 1362 km^2. The second largest influence can be achieved in the Polish NUTS regions, where 125 km^2 may be taken into protection directly and another 1140 km2 may be transformed into agroforestry systems to lower the risk of soil erosion. Introduction of silvopastoral IFNS in Italy could save 114km^2 of soil with 106km^2 being under severe wind soil erosion threat. The highest risk is particularly observed on agricultural land in UK. Silvopastoral systems could be introduced there on pastures, saving potentially up to 414km^2 of land.

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Table 1. Network of IFNS sites in partner countries.

IFNS category	Site location	Farm size	Country code	DMEEREEA Zone code*
Combined food and energy production systems	Experimental farm Taastrup, Denmark	11 ha	DK	13
Multipurpose olive tree production systems	Muzzi Farm, Bagni village, Orvieto municipality, Italy	7 ha	IT	161
Silvopastoral systems	Elm Farm (ORC) , Berkshire, United Kingdom	85 ha	UK	31
	Oikos farm, Sękowa, Poland	111 ha	PL	59
Silvoarable systems	Wakelyns Farm, Suffolk, United Kingdom	22.5 ha	UK	31

*DMEEREEA codes:
13 – Baltic mixed forests
31 – English Lowlands beech forests
59 – Carpathian montane coniferous forests
161 – Italian sclerophyllous and semi-decidous forests

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Agroforestry livestock as a garrison of the Apennine territory.

The project of the farm "Le Granaie"

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem service provision by agroforestry systems

Keywords: Appennine mountains territory retraining, agro-silvo-pastoral system, ecosystem services

Introduction

Italy is 41.6% hills, 35.2% mountains and only 23.2% plains. In the last fifty years, with the strengthening of industry, the mountain and hilly areas have suffered an inexorable abandonment, in favour of urban centers; this phenomenon is confirmed by the ISTAT data, which show that, although the majority of Italian municipalities are small (with an area of less than 20 km2), it is the municipalities with high urbanization that are home to more than 33% of the population. The depopulation of the mountain has led to the increase of wooded areas: since 1950, the forest has more than doubled its area, covering 35% of the Italian surface; Tuscany is the region with the largest wooded area (Report on the State of Forests in Tuscany, 2016). Forests have expanded to areas traditionally used for grazing animals. On the other hand, Tuscany mountain areas at 800-1000 m. asl. are used for animal production precisely because they provide quality forage productions, both for the barn, for grazing and can be used for more than 9 months a year. The aim of this work is to describe the project of the farm "Le Granaie", led by two young agricultural entrepreneurs, who decided to invest in an abandoned territory but with great agricultural and social potential. The approach of the work carried out as technicians at the farm is systemic, the farm studied and considered as a whole, the productions try to be planned in order to be in synergy with each other, with the environment and with the territory, and promote animal healt and welfare. The approach used in the relationship between technicians and farmers is participatory (Ceccarelli et al., 2009).

Description of the farm "Le Granaie"

The farm is located in the wood of the Apennine Italian, with an Eastern exposition, with coordinates 44°00'67" N 10°75'75". The altitude is between 800 and 1000 m. asl. It's a mountainous typical climate with winter characterized by many snowfalls and a cool summer, and rain precipitation is on average about 1600 mm per year.

The farm is so divided: 1 Ha orchard, 2 Ha grafted chestnut, 1.9 Ha of arboreal pasture, 3 Ha of herbaceous pasture, 1 Ha of arable cereals for human use, 15 Ha of mixed wood cultivated, partly as stump, partly as high forest, for a total area of about 20 Ha, in addition neighboring areas are rented for grazing, granted for rent.The farm produces beef, both goat and cow cheeses, pork and goat sausages, chicken meat, eggs, chestnut flour. The farm also grows for self consumption a vegetable garden of over 3000 m^2, a small area of wheat and/or rye, for the production of bread, and potato.

The farmers, Giacomo (28 years) and Simone (30 years), bought and renovated the farm in 2011, which was then in ruin with land abandoned for about 50 years. They decided to devote themselves first to breeding goats, rabbits and chickens, adding after a short time cattle and pigs. The choice of animal breeds and plant varieties present in the farm were based on their rusticity, adaptability to the territory, and, in the case of animals, on the good use of forage resources. The good organization of the forage system is one of the company's focus, both to tie animal productions to local resources, and to contain the costs of managing food; grazing systems include stable grazing meadows, wooded parts and shrubs. The pastures were recovered thanks to access to rural development funds (PSR) of the Tuscany Region, which allowed forest cutting on those areas already used for pasture before 1954. Health management is systemic: prevention and clinical monitoring is carried out and through laboratory analyses, alternative and traditional medicines are used to treat animals in the event of illness, thus limiting antibiotic prescriptions. The farm also has a stable, a milking room and a dairy installed in a prefabricated factory.

Animal productions

The cattle are "Cabannina" breed, native Ligurian, with dual attitude, rustic and small size, excellent grazing in rough environments. The breeding is semi-brad, partly on herbaceous pasture, partly in the woods. The pigs, of the "Cinta Senese" breed, are purchased every year per fattening cycle in number of 5 per ha. They live in the semi-wild state in the woods, from which they derive part of their nutritional needs. The goats are of the suede breed of the Alps, live in the semi-wild state in a fenced area of 1 ha, they graze on land adjacent to the farm. Chickens and rabbits are bred partly in grazing and partly in structures used to station animals. Chickens are left to graze in the orchard adjacent to the henhouse.

Vegetable productions

The garden covers an area of about 3000m2, and for the moment it is used only for growing vegetables in rotation for selfconsumption on arable land recovered from the forest. There are two fruits chestnuts: the first, close to the company pastures, is grafted on stump in 2015 and has yet to enter production; the second produces flour chestnuts for self-consumption and sale. For the drying and milling of chestnuts, the two young conductors share with pro loco (local association) and local producers some phases of the supply chain such as drying in "metato" (traditional method of drying chestnuts on the wood fire), the typing and grinding, as well as the management of brown seals (pruning, grafting and cleaning). The chestnut is destined to become pasture for goats and cows, just completely renovated. The forest consists mainly of chestnuts (*Castanea sativa M.*) and oak trees (*Quercus cerris L.*), from which wood is taken for the heating of the house, with an annual production around 100 q. Part of the wood is also sold.

Discussion and conclusions

The use of fresh herbaceous, shrub and arboreal fodder for ruminant animals is beneficial as they are complementary both as a seasonal distribution and from a nutritional point of view. Vitamin and mineral supplements are not needed in animal nutrition as the diverse agroecosystem provides them with what they need. The outputs of the system are not only economic, but important common goods such as a concrete state of animal welfare, promotion of the culture of the territory, quality of production, recovery and care of the territory in a state of abandonment.

Permanent pastures are important providers of ecosystem services: they maintain an efficient hydrological cycle, protect the soil against the erosive force of the rain, prevent landslides, and are therefore an element of resilience in the climate events. They also prevent and limit forest fires, determine the beauty of the landscape and tourist usability, promote fertility, and maintain highly diverse mountain ecosystems.

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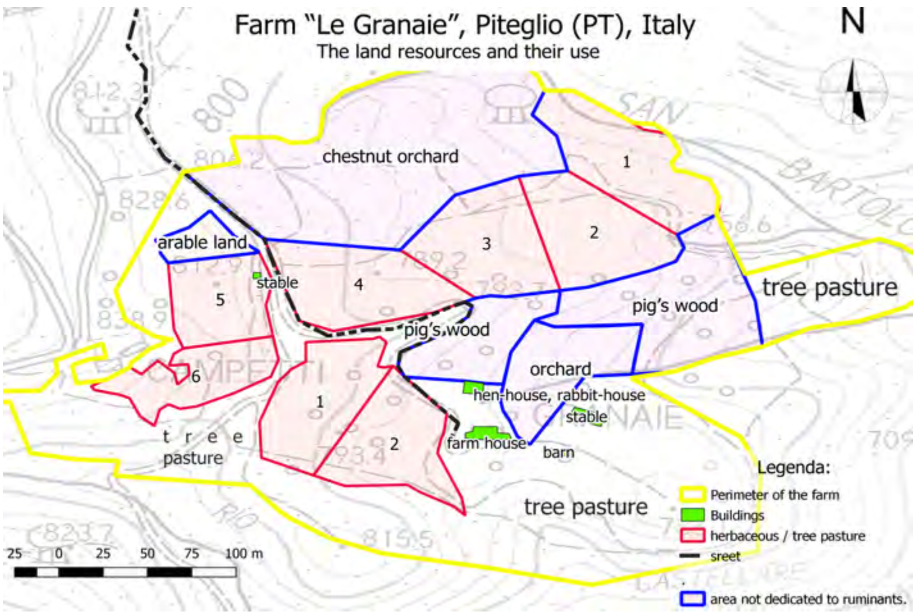

Environmental benefits and current scenario of agroforestry systems in the Brazilian Atlantic Forest

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development (Enchancing ecosystem services provision by agroforestry systems)

Keywords: Biodiversity, Ecosystem Services, Land Use Policy

Abstract

The Brazilian Atlantic Forest is the second largest biome in South America, considered a hotspot for the maintenance and conservation of ecosystem services (ES) and biodiversity on the planet. Despite its relevance, it is constantly degraded, especially in the last two centuries by the expansion of agricultural land, only 16% of its original coverage remains (Tarbarelli et al. 2005; Ferreira et al. 2019). In order to mitigate the impacts of conventional agriculture on this biome, agroforestry systems (AS) have been widespread in recent decades as a more sustainable agricultural system, for biodiversity and ES conservation and recovery degraded areas (Nair 2007; Oliveira 2016; FAO 2017). Therefore, this study aimed to diagnose the effects of AS implementation on biodiversity and ES in the Atlantic Forest biome, Brazil; through the survey of works carried out in the last 20 years, as a way to updating the current scenario and perspectives of agroforestry systems in the region. Several studies have proven the environmental gains obtained with the implementation of agroforestry and agrosilvipastoral systems to the detriment of conventional production models in the Atlantic Forest (Oliveira and Carvalhaes 2016; Alves-Pinto et al. 2017). Santos et al. (2019) noted a reduction in biodiversity loss and impact on ES, recording an increase of 45% and 65% more in biodiversity and ES levels than conventional production systems. In Brazil, well-known examples include shaded coffee agroforestry systems and cacao multistrates (Theobroma cacao) and include wood, fruits and native forest species, mainly in southern Bahia (Sagastuy and Krause 2019). However, Rolim and Chiarello (2004) warn of the low diversity and density of these systems. For Navas and Silva (2015), in applyng AS, native species should be prioritized for forest recovery. Additionally, soil and water resource conservation is also favored by AS, with erosion control, micro and macro nutrient enhancement, carbon accumulation, microbiota diversity and increased water infiltration and underground recharge (Ditt et al. 2010; Moço et al. 2010; Guimarães et al. 2014; Tavares et al. 2018). Microclimate improvements have been reported by Pezzopane et al. (2015), who observed a significant reduction in the occurrence of winds, solar radiation and increase of air humidity and soil moisture. The benefits of agroecology extend to the socioeconomic condition of the communities (Costa et al. 2017; Da Silva et al. 2018). And this must be strengthened with the development of public policies and instruments that encourage the agricultural transition and harmonious coexistence between producer and environment. A promising movement that emerges in the Paraíba Valley region and drives family farming in the agroforestry model, as a viable alternative for small producers with diversified and high value-added food production (Silva et al. 2016). However, it is noteworthy that biodiversity protection and ES provision differ according to the type of AS and that they have lower rates than native forests.

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Forest fragmentation analysis as the basis for agroforestry systems implementation

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Agroforestry, ecosystem services, landscape and rural development (Enchancing ecosystem services provision by agroforestry systems)

Keywords: Forest connectivity, Forest remaining, Landscape.

Extended Abstract:

Habitat destruction is the biggest threat to biological diversity, which occurs mainly due to the expansion of anthropogenic activities. The forest fragmentation process is mainly caused by anthropogenic factors that impact the environment and lead to numerous environmental losses (BRAGA et al., 2018). Thus, the study of forest fragmentation is fundamental for the diagnosis of potential areas for environmental recovery (Patucci et al. 2018). The agroforestry systems are more ecological then others agriculture systems, considered as an important alternative for sustainable use of tropical ecosystems. Based on geoprocessing and remote sensing techniques in a Geographic Information System - SIG, the main objective was to analyse the forest fragments in the city of Dumont - SP, in order to list potential areas for implantation of agroforestry systems, supporting the planning and agri-environmental management and sustainability public policy programs.

The analysis of forest fragments was performed using visual image interpretation techniques (Panizza and Fonseca, 2011). Fragment analysis was processed by ArcGIS 10.1 software and projected on Datum SIRGAS 2000 and the UTM - Universal Transverse Mercator linear system, Fuso 22s. The analysis of forest cover in Dumont showed strong forest fragmentation, with low occurrence of forest rebirth (Figure 1), conditions that favour ecological changes in the structure and dynamics of these ecosystems, which occur due to the isolation of the fragment and the small area of it. Twenty-five forest fragments were identified in the area, of which 68% had an area of less than 8 ha and 48% had circularity indices of less than 4, a characteristic that demonstrates more irregular and elongated shapes. This scenario highlights the high vulnerability and low connectivity of forest fragments, highlighting the need for protection of these units, low circularity indices, indicating that the edge effect is one of the main challenges for the fragment's stability and sustainability (Dekeukeleire et al., 2019). In general, the shape pattern of the forest fragments in the region are indications of the strong anthropic pressure on the forest cover, which causes smaller and more irregular and elongated fragments, leading to the edge effect and degradation of these small biodiversity strongholds (Pili et al., 2019).

In the search for strategies of appropriate agricultural production systems, the implementation of agroforestry systems as a productive model can be an important tool for the recovery of degraded areas, as this management favours forest restoration and recovery, soil conservation and agricultural production. With the high environmental vulnerability of fragments in the region, due to the edge effect and low incidence of fragments, agricultural systems that contemplate environmental conservation should be implemented. The implementation of the agroforestry system should be a priority in areas of greater fragmentation, respecting the limits of legal reserves and restricted areas. In general, the implementation of the agroforestry system is indicated to the municipality of Dumont due to the low forest cover and the strong fragmentation and lack of connectivity between these forest ecosystems, contributing to the conservation of ecosystem services without disregarding the productive, economic and social aspects.

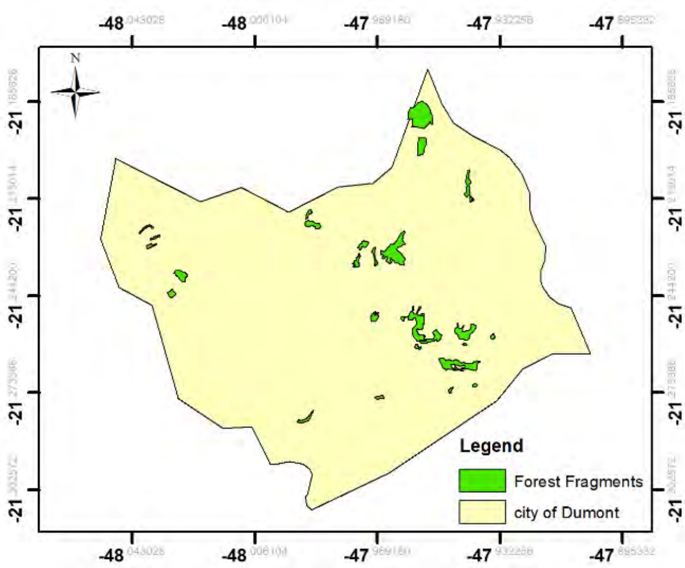

Figure 1. Dumont City, São Paulo, Brazil and forest fragments location.

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Geophysical survey of tree root zones in different production systems on agricultural land

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: soil electromagnetic conductivity, soil resistivity tomography, short rotation coppice, ligniculture, fast growing and valuable trees species

Abstract

Current trends in policy and practice indicate that introducing trees into agriculture systems may be an efficient tool for tackling multiple problems stemming from current farming trends and climate change - especially soil erosion and productivity, water retention, and humus/carbon depletion. In regions of Central and Eastern Europe (new member states), we can observe not only a decrease of trees and shrubs in the agricultural landscape due to intensification (larger fields), but also an increase in the amount of land allocated to “tree production systems”. For instance, the total area allocated to fast growing species in short rotation coppice (SRC) has been increasing in the Czech Republic and other countries due to growing interest in renewable biomass for energy and material (bioenergy and bioeconomy). Agroforestry systems with valuable broadleaved and fruit trees have been supported by subsidies (CAP) in 12 EU regions (France, UK, Hungary etc.) and they most likely will be included in measures of a new CAP (from 2021/22) in the Czech Republic. Cultivating tree species in production systems rather than practicing conventional agriculture or forestry affects economic and ecological conditions in the region because production systems create their own soil conditions that differ from conventional farm fields and forest stands. The aim of the work was to understand the soil water regime in varying spacing and cultivation phases of production systems with fast growing trees, e.g., short rotation coppice, ligniculture (arboriculture), semi- and solitary trees. Specifically, the work focused on detecting root systems that were functioning as well as determining tree water uptake area in different types of soil management.

In this work we present the results from the measurements performed in the research station Michovka of the Silva Tarouca Research Institute for Landscape and Ornamental Gardening in the village Průhonice (SE from Prague; 49.9919031 N, 14.5765778 E). Between 2017 and 2020 we applied soil conductivity measurements using a Slingram-type electromagnetic conductivity measurements (CMD Explorer, GF Instruments, Czech Republic) (Doolittle et al. 2000; Mirck and Schroeder 2018) and an electrical resistivity tomography ARES II (ARES, GF Instruments, Czech Republic) (Morelli et al. 2007; Zenone et al. 2008) in selected research sites and investigated spatial soil resistivity variations according to management types and the growth phase of varying plantations (Table.1).

Our results show that most of root systems were developed to the depth of 1m. Mapping spatial distribution of both trees (in the site) and root system areas indicating water uptake (measured and visualized graphs) allowed us to create a "spatial water regime map" of each site. When comparing all of the configurations, we found that there is a greater resistivity difference between the root system area and surrounding soil without roots in case of solitary or half solitary trees than in ligniculture or SRC plantations, which may indicate effect of competition. Sites with younger trees (up to 4 years old) had higher water content levels. Variations in a plantation's spacing influence the local environment by changes in soil electrical properties and especially regarding the water regime aspect (tree water uptake). Our study confirmed possibilities of practical application of soil conductivity measurements in many tree production systems and allowed us to detect water uptake zones of individual trees. Lastly, electromagnetic conductivity measurements were considered as more practical and time-saving mode in comparison to electrical resistivity tomography.

In conclusion, the application of geophysical methods allowed us to compare soil electrical properties in different types and phases of short rotation coppices managed within an area with unitary soil type. Our results have proven that geophysical methods have high potential for field research.

Table 1. Investigated research tree stands according to specie, growth phase, spacing and management type

Species	**Growth phase**	**Spacing**	**Management type**
Populus maximoviczii x Populus x berolinensis	28 years old	-	Solitary tree
Fraxinus excelsior var. Atlas	18 years old	0,5 x 2 m	Half solitary tree
Populus nigra	0 - 5 years old	0,5 x 2 m	Young experimental SRC plantations
Salix × smithiana *Populus maximowiczii × Populus trichocarpa* *Populus × xiaohei* *Populus trichocarpa × Populus koreana* *Populus nigra × Populus maximowiczii*	1 - 4 year	0.3 x 1,8 m	Mother orchard (stool bed)
Populus trichocarpa (and its hybrids)	28 - 30 years old	10 x 4m	Ligniculture (Arboriculture)
Populus nigra × Populus maximowiczii *Salix rokyta* *Salix stvola*	10 years old	0,5 x 2m	Short rotation coppice

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Agroforestry in the CAP: an analysis of RDP support in Italy

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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The sustainability of agroforestry systems compared to an intensive agricultural system.

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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Ecosystem services, sustainability, carbon credit,LCSA

Abstract

Agroforestry systems defined as "land use systems in which trees are grown in combination with agriculture on the same land" (Regulation UE 1305/2013) allow the achievement of international objectives to combat climate change and preserve biodiversity. Furthermore, agroforestry activities, in diversifying the productivity of farms, contribute to the protection of the natural capital of the agricultural ecosystem in which they are carried out.

Agroforestry systems have a high resilience, since they are able to guarantee their ecological functions against external disturbances, therefore they are able to continue to produce both "provisioning ecosystem services" (agricultural product and forest wood and not wood product), and "regulation ecosystem services" (carbon sequestration, biodiversity conservation, erosion and water regulation).

The present work intends to compare the environmental, economic and social sustainability of an agricultural system with an agroforestry silvoarable systems (woody species planted in parallel tree rows to allow mechanization).

The comparison between the two systems is carried out thanks to a Life Cycle Sustainability Assessment (LCSA) an integrative and holistic methodology able to catch interrelations among economic, environmental and social sustainability.

The analysis of environmental sustainability will be carried out thanks to the carbon sequestration data, obtained from the Food and Agriculture Organization of the United Nations (FAO) EX- ACT Tool, an appraisal system developed by the (FAO) providing estimates of the carbon-balance, understood as the net balance from all greenhouse gases (GHGs) expressed in CO_2 equivalent that were emitted or sequestered from land management or land use change activities expressed as CO_2 equivalent

Economic sustainability will be assessed through the monetization of all the collected inputs and outputs. This collection will be performed by multiplying the measured quantities by the unit prices of the precedent year.

For the agricultural system will be used the price data from project Farm Accountancy Data Network (FADN) an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy.

The economic value of carbon sequestration obtained through agroforestry Systems will be estimated using the price data of forest carbon credits obtained by the CREA Monitoring Carbon Center. http://www.nucleomonitoraggiocarbonio.it/it/

The analysis of the social impacts will be carried out by estimating the working hours required for soil management and for the employment generated by each system.

The aim of the work is to provide the owner of the land, the elements to make a management choice based on the objectives he wants to pursue.

The results of the research can be used by policy makers to promote, if necessary, an instrument of public economic support for farms, that make the management choice that favors the achievement of environmental and social goals at the expense of economic ones.

Resp'Haies, a national project in France to study the resilience and performances of agroforestry farms with hedges.

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development (Enhancing ecosystem services provision by agroforestry systems)

Keywords: Hedges, ecosystem services, biomass, economic performance, windbreak.

Abstract

The aim of the RES'HAIES project is to promote the establishment, management and multifunctional value of hedges within local farms and territories, so that they contribute to the resilience of farms and their economic performance, environmental and socio-territorial issues. In this perspective, RES'HAIES aims to: characterise hedges as territorial resources (1), to facilitate the understanding of ecosystem services rendered by hedges over time (2), and to evaluate their contributions to technical performances (3), the Committee of the Regions. These resources will be analysed and mobilised with a view to training and supporting (4) farmers, future farmers and managers, advisers and teachers.

A key parameter in Resp'haie will be the participatory approach in the process and methodology of the project, to help a co-creation of the knowledge inside the partnership and between the project and the end-users. For this purpose, the partnership includes an association specialised in this task.

The four actions of the project are (see Fig.1):

1. Action 1 aims to characterise hedges as territorial resources. Our approach will integrate a temporal dimension, in order to prioritize the control factors of landscape dynamics over time, in particular by confronting them with the evolutions of agricultural systems (land transfers, changes in production, changes in agricultural practices, etc.) (Marie, 2009; Preux et al, 2015) and the evolution of the wood-energy value chain (Douet and Lemarchand, 2016).
2. The objective of Action 2 is to evaluate, or even to diagnose, the agro-ecological functions and ecosystem services associated with hedges, by designing and experimenting "observatory" type schemes with management actors and advisers (Le Du et al, 2007). In particular, aerial imaging will be used to characterize water and nitrogen stress, and ultimately the yields of adjacent crops according to a radiant calculated from the hedge. (technology of photogrammetry monitoring by drone or satellite).
3. In Action 3, the contribution of hedges to the technical and economic performance of agricultural holdings will be assessed, by creating a model taking into account all the products and potential services (Liagre, 2018).
4. The objectives of Action 4 will be to mobilise, analyse and make the most of the resources produced in the previous actions. A national ressources platform will be created. It will enable farmers and hedge professionals (teachers, agro-forestry advisers, bocage technicians) to increase their skills providing tools to:
   - train future farmers or people in further training and support farmers in their multifunctional hedge management.
   - to facilitate territorial projects aimed at strengthening the place of hedges and initiating approaches to hedge management;

Partnership:

Afac-AgroforesterieS, AGROOF SCOP, University of Caen Normandy UMR Geophen, INRAE Rennes – UMR BAGAP and SAS, Association Sciences Citoyennes, EPLEFPA Melle, CEZ Bergerie Nationale de Rambouillet, SOLAGRO, CERREvMRSH Normandie, Agriculture Chamber of Normandie, SCIC Bois Energie / Wood Energy.

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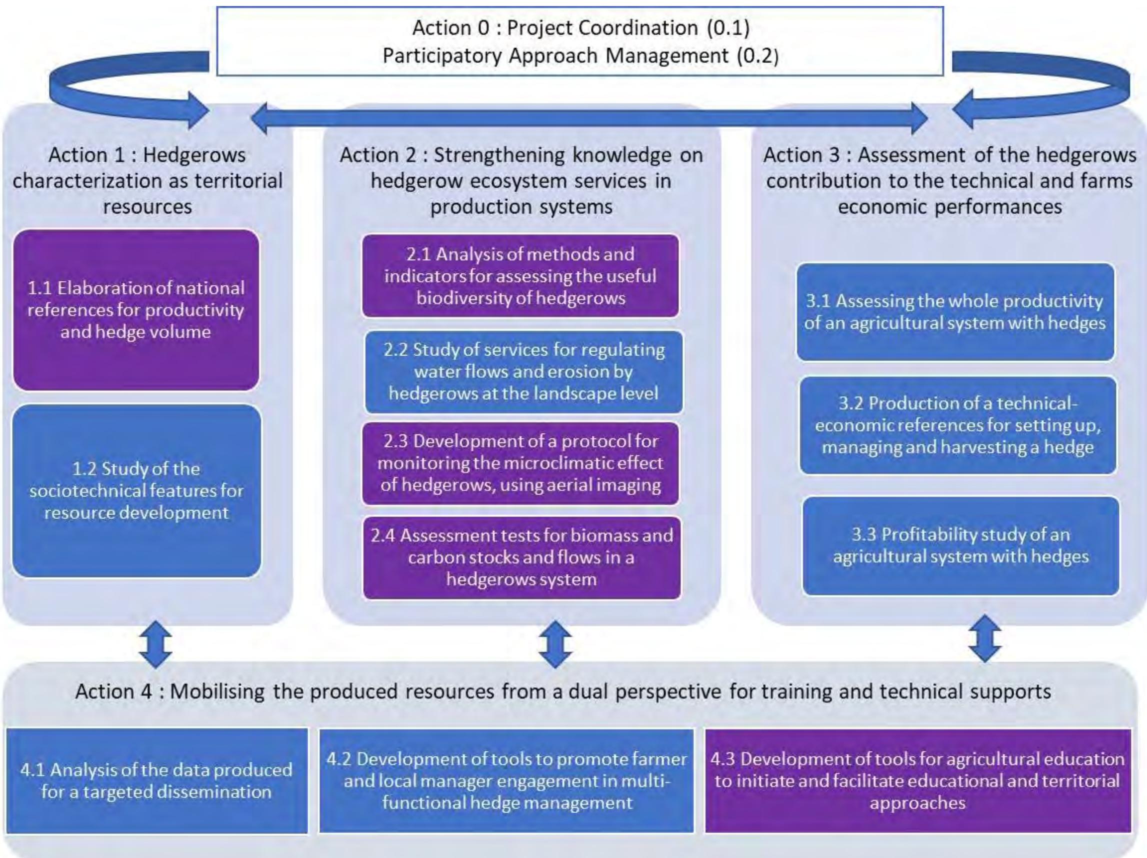

Figure 1. Organisation of the project Resp'Haies

Cork oak landscapes of Sardinia: cultural values in evolving rural economies

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: cork oak, landscape, ecosystem services, cultural values, identity, tourism, Sardinia

Abstract

Cork oak woodlands in Sardinia cover about 139,500 ha of land both as pure stands or wooded pastures, and they represent a traditional trait of the regional landscape. Cork oak is also present as sparse trees in almost 500,000 ha of mixed forests and Mediterranean pine forests. Sardinia is the greatest cork primary producer in Italy with around 90% of the Italian cork being produced in this region (Cutini et al 2019). The historical regions of Gallura, Marghine-Goceano, Monte Acuto, Nuorese, Sulcis-Iglesiente, Montiferru, Mandrolisai are the richest in cork oaks, with about 80,000 ha of cork oak forests and 60,000 ha of cork oak wooded pastures: both elements are a typical and unique feature of the Sardinian landscape, as well as an important component of the regional economy.

Cork oak landscapes (Figure 1) represent one of the best examples of the close relationship and interaction between man and nature: high-conservation-value forests alternate with farmland systems, integrating extensive agriculture, forest grazing, hunting and other recreational uses. In addition to providing a source of income for rural economies in Sardinia, cork oak ecosystems support a rich biodiversity. Current threats are related to increasing human pressures on resources (overgrazing, over-harvesting and forest clearance); ongoing societal mega trends (land abandonment, leading to shrub encroachment and forest fires); pests and diseases that lead to cork oak decline; poor forest management practices that damage cork regenerating tissues; finally, market competition and price fluctuations of cork (MIPAAFT 2018). These threats, exacerbated by climate change, affect cork oak landscapes and increase their vulnerability to diseases, pests, and extreme wildfires.

The cultural value adds-on to the economic value of these territories since cork oak landscapes have a high identity value. Cork oak cultivation and debarking in Sardinia have a strong tradition, with diversified production systems and harvesting techniques varying in different historical regions and even between close municipalities. However, like in many Italian rural contexts, these territories are experiencing a severe dynamic of land abandonment, with subsequent processes of renaturalization, mainly due to the competition with other forest species (holm and downy oak). Moreover, the lack of a well-organized value chain has hampered in Sardinia the development of a competitive market structure compared to other European countries, like Portugal and Spain, leading to price fluctuations and instability of the industrial sector.

Cork oak woodlands in Sardinia can therefore be considered "traditional rural landscapes" on the edge. Local initiatives to sustain and diversify incomes through ecotourism are slowly emerging, especially in multi-functional farms that combine the provision of services with the production of cork and other commodities, often in protected areas.

Figure 1. Typical cork oak landscape of Sardinia (Source: authors' photo)

The research activity is based on the application of a methodology aimed at evaluating, both in biophysical and economic terms (Ingaramo et al 2017), the ecosystem services provided by cork oak landscapes in Sardinia, based on the perceptions of two target groups: residents and tourists in the historical region of Goceano. Through data analysis, direct surveys and online questionnaires, provisioning, regulating and cultural values are assessed, the latter with specific reference to the identity value of cork oak woodlands for residents and tourists. The results of the evaluation showed a different willingness to pay (WTP) for residents (€ 11.78) and for tourists (€ 17.56). It is possible to underline some aspects: the elderly, traders and professionals are the categories willing to pay less; on the other hand, young people, environmental associations and entrepreneurs are willing to pay more, and are those who play sports and with a higher level of education. As for tourists, it should be emphasized that those who stay for more than a day, conditioned not only by the cork forests but also by food and wine, are also willing to pay more.

The framework of values provided – productive, ecological and identity – can be a useful basis to better define multi-functional management systems (Pollastrini et al 2018) and development strategies aimed to assist the evolution of these rural landscapes in response to climate and societal change.

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ROBUST: Agroforestry – a sustainable agricultural system for plant and milk production in northern temperate climate

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: temperate climate, ecosystem services, biodiversity, climate change, carbon storage, water irrigation, nutrient supply, dairy production, plant production, business model

Abstract

Organic Denmark has embarked on a four-year research project, ROBUST, together with 10 national partners.

The aim is to develop, investigate and spread agroforestry in DK. The objective is to document the effect of agroforestry on important green parameters such as: carbon storage in soil and wood mass, nitrogen leaching, nature value, competition with crops, feed value of deciduous biomass and animal welfare, and to model the effects of spreading forestry on a larger national scale and examine the production economic effects.

Four new organic agroforestry farms will be developed and established, and the business potential for products from these will be highlighted throughout the value chain. All four farmers will have their systems measured and continuously monitored regarding the following parameters.

Animal welfare

The project will investigate the impact of trees on cattle animal welfare during grazing in relation to shade, shelter, shelter, and skin care with the following activities:

1. Record cattle behaviour related to the shade, shelter, and shelter of trees as well as behaviour related to stinging insects on two farms
2. Register cattle's use of trees for skin care on two farms and possibly damage to trees
3. Record, using GPS, the location of cattle on the area and the time they spend using the trees in given weather conditions. This is linked, if possible, to performance level
4. The effect of tree shade on the microclimate is measured using loggers for indications of risk of heat stress

Biodiversity

The project will provide data that in the long run will form the basis for important knowledge about the biodiversity effects of forestry in northern temperate climates with the following activities:

1. Baseline measurement of insects on the soil surface, in the air and in the soil
2. Effect measurements after two years

To learn as much as possible from the four new systems, all systems will in addition to biodiversity, and animal welfare for silvo-systems be measured on the following parameters:

Carbon and nitrogen cycles

The purpose is to determine C storage and N uptake in agroforestry systems woody plants (above and below ground biomass), including the annual C accumulation and N balance with these activities:

1. Selection of focus woody plant species
2. Identification of two experimental sites, sampling of soil and measurement of C and N as well as repeated measurements of N in soil water at four different distances from the planting
3. Sampling of 30 individuals for each of 3-4 tree species and measurement of: a) biomass of wood and foliage and content of C and N; b) growth based on annual rings
4. Permanent sample of trees comprising 30 individuals for each of 3-4 species. N content and growth
5. Development of biomass and growth models for 3-4 tree species incl. effect of deciduous harvest

Interaction

To quantify and document competition between trees and agricultural crops with the following activities:

1. Repeated yield measurements in crops at two experimental sites at four different distances from the planting
2. Study of light and nutrient competition between trees and crops at two experimental sites

Business potential

To explore the business potential of agroforestry in company brands by:

1. Development of agroforestry product portfolio
2. Analysis of needs and value creation among customers
3. Development of marketing material for agroforestry products
4. Development of digital cultivation tools

Figure 1. Dairy farm with sketching of new agroforestry systems (from Skovdyrkerne)

Hybrid walnut wood quantity and quality: Agroforestry vs. Forestry systems.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Agroforestry, wood quality, growth, wood productivity, *Juglans regia x nigra*

Abstract

On an agroforestry plot, the services provided by trees are numerous, especially on the economic front since they help to improve the business model of the farm by diversifying activities and income for the farmer.

However, agroforestry trees grow in very different conditions than forestry trees mainly because of their higher exposure to wind and light, specific competition for water availability, strong interactions with annual crops, numerous human operations on branches (pruning) and root systems (due to the tillage). Production level and quality such as anatomical, chemical and technological properties of wood coming from agroforestry systems have not yet been studied. Such results could provide many interesting data to the farmers to promote access of agroforestry wood to conventional and/or niche markets.

This work started in January 2020 and is divided into two main axes: on one hand, we aim to understand how agroforestry trees adjust to their specific growing conditions, and on the other hand, we aim to study how these growing conditions affect the quality of the wood. As well as the annual wood productivity level, the notion of wood quality, which is very important because it influences the potential valorisation ways of the woods, may allow to improve their economical values. In our study, the wood quality will be addressed by considering the two following aspects: the mechanical performances and the biochemical composition. Two species are studied: hybrid walnut (*Juglans x regia x nigra* NG 23xRA) for the high aesthetic value in the wood market and poplar (*Poplar sp*) for the packaging and building market. The work is conducted by comparing, for each species, the growth and quality of wood from agroforestry trees with that from trees grown under more conventional conditions in terms of stand densities.

In this presentation, we focused on hybrid walnut trees growing into the Restinclières Agroforestry Platform (RAP), near Montpellier, France, managed by UMR ABsys INRAE team (https://umr-system.cirad.fr/en/the-unit/research-and-training-platform-in-partnership/restinclieres-agroforestery-platform-rap). Two plots with 25 years old walnuts are studied: an Agroforestry plot (AF, with 140 walnuts) and a Forestry Control plot (FC, with 235 walnuts).

Initially the planting density in both plots (AF and FC) was identical. A thinning in 2004 reduced the density of the AF plot to 100 trees/ha and walnut trees were spaced 4, 8, 12 or 16 m on a same planting line. Between each line, winter cereal crops were cultivated. In FC plot, the walnut tree density was almost 200 trees/ha and were mixed with alders (*Alnus cordata*). In both plots, tree rows were north-south oriented. In the agroforestry stand, the annual crop was fertilized with approximately 150 kg N ha^{-1} yr^{-1}, except when it was a leguminous, and the soil in the inter-row was usually ploughed to 20 cm depth every year before the crop was sown. In the forest control plot, half of the trees were fertilized until 2010 and the other half not.

Dendrometric measurements have been recorded by UMR ABSys since 1995 for the height and 1998 for the circumference at 1.30 m height and allow the comparison of wood production between agroforestry and forestry walnuts. Our first results show that radial growth of the stem in AF plot was greater than in FC plot, with mean values of circumference of 95 cm and 63 cm, respectively in 2017 (Figure 1 - left). The height of walnut trees in AF plot was also more important than those of trees from FC plot with average values of 12.8 m and 11.5 m high, respectively (Figure 1 - right).

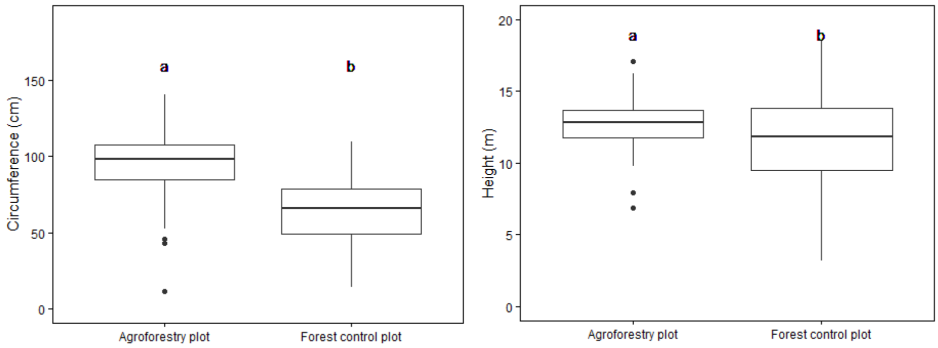

Figure 1. Left: Circumference at 1,30 m height of AF walnuts and FC walnuts, *p-value = 2.2e-16 (2018)* / **Right:** Total height of AF walnuts and FC walnuts, *p-value = 0.00012* - (2017)

Concerning radial growth, our results are in agreement with observations made on the impact of stand density on growth. In forest stands, density has significant effects on radial tree growth and crown size. Low stand density leads to the formation of trees with larger diameters than trees planted at higher densities (Jiang et al. 2007). In addition, Cabanettes et al. (2004) showed that tree spacing in agroforestry systems favored radial growth. This could be explained by the higher availability of water, light and enhanced by a higher mechanical stimulation due to the wind (Bonnesoeur et al. 2016 ; Niez et al. 2019). Concerning height growth, our results show the AF walnuts are taller than FC walnut, which differs from other studies indicating that agroforestry trees are usually smaller than forest tree (Cabanettes et al. 2004) and that axial growth could be reduced by higher mechanical stimulations due to wind (Niez et al. 2019).

After this first quantitative approach on agroforestry walnut wood, all the other experiments aim at investigating the qualitative aspects of these specific woods; in particular the duraminisation kinetic reactions, the mechanical properties and the peeling ability for an industrial target. These experiments are currently in progress.
The continuation of the study on the growth of agroforestry trees will focus on the agroforestry poplar, its mechanical properties and its aptitude for peeling. We will also focused on the impact of wind on the primary and secondary growth dynamics of the trees and on the juvenile/adult transition of the wood whose age of establishment influences the mechanical quality of the wood produced by the tree.
In parallel to these two main studies, the effect of wind on tree growth (thigmomorphogenesis) is studied on young Black Locust trees (*Robinia pseudoacacia*) in an experimental agroforestry system in South of France, in order to distinguish the effects of water, nutriments and light resources from the impact of higher exposure to wind.

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The RobustAlps project: a silvopastoral system in *Alnus viridis*-encroached alpine pastures

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Attractive points, biodiversity, GPS tracking, grassland, robust livestock

Abstract

Green alder (*Alnus viridis*) is a pioneer shrub species that has expanded over former pastures in Central Europe due to land abandonment, leading to negative agri-environmental impacts, such as an increase in nitrate leaching and soil acidification. Robust livestock breeds, such as Highland cattle, could be used to control *A. viridis* expansion and create an agro-silvopastoral system aiming at restoring alpine grassland services. The objectives of this study were to investigate the impact of *A. viridis* encroachment on plant community composition and diversity and to map the spatial distribution of Highland cattle in *A. viridis*-encroached pastures with the strategic placement of attractive points.

During the summer of 2019, three different Highland cattle herds were placed in three sites along an *A. viridis* encroachment gradient in Switzerland (Site Bovonne and Champlong) and Italy (Site Val Vogna). A total of 58 botanical surveys were carried out before grazing to assess plant community composition, pastoral value and ecological indicator values associated with *A. viridis* cover. The spatial distribution of cattle in shrub-encroached paddocks was studied at the beginning, middle, and end of the grazing period by monitoring 6 to 8 cows equipped with GPS collars in each herd. During the summer of 2020, molasse-based blocks were placed in highly encroached parts of three paddocks (two in Bovonne and one in Vogna) to attract the herds. Botanical surveys were carried out before and after grazing around both molasse-based blocks and control areas to assess the role of attractive point in increasing *A. viridis* grazing.

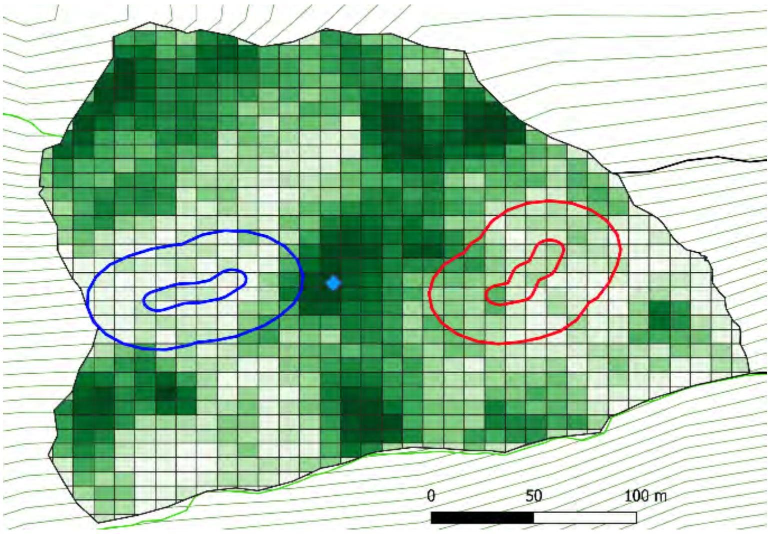
Plant species associated with higher pastoral values of the vegetation were found in areas with lower *A. viridis* cover, while highly encroached areas were dominated by a few nitrophilus and shade tolerant broad-leaved species and by ferns. In contrast to many other breeds, Highland cattle were capable of grazing on *A. viridis* encroached area, as well as on the steepest slopes and further away from water sources, as they were not significantly influenced by these harsh conditions. Moreover, cattle even preferred *A. viridis* patches and steep slopes in Champlong, during certain grazing periods, which shows that cattle are able to move to areas with the most unfavourable conditions and can stay there for relatively long periods (approximately two weeks). Vegetation cover around attractive points strongly decreased after grazing (by about 50%) compared to control areas, which resulted in increased bare

soil. Simultaneously, leaves of *A. viridis* were also more consumed and branches more damaged by cattle around attractive points.

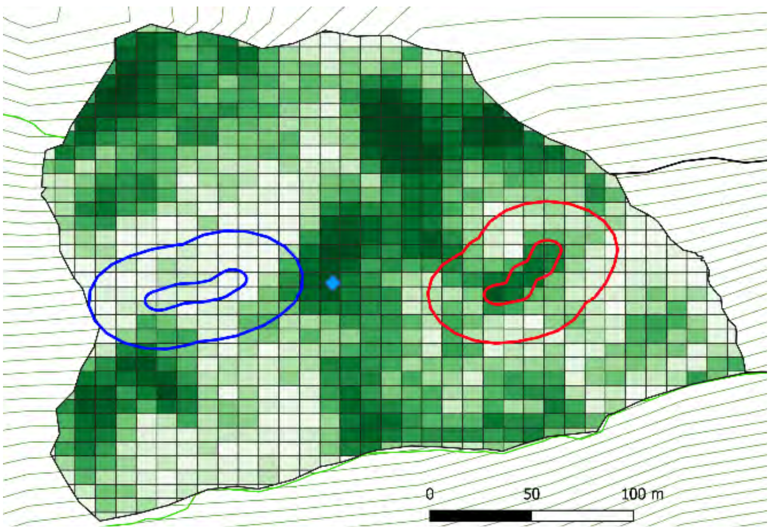
Altogether, our findings demonstrate the ability of Highland cattle to graze in harsh environmental conditions and to exploit *A. viridis*-encroached pastures. Furthermore, the presence of attractive points was shown as extremely efficient in attracting cattle toward patches highly colonized by *A. viridis* (Figure 1), where they successfully grazed and damaged *A. viridis*. Such results highlight the important role of Highland cattle and attractive point in initiating a succession from vegetation with low pastoral value (ferns, nitrophilus species) toward the re-establishment of grassland species with higher forage value. Overall, our results suggest that highland cattle have a high potential to reduce *A. viridis* encroachment in the long-term and partially restore shrub-encroached alpine grasslands.

Figure 1: Maps of the green alder-encroached paddock of Bovonne in 2019 without attractive points (a) and in 2020 when the effects of attractive points have been tested (b). Blue losange represents the water tank for cattle. Grid cells are 10 x 10 m and green color represents the exploitation by cattle (i.e. from GPS points) from low exploitation in light green to high exploitation in dark green. Red shapes (buffer of 10 m and 50 m) represent the area around attractive points while blue shapes (buffer of 10 m and 50 m) represent the control area. The maps highlight the similar exploitation by cattle of both areas in 2019, prior to the use of attractive points (a), and the higher exploitation of the area around attractive points in 2020, especially in the 10 m buffer (b).

(a) Exploitation by cattle in 2019 before the use of attractive points



(b) Exploitation by cattle in 2020 with the use of attractive points



Let's get comparable – a standardized soil sampling design for agroforestry systems in Germany

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: German agroforestry, Standardization, Experimental design, Ecosystem services, Transect sampling

Abstract

Agroforestry systems are complex and diverse agroecosystems with multiple ecosystem services and a promising potential for climate change adaptation and mitigation. As such, agroforestry practices currently gain more and more recognition in the German agricultural sector. In the last years, we have been seeing a dynamic change of land use systems with a constantly increasing number of farmers experimenting with agroforestry practices for arable land, animal husbandry, orchards and horticulture. This coincides with a change in political acceptance of agroforestry systems in Germany, recently expressed in a vote in favour of future financial support of agroforestry systems by the German parliament.

Agroforestry practices, determined by the perennial vegetation and lack of soil tillage, have direct and indirect influence on soil quality indicators and related ecosystem services including carbon sequestration, nutrient cycling, water storage and soil biodiversity. Especially silvoarable systems are expected to show differences in soil characteristics and associated services between the tree row and the adjacent arable field. This raises the question of how we can study this internal complexity of an agroforestry system.

Experimental studies often use a transect sampling design for analysing effects like soil organic carbon, aggregate stability or species abundance and diversity (Monnier et al. 2015; Battie Laclau et al. 2019; Beule et al. 2020): samples are taken in the tree row and in the adjacent arable field with various distances from the tree line to the centre of the field. Transect sampling is a well-established method to document changes in the soil and to study the development of the soil ecosystem under agroforestry practices.

However, at present, the comparability and integration of results from different studies is compromised by several factors. Beside the fact that the designs of agroforestry systems differ widely in terms of trees and field crops, distance between tree lines, planting densities, etc., the study designs are also quite heterogeneous. This latter issue seems much easier to solve than the former. Better comparability would benefit the quality of meta-studies and help researchers, farmers and decision makers in taking informed decisions.

As a contribution to increase comparability, we suggest a standardized soil sampling design for German agroforestry systems including the transect sampling method and recommendations for soil fertility analysis methods for researchers and practitioners. The standardized design will be distributed to interested practitioners providing them with simple tools (e.g. spade diagnosis, SLAKES app, tea bag index) to carry out their own soil analyses. Furthermore, we use the standardized design for our own

analyses and share it with other research groups and organisations working with agroforestry systems. Our hope is that other researchers find this standard design useful so that more comparable data is created in future studies.

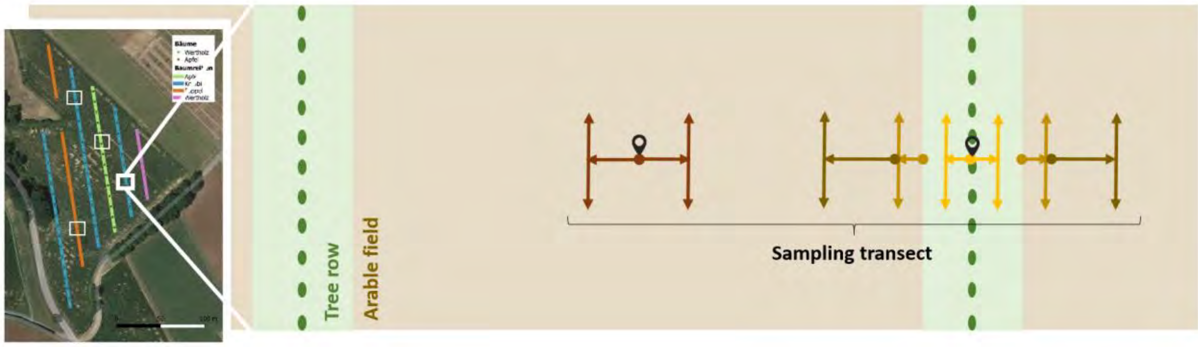

Figure 1. Schematic illustration of the standardized soil sampling design for agroforestry systems in Germany. Composite samples will be collected in a transect from the tree line to the center of the arable field. Replicate samples close to the tree row will be taken at each side of the row. At least four transects per agroforestry system is recommended. GPS coordinates are taken in the middle of the tree line and at the center of the field to allow for repetitive sampling.

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Crop yield, soil conditions and functional agrobiodiversity in temperate arable alley cropping fields throughout the first decade after tree establishment

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Arable agroforestry, alley cropping, maize, wheat, barley, potato, walnut, poplar, cherry

Abstract

Introduction

In recent decades, a renewed interest in agroforestry (AF) can be noted in large parts of temperate Europe (Reisner et al.,2007; Wolz et al.,2017). This is mainly driven by the search for increased sustainability and farm resilience, increased profitability and/or diversification or the need for applying with regulations (e.g. greening). In these regions, where farming is generally highly mechanized, in particular the practice of alley cropping may offer a promising land use alternative. In this type of AF system, trees are planted in rows across the field. As such, they can efficiently be combined with the use of modern farming techniques and machinery for the cultivation of agricultural crops in the intercropping zone. At present, this renewed interest often does not result in the simultaneous implementation of AF practices as a result of several drawbacks (Borremans et al., 2016). A main drawback is the lack of quantitative data regarding the impact of tree presence on biodiversity, soil conditions and in particular on crop yield. Therefore, in this research, yearly measurements were conducted on eight temperate arable alley cropping fields to simultaneously quantify the abovementioned variables throughout the first decade after tree planting.

Material and methods

Eight young arable alley cropping fields were selected. The year of plantation varied from 2011 till 2014. A minimum of two tree rows was present at each field and part of the fields was treeless to constitute a control situation. All fields are in an arable rotation including primarily winter wheat (*Triticum aestivum* L.), winter barley (*Hordeum vulgare* L.), maize (*Zea mays*), potato (*Solanum tuberosum* L.) and vegetables. Two of the fields are cultivated organically. On each field, three transects are established between two neighbouring tree rows (Figure 1). The transects are located perpendicularly to the tree rows and consist of six measuring plots located in the arable zone at 2, 5 and 12 m of the closest tree row for crop and soil measurements. An additional sampling plot is located in the control part of the fields. In each sampling plot a yearly measurement of crop yield is conducted (tonnes ha^{-1} and crop-relevant quality parameters), as well as a periodical analysis of the soil conditions (SOC and soil nutrient status, 0-23 cm depth). For the assessment of agrobiodiversity, two transects are established whereby the sampling plots are located in the tree rows, at 1 and 5 m of the closest tree row and in the centre of the arable zone between the two neighbouring tree rows. The activity-density of predatory (rove beetles and carabids) and detritivorous (millipedes and woodlice) arthropods is monitored in each sampling plot by the use of pitfall traps.

Preliminary results and discussion

Results will include the quantification of abovementioned variables as function of crop type, tree age, tree type and distance to the tree rows. As shown by a.o. Pardon (2018a), the impact of both beneficial and negative effects of tree presence will often be limited during the first years after establishment. Substantial effects may however occur as tree age increases. In mature systems, the revenues from wood, fruits, carbon credits or the beneficial effect of enhanced soil conditions and biodiversity may compensate for the reduced crop yields. Whereas occasional revenues may occur in maturing alley cropping systems, e.g. originating from thinning, a lag phase will generally be present whereby a negative impact on crop yields precedes these future revenues. As shown in Pardon et al. (2018b), this may partly be overcome by the choice of crop type. The yearly crop-measurements on our set of experimental fields allow the assessment of impacts on crop yield and quality during abovementioned lag phase, which may be of vital importance for the farmer from a financial point of view. Moreover, they aid in determining when (and which) crop-shifts impose themselves during a tree rotation in view of system optimization. Similarly, whereas changes in soil carbon, soil nutrient conditions and functional agrobiodiversity are substantial in older systems (Pardon, 2018a), limited effects are often observed during the first years after establishment. Our data allow for the estimation of changes over time during the first decade after tree planting. This again provides farmers and government with a more detailed estimation of the ecological value of alley cropping systems (e.g. efficacy of greening measures) and the impact on the financial level (e.g. assessing the need for fertilizer and crop protection agents, revenues from carbon credits).

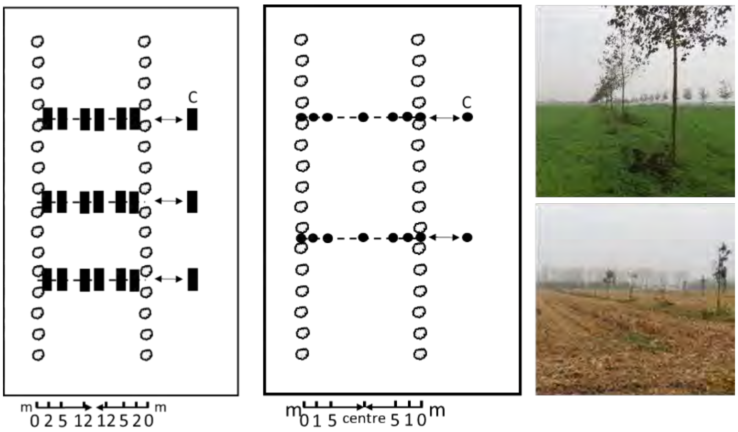

Figure 1. Experimental setup for yield, soil measurements (left) and biodiversity (right), "C": control plot (after Pardon 2018a)

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1.3

Agroforestry, biodiversity, and wildlife management

Higher biodiversity and pollination service in temperate agroforestry than in monoculture.

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: temperate agroforestry, biodiversity, pollination, abundance, richness

Abstract

Context: Agricultural intensification has resulted in trade-offs between food production and biodiversity. Biodiversity loss can negatively affect food production because it underpins ecosystem functions and services that contribute to productivity (Dainese et al. 2019). Insect pollination is one such service, contributing to crop yields and production stability (Klein et al. 2007; Fijen et al. 2018), as well as the maintenance of wild plant populations globally. Ironically, the very systems reliant on biodiversity – and the ecosystem services it supports – are also harming it, as agriculture is one of the major global drivers of biodiversity loss (IPBES 2019). At the same time, increasing human population is driving ever greater demands on crop production.

This study assessed whether agroforestry – a more biologically diverse farming system integrating woody and agricultural crops – can provide higher biodiversity and increased pollination service compared to monoculture systems, as a way of reconciling production with ecosystem service protection and biodiversity conservation. Agroforestry (AF) has shown the potential to mitigate biodiversity loss in tropical agricultural landscapes (Hass et al. 2018); however, few studies have investigated this in temperate regions and even fewer in the UK, and previously there were none investigating pollination service in temperate systems.

Methods: Six UK sites, each containing an AF and a monoculture field, were studied over three years. Sites were visited monthly from March to September. Plant species richness (SR), butterfly SR and butterfly abundance were used as proxies for overall biodiversity. Wild insect pollinator abundance and diversity were used as proxies for the magnitude and stability, respectively, of the pollinating community (Winfree et al. 2018; Castle et al. 2019). Abundance within each taxon was measured as the total number of individuals recorded during a field season in each field. SR within each taxon was measured as the total number of species recorded during a field season in each field. We also directly measured pollination service as seed set in a wild plant phytometer.

Butterfly SR and abundance, and pollinator abundance, were estimated using timed transect walks, each 200m long and carried out on each site visit. In AF fields, half of each transect (100m) was situated in the centre of the alley and the other half ran along the edge of the alley to sample both environments. Wild bee SR was investigated using UV-bright pan traps (Westphal et al. 2008; Nielsen et al. 2011) left out for 9 hours on each visit. Six pan trap sampling locations were positioned in a diagonal line across an AF alley and the set-up mimicked in the monoculture fields. Plant SR was estimated using a minimum of nine 50x50cm quadrats placed randomly in each treatment. If a subjective assessment

indicated that there were many uncaptured species remaining after nine quadrats, up to a further nine quadrats were done.

Results & Conclusions: AF had higher biodiversity than monoculture systems, with more than double the plant SR, almost three times the butterfly SR and more than three times the butterfly abundance. The higher biodiversity may have implications for the provision of other ecosystem services in agricultural landscapes: we found that SR of plants and solitary bees were strongly correlated, so managing AF systems for greater plant diversity may positively affect pollination service. Further work is necessary to investigate population-level effects and any potential disservices resulting from increased biodiversity.

The AF systems also had greater pollination service than monoculture (Varah et al. 2020): AF treatments had 3.6 times more hoverflies, twice as many solitary bees and 1.2 times more bumblebees than monoculture treatments. AF also had 4.5 times more seed set compared to the monocultures in one of the two years in which phytometers were used (in the other year, fieldwork issues affected the experiment and no firm conclusions could be drawn). At 40% of site-by-year sampling units, solitary bees were on average10.5 times more species-rich in the AF treatments. This provides evidence in favour of the expectation that AF systems support higher pollinator richness, and therefore greater stability, of pollination service. In the other sampling units, and for bumblebees (*Bombus* spp.), there was no treatment effect on SR. Further work is needed to investigate the effect of AF on SR and its mechanistic basis.

AF therefore shows great potential to help mitigate biodiversity and pollinator loss in agricultural landscapes, especially where the AF system has tree rows with vegetated understoreys and where the trees are flowering species. Our results highlight a need for careful design of AF systems, ensuring that ecosystem services outcomes such as pollination are explicitly planned at the design stage. We suggest that modern, temperate AF systems have a role to play in improving the sustainability of modern farming, contributing to biodiversity targets in agricultural landscapes and in mitigating the ongoing loss of wild pollinating insects, which is strongly driven by prevailing agricultural practices.

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Characterization and management of Russian olive accessions in Gilgit-Baltistan, northern Pakistan

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management

Keywords: Correlation, *Elaeagnus angustifolia*, medicinal plant, oleaster, principal component analysis

Abstract

Russian olive (*Elaeagnus angustifolia* L., Elagnaceae) is a native multi-purpose medicinal shrub or tree of Central Asia, and an often invasive species outside its natural habitate. In traditional medicine, Russian olive fruit, pulp powder and/or flower decoction is known for the effective treatment of tetanus, flatulence, asthma, amoebic dysentery, jaundice, vomiting, nausea, rheumatoid arthritis, and osteoarthritis (Nikniaz et al. 2014; Panahi et al. 2016; Wang et al. 2006). Due to the presence of different secondary metabolites, antioxidants and its antimicrobial activities, Russian olive extracts have also been reported to treat mastitis in-addition to its use as a natural insecticide in agriculture and as preservative agent in the food industry (Okmen and Turkcan 2013; Torbati et al. 2016). In Gilgit-Baltistan, northern Pakistan, the species is an integral part of high altitude terraced agroforestry systems (Khan and Khatoon 2008; Shedayi et al. 2014) (Figure 1). The strong increase in deforestation, urbanization, and the loss of ethnically-based medication practices in local communities in Gilgit-Baltistan are gradually leading to depletion of its stands and knowledge of its use. In view of these circumstances, this study was undertaken to characterize Russian olive accessions in Gilgit-Baltistan as a first step towards the conservation of this important wild plant genetic resource. Therefore, 93 individuals have been geographically recorded, phenologically described, and grouped according to three sampled districts: Ghizer, Gilgit, and Hunza. Threehundred-seventhy-two fruits (including seeds) and leaves each were sampled to determine morphological variability among accessions. In addition, the concentration of phenolics in the pulp of 40 fruits was determined. To assess the local importance of the tree and its crop, 42 Russian olive collectors and traders were interviewed. Data were analysed using descriptive statistics, coefficient of variation (CV%), PCA and clustering approaches. Overall, stem diameter ranged from 6 to 65 cm. Fruit and leave traits across groups were equally distributed. Largest variation was found for pulp weight and fruit volume, while the variation for other traits was moderate to low. Elevation had a positive effect on fruit and seed dimensions especially on length (r = 0.606 and 0.515, respectively) and weight (r = 0.618 and 0.695, respectively). Out of 20 morphological variables entered, 17 variables, matching the sampling adequacy

criterion, were retained for the final PCA and subsequent cluster analyses. PCA revealed that the first two PCs accounted for 55.8% of the total quantitative variation. Overall, biochemical concentration in the sampled fruits exceeded most values found in the literature. Especially total flavonoid and phenolic concentration exceeded known values by up to 100times. It must be stated that also sampling errors such as age and health of trees or time of picking may have resulted in the observed magnitude of phenological, morphological and biochemical variation and that underlying factors are difficult to determine. The socio-economic household analysis highlighted that Russian olive harvest and trade is a purely additional income strategy. Family size of households harvesting Russian olive averaged 6.6, whereby about 25% of them were involved in the collection of fruits and/or their trade. Most family members have been involved in Russian olive collection since their childhood. On average, two people were responsible for harvest at rather distant collection sites (>12 km) with daily harvesting amounts between 11 and 20 kg. On average, about 90 € (ca. 16000 PKR) were earned by a household ranging from about 35 € to about 205 € per year. Data yielded a mixed picture on morphological and biochemical diversity as well as the socio-economic background, but indicated that the region might be an important centre for biodiversity and diversification strategies. We argue for more intensive studies in neighbouring districts to better understand the underutilized agro-economic potentials of this species as well as to draw potential conservation strategies.

Figure 1. Elevation map displaying locations of surveyed *Elaeagnus angustifolia* accessions in Gilgit-Baltistan, Pakistan, 2017. Differently shaded and outlined circles indicate accessions from three districts.

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Ecosystem services in short rotation coppice in agricultural land in Latvia.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management, bees

Keywords: Short rotation coppice, agricultural land, plant diversity

Abstract

Global efforts to mitigate climate change and reduce greenhouse gas emissions from fossil fuel combustion, places an expanded use of renewable energy high on the political agenda (Sridhar et al., 2014). There is an increased demand in the European Union for wood supply, and particularly for bioenergy (Nabuurs et al. 2014). Furthermore, the European Union has set a target to increase the contribution of renewable energy up to 20% of total supply till 2020 (European Commission, 2014). Implementation of short rotation tree plantations (coppices) in agricultural land is an agroforestry method offers approach to replace fossil fuels as an energy source (Weih and Dimitriou, 2012) with a potentially carbon neutral supply of energy (Sridhar et al., 2014). Increased supply of wood resources for bioenergy can be ensured by planting fast growing tree species such as Alnus incana, Betula pendula, Salix spp. and *Populus tremuloides* x *Populus tremula* in a short rotation coppice system in agricultural land. While the main benefit of these plantations is renewable wood energy, such type of agroforestry systems are believed to provide also a number of other ecosystem services.

The research object (experimental plantation) was established in agricultural land in the central part of Latvia (in Skriveri district, 56°41 N and 25°08 E) in hemiboreal region in the spring of 2011. Trees were planted in former arable land used for seed production of annual crops. Total area of research object was 16 ha. Soil types according to the World reference base for soil resources 2006 are *Luvic Stagnic* Phaeozem, *Hypoalbic* and *Mollic Stagnosol, Ruptic, Calcaric, Endosiltic*. The dominant class of soil texture is loam and sandy loam at 0–20 cm depth and sandy loam at 20–80 cm deep. The research object was fenced in autumn 2012. Soil was ploughed last time in 2011. Within the study we evaluated ecosystem services – benefits provided by non-woody plants ingrown naturally in an experimental short rotation coppice plantation where fast growing tree species (*Alnus incana*, *Betula pendula*, *Salix spp.*, *Populus tremuloides* x *Populus tremula*) were planted in rows Trees between grasses finally managed as intercrop agroforestry system. Planted trees and naturally established meadow plants were cultivated as agroforestry. The first vegetation survey was conducted in summer 2014 (in the third year after establishment of experimental plantation), the second survey was conducted in autumn 2015 (in the fourth year after establishment of experimental plantation).

In the studied short rotation coppice plantations established in agricultural land, meadow plants dominated in the herb layer, in total 98 vascular plant species were recorded. Medicinal plants (e.g. *Achillea millefolium*, *Aegopodium podagraria*) and forage for livestock feed (e.g. *Trifolium pratense*, *Agrostis tenuis*) were indicated as the main provisioning ecosystem services provided by the herb layer.

The most suitable short rotation coppice plantations for forage were *Betula pendula* and *Salix spp.* plantations. In total 34 forage plant species were indicated in the research object, 29 of them

found in *Salix spp.* plantations. Medical plants were more frequent in *Salix spp.* plantations. A large number of the dominant herbaceous plant species (in total 20 different species) in the research object were nectar plants (e.g. *Centaurea jacea* and *Trifolium arvense*) which flowered from May till 1September coinciding with the entire period of nectar collection by bees. Another important regulating ecosystem service provided by the short rotation coppice plantations was N fixation by legumes. In total 12 different species of legumes, which improve soil conditions due to association with N-fixing bacteria, were found. The amount of the plants suitable for phytoremediation is similar in all plantations. The continuous plant cover of coppice plantations is expected to improve soil quality (organic matter and nutrient content, aeration).

Activities are continuing thanks to in European Development fund support where set of Salix alba agroforestry systems will be established during next years, as well seminars for local farmers including visits of experimental demo fields -new ones as operated since 2011 will be organized as project "Installation of innovative white willow-perennial grassland agroforestry systems fertilized with mixtures of wood ash and less demanded peat fractions" (Nr. 1.1.1.1/19/A/112).

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Figure 1. Agroforestry system below canopies of trees

Woodlands and hedgerows of the Po plain: planning instruments and policies implications on biodiversity conservation

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management
Keywords: green infrastructure, land use planning, Natura 2000, forest management

Abstract
Forests and rural hedgerows, even though altered and fragmented, are traditional elements of the floodplain rural landscape of northern Italy. Their structural characteristics can enhance their ecological functions and especially biodiversity conservation. This work (Trentanovi et al. 2016) summarises existing knowledge on woodlands and rural hedgerows within the Po plain with reference to planning instruments and policies aiming to biodiversity conservation. The study area focused on the lowlands that are bordered in the northern part by the spring belt within the Veneto region. Landscape structure is represented by a patchy mosaic of cultivated fields (from one hectare or less to several dozens), urban systems, with only small patches of natural and semi-natural ecosystems (Tempesta 1989). According to the regional map of forest types (Del Favero 2006), forests cover about 8.870 hectares (only 2% of the total study area) of the lowland in Veneto. Ancient forests represent only a small portion of this area with few patches (see Buffa & Villani 2012). In general, the most representative are plantations (63%), riparian (29%), coastal (5%) and oak-hornbeam forest types (3%). Even if altered in their composition and structure, some of these forests are habitat types protected as Natura 2000 sites by the Habitat Directive (92/43/EEC), and cover around 2,300 hectares. These woodlands are important for the conservation of amphibians and reptiles protected by the Habitat Directive. Within the studied lowland there are also some small areas that are locally protected ("aree naturalistiche minori" in Italian) under regional and local planning instruments. Some of these sites are characterized by the presence of spontaneous woodlands developing towards natural potential vegetation. These plant communities are a result of the abandonment of human activities of former land uses like quarries, mud dump sites, depressions within the rural landscape (traditionally called "Palù") of the floodplain. Plantations of native tree species were established through incentives derived by regional (regional law 2003/13) and European programmes (Rural Development Programmes). Finally, spontaneous woodlands dominated by non-native trees are located mainly on former industrial areas, and along railways and roads in urban-rural fringe. In these cases, the main non-native tree species are *Robinia pseudoacacia* L. and *Ailanthus altissima* (Mill.) which can have several impacts on biodiversity (Trentanovi et al. 2013, Nascimbene et al. 2015, Sitzia et al. 2018). In addition to forests, rural hedgerows are important ecological corridors, as they function as a connection between meta-populations, and represent an essential ecotone habitat for many animal and plant species. Indeed, hedgerows, as well as forests patches, provide several ecosystem services ranging from the mitigation of air pollution, water regulation, maintenance of microclimates suitable for crops, and the improvement of landscape quality (Dainese et al. 2017). In particular, Sitzia et al. (2011) highlight the high variability and complexity of the composition and vertical structure of rural hedgerows between different landscape structures. The same authors report that hedgerows with different physical features (e.g. drain channels, non-cultivated margins) and a complex vertical tree structure have particularly high levels of vascular species diversity. Furthermore, the distance from forests is a key factor influencing their functionality in terms of ecological corridors for herbaceous species typical of woodlands (Sitzia, 2007). With respect to the European regulatory framework, the Habitats Directive (92/43/EEC) aims to maintain and achieve a favourable conservation status of natural and semi-natural forest habitat types through specific conservation measures. The Prioritised Action Framework (PAF) identifies a number of conservation actions to be prioritised consistently with the local and regional planning and regulatory framework (Table 1). Together with the planning instruments that are directly designed for biodiversity conservation (e.g. protected areas' management plans) there are several instruments that can contribute in many ways to biodiversity conservation. For instance, the regional urban law (regional law 2004/11) has a strong influence on the planning of non-urban areas that in turn plays a role on the management of the studied habitats. The identification of the elements that characterize the rural landscape and their ecosystem services can lead to the definition of ecological strategies at different spatial scales (i.e. ecological networks). Our analysis highlighted that several activities are carried out with biodiversity

conservation purposes but this is done in a fragmented way. The assessment of the outcomes on conservation of these lowland forests and hedgerows by the different planning instruments is complex and cannot be generalised. Indeed, a positive trend must be highlighted in terms of their inclusion in planning policies and their increase in land cover. However, work still needs to be done to assess their ecological functions at the landscape scale. Furthermore, identifying appropriate requirements and good practices for the conservation of the analysed elements can be challenging for managers and stakeholders.

Table 1: Examples of conservation and management measures and the related planning instruments (PAF: Prioritised Action Framework; EP: Environmental Plan of protected areas; FP: forest plan; WHP: wildlife-hunting plan; WMP: water management plan, APR: agriculture policy regulation, UP: urban plan) to tackle specific pressures and threats to forest habitats and hedgerows (modified from Trentanovi et al. 2016)

Habitats	**Pressures and threats**	**Management and conservation measures**	
		Description	**Planning instruments**
Habitat 91E0* and 91F0 (riparian forests, coastal forests)	Invasion of non-native species; chemical pollution by fertilizers and pesticides; high intensity cutting	Enhance the presence of native tree species	PAF, EP
		Control and eradication of non-native invasive species	
		Establishment of buffer zones; Banning the use of fertilizers and pesticides around forest sites	PAT/PI, RPR, WMP
		Enhance the presence of deadwood elements and microhabitats	PAF, FP
Habitat 91L0 (lowland oak-hornbeam forests)	Invasion of non-native species; Eutrophication	Forest management treatments aiming to control non-native invasive species	PAF, FP
		Enhance the presence of deadwood elements and microhabitats	PAF, FP
Rural hedgerows	High intensity coppice	Management aiming to increase structural diversity	RPR, PFV
	Intensive farming and urbanization	Banning of removal	UP, APR, WHP

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The effects of tree species composition on soil-related biodiversity in shelterbelts

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development

Keywords: shelterbelt, biodiversity, herbaceous vegetation, soil mesofauna

Abstract

Agriculture has a major influence on biodiversity and ecosystem stability. Apart from the ecological aspects, erosion, soil drying, and loss of organic nutrient content causes difficulties in production. Several studies highlighted that using native tree species in shelterbelts have a positive impact on the bird and insect communities, but very few data can be found about the understorey vegetation. However, the diverse herbaceous flora in intensively cultivated areas offers favourable conditions for pollinating organisms, and the natural enemies of pests and pathogens. Under nutrient-poor conditions, Acari and Collembola communities have key role in supporting productivity, but even small changes in their species composition and abundance effect the local mobilization of nutrients significantly. The diversity of these communities sensitively reflect on soil quality, which prove the productivity and long-term sustainability of arable fields through organic degradation and nutrient recycling processes On the other hand, besides the green corridor function, forest belts can also promote the spread of invasive species.

The aim of our research was to assess the impact of the tree species composition of shelterbelts on herbaceous flora and soil mesofauna, compared to a native forest stand. The survey was carried out in the Little Hungarian Plain, in a shelterbelt-protected agricultural land. Samples were taken in native shelterbelts dominated by field maple (*Acer campestre*), and in exotic, black locust – green ash (*Robinia pseudoacacia – Fraxinus pennsylvanica*) plantations. As a control site, a native common oak – turkey oak (*Quercus robur – Q. cerris*) forest patch was examined. Samples for coenological analysis were taken in the longitudinal axis of the shelterbelts in 25 m^2 quadrats with tree replicates. Herbaceous species (including woody seedlings) and cover values were recorded. To analyse the species composition, we used Borhidi's social behaviour types, and the naturalness values of the Hungarian flora. According to mesofauna examination, soil core samples were taken in the same quadrats. We determined Collembola on species level and calculated the QBS-ar index, which indicates the biological quality of the soil.

Although typical forest-related vegetation did not appear in none of the shelterbelts, the native tree species composition resulted in a more favourable herbaceous layer both in terms of diversity and in terms of naturalness. However, both shelterbelt types – compared to the control forest path – showed a species-poor vegetation while the rate of invasive plants was higher.

According to the soil mesofauna, the positive impact of the native tree species is evident: both the soil biological quality measures and the Collembola community characteristics also show more favourable soil conditions in the habitats composed of native tree species. The QBS-ar index in field maple shelterbelt (133.0±4.0) was significantly higher than in the black locust plantation (85.7±5.9). Among the more sensitive groups, Diplopoda and Protura were only present in the maple shelterbelt and control forest

patch while completely missing in the soil of the allochthonous black locust plantation. Collembola species richness and diversity peaked in the control forest patch, followed by the maple shelterbelt, while the least diverse community was found in the black locust shelterbelt, well emphasised by the Rényi diversity profiles.

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Figure 1. Shelterbelt-protected agricultural land in the Little Hungarian Plain (Photo: Sándor Kalmár)

Conserving threatened beneficial insects: bees, wasps and hoverflies in UK silvoarable systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity and wildlife management

Keywords: natural pest control, natural enemies, parasitoids, pollinators, pollination

Abstract

Arable farming is facing increasing demand to improve productivity, but to do so in a sustainable manner, including mitigating declines in global biodiversity. Silvoarable agroforestry systems have the potential to be a 'win-win' solution. For example, these systems can enhance natural enemy and pollinator abundances whilst suppressing pests, compared to arable (Staton et al. 2019).

The benefits of agroforestry systems are reasonably well understood for some taxonomic groups, such as ground beetles and aphids. However, bees, wasps (including parasitoids) and hoverflies are relatively poorly studied in agroforestry, despite their importance for the natural control of pests and pollination of crops. Furthermore, bees and wasps are amongst the taxa most affected by insect declines globally (Sánchez-Bayo and Wyckhuys 2019). The aim of this study was therefore to assess whether agroforestry systems could help conserve these threatened beneficial insects.

Our study sites comprised three working farms in England, all of which contained a silvoarable agroforestry field and a monocropped arable field under the same management and rotation. Two farms were organic, the third was conventional and minimum-till. Crop rotations were based around cereals, plus oilseed rape at the conventional farm. Agroforestry alleys were 24 m wide, tree rows were 3-4 m wide and principally comprised apple trees on MM106 rootstocks, planted between 2009 and 2015. Agroforestry field sizes were approximately 5.6, 3.8 and 12 ha respectively at the three sites (the latter field set within a 52 ha agroforestry system), while the corresponding arable field sizes were 6.1, 3.0 and 7.6 ha respectively.

Sampling was undertaken in 2018 and 2019. At each site, two agroforestry alleys were selected for sampling. Within these, 16 sampling points (eight in each alley including its adjacent tree rows) were selected at set distances from the tree rows. This procedure was repeated in an arable field at each site, to act as a control. At each point, a set of three UV-bright pan traps was deployed to capture flying insects. Each trapping day lasted for at least five hours, and was repeated nine times over the two-year period. All bees, wasps and hoverflies captured in the traps were assigned to taxonomic groups (Fig. 1).

Taxonomic richness and diversity (Shannon index) of bees, wasps and hoverflies collectively were significantly higher in agroforestry than arable fields (mixed models, $t=3.007$, p-value=0.003; $t=3.414$, p-value<0.001). Six of the taxonomic groups were significantly more abundant in agroforestry than arable fields (Fig. 1). The strongest effects were seen for the two predatory wasp taxa. We hypothesise that social wasps were attracted by apples in the tree rows, but could also aid biocontrol by hunting insect pests. Two of the three parasitoid wasp taxa were significantly more abundant in agroforestry than arable fields. However the braconid wasps were less abundant in the agroforestry fields. This effect was driven by an early-season influx of braconids into the arable field at one site, possibly attracted by a high prey resource.

Two of the five pollinator groups, comprising bumblebees and the small halictid bees, were significantly more abundant in agroforestry than arable fields. This is consistent with a study in the UK showing higher solitary bee abundance in agroforestry than monocultures, although in contrast to that study, we found no significant difference for hoverfly abundance (Varah et al. 2020).

Our findings of benefits to bees, wasps and hoverflies could be explained by the higher availability of flower and nesting resources in agroforestry tree rows compared to arable fields. Pan traps are less effective in flower-dense areas (O'Connor et al. 2019), therefore, our results may underestimate the benefits of agroforestry. In addition, field sizes were relatively small at two of the sites (3.8 and 5.6 ha), and set within relatively diverse landscapes (particularly within a 2 km radius), which could allow insects to rapidly colonise the arable fields from surrounding semi-natural habitat. Stronger effects could therefore be predicted at larger-scale farms.

In conclusion, we find strong evidence for higher taxonomic richness and diversity of bees, wasps and hoverflies, and abundance of predatory wasps and pollinators, in agroforestry compared to arable fields. This suggests that agroforestry systems can play a role in the conservation of these threatened insects, while improving the sustainability of agriculture by providing natural pest control and pollination services.

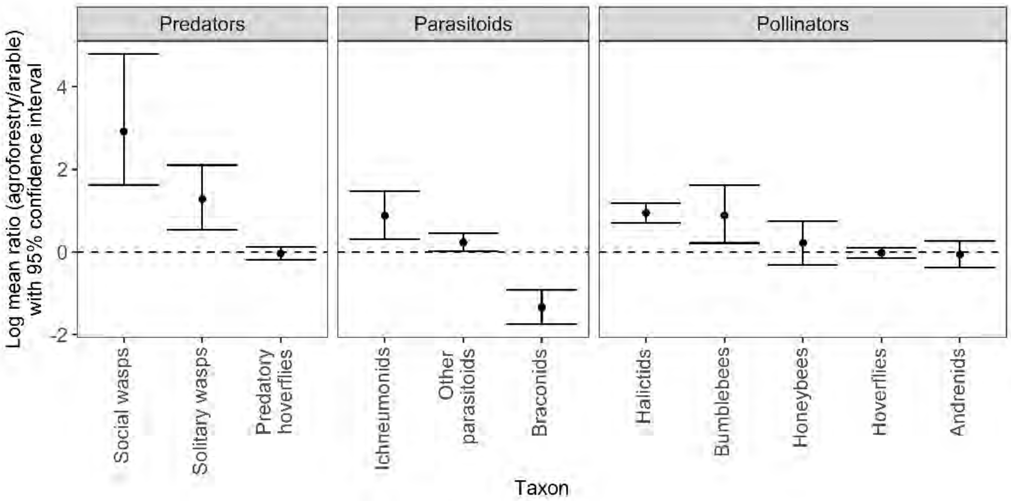

Figure 1. Abundances of bees, wasps and hoverflies in silvoarable agroforestry compared to arable controls. The area above the dashed line represents higher values in agroforestry. Analysis was undertaken using negative binomial mixed models in R software.

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Tree rows change the soil biodiversity abundance and repartition within the first year of plantation at an experimental agroforestry site in Ramecourt (Northern France)

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Keywords: alley cropping, soil biodiversity, earthworms, microarthropods, macroarthropods

Abstract

It was largely documented that agroforestry systems promote soil biodiversity in agroecosystems but little is known about the timing and the origin of this improvement after the tree plantation. The aim of this study was to measure the change in soil biodiversity abundance and repartition during the first year of tree plantation at an experimental agroforestry (AF) site in northern France. The experimental site is located in Ramecourt (50° 22' N, 2° 17' E) on an 18-ha plot according to a randomized block design with 3 replicates. Modalities with or without nitrogen-fixing trees in AF treatment are compared with sole-crop (CC) and pure-forest control (FC) plots. In November 2018, one-year-old trees and shrubs were planted in 38 meters and 7 meters wide rows for AF and FC respectively. Within rows, 6 species of tall trees (*Quercus robur, Carpinus betulus, Juglans regia x regia, Alnus glutinosa, Prunus avium, Robinia pseudoaccacia*) were planted 8 meters apart and were intercalated every 1 meter by 9 species of shrubs *(Castanea sativa, Cornus sanguinea, Acer campestris, Euonymus europaeus, Corylus avelana, Tilia cordata, Ligustrum vulgaris, Salix alba, Viburnum lantana)*. The density of tall trees is 50 and 430 trees ha^{-1} for AF and FC respectively. In AF, a spring barley was sown in February 2019 in the alley after a shallow stubble ploughing as well as in CC plots. In FC, cover plants composed of a mixture of melliferous and grass plant species were sown between tree rows in April 2019. The population of earthworms, micro and macroarthropods were measured from April to July 2019 using mustard extraction method, Berlese and Barber traps respectively. The collected organisms were counted, classified and identified thanks to a determination key based on morphological criteria. The abundance and the dominance of each recognized families, genus or species were calculated as well as the Shannon-index for the diversity. A total number of 833 earthworms was collected in all plots. Anecic species were dominant (*i.e.* between 50% and 75% of the total number) whereas endogenic and epigeic species were common (*i.e.* between 25% and 50%) and very rare (< 5%) respectively. The abundance of earthworms was not significantly different between AF (25.3 ind. m^{-2}), CC (28.6 ind. m^{-2}) and TF (19 ind. m^{-2}). The relative abundance of the same ecological category of worms was roughly the same for the three treatments. A total number of 85 microarthropods was counted. Mites and collembola represented in average 26% and 32% of the population respectively. The remaining individuals were composed of myriapods, enchytreids and insects. The calculated Shannon-index for the microarthropods was significantly higher in AF (1.03) and FC (1.19) than in CC (0.26). While 7 families of microarthropods were recorded in both AF and FC, only 3 families were noted in CC, suggesting that at this early stage of trees development, the population of microarthropods could benefit from more diverse habitat and food provided by tree lines. For macroarthropods, a total number of 11,005 individuals were collected during the 4 weeks of sampling. Some zoological groups such as *Staphylinidae, Ephistemus, Bembidion and Araneae* were only observed in AF. The abundance of macroarthropods decreased from the beginning to the end of sampling period in CC and FC whereas it remained stable in AF. This decrease was probably due to the hot and dry

weather conditions in July 2019. It can be assumed that in AF, the microclimate and habitats, which were created together by tree rows and crop canopy cover, promoted the resilience of the installed ecosystem, allowing the maintenance of food chain predators. The drying up of cover plants in FC or the absence of tree rows in CC was not favourable to maintain macroarthropods populations over time.

Our study showed that the micro and macro arthropods' community abundance and repartition in soil react very quickly within one year after tree plantation in AF, thanks to the creation of favourable habitats for their development along the tree rows. Further work is necessary to confirm these tendencies in the following years and to identify their consequence in the ecosystem functioning.

Phytosociology of Weeds in agroforestry system managements

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract

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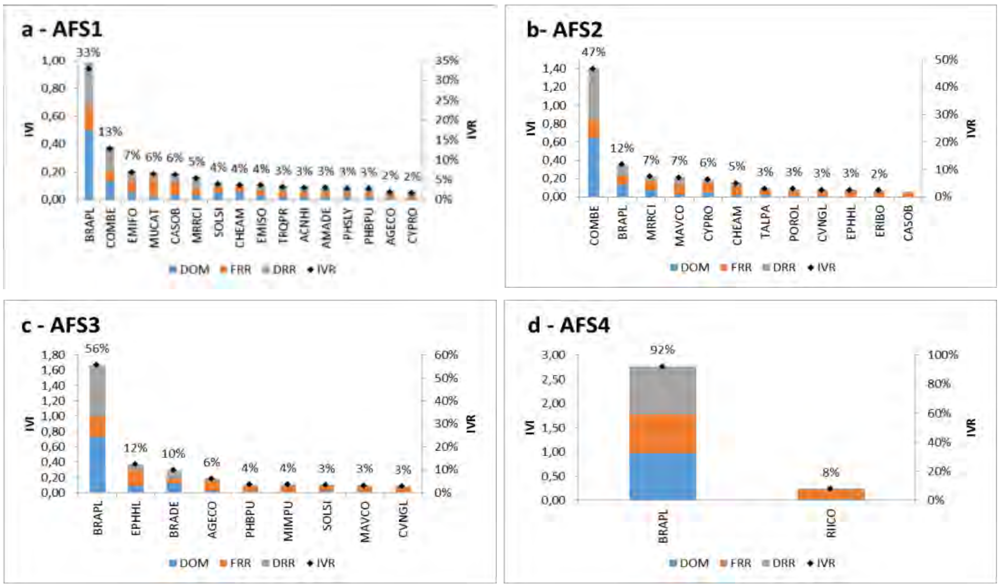
Theme: Agroforestry, biodiversity and wildlife management

Keywords: Weeds in agroforestry systems, no-tillage, land use, weeds control

Abstract

Agroforestry Systems (AFS) are land use systems in which plants of agricultural species are combined with tree species in the same land management unit. As observed by Sousa (1995), some crop combinations in AFS influenced density, frequency and biomass of weeds can also minimize competition and optimize crop yield(Schulz et al., 1994). Weeds have greater ability than cultivated plants to recruit environmental resources such as nutrients, light, water and CO2. This phytosociological survey of weeds was in an area of AFS implemented under different soil management and weed control. The experiment in Pindorama, SP, Brazil was in Kandiustalf soil, Aw climate (Köppen) where 28 native tropical forest species were planted with 3 productive species. Some pioneer species planted were: *Guazuma crinita, Joannesia princeps, Anadenanthera macrocarpa, Schinus terebinthifolia, Myrrciaria dubia, Peltrophorum dubium, Croton floribundus, Cecropia pachystachya, Albizia haslerrii, Guajava pynifera, Inga edulis, Jaracatia spinosa, Dilodendron bipinnarum, Acacia polyphylla, Ceiba Samauma, , Caesalpinia ferrea, Triplaris americana, Rapanea guianesis The climax species planted were: Gustavia augusta, Hymenaea courbaril, Cariniana legalis, Casearia gossypiosperma, Tabebuia heptaphylla, Cariniana estrellensis.* The productive species were:(*Malpighia emarginata*), rubber tree (*Hevea brasiliensis*) and annatto (*Bixa Orellana*). The treatments were identified by the management: AFS1: weed control using a tractor-mounted brush cutter, 3m x 2 m spacing between tree rows, no plantation between rows and no soil revolving; AFS2: chemical weed control, 3.5m x 2m spacing and maize cultivation under no tillage; AFS3: weed control with plow and harrow, furrows for furrowing, 3.5m x 2m spacing, conventional maize planting; AFS4: weed control with plow and harrow, furrows for furrowing, 3.5m x 2 m spacing no plantation between trees. For weeds evaluation between trees rows in each treatment two square of 1.0 m^2 per plot were randomly sampled. Weeds species were cut at the ground level, identified by species, counted and oven dried at 60°C per 72 hs to determine dry weight. Data were used to parameters: Frequency (F) = number of squares containing the specie / total number squares; Density (D) = number individuals per specie / total squares obtained; Relative frequency (FRR) = species frequency / total frequency all species; Relative Density (DER) =species density / total density all species; Relative Dominance (DOM)= dry mass a given species /total dry mass weed community. The variables Fr and Dr allow to obtain information about the relationship of each species with the other species found in the area and we come to IVI and IVR: Importance Value Index (IVI) = relative frequency + relative density + relative abundance and Relative Importance (IVR) = 100 x species importance value index ÷ total importance value index for all species. Figures 1 shows the phytosociological parameters - relative frequency (FRR), relative density (DER), relative dominance (DOM), importance value index (IVI) and relative importance value index (IVR) (Pitelli, 2000)(Braun-Blanquet,1979).



*ACNHI-*Acanthospermum hispidum*, AGECO-*Ageratum conyzoides*, AMADE-*Amaranthus deflexus*, COMBE-*Commelina bengalensis*, ERIBO-*Conyza bonariensis*, CVNGL-*Croton glandulosus*, CYPRO -*Cyperus rotundus*, CHEAM- *Dysphania ambrosioides*, EMIFO-*Emilia fosbergii*, EMISO-*Emilia sonchifolia*, EPHHL- *Euphorbia heterophylla*, PHBPU- *Ipomoea purpurea*, PHSLY-*Macroptilium lathyroides*, MAVCO-*Malvastrum coromandelianum*, MRRCI-*Merremia cissoides*, MIMPU -*Mimosa pudica*, MUCAT-*Mucuna aterrima*, POROL-*Portulaca oleracea*, RIICO- *Ricinus communis*, CASOB-*Senna obtusifolia*, SOLSI-*Solanum sisymbriifolium*, TALPA-*Talinum paniculatum*, TRQPR-*Tridax procumbens*, BRAPL-*Urochloa decumbens*, BRADE-*Urochloa decumbens*

Figure 1. Phytosociological parameters DOM, FRR, DRR, IVI and IVR for the major weed species in AFS, Pindorama,2020.

Monocotyledons gradually gain importance from AFS1 management to AFS4 management. Even in AFS1 management where there is greater distribution of importance among several species, the difficult-to-control species *Urochloa plantaginea*and *Commelina* benghalensis are still the most important.U *Urochloa decumbens* distribution was favored in AFS 4 probably due to the management that didn't introduce a crop cultivated between the trees rows.

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Agroforestry as *on-farm* conservation strategy for *Virola surinamensis*, an endangered Amazonian species

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management

Keywords: biodiversity, sustainable management, non-timber forest products, genetic resources

Abstract

Virola surinamensis (Rol.) Warb. (Myristicaceae) is a tree species of Amazonian floodplain forests intensively exploited since the 1980s. Although logging was interrupted from 1996 to 2008, legal measures did not result in protection and conservation of natural populations (Piña-Rodrigues & Mota, 2000). As a result, the species is vulnerable requiring conservation and management actions. Nowadays, besides timber extraction, seeds are harvested by cosmetic industries and juvenile individuals are removed for use in civil construction. Strategies to protect natural populations were adopted as in-situ conservation through the establishment of protected reserves and extensive plantations in Brazilian Eastern Amazonia (Piña-Rodrigues et al. 1999). Due to the failure of in-situ conservation caused by the lack of supervision to prevent exploitation, the ex-situ conservation strategy was adopted to protect endangered populations. Although seed banks are recommended for the genetic conservation of V. surinamensis (León-Lobos et al. 2012), the recalcitrant seeds have short longevity (Piña-Rodrigues & Figliolia, 2005). The germplasm banks by in-vivo collections were planted in three localities with seeds sampled from 1992 to 1994 along the Amazon river, including 1142 source trees of 24 populations from 14 localities, each one under the responsibility of a private company, a public university and municipality. But, after 25 years, these germplasm banks were abandoned, felled, or partially logged, indicating a failure of the *ex-situ* conservation initiative because of a lack of long-term commitment and/or funding. However, our field observations in Brazilian Eastern Amazonia indicated that remnants from natural populations were being conserved by native inhabitants in agroforestry systems. In Amazon, agroforestry is a social and economic reality since aligns forest production and conservation. Several models can be applied, from the intercropped planting of cultivated and forest species or just forest enrichment with tree key species. In floodplain forests, agroforestry systems have as key species the palm tree (*Euterpe oleraceae* Mart.) that is managed together with other typical lowland species such as *V. surinamensis*, *Carapa guianensis* Aubl. and *Simphonia globulifera* L.f (Santos et al. 2014), among others. This strategy of productive conservation, named *on-farm*, provide the sustainable maintenance of wild plants by growing them in similar conditions under which these materials had originated and evolved (Holubec et al. 2010). In this study, we established an *on-farm* conservation initiative of *V. surinamensis* in agroforestry systems in the Amazon estuary. We developed and proposed management practices and processes for the maintenance of genetic diversity and the conservation of genetic resources of natural populations, aiming at the sustainable use of non-timber forest products. For this purpose, we first evaluated and monitored the impact of seed collection activity in the establishment of natural regeneration and its genetic diversity, and then we propose management processes and procedures to foster *V. surinamensis on-farm* conservation in rural properties. Four localities (Figure 1) were selected for seed

sampling and seedlings from endangered provenances were produced to be planted in biodiverse agroforestry systems with palm tree, *Manihot esculenta* Crantz, and floodplain tree species. The seed productive potential was evaluated by forest inventory, phenological studies, genetic survey, evaluation of productive capacity of fruits and seeds and the monitoring of natural regeneration in 24 female trees. We observed that the *on-farm* conservation was effective to proportionate income for local inhabitants to supply seeds for industry. Based on our studies, we proposed that for each 20 kg of seeds collected, it is necessary the enrichment of agroforestry and natural forests with five seedlings and the management of 20 seedlings from natural regeneration. Genetic studies indicated that the increase in local genetic diversity should be achieved by exchanging seedlings and seeds among farmers by the enrichment of the agroforestry systems.

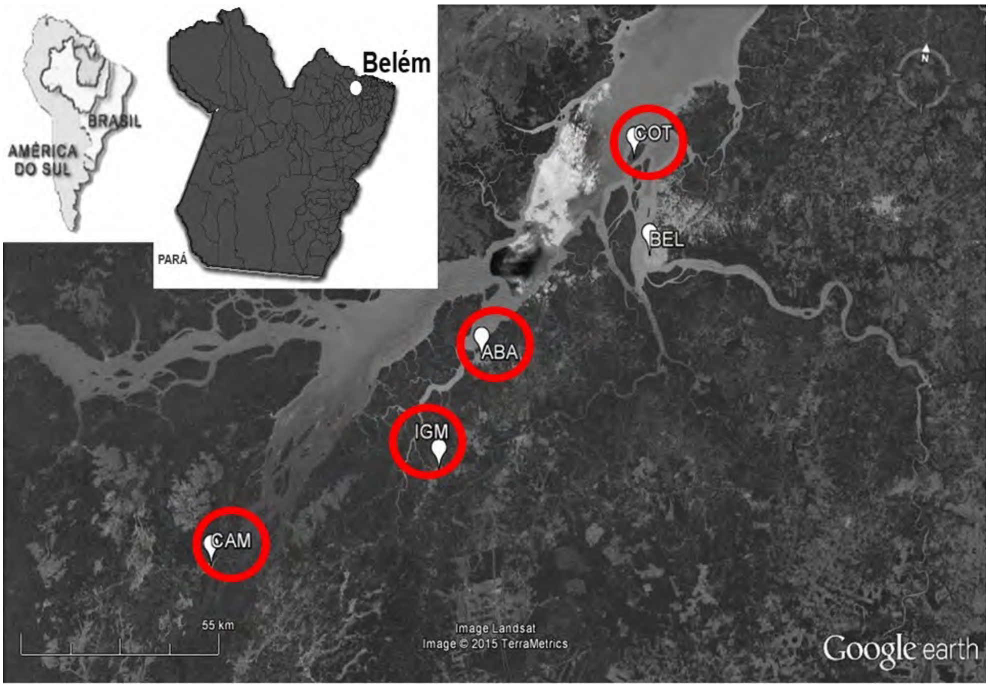

Figure 1. Localities of seed collection, extraction and *on-farm* conservation of *Virola surinamensis* (Roll) Warb. by agroforestry systems in Amazon Estuary. CAM- Cametá, IGM- Igarapé-Mirin, ABA – Abaetetuba, COT- Cotijuba, state of Pará.

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Practicing sustainable agroforestry for biodiversity conservation and sustained livelihood option for tribal in Jharkhand (India)

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Abstract
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Theme: Agroforestry, Ecosystem services, landscape and rural development

Keywords: Agroforestry, Biodiversity conservation, Ecosystem services, Jharkhand, Sustainable agroforestry

Abstract

India is a mega diverse country having 7-8% of all recorded species of the world. Of thirty four mega diversity hotspots, four are found in India, i.e. the Himalayas, the Western Ghats, the North East and the Nicobar Islands. As per India State Forest Report 2019, published by Forest Survey of India, Dehradun, India ranks among the ten countries of the world in terms of forest area. India state of Forest Report 2019 shows that there is an increase of 8021 km^2 in total forest and tree cover of the country.

Forests of Jharkhand, an eastern state of India, are also increasing. As per India state of Forest Report 2019, there has been net increase of 58.14 km^2 of forests in Jharkhand. Jharkhand has an area of 79,714 km^2. The name "Jharkhand" means "The Land of Forests". The recorded forest area of the state is 23,605 km^2, which is 29.61 % of the geographical area of the state. A study was conducted on how practicing sustainable agroforestry helps in biodiversity conservation and offers sustained livelihood option for tribal communities. The study was conducted in East Singbhum (Jamshedpur), West Singbhum Chaibasa), Saraikela- Kharsawan districts of Singbhum area, Hazaribagh, Chatra and Koderma districts of Jharkhand. Jharkhand has 32 tribal groups. They are very rich in their culture.

These people not only obtain all the resources necessary for their survival from their surrounding forests but also have a sacred cultural tie to these forests. Trees on farm offer tremendous potential to increase rural income. In Jharkhand state of India agroforestry systems have potential to provide NTFPs which in turn are source of livelihood to tribal people. People living in and around forests earn on an average about 25%-30% of their income from forest resources. With the paradigm shift in forest management that is finding avenues in payment for environment services (PES) and REDD+ as sources of revenue for rural people instead of timber management, not only will conserve forest but also give livelihood to tribes.

The enhancement in green cover increases biodiversity as well. Biodiversity is being recognized as one of the best defence against climate changes. Ecological processes such as tree growth, carbon sequestration, seed dispersal and nutrient cycling depend upon biodiversity. Biodiversity underpins ecosystem services, productivity and resilience. Biodiversity conservation should be practiced in all types of forests, whether they are managed for production, regeneration or protection. There is perceptible threat to biodiversity due to over exploitation of natural resources, climate change and land use changes. Of various means, Traditional Knowledge (TK) has been determining factor for sustainable use and conservation of biodiversity. The traditional knowledge has been acquired over ages and treasured by the local communities and tribal living in and around forests. Hence such knowledge has the potential value for sustainable forest management and biodiversity conservation.

The data and information presented in this paper have been collected after discussion with local people and members of Village Forest Protection Committees. The study was carried among six tribal

communities. In order to get an idea of the area the following steps have been executed: 1. Visit of forest area; 2. Meeting with members of Joint Forest Management Committees; 3. Use of GIS Cell to identify and verify the degraded forest area; 4. Introduction and promotion of agroforestry system which could yield livelihood option and enrich their culture; 5. Assessment of forest cover and biodiversity. A baseline socioeconomic survey using questionnaires was conducted in 175 households of these six tribal communities – Oraon, Santhal, Munda, Birhor, Ho and Bhumij. It was found that Plants raised and nurtured through agroforestry are used in various ways by the local people. Accordingly they have been grouped in: 1. Edible Products; 2. Grasses; 3. Mats, Ropes and Baskets; 4. Medicinal Plants; 5. Oil Seeds; 6. Tans and Dyes; 7. Fodder Trees; 8. Gums and Resins; 9. Fibres; 10. Animal Products and; 11. Cultural Items. Result of intervention through various schemes, projects and awareness programme can be summarized in table 1. It has also been found that Agroforestry systems can provide effective protection against soil erosion caused by wind and water.

The present paper reflects trajectories of sustainable Agroforestry, status of biodiversity and its conservation, associated aspects of livelihood and role of TK on these issues in India in general and Jharkhand in particular. The paper also discusses how with the adoption of various legal framework, especially National Environment Policy, National Agroforestry Policy 2014, National Biodiversity Action Plan, adoption of Joint Forest Management Policy, enactment of Forest Right Act 2006 and implementation Forest Working Plan Code 2014, issues related to biodiversity, resilience of ecosystem and sustainable livelihood option have been brought to the mainstream in Sustainable agroforestry.

Agroforestry products	Number of households		Number of households	
	Before intervention	Percentage	After intervention	Percentage
Edible Products	107	61.14	155	88.57
Grasses	125	71.4	132	75.42
Mats, Ropes and Baskets	130	74.28	145	82.85
Medicinal Plants	109	62.28	151	86.28
Oil Seeds	95	54.28	115	65.74
Tans and Dyes	71	40.57	85	48.57
Fodder Trees	122	69.71	138	78.85
Gums and Resins	80	45.7	140	80
Animal Products	45	25.74	132	75.42
Cultural Items	140	80	155	88.57

Table 1. Showing summary of survey results for different agroforestry products among six communities

Conservation of the macedonian oak (*Quercus trojana*) and monitoring Great Capricorn Beetle (*Cerambxy cerdo*) in Murgia Materana Regional Park

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management

Keywords: species conservation, habitat, oakwood, Cerambycidae.

Abstract

Two naturalistic aspects strictly connected were investigated in Murgia Materana Regional Park, located in the Basilicata region, Italy: *Quercus trojana* Conservation and *Cerambyx cerdo* Monitoring.

1. *Quercus trojana* Conservation: In addition to habitats such as Mediterranean steppes and bush, the Park presents relatively large Macedonian oak (*Quercus trojana* Webb) clusters. The Park is thought to constitute the westernmost point of the distribution of the Macedonian oak, throughout its natural distribution range. The aim of the research was to know the ecological conditions of the *Q. trojana* population. A census of the Macedonian oak trees present in the area was conducted, with an evaluation of plant health. The majority of the trees are located on the higher altitude zones of the Park. Large veteran trees (DBH > 200 cm) are predominantly found in the vicinities of ancient large farms ("masserie"). Wildfires were the principal threat to the survival of this species in the area and in order to reintroduce individuals in fire-damaged zones, we collected and planted acorns from selected individuals. At the present time we are about to transfer the samplings in the wild.

2. Great Capricorn Beetle (GCB) Monitoring: *Cerambyx cerdo* L. (Coleoptera, Cerambycidae) is a saproxylic insect highly dependent on oak trees. Presence of GCB was reported in the Natura 2000 site "Gravine di Matera" (code IT9220135) in the Park. The monitoring purpose was to know the conservation status of the species and to update the Natura 2000 data. For the animal and plant species included in the Habitats Directive, the Italian Ministry of the Environment, has drawn up manuals for monitoring aimed at reporting on Natura 2000 sites in Italy. In June-July 2019, we conducted the first monitoring study of this species, assessing the population size and habitat preference. The areas to be monitored were chosen based on the characteristics of the habitat and by searching for old oak trees with signs of the presence of the GCB. Baited traps were positioned on trees of different oak species present in the area to assess the population size of the GCB across the study area. The area was divided into two sections and 5 traps were used simultaneously in each section. Each sampling session lasted 10 days with 8 capture occasions. The traps were made with cylindrical plastic tubes commonly used in construction. The trap consisted in a 25cm high pipe and 20cm in diameter, it is divided in two total volume of 7853.98 cubic centimeters. A

metal mesh inside divides the cylinder into two sections, the upper one in which the beetles are collected and the lower one containing the attractive mixture. Overall, 78 beetles (37 females, 41 males) were caught during 16 days of sampling. Highest densities of *C. cerdo* were encountered on downy oak trees (*Q. trojana* and *Q. pubescens*) and tree size appears to be positively correlated with the number of *C. cerdo* individuals captured on the tree. This demonstrates the importance of the presence of large veteran trees for the conservation of this species. To monitor this species, a smartphone app has been developed that guides the detector in applying the monitoring protocol. The app also allows to track, archive and process all the data collected, returning as a result the population estimate of the species studied.

Figure 1. A trap for monitoring *Cerambyx cerdo* on *Quercus trojana* oak

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What creatures are there in my agroforestry hedge?

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract

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Theme: Enhancing ecosystem services provision by agroforestry systems

Keywords: Pests, Parasitoids, Halyomorpha halys, Citizen science

Abstract

The "What creatures is there in my hedge?" project was born out of an innovative research network that began around (i) hedges and a special form of agroforestry, "la piantata", i.e., a traditional form of agriculture which associated lines of vine mixed with trees contoured field with annual cultures, formerly prevalent in the plain of Po and Tuscan until '60s and (ii)a social form of citizen movement, ARVAIA, an agricultural cooperative in the form of CSA (Community Supported Agriculture), close to the city of Bologna. In the cultivated agricultural land, the cooperative maintains the remains of the old "piantate" and reinforces them with new hedges.

Although we imagine the potential of "piantata" and hedgerows ecosystem services, especially those related to pest control, the citizens and farmers working at ARVAIA had no clear idea of the quality of their services.

The "What creatures is there in my hedge?" project started in 2018, thanks to a passionate entomologist expert of *Hymenoptera*, and especially of the *Chalcidoidea* superfamily (Cazzuoli, 2017), who decided to study the insects of ARVAIA's "piantata" system by using a Malaise trap. In 2018, 41 species of 13 families have been identified for *Chalcidoidea* (Figure 1). The study allowed the identification of *Anastatus bifasciatus*, a *Chalcidoidea* parasitoids, of *Eupelmidae* family, able to parasitize the Brown Marmorated Stink Bug (*Halyomorpha halys*), an invasive pest emerged for the first time in Italy in the countryside near Bologna (Costi et al., 2018).

Based on this experience, the project continued in three complementary directions. First, it allowed results dissemination and divulgation activities, and the disclosure of the world of entomology to citizens, in particular to ARVAIA's associates. In this contexts, three public meetings were organised (November 2018 – July 2019) with the aim to hire volunteers to involve in a Citizen Science program, and to increase research opportunities on ecosystem services for pest control. Secondly, the project allowed the study and control of the parasitisation index of *H. halys* eggs by parasitoids, by collecting the egg masses and incubating them. Third, the project allowed to share knowledge and expertise to other farmers and agroecology and agroforestry passionate having hedges in their agricultural funds, with a facilitation service, and to assist them in the installation of Malaise traps for insect identification.

Furthermore, in 2019, CREA (Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria) coordinated a large program of observations on *H. halys* parasitization, at which ARVAIA participated as Citizens' Cooperative: a great opportunity to experiment Citizen Science. A dedicated "social media", INATURALIST, was also used to increase the dissemination of the project objectives and results (Gabrielli, 2019). Among the interesting results, the research allowed the identification of the samurai wasp (*Trissolcus mitsukurii)* (Zapponi et al., 2021), identified also at ARVAIA "piantate". Moreover, at ARVAIA, the parasitisation index found for *H. halys* eggs in the period 15 August – 15 September 2019 was about 13% out of 1,000 eggs controlled, of whose 7.8%parasitized by *Anastatus bifasciatus.*

Overall, the ARVAIA culture system and its particular biodiversity and traditional agroforestry need to be studied in depth over the next years. Our hypothesis is that, unlike conventional culture systems, this biodiversity can give stability to agro-ecological system.

The identification of effective strategies for the containment of *H. halys* will be further studied in the framework of the two-year project "Integrating preventive strategies and biological control to combat the brown marmorated stink bug – **VINDICTA**", an initiative under the framework of the Rural Development Program 2014-2020 of Emilia Romagna Region - Operation Type 16.1.01 - Focus Area 4B - Project No. 5157414 (https://www.psrvindicta.it). The project will implement a management plan to combat the Brown Marmorated Stink Bug. The plan will include: conventional monitoring actions integrated with new electronic and IT applications and new capture systems based on the integration of the aggregation pheromone with vibrational signals; biological control actions (launches of the exotic antagonist *T. japonicus*); interventions related to the enhancement of agrobiodiversity practices; forecasting models.

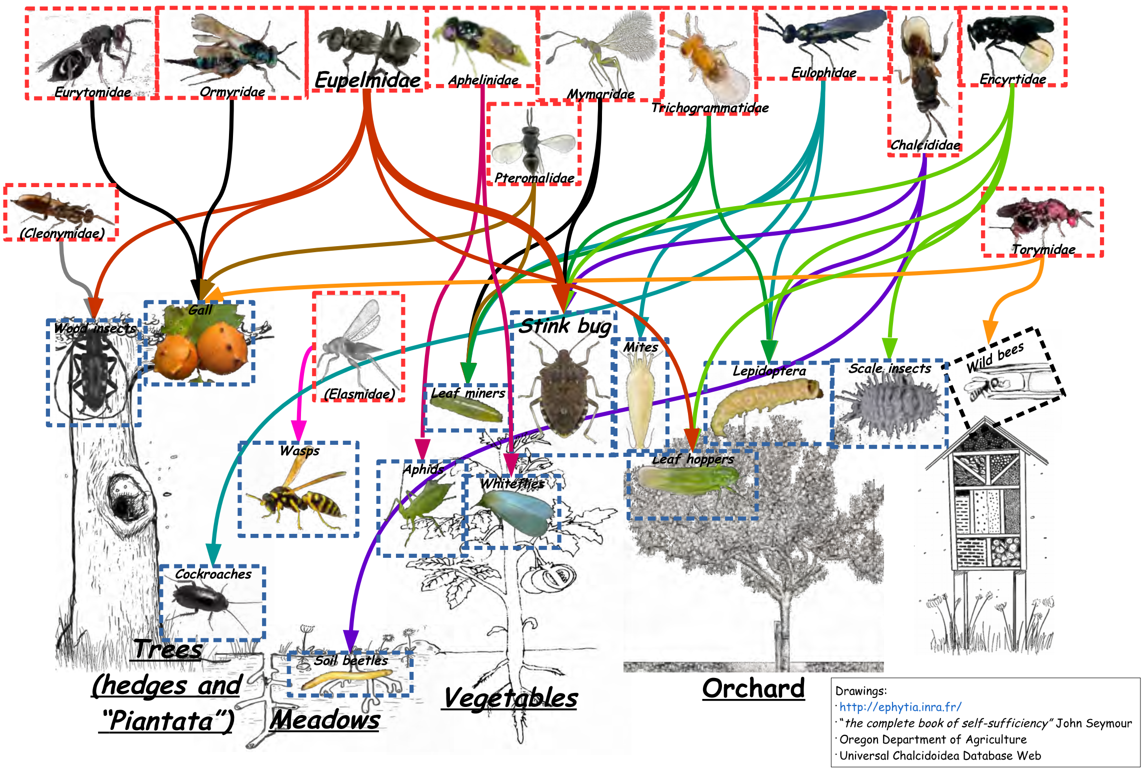

Figure 1: The *Chalcidoidea parasitoids* wasps' food web in agroforestry system at ARVAIA Cooperative (2018). - In brackets, the families of systematics that are no longer valid -

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Weeds survey in agroforestry system

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Agroforestry for the transition towards sustainability and bioeconomy

Abstract

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Theme: Agroforestry, biodiversity and wildlife management

Keywords: Weeds in agroforestry systems, no-tillage, land use, weeds control

Abstract

Agroforestry Systems (AFS) are land use that combine agricultural crops species with tree in the same area which might improve physicochemical properties of degraded soils, since the activity of microorganisms enables the increase of organic matter (Mendonça et al., 2001) causing less impact on ecosystems (Gruenewald et al., 2007). The sustainability of these systems is based on the interactions of energy flow, nutrient cycling and system biodiversity (Rodrigues, 2004). In AFSs the presence of different cultivated species and crop arrangements can exert more efficient control of invasive plants and some crop combinations influence density, frequency and biomass of weeds also minimizing competition and optimizing crop yield (Schulz et al., 1994). Weeds have greater ability than cultivated plants to recruit environmental resources such as nutrients, light, water and CO_2. Thus, these plants have propagule production capacity once they can spread by seeds or vegetative growth. Weeds generally have high spreading capacity but yield may vary among species (Brighenti et al., 2007). According to (Brighenti et al., 1997) an invasive plant, *Cyperus rotundus*, can germinate when placed up to one meter below ground surface. Competition for essential mineral nutrients, water, light and space is the best-known form of weed interference in crops. Some species allelopathically interfere with cultivated crops causing damage (Oliveira JR et al., 2011). The present study aimed to quantify and qualify the presence of weeds in an AFS implemented simultaneously under different soil management and weed control. The experiment was carried out in the municipality of Pindorama, SP, Brazil with 28 native tropical forest species planted with 3 productive species. The pioneer species were: *Guazuma crinita, Joannesia princeps, Anadenanthera macrocarpa, Psidium acutangulum, Schinus terebinthifolia, Myrrciaria dubia, Peltrophorum dubium, Mabea fistulifera, Croton floribundus, Cecropia pachystachya, Albizia haslerrii, Guajava pynifera, Inga edulis, Inga laurina, Syzygium malaccense, Jaracatia spinosa, Dilodendron bipinnarum, Acacia polyphylla, Ceiba Samauma, Chorisia glaziovii, Gallesia integrifolia, Caesalpinia ferrea, Triplaris americana, Rapanea guianesis The climax species planted were*: *Gustavia augusta, Hymenaea courbaril, Cariniana legalis, Casearia gossypiosperma, Tabebuia heptaphylla, Cariniana estrellensis.* The productive species were:(*Malpighia emarginata*), rubber tree (*Hevea brasiliensis*) and annatto (*Bixa Orellana*). The treatments with 4 repetitions each were identified by the soil management and weed control: AFS1: weed control using a tractor-mounted brushcutter, 3m x 2 m spacing between tree rows, no plantation between trees rows and without soil tillage; AFS2: chemical control of weeds, 3.5m x 2m spacing between trees rows and maize cultivation between the rows

under no tillage management; AFS3: control of weeds with plow and harrow, use of furrows for furrowing, 3.5m x 2m spacing between trees rows, maize planting under conventional system; AFS4: control of weeds with plow and harrow, use of furrows for furrowing, 3.5m x 2 m spacing between trees rows, no culture plantation between trees. For weeds evaluation between trees rows in each treatment two square of 1.0 m^2 per plot were randomly sampled. Plants were counted and identified; for dry mass evaluation aboveground parts were cut, placed in paper bags and sent to lab where they were dried in a forced air circulation oven at 60 ºC per 72 h for later weighing on a precision scale (0.01 g). The following data shows total number of species (NE), number of weeds plants per treatment (NP) and total dry mass (MS) in grams for each treatment.

Table 1: Number of species (NE), number of total weeds plants (NP), and dry mass (MS) in grams obtained in each treatment: T1 – AFS 1, T2 - AFS 2 and T3 - AFS 3 and T4 - AFS 4.

Treatment	NE	NP	MS
T1	5,25±1,36 a	40,0±8,5 a	102,9±44,1 a
T2	5,0±1,62 ab	24,5±2,8 b	116,4±84,5 b
T3	3,75±1,54 ab	16,0±3,3 b	156,5±56,0 b
T4	2,0±0,35 b	16,2±6,56 b	296,5±139,1 b
F	4,42*	11,22**	7,17*
DMS	3,12	14,83	226,76
CV%	35,35	27,78	53,22

ns- not significant, * significant at 5% and ** significant at 1% . Averages followed by the same letter, for each characteristic do not differ from each other by the 5% Tukey test.

The soil management and different weed control interfered in weed infestation. AFS 1 where the area is completely shaded, the variability and the number of plants of invasive species was higher comparing to other treatments. This management also promoted the best growth of weeds that presented significant higher values for dry mass.

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Analysis of phenological functional traits as a contribution for a network of Biodiversity - Ecosystem Functioning (BEF) experiments: the International Diversity Experiment Network with Trees (IDENT)

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management

Keywords: Biodiversity and ecosystem functioning, Phenological traits, IDENT

Abstract

Forests play a significant role in climate change mitigation by acting as "sinks", absorbing carbon from the atmosphere and storing it in biomass and soils. Reforestation with multiple tree species is considered as an important strategy for improving forest resistance against natural threats. However, particularly in drylands, reforestation often fails because seedlings suffer from severe environmental conditions in degraded areas (Gómez-Aparicio, 2009).

The adoption of polyculture plantations, instead of conventional large-scale monocultures, provides long-term benefits for dealing with climatic uncertainties (van der Plas et al., 2016). The relationship between biodiversity and forest functioning is primarily explored in mature systems, but interactions mechanisms in the early forest stages are much less investigated.

As positive interactions between species could help to overcome environmental stress leading to improved survival of seedlings, there is a strong need to better understand how the different components of diversity, i.e., species richness and functional diversity, contribute to ecosystem functioning (Tobner et al., 2016).

The International Diversity Experiment Network with Trees (IDENT) (Tobner et al., 2014; Verheyen et al., 2016) investigates questions related to intraspecific trait variation, complementarity, and environmental stress conducting research at several hierarchical levels: within individuals, neighborhoods, and communities. The goal of IDENT is to identify some of the mechanisms through which individuals and species interact to promote coexistence and the complementary use of resources. Temporal complementarity, i.e. use of resources at different times of the year, is believed to be one of the mechanisms leading to positive BEF relationships. In this sense, it is fundamental to understanding how species differently regulate their phenological phases. This study was conducted in the experimental garden located at the nursery "St. Antonio - Sardinian Forest Authority" in Macomer, Italy (40°14' N; 8°42' E; 640 m above sea level). The experimental design properly replicated all monocultures and a selection of mixed communities with different levels of species richness (SR) and functional diversity (FD) considering a total of 12 species (Van de Peer et al., 2018).

In this work, results on the characterization of phenological functional traits for the studied species are reported. An analysis of digital images was performed by the use of chromatic coordinates indices: start and duration of the growing season were determined, and the physiological status in relation to environmental drought conditions was evaluated. Six digital cameras (CC5MPX, Campbell Scientific, Logan, UT, USA) were set-up and installed on a metal pole, at 2.5 m height above ground, pointing north and west to avoid direct sun light in the camera lens as much as possible, to obtain a view scene captured by each camera containing different species. The images were collected daily for a 2-year period (April 2017 - April 2019). The ground-based phenophases for each individual were determined visually. Moreover, a digital image processing was performed using the software application MATLAB (R2015b, The MathWorks, Natick, Mass.). Reflectance information were extracted as digital numbers (DNs) and several colour indices were derived.

Information from this study can provide a valid contribution to a more detailed understanding on how individuals regulate the way in which species temporally interact within a community, and how manipulating tree species composition can overcome barriers of plant settlement in dry habitats.

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Agroforestry, Market gardening of medicinal aromas and vegetables and 3U / O-3P Initiative in Benin and Togo

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, biodiversity, and wildlife management

Keywords: Vegetable crops, Agroforestry, Medicinal plants, Biodiversity, Climate change

Abstract

Introduction: The impacts of anthropogenic actions have induced global climate change and threat plant species particularly, of medicinal plants (Sinsin B, 1985; Agbo et al 1993; Koudouvo et al, 2017). To avoid the effect of these phenomena on sustainable development, Togolese researchers have created the 3U/O-3P initiative (One person, One plant, One planet) with the NGO "GASD/SADDA-Togo", collaborating with the "CERFOPLAM" a research Center of the University of Lomé (Koudouvo et al 2019), to develop mixed vegetable and agroforestry cultivation of endangered medicinal plants. The promotion of this initiative in urban areas will help to mitigate the effects of the climate changes in Benin Republic and Togo. Usually, market gardening farmers do not associate their culture practices to foresting or reforesting (agroforestry). The aim of the study is try the cultivation of medicinal agroforestry plants with market gardening to evaluate the contribution to agroforestry.

Methodology: Creation of nurseries, planting of seeds and seedlings of endangered agroforestry species and market gardeners, monitoring of the evolution of the crops used, were the methods used. A 1 ha (Fig. 1), one half at Lomé (Togo) and the other half in a domain made available to Researchers, Teachers-Researchers and Students from four west Africa countries by the E. ADJANOHOUN Botanical and Zoological Garden/University of Abomey-Calavi (UAC), Benin on 06 December 2018, was valued for this purpose.

Results: On the area of one half ha in UAC, 26 vegetable species and 17 medicinal plants were cutltivated in association. Some of the market gardening's vegetables were Vernonia amygdalina, Ocimum gratissimum, Solanum macrocarpon, Launaea taraxacifolia, Lactuca sativa, Daucus carota and Amaranthus spp. From the 150 plants composited by 17 agroforestry medicinal species are Afzelia africana, Milicia excelsa, Khaya senegalensis, Blighia sapida, Irvingia gabonensis, Carica papaya, and Annona muricata. In addition, Talinum triangulare, Portulaca oleracea, Emilia praetermissa, and Ageratum conyzoides, have also been planted.

Conclusion: It is the first time that, market gardening is associated with medicinal plants cultivation by agroforestry to face climate change in Benin and Togo. The development of mixed-use species (market gardening and agroforestry) on the same area, contributes to mitigating the effects of global climate changes. Strengthening of the capacities of the actors will make it possible to potentiate the 3U/O-3P initiative to intensify its actions with various social strata for the achievement of 2, 13 and 14 Sustainable Development Goals.

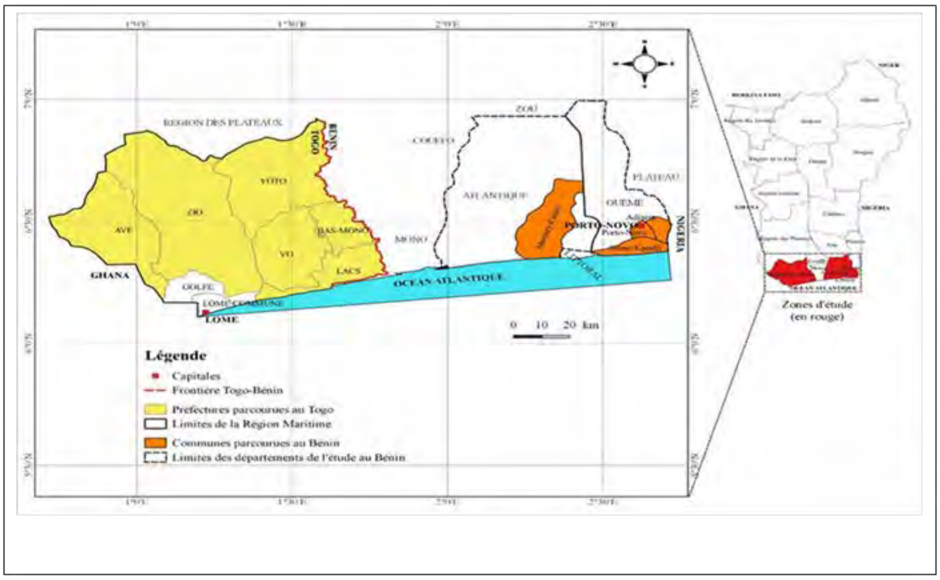

Figure 1. South part of Benin and Togo chosen for 3U/O-3P initiative

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Agroforestry practices and non-wood forest products in Northern Norway

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Biodiversity, and wildlife management

Keywords: Arctic Norway, multifunctional land-use, sustainability

Abstract

Agroforestry can be defined as sustainable and multifunctional land-use systems where trees are managed together with agricultural crops or livestock on the same piece of land. This definition fits with how the outfield has been managed in generations in Norway. The Norwegian outfields are a multifunctional land-use system. In the northern periphery area, agroforestry has a long history with woodland grazing, reindeer husbandry and gathering of different non-wood forest resources as herbs, mushrooms, and berries. Traditional agroforestry has gradually disappeared during the 20th century with the intensification of agriculture and forestry. Currently agroforestry systems are gaining new interest, not only from farmers but also from politicians, as this practice can possibly contribute to a more sustainable way of agricultural production. In the northern periphery area, the benefits of agroforestry practices can be manifold not only promoting traditional practices, but also novel systems with the use of new technology. In addition, agroforestry has environmental benefits as a method for conservation and enhancement of biodiversity, improved nutrient cycling, and water quality. Soil humus layer will also increase with several agroforestry systems leading to carbon sequestration.

The Norwegian population of 5.3 mill populate an area of 323805 km^2. The mainland of Norway is 323805 km^2 while Svalbard and Jan Mayen represent 61022 and 377 km^2, respectively. Number of persons per km^2 are 14, however, as much as 82% of the Norwegian population inhabits cities/densely populated areas. These figures tell us that Norway have a large outfield with forests and mountains.

The biggest owner of Norwegian outfield[1] is the Norwegian state by the Ministry of Agriculture and Food. The state-owned enterprise Statskog SF is set to administer the property, that alone consist of about 23% of the total outfield-area of Norway. Almost 80% of the state-owned property is above the treeline and covers mountains and alpine grassland who are valuable grazing resources for reindeer herders and local farmers. Most of the forests are also used as grazing areas for local farmers and reindeer herders. The state-owned property in the southern Norway are managed as commons, where locals have rights in commons, typically this is right to graze, hunt and fish on the state ground. In the northern part of Norway, the grazing-rights are defined as user-rights and technically not rights in commons while the right to hunt, fish and gathering of berries and herbs etc. is an "all-mans-right".

[1] Outfield is a concept that are somehow difficult to understand by non-Norwegians. It is a direct translation of the Norwegian word "utmark" and its etymological origin point towards all land outside the cultivated farm land. It includes mountains, alpine grassland as well as forest.

However, as much as 77% of the Norwegian outfield is privately owned. The private forest area is very fragmented since as much as 60% of this area are small properties with areas less than 25 ha, and 90% of the properties are less than 100 ha. Companies and different cooperatives own 7.5% of the forest area and the remaining 9,5% are owned by communes and commons ("allmenninger"). The commons can be owned by the parish, the municipality or by farm-commons. The Parish commons ("bygdeallmenning") are owned by most of the commoners themselves, and in the Farm commons ("realsameige") the rights are hold by the farm units not the person who own the farm. Farm-commons is in fact the most frequent type of commons in the Norwegian outfields. In all this different kind of commons the user rights are defined by law and secured by institutional surroundings. Therefore, it is common to find forest areas in Norway where farmers and foresters are sharing the same geographical area where all are using the area for different purpose.

In Norway the most important framework for the use of forests are "Skogloven" LOV-2015-06-19-65 (https://lovdata.no/dokument/NL/lov/2005-05-27-31) and the "Naturmangfoldloven" LOV-2018-12-14-94 (https://lovdata.no/dokument/NL/lov/2009-06-19-100). Both these laws define the Norwegian forestry practices. The State commons and the Parish commons are regulated under the Mountain Act LENKE and the Act on Parish Commons. The Farm commons are not regulated by a particular legislation like the two other commons. They are of course subject to all relevant acts. There is one default act that comes into force in case of disagreements among co-owners. This is the act on co-ownership, but because of its long history farm commons more than most things are governed by customs and contracts among the co-owners.

The "Friluftsloven - allmansright" LOV 2017-05-11-26 (https://lovdata.no/dokument/NL/lov/1957-06-28-16) states the right for everyone to use the property owned by others (including the Norwegian state). This law has an impact on different agroforestry practises. In addition, the allmansright also bring some ethical issues to agroforestry practices like hunting and harvesting of herbs and berries.

We want to define the concept of agroforestry into a northern/arctic context. Historically all use of land was linked to household economy. Modernization/industrialization of agriculture and forestry started after the second World-War. In Reindeer husbandry household economy was the tradition until 1970s. Today, we see conflicts between different stakeholders to the outlaying field. We search for an understanding of AgroForestry where sustainability of culture of all interest groups must be taken into consideration. Overall aim is to build knowledge in how to use the land in the Northern-Norway to the best for all interest groups.

1.4

Agroforestry and the landscape

The role of agroforestry systems in the FAO Globally Important Agricultural Heritage Systems (GIAHS) programme

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: GIAHS, FAO, agricultural heritage, rural landscape

Abstract

Nowadays, the world is facing numerous challenges in the economic, social, cultural, technological and political fields, together with climate change and its consequences. Concerning the rural territory, the development and productive model promoted in the last decades has not only shown to be ineffective to solve the problems of many rural areas, but it has also contributed to the loss of cultural values associated to the communities' traditions. In fact, this model, established from the second half of the last century, among the numerous consequences, has caused the degradation of valuable landscapes shaped by several generations of farmers as the result of their adaptation to the surrounding environment. This has caused the abandonment of millions of hectares of farmland difficult to be cultivated or maintained using the new machineries and as consequence it has produced phenomena like soil erosion and habitat degradation.

For that reason, the use of sustainable ecological practices related to traditional agricultural systems is a key feature to prevent such kind of consequences negative for both the environment and the life quality. In addition, these practices constitute a valid alternative to support climate change mitigation while maintaining the traditional systems and cultural values. This kind of farming may be considered as less productive from modern-intensive systems, but it has ensured sustainable yield over time, thanks to time-tested technologies and traditional know-hows, using reduced external energy inputs and adapting to difficult and diverse environmental conditions.

Based on this idea, in 2002, the Food and Agriculture Organization (FAO) of the United Nations launched the Globally Important Agricultural Heritage Systems (GIAHS) programme. This programme is focused on the identification and safeguard of agricultural sites that have survived using traditional techniques and are still providing many services to the ecosystem, while maintaining magnificent landscapes, agrobiodiversity, ancestral knowledge transmitted through generations and strong cultural and social values. Located in specific sites around the world, they sustainably provide multiple goods and services, food and livelihood security for millions of small-scale farmers while contributing to climate change mitigation. There are currently 58 sites inscribed and 12 proposed in the GIAHS programme and many of them are related to agroforestry systems. Forests has always played a fundamental role for the rural communities' economy contributing with multiple benefits according to the different agroecosystem

features. Therefore, even among the sites inscribed at the programme, woods are characterized by different degrees of importance: in some cases, the landscape is the result of a close interaction of forested and cultivated patches match, while in some other forests play only a minor part inside the agroecosystem.

This contribution intends to present the opportunities related to the GIAHS programme as well as the role assigned to forests and forest trees in the different sites and its importance at the system level. An analysis of all the application files has been carried out in order to have a detailed view about the wood importance and its influence on the systems. To do that a different score, from 0 to 3, has been assigned to each site according to the importance covered by forests and forest trees. After that, the following phase focused on the analysis of the structural and management features of the sites labelled with scores equivalent to 2 and 3 (high wood importance) in order to better understand the forests influence on the site as a whole and which are the different ways of protection and management considered in each nominated area.

In many of the analysed sites, it has been highlighted that forests and forest trees are not part of the inscribed agricultural systems or even if they are present in the GIAHS site they play only a marginal role, while in other cases they have a key role in the agro-ecosystem being one of the elements that characterizes the landscape. In nine sites, they represent a characteristic component of the GIAHS site, and its importance is essential for the sake of the agricultural products. In all the cases considered it is undoubted that wood well contributes to agrobiodiversity maintenance preventing hydrogeological risks, guaranteeing the endemic flora and fauna species protection and furnishing a different source of income for the local communities. Furthermore, a good forest management and protection plan could facilitate its role in reducing CO2 emission while contributing positively to climate change mitigation.

Evaluating the importance and the function assigned to forests and forest trees in GIAHS sites is particularly important. In fact, examples from different countries around the world could help to understand how this issue is considered in one of the most important international programs related to conservation of traditional landscapes, agricultural practices and agrobiodiversity. This programme in fact is based on the dynamic conservation principles and the sites are considered examples of human adaptation to different environments and climate change.

Landscape transitions as a chance for agroforestry. The case of Park Lingezegen, The Netherlands

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: transition, drivers for change, physical realm, social realm

The development of park Lingezegen - situated between the cities of Arnhem and Nijmegen in the east of the Netherlands - has meant a transition in the lay-out and in the use of the area (parklingezegen.nl). The area that has been designated to form park Lingezegen partly remains agricultural, but is also developed to support ecosystem services such as ecological corridors, water retention and recreation. This happens often in overlapping forms of land use. In this transition six agroforestry initiatives found the opportunity to start. What were the drivers that changed the situation if favour of agroforestry, giving these six - and possibly other initiatives - the opportunity to develop?

Klerkx et al. (2010) note the connectivity between agricultural innovation networks and their environment. They conclude that physical agricultural innovations such as an innovative hen housing system, although not totally steerable, benefit from innovation networks operating in what can be called the social realm. Following this, we argue that the transition as envisioned in the *physical realm* needs to be accompanied by a parallel transition in the *social realm* and vice versa, see figure 1. The physical realm is made up of characteristics such as the land use, landscape, nature, the presence of water and water retention capacity of the soils. The social realm encompasses aspects such as the attitude of the inhabitants, logistic connections, the current policies and laws affecting the area. In connecting these two transitions, opportunities for agroforestry can be found. In researching this we used rural appraisals, including a survey, in-depth interviews with several stakeholders, combined with speculative landscape design and workshops with stakeholders to describe the intertwined transformation of physical and social realm and to discover the drivers for change that are able to manipulate both realms simultaneously.

When reflecting on the developments as described above, there are several *drivers for change* that can be identified.

Two important drivers have been responsible for creating the situation as it is right now:

- The development of Park Lingezegen as a buffer between the urban areas of Arnhem and Nijmegen. This government-led large landscape development gave way for agroforestry opportunities in the area.
- The presence of an active change agent in the area, who advocated the opportunity to experiment with different types of agroforestry on land owned by the park.

Also, other drivers that are gaining momentum at this moment:

- Changing policies and laws on several levels: on national and local level there is more attention for farming systems and local food systems that encompass agroforestry. The Ministry of Agriculture is also currently debating whether a specific policy on agroforestry is in place (Luske et al. 2019). At local level, policies and activities based on the Green Capital activities in 2018 can provide a strong driver.

- Opening up new markets especially focusing on regional food chains and local products offer opportunities, due to the increasing awareness that in the long run the Dutch products will not be able to compete on the world market (Badada et al. 2019).
- A sense of urgency (N-discussions, climate change) that is felt on a national and international level, but also with the general public. Agroforestry has the capacity to contribute to solutions in the physical domain.
- Especially for agroforestry combined with arable systems, maintaining crop production combined with soil conservation is also seen as the key positive motivation elsewhere in Europe (García de Jalón et al. 2018).
- Other people, in the area, motivated by the current change agent, are gradually becoming more interested in agroforestry. In this way they may be able to function as ambassadors for agroforestry production.
- The changing perception of farmers in the area; current activities are tapping into the motivation of traditional farmers and are looking for new cooperation models, thus lowering the threshold to experiment with agroforestry.
- The development of new cooperation models of current farmers or landowners with newcomers in the sector will open access to land to experiment with agroforestry.
- The development of an ecological corridor through the area (Stuurgroep Park Lingezegen, 2008), provides opportunities for the development of various forms of agroforestry.

The case of Lingezegen shows that developments on a regional scale, like the establishment of landscape park Lingezegen, can give synergies with and opportunities for agroforestry on farm level. However, to achieve this, change agents need to be present, that connect opportunities in the social realm and the physical realm. For future developments, changes in the physical realm (more hectares of agroforestry in combination with landscape ecological development, resulting in a different type of landscape) will only continue if the social realm evolves alongside or even propels the proposed development of agroforestry. This interconnectedness between physical and social realm and how drivers for change influence one or both these realms is the key in understanding the processes of changing an agricultural landscape to an agroforestry landscape.

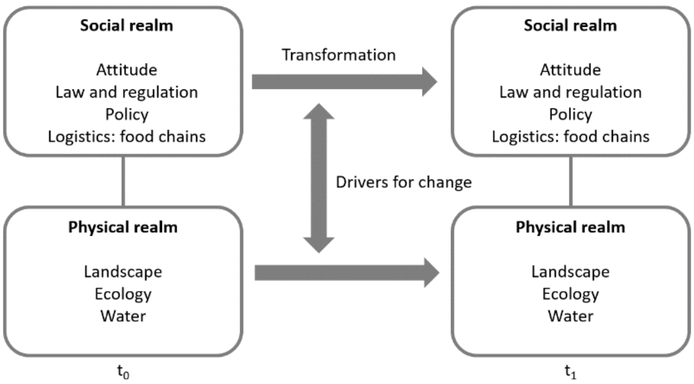

Figure 1. Transformation in the social-physical realm necessary for the development of agroforestry

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Designing urban agroforestry with people in mind

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: Urban agroforestry, ecological design, multifunctionality, psychological restoration

Abstract

While agroforestry is not specifically limited to rural landscapes, fully integrating agroforestry systems into urban environments can be challenging due to biophysical and sociocultural issues unique to the city. Edaphic conditions, for example, may constrain plant growth. Urban soils are often highly disturbed, compacted, and even contaminated with toxic metals or other compounds. Elevated air and soil temperatures, air pollution, and drought stress further threaten plant productivity, as does shading from buildings and existing trees (Wortman and Lovell 2013). At the same time, urban agroforestry sites (UAFs) may be expected to perform at higher levels of landscape multifunctionality than rural sites in order to justify the use of valuable urban land for agricultural production. Unlike their rural counterparts, UAFs may need to be not only productive and economically sustainable but also beautiful, psychologically restorative, and culturally acceptable—if not desirable—and to provide recreational and educational opportunities (Park et al. 2018). A greater variety of ecological functions may also be demanded of these sites. They may be expected to mitigate urban heat island effects, to provide habitat for wildlife, or to infiltrate stormwater (Park et al. 2018).

The archetype for multifunctional UAF projects is the food forest, a multistory, highly diverse polyculture of food-producing plants including trees, shrubs, and herbaceous perennials (Park et al. 2018). While urban landscapes with trees are generally preferred over those without, and landscape preference is often correlated with tree density (Kuo, Bacaicoa, and Sullivan 1998), this may not be true for food forests or for UAFs in general. In the absence of any empirical studies on perceptions of UAFs in the U.S., we speculate they may be perceived to be transgressive because of their aesthetics. With their high levels of plant diversity and "wildness" and use of productive plants without conventional aesthetic attributes, multistory UAFs—like native plant landscapes—may be perceived to be unkempt, unmanaged, and weedy, particularly in contrast to the manicured landscapes dominating cities.

We argue that these biophysical and sociocultural challenges can be best addressed through an ecological aesthetic design language (Egoz and Bowring 2004) that attends equally to the productive, ecological, and cultural functions of UAFs. This design language integrates principles and practices from agroecology, ecological design, landscape architecture, and environmental psychology to create multifunctional UAFs that are also socially sustainable. Agroecology, of course, is foundational for the design of any agroforestry system. Principles of complementarity and facilitation, for example, guide plant selection and vegetation layering in UAFs just as they do in non-urban systems. Other agroecological practices, however, could be adapted to address the unique biophysical challenges of urban environments. Cover cropping could prepare sites for UAF by reducing soil compaction, increasing soil

organic matter, and catalyzing the recovery of the soil microbial community. Risk from soil contamination could be reduced through phytoremediation, while soil microbial communities could be manipulated to increase contaminant uptake by phytoremediators or to reduce uptake by crop plants. Local food preferences—particularly those of underresourced communities—and the constraints of the urban environment, e.g. increased drought stress, shading, and high soil pH, must also drive crop plant selection.

Designers can draw on principles from ecological design and landscape architecture to create culturally preferred UAFs. While agroecology draws inspiration from natural ecosystems, mimicking natural forms without attention to the public's aesthetic expectations could undermine the social sustainability of UAFs. To be culturally acceptable, these novel landscapes must reflect community values. At its most basic, this may include incorporating signs of human intention or "cues to care" into the site design, e.g. framing "messy" plantings with elements such as curbs or paths, selecting plants that are both productive and conventionally attractive, or nestling art or seating amidst the plantings (Nassauer 1995). At the extreme, designers may synthesize disparate landscape aesthetics to create new, complex ecological aesthetics (Egoz and Bowring 2004), potentially integrating, for example, the layering and productive plant diversity of the food forest with the symmetry of the French formal garden.

Environmental psychology can further inform the design of UAFs that are both psychologically preferred and restorative. To be preferred, sites should be informationally rich, yet coherent (Kaplan, Kaplan, and Ryan 1998). Classic design principles—symmetry, balance, repetition, unity, and contrast—can help to create this coherence and, moreover, legibility, or a sense of distinctiveness, in the landscape. To be psychologically restorative, UAFs should be designed to afford users a sense of being away, a feeling of landscape extent, and opportunities for fascination. They must also be compatible with users' expectations (Kaplan, Kaplan, and Ryan 1998). Materially distinct from the surrounding built environment, UAFs naturally engender a sense of being away (Stoltz and Schaffer 2018) and, if appropriately designed, a feeling of extent. Their plant and animal diversity and the ecosystem processes they encompass also afford opportunities for mindless fascination (Stoltz and Schaffer 2018). Intentional design can heighten these intrinsic, restorative properties and align site characteristics with users' expectations.

Based on our synthesis of principles from these four fields—agroecology, ecological design, landscape architecture, and environmental psychology—we have developed a set of guidelines for connecting form to function in UAF design. We have drawn specific examples illustrating the guidelines from built UAFs in the U.S. We have also developed a set of scenarios, using real sites, to further illustrate the application of the guidelines. We hope that this ecological aesthetic design language can help to inform the design of socially sustainable, multifunctional UAF in temperate countries.

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Diversifying oil palm plantations in the Southern Pacific region in Costa Rica.

EURAF 2020

Agroforestry for the transition towards sustainability and bioeconomy

Abstract

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Theme: Agroforestry and the landscape.

Keywords: agroforestry system, *Elaeis guineensis, Cordia megalantha, Theobroma cacao, Musa spp.*, tropical soils, shade, production.

Abstract

In recent years, oil palm kernels are being bought by big companies at a significantly lower price, affecting the economy of local monocrop producers of palm oil (*Elais guineensis*) in the southern pacific of Costa Rica. Not only is monocrop production of oil palm representing an economical threat to local producers, it also affects the biological conductivity between forests, creating a harsh landscape, where biodiversity may be scarce and the crops are more susceptible to the attack of pests and diseases.

The Osa-Golfito Initiative (INOGO, by its Spanish acronym) developed a diversified oil palm cropping system. This model consists of *E. guineensis* Jacq. with *Cordia megalantha*, *Theobroma cacao* and *Musa spp*. The present study aims to evaluate the productive, environmental and economic potential of the oil palm agroforestry system established, in search of a more sustainable productivity model for the local community.

The model studied consists of five plots of one hectare each, where half a hectare is palm oil in a monocrop traditional system planted at 9 x 9 m, and the other half a hectare consists of the agroforestry system studied with *E. guineensis, C. megalantha, T. cacao* and *Musa spp.* In the diversified section, the different crops are mixed together in a set arrangement, with oil palm planted at a distance of 9 x 12 m. These plots were established by INOGO in 2016 and 2017 in the Osa-Golfito region of the southern pacific.

Income generated by the diversified system will be estimated throughout the years with a regular evaluation of the production of each crop and compared with income generated by the monocrop. There is a constant monitoring of growth and production for each of the species, as well as shade produced, and any symptoms of pests or diseases observed. A baseline of the chemical and physical properties of the soil were determined, making possible the evaluation of potential changes throughout the years between a monocrop traditional oil palm plantation and the diversified system studied. Three years after the system was established, the canopy structure presented a shade percentage below 12% which is relatively low for the crops used which are susceptible to the amount of shade received. Interestingly, first results show that the total height and kernel weight of the oil palm was found to be greater in the diversified plots than in monocrop plots. Furthermore, stem rot incidence in oil palm was found higher in monocrop plots than in

diversified plots (9,9%,-7,4% respectively).

In diversified productive systems, management and maintenance seems to be a key factor in guaranteeing a good crop development. An adequate appropriation from the producer increases the possibility to generate quality products, therefore generating better income.

Figure 1. Drone image taken from one of the plots studied: AFS top half and oil palm monocrop bottom half.

The role of agroforestry in a multifunctional and uncertain world: a landscapes perspective

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Agroforestry and the landscape

Keywords: Ecosystem services, forest landscape restoration, robust optimization

Abstract

Agricultural expansion has led to alarming rates of tropical deforestation. Conserving and restoring forests and halting land degradation and biodiversity loss have become major goals recognized worldwide. Panama has a national goal to restore one million hectares of deforested and degraded land before 2035. Panama's reforestation project includes commercial reforestation and bringing trees back into agricultural landscapes through agroforestry. But how much agroforestry should be embedded to balance ecological and socio-economic objectives of different stakeholders? We investigated the share and type of agroforestry selected in a landscape with optimal land allocation, accounting for social-ecological impacts at the landscape scale.

Confronted with a lack of empiric data or sufficiently validated process-based models, landscape planning often depends on expert judgement for estimating the required ecosystem service provision of different land-covers. We adopt the novel approach of Uhde et al. (2017) to quantify expert knowledge through the analytic hierarchy process (Saaty 1987), which can be used as input data for multi-objective linear robust optimization of land-cover (Knoke et al. 2016; Uhde et al. 2017). Using multi-objective optimization allowed us to investigate the complex interrelations between different land-covers and multiple ecological and socio-economic objectives. We test the modelling approach in an example landscape in the humid tropics in Eastern Panama.

Through interviews in Panama and an online survey, we quantified the ability of seven land-cover types to provide 10 ecosystem services. The land cover types included forest, abandoned land, three landscape restoration types including agroforestry systems, as well as two agricultural land-use systems. The ecosystem services address on one hand ecological objectives, i.e. the potential of a given land-cover for climatic and hydrological regulation, supporting soil fertility and biodiversity. On the other hand, they address socio-economic objectives, such as food security, long-term profit, liquidity, stability of economic return and aesthetic landscape for society. We explore the impact of increasing shares of forest landscape restoration options such as agroforestry and commercial reforestation, and other studied land-cover options on optimized land allocation of the remaining landscape. This

allows us to analyze the potential of agroforestry to increase multiple ecosystem services under different assumed landscape compositions.

One innovative feature of our robust optimization model is that we include the variability in the survey responses of experts as an aspect of uncertainty. We investigate how (dis)agreement of experts about the relative provision of different ecosystem services influence the optimized landscape composition. Our modelling approach allows us to account for multiple objectives and uncertainty, with only scarce data and low computational requirements (Knoke et al. 2015).

Results show that experts from different backgrounds and stakeholder groups (n=80) perceive agroforestry very positively. To balance ecological and socio-economic objectives under uncertainty, the model suggests a landscape comprised of a mix of different land-covers with large shares of agroforestry. Under medium uncertainty the optimized landscape composition consisted of forest (31% land share), a mosaic of forest landscape restoration options including silvopasture (21%), alley cropping (20%), and commercial forest plantation (7%), as well as the common agricultural land-uses pasture (12%) and cropland (9%).

We did not identify the studied agroforestry systems in the real study area. However, including them enhanced the anticipated ecosystem service provision, even if high shares of natural forest or agricultural land-uses exist, according to our model. In particular, including agroforestry in an agriculture-dominated landscape, improved the socio-economic objectives economic stability, food security and long-term profit. Overall, in terms of sustainable landscape development, agroforestry may best secure the full range of ecological and socio-economic objectives as part of a land-cover mix. Thus, both land-sharing and land-sparing strategies are attractive possibilities when managing a multifunctional landscape (Grass et al. 2019).

We present an approach to support sustainable landscape development of multifunctional land-cover compositions when data is scarce. Our modelling approach can help understand interrelations between land-covers and uncertain provision of ecosystem services. It can support decision-makers to systematically assess theoretical optimal land-cover composition to balance desirable but seemingly incompatible ecosystem services while considering uncertainty of the future provision of these ecosystem services.

Figure 1. Diverse landscape image of Panama (photo: Carola Paul)

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The *Meriagos*: landscape value from Sardinian agro-forestry system

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Theme: Agroforestry and the landscape

Keywords: *Dehesas*, *Meriagos*, Landscape, Agroforestry

Abstract

The *Meriagos* (Fig. 1) are pastures characterized by sparse trees in which two fundamental layers are identified: herbaceous, most often made up of semi-natural plant communities, and arboreal, with various categories named on the basis of prevalent species, i.e. "with a prevalence of cork oak", "with a prevalence of downy oak", "with a prevalence of holm oak" and "mixed".

In Sardinian language, the term "*meriàgu*" indicates a shady place, also a large tree with a typical physiognomy (with expanded foliage), which protects livestock from the summer sun; the term follows from the plural "*Meriagos*" which identifies, in Sardinia, the landscapes of the pastures with scattered trees.

In Spain and Portugal, the terms *Dehesas* and *Montados*, (Pereira & Pires da Fonseca, 2003) indicate landscapes made up of tree-lined grasslands, characterized by a density of 60-100 trees per hectare, already included among the community habitats referred to in the Directive CE 43/92.

For the purposes of protection and enhancement as an agro-forestry system and landscape property, it is important to precisely define the crown coverage values in order to identify and therefore estimate their effective consistency on the Island. The regional law (L. 8/2016), in according with national legislation (Legislative Decree 34/2018), indicates the 20% minimum coverage to define the woodland. However, also a surface with above 10% of coverage it is a forest for FAO (if the trees are at least 5 m high).We propose Meriagos should be considered belonging to the two categories (pasture and woodland), with the coverage index from 10% to 50% (if the coverage is below 20%, the Meriagos is not a forest, but only pasture). A special case is the cork oak Meriagos, which is always and, in any case, protected: therefore, a minimum limit of 5% it could be reached only for cork oaks.

The ongoing update of Sardinian Nature Map (Camarda *et al.*, 2015) highlights that Meriagos habitat covers 113,000 hectares, which represents the 6% of total surface of the island.

This work aims to clarify the definition of the Meriagos by using identification parameters that constitute objective and perception elements from a landscape and use point of view in the agro-forestry system.

The main parameters taken into consideration concern: the *coverage values* (through simulations by selecting areas and measuring the real coverage of the foliage on the ground); the *predominant species*

("prevalently of cork", "predominantly downy oak", "predominantly of holm oak" and "mixed"); the *land use* (grazed / ungrazed, worked / unworked, sown / not sown); the *presence of renewal* (absent / low / medium / high).

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Figure 1. Example of *Meriagos* in the centre of Sardinia (from Carta, 2015)

Monitoring of gypsy moth in Sardinian cork oak forests and woodlands: past, present and future implementations

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: Pest monitoring, microbiological control, Lepidoptera, cork oak

Abstract

Cork oak, *Quercus suber* L., is one of most common forest tree species in Sardinia (Italy) and it extends for approximately 140'000 hectares throughout the island. Monitoring the health status of cork oak forests is fundamental as they are at the same time an essential resource for the economy of rural communities and a critical hotspot of biodiversity (Mannu et al. 2018). One of the major threats of cork oak in the Mediterranean area is represented by lepidopteran pests, whose infestations can lead to complete defoliation of thousands of hectares of forests. The most harmful species is the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera Erebidae), which is a poliphagous species being recognized as one of the most important defoliators worldwide because of its ability to develop on more than 300 host plants (Liebhold et al. 1995). In the Mediterranean area, gypsy moth is mostly associated with *Quercus* species. Defoliations due to this pest can cause physiological imbalances in oak trees (Muzika and Liebhold 1999) and lead to a significant reduction in cork growth. Gypsy moth population density tends to oscillate through time and intervals between two consecutive outbreaks mainly depends on forest management strategy (Luciano and Prota 1995; Cocco et al. 2010; Lentini et al. 2020). In order to evaluate its density and distribution, a network of georeferenced monitoring sites was established in 1980 in the main oak woods of Sardinia (Italy) and has been implemented since then (Cocco et al. 2010). The network provided information on the annual distribution of the pest and the most infested areas, in which *Bacillus thuringiensis kurstaki* formulations have been applied at large scale since 2001 to control larval populations (Luciano and Lentini 2012; Lentini et al. 2020). The pest population density was evaluated by counting the egg masses present on a total of 40 trees per site (Fraval et al. 1978). This sampling method is highly time-consuming especially at high population densities.

The aim of this work was to summarize the main results of the long-term monitoring of *L. dispar* in the cork oak forests of Sardinia. The temporal pattern of population density and differences among different main land use were investigated. Furthermore, alternative sampling approaches were proposed.

Data obtained from more than 30 years shed some lights on the pest population dynamics. Although *L. dispar* is characterized by cyclical fluctuations of population density over time, the magnitude of outbreaks was mainly related to the complexity of the forest ecosystem (Prota and Luciano 1989; Lentini

et al. 2020). Outbreaks of gypsy moth occurred every 5-6 years in cork oak forests subjected to intense pastoral activity, whereas severe infestations were observed every 8-9 years in pure cork oak forests with a low pastoralism pressure. Moreover, in areas with mixed-oak forests, defoliations recurred at irregular intervals longer than 10 years. The monitoring program also enabled to develop alternative sampling methods that reduced the effort in evaluating the gypsy moth population density. The proposed sequential sampling method required a smaller number of sampling trees than the conventional one to estimate *L. dispar* harmful density (Mannu et al. 2019). Consequently, the application of a sequential sampling plan would provide earlier information on the cork oak areas at risk of infestation, enhance the insecticide application planning, decrease the sampling time, make possible to implement the number of sites included in the monitoring network.

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Enhancing Terraced Landscapes for Ensuring a Sustainable Development of Traditional Agroforestry Systems. A case study in Piedmont (Italy).

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the Landscape

Keywords: Rural landscape, Traditional knowledge, Landscape dynamics, Planning strategies, Diachronic analysis, Winegrowing

Abstract

In Europe, many agroforestry systems are often denoted as cultural landscapes, which are defined as landscapes managed by traditional agricultural techniques or practices. They are an expression of the coevolution between territories and rural communities through thousands of years (Agnoletti 2014). Currently, terraced agroforestry systems are receiving much attention from researchers and planners who wish to achieve multiple aims, including biodiversity preservation, landscape sustainability, and conservation of cultural values. These sites have a high degree of multifunctionality and provide ecosystem services (Pereira et al 2005; Brunori et al 2018). Moreover, terraced landscapes often safeguard ancient and qualitatively excellent vineyards cultivars and are characterized by historical anthropic settlements, so much so that the "Art of dry-stone walling" was inscribed, during 2018, in the UNESCO's "Representative List of the Intangible Cultural Heritage of Humanity". By contrast, the difficulty in terraces' management, that needs continue efforts, is one of the causes of their abandonment. This main cause determines several problems in terms of historical landscapes loss and hydrogeological risk increase (Agnoletti et al, 2019). According to Bonardi and Varotto (2016), in Italy, terraced landscapes are extended for at least 200 000 ha, but this data is underestimated because these sites are not mapped and precisely quantified. In this context, in order to increase the knowledge about terraced agroforestry systems, suppose future scenarios and propose innovative development models, multidisciplinary studies should be applied (Gullino et al., 2018).

The vineyard terraced landscape located in the Ivrea's Morainic Amphitheatre (Piedmont, North-West Italy) was studied, in order to develop a scientific methodology to evaluate it and define analytical process of enhancement and management. It is extended over about 425 ha into four municipalities in the North Turin's Metropolitan City, involving about 6 200 inhabitants. This site is characterized by traditional vineyard's pergola breeding supported by stone columns called "pilun", which play an important role in creating a microclimate advantageous to grape's maturation.

A multidisciplinary study was performed to identify a set of indicators (land use, viticulture characteristics, historical landmarks and farmer's perspectives). Terraced landscape's development across temporal and spatial scale was studied, highlighting the landscape's geographical, environmental, historical and cultural representativeness. The study accompanied the adhesion process, still in progress, to the "National Register of Historical Rural Landscapes, Agricultural Practices and Traditional Knowledges", instituted by the Italian Ministry of Agriculture, Food and Forestry in 2012. The study was carried out with cartographic and archival analysis, field inspections and farmers' involvement with a bottom-up

approach. The Savoy's Cadastral map (1789) and the Piedmont aerial image (2011) were used to study the land use changes in *Torredaniele*, that is one of the most terraced localities within the study area.

Bibliographic analysis allowed to understand that the traditional breeding system was introduced in Roman times, while the art of terracing has known moments of expansion and other of contraction. Historical and archival analyses highlighted, instead, that it is about a landscape where agroforestry system historically was well organized, with the integration of woody vegetation with crops: chestnut trees were used to produce winegrowing breeding system. Historical permeances were identified. Diachronic analysis showed that in 1789 the 16.6% of the total *Torredaniele* surface was covered by vineyards, while in 2011 it was only the 9%. By contrast, in 2011 forests covered a higher area than in 1789 (38.6% and 33.2% respectively). The photointerpretation highlighted also that in 2011 the 3.4% of surface was occupied by invasion shrubs on terraces and the 0.1% by olive trees, that were not there in 1789. From the participatory analysis (interviews with winemakers) many aspects related to possible future landscape scenarios were identified. It was also emerged that some farmers are trying new vineyard pruning and training systems as well as new crops, mainly related to olive growing. As shown in figure 1, this brings to a change of the traditional landscape but also obstruct the abandonment and consequent problems.

The research proposed an innovative and integrated approach for identifying sustainable strategies for historical landscapes and allowed to underline that the enhancement of terraces is a priority step for traditional agroforestry systems' development.

Figure 1. Ivrea's Morainic Amphitheatre's Terraced landscape (*Cesnola* locality). It is possible to understand the spatial organisation of the agroforestry system: woody areas, traditional vineyard breeding (pergola), new vineyard breeding techniques (e.g. espalier) and new crops (olive trees).

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Spatial models as a tool to evaluate afforestation actions in agrosilvopastoral systems

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Abstract
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Theme: Agroforestry and the landscape

Keywords: Dehesa, Montado, tree recruitment, data mining, afforestation schemes

Abstract

Due to land use and cover changes and the land management transformations occurred over the sylvopastoral systems all around the world and, particularly, in the Mediterranean region, those systems are facing deep transformations that, in the case of SW Iberia (dehesas in Spain and montados in Portugal), particularly affect the tree layer. Inherent problems of tree aging, deseases and lack of tree regeneration are common features of those highly valuable systems. Along recent decades, after Spain joined the European Economic Community in 1986, different afforestation programs were performed, from which, the First Afforestation of Agricultural Land program was particularly relevant, being applied trough three subprograms in different periods: 1992-1999, 2000-2006 and 2007-2013. The main aim of those actions was to retire marginal agricultural lands from exploitation, with the objective of reducing agricultural products surpluses. Those subprograms considered dehesasas suitable for subsidies to afforestation, provided certain criteria are met: During the first sub- program, dehesas should show less than 20% of tree canopy cover. In the second one, they were required to present less than 10 trees/ha or 20 juvenile trees/ha. The third period only considered dehesas with less than 5% of canopy cover or less than 10 trees/ha or 20 juvenile trees/ha. Besides, for the two lasts periods, candidate dehesas should also lack abundant and viable natural tree recruitment. On the whole, the first afforestation of agricultural land program increased oak woodlands and decreased cereal production in the 1990s. Since then, participation has dropped off as a consequence of changes in subsidies regulations. Due to the lack of exhaustive and sustained monitoring programs, data on the long-term success of those plans is very scarce. Since the presence of regeneration is very important and there has been no exhaustive control of compliance with the premises in this regard when performing afforestations in those agrosylvopastoral systems, some questions arise that constitute the main objectives of this work:

- Can we model and spatially predict the dynamic of tree regeneration at regional scale? and, based on model drivers, depict the role of the physical-environmental and anthropogenic contexts as influencing the tree dynamics?
- If the predictive models are reliable at regional scale, could they be used to assess the degree of compliance of the afforestations performed in relation with the existence of tree regeneration.

To this, predictive spatial models of the likeliness of a piece of land to undergo tree recruitment or not (binary variable) were developed for the area covered by dehesas and treeless pasturelands of Extremadura (SW Spain). Models were fed with the information provided by 51 physical-environmental and land use/cover variables, from which the main 15 were selected. MARS (Multiadaptive Regression Splines), Random Forest (RF) and Stochastic Gradient Boosting (TreeNet, TN) were used as data mining algorithms to construct the models. An model of agreement was also finally computed as ensemble technique based on the majority vote of the outcomes obtained with the three algorithms.

To train models and test their outcomes, the new trees were located over 800 sampled circular plots (100 m radius) randomly distributed over the studied systems (app. 2.500 ha), avoiding all the afforested areas. From 1956 to 2012 a number of 1650 new trees were identified in aerial orthorectified images on the sampling plots, and another 1650 places of no regeneration were also located. Furthermore, data records and locations were also gathered about the actions performed in the region corresponding to the First Afforestation of Agricultural Land program between 1992 and 2013. Approximately 5.600 afforestation events were performed during the analyzed subprograms, covering approximately 79,221 ha in the study area. From these, 47,129 ha correspond to the 3.433 actions performed in dehesas or pasturelands. Once models were constructed, they were deployed separately over dehesas and pasturelands and also over the afforested areas (at greater spatial detail), and the percentage of surface predicted as prone to tree recruitment was calculated separately for both spatial contexts. This was done to determine whether or not afforestations actions were carried out on places that either present tree regeneration or already were naturally prone to tree recruitment.

All the models performed showed a high fitness when forecasting the places that present or are prone or not to undergo natural tree recruitment. Attending to the ROC AUC, the more accurate algorithm was Random Forest (RF), which showed an AUC of 0.95 for both the learn and test datasets. Attending to the relative importance of the variables, although they were differently ranked depending on the algorithm, 6 variables among all models were rated to the top three positions, i.e., percentage of tree canopy cover, slope, percentage of shrub cover, x coordinate, proportion of cattle in AU and mean temperature of the warmest quarter. Results indicate that tree recruitment in dehesas is highly restricted to marginal areas and can be correctly forecasted by predictive models. Those models are mainly influenced by topographic and land cover characteristics, but also by other socioeconomic, bioclimatic or geographical variables (Herguido et al. 2017a, b). In the case of the studied rangelands, once all the afforestation between 1992 and 2013 were analyzed, the results evidenced that those actions were frequently done in areas that, in fact, were already prone to passive restoration through natural tree regeneration. Particularly during the first subprogram period (1992–1999), results suggest that afforestation events did not discriminate areas prone to natural tree recruitment in a high percentage of cases. This data gains relevance if it is considered that the amount of area afforested during the first subprogram is much higher than the sum of it during the last two.

Our data confirm that the Afforestation of Agricultural Land program was not specifically designed to accomplish for the dehesa requirements and, consequently, it was applied without a properly designed plan that, additionally, up to the present, lack from enough monitoring over its long-term consequences and success rates. On the understanding that the implementation of measures, resources and efforts should be focused to the areas where tree recruitment really lack and do not exhibit a potential to be naturally reforested, models as those developed herein could be useful as tools intended to spatially asses and drive the implementation of afforestation policies and measures

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The decline of the cork oak growing in Sicily is accompanied by the loss of the functions proper to agroforestry systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: agriculture, Mediterranean vegetation, *Quercus suber*, Sicily, Wildfires

Abstract

The cork oak (*Quercus suber* L.) is one of the most important tree species in the Mediterranean basin, where it covers more than 2 million hectares, almost 1.5 million of which in Europe and 700,000 hectares in North Africa. Among evergreen oaks, *Quercus suber* stands out for the variety of cultural systems in which it has been successfully employed, including typical agroforestry systems, for the main purpose to produce cork for wine stoppers. Accordingly, a wide range of ecosystem services may be associated to cork oak, including the preservation of biodiversity, carbon sequestration and forage production. In the Mediterranean, the cork oak represents a key species for many natural and seminatural landscapes and habitats, as well as playing a prominent role for the economic and social development of local communities. The importance for the conservation of biodiversity at a European level is largely acknowledged being the cork oak the dominant tree species of the Habitat 6310 "Dehesas with evergreen *Quercus* spp.", thus included in the Habitat Directive 92/34/EEC. However, there is increasing concern about the long-term conservation of both *Quercus suber* forests and *Quercus suber* agroforestry systems throughout the distribution range. In fact, a range contraction of *Quercus suber* natural distribution is expected in the next decades, especially in the southern edge and at lower altitudes of species' natural distribution range.
Many factors have been invoked to explain the on-going process, among which overgrazing, soil pathogens and land-use changes are prominent. Conversely, the lack of natural regeneration has been observed both in the Iberian Peninsula and Sardinia agroforestry systems. The aim of our work was to assess the variation in time of the area covered by the cork oak in Sicily. Different bibliographic sources were consulted, of course including the available National and Regional forest inventories. Although some discrepancies in inventory and historical data were found, an increasing trend of the area covered by the cork oak in Sicily would seem to have occurred. Notwithstanding this, a parallel worsening of the conservation status of most of these stands has been at the same time observed at a regional level. The frequent wildfires (Figure 1) and the progressive abandonment of the cork oak cultivation have been suspected to play a major role in the current situation.
It must be kept in mind that in many areas the cork oak has been favoured by man against other tree species, so the cork oak stands are in effect secondary forest stands, which rely on continuous human management. Hence, the clear decline observed is increasingly compromising the ability of the cork oak to provide ecosystem services for the community, although the area has increased. Particularly, the degradation processes may cause the loss of the ecosystem functions proper to the cork oak agro-forestry systems as they are very simplified. Thus, the value linked to the production of cork is lost, along with the pasture value, and last but not least the landscape value. In this perspective, the management of cork oak forests in Sicily should be promoted, for instance through the adoption of specific sustainability indicators and fostering quality productions. Active interventions and sound restoration practices are urgently needed if we are to preserve the valuable social, ecological and landscape value of *Quercus suber* stands occurring in Sicily.

Figure 1. A burned cork oak stand in Sicily.

Silvopastoralism and potential use in Europe

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, ecosystem services, landscape and rural development

Keywords: grassland, woody perennials, policy, LUCAS

Abstract

The main aim of the GO-GRASS project is to create new business opportunities in rural areas based on grassland and green fodder that will be demonstrated in four European regions at small scale, ensuring its replicability all through the rural communities of the Europe. An initial form to evaluate the feasibility of using alternative uses of grasslands is through the policy analysis of permanent grasslands in Europe. For this a European database such as LUCAS was employed for quantifying the current soil use and grassland distribution among Europe. A characterization of permanent and temporary grassland linked or not to agroforestry extent across the different biogeographic conditions of Europe was done considering the presence or not of woody perennials by using the methodology explained by Mosquera-Losada et al. (2018) associated to the land cover and land use systems. A map of the current extent of different types of grassland use (permanent, temporary and agroforestry) and the associated livestock types was produced at NUTS-2 level and associated to the current evolution tendencies during the past (Figure 1). In addition, a characterisation of rural requirements for grassland management were carried out based on grassland potential productivity for main livestock types (cattle, dairy cows, goat, pigs and sheep) and needs for temporary and permanent grassland potential productivity, including less favoured areas (mountain areas, marginal lands, wetlands…), high nature value (HNV) areas and conventional/organic farming systems.

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Figure 1. Silvopasture share in Europe by Nuts-2.

Innovative beef cattle grazing systems for the restoration of abandoned lands in the Alpine and Mediterranean mountains (iGRAL)

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Theme: Agroforestry and the landscape

Keywords: ants, biodiversity, ecosystem services, grass-fed meat, hardy cattle breeds, vegetation

Abstract

Throughout the last decades, socio-economic changes have determined a dramatic agropastoral abandonment of Italian mountains, with a marked decrease in the number of livestock farms and animals reared. The reduction of anthropogenic pressure has changed the traditional landscapes, either in the temperate agropastoral systems, where permanent grasslands have reduced because of natural vegetation dynamics, and in the Mediterranean sylvo-pastoral systems, where weeds and invasive shrubs have replaced the pastures representing understorey layer. These modifications have negatively affected plant and animal diversity, as well as the ecosystem services delivered by open habitats, such as food production, touristic attractiveness, reduction of wildfire and flooding risks. However, since recent years, a remarkable number of workers has been moving to the agricultural sector, but two major issues limit the development of efficient agropastoral enterprises: land degradation, due to the abovementioned dynamics, and land fragmentation, due to Italian inheritance laws.

iGRAL - Innovative beef cattle Grazing systems for the Restoration of Abandoned Lands in the Alpine and Mediterranean mountains – is a three year project funded by Mountain Agriculture programme 2017 of AGER Foundations' network, which aims at finding solutions to both the issues, respectively by 1) testing innovative grazing systems, adapted to current socio-economic and environmental conditions, and 2) promoting land consolidation associations (Beltramo et al. 2018) to enlarge the territorial base for agropastoral holdings.

Grazing with two different hardy breeds, Highland and Sarda cattle breed, which seem well adapted to Alpine and Mediterranean mountains, respectively, may help prevent further encroachment of pastures by woody species, when not control invasion, and restore more palatable vegetation. Moreover, the production of grass-fed meat from the two breeds, with its peculiar characteristics, may increase farmer revenue, in case consumers will be available to recognise meat nutritional and nutraceutical values.

In Piedmont Alps (three areas managed by two commercial farms) and Sardinia mountains (Macomer, Agris experimental station), we compare two different grazing systems: an ordinary grazing, where the current grazing management is left unchanged and, in Sardinia, cattle fattening and finishing are carried out in a conventional specialized fattening centre to produce grain-fed meat; an improved grazing (*sensu* Pittarello et al 2016), where the current grazing management is improved by adjusting stocking

rates on the basis of forage availability, by strategic placement of mineral mix supplements to change cattle spatial distribution and increase the consumption of poor-quality forages, and by improving forage production and quality through weed control and overseeding.

Plant assemblage composition and diversity are assessed in sub-areas homogeneous from the point of view of vegetation physiognomy and composition. Surveys of herbaceous and shrub layers in each sub-area were carried out using the vertical point-quadrat method (Daget and Poissonet 1971), modified to have a complete species list, during spring-summer 2019, before exploitation. Measures of shrub and herbaceous layers height were recorded using 'sward stick method' (Stewart et al. 2001). To assess the sustainability of grazing systems, ants are often used as environmental indicators for their high diversity and functional importance. Ants can establish competitive and/or mutualistic relationships with plants. As plant regeneration heavily depends on seed bank, seed-collecting species play a relevant role in shaping local plant community composition, above all in Mediterranean ecosystems. At each sampling unit, ground foraging ant assemblages were characterized using pitfall traps buried into the soil and partially filled with a solution of water and monopropylene glycol. To analyse the grazing behaviour of cattle and, specifically, assess the selection for plant species and communities, and the impacts produced by trampling on plant and ant community composition and functional diversity, about 20% of cattle heads in the herds were and will be GPS-tracked throughout the three-year period of the experiment. Moreover, the behaviour of some cattle will be surveyed by visual observation. To assess the effect of year-round grazing in Sardinia or grazing and feeding without concentrates in Piemonte, we analyse the nutritional and nutraceutical characteristics (total cholesterol, fatty acid profile, antioxidants) of the grass-fed meat produced and compare them with grain-fed meat from conventionally reared animals. The project aims also to evaluate the potential economic value of grass-fed meat from both the two hardy breeds. In particular, to obtain information about meat economic value and set an appropriate pricing on the market, economic analyses focus on the consumers' availability to spend for the grass-fed meat.

To face land fragmentation issue, land consolidation associations are promoted starting from Piedmont, where local government recently implemented a new regulation system to encourage landowners pooling their land properties together. A new territorial base will generate from consolidation, which can be managed by entrusting the sylvo-agro-pastoral management to one or more farms, whose income would also be improved, as well as the provision of the ecosystem services resulting from the implementation of sustainable grazing systems.

By the end of the project (2021), we expect: to gather new scientific and technical information for the restoration of the lands degraded by different encroaching species, in different temperate and Mediterranean environments; to improve the land "quality" of the areas concerned (more ecosystem services, lower management costs), also through land consolidation associations; to define a strategy to reduce fattening costs of calves; to set the bases for the implementation of new regulation schemes for pasture-based productions in mountain areas; to increase consumer's awareness with use of narrative labels and through the communication and dissemination actions of the project; to inform stakeholders (agriculture and environment institutions, farmers' representatives, policy makers, organizations dealing with beef cattle systems), involved with a participatory approach, about the strategies for grassland conservation and restoration in mountain areas and to identify the priority of actions.

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Agroforestry in vineyards as part of the agroecology approach: reviews, perspectives and insights from ECOVINEGOALS partnership.

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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From 17th to the 19th of May 2021

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Theme: Agroforestry and the landscape

Keywords: agroforestry, agroecology, vineyard, ecosystem services, multifunctional landscape

Abstract:
The integration of trees, shrubs, annual crops and animal husbandry into vineyards are ancient practices in the Mediterranean area. The functions of these practices, which are now grouped under the term agroforestry, are manifold: increasing the stability of the slopes, supporting the main crops, shading and mitigating extreme temperatures, protection from hail, providing forage and other products such as cereals, vegetables, fruits, berries, aromatic plants, ease in soil management, supplementary income supply, creation of landscape and natural barriers, contrast to harmful insects and pests, increase in biodiversity and organic matter in soil. These techniques, once studied and promoted as ordinary practices, are now being revived in the context of an agroecological approach to production that can reduce impacts and increase ecosystem benefits. The partnership of the ECOVINEGOALS (Interreg – ADRION programme) project aims to promote the agroecological transition of viticulture through studies and analyses, pilot experiences, training activities, exchange of experiences, broadly adopting the participatory methods. This contribution is intended to provide an initial overview of the existing and proposed agroforestry activities in the vineyards of the partner territories.
In order to exchange experience, knowledge and initiatives on agroforestry in vineyards the project partnership started with the elaboration of an info-sheet for describing the best practice, using a simple form with a short description of the practice, the aim of the practice, suggestions for implementation, expected results, improvable or critical aspects, bibliographic indications and references. The info sheet has circulated among project partners. From the project partnership we report below some Best Practices of Agroforestry in the Eastern Veneto Region and in the province of Vojvodina (Serbia).
1. VALLEVECCHIA di Caorle (VE) ITALY - Veneto Agricoltura
Since 1999 has been actively involved in agroforestry systems. This was mainly possible thanks to its network of pilot and demonstration farms (1,100 ha). The company Vallevecchia (Caorle, VE) houses an extensive system (over 20 km) of hedges for productive purposes (woody biomass for the district heating) and nature.
In addition, a project for the installation of new silvorables systems was launched in 2017 and will be used for long-term studies on carbon in soil.
2. CA' CORNIANI – CAORLE (VE) ITALY:
In the framework of the Landscape Enhancement Project of the Ca' Corniani Estate in Caorle (VE), one of the central strategies implemented by Studio LAND from the agro-environmental point of view is the insertion of pollination strips appropriately designed, placed at the edge of agricultural fields, to accompany the project's bicycle and pedestrian paths. For the realization of the strips was used a mix of herbaceous species consisting of grasses, annual and perennial wild flowering species. All the species identified are strongly linked to the pedoclimatic context in which they are inserted and the constitution of the mix is studied in such a way that the proportion between the species traces the natural condition, ensuring a safe take root and the consequent establishment of a lush and highly rustic herbaceous cover.
These strips, partly already realized and partly under construction, wind for almost 5 km inside the estate and will contribute to ensure a series of benefits at different levels, aesthetic-landscape aspect, ecological-environmental aspect, productive aspect: the presence of the strips reinforces the presence of beneficial entomofauna, which benefit the agricultural cultures through the processes of pollination and biological control of pathogens and parasites.
3. R.A.I.V.O. PROJECT OF THE CONSORTIUM OF EASTERN VENETO RECLAMATION – ITALY:
the aim of this project is to create a network of direct cooperation between the Consortium and the agricultural enterprises of the territory and more precisely to achieve the following objectives:
- Interfering with the direct inflow of chemical substances such as agropharmaceuticals and fertilizers into the minor hydraulic network through the planting of buffer strips and hedges close to cultivated plots so as to act as an environmental filter. The improvement and creation of natural habitats (groves and hedges) with tree and

shrub species belonging to the local flora to form new settlements for the local fauna, the increase and the safeguard of some local ornithological species. For example, artificial nests, placed on trees in groves already existing in the farms or realized with the present announcement or in hedges placed on appropriate supports, the requalification of the biological quality of the minor hydraulic network and the creation of aquatic ecosystems based on the development of several vegetation components, through the enlargement of pre-existing ditches or through the realization of new ditch heads.

4. PROVINCE OF VOJVODINA - SERBIA: "Forestry, spatial planning and protective plantation"

Since 2009 in the province of Vojvodina (Serbia) seven municipalities issued a common plan for the construction of agricultural protection zones and agro-forest production systems. At present, all the ecosystems (agro and forest ecosystems), in this region are highly endangered. Of the total land area of 2,150,600 ha in Vojvodina, about 83.24% is used for agricultural production and wind erosion represent a very destructive factor because, causes the detachment and transport of the most fertile particles of the arable topsoil, permanently changing its fertility properties. (Galic Z., Orlovic S., Galovic V., Poljakovic-Pajnik L., Pap P., Vasic V.; 2009).

The process for a diffusion of agroforestry in vineyard has begun and it is still ongoing. The issue of agricultural protection belts is systemic and very important for Vojvodina, because this province has the lowest percentage of forested land in Europe. In this province there are 50.317 ha under vineyards so the definition of best practices for the implementation of agroforestry in vineyards is of great importance.

In accordance with the standards of developed countries, the optimal area under forests and protective plantations is 0,16 hectares per resident. According to this standard, forests in the Autonomous Province of Vojvodina should cover an area of about 308,000 hectares, of which about 193,000 are under forest and about 84,000 are protected plantations in agriculture. This means that currently Vojvodina lacks about 170 thousand hectares of new forests and protective plantations.

Protective plantations reduce microclimatic extremes, change the air flows and reduce wind speed up to 50%, thus reducing soil dispersal and wind erosion, preventing the application of sand to fields. Protective plantation can have a multi-functional use as greenways, shelterbelts, beekeeping plantations, buffer plantations and eco-corridors. Shelterbelts can additionally increase income from wood assortments, fruits and biomass, increase biodiversity, contribute to the migration of wild species and contribute to the beauty of landscapes. They can compensate the fact that protected natural areas covers only the 5,5% of total of 2.150.600 ha land in Vojvodina Province that is considered as insufficient for species expansion. The important thing is that just raising protective plantings is not enough. Care measures, such as weeding or watering, should also be implemented at least five years after planting.

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An example of agroforestry in Vojvodina Serbia

Microbiological control against *Lymantria dispar* (L.) and *Malacosoma neustrium* (L.) in the cork oak forests of Sardinia (Italy)

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Abstract
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Theme: Agroforestry and the landscape

Keywords: Microbiological control, gypsy moth, tent caterpillar, cork oak forest

Abstract

The gypsy moth, *Lymantria dispar* (L.) (Lepidoptera Erebidae), and the tent caterpillar, *Malacosoma neustrium* (L.) (Lepidoptera Lasiocampidae), are the most important defoliators of Mediterranean forests. Both pests complete one generation per year and larvae, which appear in spring, can develop on different tree species, even though they are mainly associated with *Quercus* species. Larvae feeding on canopies can cause severe defoliations with a subsequent decrease in plant growth, thus compromising the health status of trees and cork production (Cambini 1971; Gottschalk et al. 1998). *Lymantria dispar* and *M. neustrium* populations tend to oscillate over the time showing cyclical fluctuations of density, also called gradations, so that outbreaks generally occur every 7-9 years (Lentini et al. in press). In Sardinia (Italy), gypsy moth and tent caterpillar are the major threats of cork oak (*Quercus suber* L.), which grows on more than 140'000 hectares of forests and woodlands over the island. Gypsy moth populations have been monitored since 1980 in a network of permanent monitoring sites covering all the oak woods of Sardinia (Cocco et al. 2010). The network resulted to be essential to estimate the population distribution and identify the areas more likely to be exposed to severe infestations. The density of tent caterpillar population was estimated only in some forest areas from 2005 to 2012, whereas, starting from 2013, the boundaries of cork oak forests to be protected from tent caterpillar infestations were based on defoliations occurred in the previous year.

In order to control defoliators, *Bacillus thuringiensis kurstaki* (*Btk*) formulations were applied at large scale in the areas where populations reached harmful densities. The control program started in 2001 following a long experimental period during which different *Btk* strains, commercial formulations, and aerial distribution techniques were tested (Luciano and Lentini 2012; Ruiu et al. 2013).

This work reports the results of the control program carried out in Sardinia against *L. dispar* and *M. neustrium*. Data on the amount of protected areas, application procedures, and techniques aiming at improving the effectiveness of aerial sprayings are reported.

Applications of *Btk* were made in 14 years since the beginning of the control program. Considering areas where applications were repeated more than once, approximately 214'000 hectares of cork oak forests were protected by spraying *Btk*-based insecticides, with a maximum of almost 30'000 ha in 2018 and 2019.

The microbiological control program efficiently protected cork oaks from gypsy moth and tent caterpillar causing an annual mean larval mortality overall higher than 60%. The maximum mortality rates observed for *L. dispar* and *M. neustrium* were 89.9% and 98.0%, respectively. After testing different strains and formulations, products providing the highest reductions in larval density were Foray® 48B and Foray® 76B (Valent BioSciences Corporation, Libertyville, Illinois, USA) sprayed at the dose of approximately 50 Billion International Units (BIU) per hectare with drops of an average size of 160 micron. The use of these formulations along with improved application devices, such as the flow control systems, increased the efficiency of bioinsecticide applications (Figure 1A) and reduced the cost of sprayings (Figure 1B). Concerning application against gypsy moth, *Btk*-based insecticides should be applied in the culmination phase of the population development. In fact, *Btk* was equally effective in controlling *L. dispar* in the year of spraying when applied in the progradation and culmination phases. However, bioinsecticide applications in culmination enhanced long-term effectiveness, as they did not affect other mortality factors (in particular parasitoids and predators) that maintain populations at low level in the years following the application (Mannu et al. 2019).

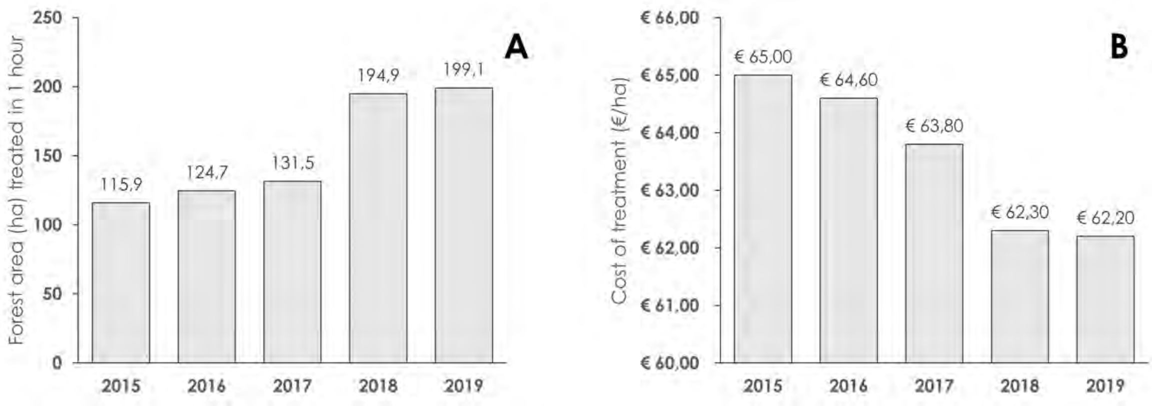

Figure 1. Forested area treated on average in one hour (A) and spraying costs for each treated hectare of forest (B).

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SAR and optical data comparison for detecting Trees Outside Forest in agroforestry landscapes

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Abstract
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Theme: Agroforestry and the landscape

Keywords: Remote sensing, Tree Hedgerow, Vegetation index, Sentinel-1, Sentinel-2

Abstract

Trees Outside Forest (TOF) have an important role in rural landscapes, enhancing their ecological connectivity, hosting biodiversity and having significant impact on biomass and carbon stocks. TOF are fundamental elements of agroforestry systems, those where trees coexist with crops and/or livestock components. Trees supply goods and other environmental services, essential for people livelihood in many regions of the world. Several national forest inventories include TOF using a conventional sampling unit network-based survey. However, TOF-related characteristics are rarely considered (Schnell et al. 2015). Combining field surveys with remote sensing methodologies could improve the TOF estimates. Despite the increasing number of studies based on remote sensing for the identification and classification of TOF, guidelines for TOF inventory in agroforestry systems are still lacking. The identification and classification of TOF on a small area are easy to be accomplished. However, identifying, classifying and mapping TOF at regional or national level are complex, expensive and time-consuming tasks. Precise and fast techniques to estimate the agroforestry surfaces at both regional and national levels are needed. In fact, an accurate and objective estimate of the extent and geographical distribution of agroforestry systems in Europe is crucial for the development of supporting policies. Recently den Herder et al. (2017) mapped agroforestry areas in the EU using LUCAS data (Land Use/Cover Area frame Survey; Eurostat, 2015), estimating that about 3.6% of the territorial area is agroforestry managed, corresponding to 8.8% of the utilised agricultural area. Italy results the fourth country with the largest absolute extent of agroforestry, following Spain, Greece and France. Traditional tree-based agriculture systems, involving different multipurpose trees such as chestnuts (*Castanea* spp.), oaks (*Quercus* spp.), and olive (*Olea europaea*), are common in Italy as well in other Mediterranean countries. Such a long tradition in agroforestry is counteracted by processes of modernization in agriculture, which push toward the simplification and intensification of the agroecosystems. Given that the Italian rural development policies are planned at the regional level, more accurate estimates of the agroforestry areas are especially needed on the corresponding spatial scale.
To achieve such an ambitious goal, we first concentrated on identifying TOF in rural areas. Basing on our precedent results (Chiocchini et al. 2019), in this study, we compare the use of Synthetic Aperture Radar (SAR) and optical data, derived from the Sentinel mission dataset, for detecting, classifying and mapping TOF in Italian traditional agroforestry landscapes. We started to test the methodology in two Areas of Interest (AoI) located in Umbria region (central Italy) where oak trees hedgerows coexist with crops.
We tried to implement an automatic process, divided in three main tasks. In the first task, we processed the interferometric Sentinel-1 Wide-swath (IW) and the Sentinel-2 Multi Spectral Instrument (MSI) images. We calculated several optical indices (Standard-, Green-, Blue- and Pan-Normalized Difference Vegetation Indices and the Negative Luminance index) and polarimetric features for the detection of the vegetation cover. This allowed separating trees covered surfaces from surfaces without trees. In the second task, we classified TOF elements in three categories, basing on their geometrical properties: isolated trees, tree hedgerows and little groves or forest patches, distinguished from forests. Finally, in the

third task, we tested the accuracy of our TOF classification through a GPS survey of the vegetated areas and the visual photointerpretation of aerial imagery. Our results indicated that Sentinel-2 derived optical indices were more accurate than Sentinel-1 SAR data in detecting and mapping. Negative Luminance (NL) resulted the best performer optical index in identifying the tree pixels, with the best scores for Overall Accuracy (OA) respect to the other indices for both AoI. The automated classification of TOF, based on NL, showed an OA of about 90 % for both AoI, while the Producer Accuracy and the User Accuracy for individual classes resulted low, due to the moderate spatial resolution of Sentinel-2 images.

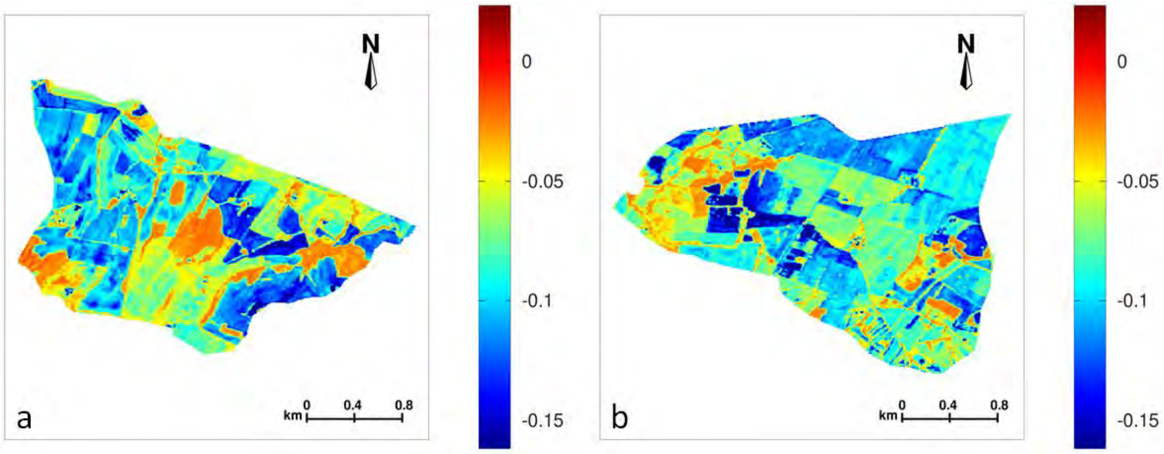

Figure 1. Negative Luminance (NL) values, based on Sentinel-2, for: a) AoI 1and b) AoI 2.

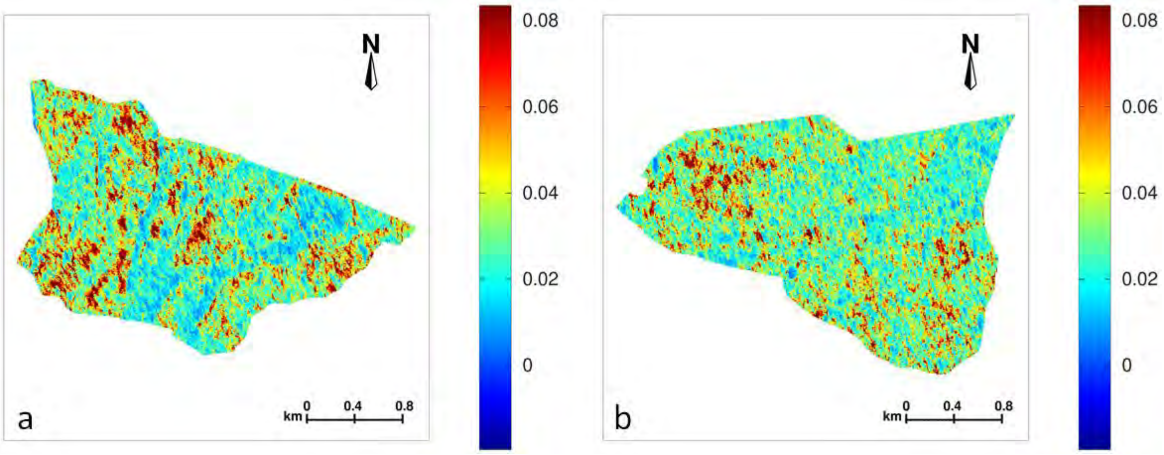

Figure 2. Eigenvalue difference (Δλ), derived from Sentinel-1, for: a) AoI 1 and b) AoI 2.

In conclusion, Sentinel-2 optical imagery, rather than Sentinel-1 radar ones, are suitable for a fairly accurate mapping and classification of TOF in agroforestry landscapes. The proposed method is promising in responding to the lack of information on the extent of Italian TOF on both regional and national scale, which can be crucial to respond to agri-environmental measures and for the correct planning of national rural development policies.

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Riparian habitat quality evaluation – development and implementation of a new methodological approach with potential use in agroforestry research

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Theme: Agroforestry, biodiversity, and wildlife management

Keywords: riparian habitat, RHQI, agroforestry systems

Abstract

Riparian habitats, which are part of agroforestry systems represent an important ecosystem providing a range of functions and services important to humans – e.g. biodiversity support, reduction of erosion risk or transport of pollutants from the surrounding landscape to watercourses. At the same time, it is unfortunately an environment that has been very often subjected to significant pressure during the agricultural cultivation of the landscape or the development of industrial and residential activities of human society. Thus, a large number of riparian ecosystems has disappeared or has been degraded. The assessment of the overall ecological status of riparian habitats thus constitutes an important source of information for the needs of watercourse management and landscape planning in the riparian landscape. The aim of such an assessment should be to maintain good status or to improve the current unsatisfactory state of these habitats. In Slovakia and the Czech Republic, there is not yet a comprehensive assessment procedure that would take into account not only the important partial variables affecting the current state (e.g. morphological state of watercourses or prevailing categories of land-use in the surrounding), but also the potential reference state. For this reason, a methodology for evaluation of the ecological status of riparian habitats – "Riparian Habitat Quality Index" (RHQI) is currently being developed. The RHQI mapping of riparian habitats takes place in two phases. The first phase is based on the actual field survey of the selected watercourse together with its riparian zones and completion of the appropriate form. The second phase is the processing of the obtained field data and their evaluation. A specialized tool (software) is being developed to facilitate data processing (including automated acquisition of distance data freely provided by the competent authorities) and to evaluate the potential reference state of riparian zone.
The RHQI methodology was applied experimentally to a selected area of interest – the basin of the Všemínka stream in the Zlín Region. During the field mapping, homogeneous segments of the stream were defined in terms of the prevalent vegetation of the riparian zone as well as the morphological state of the riverbed. It was found that the area was very diverse, with a very often changing state of these properties. Significant spatial variability was observed especially within urbanized areas, where the character of the riverbed and the riparian zone were changed in tens of meters. On the other hand, segments more than one kilometer long were defined in the agricultural landscape in the central part of the river basin. As expected, it was shown that the stream segments occurring in the built-up area were characterized by the most degraded state of the riparian zone. However, in the industrial areas, the resulting values was not degraded too much in the area of interest. During the field research was revealed that there is very often a problem concerning the exact determination (delineation) of the riparian zone boundary – especially in case of anthropogenically modified landscape. The riparian zone mostly

includes sloping areas, whose vegetation cover usually extends beyond the edge of the riverbed itself and their extent is influenced by the nature of the use of the surrounding landscape.

Figure 1. Riparian vegetation lining small stream in typical Czech agricultural landscape

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Agro-Forestry and microclimate in the Pamir

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: Poplar, green infra-structures, micro-climate, dry ecosystems

Abstract

It is well established that the effect of climate extremes and climate change is stronger in mountain and arid/semi-arid areas, thus affecting populations already suffering from several economic disadvantages. Enforcing adaptation and development strategies in these areas thereof would safeguard livelihood of rural communities, reduce displacement of climate refuges and preserve unique traditional knowledge that could offer alternative adaptation schemes to adverse climate conditions. The Pamir area of Central Asia is a clear example of this problem: villages are located at elevations usually above 2000 and up to 3500 m. The climate is extremely dry and populations in villages rely almost entirely on water from melting glaciers which is brought through a complex network of channels. Villages can therefore be seen as oases where overlap of irrigated agricultural crops and trees leads to changes in the surface energy budget, creating a micro-climate which buffers climatic extremes and in general ameliorates the climatic conditions for both humans and crops (Figure 1).

Figure 1. View of the Savnob village, in the heart of the Pamir mountains.

Green infrastructures or ecosystem-based adaption options, in the shape of Agro-Forestry, are often seen as a key element in adaptation strategies to climate change, and in particular oases are characterized by a strong contrast and sharp gradients with the surrounding area offering an optimal and simplified system to study the combined effect of vegetation and trees to induce micro-climate niches within otherwise harsher climate conditions. In the framework of the ECCAP project (Ecological Calendar and Climate Adaptation in the Pamir), a number of meteorological sensors have been placed to follow the climatic gradient between 2500 m up to 3200 m. Within this project additional sensors have been placed in a gradient from the center to the outer skirts of few villages, where vegetation and tree distribution shows an articulated but sensible climate variation (Figure 2).

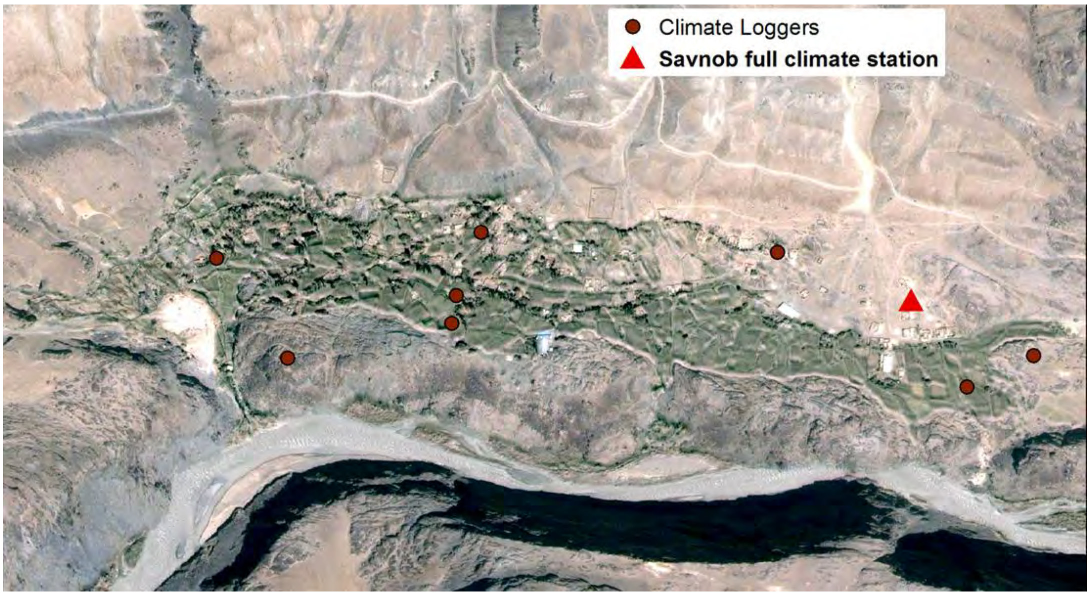

Figure 2. Location of climate loggers and full climate station within and around Savnob.

Such sensors are used to study the effect of vegetation and irrigation distribution in modulating the macroclimate into specific micro-climates, and thus allow to deepen our understanding of how green

infrastructures, and agro-forestry, can be used to contrast climatic extremes (e.g. reduce yields losses due to frost events). Furthermore, remote sensing images at both high and medium resolution are used to define spatial distribution of agricultural fields and tree inclusion over the landscape at village level, and monitor seasonal phenological of main crops. Field observations of crop phenology in the villages are also currently acquired through field campaigns in the ECCAP project, and functionally linked within the specific influence of climate, agronomic practices and green infrastructures.

Although of direct interest to ameliorate adaptation capacity to climate change in Pamir villages, results of such monitoring activities in the project may also be useful to better understand climate profiles over agro/forestry landscapes allowing to engineer other green infrastructures and to optimize the distribution of irrigated crops and trees. Furthermore, such understanding may help scaling down macroclimate from Global and Regional climate models to be more representative of microclimate conditions on the ground, which helps the fine tuning and validation of crop modelling with ground measurements at field level.

Agroforestry in European peri-urban areas, new landscapes for a territorial transition

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and the landscape

Keywords: Peri-urban, planning, territorial transition, landscape

Agroforestry in European peri-urban areas, new landscapes for a territorial transition

Urban areas in most of Europe have sprawled and expanded on agricultural lands for the past 50 years (Agreste and Teruti Lucas 2015 for France). This sprawling had rapidly led the public authorities to regulate using planning documentations including zoning plans, conceived as soil protection policies.

In the same time this zoning led to an opposition and a landscapes specialization according to their intended uses. Peri-urban areas developed in logistics, artisanal and commercial zones thanks to transports and traffic connections, creating urban fringes sprawling on agricultural land, a complex peri-urban grid, a stretched urban fabric of the « Zwischenstadt » (in-between city) (Sieverts, 97). The high mechanical optimization and deep changes in agricultural practices also led to changes in rural landscapes, a grid of specialized and more productive lands where trees rapidly disappeared (Dupraz, 2008).
This situation in Europe locally generated the implementation of agricultural protection zoning, managed regionally by the CAP since 2007 with Rural Development Programs (RDP), 118 Approved RDP in 2019 (European Commission, 2019).
Urban and rural areas have their zoning and planning which defend their own territory leading to the ideal application of a territorial separation between nature and society (Lowe & Murdoch, 2003).
Environmental concerns appear in the CAP documents since 1992, with an indication about planting trees and hedges. Following Latour (1997), greening consciences and territorial actions slowly dissolved the modern opposition between town and country. This greening awareness has led to understand that urban and rural areas need a complexification of landscapes and a territorial 'despecialization' specially in peri-urban areas.

Agroforestry questions agricultural production, forestry and wood industry but also all the local territorial ecosystem. When mentioning rural, urban or peri-urban areas, the planting of trees deeply modifies landscapes and ecosystems. Agroforestry in peri-urban areas involves an economical, sociological and landscape approach of the territory. It also mobilizes different local actors like stakeholders, farmers, foresters, wood industry actors, land planners and public authorities.
Agroforestry necessarily questions a local culture, in terms of sectors, land and ecological expertise, local knowledge.
This field transversality needs a field governance which involves a management by the local economic actors rather than the public authorities, which also means involving farmers in territorial planning operations (Piraux & al., 2010).
Farmers are thinking about rationality, yields and profitability, naturalist societies are thinking protection, natural assets and their biological diversity, planners and public authorities are thinking territorial development. Agroforestry integrated in a terroriality system drive to a despecialisation of activities and

a necessary collaborative work between field actors, pursuing a common goal of a territorial transition and a territorial efficiency.
This territorial transition falls into the 'agroecological transition trajectory' theory as analysed by Petersen & Silveira (2007) and detailed in three stages:
1 – Alternative technologies learning 2 – Diffusion of experimentation 3 – Changing scale of strategy.
Applied to European urban areas scale, this theory could be compared to the establishment of Agricultural Parks, created to limit urban sprawl and soil consumption in peri-urban contexts (Branduini & Scazzosi, 2011). Those local actions with horizontal work and sharing between farmers have led to the development of a European metropolis network, sharing a program of agricultural peri-urban regions protection in order to limit urban pressure known as Peri-Urban Regions Platform Europe (PURPLE), created in 2004.
Territorial transition needs structural instruments and institutional framework different from the existing ones concerning regulation and control, materialized today by the creation of transversal and local initiatives. Agroforestry offers a hybrid solution for a transversality of actors and sustainable resources but can it also be a hybrid solution of planning, a new way of shaping the territory, in an innovative and reasonable way? This new agricultural process which combines abilities and landscapes frameworks should offer local solutions before developing itself as a territorial transition system.

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2

Agroforestry and policy for sustainable development

2.1

Agroforestry, quality food products and certification

Certification of agroforestry systems and products according to the PEFC

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Session B-1 Agroforestry, quality food products & certification

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Theme: Agroforestry, quality food products & certification

Keywords: certification, sustainability, products, market

The Programme for the Endorsement of Forest Certification (PEFC) is an international, non-profit, non-governmental organization dedicated to promoting Sustainable Forest Management (SFM) through independent third-party certification. PEFC works throughout the entire forest supply chain to promote good practice in the forest and to ensure that timber and non-timber forest products are produced with respect for the highest ecological, social and ethical standards. Thanks to its eco-label, customers and consumers are able to identify products from sustainably managed forests. In 2018 the general assembly of PEFC International agreed that expanding PEFC's scope from trees within forests, to include Trees outside Forests (ToF), was an important consideration for advancing sustainable landscapes and rural livelihoods. The term ToF refers to all trees that are grown outside the nationally "designated forestland"; and includes both intensive and extensive, agriculture or settlement production systems, e.g. agroforestry systems and urban forest areas.

Sustainable management criteria and guidelines for ToF are necessary to achieve certification, since this land use is growing in importance. The management guidelines are administered in a similar way to forestry. These form the basis of certification of products from sustainably managed agroforestry systems. Agroforestry certification will bring this productive system to the attention of consumers, while emphasising its importance for the sustainable production of food, timber, fuel and environmental services. ToF certification standards at a national level can be developed and later endorsed by PEFC International. Examples of existing national certification standards and agroforestry certified products are presented.

FireFlocks: Managing wildfire risk by adding value to flocks' products

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Theme: Agroforestry, quality food products & certification

Keywords: wildfire risk management, added value product, Silvopastoralism, landscape conservation, Mediterranean basin

Abstract.

The Mediterranean basin is characterized by unmanaged forests. Rural abandonment and the reduction of traditional grazing has allowed a proliferation of shrubby and bushy species in abandoned agricultural lands. Moreover, the landscape has suffered a process of homogenisation, creating thousands of hectares of highly fire-prone forests. These forests are increasingly vulnerable to wildfires due to climate change and the absence of management. As a result, although only a small number of wildfires escape control, these fires affect large areas each year. These large forest fires represent a growing risk for society, as they overwhelm the firefighting services: despite the high budgets and investments allocated to fire-control. However, management treatments such as thinning, prescribed burning or grazing can be used as tools to reduce the fuel-load and fire risk and severity in a much more efficient way. The aim of these treatments is generally to reduce the fuel-load so that, when a wildfire occurs, it spreads more slowly and with less intensity. Successful management practices also increase resilience against wildfires. Fuel management treatments should consider one or more of the following four basic principles: reducing surface fuel, increasing the distance between surface and the live crown, decreasing crown density and keeping large trees of fire-resistant species.

Silvopastoralism is a useful tool for sustainable management of Mediterranean forests from a biological, social and economic perspective. It is a common practice, with high benefits for society (i.e. landscape conservation, preservation of ecosystem services, fire risk management, and the production of high-quality products). However, the presence of shepherds and their livestock has reduced, and is almost nonexistent in certain areas: leading to an increase in fuel-loads in forests, and the expansion of fire-prone forests. The need to reinsert livestock in Mediterranean ecosystems, to motivate rural economies and to innovatively target wildfire risk management led to the creation of the Fireflocks initiative. It was under this framework in 2016 when FireFlocks project was created and first implemented in three pilot sites of the Girona region (north-east Spain) using the original name of 'Ramats de Foc'.

The overarching objective of the project is to create fire resilient landscapes through innovative support for extensive livestock farming. The specific objectives are to graze the understory of forests and shrublands, as a means of reducing fuel-load, and to create open spaces between forested areas. These open-spaces are grazed and are identified by the fire services as key to managing wildfires. By acting within these open-spaces, firefighters are able to operate safely while tackling the fires in nearby areas. The project also aims to promote the bioeconomy in rural areas: raising the esteem of shepherding as a profession, and increasing the value of the livestock, and of livestock products. For this reason, the project has developed a certification scheme for products produced from the "fire-flocks". The strategy is accompanied with a communication campaign (e.g. website, promotional video and cards), to motivate the citizens to consume products from "fire-flocks", while building knowledge of the advantage of shepherding for fire-control.

Under the coordination of Pau Costa Foundation, the FireFlocks project brings together all public and private agents interested in the continuity of silvopastoralism. It seeks to align their various needs, and develops a chain of production and consumption from herds to the consumer, with the added value of reducing the fire risk. Wildfire management services identify woodlands that are strategic in fire propagation dynamics, the so called 'Strategic Management Points (SMP)' that are areas that, if properly managed, appease fire behaviour (flame length and spread rate). They also describe what fuel reduction and structure results are to be attained through pastoralism. Extensive livestock farms graze the strategic areas with their animals (sheep, goats and/or cows), following a previously agreed grazing plan. Butchers and restaurants sell meat and dairy products from flocks under the 'Ramats de Foc' label and explain to final consumers the added value behind them. End customers become part of the fight against wildfires through the regular consumption of 'Ramats de Foc' products and support the continuity of extensive livestock farming in our forests by facilitating the economic viability of livestock exploitations. Foresters contribute to the value chain by visiting the strategic areas in order to assure that fuel reduction is achieved according to the grazing plan. To do that, a certification factsheet to assess the status and structure of vegetation was created specifically for the project.

The project is currently consolidated in the Girona region (Figure 1) and expanding to other regions that find in FireFlocks an opportunity to reactivate rural economy as well as reducing fire risk. The current vs. initial status of FireFlocks network is summarized in Table 1. This increase in participants and hectares managed is favourable for the project, accepted by the territory and a positive symptom of the incentive for the rural economy. The assessment of the economic impact has been done for some shepherds(data collected between January and June in 2017 and 2018). The overall result is positive, indicating an increase of 12% in sales of meat from butchers, and an increase of 40% in the restaurants. However, these numbers still need to be analysed for the recent incorporations of the project in order to obtain significative results. With FireFlocks, shepherds release their livestock in forests with predefined understory vegetation control targets. The commercialisation and valorisation strategy in key to reinforce the sellings..

In 2020, around 30 new shepherds from Girona have expressed interest in participating in the FireFlocks project. The inclusion of new shepherds is subject to review specific conditions that all must meet: (a) capacity to graze in strategic areas for fire management, (b) define the grazing plan, and (c) list the butchers and restaurants where the products can be sold with FireFlocks labels. Shepherds have expressed three main motivations to join Fire Flocks: (a) access to land, (b) added commercialisation value, and (c) recognition of its work in relation to silvopastoralism and the management of the risk of fires. Together with the Artisan Butchers Guild of Girona counties, FireFlocks is describing the regulations for the FireFlocks label use.

[1]

[2]	2017	2020
Nº of shepherds	3	18
Nº of SMP	4	30
Hectares managed	48	530
Nº of restaurants and butchers selling FireFlocks label	4	25

[1] Figure 1: Map of the current status (2020) of FireFlocks project in Girona region.
[2] Table 1: Initial and current status of FireFlocks project.

The potential of geographical indications for labelling in Mediterranean agroforestry systems

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Agroforestry for the transition towards sustainability and bioeconomy

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Theme Agroforestry, quality food products and certification

Keywords Certification, Sustainable Development Goals (SDGs), Delphi Study, Umbrella Indicators, Multifunctional Agriculture, Landscape Management

Abstract

In the face of unsustainable land-use changes including intensified production and abandonment, agroforestry systems have the potential to support a diversity of social and ecological functions in agricultural landscapes. Mediterranean agroforestry landscapes have been conserved through traditional practices mostly embedded in small scale, family businesses. Production labels bear the opportunity to indicate sustainable management along the supply chain and at the same time generate higher incomes for sustainably producing farms. We used an expert-based Delphi survey with three rounds of questions to analyse i) the relevance of different sustainability aspects in agroforestry systems, ii) the suitability of derived indicators for labelling, and iii) the specific potentials and barriers for labelling in Mediterranean agroforestry production systems. The Delphi technique helped us to identify common opinions by using the multi-round approach, we were able to feed intermediate results back into the survey in an anonymized way.

The results showed that 12 of 17 sustainability aspects – each linked to one of the UN Sustainable Development Goals (SDGs) – are considered relevant for agroforestry systems: representing social-ecological and economic interests in a balanced way. Further, from analysing the sustainability indicators, we derived a recommendation of 4 umbrella indicators: salaries of farmworkers, no chemical fertilisers and pesticides, use of cultural traditions for marketing and areas set aside for conservation. Those four indicators seem to cover a broad range of the relevant sustainability aspects and are feasible to apply as well as easy to communicate within agroforestry (see *Table 1*).

Finally, the experts' assessment of the labelling schemes revealed a surprisingly high valuation of geographical indication (GI) labels with regard to agroforestry systems. Even better than eco-labels and social labels, GIs were suggested as the most suitable options for the agroforestry context. For four different issues (easiness to introduce a guarantee of the standard, potential trade-offs or conflicts, producers' identification with and consumers' understanding of the label) GIs received the best rating (see figure 1). Experts highlighted the potential of GIs with one of them demanding a geographical agroforestry label that is built on the established framework of GIs and incorporates agroforestry practices. Three more respondents suggested using GIs or *terroir* characteristics for labelling in agroforestry systems. In our study, GIs were suggested for their unique potential to support cultural heritage and for offering access to alternative financing options. Despite not being developed for sustainability reasons in the first place, GIs guarantee traditional production standards and protect local specialities within a limited area. Thus, GIs can create an inherent interest in the producing community to use the resources (which are limited by definition) in sustainable ways. The term '*terroir*' is used to refer to product characteristics linked to a specific geographic area and landscape management and previous studies from the tropical context have already shown that GIs can transmit values of sustainable landscape management to consumers and protect intellectual properties regarding place-based traditional processing techniques.

Table 1 Ratings of sustainability indicators for agroforestry systems based on the SDGs.

SDG	Sustainability aspect for AFS	Aspects' suitability for product labelling	Aspects' suitability for landscape labelling	Sustainability indicator for AFS	Indicators rated for applicability	Indicators rated for comprehensibility	Classification of indicators' suitability
1 NO POVERTY	Income & social coherence from agroforestry	4	9	Salaries paid to farmworkers	4.00	4.11	Applicable and understandable
3 GOOD HEALTH AND WELL-BEING	Improved quality of rural living conditions	5	4	Paid vacation days	3.18	3.65	Understandable but problematic applicability
4 QUALITY EDUCATION	Education & knowledge on sustainable agroforestry	9	6	Training-days on sustainability practices	3.67	2.88	Applicable but problematic understanding
6 CLEAN WATER AND SANITATION	Sustainable pest & fertilizer management	6	12	No chemical fertilizers and pesticides	4.18	4.56	Applicable and understandable
8 DECENT WORK AND ECONOMIC GROWTH	Diversification & innovation for competitive agroforestry farms	2	5	Revenues from direct sales	3.06	3.00	Critical applicability
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Cultural heritage & social networks	12	11	Use of cultural landscape characteristics for marketing	3.50	3.50	Applicable and understandable
10 REDUCED INEQUALITIES	Access to financing options	10	9	Final revenues for producer	3.25	3.41	Understandable but problematic applicability
10 REDUCED INEQUALITIES				Revenues, compensating for ES provision	3.56	3.00	Applicable but problematic understanding
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Efficient use of natural resources	1	1	Availability of environmental management plan	4.22	3.35	Applicable but problematic understanding
13 CLIMATE ACTION	Climate-smart agriculture	3	3	Number of trees per area	3.35	3.83	Understandable but problematic applicability
13 CLIMATE ACTION				Renewable energy consumption	3.18	3.56	Understandable but problematic applicability
15 LIFE ON LAND	Structural and functional biodiversity	7	2	Area set aside for natural vegetation	4.00	3.56	Applicable and understandable
15 LIFE ON LAND				Registered bird species	2.81	3.56	Critical applicability
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Support for sustainable production infrastructure	11	7	Involvement in landscape planning processes	3.50	2.72	Critical understanding
17 PARTNERSHIPS FOR THE GOALS	Community participation & stakeholder empowerment	8	8	Access to knowledge networks	3.83	2.78	Critical understanding

Initial and ongoing costs were stated to be the major reason for not joining labelling schemes and the missing consumer awareness for agroforestry was claimed to be the main obstacle for the creation of an agroforestry-specific label. At this point, the geographical indications framework of the European Union could offer a well-known and proven labelling system in which costs are distributed among a producing community and the labels are known already. We also assessed the possibility of an agroforestry-specific label, what barriers could occur and why elements of geographical indication labels may fit well for this purpose.

We suggest that a future agroforestry label should at least partly include elements of distinct regional and geographical characteristics, such as *terroir*, traditional management practices, traditional processing and place-based social-cultural values. The potential to make use of those geographical characteristics in relation to AFS is currently underestimated or at least not systematically used. Figure 1: Assessment of four labelling options according to four questions. The original questions have been: i) How easy are they to introduce and to guarantee standards along the value chain?, ii) How many trade-offs or stakeholder conflicts you would expect?, iii) How well producers could identify with them?, and iv) How well can consumers understand the meaning of these labels?

Understanding the resilience of agroforestry systems in a changing biosphere: a review of stable isotopes in ecophysiological studies

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Theme: Agroforestry and policy for sustainable development: Agroforestry, quality food products and certification

Keywords: climate, drought, desertification, biodiversity, water-use efficiency, isoscapes

Abstract

In 2006 the consensus was "no doubt about it, the world is warming" (Kerr 2006). Ten years later the discussion is about the degree of heating (Guiot and Cramer 2016), with the goal of recent UNFCCC conferences being to limit the increase to 1.5°C, in order to avoid irreversible ecosystem changes. The 1.5°C limit, unfortunately, appears at present a poorly defensible boundary and requires urgent mitigation and adaptation actions. These should be locally tuned and globally adopted. Rural and forest ecosystems require specific management strategies in order to counterbalance the detrimental effects of climate changes. Worldwide, agroforestry raises expectations of a multifunctional and resilient agriculture, with positive outputs in terms of ecosystem services. Enhanced environmental risks urgently need greater knowledge on the effectiveness of mitigation and adaptation measures.

Stable isotopes are powerful tools to investigate biological performance: giving insights on cell metabolism, plant organs and whole plant functions, biocenosis and bioregion dynamics. Furthermore, advances in analytical techniques using stable isotopes are enlarging our biological comprehension of spatial and temporal implications related to ecosystem services.

Plants and their biocenosis have two ways to cope with environmental changes: to adapt or to move. Innovative agroforestry systems must take this concept into account. In order to adapt, variability in adaptive traits is fundamental for plant populations as well as for managed systems. Physiological and genetic knowledge on the adaptability of forest species is urgently needed in order to properly manage the forests in changing climates. Many forest species are able to colonise regions with contrasting environmental conditions, suggesting that there is a large genetic variation in quantitative traits of adaptive relevance. These adaptive traits include: plant architecture, stem form, phenology, physiological resistance to and/or avoidance of biotic and abiotic stresses, growth potential.

Studies on plant adaptive traits are supported by phenotypic plasticity observations from networks of gardens, containing contrasting provenances. Stable isotope physiological assays support the investigation of adaptive mechanisms, and provide the basis for selection of genetic material. Stable isotopes assays provide information on resistance to environmental stresses and resource use efficiency. This information is primarily needed to plan resilient silviculture and agroforestry systems in view of both present and future scenarios. The capability to uptake water and nutrients and to make an efficient use of these resources is a prominent feature of agroforestry systems adapted to constrained, resource

limited scenarios. Consequently, the main target for research concerns the evaluation of productive associations among trees, shrubs and herbaceous crops in relation to their adaptation to environmental constraints and efficiency for water and nutrients use.

During recent decades, studies have allowed the quantification of the impact of stress on plants, in terms of gas exchange, efficiency of light utilization and capability to use water resources: concluding that an environmental water limitation has relevant effects on plant carbon assimilation. Water limitation affects, firstly, stomatal conductance but might also affect photosynthetic biochemistry. An important plant performance indicator, water-use efficiency (WUE; the amount of carbon assimilated by a plant per unit of water transpired) is largely controlled by both genetic and environmental factors, being highly responsive to water availability variations. During the autotrophic CO_2 assimilation by C3 plants, an isotope fractionation occurs against the heavy stable isotope ^{13}C. As a consequence, plant organic material has a lower $^{13}C/^{12}C$ ratio than that of atmospheric CO_2. This deviation is termed carbon isotope discrimination ($\Delta^{13}C$). It is well known (Farquhar et al., 1989) that a positive relationship exists between $\Delta^{13}C$ and the ratio of intercellular to atmospheric CO_2 concentration (Ci/Ca). On the contrary, $\Delta^{13}C$ is negatively related to WUE. In this way $\Delta^{13}C$ is an important proxy to study WUE variations in C3 plants on different time scales: minutes ($\Delta^{13}C$ "on-line" with leaf gas exchanges), days ($\Delta^{13}C$ on leaf soluble sugars), seasons or whole life- span ($\Delta^{13}C$ on whole plant biomass or tree rings).

In recent decades, stable isotopes have contributed to our knowledge of stress physiology, especially concerning drought and salinity acclimation and adaptation responses. Stable isotope applications are progressively becoming more reliable and accessible, owing to significant technological progress in the field of isotope ratio mass spectrometry (IRMS). Especially, the viability of applying stable isotope techniques in natural environments enlarged the perspectives to the ecophysiological dimension. Biologically relevant elements (H, C, N, O and S) are increasingly involved in stable isotope studies, encompassing both controlled and real environments. Stable isotope applications are providing knowledge on fundamental questions: plant adaptedness and resilience related to global change disturbance; ecosystem carbon balance and dissection of autotrophic and respiratory carbon fluxes; hydrology, water resources and plant water use; soil-plant nitrogen dynamics and relationships with soil microbiology, plant nutrition and carbon cycling. Spatial and temporal implications of stable isotope fractionations (Rascher et al 2012; Chiocchini et al. 2016) are increasingly investigated, providing insights in dendrophysiology, geographical origin of biological materials, climatology and climate change large- scale effects.

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Explore the economic opportunities and health benefits of the specialty crops in the agroforestry system

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: *Agroforestry, quality food products & certification*

Keywords: *value added products*

Abstract

Black walnuts (*Juglans nigra*), American elderberry (*Sambucus canadensis*) and pawpaw (*Asimina triloba*) are among rapidly emerging new perennial non-timber forest products for the agroforestry systems in the US. Missouri has been one of the leading producers of these specialty crops. The aim of this presentation is to explore the novel uses of these specialty crops and their byproducts, by systematically examining their health-promoting compounds. The specific objectives of the study include: 1) conduct scientific research in characterizing the health-promoting compounds in these specialty crops and their byproducts (juices, stem barks, leaves, fruits, and root extracts) through modern mass spectrometry, global metabolomic analysis and high-throughput screening bioassay protocol, 2) conduct a market research to identify potential uses of the identified health-promoting compounds from elderberry and byproducts for cosmetic, personal care products and pharmaceutical industries; and 3) examine the niche market of the identified value-added products.

For the chemical profiling of the bioactive molecules, the phytochemicals were extracted and analyzed by a Waters ultra-performance liquid chromatography (UHPLC) coupled to a Bruker maXis impact quadrupole-time-of-flight high resolution mass spectrometer (UHPLC-QTOF-HRMS). The ion chromatograms generated were submitted to XCMS platform operated by the Center for Metabolomics at the Scripps Research Institute. The XCMS Online was used to perform peak detection, peak grouping, spectra extraction, and novel non-linear retention time correction/alignment. The spectra will be annotated and the metabolites will be identified with the integration of the METLIN, the world's largest metabolite database. Multivariate analysis and principal component analysis (PCA) and orthogonal partial least squares discriminant analysis (OPLS-DA) were performed by XCMS to compare the differences in metabolic profiles between different cultivars. The upregulated and downregulated production of the metabolites between the treatments were acquired by ANOVA (fold change<2, P<0.05) and identified with the online database METLIN and an in-house database.

We examined the effectiveness of these compounds on activation of the Nrf2-antioxidant response element signaling pathway in HepG2 hepatoma cells, a defense mechanism against oxidative or electrophilic stress. The antioxidant capacity of the phenolic compounds was evaluated using total antioxidant capacity (TAC) colorimetric assay kit. We have examined the effects of the black walnut extracts on the expression of 6 human inflammatory cytokines/chemokines in the human pro-monocytic

cell line U-937 using a bead-based, flow cytometric multiplex assay. The methanolic extracts of these cultivars were added at four concentrations (0.1, 0.3, 1, and 10 mg/mL) either before and after the addition of lipopolysaccharide (LPS) to human U-937 cells to examine their effect on cytokine production.

Our findings suggested that among 22 black walnut cultivars examined, Mystery and Surprise exhibited the strongest antioxidant and antibacterial activities, whereas. Sparrow and Surprise represent promising preventive agents for inflammatory diseases. Our results demonstrated a wealth of health-promoting bioactive compounds (e.g., polyphenols) present in black walnut kernels. Glansreginin A is the major antibacterial compound in black walnuts, and this is the first report for the antibacterial activity of glansreginin A. We have identified more than 173 bioactive phenolics from black walnuts, American elderberry and pawpaw) which have been previously reported as bioactive agents that are important to human health. The anti-microbial, antioxidant, and anti-tumor properties of each compound have been examined using high throughput screening assays. The anti-inflammatory properties of the extracts have been assessed in the human pro-monocytic cell line by evaluating the effects of the extracts on the expression of 13 human inflammatory cytokines/chemokines. A market guide has been compiled to provide information on health-promoting compounds from the plant materials and their potential uses in producing value-added products in the industries.

The findings will increase the overall incomes of the chain production and benefit all the participants involved in the supply chain of specialty crops in agroforestry operations.

Spatial-temporal models and authenticity maps to reinforce commercial value of Mediterranean high-value products: displaying the REALMed approach

EURAF 2021 Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Agroforestry, quality food products & certification

Keywords: authenticity, Mediterranean high-value products, isoscapes, intrinsic value

Abstract

Concepts such as food traceability and authenticity should be priorities in the area of food quality. Even if they are not innovative concepts, their importance is increasing because of greater consumer sensitivity to the food origins and production practices. That is even more important for many Mediterranean high-value products, that have in common their provenance from semi-arid environments. REALMed is an international project which focuses on Mediterranean traditional products, seeking to give them added value by authenticating their origins. Its aims are: a) to provide reliable tools for product authentication and quality assessment; b) to make these tools easily available to stakeholders and consumers; and c) to promote the traditional and sustainable development of local economies. These aims are common to other projects, but REALMed offers a unique transdisciplinary approach. REALMed products under evaluation are: the Iberian Pig (Portugal and Spain), Argan Oil (Morocco), Truffles (Italy and Slovenia) and Mountain Lamb and Kid (Tunisia).

REALMed's focus on traditional high value products emphasizes the importance of social and organizational investments on the rural potential of a region, by enhancing its economic development. With respect to local products, we need to mobilize environmental resources that create a strong link between the region, the product and the actors in the region. Indeed, over time, local economies may differentiate their regions by the unique or multiple uses of the region's agro-ecological and social resources. These local products commonly have deep historical and cultural roots that are the foundation

of what are called authentic products. In some cases, these products also result in socio- political actions that could lead to the creation of denomination of origin. Distinctiveness is recognition. Products gain wide recognition based on intrinsic and extrinsic features. Identifying the origin of a product commonly involves two objectives: 1) specifying the relationship between the characteristics of a particular environment and the associated product, and 2) involving a sufficiently large number of actors into the development of the quantitative and qualitative aspects of territorial/rural development. Methodological approaches will include stable isotope ratio analysis (C, O, H, N) combined with elemental profiling and DNA characterization. Data will be expressed by isoscapes: spatial predictions of elemental isotope ratios (δ), that are produced through the application of process-level models of elemental isotope fractionation or distribution in a Geographic Information System (GIS). Isoscapes will be a sound background for traceability analyses and future comparison. Know-how transfer will be accomplished by directly involving stakeholders and the market: starting from value chain description of the four products and concluding by policy recommendations. Technical issues will be related to socioeconomic effects, to add value to territorial products with Protected Designation of Origin (PDO) and Protected Geographical Indications (PGI).

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1. Map of the Mediterranean area with the traditional products. Map by O H 237, file licensed under the Creative Commons Attribution-Share Alike 4.0 International

Effects of shading orientation on soybean isoflavone concentration to predict the influence of trees in agroforestry systems

EURAF 2020 Agroforestry, ecosystem services, landscape and rural developmentAbstract

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Theme: Agroforestry, quality food products and certification

Keywords: soybean, isoflavones, shading, light composition

Abstract

Introduction Soybean cultivation in Italy has developed since the 80s mainly for animal feeding, thanks to its high protein content, and for human uses mainly for oil production.

Agroforestry practices are becoming increasingly important as a means to improve carbon sequestration and mitigate climate change. Soybean is a crop that could fit well with this new agricultural approach, especially because it is a nitrogen fixing species. Soybean is also increasingly used for nutraceutical production. Isoflavones are the most important nutraceutical compounds, and are used for their antioxidant activity and anticholesterolemic effect.

Materials and methods The experimental trials were carried out in 2019 at the experimental farm of the University of Padova (Legnaro, Padova, I). Total seed isoflavone concentration (TIC) and the isoflavone profile was evaluated in the variety "Sarema" (Semfor, Casaleone – Verona, I), which is largely cultivated in NE Italy. The aim of the work was to study the effects of differently-orientated artificial shading on TIC in soybean in order to predict the effects of shading due to tree lines within an agroforestry system.

Soybean plants were cultivated under four 4-m^2 shaded areas within cube structures (isolators), two of which had only one open side (with light entering) facing to East, and two facing to West. The shading level of the net covering the isolators was 50% of photosynthetic active radiation (PAR). An external control under full sun conditions was evaluated near the shaded plants. Three independent sampling areas were considered in each isolator and in the control area (n = 6). Sowing density was 30 plants m^{-2}. At harvest the TIC was measured by HPLC (Hubert et al., 2005).

The East-West shading orientation was chosen based on the documented greater morphological modifications induced on soybean plants compared to North-South directions (Kasperbauer et al., 1987).

Results TIC of East-lit plants (i.e., lighting from East) was 25% higher than in the unshaded controls (NSC), and 27% higher than West-lit plants (i.e., lighting from West)(P<0.05)(Figure 1). This effect may be related to the different light quality of East- or West-lighted soybean plants. In fact, light with the main direction East, from 07.00-12.00 a.m., is expected to be more depleted in its far red (FR) component, This being preferentially filtered by the abundance of both morning mist and low cloud cover (+ 30% low cloud cover in the time 7.00-12.00 a.m. vs. 14.00-19.00 p.m.) (from Meteo Blue, CH).

It is known that light with a relatively high R (red) / FR (far red) ratio (i.e., light from the East, at morning) stimulates the transition from inactive phytochrome "pr" to the active form "pfr" by isomerization of the phytochromobilin. This isomerization causes a morphological modification of the phytochrome Holo-proteins, thus exposing their nuclear localization sequences (NLSs) by which they can be transported to

the cell nucleus and be activated by dephosphorylation (Lorrain et al., 2008). Phytochrome "pfr" prevents the expression of genes for cell expansion by marking the PIF proteins with ubiquitin (Xu et al., 2017).

This effect could lead the plants exposed to light from the East to produce less biomass, as was observed (-22% vs. West-exposed, P<0.05) and lower yield. It is also known that the activity of the PAL enzyme (Phenylalanine ammonium-lyase), one of the main enzymes of the metabolic pathway of flavonoids and isoflavones, is proportional to the concentration of the "pfr" form of phytochrome and this would explain the greater isoflavone concentrations observed in East-lighted plants (Brodenfeldt 1988).

Conclusions The East or West orientation of shading affects the metabolic activity of soybean plants. A principal exposure to light from the East (e.g., soybean at the East side of a possible tree row) can stimulate greater activity of the isoflavone pathway at the expense of growth and yield. The choice of the shading orientation in agroforestry systems could be relevant to maximise yield or nutraceutical compounds.

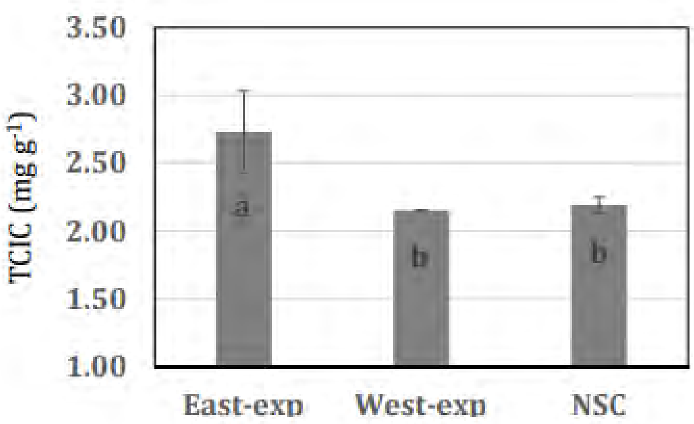

Figure 1. Total Isoflavone Concentration (TIC) in soybean variety Sarema cultivated under prevalently light exposure to East (East-exp) and West (West-exp), compared to not shading controls (NSC, full sun) (Tukey-Kramer test, P<0.05).

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Effect of season, altitude and ripening period on fatty acid profiles of sheep cheese

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Theme: Agroforestry, quality food products certification

Keywords: fatty acids, sheep cheese, altitude, ripening

Abstract

The Sardinian dairy sheep industry is mainly based on milk production in farms where flocks are largely fed on pasture. A considerable part of grazing is located in an agroforestry landscape called Meriagos (Pilla e Pulina, 2014). These silvopastoral systems characterize the pastures of sheep farms located in the mountain areas, while they are less present in hill farms and almost lacking in lowland farms. The aim of this study was to characterize the effect of different pasture locations, and indirectly the contribution of agroforestry Meriagos, on the fatty acid (FA) profile of Sarda sheep cheese. The effect of the grazing season and the duration of ripening were also evaluated.

The nutritional quality of animal foods has become an important issue in recent decades, due to the increasing interest of consumers. The FA profile plays a crucial role in determining the quality of milk and dairy products, since it includes compounds considered beneficial for human health, such as polyunsaturated FA belonging to the omega-3 and omega-6 families (PUFA n3 and PUFA n6), or conjugated linoleic acid (CLA); and other compounds considered harmful, such as saturated FA (SFA) (McGuire and McGuire, 2000; Ruxton et al., 2004). The diet of sheep is the most important factor affecting the FA profile of milk and dairy products. In particular, the intake of fresh forages can increase the concentration of PUFA n3 and n6 and CLA in milk and cheese compared with diets based on dry forage or concentrates (Nudda et al., 2014). Such differences in the diet can be related to the season of grazing and also to the altitude of grazing areas, that, in fact, can be characterized by different grass availability and botanical composition of the pasture. In addition to the factors that can affect FA composition of milk, the cheese FA profile can be also affected by the time of ripening, due to the maturation processes that occur in this biological matrix.

The cheeses analysed were produced using bulk milk from different seasons: i) late winter (February-March), ii) spring (April-May) and iii) summer (July) from 36 flocks located at different altitudes of Sardinia: lowland (Low), hills (Hill) and mountain (Mount). The samples were collected with different durations of ripening: 0, 60 and 120 days. Cheese FA profile was determined using gas-chromatography, following the method described by Nudda et al. (2006). Data were analyzed with a linear regression model where pastur location (altitude, A), season (S), duration of ripening (T), A x S interaction and A x T interactions were considered as fixed factors.

Table 1. Effect of time of ripening (T), altitude of flock (A) and season (S) on cheese FA profile

	Late winter			Spring			Summer			P-value[1]		
Fatty acid, %	Low	Hill	Mount	Low	Hill	Mount	Low	Hill	Mount	T	A	S
C18:0	13.25	11.72	12.67	12.53	11.76	11.46	10.66	8.36	9.56	**	**	**
C18:1 t11	4.00	4.71	3.83	1.65	1.64	1.77	1.21	0.84	1.07	**	ns	**
C18:1c9	21.67	21.56	23.42	23.15	22.07	23.23	26.97	25.25	27.45	*	ns	**
C18:2n6	2.87	3.03	3.08	2.17	2.93	2.60	2.35	2.59	2.64	ns	**	**
C18:3n3	1.41	1.61	1.33	0.93	1.22	0.88	0.70	0.51	0.60	ns	ns	**
CLAc9t11	1.89	2.26	1.86	0.96	0.95	1.02	0.96	0.80	0.92	ns	ns	**
SCFA	9.02	9.80	9.23	8.76	8.80	8.82	5.95	5.94	5.28	**	ns	**
MCFA	39.58	39.10	38.70	44.00	44.43	43.75	45.29	49.28	45.70	**	ns	**
LCFA	50.44	50.25	51.24	45.47	44.84	45.62	46.90	42.69	46.98	**	ns	**
SFA	61.14	59.84	59.77	64.71	64.33	63.43	60.90	62.49	59.58	ns	ns	**
UFA	37.90	39.31	39.40	33.52	33.74	34.76	37.24	35.42	38.38	**	ns	**
MUFA	29.86	30.55	31.31	28.17	27.28	28.96	31.87	30.05	32.58	*	ns	**
PUFA	8.05	8.76	8.09	5.35	6.46	5.80	5.37	5.37	5.80	**	ns	**
n3	1.50	1.70	1.40	1.04	1.34	0.96	0.78	0.59	0.68	ns	ns	**
n6/n3	2.22	2.04	2.41	2.34	2.75	2.91	3.84	5.32	6.17	ns	ns	**
OBCFA	2.87	2.51	2.65	3.05	3.13	2.99	3.07	3.63	3.41	**	ns	**

[1] *P<0.05; **P<0.01; ns = not significant

As expected, the season and the duration of ripening greatly influenced the cheese FA profile. Among individual fatty acids: vaccenic, rumenic and linolenic acids were higher in late winter than the other seasons (P < 0.05); PUFA concentration (% on total FA) was 5.69% in the spring and summer seasons (mean) and 8.30% in late winter (Table 1). It is well known that the milk FA precursors, existing in pasture, change during the season, with the plant maturation. For example, in late winter, the physiological state of the plants provides a high level of alpha-linolenic acid, which is an important PUFA n3 and that represents the main precursor of vaccenic acid and, indirectly, of the rumenic acid (trans9cis11CLA). The effect of cheese ripening was not related to changes in the concentration of FA of particular nutritional interest, whereas, a large effect can be noticed on the short chain FA (SCFA) that decreased significantly with the increase of ripening duration (9.90, 7.35 and 6.06 %, after 0, 60 and 120 days of ripening, respectively). This result could be related to the microorganism and enzymatic activity occurring during ripening, especially on the sn3 position of triglycerides, which is the preferential position of the SCFA (Marai et al., 1969). The effect of pasture location (altitude of flock location) was very limited also when it was considered as interaction with the other two effects. The only notable effect was the altitude x season interaction for the rumenic acid, which had a higher value in the hill flock compared to that of Lowlands and Mountains, during the late winter, whereas there was no difference in altitudes in the other seasons.

In conclusion, as expected, the season of milk production and the duration of ripening greatly affected the cheese FA profile, even if in different ways. The expected effect of the pasture location (home altitude of the flock) was not observed in the present investigation, probably because of different food supplements given to the animals reared at the different altitudes.

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Truffles and agroforestry: a binomial to be explored, planned and spread

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Theme: Agroforestry and policy for sustainable development: Agroforestry, quality food products and certification

Keywords: stable isotopes, mycorrhiza, productive hedgerows, truffle grounds

Abstract

Edible truffles, the hypogeous fruiting bodies of several species of the Tuber genus, are Ascomycetes fungi giving rise to mycorrhizal mutualisms with various forest species and within various ecosystems. Truffles are premium products, in high demand by elite consumers. Traditionally, their harvest is carried out by truffle hunters, who usually find wild truffles with the help of skilled dogs. Only recently, biological and agronomic knowledge has provided the basis for the plantation and management of truffle producing grounds. The most renowned truffle producing countries are Spain, France, Italy, Slovenia and Hungary. The Mediterranean region is the global leader in truffle production, transformation and marketing. However, the role of artificial or ameliorated truffle grounds in the value chain is rather unclear, owing to the uncertain nature of the wild truffle harvest. For example, in Italy, 1200 ha of cultivated grounds were officially reported in 2008, producing around 100 tonnes of truffles.

No official data is available for the wild truffle harvest. It could account for up to 7 times the weight of cultivated production. The area used for wild harvests is uncertain, but is suspected to cover several million ha of diverse landscapes, where more than 60,000 truffle hunters are in action (Furlani 2015). Aside from these uncertainties, the high truffle value and healthy consumer demand strongly suggests the opportunity to establish agroforestry truffle-farms.

In order to test the viability of truffle production in agroforestry, proper ecophysiological tools are needed. The potential tree-fungi relationship is critical in choosing the trees species and managing the soil to maximise the chance of truffle production. Stable isotope technologies allow a detailed investigation on the effectiveness of the mycorrhizal relationship in the field. Here, we report a former explanatory case study performed in a semi-natural truffle bed in central Italy (Ciolfi 2016). The investigation particularly concerned the dynamics of mycorrhizal relationships after repeated thinning in a pine stand, which was partially converted to a mixed wood. Planting of pines took place from the 1940s to 70s and thinning started in the first decade of 2000s.

The main goal was to find the host trees through stable isotope methods. We applied a simplified interaction model, looking at the exchange of carbon (^{13}C) and nitrogen (^{15}N) by the fungi (*Tuber aestivum*) vs the host trees. A biogeochemical process is usually characterised by a more or less pronounced preference towards the lighter isotopes in the chemical species involved: the so-called isotope fractionation. In our case, a high fractionation in N translocation (fungi to trees) is expected, while a negligible one in C exchange (trees to fungi) (Henn and Chapela 2001). The stable isotope's relative abundances are expressed in δ-notation, representing the deviation from one of the ratios of the isotope ratios of, respectively, the sample and the international standard. A fractionation

occurrence is generally expressed in capital Δ notation, representing differences between δ-value of reactants and of products along a given reaction or process. We sought for large $\Delta^{15}N$ and small or null $\Delta^{13}C$ between putative host trees' leaves and fungi, as a statistical signature of the mycorrhiza effectiveness. Surprisingly, we highlighted a variable survival strategy in *T. aestivum*. In fact, following thinning, the fungus was able to switch toward a saprophytic behaviour at the expense of residual pine stumps, resulting in no N fractionation, owing to a reverse and not competitive N flow (stump to fungus). All the data collected along the truffles harvesting season were georeferenced. The soil N isotopic variability was also considered, as a bias correction. Further corrections were required for the fungal $\delta^{15}N$, since continuous ^{15}N fractionation occurred during the season.

A comprehensive geodatabase was developed in order to produce the maps of the spatial variability of the isotopic abundances and to trace an isotopic landscape (isoscape; West et al. 2010). The isoscape geostatistical analysis suggested a symbiotic relationship with the remaining pines and no relation with the other broadleaves species (the T1, T2 and T8 truffle beds in the figure). On the other hand, we found statistical evidence of a saprophytic relationship with the pine stumps in cleared areas (the T4, T5, T6, T7 and T9 beds).

Our conclusion is that establishing new mycorrhizal relationships is not easy in forest ecosystems. We foresee even worse conditions in an agroforestry managed farm, where truffle producing grounds have to cope with neighbouring agronomic disturbances. Proper ecophysiological experiments are needed to validate possible innovation of agroforestry systems in integrating truffle and fleshy mushrooms. Particularly, the capability of mycorrhiza propagation through newly established root colonization and anastomosis should be investigated.

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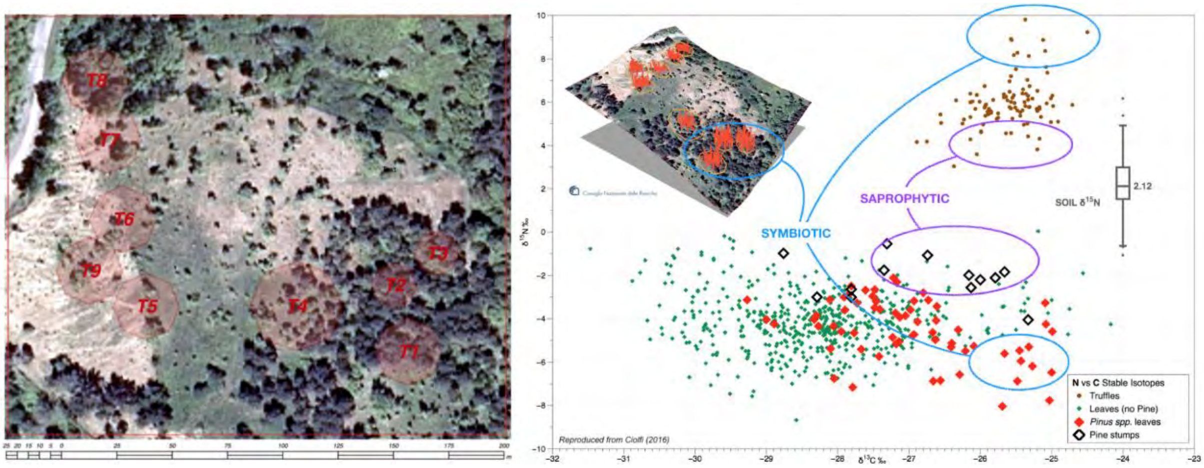

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Honey, an agroforestry product featured by the territory. A characterization of locally produced honey

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Topic: Agroforestry, quality food products and certification

Keywords: honey, agroforestry products, territory, phenolic antioxidants

Abstract

Worldwide apiculture represents an important agroforestry practice as tree growing and beekeeping can be easily combined (Hill and Webster, 1995). Honey, the product of bees' digestion, is a nutritious, healthy and flavoured product. It is a concentrated aqueous solution of sugars, containing also a complex mixture of other saccharides, enzymes, amino acids, organic acids, polyphenols, carotenoid-like substances, vitamins and minerals (Gheldof et al, 2002). It has a particular biological antioxidant activity due to polyphenols, an important group of secondary metabolites of plant origin with different biological functions, including antimicrobial, antifungal, anti-inflammatory, and anti-radical properties. A polyphenol-rich diet can be particularly valuable and functional foods, enriched foods and nutraceuticals, well suit the concept of optimal nutrition and health properties of our diet. The polyphenol concentration in honey depends on its botanical and geographical origin, but also on the processing methods. The filtration and pasteurization heat treatment in industrial processes affect the natural composition of raw honeys which is instead generally preserved in honey produced from smallholder farmers who, through their work, also provide honey with local environment and biodiversity added value.

In Italy, there are 50.236 beekeepers: 31.425 of them (63%) produce honey for self-consumption while 18.811 (37%) produce it for the market. Italy is ranked fifth in Europe for honey production[1]. In 2018 the Italian and Sardinian honey production was estimated at kg 21.010.193 and kg 849.882, respectively. Furthermore, in Italy about 1.138.685 beehives are recorded: 80% of them belonging to professional beekeepers, highlighting the agro-economical relevance of the sector. Honey can be produced in different environments and can be one of the ecosystem services provided by forests, pastures and scrublands (Tognetti et al, 2017). The linkage of honey with special areas of production is reported by studies on the Optional Quality Term "Mountain Product"[2] introduced by the EU Legislation to provide value to foodstuffs from mountain areas (Bonadonna, 2016). The aim of this work is to undertake a preliminary characterization of honey produced in agroforestry systems. The aim is also to contribute to a label of the terroir identified with agroforestry systems.

Methods. Two types of Sardinian honey were analysed provided by FoReSTAS (Agenzia forestale regionale per lo sviluppo del territorio e dell'ambiente della Sardegna): the monofloral strawberry- tree (Arbutus unedo L.) honey and wildflower honey. A commercial and industrially processed multi-flower honey was used as the test control. Both the two Sardinian honeys were produced in the area of Arci-Grighine (Oristano). Agrosilvopastoral systems cover about 16% of the area. Apiculture can exploit the particularly rich flora of this area. Out of 2000 Sardinian plant species, 500 can be found on the slopes of the Arci mountain, i.e.: strawberry-tree, phillyrea, tree heather, sarsaparilla, hawthorn, honeysuckle, wild

[1] www.informamiele.it

[2] https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/quality-schemes-explained/regulations-mountain-products_en

olive, myrtle, several cistus, lentisk, euphorbia tree, asphodelus, rock-rose, holly tree, several wild orchids. All these species are grouped in communities according to their eco-climatic similarities and shape the landscape[3]. The antioxidant capacity of honey extracts was detected through the assessment of total phenols by Folin-Ciocalteau assay,

Results and Conclusions. The investigated honeys showed a high variability in the total amount of Results and Conclusions. The investigated honeys showed a high variability in the total amount of phenolic compounds (Table 1). The Sardinian wildflower honey shows phenolic content 1.8 times higher than the control, while the strawberry-tree honey, known as ''bitter honey'', shows even a 31-fold higher phenolic content. Such monofloral honey was already reported as the most active honey in in vitro test for the assessment of the antiradical activity and the homogentisic acid was identified as the most abundant phenolic compound in this honey, with an average amount of 414.1 ± 69.8 mg/kg (Tuberoso et al., 2013). Accordingly, the antiradical efficiency AE (calculated as 1/IC50*100) of the strawberry-tree and wildflower honey was about 12-fold and 2.4-fold higher, respectively, in comparison with the control. It has to be highlighted that the AE of the wild flower did not change 5 months after opening the honey jar while the AE of the strawberry tree honey, even though decreased 1.4 fold, still showed its efficacy.

	Control Honey	Wildflower Honey	Strawberry tree Honey
Colour	Amber yellow	Orange yellow	Dark yellow
pH	3.75	4.18	4.31
Consistency	Fluid	Fluid	Hard (high level of crystallization)
Viscosity (cps)	14800	7000	ND
Simple sugars in diluted honey 1:1 (°Bx)	39.9	35.6	40.1
Total Phenolics (as GAE, mg gallic acid/ g of sample)	2.91±0.14	5.16±1.50	91.39±9.87
Antiradical Efficiency (AE)	**0.056**	**0.135**	**0.676**
5 months after opening the jar	**ND**	**0.131**	**0.476**

Table 1. Product characteristics of the honeys, phenolic concentration and antiradical activity.

As honey is becoming increasingly popular with consumers for its nutritional benefits, such analyses should be integrated with further investigations to determine factors related to its chemical composition and the consumers' preferences, assessing the importance of honey characteristics linked to special territories and identify the main features of an ideal honey profile.

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Agroforestry in a farm in central Italy. Agroforestry project for Azienda Agricola Boccea

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Theme: Agroforestry, quality food products and certification

Keywords: Agroforestry system for grazing beef cattle, Biodiversity and agricultural practices.

Abstract:

Today, many universities around the world are studying new agricultural practices with new terms like agroecology and agroforestry. These terms describe agricultural practices which protect the environment and produce healthy food. Successful agricultural methods depend on understanding ecosystems and biodiversity. Biodiversity is the set of knowledge and survival strategies that species have developed during their evolution over millions of years. From an aesthetic point of view each species is unique, a work of nature that cannot be recreated once lost. The environmental inefficiency of the agri-industry system is highlighted by the fact that 75% of our food comes from a dozen plant species and five animal species. Monocultures in agriculture are widespread and this makes our crops and industrial farms subject to the attack of parasites, putting at risk the system we have built for the production of our food. [1]

Azienda Agricola Boccea

Agricola Boccea is an organic and biodynamic farm with over 270 hectares, with wooded areas and plateaus crossed by long rows of olive trees, and a fertile plain. Grazing animals are necessary in such a varied ecosystem, as their presence helps to preserve the environment and the fertility of the soils. They control soil erosion and keep rough and wooded areas clean. On the farm there are about 320 head of beef cattle. Hey use marginal areas such as wooded land and the steepest hillsides which are difficult to cultivate. Alternating pastures with arable land increases the fertility of the soils, and captures carbon from the atmosphere. This system of cattle rearing was dictated by their welfare need, the "T-shape" of the farm, its size and its soil and natural flora. The aim is for a harmonious coexistence between the environment, animals and man: respecting the different needs of each, with an agro-ecological approach [2] Pastures are managed with rotational grazing techniques allowing the maintenance of stable pastures which preserve the soil from erosion and runoff. There are three herds of beef cattle who live on pasture, with the bull present all year round. All the breeds have horns: Marchigiane , Limousines and Meticce.

The Agroforestry Project

The farm olive grove consists of about 2000 trees, set in long rows which are 40 or 80 meters apart. The trees were planted in the early 1950s. The varieties are Leccino, Moraiolo, Frantoio and Canino. They mature gradually and are arranged in areas where only one variety is prevalent to facilitate harvesting.. The lower branches of olive trees are usually rich in olives. However, we have dedicated part of the olive groves to grazing cattle, and they tend to eat the lower branches. We have therefore changed the pruning system from traditional to "polyconic vase" that allows fruitful branches to grow at the top of the crown. We believe that about 30% of the production is consumed by cattle, but in return the animals fertilize the soils and feed on the epicormic branches of the trees. reducing pruning times. They value the opportunity to graze the pruned branches, and this can reduce the need for hay in winter. Cattle-grazing also reduces the mass of prunings and leaves only branches that can be easily chopped. It would be interesting to assess the differences in costs and production between the portion of the grazed olive grove and the portion where the animals are kept away. We also grow seasonal vegetables, cereals and legumes for human consumption and for our cattle. We use only a portion of the wooded areas for grazing cattle: where we send young calves during the winter or summer months to decrease the load of animals on pastures and to ensure a more protected environment during adverse weather conditions.

The Agroforestry Project plans to introduce trees into arable plots and more consistently to utilize all forest groves, totalling about 40 ha, which today are abandoned and overrun by brambles. A Grazing Planis being developed by a pool of AIAF experts and business consultants that will include the wooded areas of the farm. The most marginal, hard-to-cultivate areas of the farm will be diversified to raise broiler chickens in a plot of one and a half hectare that is unused, adding a pergola of strawberry grapes, a walnut and a couple of hazelnuts. Chickens tend to grow in harmony with the fruit trees, and we trust that they can help us destroy the larvae of flies that attack the fruits [3]. Their grazing will be rotated. For the shade we have planted mulberries and other fruit trees. When the blackberries fall they will attract the insects that are needed by chickens. At the moment the mulberries are still small and we have built shaded areas with temporary canopies.

Discussion and Conclusions

Thanks to the desire to obtain measured and quality productions, Agricola Boccea has been able to increase the fertility of its soil , to give well-being to the animals raised in the pasture and to maintain and ensure the biodiversity necessary to maintain stable production. Cultivating the farm according to agro-ecological principles has been a complex revolution: a learning process that we started from the beginning. In nature there is already everything that is needed and for this reason, it cannot be adjusted according to the individual needs of the moment. The approach pursued was to imitate natural processes. How do you get a fertile soil rich in humus? The process is circular: what is removed is returned in a different form but suitable to accommodate living organisms. The impulses that brought about change were love for nature and a care for the environment. Because biodynamic farming, agro-ecology and agro-forestry means reinventing agriculture. They are and will be the future. They allow us to use fewer resources and produce more but with greater production diversification for each farm.

Increasing biodiversity by introducing tree species is an effective resources to remove carbon dioxide from the atmosphere but also a good resource to feed animals and produce income both from wood and fruit production but it is also a landscape development for recreational and tourist purposes. The virtuous agricultural systems that include associations of tree species and herbaceous cultures together with rearing animals and the use of forests for controlled grazing and for the development of agricultural tourism would allow all of us to enjoy the beautiful landscapes and the delicious products of our territories.

Figure 1. Azienda Agricola Boccea

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The Edible Park: agroforestry with horticultural crops – A multifunctional farm for peri-urban areas ¶

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Theme: Agroforestry, quality food products and certification

Keywords: mulberry, horticultural crops, short supply chain, historical landscape, C footprint

Abstract

Edible Park ('Parco Commestibile' in Italian) is an innovative concept aiming to strengthen the integration of farming activity within the local socio-economic context. It is based on a renewed interest in agroforestry systems as a sustainable production model and brings high quality food products to local consumers, while stimulating societal engagement in the farming activity, and reducing environmental impact. ¶

Edible Park was inspired by the Milan Urban Food Policy Pact (EXPO 2015) and set up as an EIP Operational Group project funded by the Rural Development Programme (RDP) of the Emilia- Romagna Region and supported by the Municipality of Reggio Emilia, Italy. It aims to implement a model of multifunctional farming in peri-urban areas which is environmentally and economically sustainable, and has potential for scaling up in terms of number of producers and consumers involved. ¶

The main needs that the project aims to address are: ¶

- the growing demand from consumers for local, healthy and low environmental impact products¶
- the cultivation of peri-urban agricultural land with valuable crops, while addressing their state of semi-abandonment ¶
- the creation of new multifunctional agricultural spaces, with productive but also landscape, educational and social goals. ¶

Edible Park is therefore a project for farmers but also for landowners in peri-urban areas, and for citizens (from children to the elderly, without limitation of age and gender) interested in both attending the Edible Park activities and buying its products. ¶

At present, Edible Park is a plot of one hectare where 80 mulberry trees (of 5 different certified species/varieties) were planted in rows, according to the principles of agroforestry, to rebuild the traditional rural landscape of the area, giving a contribution to carbon sequestration and biodiversity enhancement. Horticultural crops are cultivated between trees to supply fresh vegetables to the nearby town (Reggio Emilia), favouring manual operations and the inclusion of disadvantaged workers. "Parco Commestibile" is the brand used for experimental new supply chain models. ¶

Recycling of crop residues through composting and use as fertiliser in the field is also practiced. Part of the horticultural production is processed to take into account the evolution of consumers' habits. ¶A strong promotional activity is carried out towards the families living nearby to increase their awareness of the opportunity to enjoy a short supply chain of horticultural products, strictly controlled in accordance with

objective quality standards. Data are collected on the field to evaluate the social, economic and environmental impacts.

Environmental impact:

- reduction of fossil fuel consumption and greenhouse gas emissions by promoting manual operations and the proximity of the production site to consumers (km 0 concept of local agricultural production). Imported food have higher environmental costs in terms of energy consumption (estimated C-footprint of 0.38 kg CO_2eq/kg vegetables against 0.12 kg CO_2eq/kg vegetables from Edible Park);
- reduction of the release of nitrates and pesticides to water bodies thanks to the agroforestry system implemented and the adoption of organic farming methods (low levels of nitrates were measured in the soil water, below the drinking limit of 50 mg/l); - increase of the organic matter in the soil thanks to the recycling of organic waste and the continuous coverage of the soil (two-three crops per year on the same plots, plus trees).

Economic impact:

- increase in the added value of crop production deriving from the Edible Park model thanks to the collateral benefits - since the majority of citizens have expressed willingness to pay a supplement for the Edible Park vegetables;
- future possible creation of new jobs linked to the spread and expansion of this model of peri-urban agriculture.

Social impact:

- establishing a direct relationship between producer and consumer based on mutual knowledge;
- trust and a balance between remuneration and price;
- actions aimed at ethical and social sustainability with the inclusion of disadvantaged workers and educational/recreational initiatives in the park (more than 10 disadvantaged workers have been involved in the last 3 years, and over 300 children in educational activities in the Edible Park).

With the aim of strengthening this experience, a "rural" Living Lab has been set up in the H2020 LIVERUR project, to consolidate the innovative business model capable of ensuring environmental, social and economic sustainability according to the "Farm to Fork" strategy. The objective of the Living Lab is to promote co-creation paths based on dialogue between public and entrepreneurial entities (agricultural and social), also involving citizens, who represent the final client/beneficiary of the results of the initiative.

http://parcocommestibile.crpa.it

Perceptions on Constraints to Agroforestry Competitiveness: A Case Study of Agrosilviculture Community Growers in Limpopo & Mpumalanga Provinces, South Africa.

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Theme: **Agroforestry and policy for sustainable development**

Keywords: Agrosilviculture Community Growers, Agroforestry, Perceptions, Limpopo Province, Mpumalanga Province and South Africa.

Abstract

Agroforestry is a land use system that includes the use of woody perennial, agricultural crops and animals in combination to achieve beneficial ecological and economical interactions for food, fiber and livestock production. However, limited understanding, incorrect information and a negative mindset could hinder the competitiveness of this practice. According to Sanou et al. (2019), an agroforestry project will be more successful if the diversity of smallholder farmer socio-economic characteristics and their perceptions are considered in its design. Hence, this case study of agrosilviculture community growers in Limpopo and Mpumalanga Provinces, South Africa attempts to explain the community growers' constraints to agroforestry competitiveness by analysing their perception on agroforestry. Hence, the aim of the study was to document community growers perception on the constraints to agroforestry competeveness in Limpopo and Mpumalanga Provinces. A total of 182 agrosilviculture community growers from 30 villages participated in the study and were spread as follows: Vhembe District (43), Mopani District (62) and Ehlanzeni District (77). Quantitative and qualitative designs were used as a questionnaire written in English, stakeholder's discussion and field observations were part of the data collection. A purposive sampling technique was used to select 182 agrosilviculture community growers from communities that were allocated land by South Africa Forestry Company Limited (SAFCOL); Mountain to Ocean (MTO) Forests, White River; Ratombo Plantations and Dimani. Data was coded, captured, and analysed using SPSS. The agrosilviculture community growers were asked about their perceptions in terms of the following: (1) Production factors (2) Demand conditions (3) Related and supporting industries (4) Government support (5) Chance. The results indicated that the production factors were causing a decrease in agroforestry competitiveness as majority of community growers strongly agreed (Total rating at 110) and agreed (Total rating at 993). Among the thirteen factors of production; the cost of production (Strongly agreed/agreed by 164 community growers), insufficient source of water (Strongly agreed/agreed by 148 community growers) and labour (Strongly agreed/agreed by 161 community growers) were perceived as the most important factors causing a decrease in agroforestry competitiveness. The demand conditions were causing a decrease in agroforestry competitiveness as the majority of farmers agreed (total rating at 323). Among the five demand conditions; distance to the market (Agreed by 75 and not sure by 101 community growers), Market information (Agreed by 70 and not sure by 106 community growers), Agroforestry market (Agreed by 65 and not sure by 109 community growers) and cost to market (Agreed by 69 and not sure by 105 community growers) were perceived as the factors mostly causing a decrease in

agroforestry competitiveness. In addition, related and supporting industries were causing a decrease in agroforestry competitiveness as the majority of community growers strongly agreed (total rating at 95) and agreed (total rating at 174). Among the four related and supporting industries; financial institutions (Strongly agreed/agreed by 80 community growers), research institutions (Strongly agreed/agreed by 72 community growers) and suppliers (Strongly agreed by 62 community growers) were perceived as the factors mostly causing a decrease in agroforestry competitiveness. Government support was also causing a decrease in agroforestry competitiveness as the majority of community growers strongly agreed (total rating at 84) and agreed (total rating at 484). Among the six-government support; (1) Land reform policy (Strongly agreed/agreed by 151 community growers) and (2) Poor interaction and support between government departments (Strongly agreed/agreed by 102 community growers) were perceived as the factors mostly causing a decrease in agroforestry competitiveness. Chance was again causing a decrease in agroforestry competitiveness as the majority of community growers strongly agreed (total rating at 67) and agreed (total rating at 521). Among nine chance, (1) Drought (Strongly agreed/agreed by 169 community growers) and (2) Crime (Strongly agreed/agreed by 131 community growers) were perceived as the most factors causing a decrease in agroforestry competitiveness. This perception results are in line with the study conducted in Limpopo Province (Maponya et al. 2018). In conclusion, identified community growers perceptions are in line with some of the researcher field observations and it is thus recommended that stakeholders should take note of the constraints identified by the agrosilviculture community growers in an attempt to increase agroforestry competitiveness in South Africa.

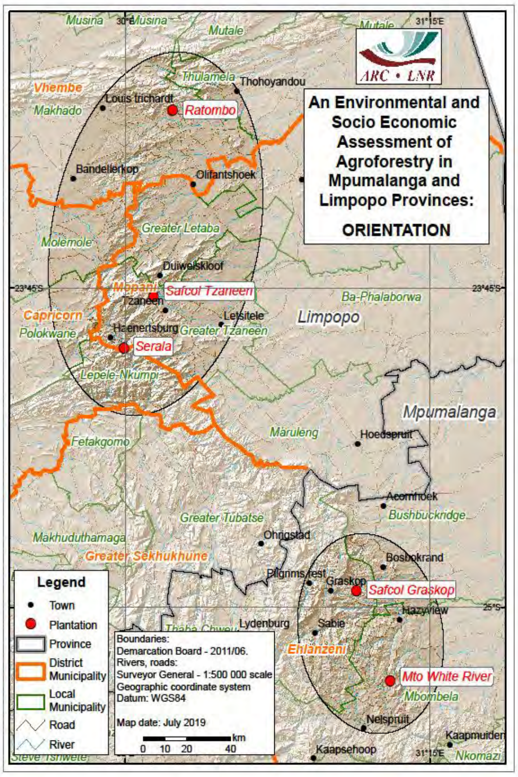

Figure 1. Location of the Agrosilviculture Community Growers in Limpopo & Mpumalanga Provinces

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Flattening the Food Insecurity Curve Through Agroforestry: A Case Study of Agrosilviculture Community Growers in Limpopo & Mpumalanga Provinces, South Africa.

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Theme: Agroforestry and policy for sustainable development

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Abstract

Results from several studies have indicated that agroforestry practices are perceived in different ways. According to Lundgren and Raintree (1982), agroforestry is viewed as the set of land-use practices, which involves the combination of trees, agricultural crops and/or animals on the same land management unit. Nair (1993) emphasized that although cultivating trees in combination with crops and livestock is considered an ancient practice, factors such as the deteriorating economic situation in many parts of the developing world, increased tropical deforestation, incorrect agricultural practices, degradation and scarcity of land because of population pressures, and growing interest in farming systems, intercropping and the environment have contributed to a rising interest in agroforestry since the 1970s. According to Maponya et al. (2019), agroforestry practices are not well established in South Africa. However, it is practiced in some parts of the country, for instance in the Eastern Cape, Limpopo and Mpumalanga Provinces (Maponya et al. 2020). Hence, the aim of this study was to identify the food security status of the agrosilviculture community growers in Limpopo and Mpumalanga Province. In order to address the aim, the study identified the agrosilviculture community growers before and after intervention food insecurity status and levels as an objective. A total of 182 agrosilviculture community growers from 30 villages participated in the study and were spread as follows: Vhembe District (43), Mopani District (62) and Ehlanzeni District (77). Quantitative and qualitative designs were used as a questionnaire written in English, stakeholder's discussion and field observations were part of the data collection. A purposive sampling technique was used to select 182 agrosilviculture community growers from communities that were allocated land by South Africa Forestry Company Limited (SAFCOL); Mountain to Ocean (MTO) Forests, White River; Ratombo Plantations and Dimani. Each agrosilviculture community grower was allocated a row of m^2 as follows for production: (1) SAFCOL (3226m^2 : 1ha = 10000m^2; 20ha * 10000 = 200000m^2/62); (2) MTO (1272m^2 : 1ha = 10000m^2; 9.8ha * 10000 = 98000m^2/77); Dimani (1351m^2 : 1ha = 10000m^2; 5ha * 10000 =50000m^2/37) and Ratombo Plantation (3333m^2 : 1ha = 10000m^2; 2ha * 10000 =20000m^2/6). The eucalyptus trees were then integrated with other crops including Maize, Sweet Potatoes, Dry Beans, Groundnuts, Bambara Nuts and Vegetables. Furthermore, the study employed the following food security indicators: Food Availability, Food Accessibility and Food Diversity. The community growers were also categorized as follows: (1) **Food secure** (2) **Mildly food insecure** (3) **Moderately food insecure and** (4) **Severe food insecure.** The before intervention and after intervention data was coded, captured, and analysed using SPSS. **In terms of food availability before intervention**: Most of the community growers (115 sometimes; 39 often and 7 always) indicated that their food runs out before they get money to buy more. **In terms of food availability after intervention***:* Most community

growers (163 never) indicated that they do not runs out of food before they get money to buy more. Most community growers can now buy or have enough food and they are often not hungry. The children also are now getting enough to eat and community growers can afford to eat enough everyday (182 always). **In terms of food accessibility before intervention**: According to Maponya et al. (2020), one of the reasons for community growers not accessing enough food is the lack of resources. 148 community growers indicated that they do not have resources like land to grow or access food. **In terms of food accessibility after intervention**: A whopping 163 community growers indicated that they can now access food as the land allocated and production inputs given by South Africa Forestry Company Limited (SAFCOL), Mountain to Ocean (MTO), Department of Environment, Forestry and Fisheries (DEFF) and Agricultural Research Council (ARC) enabled them to produce food for themselves. Only 19 community growers indicated that they are still food insecure because of lack of transport money to monitor their land allocation and in some instance, the animals destroyed their crops. Some community growers indicated that they were able to sell a minimum of 10 bags X 80kg of groundnuts per row allocated. In terms of food diversity, the community growers have access to the following food groups: cereals, white tubers and roots, vitamin A rich vegetables, fruit, dark green leafy vegetables, other vegetables, legumes, meat and fish, eggs, dairy, oil and fat, sugar, and spices, condiments and beverages. In conclusion, the study indicated that the food insecurity status and levels of the agrosilviculture community growers was flattened as indicated in Tables 1 & 2. It is thus recommended that agroforestry practice should be intensified across South Africa as is contributing to food security and sustainable livelihoods.

Table 1: Before Intervention Agrosilviculture Community Growers Food Security Levels & Extent of Food Insecurity

Variable	**Category**	**Community Grower**	**Total**
Food Security Level	Food Secure	34	34/19%
	Food Insecure	148	148/81%
Extent of Food Insecurity	Mild	48	48/32%
	Moderate	74	74/50%
	Severe	26	26/18%

Table 2: After Intervention Agrosilviculture Community Growers Food Security Levels & Extent of Food Insecurity

Variable	**Category**	**Community Grower**	**Total**
Food Security Level	Food Secure	163	163/90%
	Food Insecure	19	19/10%
Extent of Food Insecurity	Mild	1	1/5%
	Moderate	15	15/79%
	Severe	3	3/16%

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2.2

Policy

AGROMIX – Introducing Policy Co-Development for Agroforestry and Mixed Farming

EURAF 2021
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Policy

Keywords: EURAF 2021, policy, citizen juries, policy co-development, agroforestry, mixed farming, AGROMIX

Abstract

Background
Mixed farming systems have been the predominant farming system in Europe for many centuries. However, the first mention of the word 'agroforestry' in policy documents of the EU's common agricultural policy (CAP) was only recently, in the 1998 EU forestry strategy (Larson et al. 2019). The first World Agroforestry Congress in Europe was only held in May 2019. Agroforestry as a mainstream land use has come to Europe late and spearheaded by pioneers like e.g. Martin Wolfe, the late Professor working at Coventry University and Wakelyns agroforestry (Wolfe and Pasiecznik, 2000). Den Herder et al. (2017) estimated the total area under agroforestry in the EU-27 about 15.4 million ha which is equivalent to about 8.8% of the utilised agricultural area (UAA). Over the last decades, structural changes in the EU agriculture have been reflected by declining number of farms, farm size growth and re-specialization of production, moving away from mixed farming (Neuenfeldt et al., 2018, EC Eurostat). The percentage of mixed farming of total agricultural holdings in EU-28 has decreased from 30% in 2005 to 21% in 2016 (EC Eurostat). With 8.8% of the UAA in Europe this is already a substantial area and currently more than the certified organic UAA. Although, certified organic farming is fast growing and likely to double in size in the next 20 years, it is not always, but mostly, mixed farming. In contrast, agroforestry within organic farms can be found more often but it is by no means exclusive to certified organic farming, or farming systems based on agroecological farming practices. Often low input farmers with mixed grazing or agroforestry (e.g. pasture feed beef, hay-milk systems, free-range chicken or agroforestry free-range pigs, chicken, sheep & beef,) are very close to organic management and could convert to organic farming quickly if the market can accommodate further organic produce. Therefore, both systems overlap and there are synergies which need to be considered in the policy work. Especially if another 10% of the UAA in Europe is converted to certified farming systems, including mixed farming and agroforestry in EU legislation regulating certified farming systems is one the policy options.

Research
The working assumption in AGROMIX's policy research is that despite several agroforestry and mixed farming support policies the full potential of this system in Europe has yet to be lifted. AGROMIX is a new 4-year H2020 project which started in November 2020. The AGROMIX policy workshops will contribute to a better scientific understanding of policy co-development from a bottom-up citizen perspective, contributing to the 2021-2027 CAP policy dialog. Novel for agroforestry and mixed farming policy development is a set of comparative policy workshops at different policy levels: EU level, member states in Eastern and Western Europe but also non-EU states within Europe, like Switzerland and UK. Those may have more flexible regulations like Lawson et al. (2019) report for Switzerland (Dupraz et al., 2019) or potentially better (or worse) regulation for 'Environmental Land Management' as planned in the UK. In addition, devolved federal state levels are studied, e.g. in East and West Germany. This multiple approach gives a better policy understanding for the EU level and the stakeholder-led bottom-up approach will help ascertain which policies (related to agroforestry and mixed farming) are best pursued at which level to maximise impact. The workshops adopt a format similar to the 'citizen jury' methodology used in social

science as a form of mini-public (Bryant and Hall, 2017, Wakeford et al., 2015). The participants are citizens, but already with prior knowledge and interest in food and farming policy. They can be farmers, food-chain actors, environmental charities or any other interested stakeholders, but their input will be as citizen not necessarily as representative of a specific lobby group or agenda. As in previous work (Burbi et al., 2016, Zasada, Schmutz et al., 2019) participants will be presented with preliminary scenario modelling results/visualisations. Input from across the world (Kumar, 2019) and especially through the AGROMIX advisory board will also be used.

This presentation introduces the research concept, and invites a critical discussion on the research and modelling approaches proposed (AGROMIX, 2020).

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Figure 1. AGROMIX H2020 logo, www.agromix.com

Policy lessons from fifty years of trees on farms in New Zealand

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Policy

Keywords: Forest policy, Strong institutions; Advisory services, Forestry research

Abstract

New Zealand farm forestry is dominated by woodlots and silvo-pastoral systems but uptake and practices have changed dramatically over the last 50 years. This paper explores what led to these changes and what is required to support and ensure farmers embrace trees.

Background: New Zealand forestry underwent profound change in the late 1980s beginning with the 'reform' of Government institutions and services (Levack, Poole and Bateson 2002; Eyles 2014). This included the disestablishment of the NZ Forest Service and The National Water and Soil Conservation Organisation (NWSCO) and Catchment Boards, all which encouraged tree planting on farms. The States large scale plantation forests were subsequently sold so that today many plantations are foreign owned. At the same time the States research institutes were remodelled into business with greater industry involvement.
It was hoped that the new forest owners would invest in wood processing as the harvesting volume from plantations rose from 10 M m^3 per year in 1988 to 33 M m^3 in 2018 (Ministry for Primary Industries 2019). Volumes harvested from natural forests is only 20 000 m^3! However, most of this increase was exported in log form to Asia (increasing from <1 M to 20 M m^3) partly because of a lack of vertical integration (Evison 2016). Thus farm foresters, as price takers, became directly subject to fluctuating exchange rates, demand and transport costs and cannot rely on local industries to take their wood.

Rates of new planting: Before the demise of the NZFS in 1987 new tree planting was about 40 000 ha/yr supported by Government policies. This halved by 1992. However, there was a sudden surge of new planting between 1992 and 2000 peaking at 98 000 ha in 1994. This sudden rise was due to widespread planting of commercial trees on farms because of a spike in wood prices (Evison 2016) that boosted people's expectations. As a result, 14 000 owners currently own 27% of the plantation area and most of them have less than 40 ha (Ministry for Primary Industries 2019). When wood prices dropped after 2000 new planting stopped but the 2019 provisional figures show it has increased again. The total plantation area actually decreased, most notably from 2005 to 2007, because of conversion to dairy farms
.

Advisory services: The NZFS and NSWCO supporting farm forestry with advisory services to farmers. However, with the Government reforms these advisory roles had disappeared by 1990 (Hosking 1990; Eyles 2014). The NZ Farm Forestry Association (NZFFA) partly filled this advisory role – currently it has 25 branches and 8 speciality interest groups. The NZFFA membership peaked at 4700 in 1995 but as interest in farm forestry decreased membership has dropped to 1500. Nevertheless, the NZFFA with its enthusiastic, innovative leaders, field days, Conferences, and New Zealand Tree Grower magazine continues to promote trees on farms.

Billion tree programme: In a surprising move in 2018 the new Coalition Government re-established a small forest service (Te Uru Rākau) and aims to plant a billion trees over the next 10 years, 60% with native trees (Collins, 2018, 2019). This programme includes financial assistance to small growers; this has not been available except for some restricted erosion control areas, since 1984. The main driver behind this tree planting programme is to mitigate greenhouse gas emissions, but also to increase biodiversity, erosion control and employment. New Zealand has an Emissions Trading Scheme which makes growing of trees to capture CO_2 much more attractive.

Land-use changes: Since 1980 dairy cow numbers in New Zealand have increased from 2 million to 5 million, milk production has risen three times and dairy farm area has increased from <1 M ha to 1.75 M ha (LIC and DairyNZ.2019). This is largely due to a switch away from sheep farming but there has also been some conversion of forest land. This land-use change has led to increased pollution of waterways and groundwater aquifers. The dairy industry has responded by increased riparian planting of waterways. Where irrigation is employed this has often led to removal of windbreaks that were a major feature of dryland sheep farming.
Another recent land-use change has been the establishment of mānuka plantations (*Leptospermum scoparium*) for honey and oil production (McPherson 2016). Traditionally mānuka was as an impediment to pasture farming. These plantations look financially attractive.
Covenanting native vegetation into trusts is seen as a way of preserving their values (Mead, Millner and Smail1999). For example, the QE II National Trust has over 4425 covenants protecting 180 000 ha of private land (Bythell2018).

Research: Research is essential to develop sustainable agroforestry systems. For example, grazing under low-stocked pruned radiata pine was promoted in the 1980s and 1990s but intensive research showed this was not viable (Mead 2013). The Government business model for research institutions disadvantaged agroforestry research and led, for example, to the abandonment of willow and poplar research (Eyles 2014). In 2014 a levy was imposed on harvested wood to support research and the NZFFA is represented on allocating these funds (Thompson 2019). Much of the research funding will indirectly assist farm foresters with a small amount allocated to alternative species that are of special interest to farm foresters.

Government policies: New Zealand does not have a national forest policy and this is a major weakness that has affected decisions (McEwen 2013). More recently it has passed a strong climate action law. Clean freshwater and biodiversity policies are currently being strengthened. The Resource Management Act is also under review. All these policies impact on farm forestry.

Policy implications: Farm forestry requires strong Government leadership, well accepted national policies, strong advisory services, and greater research support. The lack of these has hampered farm forestry in New Zealand for 25 years. The recent harvesting levy, the re-establishment of a state forestry service, bold tree planting goals, and policy commitments to climate mitigation, water quality and biodiversity, should boost farm forestry/agroforestry in New Zealand.

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Agroforestry in the CAP: an analysis of RDP support in Italy

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Policy

Keywords: Agroforestry, Italy, RDP, sub measure 8.2, cross-compliance, greening

Abstract

The European Union recognises the strategic role of agroforestry systems to pursue the Agenda 2030's goals and for adapting to climate change. For this reason, in both the previous and the current programming periods, the Common Agricultural Policy (CAP) has supported and encouraged agroforestry systems through both Pillars.

The Rural Development Programmes (RDP) have financed agroforestry both directly (through measure 222 in 2007-2013 programming period and sub-measure 8.2 in 2014-2000 programming period) and indirectly, by supporting agroforestry actions and practices (sub-measure 4.4 and measure 10). Agroforestry systems have been also encouraged by Pillar I, where specific requirements have been established in the framework of cross-compliance (Reg. CE n. 73/2009 and Reg. UE n. 1306/2013) and for *greening* practices (art. 43 Reg. UE n.1307/2013). With regard to *greening*, for example, agroforestry areas that receive, or have received, support from sub-measure 8.2 could be included as Ecological Focus Areas (art.46 Reg. UE n.1307/2013).

Despite the increasing attention to agroforestry within the CAP, in Europe the implementation of the related RDP measures (measure 222 in 2007-2013 and sub-measure 8.2 in 2014-2020) has been rather unsatisfactory.

The research analyses and compares several decisions made by the Italian Regions (NUTS2) about the sub-measure 8.2 (art. 23 Reg. UE 1305/2013 on the establishment of agroforestry systems), by analysing the different implementation methods, the funds allocated and the results achieved. Despite the increasing recognition of the strategical role of agroforestry for the achievement of environmental and climate goals, in terms of the planned funds, in Italy the sub-measure 8.2 was the least funded among the forestry sub measures. Its execution obtained a very limited success, with a very few numbers of calls and applications. The analysis also shows the potential role of such measure where combined with the obligations of greening and cross-compliance, also in the light of the new CAP proposals for the 2021-2027 programming period, which includes a greater political commitment to achieving environmental, biodiversity and climate objectives.

Preliminary results help to better understand not only the main limitations of the design and implementation of sub-measure 8.2, but they also allow to formulate some policy recommendations on how a dedicated RDP measure on agroforestry could give concrete (economic and environmental) advantages to farmers, especially to comply with the more ambitious requirements of direct payment in the future CAP.

Agroforestry Options in the next CAP

EURAF 2020

Agroforestry for the transition towards sustainability and bioeconomy

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Theme: Agroforestry and Policy for Sustainable Development

Keywords: CAP, Rural Development, Climate, Green Deal, Strategic Plans, Subsidiarity

Introduction

Agroforestry (AF) is recognised by the International Panel for Climate Change (IPCC) as a land use giving the triple-win of increased productivity, climate resilience and carbon capture [1]. This becomes, at least, a quadruple-win when the benefits of agrobiodiversity, ecosystem services and fire-risk reduction are added [2,3]. The potential of AF was also recognised in the EU's 2050 strategic long term climate vision [4], which stated …

> *Farmers are increasingly seen as providers of resources and providers of essential raw materials. There are new business opportunities through the circular bio-economy. Better farming systems, **including agroforestry techniques** that efficiently use nutrient resources exist, enhancing not only soil carbon but also biodiversity and improving resilience of farming to climate change itself.*

Agroecology and agroforestry were also identified as key sustainable agricultural practices in the European Green Deal [5], which committed at least 40% of the Common Agricultural Policy's budget to climate action, and added…

> *The Commission will work with the Member States and stakeholders to ensure that from the outset the national strategic plans for agriculture fully reflect the ambition of the Green Deal and the Farm to Fork Strategy. The Commission will ensure that national CAP Strategic Plans are assessed against robust climate and environmental criteria. These plans should lead to the use of sustainable practices, such as precision agriculture, organic farming, agro-ecology, **agroforestry** and stricter animal welfare standards.*

Similarly, part of the European Parliament resolution adopted prior to the UNFCCC COP25 (para 79) says

> *... while agriculture is responsible for around 10 % of the EU's GHG emissions, it has the potential to help the EU reduce its emissions through good soil management, **agroforestry,** the protection of biodiversity and other land management techniques; recognises that agriculture has the potential to make annual emission savings of about 3,9 gigatonnes of CO2 equivalents by 2050 – around 8 % of the current global GHG emissions;*

Recent studies have confirmed the high carbon-sequestration potential for agroforestry [6–8], and it is being considered within the current DG-CLIMA "Carbon Farming Initiative" [9]. Much more data is required, however, and from a wider range of mature agroforestry systems.

Agroforestry and agroecology are very high on the EU's agenda for the CAP (2021-2027). The establishment of new agroforestry systems is supported in the current CAP (2014-2020), and to a lesser extent, was supported in the previous CAP (2007-2013). Uptake by farmers was disappointing however, and the Mid-Term Review of the success of CAP forestry measures across Member States [10] concluded:

> ***Agroforestry** is an important potential tool for the implementation of new management practices. It could provide new economic opportunities in marginal farming areas, deliver significant additional ecosystem services and biodiversity benefits (EQ6), and lead to better adaptation of farming systems to climate change. In the evaluator's opinion, **its importance may rise in the coming years, provided that a sufficient level of incentive is included in the premium and technical advice is readily available.***

A discussion document on CAP policy issues has therefore been produced by EURAF , which is summarised here.

Definitions. For policy purposes agroforestry needs a very simple definition. The current current Rural Development Regulation is adequate: *"**Land use systems in which trees are grown in combination with agriculture on the same***

land". Thus, Member States (MS) should encourage agroforestry on **both** agricultural and forest land. Controlled grazing on parts of forest land is increasingly vital to reduce the risk and intensity of fires.

Pillar i Conditionality. Agroforestry contributes to most of the Pillar I requirements for "Good Agricultural And Environmental Conditions" especially GAEC 1,4,5,6,7,9. MS should all mention agroforestry in their "Conditionality Rules"

Pillar i Ecoschemes. EURAF proposes a "light-touch Agroforestry and Landscape Feature Ecoscheme" to establish small areas of trees outside forests, and to contribute in a significant way to GAEC-9 (regional targets for a minimum % area thresholds for "Landscape Features and Non-Productive Areas" - GAEC9). MS should implement agroforestry ecoschemes accessible to all farmers

Pillar I Basic Payment eligibility. DG-AGRI instructions are that "*MS have the leeway to ensure agricultural area under agroforestry is fully eligible for payments, when justified based on the local specificities (e.g. density/species/size of the trees and pedo- climatic conditions) and the value added of the presence of trees to ensure sustainable agricultural use of the land.*" MS should publicise and use this flexibility

Pillar II Agri Environment Climate Schemes (AECM) are currently constrained by DG AGRI's over-literal reading of GATT (1994) rules. AECM schemes should bring higher payments for farmers that use the "light-touch" ecoschemes. Currently, AECM payments are limited to costs and income forgone. This is damaging: it suggests that agroforestry reduces incomes, when in fact it usually boosts them, and it unnecessarily prohibits payments by results - e.g. per tonne of carbon in modelled reductions in GHG emissions. MS should make AECM payments to farmers and farmer groups who undertake management contracts for long-term "*Carbon Farming with Agroforestry*".

CAP Reporting and Result Indicators. AF contributes to almost all the proposed Result Indicators (see presentation at annex). Therefore, Result Indicator 17, "*Area of Land Afforested*" should be renamed "*Area of Land Afforested and Agroforested*". Because agroforestry on agricultural land will remain classified as agricultural land, and is not afforestation. MS should report agroforestation separately to afforestation in RI-17.

Legislative Frameworks. Some countries have fully or partially excluded Pillar II support for forestry from the CAP. This trend stops forestry and agriculture being planned and reported on in an integrated way (e.g. Report Indicators are only to be used for measures in the CAP). Commission guidelines for the MS Strategic Plans should specify that proposals for significant agroforestry support measures must be included. Much greater transparency and spatial detail is needed in the LULUCF reporting of Member States. The LULUCF Regulation "recommends" that MS should use the IPCC "Approach 3" method to identify land use in their annual UNFCCC reporting. This involves 'wall-to-wall tracking of parcels and their land-uses. Most MS are using CAP-LPIS parcel data for this purpose and could make small-scale data from these emissions calculations available to farmers through LPIS GIS systems. This local-scale data could form the basis of AECM schemes implemented by groups of farmers assisted by consultants.

Research and extension. Research results from H2020, and extension results from LIFE and Interreg projects are crucial to help farmers understand the impact of agroforestry on crops and animals. The GAEC-5 Farm Sustainability Tool (FaST) is an excellent opportunity to link research with farming practice and should be extended to include the spatial impact of trees, using results from H2020 projects.

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Measures of adaptation and mitigation in forestry and rural areas from the perspective of the Regional Strategy on Climate Change

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and policy for sustainable development

Key words: contrast, Rural Development Program, adaptation, mitigation, strategy

Abstract

The functions of Italian regions for combating climate change is recognized by the Paris Agreement, international reference document for combating climate change. The regional authorities have a decisive role on the climate issue: they are the subjects with planning, legislative and regulatory powers, as attributed to it by the Constitution and by the Italian State. At the base of the functions listed above there is also a good knowledge of the territory. The Piemonte Region has started work on combating climate change with an address to the offices for the preparation of the Regional Strategy on Climate Change. For the drafting of the document it formalized the constitution of an interdirectional technical group that works with the support of Arpa Piemonte. The forestry and rural areas are also represented in the Working Group, composed of officials from various regional departments, considered the role played by forests and agroforestry in the fight against climate change.

There are two lines of action to tackle climate change on a global level: mitigation and adaptation. These measures are complementary to each other: on the one hand, we act on the causes to prevent the risks that climate change entails and on the other on the effects. Mitigation consists mainly of reducing greenhouse gas emissions from human activities and slowing their accumulation in the atmosphere, while adaptation focuses on reducing territorial and socio-economic vulnerability to climate change.

In November 2020 the Piemonte Region approved the first Address Document "Towards the Regional Strategy on Climate Change". The implementation of the Regional Forest Plan, whose general objectives are focused on the protection of Piemonte forest resources and sustainable forest management, helps to reduce the impact of climate change. The resources deployed, over the ten years of validity of the plan, are mainly related to the European structural funds.

The Regional Forest Plan enhances also the identity of mountain territories and rural areas. There are four priority areas for intervention and financing: production-economy-market, environment and public functions, social aspects, governance.

Among the main tools provided by the Regional Forest Plan to achieve the numerous objectives identified, there is the implementation of the Measures of the Rural Development Program. Many measures of the Rural Development Program are key to both adaptation and mitigation strategies: for forests the main one is Measure 8.

This tool contributes to improving the sustainable competitiveness of enterprises and operators in the forestry sector, to preventing and restoring phytosanitary and environmental damage related to climate change. The operations of Measure 8 also contribute to supporting the restoration, maintenance and improvement of natural biodiversity and the landscape and finally, the Measure 8 contribute to spreading forestry practices suitable for increasing carbon sequestration. Other Measures (Measure 16, divided into several operations and focused on cooperation) concur and some can contribute in a transversal way (Measure 1, divided into several operations and focused on training, information and communication) to the two lines of action "adaptation" and "mitigation".

Another fundamental tool for forestry policies and climate-related strategies is undoubtedly represented by the regional guidelines for joining the voluntary market for forestry carbon credits and the definition of a procedure for determining, accounting, validating and marketing carbon credits from forestry in Piemonte.

Cooperation projects for the implementation of Piemonte Region Rural Development Program 2014-2020 - Measure 16

EURAF 2020
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Theme: Agroforestation policies

Keywords: innovation, cooperation; management; territory, climate action, rural areas;

Introduction

The Piemonte Region with its partecipation in EURAF 2020 intends to inform the public, beyond its borders, about the activities promoted in the frame of the measure 16 of the Rural Development Program. The Measures of the 2014-2020 RDPs are a useful tool to implement the regional forestry policies. The Regional administration underlines that the strength of M16 is the cooperation between stakeholders. Each funded project then has the following specific objectives: fostering the competitiveness; ensuring the sustainable management of natural resources and climate action; achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment. The results achieved by the cooperation contribute to the implementation of regional forestry policies. Finally, the Piemonte Region intends above all to promote the dissemination of the applied methodologies and the expected results of the following projects linked to agroforestry: #Castagnopiemonte and Food For Forest

Measure 16 and regional policies

The implementation of the Measure 16 (2014-2020 RDP) is one of the tools provided by Piemonte Region to preserve the forest resources through an active and sustainable management strategy, combining economic development with environmental protection. Innovation projects and pilot projects are funded respectively in operations 16.1 and 16.2. These actions support: - fostering knowledge transfer and innovation in forestry and rural areas, - enhancing the viability and competitiveness, - promoting resource efficiency and supporting the shift toward a low-carbon and climate resilient economy in the forestry sectors. The methodology supported by the Region essentially consists in the implementation of cooperation projects between two or more public and private stakeholders that constitute cooperation groups (forest companies, researchers, consultants, environmental associations).

The "#castagnopiemonte" project

The #castagnopiemonte project supports the competitive, sustainable, integrated and multifunctional development of the regional chestnut sector. The cooperation between the project partners and local companies has favoured the transfer of research products for the innovation of the crop, preserving the multiple values of traditional chestnut cultivation.

To improve the R&D strategies and policies in chestnut cultivation and to further develop the chestnut industry, the Piemonte Region with the University of Torino, Dept. of Agriculture, Forestry and Food established in 2005 the Chestnut Regional Centre, located in Chiusa Pesio (Cuneo Province). The Region supports the Centre with human resources and structures (nurseries, land). The main activity of the Centre is R&D in several fields, including chestnut germplasm conservation, advanced propagation techniques, optimization of cultural practices, pest and diseases management. The Center, thanks to the project #castagnopiemonte implemented the dissemination and extension service activities.

In the Centre, a germplasm collection of chestnut genetic variability has been established on a 3 ha surface. Main local and national cultivars are included, with several European varieties from Portugal, Spain, France, Switzerland and other accessions from U.S.A., China, and Japan. The collection is in progress and will be completed in the next years. A technical newsletter published in English and Italian informs researchers, technicians and growers periodically (https://centrocastanicoltura.org/en/magazine/). The Centre is today a national conservatory of the chestnut biodiversity and a reference for research and development activities on *Castanea* species.

Thanks to the #castagnopiemonte project the Center activities were implemented, also involving new stakeholders such many companies conducing pilot tree-climbing pruning in some regional chestnut orchards. Thanks to the #castagnopiemonte project, many private regional companies were also involved into chestnut forestry and wood innovative utilisations. Appropriate management models for coppices are studied, the best soils for timber production are identified, and the more suitable and innovative utilisation for chestnut wood are investigated on the basis of their market potential.

Many dissemination actions[1] are carried on, such as the magazine CASTANEA, a councelling service, open days and technical courses for chestnut growers.

Food For Forest

'Food For Forest' pilot project envisages the use of pig grazing in forestlands as a silvicultural tool to: control understorey weeds; promote the growth and renewal of high-quality timber species; reduce the burnable biomass. The project is carried out in the woodlands of Turin, Chivasso and Casale hills where hydrogeological instability and silvicultural management issues occur. The following results are expected: i) to improve woodland accessibility for forestry operations so to increase economic sustainability; ii) to start an appropriate silvicultural management of highly degraded stands; iii) to eradicate Virginia creeper plants which are encroaching large abandoned areas and host Scaphoideus titanus, vector of grapewine flavescence dorée phytoplasma that causes serious damage to viticulture and may spread from neighbouring wooded areas. Last but not least, the project aims at obtaining high-quality pork meat from the pigs fed the rough feed they can forage in abandoned woodlands. The Operational Group is made by the Land Association Cornalin, the University of Turin - DISAFA, the Municipalities of Cella Monte and Sala Monferrato (AL), two farms "La Casaccia" (winery) and "Parva Domus" (pig farmer), the forestry company Ferrari Boris and a consultancy and design company in the environmental field (SEACOOP). For further information on the project watch "New life in the woods with pig grazing" on Youtube (https://www.youtube.com/watch?v=pGz_FM4X7k0&feature=youtu.be).

1 website: https://centrocastanicoltura.org; Email: info@centrocastanicoltura.org; Twitter: https://twitter.com/hashtag/castagnopiemonte,Facebook:https://www.facebook.com/castagnopiemonte

Agroforestry in the Czech Republic – history, present state and perspectives

EURAF 2021
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Policy

Keywords: alley cropping; CAP; farmers perception; grazed orchards, silvopastoral; woody pastures

Abstract

The main objective of this study was to review the historical background, the current state and the future perspectives of AF in the Czech Republic.

History

In the history, AF was a very common practice in forests, but also AF on agricultural land used to be a common land use. Various forms of AFS were all attuned to natural and cultural conditions: with more intensively managed fruit trees on pastures and meadows (fruit AF) in the proximity of highly developed lowlands with fertile soils; and trees for wood production (wood AF) in mountainous and mainly forested regions. However, by the end of 19th century no written signs of AF in the official literature could be found. The agricultural intensification led to: (i) the substitution of orchard agroforestry with large-scale intensive production on fertile soil, (ii) the abandonment of less fertile areas of silvopastoral systems (particularly at higher elevations) and their change to productive forest. Further on, during the era of communist collectivization (1945-1990), the remaining trees were gradually removed from agricultural land.

Present state extension

According to the current classification of AFS in Europe (Dupraz et al. 2018), five major categories with eight subcategories of AF practices were identified in Czechia. According to data from LUCAS database (methodology described by den Herder et al. 2018), the estimated area of AFS in the Czech Republic 35,750 ha (less than 1% of utilized agricultural area), which was solely represented by silvopastoral AFS, particularly by established forest trees on pastures, here classified as wood pastures (30,030 ha, 84% of total agroforestry area) and grazing under fruit trees, classified as orchard grazing (5,720 ha, 16%).

The farmers' motivations and barriers for AF adoption

The results from focus group discussions and farmer survey (488 participants) show relatively high interest in AF among Czech farmers, as most of them has some experience with tree growing on their farm and high number of farmers (nearly 80%) would like to establish AFS. Silvopastoral AF would be preferable by 54% of farmers and 26% of farmers would rather opt for silvoarable AF. When asked about their expectations of the benefits of AF establishment on their farmland, most farmers agreed on the beneficial function of trees in microclimate improvement (76%), erosion control (71%), the overall biodiversity

conservation and pest control (50%) (Figure 1a). These functions are linked with an expected improvement of farming image (60%). Concerning productive role of trees, only 32% of farmers expected the adoption of AF to be economically beneficial. Looking at the major concerns connected with AF (Figure 1b), the majority of participants stated that AF establishment and management would involve higher labour requirements (73%), while agreeing in low return on this investment (68%). The biggest concern, however, lies in the bureaucratization of the process of AF establishment under the current legislation (79%).

Future perspectives of AF under new CAP

Agroforestry will be included in the National CAP Strategic Plan and The Czech Ministry of Agriculture is therefore proposing a new AF measure (one of the Agri-Climate-Environment Measure) to support establishment and maintenance of AFS, similar to the previous Article 23/Measure 8.2 support. Two categories are proposed for support: (i) silvoarable systems (80-100 of forest or fruit trees per ha grown in alley cropping design on arable land); and (ii) and silvopastoral systems (80-100 scattered trees per ha on pastures). Financial support will be for the establishment, and maintenance during the first five years.

Conclusion

We foresee the future development of AF in the Czech Republic as following these trends:

(i) Maintenance of traditional AFS, for their high nature and cultural values, could be supported under already existing schemes.

(ii) Only two AFS will be eligible within the future Czech National CAP Strategic Plan for financial support (silvopasture and alley cropping).

(iii) More outputs of research/training/demonstrations could be expected in the future, which may lead to a slow equilibration between silvopastoral and silvoarable systems.

(iv) AF needs clear political support to be included in various strategies, regulation and support measures, to create positive as well as negative incentives for farmers.

We suggest that the creation of systematic support beyond subsidies, such as raising awareness, research, improving policy, legislation and training for different types of AF, is a key in development of agroforestry.

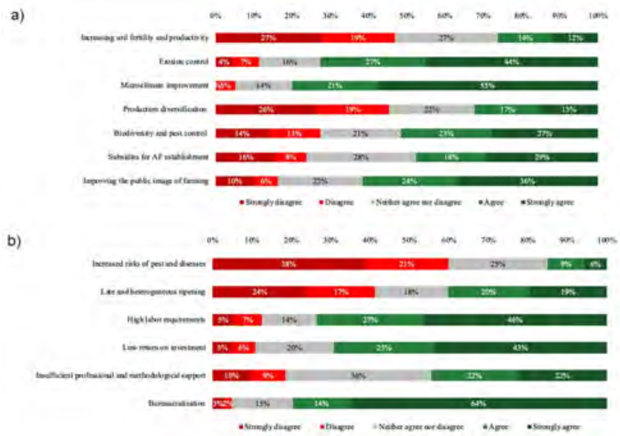

Figure 1. Farmers' a) expectation from and b) concerns about the establishment of AFS.

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Post Nijmegen: what happened to agroforestry policy in the Netherlands after the 2018 EURAF Conference?

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Policy

Keywords: Nature inclusive farming, rural development, land use, legislation, knowledge transfer, climate mitigation, climate adaptation

Abstract

_Introduction
The 2018 EURAF Conference took place in Nijmegen, the Netherlands, as the city was elected as European Green Capital. Since then, the attention for agroforestry increased a lot among policy makers. During the conference, a statement (EURAF 2008) was written with input from all 250 participants of the conference. The statement points out the role of agroforestry for mitigating and adapting to climate change and the transition towards this sustainable land use type should be accelerated. Following the statement and other societal movements, in 2019, The Dutch Ministry of Agriculture, Nature and Food (LNV) requested a plan for the implementation and upscaling of agroforestry in the Netherlands. This was an important step, as agroforestry was not yet defined in agricultural policy or acknowledged as a land use type. In this abstract the motive and circumstances, the design process the rough outline of the advice for this agroforestry plan are described.

The motive of the government for requesting a national plan for the upscaling of agroforestry, came from the problem of climate change. In the process of formalizing a climate deal (www.klimaatakkoord.nl), the government organised round table discussions about climate change ('klimaattafels'). During the round tables discussions the realization of 25.000 ha of agroforestry was mentioned as one of the measures to mitigate climate change. Therefore, the upscaling of agroforestry was recorded in the Dutch climate deal as one of the measures for climate change mitigation and adaptation. Also the Dutch minister of agriculture Carola Schouten, mentioned agroforestry in her vision and realisation plan of the future of Dutch agriculture for closing nutrient cycles (LNV 2019). These were the first official Dutch policy documents that mention agroforestry as a type of land use. Therefore, the question was raised on what agroforestry is and how agroforestry can be implemented and scaled up in the Netherlands.

_Method
A team of agroforestry pioneers and researchers came together to explore the steps needed for the upscaling of agroforestry. Based on literature and experiences, five themes were defined which play a crucial role in the development of agroforestry: knowledge & research, legislation, education & training, policy & land use and finance & supply chain. Subsequently, all team members conducted surveys among stakeholders, asking stakeholders about the opportunities and barriers for agroforestry in The Netherlands. The findings of Borremans (2019) in Flanders were also valuable input. During a stakeholder

meeting the first findings were shared and further updated. This resulted in a SWOT-analysis. Based upon this, the team formulated an advice for a national agroforestry program. A first draft of the plan was presented at the ministry and adjusted to the questions and remarks raised during the meeting.

Results

In order to reach 25.000 hectares of agroforestry in the Netherlands, the team advised the Ministry of Agriculture to set up a national agroforestry program (Luske et al. 2020a). The program should focus on the development of different types of agroforestry like silvopastoral and silvoarable systems in different regions of the country. In short, the team advised to develop opportunities for agroforestry in several regions and sectors and to combine this with scientific monitoring and a national online knowledge platform for agroforestry. On top of that, the advice is to focus on taking away the barriers for agroforestry (Table 1). In 2020, the legal-financial barriers for farmers that hamper tree planting were examined (Luske 2020b). The study reveals that crop registration in the Netherlands is not ready yet for agroforestry and that more tree species and higher number of trees should be allowed on agricultural land. We can benefit from the experiences in for instance Flanders. At the moment, resources are explored for starting a national agroforestry program in the Netherlands. How the program will be formalized is under debate yet. Certain is that also the forestry departments are interested in agroforestry, as it may help to reach the forest planting goals ('Bossentrategie').

Table 1. SWOT-analysis Agroforestry in the Netherlands

	Strengths	**Weaknesses**
Internal analysis	-Corresponds to the vision of the recent minister Schouten of agriculture -Acknowledged in CAP and science as a land use type -High land use equivalent ratio (LER) -Addresses long term sustainability of land use -Implementation possible in many ways and regions	-Lack of mature agroforestry systems in the country -Knowledge intensive -Knowledge and initiatives are diffuse and scarce -Labor is an uncertain and expensive factor in agroforestry systems -Suitable techniques and mechanization are not available yet -Long term investments are needed for implementation -No formal education available -Agroforestry is not applicable in all landscapes (peat soils and polders)
	Opportunities	**Barriers**
External analysis	-Agroforestry could connect several societal issues (climate change adaptation and mitigation, restoration of biodiversity and landscape etc.) -Agriculture and nature are growing towards each other in society -Designing climate adaptive and biodiverse regions with agroforestry -Growing interest of students and farmers -Expand and link agroforestry with existing tree planting programs -Develop a system for payments of ecosystem service (PES)	-In Dutch policy, agroforestry doesn't exist yet -Legislation is a bottleneck -Agroforestry is often not known as a land use type among land owners -Agriculture and forestry are two different 'worlds'

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Agroforestry in Switzerland – current research focus and policy developments

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Agroforestry and policy for sustainable development - Policy

Keywords: Resource protection, soil, water, biodiversity, climate

Abstract

Switzerland, as a non-EU country, has an individual Federal Government Agricultural Policy. This aims inter alia to provide agricultural ecosystem services, reduce environmental impacts, and increase the resilience of the agricultural sector. In comparison to EU proceedings, the new Swiss agricultural policy starting in 2022 (AP22+) is currently on debate (BLW 2018). Agroforestry – the integration of trees and hedges into agricultural production - will be eligible for direct payments, as it can contribute to achieve the overall goals without substantially limiting agricultural production.

Agroforestry systems are well-known, widely established, and financially beneficial in Mediterranean countries even nowadays (Kay et al. 2019a). Contrastingly, in Switzerland mainly traditional agroforestry systems such as fruit orchards, wooded pastures, and chestnut groves remained (Herzog et al. 2018). These systems are mostly unprofitable, but highly substituted for aesthetic, cultural, and biodiversity reasons. Modern agroforestry systems e.g. alley-cropping, fodder hedges, wooded pastures promise to combine environmentally friendly agricultural production while being rentable and therefore attractive for farmers.

Even though this sounds very promising, many questions remain. On the one hand, there are practical questions such as "What does a good system look like?", "Which local conditions (soil, water, etc.) need to be taken into account?", and "What is an optimal and fully rentable management?" On the other hand, there are scientific research questions such as "What are the environmental benefits of each system? And how to quantify them?" To answer this cluster of open queries, an applied research project was launched with special focus on Swiss climate, policy, and market conditions (Schoop et al., 2019).

In view of this, several federal administrations (cantons Vaud, Geneva, Neuchatel, and Jura), farmers, and researchers are willing to establish up to 240 ha of modern agroforestry systems in western Switzerland covering the whole range of agricultural – arable and livestock – production. With the aim to measure environmental effects, we started the process by identifying regions where environmental pressures (as defined by the Agricultural Environmental Objectives; BAFU and BLW, 2016) occur and where agroforestry systems can contribute to reducing these impacts. Eleven national deficit maps for the environmental sectors of biodiversity, landscape, climate, air, water, and soil were analysed (Kay et al. 2019b). Specifically, we focussed on regions with soil loss, nitrate and phosphorus surplus, reduced honeybee pollination and pest control potential, corridors for wild animals, water buffers and extreme climate exposure such as temperature rise and precipitation changes. Areas where those deficits exist were selected as potential agroforestry plots. In a second step, agricultural extension services, consultants, and regional advisors will be trained to support farmers in designing and managing optimal agroforestry systems, which are adapted to the present deficits. Within the following 8 years, the applied

research project will monitor economic, environmental, and social impacts of these new agroforestry systems.

In conclusion, the project will provide a deeper insight in what is practically feasible within Swiss agricultural production. It will demonstrate the limits and the benefits for farmers and society. In addition, it will help to quantify to what extent Swiss environment can benefit. Are the environmentally promising ideas of sustainable intensification realistic? If not, where are the drawbacks? In the end, hopefully, it will enable us to develop strategies geared to local conditions and to environmental targets and can be integrated into future Federal Government Agricultural Policy.

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Towards Net Zero Carbon: Developing High-resolution Farm-Level Carbon Inventory Maps

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Policy or Climate change (adaptation and mitigation)

Keywords: Net-zero carbon, carbon, spatial, farm management

Abstract

In order to minimise the effects of climate change, the UK Government has legislated that the country will achieve no net emission of greenhouse gases by 2050, which is commonly termed "net zero carbon" (UK Government 2019). Organisations such as the UK National Farmers Union have indicated that net-zero emissions should even be achieved more quickly by 2040 (NFU 2019). Although the policy mechanisms to achieve this are still being developed, farmers and policymakers will need improved ways to simply and robustly calculate how much carbon is stored on farmland and how different land uses affect storage and sequestration.

The development of farm-level carbon management plans could be a very effective results-focused measure for promoting the uptake of agroforestry on farms (See Recommendation 12 in Mosquera-Losada et al. 2017). Such plans would provide a way for landowners to calculate how their businesses are contributing to net-zero emissions and provide a basis of business certification and potentially sale of carbon credits. Hence, we have been proposing to policymakers that each landowner should receive governmental support to prepare a spatial inventory of farm carbon storage. Such an inventory would also help bring the disciplines of agriculture and forestry together.

Our presentation describes the initial results of a PhD project that aims to review, develop, apply and evaluate scalable and robust methods for creating high-resolution 3-D maps and models for below and above ground carbon stocks for potential use by farm and landscape managers in the UK. The proposed four-stage approach to estimate above and below ground carbon stocks can be seen in Figure 1.

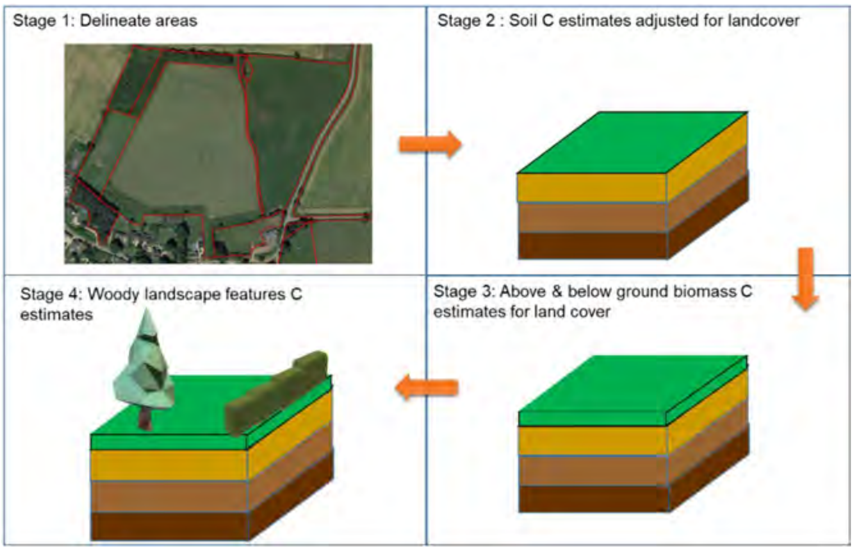

Figure 1. Four-stage proposed approach for carbon stock estimation

In a literature review, we identified existing methods of mapping farms and modelling farm carbon storage. Although there are tools to describe farm-level greenhouse gas emissions in a non-spatial way such as the Cool Farm Tool (Cool Farm Alliance 2020), and the Farm Carbon Calculator (Farm Carbon Toolkit 2000), there are few high-resolution tools that can provide a spatial inventory of farm carbon.

The first step in our approach is to delineate components of the farm area (Figure 1 stage 1). Each farmer in the European Union has to report crop areas annually using the land parcel identification system (LPIS) (European Court of Auditors, 2016) which has been developed using satellite or aerial photographs. The data have been used in the UK to develop field management tools (The Land App 2020).

On-farm carbon storage occurs both below ground (soil carbon and roots) and above ground (crops, woodland, and landscape features such as hedgerows and trees). There are datasets of measured values of soil organic carbon (SOC) in England and Wales and these can be used to create spatial soil organic carbon (SOC) maps that account for the effect of depth, soil type and land cover (Figure 1; stage 2). Estimates of the impact of land cover on above- and below-ground biomass carbon can be developed using look-up tables derived from collations of reported data similar to those developed by Cantarello, Newton and Hill (2011) (Figure 1; stage 3). Lastly the extent of landscape features can be partly derived from LIDAR data, and the amount of carbon stored can be estimated using experimental measurements from agroforestry sites (Fornara et al., 2017; Upson and Burgess 2013, Upson et al 2016) and hedgerows (Axe, Grange and Conway, 2017) (Figure 1; stage 4). During 2020 and 2021, we are applying this approach to case study areas where the predicted results will be compared with local measurements, with the aim of developing a scalable approach to develop rigorous spatial fam-scale carbon inventories.

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Main foundations of the afforestation strategy in Ukraine

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Theme: Policy [WG Agroforestry and policy for sustainable development]

Keywords: agro-landscape, amelioration impact, erosion, legislation, protective forest plantations.

Abstract

The environmental situation in the regions of Ukraine is influenced by a number of reasons, among which the most characteristic are the insufficient area of forests and protective forest plantations, irrational structure of land use of agricultural landscapes, intensification of erosion processes, reduction of soil fertility, pollution of water and air, reducing the diversity of flora and fauna.

Agricultural land occupies 70% of the territory of Ukraine, of which arable land - about 33 million hectares or 80% of their area [1]. The huge plowing of the territory led to the development of erosion processes in large volumes. Thus, annual soil losses are 600 million tons, humus - about 20 million tons, water - 15 billion m^3. Annual losses of net income from agriculture reach nearly $ 3 billion [3].

The current volumes of afforestation are low, carried out systemless and fragmented, and therefore cannot significantly increase the forest cover of country. After the land reform, as of January 1, 2008, there were 318.1 thousand hectares of windbreaks on the lands of the settlement councils, and 115 thousand hectares in the field of management of the Ministry of Agrarian Policy [4].

In the windbreaks located on the lands of the settlement councils, protection, care and reproduction are not carried out, which leads to the impossibility of performing the plantations of their protective functions. Due to the thinning of the plantations with illegal felling, the processes of soil retardation and compaction are developing, the appearance of overgrown and shrub vegetation. Often, windbreaks become cattle grazing sites, garbage dumps, weed nurseries, fires of stubble, etc. Lack of forest care causes the windbreaks to lose their protective properties. The problem is compounded by the fact that the state inventory of these plantations were carried out only at the end of the last century.

In this regard, the urgency of afforestation in Ukraine is very high, but its successful solution is preceded by a number of complex issues. First of all, there is no cadastral land assessment that could determine the feasibility of transferring land for forest cultivation; targeted land transfer is not regulated by law for the creation of protective forest plantations. There is no appropriate regulatory framework for the assessment of land suitable for forest cultivation, which makes it impossible to draw up a Master Plan for the creation of systems of windbreaks and other plantations, there is no legal support for the motivation and financing of forestry works, regardless of the form of land ownership.

The theoretical and methodological basis of forest cultivation is the doctrine of the pertinent (space) impact of the forest, which is able to extend both in the area occupied by forest plantations and adjacent areas, which provides reliable protection of agricultural land, promotes the formation of sustainable and highly productive agro-landscapes. Forest plantations can operate above, deeper, further than any other plant community. The basic provisions of the forestry strategy are as follows.

The priority tasks of afforestation are to carry out a full-scale inventory of protective forest plantations in all categories of land, in particular windbreaks, to obtain objective information on their conservation, current status, reclamation efficiency and the need for forest management activities. It is necessary to scientifically substantiate the volume of forest cultivation, having started the creation of timber land reclamation complexes according to the catchment or landscape principle. The main priority of steppe afforestation should be to create afforestation in the eroded areas where they are most needed, as well as on steep slopes, beams, banks and floodplains of rivers, ravines and loose sands. From this point of view, it is advisable to develop a general scheme of amelioration land improvement of the territory.

The strategy of afforestation development in Ukraine envisages the creation of a complete system of windbreaks, new forests on the lands of the country, regardless of ownership, as a mandatory component of national and other environmental conservation programs.

The legal basis for implementing the provisions of the afforestation strategy is the ratified international conventions: the Convention on Biological Diversity, the Pan-European Strategy for the Conservation of Biological and Landscape Diversity, the European Landscape Convention as well as Forest Code of Ukraine, Concept of Agroforestry Development in Ukraine etc [2].

In the Steppe, afforestation should be carried out on an area of 838.1 thousand hectares (57.8%) with dominated by linear plantations. An important component of the strategy is the development of recommendations for the improvement of afforestation on land withdrawn from agricultural use in the Polissia and Forest-Steppe, the development of methods and technologies, the search for technical means for planting and cultivation of target forest plantations of various purposes - forestry, sanitary-hygienic, landscape, water and soil conservation etc. Mapping and aerospace monitoring of the state, development and optimization of agro-landscapes with forest land reclamation must be implemented to ensure the restoration and conservation of their biodiversity and productivity.

The implementation of the afforestation strategy should be based on the well-established work of forestry, agriculture, as well as industry producing machinery and equipment required for forestry. A number of provisions need to be put in place to successfully implement strategic tasks at the legislative level. For instance, land transferred to forestry should be exempted from the compensation of losses to the local budget; landowners should also be exempted from paying the land tax in the case of conservation for environmental use.

Legislative provision should be made for compensation for the loss of income of landowners and land users from the lack of receipt of agricultural products on lands transferred under the creation of protective forest plantations prior to the start of their protective functions. It is also necessary to introduce a 50% reduction of the land tax on agricultural lands, on which the afforestation is carried out in the amounts stipulated by the project for the period before the introduction of protective forest plantations into operation.

Proper management of afforestation is required to effectively manage the implementation of forest management measures. For this purpose, it is advisable to create a service for agroforestry under the Ministry of Economy, Trade and Agriculture of Ukraine, regional and local administrations.

It is advisable to renew training of specialists in agroforestry, to provide retraining of management and engineering-technical staff, training of scientific personnel in universities and colleges.

Funds for afforestation tasks are provided mainly from the state budget, as well as local budgets, funds from landowners, land users, investors, philanthropists, international funds and other funds in accordance with the current legislation of Ukraine. It is also necessary to create a system of financial crediting for forestry activities, leasing of machines and mechanisms, including imported.

Afforestation is a significant component of the state strategy of preserving the environment, rational use and multiplication of Ukraine's natural resource potential, solving its environmental and food security problems.

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SWOT analsyis of silvopastoralism: CAP strategic plans

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Abstract
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Theme: Agroforestry and policy for sustainable Development - Subtopic Policy

Keywords: Forest fires, permanent grasslands, woody perennials, extensive grazing

Abstract

Extensive grazing systems are needed to reduce forest fires of those areas encroached with shrubs that are indeed prone to be destroyed by fires. Open2preserve is a INTERREG-SUDOE project that aims at to promote extensive grazing systems by preserving the permanent grasslands including woody perennials in Spain to prevent forest fires. This paper aims at carrying out a SWOT analysis (Table 1) to provide policy makers insights with regard of the use of silvopastoralism within their CAP Strategic Plans. The SWOT analysis was carried out using expert method.

Table 1. SWOT analysis of prescribed burns and extensive grazing for North West Spain.

	Internal factors	External factors
Negative	**Weaknesses** - Lack of public policies to allocate public resources on prescribed burnings - Lack of legislation regarding extensive livestock - Technical documents are not public usually - Disconformities among administrations - Bad reputation of prescribed burnings, even among people with forestry knowledge - There are studies assessing prescribed burning effects on soil and vegetation, but not enough known - Lack of data about livestock census and prescribed burnings - There is not a training activity on prescribed burnings for private companies and advisors - Lack of knowledge of land management after prescribed burning - Uncertanty in the use of communal lands - Soil degradation of uncontrolled and abandoned fired areas - Minifundism, dispersion and small farms - Lack of profitability of the current farms - Lack of cooperation - Loss of artisanal industry - Lack of women representativeness in the Local action groups government - Lack of visibility of the women work - Depopulation - Population ageing - Lack of funds - Administrative burden	**Threats** - Climate change threatens natural mountain open areas, as large forest fires are prone to happen - Lack of shepherds to manage open areas - Need to have water points near to places were livestock graze. - Unknown economic viability of extensive livestock - Being a Shepherds implies a lot of work, without holidays - Prescribed burnings need suitable weather conditions that may be difficult to find - Lack of appropriate value chain - Lack of value of the livestock products associated to more quality food - Lack of appropriate markets - Losses of traditional knowledge - Land abandonment - Loss of services - Isolation of the area - Administration burden - Lack of coordination among the competent organisms - Lack of public investments
Positive	**Strengths** - Each community manage its own resources - Regarding the laws, extensive livestock is considered a positive activity - There is a large sort of animal species that can graze shrubland areas - Rural development programs are trying to foster rural life - Good control of prescribed burning - Traditional management - Compulsory participation of the Equipments of forest fire integrated prevention (EPRIF) - Quality product production - Denomination of origin (DO) of some products - Excellent natural resources availability - Large areas able to use prescribed burnings - Sector awareness about research and formation for the future - Some young people started farms after the global crisis	**Opportunities** - Nowadays people are more open to changes; they start thinking that fire can be an ally, not only an enemy - There are projects already working on extensive livestock for fire prevention - Mountain pastures with animals grazing are a tourism resource - Knowledge about prescribed burnings is increasing - It is needed to train advisors and certify their capacities to apply prescribed fire to fuel management - Increase of strategies for valuing the products - Short value chains - Use of new technologies for improving the system - Adequacy of the area to develop organic farming - Employment generation - Improvement of the sector image - Availability of young people with good knowledge and capabilities

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Biodiversity and climate protection by agroforestry in Germany

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Abstract
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Theme: Agroforestry, climate protection, biodiversity and wildlife management; Policy

Keywords: Biodiversity, nature protection, climate change, policy, climate protection, biomass, foundation

Abstract

Non-profit and charitable VRD Foundation for Renewable Energy tries to mitigate climate warming and promoting renewable energy in order to reduce emissions. Especially education in schools and kindergartens are focused. Since 2019, agroforestry completes these efforts by helping binding emissions from the atmosphere as agroforestry integrates trees into the agricultural area. Combined with flower strips beneath the trees biodiversity rises compared with huge monocultural areas.

In Germany, agriculture dominates more than 50% of the country's area. Agriculture thus influences biodiversity of crop plants and animals as well as natural flora and fauna. This also applies to the emission of climate-affecting gases and vice versa their binding in biomass and humus, landscaping (recreational effect), water balance, groundwater and food quality, yield levels and soil fertility. These parameters are closely related to the agro-ecosystem: one measure most often improves several other factors, especially if trees are integrated. This project aims to revitalize this "field tree management", as used in former times, in a modern way to improve the entire cultivation system:

Funded by German Veolia Foundation and Postcode Lottery, consultants now create agroforestry areas with interested farmers and thus remove strip-like areas from direct cultivation. Perennial flower strips are sown under the trees, as long as they stay initially small, and shrubs are sometimes planted in between to promote insects (e.g. wintering). In cooperation with seed companies and selected tree nurseries, various multi-year seed mixtures are combined with trees and tested.

This creates "hotspots" of biodiversity above and below ground (soil-life) to be optimized. Meanwhile, these structures create wind and evaporation protection, bind CO_2 through building up wood and humus, protect groundwater through deep growing tree roots, helping meanwhile diversify the company's product-range. The aim is to at least create as many areas as possible, each more than 2 hectares. Promoting this offer we realize, farmer`s need for advice in all parts of Germany is increasing rapidly. One reason may be the drought in parts of the country, another will be the need of the agricultural sector to reduce carbon emissions in order to fit the Paris` climate aims.

Until today, the German federal states ("Bundesländer") do not co-finance European grants, existing since 2006, to establish agroforestry systems for the first time. Therefore, Germany stucks in an uncomfortable situation in relation to agroforestry. Actually, everything is missing and it reminds to the beginning of "German Energiewende" decades ago. But new development takes place as first federal states now show interest in beeing advised how to organise legal regulation

Thus, in this project

1. interested farmers are advised and accompanied free of charge initiating hot-spots of biodiversity and carbon-sequestration by building-up agroforestry systems in different parts of Germany,
2. agricultural policy is advised to build up regulations and safety for farmers willing to plant trees, and
3. work on information and public relations is done.

Figure 1. agroforestry simulation in Germany (references see above)

New agroforestry field in Germany, Gießen, and simulation (second)

Trees + grapevines. Southern European traditional vineyard agroforestry landscapes and their preservation: a challenge for policies

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Agroforestry and the landscape / Policy

Keywords: traditional vineyard agroforestry, "coltura promiscua", survey, heritage, preservation policies.

Abstract

The fortune of modern agroforestry and the interest in the multifunctionality of the agricultural landscape have re-sparked attention on traditional agroforestry systems. Traditional agroforestry systems may be described as the association between trees and crops with mutual benefits, practiced across the world in the frame of pre-industrial agricultural landscape. These systems have suffered a sharp decline in 20th century, but are still practiced in some regions of the world.

Various traditional agroforestry systems were diffused in Europe, involving a large variety of trees, crops, meadows, pastures, differently combined according to regional traditions. After the early work of Zimmermann (1981), several reviews of traditional agroforestry systems have followed since the 1990s (Meus et al. 1990; Pinto Correia, Vos, 2006; Eichhorn et al., 2006; Nerlich et al., 2013)

Among these traditional systems, the grapevine used to have a crucial place in Southern Europe. Vineyard agroforestry used to be practised in Portugal (*vinha de enforcado*, *arjoado*) (Stanislawski, 1970; Altieri, Nicholls, 2002), in Southern France (*jouelles*, *hautains*) (Lavignac, 2001) in Italy (*piantata*, *alberata*) (Sereni, 1961; Ferrario, 2019), in Greece (Papanastasis et al., 2009) in Turkey (Tabak, 2008). Before the advent of industrial agriculture in the second half of the 20th century, Italy probably enjoyed pride of place in vineyard agroforestry systems.

Although very famous, traditional vineyard agroforestry is still poorly studied and there is a scarce knowledge of what remains today still standing in agricultural landscapes. To try to fill this gap, this paper presents a review of the traditional vineyard agroforestry systems in Southern Europe, with particular focus on the Italian peninsula, where a number of relics can still be found and a preservation policy is still lacking. Nowadays, viticulture is reintroducing trees into the vineyard: as it has been noticed, agroforestry development could greatly benefit from a better knowledge of traditional systems (Coulon et al., 2000).

This work adopts a geographical approach, and consists of three parts:

a. A review of traditional vineyard-based agroforestry systems in Southern Europe, with special focus on Italy: analogies and differences among the various regional systems, as described in the literature and represented in iconography, from the 18th century onwards.

b. The results of a survey of traditional vineyard agroforestry in North-eastern Italy, where a number of relics can still be found: from the remnants of ancient "coltura promiscua" (arable land + trees+ grapevines) in the Po Valley, to vineyards with fruit trees in some Pre-alpine valleys. The survey is based on mapping, fieldwork and interviews with farmers.

c. Some considerations on traditional vineyard agroforestry as heritage. As it emerges from field survey, relics are beginning to obtain a heritage value as traditional landscapes. They are being considered

increasingly important in regional identity and even in marketing. In recent years, some initiatives have been launched to protect them in Italy. In this part I will focus on threats and on preservation initiatives.

Results show a range of concrete possible measures of a desirable preservation policy of traditional vineyard agroforestry landscapes, that will be presented in detail.

Figure 1. Relics of traditional vineyard agroforestry.
Fruit trees in intensive viticulture landscape in North-eastern Italy (Google Earth, April 11th, 2015)

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Learning and spreading lessons about agroforestry integration in the open landscape dominated province of North-Holland, Netherlands

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Theme: Agroforestry and policy for sustainable development

Keywords: agroforestry integration, implementation, landscape, Netherlands, policy

Abstract:

Introduction

Finally, agroforestry in The Netherlands is identified as one of the possible solutions for creating sustainable agriculture, while achieving national and European aims in lowering the impact of agriculture (LNV 2010) and increasing the area of forest and number of trees (LNV 2020). Commissioned by the Ministry of Agriculture, Nature and Food Quality a national Master Plan was developed for scaling up agroforestry in which the lack of practical knowledge, lack of revenue models and limiting laws and regulations were identified as the most pressing bottlenecks in applying agroforestry (Luske et al. 2020a). Whereas in the entire country strict regulations are in place due to spatial planning, in the province of North Holland agroforestry is hampered even more by the need to preserve an open landscape and the related aim for specific biodiversity, such as meadow birds. This makes farmers hesitant to explore ways to integrating trees on their farms, resulting in missed opportunities for creating agroforestry integrated farming systems that benefit farmers, biodiversity and landscape. A participatory research project with agroforestry pioneers could help opening up the discussion about agroforestry. The lessons learned from such a process were valuable input for an integral step-by-step guide for farmers and other land owners for the implementation of agroforestry in North-Holland.

Method

From 2018 to 2021 a group of five pioneers from North-Holland were guided through the entire process from idea to realisation of agroforestry on their property. The diverse group of farmers included a fruit farmer, dairy farmer, two arable farmers and a care facility. A participative approach was taken, in which the pioneers were intensively guided by researchers (Louis Bolk Institute) an education institute (Clusius College), a landscape designer (Landscape Foodscape) and Nature and Environment Federation North Holland. Interactive knowledge sessions and design sessions were organised on the locations of the pioneers. From all sessions, relevant information was gathered and published online. For exploring the bottlenecks and opportunities in policy, desk research was conducted and policy makers were interviewed.

Results

The process resulted in a step-by-step guide on implementation of agroforestry in the province of North Holland on designing steps, reliable sources of information and policy (Luske et al. 2020b). To give a quick overview on the restrictions of regulations, a suitability map was created (fig. 1). Major areas in the province are under strict regulations for the conservation of meadow birds and open landscape (most of

the transparent areas in fig. 1). In these areas pioneers are advised to discuss with local agricultural nature associations how small scale agroforestry can benefit local biodiversity goals. Other areas with a more urban setting and sheltered, varied landscape, are rated with low to medium suitability. Areas close to cities, dunes and forested areas are rated with high suitability. Here, agroforestry serves as a much needed buffer between conventional agriculture and cities and nature. Additional information such as the designs and personal lessons where published in openly accessible online dossiers and presented in a well-attended online seminar.

Conclusion and Discussion

Large parts of the province of North Holland consists of open landscapes. These landscapes offer a unique scenery and habitat for meadow birds. Policy to maintain this landscape should therefore be respected. However, this research project opened up the discussion on finding ways to integrate more trees in the landscape of North Holland. Following from the discussion, the province included agroforestry as one of the means to increase biodiversity. Also, investments are made to create a community of practice on the topic of agroforestry. This is seen as the start of a movement. More work is to be done. All local governments in the Netherlands are working towards a new system for spatial planning (Omgevingswet) in which agroforestry needs to become facilitated even more.

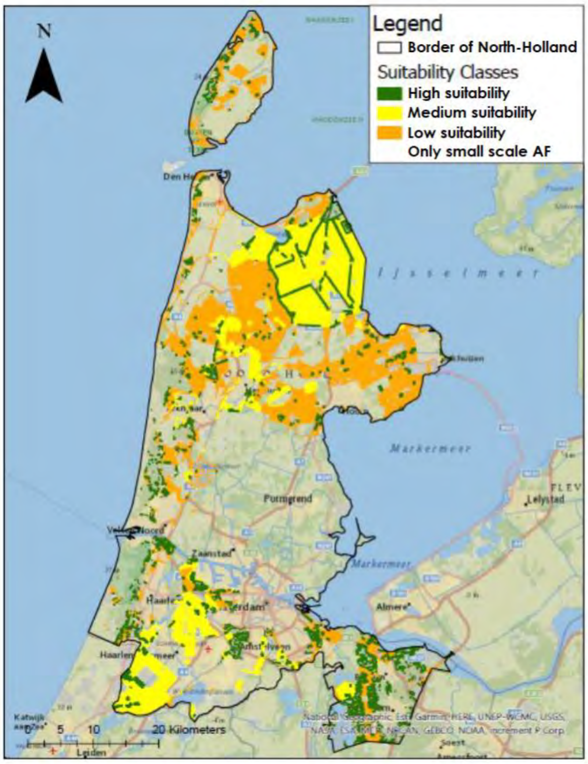

Figure 1. Suitability map for agroforestry in the province of North-Holland

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Boosting agroforestry implementation in The Netherlands: moving forward with a national community of practice

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and policy for sustainable development

Keywords: policy, community of practice, inventory, knowledge transfer, upscaling

Introduction

Like in other countries that are dominated with intensive forms of agriculture, ecosystems in The Netherlands are under pressure. Agroforestry is mentioned as a feasible instrument for providing ecosystem services, while maintaining or increasing productivity (Smith et al. 2013). Recently agroforestry is mentioned by the Dutch Ministry of Agriculture, Nature and Food Quality as one of the ways forward in increasing the sustainability of agriculture (LNV, 2019) and to achieve the nations goals in planting additional trees to mitigate climate change (LNV, 2020). Although a relative small group of farmers in The Netherlands started implementing agroforestry, the Dutch agricultural sector in general is lacking behind compared to neighbouring countries. In an attempt to understand the factors behind this phenomenon and the need to know which stakeholders need to act, a Master plan (Luske et al., 2020a) and an advice on how to deal with regulations concerning spatial regulations (Luske et al. 2020b) were written. The next step, also commissioned by the above mentioned ministry, was to describe the necessary development towards a community of practice, including the current and future situation.

Method

First an inventory was made of farmers who practice agroforestry, by updating information from earlier agroforestry projects and contacting local parties. A list was compiled of agroforestry famers, location, type and area of agroforestry, age of the farmer and years of experience with agroforestry. Also the current means of exchange of information were mapped and the exchange of information in Belgium was examined. A last ingredient in the process was a quick scan of other communities of practice with comparable topics that were supported by authorities. From this information an advise for a national community of practice was drafted.

Results

From the quick inventory 154 famers were localised who realised over 400 hectares of agroforestry in The Netherlands (table 1). Most of these farmers didn't identify themselves as agroforestry farmers, but prefer to see themselves as farmers who integrate nature. This is one of the reasons it is hard to make a complete inventory of agroforestry farmers. From these figures it is estimated that in reality aver 200 farmers in the Netherlands are applying over 500 ha of agroforestry. Differences between provinces are strong. Most of these farmers are located in the province of Noord-Brabant and Gelderland. In these provinces strong local agroforestry networks are operating, ensuring the exchange of information on a local level. In other provinces initiatives for local networks are being prepared. Popular forms of agroforestry in The Netherlands are silvopastoral systems (fruit and nut trees in pasture and fodder trees) and planting trees in chicken runs.

Current agroforestry networks are dependent on short term project funding and the information from these projects are not always available to other farmers. The extremely valuable lessons that are learned by the small but motivated group of pioneering agroforestry farmers in the Netherlands needs to be become available for other farmers. Local networks and communities of practice need to play an import role in these pilots.

It is advised to start a national community of practice to enhance the transfer of information from local networks to other farmers and other networks. A national community of practice also needs to have a strong role in handling issues that transcend regional and sectoral issues, such as national (spatial planning and nature protection) policies that prevent agroforestry practices. The national community of practice needs to reconnect practice (farmers), science (researchers) and government in order to take away barriers for agroforestry and set up research programmes and demonstration sites.

Conclusion and discussion

This study recommends a community of practice is a useful tool to exchange and streamline practical information and to connect farmers and other stakeholders. Over 200 farmers are applying agroforestry and an even bigger group of farmers is making plans to follow. This is the time to embrace agroforestry as the way forward to increase biodiversity, offer sustainable revenue models to farmers, and achieving European objectives concerning biodiversity and climate mitigation. A national community of practice gives very needed and anticipated body to the integrated rollout of the earlier published Master Plan Agroforestry.

Table 1. Number of agroforestry farmers found per province in the Netherlands and the total area of agroforestry

Province	Number of farmers	Area of agroforestry (ha)
Drenthe	2	6
Flevoland	8	20
Friesland	6	6
Gelderland	34	125
Groningen	3	7
Limburg	4	7
Noord-Brabant	63	162
Noord-Holland	2	9
Overijssel	13	42
Utrecht	6	11
Zeeland	9	16
Zuid-Holland	4	11
Totals	**154**	**413** **(Av. 2,7 ha/farm)**

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Rural and Peri-Urban Areas Planning with the View to Improving Agroforestry and Landscape – EU Experience in Serbia

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and policy for sustainable development

Keywords: spatial and urban planning, forests, environmental protection

Abstract

Spatial and urban planning are fundamental spatial development mechanisms. Spatial development takes into account complex relationships of different activities and functions in space with the view to facilitating the establishment of the most optimal spatial interactions, on the one hand, and preventing conflicts in space, on the other. That is why spatial and urban planning is so crucial in all kinds of social activities in the specific space. With all that in mind, spatial and urban planning plays a significant part in improving agroforestry and landscape in rural and peri-urban areas as well, since these functions are especially important in such areas. This paper aims at stressing the significance of planning in improving agroforestry and landscape in the times of agricultural intensification, specific changes in the ownership over the land during the transition period in the Republic of Serbia, and the change of demographic structure and increasingly negative demographic trends, especially in rural areas. All these circumstances have caused the increased degradation of agricultural land (soil erosion, salinisation, chemical pollution, etc.), the change in the endemic landscape architecture (cutting down small forested areas, alleys, individual trees or groves, destroying wildlife habitats, flora and fauna loss, etc.), the abandonment of certain agricultural areas, and the pollution of both groundwater and surface water. The role of planning is to implement the EU directives and specific experience from the areas of supporting agricultural production development, improving demographic circumstances, and reducing negative impacts of intensive agricultural production on the environment. The concept rests on the symbiosis of the existing phenomena and processes, which serve as a basis for shaping spatial development policies and defining measures for the agroforestry and landscape improvement, and is an authentic European experience in Serbia. Urban planning measures are directed towards the increase of forested areas and windbreaks, recultivation and melioration of degraded agricultural areas, and the preservation of authentic landscape, trees or groves. The protection of natural resources is an integral part of every urban planning document in the Republic of Serbia. The current Spatial Plan of the Republic of Serbia, (SPRS) a framework planning document in the country, covers the topic of forestry and recognises the significance of protective forests. The protection and preservation of forests are planned to the purpose of preserving soil from degradation, improving the quality of forest and agricultural land, and environmental protection in

general. The guidelines stipulated in SPRS are implemented by means of the planning documents deriving from the Plan, following the hierarchically ordered planning system in Serbia, down to the level of urban regulatory plans. Still, the examples of planning greenfield locations and repurposing of forest land into building land exceed the number of planned brownfield locations. A good practice example is planning shelterbelts around recultivated former minig sites. Putting in practice such documentation, aided by GIS tools and strategic environmental assessment, results in the integral protection and preservation of agricultural and forest areas, landscape, and the environment.

3

Agroforestry systems and innovations

3.1

Agroforestry and wildfire prevention

Forest fire prevention and agroforestry: the case of the Zonza forest (South Corsica, France)

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and wildfire prevention

Keywords: wildfire prevention, Agroforestry, Forestry (Silviculture), ZAL (support zone for fighting), DFCI (Defence of the Forest against the Fires), self-sustaining zone

Abstract: A highlight for tourism, the landscape protected site of Zonza-Bavella is one of the jewels of Corsica. This massif, damaged by several large recurring fires in the past, is still very sensitive to fire. Indeed, the analysis of historical photos and the compilation of inventory data of the National Forest Office revealed an increase in fuel made of leaves, wood and litter, and its homogeneity (predominance of pine forests) since the 1950s, due to a multiplicity of factors.

However, the now high number of visitors and the whole economy of the micro-region mainly based on tourism, is directly related to the quality of this landscape. Thus, people and forest are threatened by fire. Forest and fire prevention plans take these issues into account by prescribing appropriate prevention structures using an innovative silvicultural system, specifically studied to preserve forest and landscape. Below are showed two complementary sites.

The 100 hectare Bavella-Velaco site is managed to protect the forested landscape in external vision, to integrate recreation by securing visitor fire hazard as well as by enhancing the landscape in internal vision, and to reduce the spread of fire likelihood. Therefore, different types of prevention structures are set: ZAL (support zone for fighting) to secure firemen fighting against a large fire, Autorésistance (self-sustaining zone) to limit effects of fire by keeping the canopy green, and ZRC (fuel reduction zone) to protect visitors. To respond best to this spatial gradation, it was decided to divide the area into five strips according to the aims pursued.
Canopy protection concerns the whole area (strips 1 to 5) and deals with the three layers of fuel:
- Eliminating low fuel, thus preserving part of tree regeneration. In case of prescribed burning, the best tool to eliminate fuel contained in the litter, landscaping guidelines must be taken into account, such as banning the crowns of mature trees turning russet.
- Decreasing scale fuel by removing Mediterranean scrub and spacing young stems (distance is defined according to height)
- Reducing aerial fuel by removing dominated and dead trees.

Prescriptions for the support zone for fighting (on strip 1) deals with:
- Eliminating low and scale fuel, by removing Mediterranean brushwood and pruning remaining stems
- Limiting the total amount of young stems to a minimum to insure natural regeneration and choose the remaining ones on isolated places to guarantee horizontal and vertical discontinuity
- Reducing aerial fuel by removing dominated, sick and dead trees and any tree hindered by robust designed and well localised trees

Prescriptions for recreation management deals with:
- Guiding visitors on a safely designed trail located on firefighting zone (ZAL) on strip 1
- eliminating fuel gradually on nearing the trail for safety reason on strip 2 to 4 (density for remaining trees depends on the strip)

- paying attention to internal landscape in areas visible from the trail (zones 2 and 3) by conserving aesthetically-crowned trees and minimizing the impacts of silvicultural work, such as avoiding geometric shapes, limiting blackening on burned stems, eliminating the remains of burned brushwood, working in pre-season to ensure greening ...

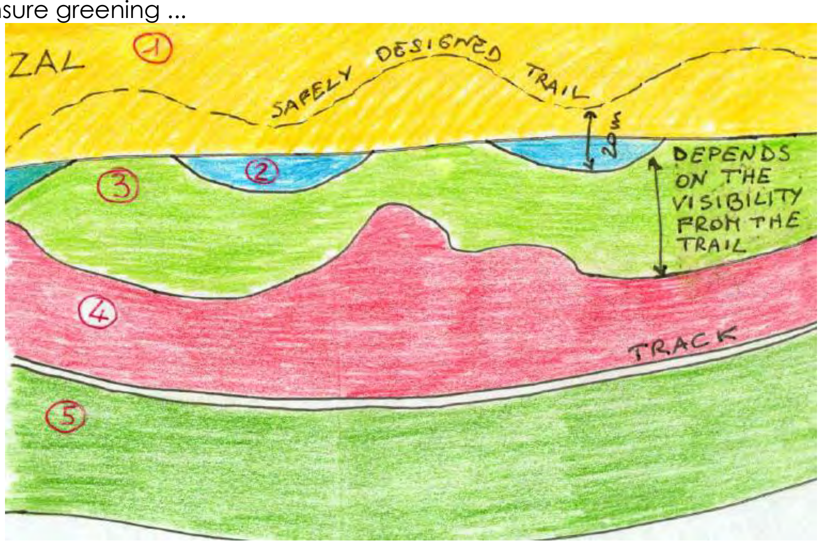

Figure 1. Subivision of the area into five strips according to the aims pursued

As part of the European program Marittimo (Med Forest Project), different methods of fuel reduction are tested for fire prevention structures: silvicultural treatments (pruning, thinning in young and adult stands), scrub elimination (by brush cutting or prescribed burning), and slash removal (by grinding, burning or natural degradation).
As the high visitor number and the presence of an unmanaged cattle herd represent disturbance factors for mouflon (Ovis gmelinii musimon) which live in this forested area (species listed in Appendix II of the Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora), as a result of fire prevention treatments, landscape opening will increase and improve the distribution of trophic resource for the herbivorous. This new fodder resource will be used to enhance space organisation: managed cattle will be localised on fire prevention and visitor protection structures (ZAL and ZRC), visitors will be oriented on designed safe trail and mouflon could stay on quiet area. The grazing of cattle has another positive role by maintaining a low level of fuel in these prevention structures

The fire prevention structures of the Zonza-Prunetu site intends only to reduce fire spreading. Here, topography is not a big help to reduce the risk and multiple ZAL had to be installed. Therefore, in support of these areas, "green strips" will be tested to limit the intensity of likely fire occurring on these structures. Hardwood, less prowned to fire propagation when in adult stand, will be planted or promoted along the edge of riparian forests. A specific silvicultural system is prescribed there, including plantation density, thinning in young and adults, and pruning. Wood productive species, already there, will be kept at a low density inside the hardwood stand to produce timber in the long term.
Regarding the choice of hardwood species, the chestnut tree has been suggested to the owners of this forest. Indeed, this species creates a good canopy cover that limits the increase of Mediterranean scrub wood. The owners were very keen on reintroducing the chestnut tree, which has played a major role in the past in feeding local people. By the way, planting grafted tree will also contribute to supply the Corsican castanicultural sector with agri-food products. Agreement of a private farmer will definitely be needed to maintain fire prevention on this site on the long term, while guaranteeing the development of a new economic activity.

These examples show that the protection of forest and people against fire can be achieved in the respect of the landscape, while enhancing the economic and ecological forest functions, and taking into account its agroforestry potential. Thus, in this forest, multifunctionality is a reality.

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Swidden Agriculture as a Sustainable Production System: a case study on soils in the Southeast Atlantic Forest of Brazil

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry Systems and Innovations

Keywords: shifting cultivation, the swidden cycle, chronosequence, chemical soil fertility, fallow period

Abstract

Swidden agriculture has been practiced for centuries and is based on ecological processes of forest ecosystems (Altieri 1991; Filho et al. 2013). It is a system in which fragments of forest land are cultivated temporarily and allowed to revert to their natural vegetation after harvest (Siahaya et al. 2016). Institutions place bans or restrictions on shifting cultivation and bring forests under protection by increasing reserves. Yet, research finds that smallholder farmers continue to practice swidden cultivation as their subsistence and farming livelihoods depend upon these ancient techniques. However, due to these restrictions, smallholder farmers are pushed to other types of livelihood activities alongside of swidden cultivation, such as the illegal extraction of forest products. Swidden agriculture is often cited as the primary source of deforestation and forest degradation (Lawrence et al. 2010). Yet, the sustainable regrowth of the forest, after temporal land use, depends upon a combination of ecological, economic, socio-cultural and political factors. Fire management at different stages in the swidden cycle is highly contextual and can differ per farming community or even family, with huge differences within countries and regions. Tropical agro-ecosystems are quickly changing and population pressure and exploitation of the tropical forest affects the practice of swidden agriculture threatening its inherent sustainability (Beckerman 1983; Lawrence et al. 2010).

This study focuses on (chemical) soil fertility in areas of secondary succession, in comparison to more preserved forests to evaluate the sustainability of swidden cultivation. Through this study, we add to the debate regarding the impact of human presence inside protected areas. Sampling took place at the Itapanhapima extractive reserve and Bairro Santa Maria (Taquari), located in the Atlantic Forest, southeast Brazil (Fig. 1). Soil samples were collected from forest patches belonging to six different smallholder families. All secondary forest units, varied in fallow age, which allowed for post-burning analyses with the establishment of chronosequences. Soil sampling (n=50) occurred in three rectangular shaped plots (30x10) constructed within each forest unit (n=24). Soil samples were analysed for texture, macro nutrients, micro nutrients, bulk density, pH, C and N stocks. Soils were overall acidic (pH < 4) and aluminum content was high (> 5 mmolc dm^{-3}). Key indicators of (chemical) soil fertility, like N, P, K, S, soil organic matter and soil organic carbon, in post-swidden agriculture soils were limited influenced by fallow period. Directly after combustion nutrients were overall more available for plant up-take compared to more preserved forests. For Mg, Mn and Ca we observed that the nutrients stocks over time returned to values equal to those of more preserved forests. Like most of the tropical soils, the investigated soils were poor in nutrients, yet little affected by swidden agriculture.

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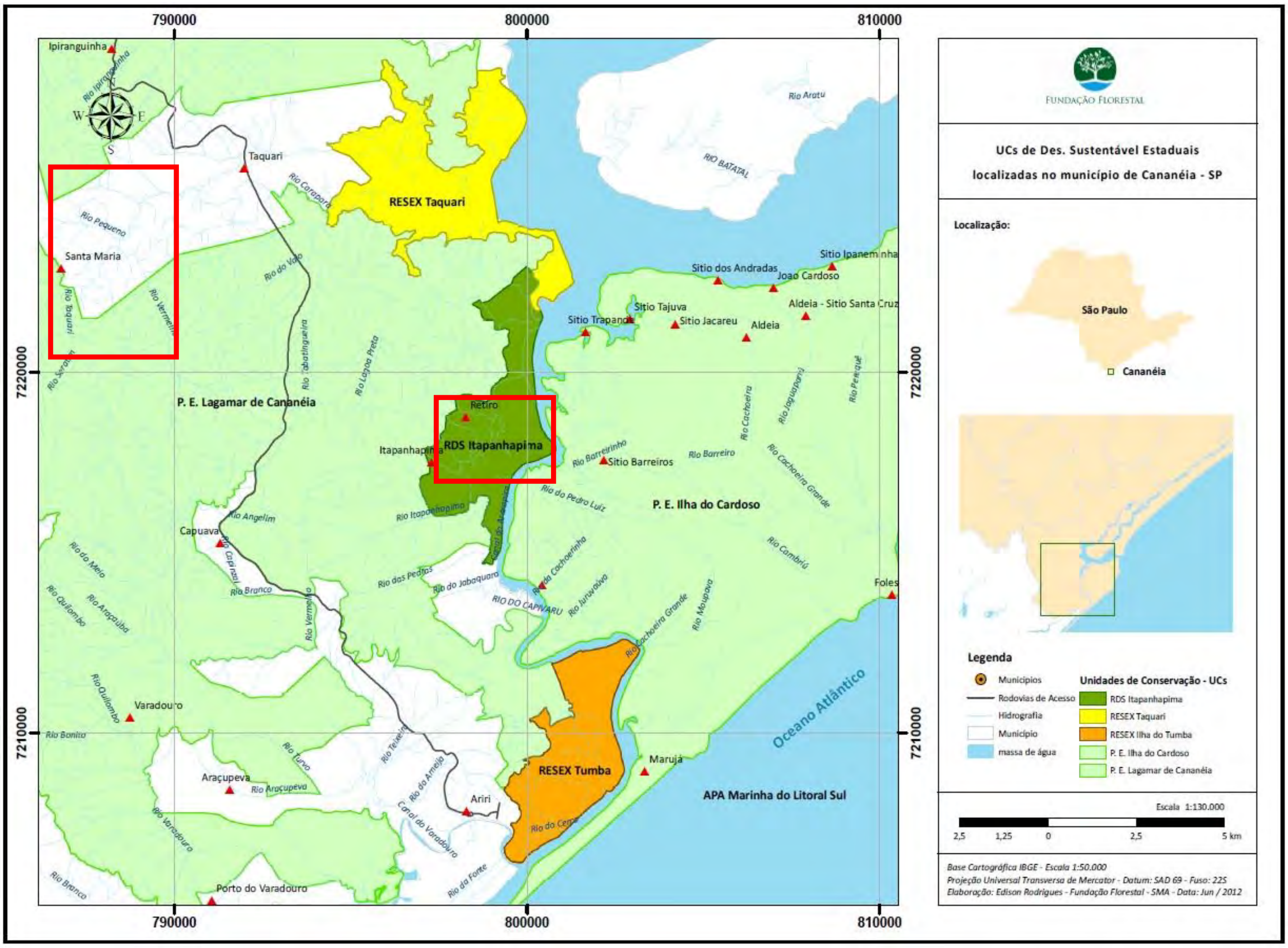
Figure 1. Lay-out sampling area in Cananéia, Sao Paulo, Brazil (Sampling took place at the area within the red quadrants).



Fire as a tool for territorial management in agroforestry contexts

EURAF 2020 Agroforestry for the transition towards sustainability and bioeconomy Abstract
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Theme: Agroforestry systems and innovations - Agroforestry and wildfire prevention

Keywords: wildfire prevention, prescribed burning, land managing, arsonist control.

Abstract

The frequency of wildfire ignitions and the area of burnt surfaces have been increasing throughout the Mediterranean basin at least since the second half of the twentieth century, actually by the time data started to be available. Concurrent causes are:

- the socio-economic dynamics leading to progressive change in land use with diffuse land abandonment;
- the displacement of the workforce from the primary sector to the secondary and later to tertiary sectors, with exodus from the countryside to the urban areas, phenomena that have entailed, not only the abandonment of the lands and the increased load and spatial contiguity of fuels, but also the sprawl of rural urban interface areas in which assets and people are jeopardized by wildfires.

At the same time, a cultural change relatively to fire use in agriculture led to:

- a gradual distrust towards the flames for pasture renewal and territory management;
- a progressive criminalization of those primary sector operators who continued using fire;
- a professionalization of firefight for wildfire extinguishment.

Sardinia, the second largest island in the Mediterranean, has a well-structured Regional Plan and a very effective fire-fighting apparatus which integrates an excellent judicial police system for prosecuting wildfire criminal offences. Despite the continuous increase of costs and capacity of the regional firefight system and of crime repression, the fire regime has changed over time and today is particularly critical because of numerous wildfires of unprecedented speed, intensity and magnitude that are able to overcome the suppression capability causing damage to forests, homes and people's lives.

Beyond cultural and bureaucratic difficulties, the European Union is deploying an active policy for planting and promoting innovative agroforestry systems and is favouring the maintenance and revitalization of traditional integrated land management techniques, not just for their important cultural

imprint and for sustainably productivity increase, but also for other numerous benefits to biodiversity, to populations in terms of ecosystem services and, not least, to the protection from wildfires.

The present work reports the results of an important project carried out by the Sardinian Forest Service (Corpo Forestale e di Vigilanza Ambientale - CFVA) in Planargia, a sub region of the northwest of the island, started in 2012 and still in progress. The area has always been characterized by a large number of fires triggered for pasture renewal just before the first rains after summer. Actually, the unburnt residues of the previous year straw undergo to a decomposition process with the presence of different fungi species that make the new grasses very unappealing for reared animals. On the contrary if small flames are not intense and pass quickly just burning the residual hay of the past season, the do not damage the seed stock, guaranteeing the maintenance of the typical local landscape and the annual renewal of the natural turf.

The demonization of fire and the criminalization of the same act of igniting any flame has led the owners of livestock farms to illegally light late summer fires.

No clandestine burns is conducted in workmanlike manner and fires often became uncontrollable wildfires entailing both great suppression costs for aerial and terrestrial means and the application of numerous administrative penalties and/or criminal offences that exacerbated the level of social conflict between land owners and CFVA.

The project actions constitute the implementation of a cultural evolution in the same conception of fire: the paradigm of fire exclusion from the ecosystem, according to which no fires must arise and all fires must be immediately extinguished, gave way to the systemic integration of fire as an ecosystemic factor, a vision considering not all flames as wildfires and which recognizes well conducted fires as a tool for land management.

The aim of the project was to create a virtuous self-sustainable territorial system capable of both controlling fuel load and maintaining the typical landscape and the local socio-economic productive system through a program of prescribed fires to be carried out after summer season. A series of actions shared by CFVA, local administrations and landowners were carried out to create a calendar of fires to be conducted by groups of farmers/breeders, assisted by CFVA crews.

The collaboration led to create a tight-knit territorial system of mutual cooperation between owners, and, over the years, the need of CFVA crews intervention has gradually reduced.

Direct consequence of the project were a drastic drop of outbreaks and burnt areas, the reduction of forest fires, the zeroing of the economic costs for wildfire suppression.

A series of important results and effects on territorial processes were also obtained:

- a proliferation of an articulated variety of natural forage essences;
- the reduced use of pesticides to control the presence of fungi/insects/parasites;
- the opportunity for firefight crews to carry out training and improve knowledge on flame dynamics;
- the softening of social conflict related to the use of fire resulted in very few cases of indicting to judicial authority and administrative penalty;
- the recognition of the value of an entire world of ancient techniques that have an identity value for local populations.

There was a composition of the different territorial instances: who needs to close the cultivation cycle of pastures by the use of fire, worked together with who prevents that flames become uncontrolled fires. In the contact the very conception of fire as instrument became more complete, organic and articulated for all the project actors, and the development of a collaboration protocol and of a territorial system has improved the environmental and social control of the entire territory.

The rational reinterpretation of an ancient agro-pastoral technique was not the mere re-proposing of practises of the past but the revival of a world of knowledges and praxis that shows its deep identitarian value for population in a modern and scientific perspective. Inserted in an organic process of agrosilvopastoral government of the territory, fire has been recognized as a tool for managing the land and the local socio-economic processes at landscape scale.

Improving silvopasture farming systems in highly biodiverse areas through the use of aerial images

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry systems and innovations

Keywords: prescribed burning, vegetation index, EGI, UAV

Abstract

Europe is facing strong ageing of its rural areas that is causing a reduction of the management of large European territories linked to High Nature Value Farming (HNV) and Nature 2000. Land management facilitation is key to attract young farmers to the most remote mountain areas where livestock production should be based on extensive grazing of natural resources that should be managed in such a way that allows a high pasture quality. Encroachment and the increase of low palatable woody perennials may limit pasture quality for feeding animals including shrubs and herbaceous vegetation. When encroachment happens a renewal of the land is needed but this is very expensive in remote areas. Prescribed burnings are a cheap alternative to expensive and non-renewal energy use of mechanical clearance systems, but environmental systems should be evaluated through the use of aerial images to quantify soil evolution and biodiversity, mostly needed in these remote and highly biodiverse areas. This study aimed to test the effect of prescribed burnings on sustainability and productivity of mountain livestock systems grazed with horses in Galicia (NW Spain) in the framework of a network of prescribed burnings (Open2preserve, INTERREG-SUDOE project). In this context, aerial images before the prescribed burning (20th February 2019), after the prescribed burning (28th February 2019) and after grazing (October 2019) were compared. The aerial image photointerpretation proven system was used to detect changes in vegetation and its status based on no visible bands as Red Edge or Near Infrared, but possible with RGB Photo bands. Satellites allow to take data constantly, but they have several deficiencies, as clouds prevent you from seeing land surface or their ground sample distance (10m/pixel or more) is not the most accurate to study small plots, unmanned aerial vehicle (UAV) flying in low high is able to take centimetric accurate(Carvajal-Ramírez 2019). Moreover, in this study, the Excess of Green Index (EGI) was used to estimate the fire severity and the vegetation growth in the month after the prescribed burning. The EGI was calculated with the formula EGI=2*Green-Red-Blue (McKenna et al. 2017). In this study, before the prescribed burning (20th February 2019), the aerial images showed quite homogeneous vegetation in all the area (Figure 1). However, after the prescribed burning (28th February 2019), the aerial images showed how burning did not take the same intensity in the whole area, being less intense in the centre and more intense on the lips where the burning was controlled by the fire-fighters who fixed the burning. In the aerial images, a control area without burning can also be observed. After the prescribed burning, in this study, the burned area was divided into two experimental units: i) experimental unit with horse grazing, ii) experimental unit without grazing, being these experiment units compared with the control area without burning. Finally, after grazing (October 2019), the evolution of the vegetation could be observed. In general, in the area without burning, the vegetation growth was higher than in the burned and grazed area. Moreover, in the burned area without grazing, the vegetation growth was also higher compared with the burned and grazed area

but without reaching the growth rate of the area without burning. Therefore, Galician initial results show that after prescribed burnings, recovery of the palatable woody perennials and herbaceous vegetation is obtained preserving high value environment indicator species.

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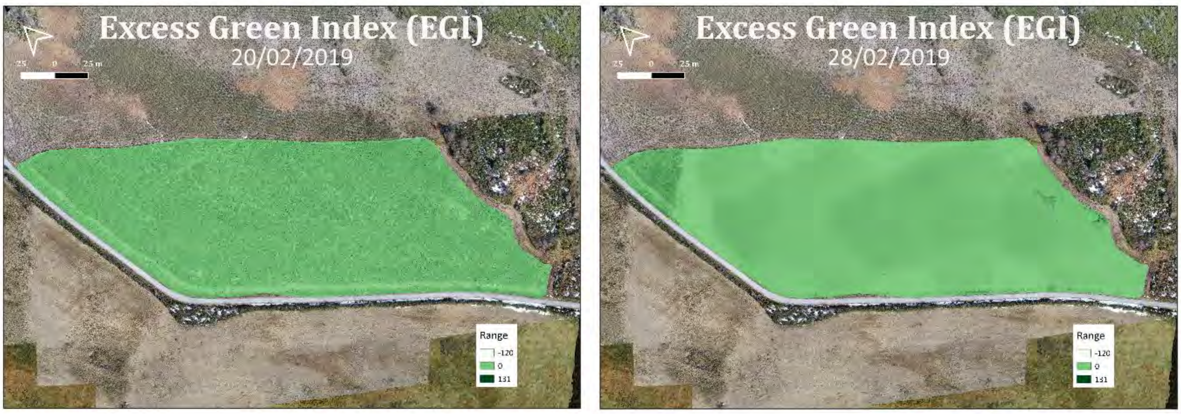

Figure 1. Excess Green Index from RGB UVA cameras before the prescribed burning (20th February 2019), after the prescribed burning (28th February 2019) and after grazing (October 2019).

Impact of wildfires burning on forest and peatland environment in Latvia

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Wildfire prevention

Keywords:, peat, ecosystem recovery, wildfire character

Abstract

Around 52% or 3,354,000 hectares of the territory of Latvia is covered in forests which is fourth-largest forest area among all EU countries, surpassed only by Finland (77%), Sweden (76%) and Slovenia (63%) (Forest Europe, 2015). A significant part of Latvia's forested areas is occupied by bogged forests and peatlands, reaching approximately 9,4 % from the entire area (Silamiķele et al., 2020). Hundreds of fires are extinguished in Latvia's forests every year, but periodically fires in large areas also affect bogs (Stivriņš, et al., 2020). Peatlands are in direct contact with forests, indicating the importance of management measures, including fire safety, that must be carried out in a complex way, considering characteristics of forests and bogs.

Until now, when assessing the fire safety of forests and planning their fire safety management, little attention has been paid to the fire safety and possibility of burning bogs and the regularity and volume that has taken place. Therefore, a project "Investigations of the environment affected by bog fires and the intensity of bog regeneration" was launched. The aim was to evaluate as much scientifically-based information on the impact of fire under the different intensity degrees on the bog environment and develop a methodology for the assessment of different fire conditions and the detection of historical burns (Silamiķele et al., 2020).

Within the framework of the research, multidisciplinary approach of field and laboratory methods and modelling was applied. General overview of obtained data regarding impact of fires and burning in bogs was prepared. In this overview changes in peat properties caused due combustion by using field and laboratory research methods of different disciplines, including sediment composition, macroscopic and microscopic residue composition, peat chemical composition, etc. analysis are described and evaluated (Ivanovs, 2020). Particular emphasis is placed on microbiological analysis, which should be developed in the future as it provides unique and valuable information.

Due to climate change, forest and bog fires can be expected to occur more frequently. To proactively prevent wildfires special attention on forests and peatlands including also peat cutting areas must be paid (Kalniņa et al., 2018).

Peatlands are ecosystems existing on peat that is rich in decayed organic matter. It is assumed that in their healthy, natural state, peatlands are quite fire-resistant. However, number of peatland wildfires has increased over recent decades. It is usually caused by reckless human activity or natural ignition, which can be partly explained by climate change. Air temperatures soar during summer seasons and are usually accompanied by a very low volume of precipitation. Dry and hot spells like this are becoming longer, causing a lowering of groundwater level in peatlands. Wildfires have occurred in natural mires including protected nature areas and in peat fields, in different places in Latvia.

Fires in bogs are relatively uncommon, but if they do occur, the area affected is usually significantly more extensive than in forests, as it is more difficult to access and obtain water for extinguishing. Due to more complicated access, pristine bogs are more endangered than the affected peatlands and peat fields. Studies are showing high CO2 emissions from peatlands. Simultaneously, fires in mires are not considered a significant threat to the biodiversity of mire ecosystems, as they create new niches. However, environmental change persists in a natural mire for up to 60 years after a sufficiently severe fire.

Aim of this study was also to identify localities where fires occurred and to determine , firstly, level of impact fires had left on the peatland environment, secondly, what fire prevention measures must be performed and how quickly respective ecosystem had recovered. It was found that usually wildfires had happened in areas with the dominance of raised bogs or raised bog peat type, mainly Sphagnum. Large areas that are affected by fires (also reoccurring fires) are in many of specially protected territories, such as Bazi Mire in Slitere National Park, Teici Bog in Teici Nature Reserve, Kemeri Bog in Kemeri National Park. Recently wildfires have damaged Lielsala Bog (2018, more than 500 ha) and Saklaura Bog (2018, more than 300 ha) (Ivanovs, 2020, Silamiķele et al., 2020). Fires change the vegetation of mire, but its rehabilitation depends on many factors. It is known that the bare peat field are colonized first by dwarf shrubs and only then by trees, predominately birches. Similar scenario of succession is evident after fire in mires. Burning of fens or wet grasslands is rare in Latvia. Survey of these places revealed that fire has left no adverse effects on the composition of plant species.

The fire-affected areas of peat fields were also studied to determine differences of impact level and character in comparison to pristine bogs, as well as to what extent the peat characteristics had changed, thus impacting peat quality.

Results of this study enables us to conclude that the greatest impact of burning is on the trees, damaging their trunks and crowns, affecting future viability of the tree; in the case of bog fires, burn-out intensity of peat-forming plant residue layer is essential; nature of the microrelief changes as the hummocks of plant residue burn out; the rest of the vegetation is recovering sufficiently fast.

The results of the study give suggestions to the future management of bog ecosystems and peatlands in the light of climate warming.

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Fire risk management with pastures

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Abstract
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Theme: Agroforestry and wildfire prevention

Keywords: wildfire prevention, fuel treatment, prescribed grazing.

Abstract

An appropriate approach to wildfire prevention must be aimed at both lessening the possibility of a fire occurring and minimizing its spread should one occur. This can be achieved through fuel treatments for biomass reduction, which are paramount to wildfire abatement (Omi & Martinson 2002). Fuel treatments aimed at reducing both horizontal and vertical continuity in fuels are of paramount importance as a prevention measure against fire propagation. The range of possible treatments to modify forest fuels is rather wide, varying from pruning (Leone 2002) to thinning, to mechanical thinning, to fuel mastication (Harrington 2012) to prescribed fire (Fernandes & Botelho 2003, Rego & Montiel 2010) to grazing (Hart 2001, Ruiz-Mirazo 2011). As an alternative to some techniques, a few of which are often perceived as aggressive according to public opinion - such as prescribed fire (Vélez 2010) or herbicides - the use of grazing animals could be an efficient method for controlling shrub encroachment and reducing the risk of fire through the elimination of dangerous fuel ladders, as represented by the continuity of grasses and shrubs which enable rapid fire propagation and which permit the transition from high intensity running fires to crown fires (Lovreglio et al., 2014, Fernandes & Botelho 2003). Fuel reduction via prescribed herbivory has now become an acceptable and generalized tool, although as little as 15 to 20 years ago the use of livestock was not officially considered an appropriate tool for fuel reduction (e.g., Pittroff et al. 2006 for California). In relation to this prevention tool we want to propose an intelligent and economically interesting use for Sardinia and all the Mediterranean countries as it was implemented in Spain as part of the "Ramats de Foc" project (https://www.ramatsdefoc.org/en/). In relation to this prevention tool we want to propose for Sardinia and all the Mediterranean countries an intelligent and economically interesting use as has been proposed in Spain within the "Ramats de Foc" project. The project, in addition to encouraging pastoralism as a means of reducing the fuel load, suggests a recognition on the end products of the livestock supply chain with a specific product mark on dairy products from areas where the pasture has also had the purpose of reducing the risk fire. In marginal agro silvo pastoral areas enhancing the products of the territory with forms of marketing that aim to provide added value are possible tools aimed at increasing profit margins. Cattle must be confined in pens of an area of approximately 0.9 hectares which are enclosed by a traditional metal fence, electrified netting or por-wire polywire fence. An electrified fence must be energized by low impedance battery-powered fence energizers, which send a pulse of electricity through the wires, eliminating the possibility of overheating (Fig.1). Solar panels can be used to keep batteries charged. Predators, if any, can be discouraged by electric fencing (Correa 2012). Prescribed grazing is the most cost-effective, non-toxic, non-polluting solution available; it is greatly appreciated by the general public and it is an environmentally friendly and effective method of nearly carbon-neutral weed control that deserve further attention and applied research.

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Figure 1 Pasture confined to electric fences

Characterization of canopy in *Quercus ilex* stands by terrestrial laser scanning

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and wildfire prevention

Keywords: Terrestrial laser scanner (TLS), forest inventory, wood volume, *Quercus ilex*

Abstract

Quercus ilex (holm oak) is a broad leaved non-deciduous tree that plays an important role in Western Mediterranean ecosystems. In Sardinia the holm oak woodlands have been traditionally managed by human activity as pastures with large isolated trees that provide livestock with shade and acorns.

Information on forest canopy structure and reconstruction of tree geometry is required at a wide range of spatial scales for several environmental applications such as carbon dynamic and ecological studies, ecological and forest management, ecosystem productivity model, description of fuel properties, etc.

In particular, an accurate description of fuel is crucial for fire hazard mitigation planning by predicting potential fire behavior and effects of fuel treatment. Landscape-level fuel maps availability, in fact, makes it possible to provide the required inputs for the fire behavior and growth models that are increasingly used to support fire management decision making. A correct characterization and classification of fuel needs accurate estimates of vegetation structure and crown attributes. However many fuel characteristics are often operationally hard to be measured requiring manual field measurements and cutting.

Recently several studies reported different potential applications of the terrestrial laser scanner (TLS) for forest stand and canopy variables estimation. Terrestrial Laser Scanner (TLS), based on Lidar technology, could be an effective alternative to overcome the limitations of the conventional ground-based forest inventory techniques: time consuming, limited accuracy, destructive measurements.

However, the accuracy and applicability of TLS techniques for canopy characterization of broadleaf evergreen forests needs further investigations. In particular, estimation of tree attributes such as canopy density, crown bulk density, branch size distribution, etc., in evergreen plants presupposes a correct separation between points representing shrubs, woody material, leaves and small branches.

In a previous work (Ferrara et al, 2018) we proposed an approach based on the point density algorithm DBSCAN for wood-leaf separation from terrestrial LIDAR point clouds of single trees. The TLS data set collected in field by multiple scanning on single trees were partitioned in cubic volumes (voxels) that were used as input to generate clusters through DBSCAN. The most highly populated cluster, due to continuous bark shape versus chaotic leaf distribution, represented wood voxels. So that process led to the identification of wood and non-wood voxels.

In this work we applied the previous DBSCAN based approach at plot level in order to evaluate performance of the proposed procedure in estimating woody material volumes, tree density and canopy cover in holm oak forest stand.

The study was carried out in an area located in South-East Sardinia, Italy. The area was covered by broadleaf forests dominated by holm oak with associated species consisting of *Arbutus unedo*, *Erica arborea*, etc. Destructive and non-destructive measurements were done inside two circular plots of 10 m radius. TLS data sets were also collected in field by multiple scanning of the two plots. The TLS data set collected in field were processed as reported in figure 1 with the purpose of isolating trees from understorey and separating wood from foliage. With respect to the single tree approach, in this case the identification of wood voxel clusters was made by applying the principal component analysis.

Experimental results show that the proposed method can accurately discriminate wood and foliage clusters and consequently correctly identify foliage, trunk and main branches. The method proposed seems to be a promising approach for improving the estimate of woody material, tree density and crown projection area especially when understory layer is dominated by low herbaceous vegetation. However, despite this approach could be a good starting point for measuring forest structure from 3D point clouds, further studies are still needed to evaluate the capability of this method in forest stands with high and dense understory and/or with different tree species.

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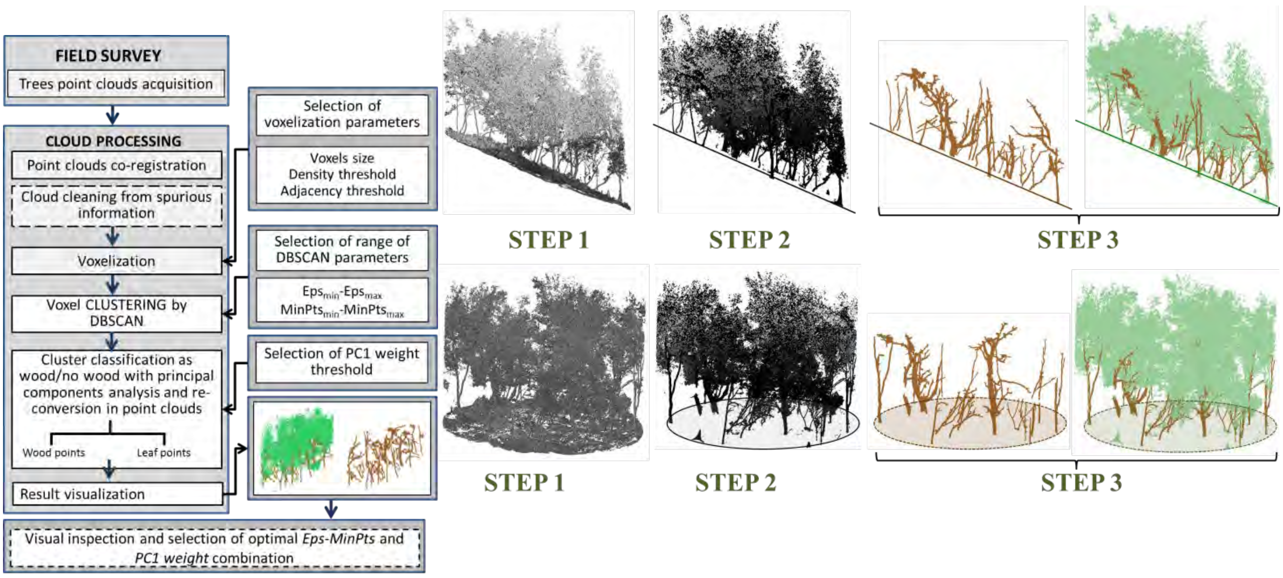

(a) (b)

Figure 1. Scheme of proposed approach at plot level for wood separation (a) and an example of qualitative final segmentation results from the elaboration of the plot scans (b)

New Business Models for innovating the cork sector and contrasting cork oak woodland abandonment

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Abstract
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Theme: Agroforestry and wildfire prevention

Keywords: Cork oak forest management, sustainability, Life cycle assessment, wildfire

Abstract

The traditional agro-silvo-pastoral system are characterized by wooded grasslands derived from human-induced transformation of forests by tree clearing and tillage. One of most common tree species of agro-silvo-pastoral systems in Sicily is cork oak (*Quercus suber* L.). According the regional inventory this species cover 18830 ha (Camerano et al., 2011) from sea level up to 600 m a.s.l. in siliceous and volcanic substrates. Traditional management of cork oak forest is an example of integration of sustainable land-use and biodiversity conservation. Cork oak woodlands are ecologically sensitive and maintained by active human management. Currently this ecosystem in the Mediterranean Basin is decreasing and it is threatening by poor or non-existent land-management practices. Especially, the Sicilian cork oaks are in decline and most of cork oak forests are not management, overexploitation of the land led to soil degradation and a lack of natural regeneration of cork oak trees. But the cork oak forest present a great potential, indeed cork is a multipurpose material used in many sectors, first the production of cork stoppers for the wine industry and other use as building materials (e.g. architecture, ship, fashion) moreover cork oak has other functions for example landscape value, improve the biodiversity.

In recent years, land abandonment is generally widespread throughout most of Mediterranean Basin, in particular the abandonment of practices of management conducts an invasion of shrubs and other oaks increasing the competition that also increases the vulnerability to wildfire. Sustainable forest management is the most important asset for cork oak conservation because this is maintained only through human use.

The aim of this work was evaluated the effect of recovery of degraded cork oak forest through sustainable management practices. The objective of management is to generate a stable structure for producing high quality cork with vigorous trees and promoting regeneration; the management strategy combines the cork production with fire preventions.

The practices for the recovery were selectived thinning, removing disease trees, scrubs management and the selective cutting of other trees (e.g. ash and other oaks). The products obtained from thinning, shrub clearing, and sanitary felling were used for firewood and woodchips.

In some cases it is necessary to plant new trees of cork oak, and also it is necessary to defend by grazing. The role played by shrubs is controversial, it is important to understand the relative importance of competing or facilitating effects of shrubs on cork oak for the successful regeneration. Also it is very important for the recovery of degrade cork oak, the stripping, this first obtained product will be poor quality but the next cork produced it will be better grade.
In this work we evaluated the ecological effects and the Life Cycle Assessment (LCA) of these practices. The LCA is a tool for the analysis of the energy balance and environmental impacts of a process from production to extraction of cork. The elimination of the shrub layer as well as favouring the development of the cork oak reduce the fire risk and the residues extracted are chipped and reused in the transformation process of cork. LCA was carried out to assess the environmental impact of management practices.

Figure 1. The photo shows how cork plants are totally invaded by shrubs that predispose them to the fire.

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Using pigs as a complementary source of income in silvopasture to reduce fire risk

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Theme: Agroforestry systems and innovations

Keywords: biodiversity, grazing, shrubs, herbaceous

Abstract

Galicia (NW Spain) has around 600000 hectares allocated to communal forestlands. Using forest understory to feed pigs could be a sustainable form of preserving the forest and increase understory biodiversity, reduce fire risk while complementing the income of farmers based on the products they can sell (Rigueiro-Rodríguez et al. 2009). However, large infrastructures are needed to reduce personnel resources that allow farmers to make this activity compatible with their full-time job. Pig grazing should be evaluated to understand how the interaction among the grazing and the understory production and composition is produced. This study aimed to evaluate the effect of grazing with celtic pigs on the variation of the understory composition in a silvopastoral system established under *Pinus sylvestris* L. in Galicia. In 2018, a silvopastoral system was established in a plantation of *Pinus sylvestris* L. (400 trees ha^{-1}) in the communal forest "Monte de Carballo" (Friol, Lugo, Galicia). In this plantation, a plot of 50 ha was established with an electrified mobile fence. During one year, this plot was grazed with 60 celtic pigs which were also fed with an automatic system at fixed points of the plot every day. At the beginning of the experiment (July 2018) and before moving the electrified fence to establish a new plot (April 2019), the percentage of the different species in the understory was estimated at three distances from the feed and water resource (near, medium and far). In those distances, the percentage of the species in the understory was estimated by visually identifying the species located in three random squares of known surface (4 m^2). The results of this study showed that the grazing with pigs decreased the percentage of *Rubus* and *Erica* in the understory over time, increasing the percentage of grass and bare soil after the pigs left the plot (Figure 1). Therefore, in this study, the pig grazing decreased the shrub production in the understory which could decrease the fire risk, as shrubs are more flammable than herbaceous vegetation (Ferreiro-Domínguez et al. 2014). This result is very important in Galicia because the Galician region is one of the most fire-prone areas of Europe, mainly due to the warm temperatures and adequate water availability throughout the year, which makes Galicia the region of Europe with the highest forest growth rates. Moreover, in this experiment, a gradient of grazing intensity was found if considering the distance from the feed and water resource. Bare soil was reduced as the distance from the area grazed and the water and feed container was increased. However, after grazing, there was a recovery of the understory mainly converted in grass species.

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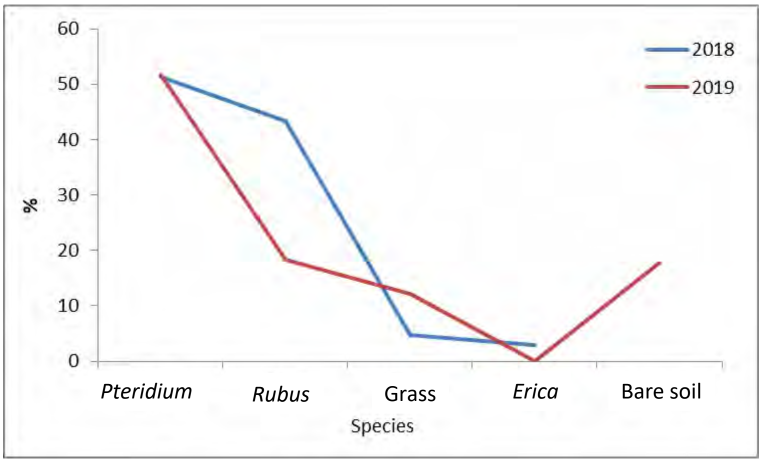

Figure 1. Variation of the understory composition (%) in a silvopastoral system established in a plantation of *Pinus sylvestris* L. with celtic pigs in Galicia (NW Spain).

Predicting wildfire probability and intensity in Mediterranean agro-pastoral systems

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry systems and innovations (Agroforestry and wildfire prevention)

Keywords: *grazing, fuel management, FlamMap, wildfire simulators*.

Abstract

Mediterranean rural landscapes are often characterized by a complex matrix of grasslands, open wooded pastures, shrublands and broadleaf forests. This mosaic of vegetation types was essentially determined by the occurrence of different anthropogenic disturbances: wildland fires, deforestation, grazing, and other modifications of land use (Weissteiner et al., 2011). As regards to wildland fires, their occurrence and propagation is mainly affected by human factors that, in association with the environmental factors (vegetation, weather and terrain), determine the wildland fire probability and intensity.
The modeling approach can be used to estimate and map the landscape areas affected by high values of wildfire probability and intensity; in addition, models can be used to predict the effects of different fire prevention and fire management interventions, as required by the agencies devoted to the design of fire prevention plans (Salis et al., 2018).
The aim of this study is to simulate the effect of different silvopastoral interventions on the probability and intensity of wildland fires on a silvopastoral system located at Monte Pisanu, Central Sardinia, Italy. With this purpose, we simulated fire spread and behavior considering different scenarios of fuel load, grazing pressure and environmental conditions.
The study area is mainly covered by wooded pastures and is grazed extensively by dairy sheep and cattles. Within the study area, we established a set of 23 sample plots along the elevation gradient. At each sample plot, a grazing exclosure cage was placed for simulating a non-grazed scenario. For both scenarios, we collected herbaceous fuel load and height at the beginning and at the end of the fire season, in order to characterize the variations of herbaceous fuel model. In addition, we measured canopy characteristics (canopy height and crown base height) to evaluate the probability of active and passive crown fire behaviour. The recent fire regime of the experimental area, including the surrounding areas which mainly act as fire source, was studied in order to define a map of wildfire ignition; in addition, we defined severe and extreme fire weather scenarios (wind field and fuel moisture) by analysing historical weather. The data on ignition probability together with the data on fuel models, the weather scenarios and other descriptors of landscape characteristics (elevation, slope, aspect, etc.) were used to initialize a set of simulations using the FlamMap fire mapping and analysis system.
Fire probability maps provided by the FlamMap simulator (Finney, 2006) showed low values of wildfire probability in the grazed scenarios (Figure 1) for both short-term (3 hours) and medium-term (5 hours) wildfire duration. Considering the north-west prevailing winds, the grazing of the north-west uplands in the central sector of the area was able to reduce the burn probability even in the steeper areas near the south-east sector, where most of the relevant forest values are concentrated. The study provided evidence of the reduction of the area affected by crown fire in the grazing scenarios, due to the reduc-

tion of vertical continuity between surface herbaceous vegetation and canopy layer. The modeling approach also allows to identify areas characterized by high fireline intensity values, where crown fires are more likely to occur and firefighting interventions are more difficult.
The study showed the capabilities of the proposed modelling approach in providing useful data and maps to assess the effects of grazing pressure on fire behaviour, identify the areas with high probability of burning, and design fire prevention and management practices. Therefore, pastoral activity, sized on the real potential of natural pastures, can make agroforestry systems more resilient to fire preserving the multifunctional use of them.

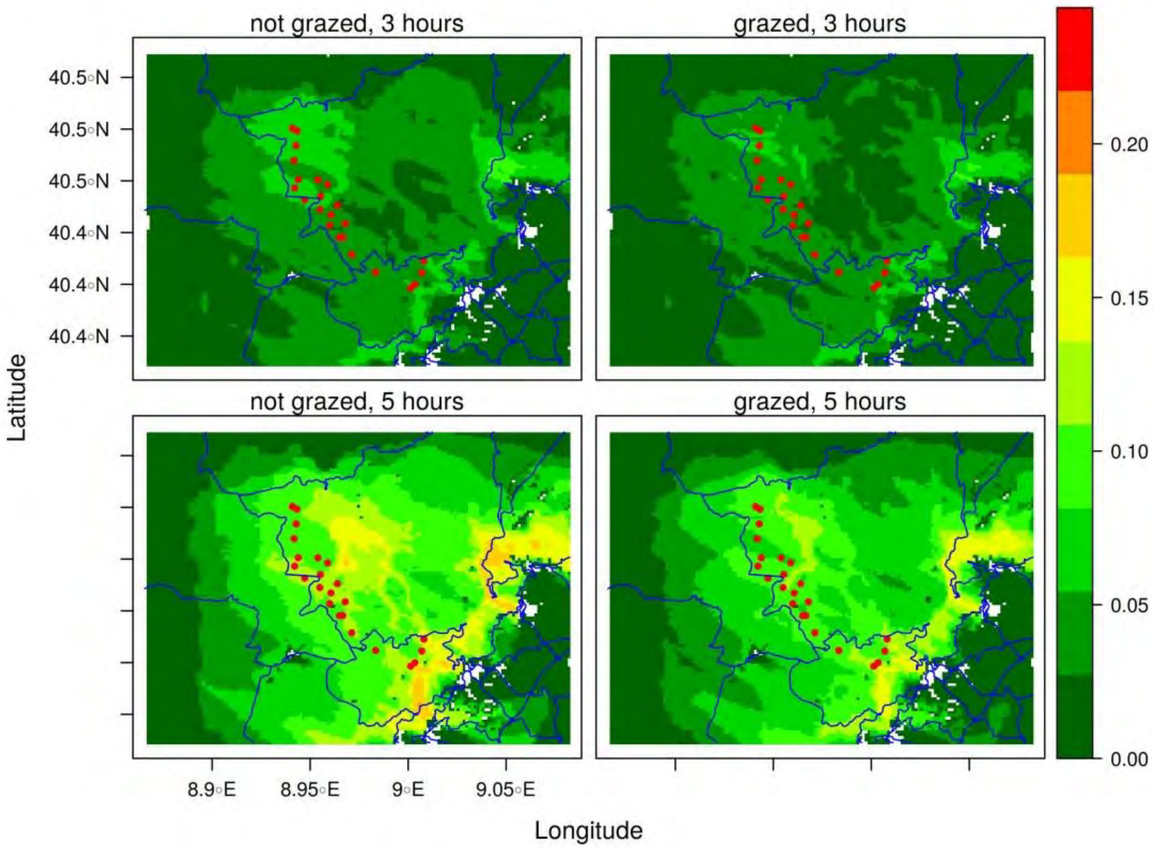

Figure 1. Spatial pattern of burn probabilities simulated using not-grazed and grazed scenarios and considering short-term (3 hours) and medium-term (5 hours) duration of wildfire propagation. To perform the simulations, we considered the fuel load estimated by field measurements (sample points in red), the prevailing north-west wind scenario and a random sample of wildfire ignitions.

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Mapping Wildfire Risk in Lebanon: Challenging a Stepwise Approach for Effective Purposes

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and wildfire prevention

Keywords: wildfire risk, impact chain, exposure, hazard, sensitivity, adaptive capacity

ABSTRACT

Forests in Lebanon are a unique feature of the Eastern Mediterranean; they comprise various broadleaf and conifer trees covering the mountains in patches. Recurrent fires, improper management, outdated laws, poor policy enforcement, and climate change increasingly affected Lebanese forest degradation. During the past two decades, fires have been significantly damaging Lebanese forest landscapes in Lebanon.

In this context, wildfire risk assessment is an essential component of wildfire management by supporting fire prevention measures and risk mitigations. Simultaneously, appropriate fire vulnerability assessments are needed to be investigated and assessed under climate change conditions to help assess fire impacts and prioritize adaptation options and development plans.

According to the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5), risk is the interaction of vulnerability (e.g., propensity or predisposition to be adversely affected), exposure (e.g., presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, socio-economic and cultural assets in places and settings that could be adversely affected), and hazard (e.g., climate-related physical events, their trends and their physical impacts).

In this study, the main objective was to develop a forest fire risk assessment and mapping model under actual and future climatic conditions (i.e., in the context of the IPCC AR5 framework) and in the function of hazard, vulnerability and exposure. The study area comprised the Beirut river watershed characterized by a dense vegetation cover and increased fire hazard.

The work methodology involved a stepwise approach (i.e., impact chain) to evaluate the following main components: exposure, sensitivity, hazard and adaptive capacity in the context of the IPCC AR5.

Multi-sources spatial data on natural, human, infrastructure, economic and financial factors were collected and integrated to create composite indices, representing each of the evaluated components and expressed in multiple dimensions. Besides, 87 municipalities and 15 civil defense centers (i.e., fire-fighting stations) were also surveyed to acquire data concerning the adaptive capacity components.

Aggregating and weigthing the different components through the impact chain resulted in the final risk assessment for Lebanon (provinces level) (an example in Figure 1) and the study area.

Overall, this work highlighted the potential of the proposed approach to visualize the main vulnerable areas to fire risk and possible gaps in adaptation to fire risk. This approach is expected to help identify and select future adaptation measures that could support the development of fire risk management plans and strategies, taking into account variations in climatic conditions.

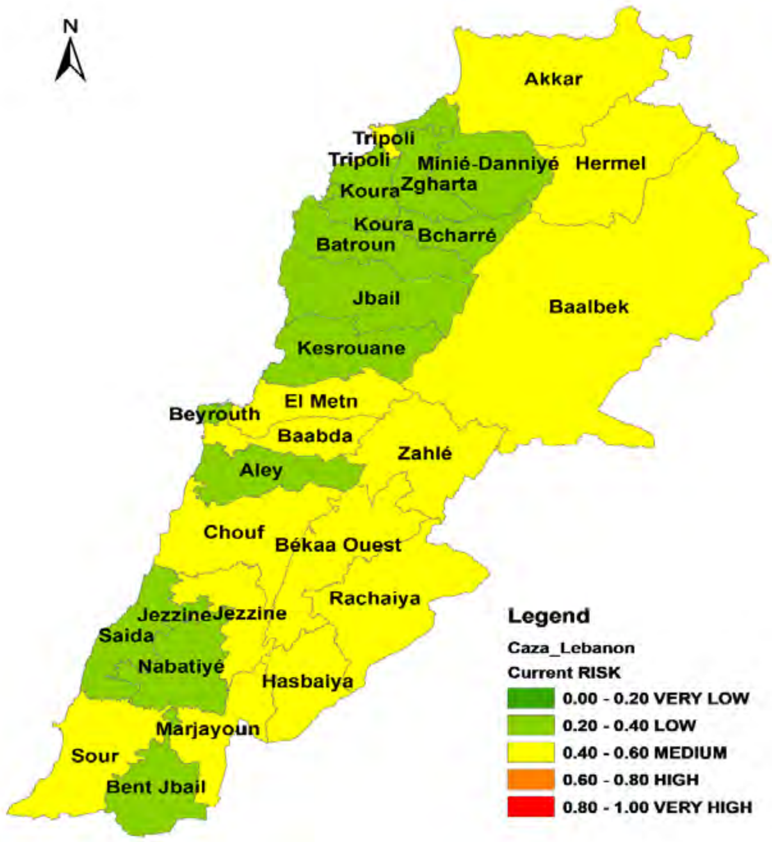

Figure 1. Lebanon risk map for the current period

3.2

Agroforestry innovations toward innovative agroforestry systems

Do agroforestry practices improve tree performance compared to monoculture? Case study of agroforestry plantations including fast-growing trees

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry systems and innovations

Keywords: Temperate agroforestry, Tree-crop interactions, Alley-cropping, Tree growth

Abstract

Introduction

In the northeastern region in France, agroforestry practices are emerging, and farmers have many questions about the value of these systems. They generally have little or no experience in managing the tree component that they will integrate into their cultivation systems. It is therefore necessary to provide tools to farmers to understand the functioning of the tree component and tree-crop interactions in agroforestry systems. Nowadays, the processes of interactions between species are still poorly understood, especially when it comes to interactions between herbaceous and woody species due to the positioning of agroforestry at the crossroads of forestry and agronomy. In agroforestry systems, interactions between woody and herbaceous components can be negative, positive, or neutral (Jose et al. 2004). The performance of these systems is the net result of these different kinds of interactions.
The aim of this work is to assess the performance of fast-growing trees, i.e. poplar and alder, in association with alfalfa and cereals respectively, through the effects of crops on tree growth compared to their respective tree monocultures. The main hypothesis is that interspecific competition in agroforestry will be less strong than intra-specific competition in tree monocultures due to a sharing of niches between species. It is therefore expected that trees will be larger and taller in agroforestry than in monocultures. We suppose that the stratification of the canopy and the root systems in agroforestry will allow a more efficient capture of light, water, and nutrients resources (Bai et al., 2016).

Experimental design

The plantation is located on an agricultural plot of the experimental farm of La Bouzule located near Nancy, northeastern France. The plantation is instrumented to monitor environmental conditions since tree plantation in 2014 (rainfall, soil and atmospheric temperature and moisture, irradiance…). It consists of three blocks each of them composed of (1) "forest" plots (poplar/alder in monoculture) and (2) "agroforestry" plots (poplar/alfalfa mixture, alder/cereals mixture). The "forest" plots have a density of 2000 stems per hectare. In the agroforestry plots, every second tree line has been replaced by crops as compared to tree monocultures. Height and diameter at breast height (DBH) were measured at the end of each growing season for all trees since 2015 and 2017, respectively. For each tree, the height to DBH (*h*/*d*) ratio was calculated and used as a competition index (Ghorbani et al., 2018).

Results

Table 1 shows that, until 2018, the mean height of poplars was higher in monoculture than in agroforestry with 276 cm and 223 cm in 2017, respectively. From 2018, poplars in agroforestry are catching up with poplars in monoculture and at the end of the 2019 growing season, agroforestry poplars had an average height not significantly different from poplars in monoculture with 467 cm and 464 cm, respectively. For DBH, agroforestry poplars exhibited significantly larger stems than poplars in monoculture from 2019 with a value of 46 mm *versus* 37 mm, respectively. After six growing seasons, agroforestry alders were not significantly different as compared to alders in monoculture in terms of stem height and diameter with 322 cm and 24 mm *versus* 310 cm and 22 mm, respectively.

Discussion & Conclusion

Based on the results, we assume that there is a change over time in the nature of the interaction between alfalfa and poplars in agroforestry. The first years after planting, we suppose that competition was predominant in agroforestry, as tree height was significantly lower compared to poplar monoculture. Powell and Bork (2004) showed that height and diameter of poplars were reduced by 30% when they were associated with alfalfa during early stages of development. From 2018, the predominant interaction seems to shift from competition to a combination of competition reduction and facilitation in poplar agroforestry plots. Taghiyari and Efhami (2001) showed a positive effect on the increase in diameter of poplars in an agroforestry system with alfalfa after ten years. In our study, it may be possible that alfalfa, as a nitrogen-fixing species, had a positive effect on poplar growth. A second reason may be that, since the spacing between two poplar rows in agroforestry is larger, the competition for light is reduced. For alders, agroforestry practices had no significant effect on tree growth.

To conclude, height and diameter growth of alders did not appear to be affected by the association with the crop, suggesting that intra- and interspecific competition is equivalent or that it is too early to observe interactions. After six years of growth, positive interactions seem to be effective in the poplar/alfalfa association in agreement with our hypothesis. To better understand the processes of interactions between species in these associations, the efficiencies with which trees use water and nitrogen resources, tree architecture, phenology, gas exchanges as well as biomass production will be estimated in each plot.

Table 1. Height and diameter at breast height (DBH, mean ± standard error) of poplars and alders in monoculture and in agroforestry. Different letters indicate significant differences between species and treatments for each year.

		Tree height (cm)					DBH (mm)		
		2015	2016	2017	2018	2019	2017	2018	2019
Poplar	Monoculture	158 ± 2.7 c	223 ± 3.5 b	276 ± 4.4 d	348 ± 5.5 b	464 ± 20.2 b	21 ± 0.4 c	27 ± 0.6 b	37 ± 0.8 b
	Agroforestry	106 ± 2.5 b	146 ± 3.9 a	223 ± 4.4 b,c	343 ± 6.5 b	467 ± 20.1 b	15 ± 0.5 b	27 ± 0.8 b	46 ± 1.2 c
Alder	Monoculture	101 ± 1.0 a,b	157 ± 1.7 a	186 ± 1.9 a,b	262 ± 2.3 a	322 ± 9.3 a	11 ± 0.2 a	17 ± 0.3 a	22 ± 0.3 a
	Agroforestry	82 ± 1.1 a,b	151 ± 1.9 a	187 ± 2.2 a	264 ± 2.9 a	310 ± 8.3 a	11 ± 0.2 a	19 ± 0.3 a	24 ± 0.5 a

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3 years of agroforestry implementation in Brandenburg – main findings, lessons learnt, outlook

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems / Education, information sharing, and awareness raising in agroforestry

Keywords: Brandenburg, high value timber, drought resistance, biodiversity, grazing, sustainable development, education

Abstract

The Eberswalde University for Sustainable Development implemented an innovative agroforestry system (Ackerbau(m)) 3 years ago on sandy soils in Brandenburg, with the goal, to increase biodiversity, decrease wind and water erosion and establish a site that can serve as a model project for farmers, land users and politicians in Brandenburg and Berlin. At the same time, the project should serve as a teaching and learning site for Bachelor- and Master-students of the university, showing a real case example with real problems and challenges that students have to cope with within the modules.

Based on several Bachelor theses, the tree rows for the production of high value timber were planted December 2017, with a distance of 38 m between the rows. As well, hedge rows were planted and fruit bearing shrubs (see fig. 1). The site was further developed each semester and data on e.g. avifauna, biodiversity, plant health and soil composition were collected twice per year.

Based on our analyses, the following can be said:

Covering the soil around all freshly planted trees considerably increased the survival rate of the trees. In the hot summers of 2018 and 2019, many farmers and forest owners in Brandenburg were facing difficulties regarding drought and dieback of crops/ trees. In contrast to this, survival rate of the trees on our site was high: in total, 73 % of all trees survived the two summers without problems. As a result, only some replanting of trees had to be done some weeks ago, to ensure a sufficient high number of trees in the future. Interestingly, it was not the trees species that we expected to survive that did survive: while especially the different oak species (*Quercus rubra* and *Quercus petraea*) were dying and showing high rates of trees in critical state or dead (58 % and 38 %), other tree species such as sorb tree (*Sorbus domestica*), service tree (*Sorbus terminalis*) and wild pear (*Pyrus pyraster*) were coping with the extreme conditions in summer much better, which resulted in survival rates between 94-98 %.

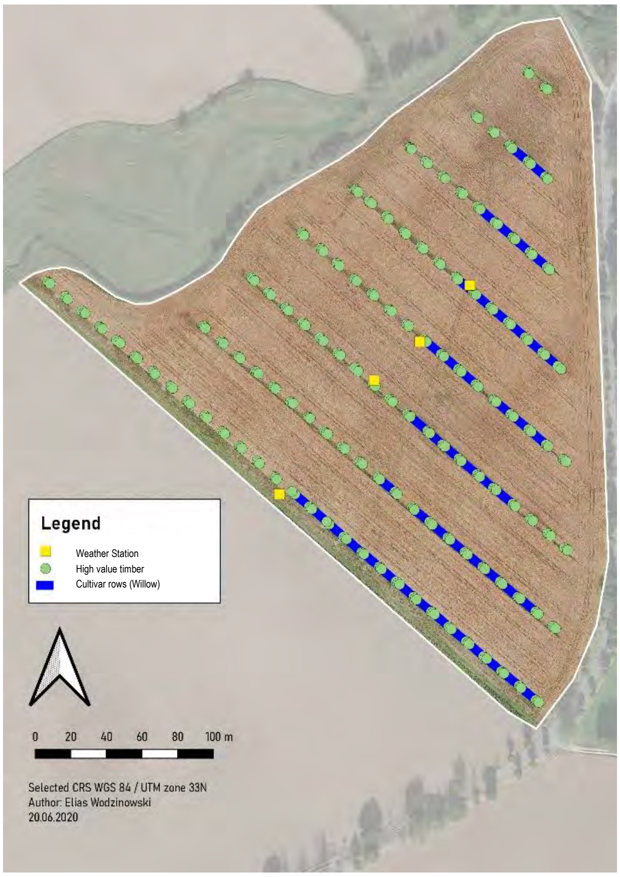

Figure 1: Agroforestry site in Löwenberger Land, Brandenburg, Germany

As well, we learnt that protection against grazing is an absolute must! While all the trees were protected using TUBEX shelters, the hedges and fruit bearing shrubs that were only partly or not at all protected are showing loss rates of nearly 100 %. In consequence, this can mean, that agroforestry systems in regions, that are known for a high pressure of deer should be protected by fencing them, although this might result in higher cost for the fencing itself, but also in higher cost for managing the site.

The growth of the trees is better than expected: especially tree species such as sorb tree, service tree and Turkish hazel (*Corylus colurna*) show promising growth rates in the first two vegetation periods with an annual growth of up to 0,8 m.

As well, first changes in biodiversity can be seen: birds such as the red kite (*Milvus milvus*) or the Thrush nightingale (*Luscinia luscinia*) could be proven on the site and the conditions of the agroforestry system are obviously beneficial for such bird species, in terms of e.g. coverage and food supply.

Finally, weed pressure is an issue that has to be handled, especially within the tree rows - thistle (*Cirsium arvense*) and other weed were growing very well in the non-managed areas between the tree groups, and concepts on how to handle these areas are being developed. First approaches to handle the weed might result in the planting of willow trees in these spaces, to decrease light and water availability for the weed, while at the same time further decreasing wind speed and therewith wind erosion on the site in total.

In summary, it can be said that a successful implementation of agroforestry systems using high value timber trees is possible, but requires a lot of manual labour and efforts to guarantee a successful establishment of the trees. An economic analysis of all the inputs into our agroforestry system was not yet performed but will be done in the future.

Agroforestry between tradition and innovation: redesigning organic long-term experiments in Italy through participatory approach

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Agroecology, sustainable development, participatory action research, agricultural systems redesign, organic farming

Abstract

With the Green Revolution, specialization and industrialization of agriculture has led to the drastic decline of rural traditional models based on the integration of plants (i.e. arable, vegetable, perennial fruit crops) and animals. Mechanization, chemical inputs, and the increasing cost of agricultural labour have progressively caused the simplification of the agroecosystems, as far as drastically reduced the farmers' ability to design their own farming system to optimize the local resource use.

In response, agroecology offers the possibility to build more sustainable agroecosystems by promoting diversification, emphasizing the interrelatedness of the system components and the complex dynamics of ecological processes (Vandermeer, 1995). Together, it aims to restore the decision-making role of farmers in the agro-food system by encouraging their direct involvement in the research, enriched in this way with their knowledge and experience (Ciaccia et al., 2019). In such a context, the co-design of agro-food systems able to encompass the environmental, economic and social dimensions of agriculture, identifying the trade-offs between potential issues (i.e. yield reduction, labour increase) and positive impacts (environmental footprint reduction) is activated by participatory action research (PAR) (Kemmis and McTaggart, 2008).

Agroforestry, miming natural ecological processes, has been attracting, across Europe, increasing interest as agroecological approach for sustainable (agroecological) intensification (Smith et al., 2012). Italy holds an important tradition in agroforestry (Paris et al., 2019). Until the 60s the *coltura promiscua* (the cultivation of vineyard associated to trees and arable crops) widely characterized the Italian agricultural landscape. The arable land was overspread of isolated trees producing wood, fruits or leaves, or crossed by tree rows that served as live supports for the vineyard. Still today, many Italian agricultural lands are registered as "*seminativo arborato*", literally tree-covered arable land, being this name associated to such systems during the nineteenth century. These mixed systems, together with silvopastoral systems, had a pivotal role in the national rural economy, landscape management and in the maintenance of high levels of agroecosystem biodiversity and resilience.

Agroforestry maintains a significant potential to improve farming productivity and profitability (Rois-Díaz et al., 2018), while increasing the system sustainability in terms of environmental impact and climate change adaptation. However, the (re)turn to agroforestry systems requires important efforts in innovation and knowledge, in terms of studying the synergistic association of crops and exploitation of resources at

field and farm scale, but also of re-thinking the entire food supply and value chain, no longer suitable for valorising diversified incomes in smaller volumes in relation to local social and economic conditions.

The main objective of this work is to demonstrate that the PAR process could represent a powerful approach to re-design sustainable diversified agroecosystems, implementing agroecology. For this purpose, the local actors' communities connected with two already existing organic Long Term Experiments (LTEs), were activated. In detail, the LTEs were:

i) MAIOR (*MAIntenance of Organic oRchards*) LTE, at the experimental farm of the Research Centre for Olive, Citrus and Tree Fruit of CREA, located in Rome (latitude 41° 47'N, 12° 37'E), characterized by an organic apricot orchard in which soil and biodiversity are managed following agroecological principles (use of agro-ecological services crops, spontaneous flora functionality exploitation, on-farm inputs for soil fertility, reduced tillage), in which a new fruit orchard is being designed and planted.
ii) MITIORG (*Long-term climatic change adaptation in organic farming: synergistic combination of hydraulic arrangement, crop rotations, agro-ecological service crops, and agronomic techniques*) LTE, at the experimental farm of the Research Centre for Agriculture and Environment of CREA, located in Metaponto (MT), South of Italy (lat. 40° 24' N; long. 16° 48' E, 8 m above the sea level), where agro-ecological practices, to adapt organic vegetable production to climate change conditions, are tested (Diacono et al., 2016), in which a new vegetable rotation is being designed and introduced.

Following the methodology reported in Ciaccia et al, 2019, in a first step, the informal, local multi-actor networks (organic farmers, advisors, processors) connected with the two LTEs were activated through participatory meetings, where participants were questioned on the main choices and research priorities to be addressed in order to build the two new LTEs, based on their experience and perception of the main issues of the local agro-food systems. In a second step, a focus group composed of researchers has been set up, with the aim to discuss the multi-actors' proposals and evaluate their feasibility on the basis of commonly identified criteria, to achieve joint solutions potentially up-scalable in the territory.

As main output of this two-step interaction process, agroforestry was highlighted as the key to rethink the two systems. Therefore, in parallel, maintaining as much as possible the vocation of MAIOR and MITIORG LTEs, vegetable/shrubby and tree/shrubby components are being introduced, respectively.
Combining local knowledge and experiences with scientific knowledges, the discussion is currently open within the activated networks (third step of the process) and is moving towards the definition of the strategies to manage complexity and innovation. An updated long-term perspective research protocol will be designed for both the LTEs which, being pivotal research and innovation living labs, will accompany the transition towards more sustainable local agricultural systems.

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Differences in measured and modeled transmitted photosynthetically active radiation in different orchards and their impact on understory crop photosynthesis

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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Precision agroforestry, alley cropping, light, modeling, chestnut, Castanea

Abstract

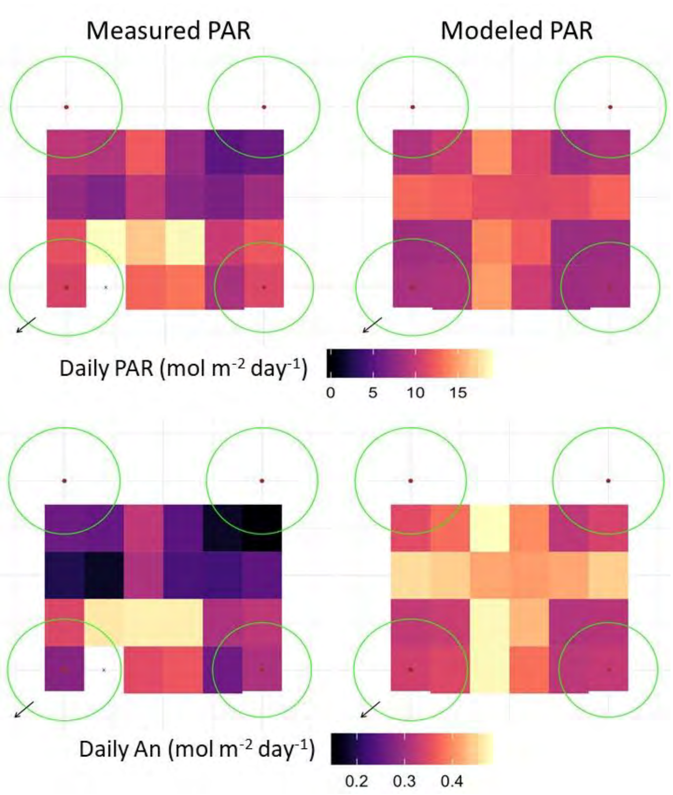
Agroforestry can be an opportunity to increase productivity and income per unit of land by producing understory crops under trees. However, crop performance under trees is usually limited by low photosynthetically active radiation (PAR) availability (Friday and Fownes 2002). The PAR transmitted by the trees and available for understory crops is strongly influenced by tree density and canopy size and is not uniform in the alley, creating areas with different PAR availability. Knowing exactly how the transmitted PAR is distributed in space and time below tree crowns is essential to identify the best intercropping strategies and crop positioning.

In this work we measured the PAR transmitted under the canopy of two young (Young A and B) and two mature (Mature A and B) chestnut orchards, located at the Horticulture and Agroforestry Research Center of the University of Missouri, in New Franklin, MO, USA. The young orchards were five years old and the mature orchards were 20 years old. In the young orchards tree spacing was 4 m along the row and 6.5 m between rows. In the mature orchards tree spacing was 8.2 by 9.3 m (Mature A) and 8 by 8 (Mature B). Transmitted PAR was measured in a 24-point grid below four adjacent trees per orchard, during several clear and overcast days in September and October 2016, using calibrated photosensors (GaAsP, Hamamatsu, Japan). The photosensors were connected to a data logger (DL6, Delta-T, UK) taking records every minute. For each position, day and orchard, the daily PAR transmitted by the trees was calculated by integrating the instantaneous measurements over the day. Transmitted PAR on the same points was also estimated using a purposely build 3D, spatially explicit, ray-tracing light interception model where canopy porosity was calibrated to match the overall (i.e. average of the 24 sensors) measured transmitted PAR. The model assumed a regular tree canopy shape (i.e. cylinder or ellipsoid) which was parameterized with actual canopy size from field measurements. Finally, we used both the measured and modeled transmitted PAR patterns in each position/day/orchard to estimate the correspondent daily net photosynthesis (An) of an understory wheat leaf. Further details can be found in Rosati et al. (2020).

Despite calibrating the model to match measured overall (i.e. average of the 24 positions) transmitted PAR, modeled and measured PAR differed substantially when comparing individual positions. Particularly, measured PAR had greater extremes than modeled, and clear spatial PAR patters predicted by the model tended to disappear in the measured datasets. Figure 1 shows the example of one day (October 13) in orchard Mature B: the model predicted higher PAR level in the center of the alley, in both directions (top right panel), however, measured PAR did not show such patterns (top left panel). Additionally, the range of PAR values was more uniform for modeled PAR (7-15 mol m^{-2} day^{-1}) than for measured PAR (4-20 mol m^{-2} day^{-1}). Estimating An from measured and modeled PAR resulted in similar differences, i.e. disappearance of clear spatial patterns and greater range of values for measured PAR (bottom panels). Additionally, while for PAR patterns the overall PAR (average of 24 sensors) coincided by default (due to calibrated porosity), the estimated An was much less (i.e. generally darker colors) with measured PAR. This was because measured and modeled PAR differ not only in space, but also in time, during the day. Figure 2 shows the class distribution

frequency of measured and modeled daily PAR values for a sample but representative sensor on the same day (October 13): modeled PAR underestimated the frequencies of very low and high PAR values, and overestimated those of intermediate values. Photosynthesis is more efficient (i.e. greater radiation use efficiency) at intermediate PAR levels than at both very high (due to saturation) and very low (due to leaf respiration) PAR levels (Hirose and Bazzaz, 1998; Rosati and DeJong, 2003). Therefore, more time spent at intermediate irradiance results in greater An than at extreme levels, even if the total daily irradiance is the same.

These results suggest that, for the purpose of designing an efficient intercropping management, it is not enough to know the overall PAR transmittance under the trees, as commonly done by either measuring or modeling transmitted PAR, but it is important to know how the PAR is distributed in space, and its dynamic over time. In fact, an understory crop will perform differently in the different positions in the alley, based on the actual PAR available, both in terms of total PAR availability and in terms of dynamic changes over time. Crop performance is likely to be greater where higher PAR is available, but current models, assuming regular canopy shape, do not predict correctly this availability, thus leading to bias mapping of available understory light. Additionally, even when the daily light is correct, assuming uniform canopy porosity results in modeled daily patterns that are more uniform over time than in reality, even when models are designed to output PAR for every minute, leading to overestimation of crop photosynthesis.



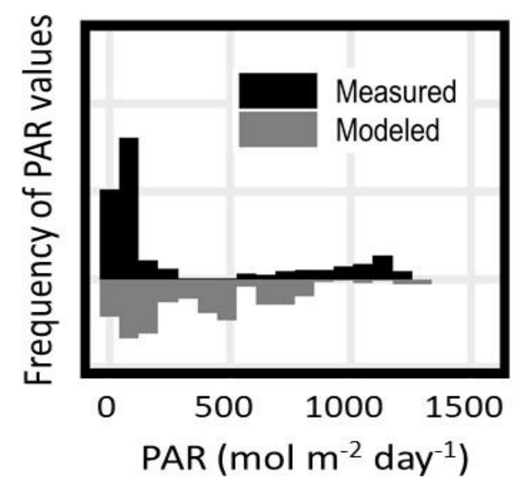


Figure 1. Left (series of 4 panels): spatial distribution of modeled (right panels) and measured (left panels) daily transmitted PAR (top panels) and of the correspondent estimated photosynthesis of a wheat leaf (bottom panels) at 24 positions under a mature chestnut orchard. Data are for October 13, a clear day. Green circles represent actual canopy size. Right (one panel) panel: class frequency distribution of measured and modeled transmitted PAR values for one representative position as in the left figure (top panels).

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From early adopters to mainstream: Facilitating the developing agroforestry community in the Netherlands

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: The Netherlands, System design , Silvoarable agroforestry experiment, community of practice

Abstract

The Netherlands is well known globally for its large-scale and productive agriculture but less well known for agroforestry. Recently, agroforestry has been taken up in several national policy documents as one of the solutions for reaching the set goals for climate mitigation and adaptation, biodiversity and soil quality. Dutch agroforestry is now seeing pioneers, or early adopters, who have taken the leap in designing and developing novel agroforestry systems adapted to their specific context. As a research institute we have set up a programme to facilitate this innovative movement by supporting with scientific and agronomic expertise, the setting up of a research facility, by monitoring the effects on ecosystem services at a selection of farms and by facilitating knowledge dissemination and the creation of regional networks.

The programme goals are the following: 1. Identify barriers to agroforestry implementation in the Netherlands, 2. Develop a stepwise plan to overcome them, 3. Explore the potential of Agroforestry to meet various policy goals regarding production, climate mitigation and adaptation, soil, water quality and biodiversity, 4. Design and implement a set of diverse agroforestry systems in collaboration with entrepreneurial farmers, 5. Set up a 'Community of practice' that involves and engages a wide range of stakeholders from multiple disciplines (e.g. farmers, policy makers, financing entities, buyers) to broaden the knowledge base and accelerate the creation of knowledge regarding optimal tree-crop combinations and system design.

For knowledge dissemination we have published five Factsheets (in Dutch) to provide pioneering farmers with valuable knowledge on agroforestry. These are focused on the identified barriers for implementation and important topics in the current policy environment. These factsheets include: 1. "Laws and regulations: Planting trees on Farmland: what am I allowed to do?" 2. "Biodiversity: Increasing biodiversity, how do I do that?"; 3. "Carbon sequestration: Climate compensation with agroforestry, what is possible?"; and 4. "Economy: Agroforestry, what is the economic performance?"; "Mechanisation: What are the possibilities for mechanisation?".

To be able to answer the most important research questions for agroforestry in the Netherlands a research facility for silvoarable agroforestry has been set up. The experiment features windbreaks using a variety of species as well as hazelnuts on different alley widths. The idea is that the windbreaks will nurse the young hazelnuts and later be replaced by them. We will be investigating whether hazelnut is a suitable crop for agroforestry systems in the Netherlands. Due to the open landscape and strong winds, we also investigate

whether hazelnuts are suitable windbreaks with positive effects on the microclimate of the arable crops. In the experiment we will carefully monitor the interactions between crops and trees, as well as the economic performance and effects on biodiversity and soil.

Each pioneering farmer in the project receives support in the design of their context-specific agroforestry system. From implementation onwards we are monitoring impacts on crop yield and quality, biodiversity, resilience, investments, economic feasibility and labour. Currently, we are working on six designs with six different entrepreneurs including: a pear and arable alley cropping system within a large scale strip-cropping field; a silvoarable hazelnut and walnut hedgerow system; a market garden with a diverse alley cropping system with specialty and medicinal crops and trees. In the process of designing and developing these systems we have gained new knowledge and insights together with the farmers. In this presentation will share these experiences and the key learning points from the programme so far.

Paulownia in Northern Italy and its potential use in silvoarable systems

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry

Keywords: paulownia tree, paulownia wood, silvoarable system, comparison field

Abstract

The trees of the gen. Paulownia have been used for millennia in China to produce timber and other products (fodder for livestock, etc.). Paulownia wood has very peculiar characteristics (lightness, stability, durability) that make it a commodity required all over the world. Today we find it ubiquitous in the large furniture and furnishing chains (for example IKEA and Maison du Monde). Starting in 1983, thanks to a project funded by the International Development Research Center (IDRC) of Canada and developed by the Chinese Academy of Forestry, a rapid process of genetic improvement was initiated that led to the establishment of hybrids that further enhanced the basic characteristics of Paulownia trees: rapid growth and production of a very light and precious timber (Chinese Academy of Forestry 1986). In China Paulownia trees are traditionally cultivated in agroforestry systems, planted in the "four sides" (house side, village side, road side and water side). The cohabitation between Paulownia and other crops is favored by some characteristics of these trees: sparse crown and deep root system. Since the ‘80s Paulownia trees began to be planted in several other temperate and subtropical countries. Italy was one of the first European countries to start growing Paulownias. The interest in this tree has had three phases so far:

- 70s: first trials in Sardinia and Central Italy (Mezzalira 1997);
- ‘90s: spreading of plantations in the regions of Northern Italy thanks due to the funds of EU Regulation 2080/92; pioneering phase, in the absence of a wood market, supported by the work of the Italian Paulownia Association (Associazione Italiana Paulownia, AIP) (Mezzalira 2002);
- '10s: introduction of hybrid clones; ultra-short rotation forestry (3 - 5 years) aimed at producing timber for the furniture industry.

The plantations built in the ‘90s (about 1,000 plots) were characterized by small scale (a few tens or hundreds of individuals), planted mainly in small groves, using non-clonal materials, mainly belonging to the species Paulownia tomentosa. The context was not agroforestry (Mezzalira 1999). The technological quality of the wood produced in the first Italian plantations was found to be very high (Gridelli 1999). The results obtained in these plantations, now being harvested, allow us to have initial information on the productive potential of the species. The growing demand of paulownia wood, which has since become well known by the local market, now allows to define a sale price by the producer and to set a precise economic analysis of the profitability of the plantations.

In the year 2000, thanks to the collaboration between the Italian company Paulownia Italia srl and the Chinese Academy of Forestry (prof. Zhang Huaxin), in the Lombardy region (Monzambano, MN, N Italy)

a comparison field was created to test 17 different Chinese origins belonging to three Paulownia species (*P. Tomentosa*, *P. Fortunei*, *P. Elongata*). The development of the different individuals of the different species has been followed in the first 10 years (Scomazzon 2009). In December 2019 Veneto Agricoltura (Veneto Region Agency for Innovation in the Primary Sector) detected auxometric parameters of all the individuals surviving in the comparison field after 20 years, as well as some characteristics concerning the shape of the crown, the stem, the branches and the vitality of the plant.

The main objective of the Veneto Agriculture project is the development of clones suitable for cultivation in agroforestry systems, enhancing the pioneering work started over 20 years in the Veneto region with the introduction of a wide spectrum of Chinese origins of different species of Paulownia. Starting from these data they have been identified the plus trees corresponding to their respective origins and, through micro-propagation techniques, seedlings will be produced for the creation of a second comparison field. Controlled pollination between these individuals will bring to the new clones.

The Veneto Agency for Innovation in the Primary Sector has finally built a clonal comparison field in its pilot and demonstration farm "Sasse Rami" (Ceregnano, Rovigo, NE Italy) to evaluate the performances of the various Paulownia clones introduced in cultivation in Italy in recent years. Next year in the same pilot farm is planned the plantation of a silvoarable system where different clones will be planted along the ditches present in the agrarian arrangements called "ferrarese piana", widespread in the plains of northern Italy. The originality of the project consists in selecting the new paulownia clones starting from an agroforestry contest.

Conclusions

In recent years in Italy a new phase has begun in the cultivation of Paulownia trees. This renewed interest is based on the local demand for Paulownia wood and on the search for economic alternatives to traditional agricultural crops (arable crops). The ecological characteristics of Paulownia trees in China have traditionally led to the creation of agroforestry systems of different nature. We have reason to believe that this cultivation model, alternative to the traditional arboriculture, could be suitable for the reality of vast lowland and hilly areas of Italy and other European countries. The strengths of this new silvoarable agroforestry system are many:

- high growth rate of the trees;
- high compatibility between Paulownia trees and agricultural crops
- differentiation of productions;
- lower financial advances;
- landscape and environmental improvement.

The agronomic choices of the agroforestry systems with Paulownia that are being to be proposed in the Veneto region are substantially two:

- use of hybrid clones;
- plantations on the "four corners", exploiting in a particular way the ditches present in the agrarian arrangements called "ferrarese piana".

The experience gained in Italy in the cultivation of Paulownia in the last 30 years and the birth of a local wood market are the basis of an interesting perspective for agroforestry systems with Paulownia also in Italy.

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Integrating the dynamics of soil erosion under agroforestry systems in process based dynamic crop models: challenges and the way forward

EURAF 2020
Agroforestry for the transition towards sustainability and bio economy
Abstract
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Theme: Agroforestry systems and innovations (Agroforestry innovations toward innovative agroforestry systems)

Keywords: Ecosystem services, Decision support system, System for future, modelling

Abstract

Current crop and forest production systems are challenged by need to account for climate change and to reduce their negative impact on the environment. Sustainable production is crucial to ensure food security. As opposed to conventional (monoculture) cropping systems, agroforestry (AF) has been shown to promote several ecosystems services (ESS), like biodiversity, while not even compromising the productivity or economic returns. Agroforestry systems, thus, have the potential to support climate resilient production system by considering the both pillars of climate change i.e., strategies for adaptation and mitigation (carbon sequestration). Since, most process-based crop simulation models have been optimised for simulating conventional cropping systems, the integration of AF systems as well as the simulation of major ESS, such as erosion control, enhanced soil fertility, carbon sequestration, reduced fertilizer losses especially nitrogen leaching and wind and water regulations, is challenging. Simulations of ESS are rarely available in current modelling system, while integration of these ESS in crop system models is also a challenge.

In this context, we here present a research project "Digital Agricultural Knowledge and Information System (DAKIS)" that targets the development of future agricultural systems. One important objectives of the project is to develop innovative management decision support system (DSS) which requires a more complex and holistic simulation of agricultural systems. Most importantly, crop system models are required not only to simulate the crop yield returns, but also other major ESS provided. In this study, we specifically address the challenges and opportunities to integrate AF system in a process-based dynamic crop modelling framework (SIMPLACE <LINTUL5>) for simulating the prevention of soil erosion. Soil erosion is a serious environmental problem in current agricultural production system and predominantly acute in regions with different elevation and slope. AF system have great potential to reduce the soil erosion. For better understanding of the processes and integration of information to facilitate the decision-making for better management, it is quite crucial to develop the innovative decision support tools and models. While a number of AF models have been developed (Cannell et al. 1998; Van Noordwijk and Lusiana 1999; van der Werf et al. 2007; Dupraz et al. 2019). It is challenging to integrate these approaches in established dynamic crop simulation models. Further, soil erosion modules are often missing in AF models or not even functional (van Noordwijk and Lusiana 1999). Lumped and distributed parameter models are available to simulate the soil erosion but are limited to physical and empirical based equations like RUSLE, RUWLE, EPIC, LISEM, SWAT and many others. These models, however, often operate at the hydrological catchment scale while dynamic crop simulation models require field based simulations of soil erosion effects.

Objective of the current study is to explore the possible options to develop a suitable soil erosion model to simulate related effects. To meet the objective, there are different possible options, i) add soil erosion modules in already existed AF models, ii) develop independent new AF models have potential to simulate the soil erosion, and iii) develop new modules of soil erosion and combine them with a well-developed modelling framework where all components and modules work in a better way. Crop modelling frameworks like SIMPLACE (Enders et al. 2010) have the potential to simulate the dynamics of the

interaction between critical components of agricultural systems (light, water and nutrients). Potential possibly option is to develop soil erosion sim-component under SIMPLACE modelling framework at field scale and further it can be upscale to region. There are two and three dimensional interactions and competition above and below ground need to consider while trees can be added as crop type in the modelling framework. There are many complex steps especially to develop below ground sim-components for soil erosion, and have to consider the competition for water and nutrients between trees and crops root at both temporal and spatial scales. Although, there may be many possible options can be adopted for soil erosion module like RUSLE and RUWLE can be used with proper modification soil erosion losses by water and wind, respectively. Output like runoff, sedimentation and soil loss can be used as input into SIMPLACE framework while there will be further modification required in other sim-components of SIMPLACE like water and nutrients to consider the root architecture of trees and crops. Soil erosion sim-component will be linked with other components under SIMPLACE modelling framework. We started to develop a light module for agroforestry first by using light sim- component in SIMPLACE to simulate the light interception and competition between trees an crop. The fractions of radiation intercepted are determined by canopy boundaries and LAI of tree and crop in different zone and layers by directly applying the Beer's law (Eq.No.1).

$$Ij = Ij0\ [1 - \exp(- Kj1LAIj1 - Kj2LAIj2 - Kj3LAIj3)]\ldots\ldots\ldots\ldots 1$$

Where Ij (Light_TCCap is the light captured by tree and crop in mixed canopy layer, competition for light between tree and crop canopy) is the daily amount of light intercepted within layer j. Ij0 is amount of solar radiation entering the top of layer j and kj1, kj2, kj3 and LAIj1, LAIj2, LAIj3 are the radiation extinction coefficients and leaf area indices contained within layer j for tree leaves, tree branches and crop leaves respectively. It is the model executed to estimate the light interception having the interaction of tree with crop. While, light captured by the crop canopy is estimated following below equation

$$Light\_CCap = Light\_TCCap \times (K\_C \times LAI\_C) / (K\_T \times LAI\_T) + (K\_C \times LAI\_C) + (K\_TB \times BAI\_T)\ldots\ldots\ldots 2$$

Where, Light_CCap is the light captured by the crop canopy in any specific layer (there is no competition with tree). LAI_C, LAI_T and BAI_T are leaf area index of crop, tree and branch area index of tree in that specific layer while K_C, K_T and K_TB are radiation extinction coefficients for crop, and tree leaves and branch of tree.

$$Light\_TCap = Light\_TCCap \times (K\_T \times LAI\_T) / (K\_T \times LAI\_T) + (K\_C \times LAI\_C) + (K\_TB \times BAI\_T)\ldots\ldots\ldots 3$$

Where, Light_TCap is the light captured by tree canopy in any specific layer (there is no competition with crop). Light interception model for tree and crop interaction showed that LAI is the most sensitive parameter for tree and crop. These above discussed equation are developed in SIMPLACE and future work is in progress to develop comprehensive AF model. Water, nutrient and soil erosion modules will also be develop in near future to simulate the ESS. Extensive field experiments are in progress to monitor the ESS while comprehensive data set about soil, water, nutrients, crops, tress, weather and ESS parameters is being collected through ground based observations and remotely sensed techniques. Data sets will be used to validate the sim-components of AF model developed. These decision support tools/sim-components will be available to all stakeholders from the DAKIS platform for further validation while improvement will be continued with the passage of time.

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Agroforestry: New perspectives for water conservation/development and regional added value in rural economy

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations towards innovative agroforestry systems

Keywords: EU Water Framework Directive, water management agroforestry multi-use system, conservation of agricultural land, regional added value.

Agroforestry: New perspectives for water conservation/management and rural economy growth

In line with the main issues addressed by the EU Water Framework Directive (EU WFD) concerning the protection of inland water surfaces, transitional water and groundwater, multi-use agroforestry systems can prevent further aquatic ecosystem deterioration, counteracting air and underground pollution as well as contributing to mitigation of the effects of floods and droughts. Besides, it results in an overall improvement of local biotope network and biodiversity.

Within this framework and through the cooperation of municipalities and farmers, the project WERTvoll aims to establish renaturation measures that combine agriculture, water bodies conservation, economic growth and regional added value creation diversifying the use of land. Hence, agricultural systems are supported and maintained towards a multifunctional and complementary land use structuring approach.

The Federal Ministry of Education and Research (BMBF) funds the project with the intention to improve the urban-rural partnership between Leipzig (Germany) and the surrounding rural municipalities. In this abstract, the work for the development of solutions for natural and economically feasible water renaturations is described.

The project's renaturation concept focuses on the professional ecological restoration of water bodies and the establishment of an unspoilt wood strip in direct proximity to water bodies. Adjacent to the strip, high-yielding agricultural trees such as poplars are planted and managed ecologically (agroforestry system). Modern management approach is based on old practices such as central forests, coppice forests and short rotation coppice forests. The resulting agroforestry systems are not only a source of wood material but through the implementation of new value chain strategies, it can provide new economic benefits in terms of climate-friendly regional added value sources. As far as the functional element and the available space are concerned, 2 to 5 rows of trees are placed on each side of the water basins and harvested at different intervals (between 10-30 years). The trees are chosen taking into consideration their composition, plant density and harvesting periods. As a result, the total origin of wood has a width of 38 m and therefore, approx. 30 m can be used for agricultural purposes (approx. 79 %).

With regard to the binding water renaturation, the implementation of these multi-use agroforestry systems makes the cooperation with farmers more profitable for the municipalities. A classic water renaturation without any use of the trees costs the municipality about 2,000 € per hectare and year. If most of the land used for water body restoration remains in agricultural use, the municipality only pays the farmers the costs of abandoning the regionally customary crop rotation (about 500 € per hectare and year).

Various modules are comprised in the project ensuring that they that can be combined according to local requirements and financing instruments. The selection of tree species determines the economic efficiency of biomass production and can be adapted locally. New value chains and therefore rural areas' economic growth can be achieved through associated financing instruments such as production-integrated compensation or voluntary climate protection services.

If the municipality combines water renaturation and long-term agricultural wood use with a municipal heat sink, a number of other regional value-added effects can be created. The biomass produced can, for example, be fed into a local heating network in the form of wood chips, thus reducing the costs of providing gas and oil. Consequently, water renaturation with use is far more attractive for the community than an unused variant.

From the agricultural point of view, it is particularly important that the land used for the renaturation of water bodies remains predominantly in agricultural use and could be used again as arable land after the cessation of agricultural wood production. From the environmental point of view, wind and water erosion protection on both water bodies and fields are provided and biotope networks are established increasing biodiversity.

As a result, the farmers will receive support from the municipality and therefore will be more encouraged to implement agroforestry multi-use approaches that combine economic growth, ecosystem services, water protection and effective use of nutrients.

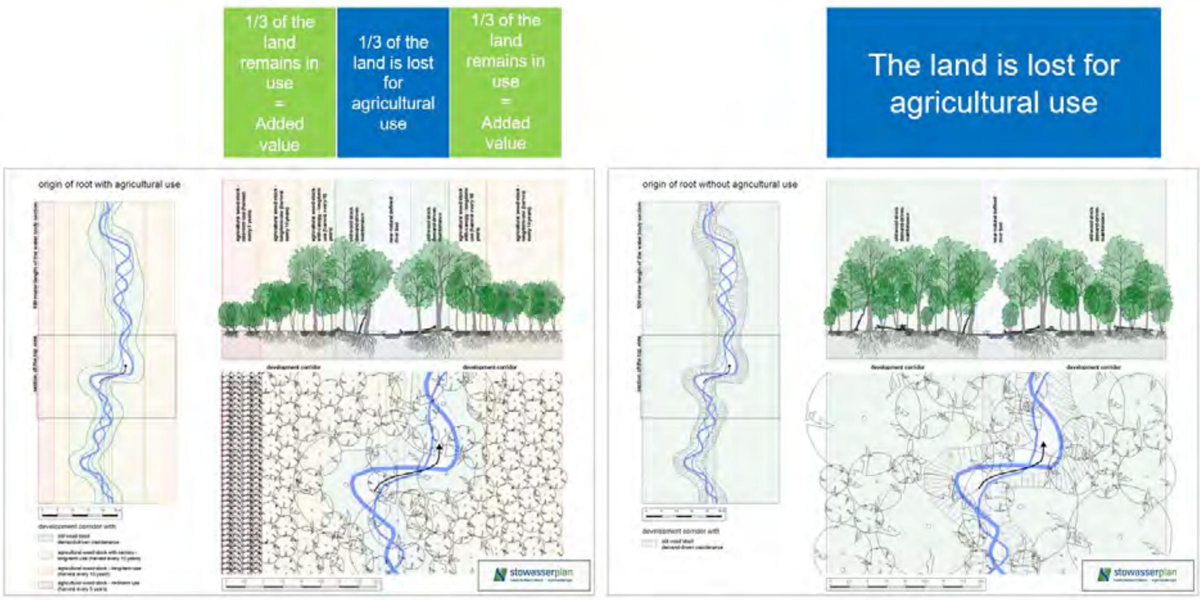

Figure 1: Water body renaturation with agroforestry in agricultural use compared to natural water body renaturation without any use of the trees (from Stowasserplan GmbH & Co. KG 2019).

Above ground dendromass of black locust (*Robinia pseudoacacia* L.) in alley cropping systems

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Agroforestry Innovations toward innovative agroforestry systems

Keywords: black locust, *Robinia pseudoacacia* L., alley cropping, above ground dendromass, demonstration site

Abstract

Black locust (*Robinia pseudoacacia* L.) is a multi-purpose, exotic tree species native to North-America, which was introduced in Europe in 1601. It is a popular tree species worldwide, due to its many favourable attributes, such as: easy propagation, abundant and frequent seed production, high seedling survival, adaptability to environmental stress (e.g. drought) and excellent coppicing. It is a stress tolerant fast growing, nitrogen fixing tree with high quality durable wood, which can be utilized for several purposes including furniture, vine props, panelling, pulp and paper. Furthermore, black locust provides abundant flowers providing fodder for bees, can serve as an animal feed stock or biomass energy. Black locust is grown for about 300 years in Hungary and today occupies approximately 465 000 ha, which counts for approximately 24% of the forested land, and it provides 13,5% of the country's annual timber output (Rédei 2015). This tree species is mainly grown under ecological conditions where forest management is unfavourable. In Hungary black locust is the basis for apiculture and honey production and it also barely has any fungi or insect pests. Its importance is increasing and interest is growing in many other countries, especially due to the effects of climate change. Since agricultural production and forestry management has been officially and practically separated, (re)introducing agroforestry isn't an easy task. We need to put on the glasses of the foresters and also of the farmers, to understand their problems and offer adaptable solutions to their challenges. Private forest owners may see alley cropping as an alternative income opportunity between the cultivated tree rows, or a protection for tree seedlings, but in any case, one doesn't need to convince them to plant trees. Farmers often don't understand the point of trees on the land, therefore education, knowledge transfer, and good examples are needed to help the transition towards agroforestry systems, as it was also laid out in the Montpellier Declaration. The Forest Research Institute of University of Sopron has been actively disseminating knowledge on the topic at conferences, forester and farmer foras, journals, and also published a book – the first of its kind in Hungarian – dedicated to agroforestry (Gyuricza and Borovics 2018). An experimental site was also established in 2017 as a cooperation between former NARIC institution of Agricultural Engineering and the Forest Research Institute, which not only serves research, but also as a demonstration site. There is a long history of black locust research at the Forest Research Institute, and lately it has been extended to investigate its role, growth rate and dendromass in agroforestry systems.

This study focuses on the aboveground dendromass of black locust stands intercropped with triticale (x *Triticosecale*) in six different planting spaces (treatments) with four replications in the year 2017, 2018 and 2019 when the trees were 3, 4, and 5 years old respectively. The planting spaces and growing spaces are shown in Figure 1, at the ordinate axis. The number of trees per hectare corresponding to each planting space are as follows: 155 (21 x 3), 230 (21 x 2), 341 (9 x 3), 455 (21 x 1), 506 (9 x 2), 1001 (9 x 1). It was

counted considering policy criteria in Hungary (tree planting at a distance of minimum 5 meters from the field's border).

The average dry weight of individual trees according to each planting space were analyzed, and the highest production was found at 9 m x 2 m planting space in 2017 and 2018, and at 9 m x 3 m in 2019. There was significant difference (p=0,05) at the age of 3 (in 2017) but only between the planting space 9 m x 2 m (12,22 kg/tree) and 21 m x 3 m, (8,32 kg/tree) and not in any other configuration.

As it was expected, Figure 1 shows that the highest dendromass was produced in the most dense stand, at 9 m x 1 m planting space (1001 trees/ha), and the lowest production was observed in 21 m x 3 m spacing (155 trees/ha) in all the three years, due to the number of trees per hectare. At the age of 5 (in 2019) the dry dendromass was 17,3 tons/ha in the most dense stand, while it only reached 2,8 tons/hectare in the case of the most wide planting space.

As the yields do not collerate with the growing space, it is assumed that in such young stands the in-row spacing (1, 2 or 3 meters) is more relevant than the row spacing (9 or 21 meters), which will be examined in the future. Also, the fact that the average dry weight of individual trees in the 9 m x 2 m exceed the 9 m x 1 m planting space suggests that the 1 meter distancing may be too close at age of 3 in the case of 9 m row spacing, and tending operations may be favourable. These findings will be completed with the yields of the companion crops, so conclusions and suggestions can be made.

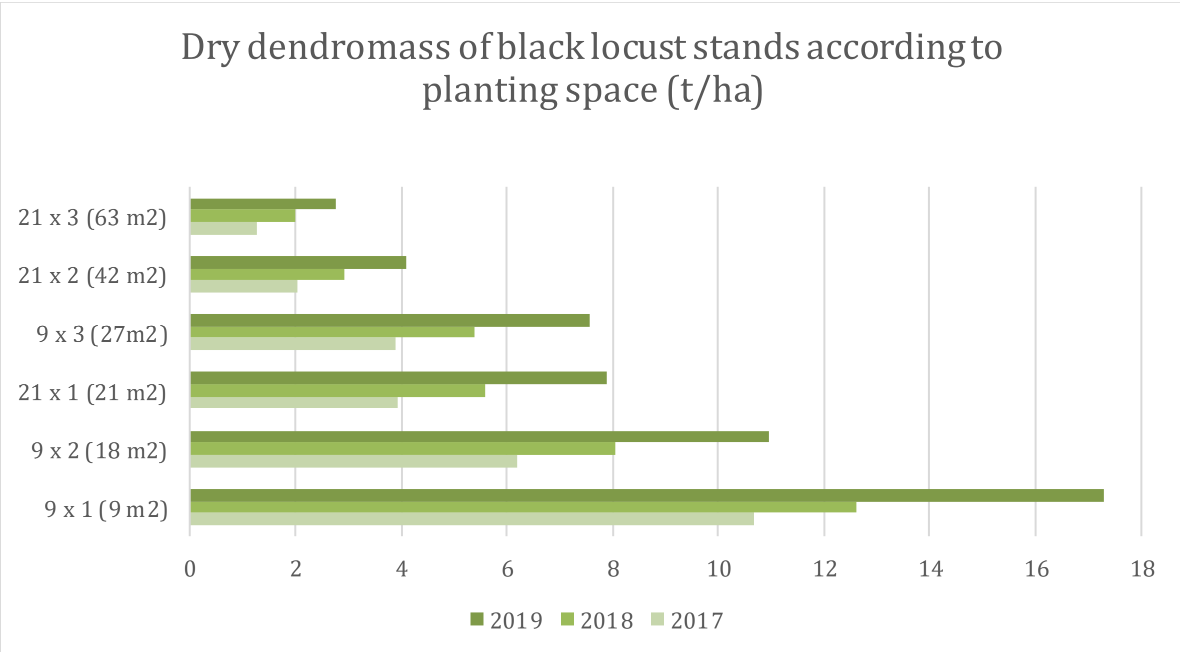

Figure 1. Dry dendromass of black locust stands according to planting space (and growing space) in the agroforestry experiment

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Rédei K (2015) Akác sarjerdő-gazdálkodás. NAIK ERTI, Sárvár

Productivity of a soybean-sorghum two-year crop rotation in an innovative poplar short rotation coppice silvoarable system

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: agroforestry; alley-cropping system; intercropping; sustainable intensification

Abstract

Alley-Cropping Systems (ACS) are characterized by the intercropping of crops and wide-row trees, providing a variety of products, such as food, feed, fibers, fuelwood and timber, while increasing the potential delivery of agroecosystems services (Tsonkova et al., 2012). Soybean represents one of the largest sources of vegetable oil and animal protein feed and imported soybean meal for animal feeding (i) represents 70% of protein-rich feed stuff used in the European Union (EU) (EIP-AGRI, 2014). Grain sorghum, due to its wide adaptation to different environmental conditions, represents a promising crop for livestock feeding in Europe (Berenji and Dahlberg, 2004). Generally, soybean yield is negatively affected by tree presence, especially in the tree–crop interface zone. Moreover, several authors highlighted that competition for light between trees and soybean is more important than competition for water (Reynolds et al., 2007; Mantino et al., 2020). Sorghum biomass accumulation, as other C4 crops, could be more affected by reduced light availability respect to C3 species (Reynolds et al., 2007). Nevertheless, a simulation of reduced light availability on broomcorn (*Sorghum bicolor* L.) made in Brazil by Righi et al. (2016) suggested that sorghum species could adapt to partial shade by increasing radiation use efficiency.

Based on this, the aims of this study are: (i) to assess the productivity of a two-year warm-season crop rotation, soybean and sorghum, in an ACS and (ii) to determine soybean and sorghum yield according to the position in the alley (West, Mid-West, Centre, Mid-East, East).

The experiment is located in Pisa (Italy) 3 m a.s.l. on a sandy-loam to clay-loam soil with 7.6 pH on average. The ACS was originated from a former poplar Short Rotation Coppice (SRC) established in 2009. The stand had a planting design of 30 rows spaced 2.7 m inter-row and 0.5 m between trees. From 2009 to 2016, poplar plants were coppiced every two years with a cut-and-chip harvester at the end of February, before the vegetative regrowth. In March 2017, arable alleys have been created by removing four out of five rows. Rows of poplar SRC are spaced 13.5 m and North-South oriented (Fig.1A). In 2017 after the conversion from SRC to ACS the arable alleys were left as fallow.

In the first year of experiment (2018), sorghum was sown on 6th June with 40 seeds per m_2 while soybean was sown on 12th June 2018 with 50 seeds per m_2. In the second year of experiment (2019), sorghum and soybean were sown on 29th April with the same sowing densities. Light Availability (LA) and its variability in

the alleys was measured by means of hemispherical photos taken according to a transect replicated three times (every 10 m) in each plot (n=4). A transect consisted in five positions from west to east within the alleys: 2.5 m-West; 4.5 m-Mid-West; 6.75 m-Center, 4.5 m-Mid-East; 2.5 m-East. LA was obtained by processing the images with the free software Gap Light Analyzer 2.0 GLA.

In the first year, during crop growth period, cumulated rainfall was 90 mm and the average temperature was 22.9 °C while in the second year, cumulated rainfall was 253 mm and the average temperature was 21.2 °C. The average LA in 2018 was 86.1% and 86.6% in sorghum and soybean plots, respectively. In 2019, LA was 97.4% and 96.8% in sorghum and soybean plots, respectively. In the two years of study LA varied according: (i) to the tree distance, showing a strong reduction from the centre to the tree-crop interface and (ii) to the tree size related to poplar harvest cycle. Crop yield showed different patterns in sorghum and soybean in the two years of study (Fig.1). Sorghum in 2018 suffered an extensive attack by sorghum midge (*Stenodiplosis sorghicola*), favoured by late sowing. In fact in 2019, sorghum yields were higher in all the investigated positions respect to 2018. Soybean showed similar yields in the two years of study with a relevant reduction only in west position in 2018 respect to 2019. Yields of shaded sorghum and soybean are similar to average yields of study area, 4.6 and 2.4 Mg Ha^{-1} respectively (Pisa Province, years 2018 and 2019; www.istat.it). Data collection will be carried out also in 2020.

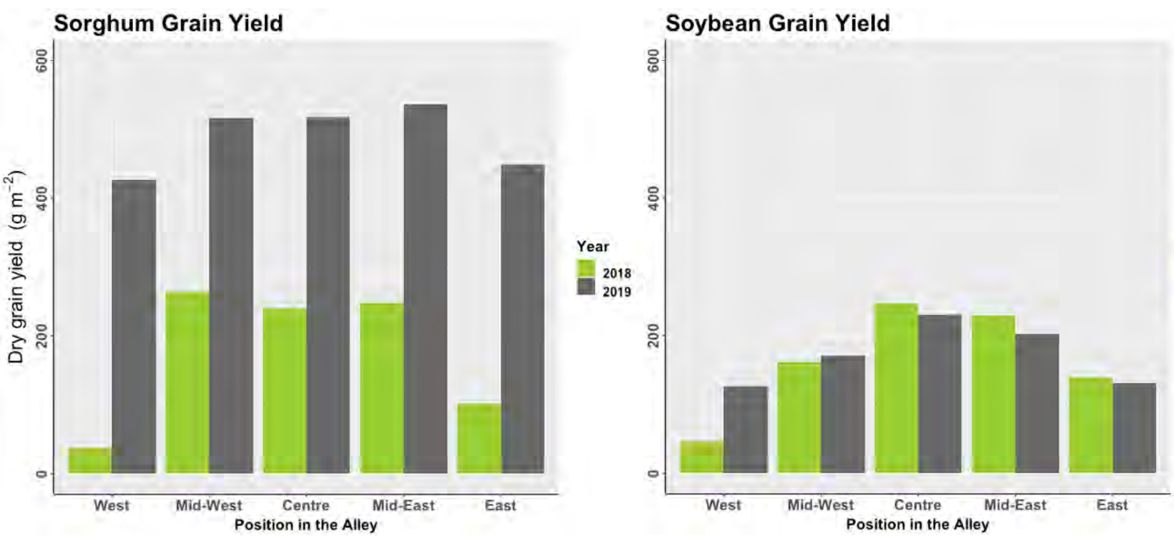

Figure 1. Sorghum and soybean yield in poplar SRC alley-cropping system for year 2018 and 2019, Pisa (Italy).

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Two experiences of Alley Coppice in Northern Italy

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Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Alley Coppice, poplar, walnut, biomass yield

Abstract

The 'Alley Coppice' system (Morhart et al., 2014), that combines valuable timber species (walnut, cherry tree and others) and Short Rotation Coppices (SRC) with poplar (Populus spp.), willow (Salix spp.) and others fast growing species for biomass production is being studied in two sites of northern Italy (Woodnat – H2020 and Suscace - MiPAAF projects). This kind of plantation has been developed trying to associate the positive effect of the intercropping with the easy sale of raw material for industrial uses and biomass for energy purposes (Pra et al., 2019); this represents a strong innovation that makes these plantations more profitable both from the economic and environmental point of view with respect to pure plantations. This model has been introduced in Italy in two Regions: Piedmont and Lombardy. The trial of Piedmont was planted in Brusnengo (BI) in Spring 2005 on inceptisol soil; it covers an area of approximately 1.5 ha, contains 4 poplar and 4 willow genotypes and different timber species: Acer spp., *Prunus avium, Quercus robur, Carpinus betulus, Pyrus communis.* The planting layout is: 12 × 6 m for timber species (in each position were planted two seedlings of the same specie at the distance of 100 cm), with a distance from SRC double rows of about 4 m; the SRC double rows have a spacing of 4 × 0.70 m. The final density is about 2380 trees ha-1 for SRC and 139 tree ha-1 for timber species. Poplar and willow genotypes were tested with Randomized Complete Block Design, with 3 replications; timber species are arranged according to a module repeated several times on the rows. The trial of Lombardy was planted in Meleti (LO) in 2006 on 4.5 ha of surface; it was established in a site characterized by deep, silty-sandy and moderately alkaline soils, planting common walnut and the poplar 'I-214' as principal species for respectively veneer and plywood production, and others poplar clones ('AF2') and species (*Platanus ibrida*, *Fraxinus angustifolia*, *Ulmus minor*, *Corylus avellana*, *Ostrya carpinifolia* and *Carpinus betulus*) for biomass production. Common walnut and the poplar clone 'I-214' were planted in alternating lines, 11 m apart from each other, and 3 different planting distances were changed in the lines: for walnut the distances chosen were 6, 7, and 8 m corresponding respectively to a density of 75, 65 and 57 trees per hectare and for poplar were 4, 5 and 6 m corresponding respectively to a density of 114, 91 and 76 trees per hectare. The fields were prepared using deep ripper with multiple shanks (0.7 m deep), then ploughed up to 30 cm and disc harrowed. The establishment of SRC cuttings and seedlings was effected using a mechanical transplanter. One year old seedlings of timber species have been planted manually, then endowed with shelter and wood chips mulch. In Brusnengo, during the growing season of the first years, The weeds control consisted on one disc harrowing and one mulching between the rows. No irrigation (due to high water availability) and disease controls (due to genotypes resistance) were made. In 2007 was necessary to use a deep ripper with single shanks between rows, to ameliorate the soil oxygenation. In 2011 the SRC was harvested for the first time (7 years old) even if the planting layout was optimized for a harvest at 5 year. In the same period the thinning of timber species consisted on harvesting of the worst tree of each pair, leaving space for growth to the best trees. In Meleti, weed control was carried out during the first three years by two disk harrowing and only one chopping per year in the following period. Pruning of walnut and poplar started in summer 2008 and

lasted in 2012. Walnuts were pruned until to 3.0-3.5 metres, while poplars until to 5.5-6 metres. In the polycyclic plantations, the mixture of different species and the presence of N-fixing trees and shrubs allows a management with limited use of pesticides, fertilizers and irrigations. According to Italian studies, this management can be considered low-intensity management compared to traditional poplar monoculture (3-5 pesticide treatments per year; irrigation and weed control normally applied at higher intensities). No fertilizers have been applied during the lifespan of the plantations. Only in the trial of Meleti, localized insect and pest control were carried out and some bio-gas digestate was spread two times over the whole plantations after SRC harvesting. Only in Meleti one irrigation during the summer was applied, when strictly necessary and during first four years. The SRC in trial of Brusnengo was harvested after seven years, while the SRC in trial of Meleti was harvested and chipped after five years, in spring 2011. The biomass average yields in Brusnengo reached 6.6 Mgr ha^{-1} y^{-1}, with 14.5 Mgr ha^{-1} y^{-1} for 'Orion', the best poplar clone, and 6.7 Mgr ha^{-1} y^{-1} for 'Drago', the best willow clone (corresponding respectively to a production at the end of 7 year of 6.1 and 2.8 Mg per 100 m row). Considering the low planting density, the results are quite good. In the trial of Meleti interesting biomass production have been obtained with poplar 'AF2' (11.1 Mgr ha-1 y^{-1}), elm (7.4 Mgr ha^{-1} y^{-1}), and plane (6.3 Mgr ha^{-1} y^{-1}) using only 64% of the whole surface of plantation. For the other species, with lower yields, a longer rotation could be designed. Poplar clones for plywood have grown also faster than usual, thanks to the wider spacing: diameters of about 40-50 cm, instead of 30-35 cm as in the case of traditional monoculture, can be obtained in 10-12 years. This kind of plantations, which are more resistant to external disturbances and less demanding in terms of energetic inputs, have proved to be innovative and more sustainable than poplar and walnut monoculture.

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A COMPARISON OF WEED SEED BANK DYNAMICS AMONG DIFFERENT CROPPING SYSTEMS OF DRYLAND AGRO-ECOSYSTEM, INDIA

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Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Agroforestry system, altitudinal ranges, land use system, soil depth, weed seed bank

Abstract

Globally, weeds annually cause a significant crop loss (> USD 100 billion), and there is an urgent need for integrated weed management strategies (IWMS) to tackle this problem. The weed seed bank (WSB) can help to develop a more effective and efficient IWMS. WSB is the primary source of weed infestation in any cropping system, and its knowledge can provide past field management practices evidence (successes or failures) in addition to forecast the future crop-weed competition (Menalled 2013). Moreover, WSB also varied among the different cropping system due to differential components (crop and trees alone or together) associated with each cropping system.

Keeping these facts in view, an experiment was undertaken at RGSC farm-BHU, Vindhyan region (a semi-arid region) in factorial randomized block design. The first factor comprised of 6-cropping system [2-Agri-horticulture system (AHS): guava and mango based; 3-pure orchard (PO): guava, mango, and aonla; and annual crop system (ACS)], whereas, the second and third factor comprised of 2-altitudes ranges (lowland and upland) and 2-soil depths (0-15 and 15-30 cm) respectively. On June 30, 2017 soil samples were drawn and placed on the perforated aluminum trays and optimally moistened. Germination method of WSB assessment (as described by Forcella *et al.* (2003) used.

Results showed that WSB consist of twelve weed species including eight broad-leaved weeds [*Ammania baccifera* (AMBA), *Anagallis arvensis* (ANAR), *Euphorbia hirta* (EUHI), *Launaea asplenifolia* (LAAS), *Ludwigia hyssopifolia* (LUHY), *Oldendandiya corymbosa* (OLCO), *Phyllanthus niruri* (PHNI2), *Portulaca oleracea* (POOL)] three grasses [*Dactyloctenium aegyptium* (DAAE), *Digitaria sanguinalis* (DISA), *Eragrostis pilosa* (ERPI)] and one sedges [*Cyperus* spp.]. Among different cropping system, Guava-AHS recorded the highest seed bank (SB) of the AMBA, ANAR, DISA, EUHI, OLCO, PHNI2, and *Cyperus* spp. Although, the highest ERPI SB recorded in the mango-AHS and DAAE SB did not vary among different cropping system. The higher WSB in AHS over ACS and PO system is due to the microclimate moderation effect of the agroforestry system, which provides a better condition for the proliferation of the crop as well as the weeds (Hawke and Wedderburn 1994), especially in the semi-arid region. Moreover, higher biodiversity is a sign of a healthy ecosystem and will not only enhance the productivity and stability of the system but also lessen the susceptibility of invasion to the non-native species. Furthermore, mango-PO observed the lowest WSB, except the DISA (highest in aonla-PO) and EUHI (in guava-PO). Dense canopy in PO lacks light stimulation and ultimately suppresses the weeds. Whereas ACS in the semi-arid region provides the unsuitable condition for the growth of crops as well as weeds, thus restrict WSB. Lowland altitudinal range observed highest ERPI and *Cyperus* spp. SB while PHNI2 dominates the upland range. Except for these two, all other weeds did not vary among the altitudinal ranges. Furthermore, all the weeds recorded inverse relationship with the soil depth because

weed seeds from plants firstly occupy the upper soil surface during primary dispersal process later on; through soil turning tillage process or cracks, the dormant seeds reach to the deeper layer. Our study concludes that AHS in the semi-arid region contains more biodiversity (in terms of weeds) compared to ACS and PO. It also contradicts previous studies, which directly presumes that agroforestry systems decrease the weeds infestation.

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Table 1. Change in weed seed bank with different land-use system of dryland agro-ecosystem, India.

Treatment		Density of Weeds (number/m²)							
		Ammania baccifera	*Anagallis arvensis*	*Digitaria sanguinalis*	*Cyperus spp.*	*Eragrostis pilosa*	*Euphorbia hirta*	*Oldenlandia corymbosa*	*Phyllanthus niruri*
Cropping System									
AHS	Guava	21.04	46.04	29.25	62.41	5.13	29.99	40.09	64.80
	Mango	6.95	33.70	12.75	41.53	13.75	11.60	30.35	62.29
POS	Guava	2.53	24.64	8.93	32.39	2.53	2.53	12.21	39.10
	Mango	3.31	10.75	21.03	18.28	2.53	15.98	8.78	34.50
	Aonla	2.53	22.67	2.53	29.86	4.35	4.41	16.62	50.95
ACS		11.38	25.77	21.88	52.62	6.95	14.10	24.41	49.70
CD (P=0.05)		6.98	13.54	13.90	11.27	7.55	11.37	9.44	15.96
Altitudinal range									
Lowland		6.86	23.91	18.20	42.89	8.35	14.06	23.18	42.45
Upland		9.05	30.62	13.93	36.14	3.40	12.15	20.97	58.00
CD (P=0.05)		NS	NS	NS	6.51	4.36	NS	NS	9.21
Soil depth									
0-15 cm		14.60	40.09	23.02	52.19	10.43	23.16	37.37	60.38
15-30 cm		1.31	14.43	9.10	26.84	1.31	3.05	6.78	40.07
CD (P=0.05)		4.03	7.82	8.03	6.51	4.36	6.57	5.45	9.21

Data are subjected to square root transformation ($\sqrt{x+0.5}$). AHS-Agri-horticulture System; POS-Pure orchard system; ACS-Annual crop system,

PHENOLOGY BASED NITROGEN AND ZINC FERTILIZER SCHEDULING IN PEARL MILLET BASED ALLEY CROPPED

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Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Alley cropping, Agroforestry system, pearl millet, nitrogen scheduling, zinc scheduling,

Abstract

Pearl millet (*Pennisetum glaucam* (L.) R. Br.), is a major warm-season cereal cultivated in the semi-arid region, highly tolerant to heat, drought, and salinity. It is mainly cultivated for the dual purpose, i.e., for human food as well as feed for livestock; and more than 90 millions peoples in about 30 countries directly or indirectly depend on the pearl millet. Unfortunately, excessive use of the nitrogen (N) fertilizer in the past few decades' causes the widespread deficiency of the zinc (Zn), decreases the quality of the products and induces Zn malnutrition which ultimately leads to hidden hunger. Already several studies had reported highly responsive of pearl millet to N and Zn fertilization. Moreover, the fertilizer scheduling at different growth and development stages increases not only the yield but also the nutrient use efficiency, which eventually raises the nutrient uptake. Furthermore, being a semi-arid crop, there is ample scope if pearl millet integrated into the agroforestry systems, especially in the agri-horticulture system [pearl millet + custard apple (*Annona squamosa* L.)].

Given the above, an agronomic field experiment conducted at RGSC-Banaras Hindu University, Mirzapur during 2017-*Rainy* season comprised of two factors each replicated thrice. Factor-I comprised of four nitrogen (N) scheduling's [no N-application; ½ [basal] + ½[3rd visible leaf (VL)]; ¼ [basal] + ½ [3rdVL] + ¼ [panicle extended in flag leaf sheath (PEFLS)]; ½ [basal] + ¼ [3rd VL] + ¼ [stigma visible (SV)]. Factor-II also consist 4- Zn scheduling's [No Zn-application; 2.5 kg/ha [basal] + 0.25% spray (*) [panicle initiation (PI)]; 2.5 kg/ha [basal] +0.25% [PI]*+ 0.25% [PEFLS]*; 2.5 kg/ha [basal] + 0.25% [50% stigma emergence (SE)]* + 0.25% [milk stage (MS)]*. The scheduling of the N and Zn mainly based in on the growth and development phases of the pearl millet as given by Maiti and Bidinger (1981).

Results revealed N split doses increases the growth parameters by up to 263 per cent, yield parameter up to 95 per cent and grain yield up to 65 per cent as compared to the control. Specifically, despite the tallest plant height recorded in N scheduling ½ [basal] + ¼ [3rd VL] + ¼ [SV], maximum tiller counts in RDN @ ½ [basal] + ½[3rd VL] and maximum internode count, internode length, ear per plant and panicle length in ¼ [basal] + ½ [3rd VL] + ¼ [PEFLS]. Although, the N scheduling except the no N-application produced statistically at par results for the above-mentioned growth, yield attributes, yield. It may attribute to the scheduling of N at the different growth and development that reduces the N loss, leaching, denitrification, volatilization, and runoff, thus distribute the supply of the N over a more extended period. Moreover, in pearl millet stem elongation continues to increase even after the flowering. Likewise, the dry matter which is a function of the stem elongation continues to increase even after the flowering Moreover, the higher N availability (50% at sowing) during the early vegetative phase helped in the build-up of vegetative growth and increasing the number of tillers per plant. Also, tillers buds formed before the panicle development phase (Maiti and Bidinger 1981) so the N applied in the

later stages has no major role in tillers increment. N scheduling positively affects the grain and biological yield and maximum grain, and biological yield recorded when the last split of ½ RDN applied during PEFLS as compared to the SV. As, up to the PEFLS, the panicle development completed, only grain dry weight increases from the milk to dough stages.

Conversely, Zinc schedules did not significantly affect the growth parameters (except dry-matter) and ear per plant. Furthermore, 2.5 kg Zn/ha (basal) + 0.25% [SE]* + 0.25% [MS]* recorded the highest dry matter, seed per ear and biological yield while highest test weight, panicle length and grain yield in 2.5 kg Zn/ha [basal] +0.25% [PI]* + 0.25% [PEFLS]. Zn had a catalytic effect on most of the physiological and metabolic processes of plants. Furthermore, it helps in the biosynthesis of IAA that leads to initiation of primordial reproductive parts and partitioning of photosynthates towards sinks which are responsible for increased yields attributes (Meena et al. 2017). Moreover, Zn spray in the later growth stages helps in N accumulation and simultaneously increases the dry matter, straw, and biological yield. Our study concludes that there are new opportunities for managing the N and Zn fertilizers more judiciously and efficiently in pearl millet to get the augmented nutrient uptake and higher yield. Moreover, it can be the cheapest and easiest way to biofortify the crop to combat the hidden hunger.

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Table 1. Effect of the scheduling of nitrogen and zinc fertilizer on growth, yield attributes and yield of pearl millet-based alley cropped.

Treatments	Plant height (cm)	Tillers/ plant	Internode /plant	Dry matter (g/plant)	Test weight (g)	Grain yield (kg/ha)
Nitrogen Scheduling (N)						
No N (control)	129.50	0.19	5.72	18.88	6.14	1359.79
½ [basal] + ½[3rd VL]	227.33	0.78	9.81	27.93	7.47	1772.91
¼ [basal] + ½ [3rd VL] + ¼ [PEFLS]	228.44	0.67	9.94	35.05	8.68	2247.00
½ [basal] + ¼ [3rd VL] + ¼ [SV]	228.73	0.69	9.56	42.58	7.72	2002.12
CD (p = 0.05)	17.04	0.28	0.89	4.53	0.59	165.29
Zinc Scheduling (Zn)						
No Zn (control)	198.48	0.39	8.03	18.75	6.77	1504.52
2.5 kg/ha [basal] + 0.25% [PI]*	200.33	0.58	9.08	30.92	7.65	1841.37
2.5 kg/ha [basal] + 0.25%[PI]* + 0.25% [PEFLS]*	208.87	0.75	9.06	35.76	7.88	2062.92
2.5 kg/ha [basal] + 0.25% [SE]* + 0.25% [MS]*	206.32	0.61	8.86	39.02	7.70	1973.01
CD (p = 0.05)	NS	NS	NS	4.53	0.59	162.71

Reaching a farming system level of understanding of agroforestry systems in Switzerland – a methodology gap review and a way forward

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: alley-cropping, economics, farming system, Switzerland, modelling

Abstract

Multiple issues facing agriculture and society, notably climate change and declining biodiversity bring forth agroecological solutions able to mitigate and adapt to climate change while providing habitats to a greater biodiversity. Agroforestry(AF), understood as the intentional combination of agriculture and trees in the same place and time may well provide part of the solution to these issues. Its performance in various pedoclimatic conditions and following various management strategies remains however difficult to assess. In particular, the economic effects of implementing agroforestry for a farmer, although a probable major driver of the adoption of such a practice, is only partially assessed for certain particular and often rather simple farm systems. Since it combines perennials and annual crops on a same field, agroforestry means more interactions and more complexity within a given agroecosystem. New elements come into the cropping and farming system and may induce shifts in unexpected ways.

The complex nature of agroecosystems makes it difficult for reductionist approaches, i.e. assuming that understanding complex systems can be done by analysing their individual parts (Mazzocchi 2008). Indeed, what happens at one level does not fully cover what happens at a higher level, as interactions happen. AF research itself is carried because of this complexity, as isolating trees and crops is not appropriate to understand the combined results, and the sole analysis of this interaction is particularly difficult, even when remaining at small scale and focusing on plant physiology and soils. AF research is all mostly trying to assess the interaction effects, and it proves to be difficult, resulting in an apparent imprecise science (Nair 2012). Reaching a farm system level for economic assessments is however a necessary step for a better understanding of adoption patterns. It allows revealing synergies and farmer strategies that go beyond a simple calculation of "return of investment" ratio.

Two major issues arise when trying to understand and model farm level dynamics of agroforestry systems, and may explain the limited literature and models at this scale (figure 1). One obvious is the lifetime of agroforestry systems compared to the age of existing agroforestry systems. This issue can be partially addressed by using bio-economic models and doing assumptions on the future. The other issue is more of a statistical problem: it is both the limited number of existing farms doing agroforestry and their apparent great diversity. This latter issue may require methodologies enabling to characterise the diversity to enable the building of multiple scenarios. The exploratory modelling work of Morel (2017) is to this extent a strong basis to build on.

A case study in Switzerland is currently conducted as part of a large transdisciplinary project, notably exploring this methodology. To this aim, the authors plan on using existing plot-level bio-economic models, Yield-SAFE, developped by Graves et al. (2007), technical economic typology of farming systems doing alley-cropping AF in Switzerland, following compared agriculture approach (Cochet et al. 2007), and farm economics modelling methodology by Morel (2017).

It appears the farms starting agroforestry in Switzerland show particularly high levels of diversification, often including already tree-based products, linked with more direct selling channels than most farms. This allows them to have readily available selling channels and high value-pe- product for future tree-based productions. On a different level, they are often already trained to work with trees and landscape management, having followed different training programmes than their fellow farmers. This may help them reduce labour requirements and provide more confidence in the future of their AF systems. These early findings suggest a more radical approach to promoting agroforestry through farmer training and supporting the development of markets for AF-based products.

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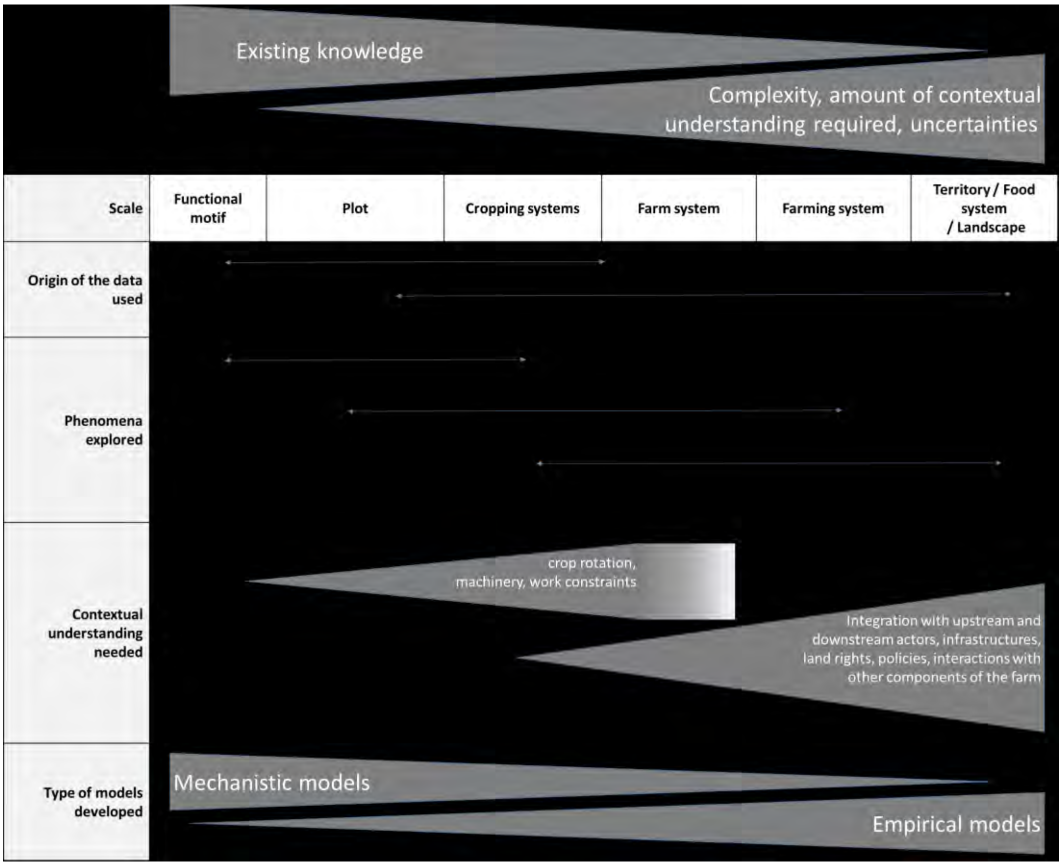

Figure 1. Modelling across scales in agroecosystems. Source: authors

Agroforestry potentials and opportunities for developing a Mediterranean "superfruit": strawberry-tree fruit in the Hérault department - The case of the Boisisère valley

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: superfruit, food supplements, scrubland, *Arbutus unedo,* sylvopastoralism

Abstract

Introduction and context : The fruit of the strawberry tree (Arbutus unedo) is considered a super fruit for its nutraceutical qualities and in particular its great richness in vitamins C and E, in polyphenols, in antioxidants and also in potassium, and zinc. The booming superfruit market is an opportunity for economic development for a local resource in Hérault department with little or no value. It is a common species throughout the Mediterranean. It can represent significant populations also in France in the great South and Atlantic coast and several factors favor a "natural" dynamic of expansion of populations (natural decarbonation of soils, pressure on the environment as fires, clear cuts, and agricultural and pastoral abandonment).

In the Boissière valley in the Hérault department, stands are important and can even constitute monospecific stands. Local toponymy testifies to this abundance, like many places called arboussas

But this resource remains very little or not exploited at all. In this context, can agroforestry be a relevant means of development? If yes, how? With what means, techniques and which actors?

Methodology and tools: A review of existing documentation and interviews with key persons as well as observations on some areas of the Hérault department and more specifically in the Boissière valley were carried out, in order to identify the potential for developing this resource locally.

Results: Real assets to develop:

<u>Ability to coppicing</u>: The strawberry tree has a very important ability to coppers (see figure 1). This makes it possible to imagine a rejuvenation of current stands at a lower cost by clear cutting and coppicing with a selection of strands. This copse management would also limit height development and facilitate harvesting

<u>A resilient species</u>: The species also seems to benefit from a good resistance to drought. The strawberry tree seems to have suffered much less from the recent heat wave in June 2019.

<u>A short entry into production period</u>: the entry into production time for agroforestry species is often perceived as a dissuasive constraint for project leaders. In the case of stands from coppice, this is relatively short, 4 to 5 years according to our observations.

<u>An advantageous phenology</u>: seasonality, especially for fruit species, is also a constraint for the agroforestry association. The late fruiting of the strawberry tree from September to November, allows to limit competition with other productions and an asset for a possible diversification of culture.

The contribution of an adapted agroforestry:

Improve access to the resource: accessibility in the scrublands is made difficult by the presence of dense shrubby vegetation, limiting harvesting. The introduction of other productions would open up the environment and improve access to the fruit resource.

Significantly improve production: competition with other species such as holm oak (Quercus ilex) limits the development of this heliophilous species as well as its fruit production. The opening of the environment would reduce this competition. The selection of the most productive strands or also suitable grafting techniques would improve the quality and quantity of fruit production.

Incentive arguments for the forest owners: the most current forest management is focused on production of wood energy (mainly holm oak) with clear cuts every 40 to 50 years. The association of a fruit production could constitute an incentive argument with the very many forest owners for a more sustainable management of these spaces and partially finance the work of establishment and maintenance of orchards.

Towards the creation of mixed and multi-productive spaces: Silvopastoralism is certainly one of the most promising agricultural activities for the agroforestry development of this resource, particularly sheep farming by promoting the development of a herbaceous layer. A beekeeping activity could also be developed with the production of monofloral honey which is sought after and recognized for its organoleptic qualities. Other productions and crops could be added to these new spaces: mushrooms, aromatic and medicinal plants,... The traditional use of the species and its transformation in particular into alcohol is evidenced by the old reports of municipal councils mentioning and debating litigation on the allocation of plots of strawberry trees (arboussas)

Discussion and conclusion: The absence of a real marketing and processing sector is a major constraint to the development of this resource. Despite its nutritional value, the arbutus remains little consumed anyway, in the fresh state certain elements limit its gustatory quality: large quantity of seeds, rough skin, without very pronounced taste. Recent initiatives of innovative process of the fruit (compote, beer) have however made it possible to overcome these constraints and confirmed the commercial potential of arbutus-based products.

Additional research remains to be carried out to gain a better understanding of the state of the resource. A better knowledge of old uses and practices would be useful, as well as the potential market for new products being developed (local beer developed by the Association “Forêt Modèle de Provence” and compote developed by Vert Paradis via « Coeur des Garrigues) or coming (wines and spirits).

Lastly, the agroforestry potential of the strawberry tree must be replaced in the context of more global land-use planning issues in the region and especially in the scrublands area (“Territoire des Garrigues”): urbanization, agricultural abandonment, fire-fighting, tourist development. To think of an agroforestry around the strawberry tree is also to think of a proposal to reconquer "mixed" spaces between forest and fields, most of which have been abandoned, recreate new agricultural activities, develop new related industries with the territory in complementarity with current economic development, particularly agritourism.

Figure 1. Example of coppicing: on the right on a very recent clear cut (less than 2 years) - note the vigor of the strands - and on the left on an old cut

MICROCLIMATE SURVEYING IN FORESTRY INTERCROPPING SYSTEMS IN HUNGARY

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry systems and innovations (Agroforestry innovations toward innovative agroforestry systems)

Keywords: Alley cropping, intercropping, microclimate, forest, soil

A special form of alley cropping system is the intercropping of forest, which is traditional and still used nowadays worldwide in afforestation. In Hungary this practice is used mostly on the non-protected areas of the Great Hungarian Plain. This study addresses measurements and observations performed in two trial sites in north-western Hungary, with the aim of examining the extent to which intercropping modifies the development of seedlings compared to the current practice of reforestation.

The experimental areas have different ecological features thus, the effects of intermediate cultivation could be investigated under different conditions and in different forest stands. The Hajdúhadház experimental area (Plot 1) was established in 2015; observations and measurements at this site were conducted until 2017. The experimental area in Kapuvár (Plot 2) was initiated in 2019. Soil temperature, conductivity, and biomass growth measurements were completed at both sites. Control areas with similar parameters were designated near the trial sites in both locations.

Measurements in plot 1: Hajdúhadház

After the observation we designed the part of experiment that based on microclime assessment. We exemined every single point (those are mentioned below) but air temperature and temporal precipitation were collected from weathercast database.

In Hajdúhadház was recorded:

- Air temperature
- Temporal precipitation
- Soil temperature
- Soil conductivity
- Growth parameters (height of trees (H))

The soil temperature and soil conductivity were surveyed at two point per area in 2016 as outcomes and experiences were favourable, thus in 2017 we have increased the number of the sampling points from two to 17 per area. The height of sampling seedlings was measured by measuring tape at the end of the August.

Measurement plot 2: Kapuvár

At the sites of Kapuvár Forestry Office the scientific assessment was expanded on the boarder range of microclimate measurements to get more information of the forestry alley cropping system and the control parcel for preparing more detailed report. In Kapuvár was recorded:

- Air temperature
- Air humidity
- Temporal precipitation
- Soil temperature
- Soil conductivity
- Growth parameters (diameter at the base (Db), diameter at breast height (DBH) and height of trees (H))

The trial points were selected in such a way that those in each plot equally distributed as including worse conditional part of stands. These points stand of segments which involve two opposite trees and the corn plants between two seedlings. The assessment can be allocated to three different group according to the location of the sampling points in the segments. The first group comprise the survey of soil temperature and soil conductivity at two difference depth (on the surface and 10 cm below surface) in every row' space. The second group include the air temperature and air humidity at three different height (10 cm, 1 m and 2 m above surface), which were positioned midway between the two seedlings. The growth parameters (diameter at the base (Db), diameter at breast height (DBH) and height of trees (H)) are in the third group.

Though tree species and plantation structures differ in the two areas, the objectives of forestry companies operating in both locations are essentially the same: utilizing available space, protecting seedlings, and ensuring successful afforestation. Thus far, research results indicate that soil microclimate is more advantageous in the alley cropping system, which contributes to superior seedling development. Using maize as an intercrop in alleys made fodder production for animal stock and game management feasible. Further data from Plot 2 measurements are under process and the results are planned to be published in spring 2020. Further investigations on yields and microclimate are planned in the Kapuvár Forest Company area in the next three years.

Component interactions and their influence on the production of apple based agroforestry systems in wet temperate zone of Himachal Himalayas

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry systems and Innovations

Keywords: Agri-horticulture system, Himachal Pradesh, Intercropping, Apple

Abstract

Temperate wet zone of Himachal Pradesh, India is dominated by apple cultivation. In the apple orchards, different cereals, pulses and vegetables are intercropped. Farmers are using indigenous intercropping management practices evolved over time for cultivating the intercrops in the apple orchards. Intercropping of cereals and vegetables in the apple orchards have been accepted by the farmers as a sustainable management practice. However, adequate data based on the systematic scientific studies lacks to prove the sustainability of the practice in terms of production and economic profitability. Therefore, the present study was conducted for two years from 2007-2008 to investigate the growth and yield performance of the components under apple and assess the financial benefits from the agri-horticulture agroforestry system. The experimental site is located at 31.85oN and 77.08oE with an elevation of 1600 masl. The mean annual rainfall during the study period was about 1000 mm. Temperature mean max 28.3oC and mean min 2.7oC were recorded during the months of June and January, respectively. Average humidity was about 76% with the mean max and mean min 87% and 72.6% in the months of January and August, respectively. Average sunshine was also observed to be 5.7 hrs/day with average maximum of 6.9 hrs/day, in June and average min of 3.0 hrs/day in January.

Fruit tree species involved in the experiments was – Apple (Malus domestica Borkh), Variety – Royal Delicious; planted in 6 x 6 meter spacing with line planting, 23 years old orchard (Fig 1). The study evaluated effect of intercropping on growth and yield performance of annual intercrops viz. Rabi crops (Nov-May): i) Vegetable (pea – Pisum sativum L. variety Azad P1), ii) Cereal (wheat – Triticum aestivum L. variety UP 2338); Kharif crops (June-Oct): i) Vegetable (tomato–Lycopersicon esculentum L. variety - Himsona), ii) Pulse (field bean – Phaseolis vulgaris L. variety Jwala). It involved five system units viz. S1 (Apple + Wheat - Tomato), S2 (Apple + Pea - Tomato), S3 (Apple + Wheat - Bean), S4 (Apple alone) and S5 (annual crop controls) with two rabi crops followed by two other kharif ones. The expression ''+'' means planted with in the current season, whereas "-'' means followed by in the other season. Intercropping experiments with five treatments in each case where three-crown distances (1m, 2m, and 3m) were considered under the apple tree compared with open crop controls in each season including the sole apple. The experiment was laid out using systematic randomized block design with four replications. All parameters were studied under the farmers' management level and practices.

Data on crop growth and yield, the crown spread as well as fruit yield of apple, microclimatic changes around the apple tree, effect on soil physico-chemical attributes, effect on leaf nutrient concentration of the system components were recorded. Cost and benefit analysis of the systems for two years was conducted by discounting the benefit and cost streams using the current bank discount rate. Among

wheat growth parameters studied, plant height (Plate 1) was maximum (95.15cm) and different at 1m from the tree base. The yield parameters viz. grain yield, thousand grain weight, biological yield and harvest index were higher at the open control ($p<0.05$). In field bean (Plate 3), all the studied growth and yield parameters showed higher values in the open control. Pea pod number per plant was higher under the apple tree, however, the harvest index showed the reverse higher value in the open control (Plate 2). Tomato had significantly higher plant height under the tree ($p<0.05$) than in the open control; however, number of fruits per plant and fruit yield per plant under the apple canopy and away were statistically at par (Plate 4). Suvera et al. (2015) also indicated significantly higher total herbage and oil yield of Ocimum spp. recorded under silvi-medicinal systems compared to sole cropping. Among apple trees, there was no difference ($p>0.05$) in canopy spread between intercropped and the pure orchard, however, fruit yield was significantly higher ($p<0.05$) in the pure apple. Soil moisture was limiting in the rabi season (Nov - May) mainly at germination and grain filling stage of wheat and harvest of pea. Apple canopy intense shading commenced at anthesis of wheat in the first week of April. It had adverse effect on grain yield of wheat in the rabi and later on field bean in the kharif season (June - Oct). Soil available NPK showed positive net gains under intercropping than the soils in pure apple orchard. Among soil micronutrients iron level was significantly lower ($p<0.05$) under intercropping. Soil pH was acidic to slightly acidic whereas EC was in suitable range for the growth of all types of crops. Leaf nutrient concentration of all the crops involved in the AH system had sufficient to high level of leaf nutrients. Net benefit/loss from annual intercrops: winter wheat generated 76,073 Rupees net loss -yr -ha from the agroforestry combination; whereas summer field bean, winter pea, and summer tomato generated net profit of 125,060.00; 284,676.00 and 531,966.08 Rupees -ha -yr, respectively. In addition to net revenue from integrated annual crops, net average benefit in two study years from apple alone was 1,045,523 Rupees -ha -yr. Hence, the highest monetary returns were achieved from the intercropping of apple with annuals in the order: Tomato > Pea > Field bean. Ghosh (2001) also recorded highest monetary returns from guava orchard intercropped with groundnut and ridge gourd.

Plate - 1: Apple + Wheat in AH system

Plate – 2: Apple + Pea in AH system

Plate – 3: Apple + Field bean in AH system

Plate – 4: Apple + Tomato in AH system

Figure 1. Plates with apple tree and crop combination in Agri-Horticulture (AH) agroforestry system

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Allelopathic and shading effects of *Mangifera indica* L. on germination and early growth of associated crops at Chano Mille, Arba Minch Zuria Woreda, Gamo Gofa Zone, Southern Ethiopia

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Theme: Agroforestry Systems and Innovations

Key words: Allelopathy, Bioassay, Leaf extract, *Mangifera indica*, Arba Minch

Abstract

Mango (Mangifera indica L), evergreen tropical fruit tree with dense crown cover is widely grown in agroforestry combination as homegarden and scattered tree in the farm land with annual cereal, pulse and perennial herbaceous banana plantation at Chano Mille, Arba Minch Zuria woreda, Ethiopia. The dense canopy allows through little photosynthetically active radiation which isn't enough for successful growth of many associated crops. The leaves falling under are also claimed to have allelopathic effect to crop combinations. Therefore, two experiments were conducted to: i) examine the mango leaf extracts allelopathic effect on germination and early growth of cereal and pulse crops ii) Measure the light transmission ratio at different crown distances from the tree bole and assess growth performance of some companion shade tolerant medicinal plants.

For evaluation of allelopathic effects of aqueous leaf extract of mango leaves, mature leaves of mango were collected from mango orchards at Chano Mille, Arba Minch. Collected leaves were washed several times in distilled water, dried under shade for two days and then in oven at 60°C for 24 hrs. The dried leaves were ground into fine powder and then sieved by mesh consecutively. Water extracts were prepared according to Norsworthy (2003); Hussain and Gadoon (1981) in such a way that 100,150 and 200 g of dry leaf powder was mixed with 1000 ml of distilled water and kept for 24 h at room temperature. The mixtures were filtered through muslin cloth to remove debris and after that through filter paper. Obtained extracts were diluted with distilled water to give final concentrations of 10, 15 and 20% (100,150 and 200 g of leaf biomass per liter) and the control only had distilled water to irrigate the seeds.

For the Bioassays: Sufficient quantity of healthy seeds of three food crops viz. maize (BH 540), peanut (local) and haricot bean (Hawasa Dume) were obtained from Arbaminch Agricultural Research Center. True to species, well fed and healthy seeds of each food crop were surface sterilized in 15% sodium hypochlorite for 20 min and rinsed several times with distilled water (Humaid and Warrag, 1998). The experiments were done in 9.0 cm diameter Petri dish in which sterile Whatman No.1 filter paper was placed. The Petri dishes were washed, and then sterilized within autoclave. In each petri dish, ten seeds of each food crops were evenly distributed on the filter paper and 5 ml of each extract solution was added to each petri dish. The seeds used as control were treated with only distilled water of the same amount. Moisture in the petri dishes was maintained by adding 2 ml of aqueous extracts or distilled water every 2 days. Petri dishes were incubated at room temperature (21 °C) for ten days. The experiment was carried out using a Completely Randomized Design (CRD) with four treatments and four replications. In similarly design, for pot culture, a plastic pots of 10 cm diameter were filled with 500 g soil mixture (soil: sand: peat in ratio of 3:1:1)

where each pot was sown with 5 seeds of test crops and then irrigated with enough amounts of aqueous leaf extracts (10, 15 and 20%) of *M. indica* leaves and the control pots were irrigated with distilled water. Fresh and dry weights of test crops were recorded at 28 days after sowing.

For field screening of medicinal and aromatic plants (WG-H. Jamaica and WG-H. Sudan) were procured from Wondo Genet Agricultural Research Centre under. The experiment was laid out in randomized complete block design (RCBD) with three replications where individual trees considered as replica and their crown distances as treatment plots. In such a way that i) The tree crown was subdivided into three equal distances which had an open control away from canopy influence for comparison. The first distance was at 1/3 of the tree crown, the second at 1/2 of the crown and the third distance was at the full periphery of the tree crown. ii) Experimental plants were grown at these distances around the tree bole in circular plots. Randomly designated plots of one square meter ($1m^2$) were devoted for each of the plants for data comparison. iii) Medicinal and aromatic plants were sown on well prepared soil under the experimental distances and the open control for field evaluation.

Results of both bioassays and pot culture indicated that mango leaf extracts have both stimulatory and inhibitory effects on germination and early growth of cereal and pulse crops compared to the control treatments. The most inhibited crop was haricot bean at 10% leaf extract concentration, and the inhibitory effect was much pronounced in shoot lengths ($p<0.05$). Maize, peanut and haricot bean seedlings indicated tolerance to allelopathic stress of mango leaf extract at lower concentrations, but as the absorption increases, significant reduction occurs in fresh weight of seedlings. The reason could be inhibitory effect of allelochemicals in uptake of water by the seedlings and reduction in other physiological processes of food crops. Similar results were obtained by Khan et al. (2009) after treatment of wheat varieties with *Eucalyptus camaldulensis* leaf extract.

Results from field screening also suggest that growth performance of the medicinal plants was suppressed under mango canopy. Germination was significantly low ($p<0.05$) at the nearest distance from the tree bole. As the distances increase towards the periphery of the tree crown, germination of the medicinal plants also increased (Table 1). In the same manner, the lowest growth performance was at 1/3 distance of the tree crown, and was more pronounced in WG-Hibiscus-Sudan ($p<0.05$). The significantly lowest light transmission ratio was recorded at the 1/3 inner concentric circular plot ($p<0.05$) near the tree bole. This informs to conclude that peanut, and WG-Hibiscus-Sudan should not be planted at the very closest distance from the mango trees stem due to allelopathic and shading effects respectively.

Table 1. Germination of Roselle varieties (medicinal plant) at different canopy distances from mango tree

Parameter	Roselle varieties	Distance treatments from tree bole			
		control	zone1	zone2	zone3
G (%)	WG-H. Jamaica	96.25 ± 2.50^{a}	70 ± 0.00^{d}	78.75 ± 2.50^{c}	87.5 ± 2.89^{b}
	WG-H. Sudan	87.5 ± 2.89^{a}	61.25 ± 2.50^{d}	70 ± 0.00^{c}	78.75 ± 2.50^{b}

Means ± SE values followed by same superscript letters in the same row are not significantly different separated by LSD at probability level of 0.05. G = Germination; WG-H. Jamaica = Wondo Genet Hibiscus Jamaica; WG-H. Sudan = Wondo Genet Hibiscus Sudan

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What light is available for understory crops in high-density and super-high-density olive orchards? Spatial and temporal patterns of transmitted photosynthetically active radiation

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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Precision agroforestry, sustainable intensification, alley cropping.

Abstract

Agroforestry can be an opportunity to increase productivity and income in olive orchards (Rosati et al. 2009). In fact, even in intensive olive systems, the maximum oil yield is obtained when the trees intercept 55% of the incident photosynthetically active radiation (PAR) (Villalobos et al. 2006), thus leaving much radiation available for understory crops. PAR is usually the most limiting factor for crops in agroforestry systems (Friday and Fownes 2002) and its availability in the alley is strongly influenced by tree density and canopy size (Rosati et al., 2020). Additionally, the PAR transmitted by the trees is not uniform in the alley, creating areas with different PAR availability. Knowing exactly how the transmitted PAR is distributed in space and time below the crowns, becomes essential to identify the best intercropping strategies and crop positioning.

In this work we measured the PAR transmitted under the canopy of a high density (HD) and a super-high-density (SHD, i.e. hedgerow system) olive orchard. In the HD orchard tree spacing was 3.5 m along the row and 5 m between rows. In the SHD tree spacing was 1.5 m along the row and 4 m between rows. Tree row orientation was NNE-SSW for both systems. The transmitted PAR was measured below the trees at ground level, along four transects (i.e. four replications) across tree rows, placing calibrated photosensors (GaAsP, Hamamatsu, Japan) below the tree row and at increasing distance (0.5 m steps) on both the east and west side of the tree rows, up to the middle of the alley. The photosensors were connected to data logger (DL6, Delta-T, UK) taking records every minute during two days per month, from March to September, in each of the two orchards. For each position in the transects, the daily transmitted PAR was calculated by integrating the instantaneous measurements over the day, and expressed as a fraction of the daily PAR incident above the trees on the same days. Daily PAR fractions for each position and each month (i.e. average of the two measuring days) were multiplied by the monthly incident PAR obtained from a nearby whether station, to estimate the monthly and then seasonal (March to September) transmitted PAR in each position along the transects. The seasonal transmitted PAR for each position was divided by the seasonal incident PAR (from the weather station) to calculate the overall seasonal fraction of transmitted PAR in each position.

The two olive systems had different transmitted PAR patterns along the transects. The SHD had variable PAR, with minimum values under the tree rows (PAR = 0.21, Fig. 1) and increasing values at increasing distance from the tree row, up to the center of the alley where transmitted PAR was about three folds (i.e. up to 0.62). In the HD system, instead, transmitted PAR was rather uniform along the transect, with no clear pattern. Overall (i.e. across all positions), the SHD system transmitted a bigger fraction of incident PAR (0.43 ± 0.002) compared to the HD system (0.38 ± 0.03). Despite the greater fraction of overall transmitted PAR, the SHD orchard had lower levels of transmitted PAR under the trees, but higher level in the central parts of the alley.

To further investigate the characteristics of the PAR transmitted under the two orchard systems (HD and SHD) we analyzed the class frequency distribution of transmitted PAR values, by assessing, for each position along the transects, the daily frequency of PAR values (measured every minute) within classes of transmitted PAR. In the SHD system, the variability in transmitted PAR along the transects (Fig.1A) resulted in differences in the frequency distributions of transmitted PAR values for the different positions. Figure 1B shows the data for the incident PAR of a clear day in May and for the transmitted PAR on the same day, for both the most shaded

(PAR = 0.21, under tree row) and the most sunlit (PAR = 0.62, center of the alley) positions. Compared to the incident PAR, with rather uniform frequencies in all PAR classes, in the most shaded position, low light intensities (50-200 µmol m^{-2} s^{-1}) were the most frequent and transmitted PAR was always <1400 µmol m^{-2} s^{-1}, while in the center of the alley, the most recurrent transmitted PAR levels were both low (50-200) and high (>2000) ones. This is because, in the hedgerow system, there is no tree shade in the center of the alley during midday hours when PAR is highest, therefore ground light is high for a similar duration as without trees (i.e. as for the incident PAR). When the sun is at lower elevations, tree canopies shade the middle of the alley, increasing exposure time to low PAR and reducing time at intermediate PAR. Under the tree rows, instead, trees cast their shade at midday, when incident PAR is highest, thus dramatically reducing exposure time at high PAR and increasing time at low PAR.

In conclusion, the two different olive orchard systems (i.e. high density, HD, vs. super high density or hedgerow, SHD) had relatively small differences in the overall fraction of transmitted PAR (0.38 vs. 0.43, respectively) but more important differences in the spatial (along the transect across tree rows) and temporal (class frequency) distributions of transmitted PAR values. These results suggest that, for the purpose of designing an efficient intercropping management, it is not sufficient to know the overall PAR transmittance under the trees, as commonly done, but it is important to know how the PAR is distributed in space, and its dynamic over time. In fact, a crop placed in the middle of the alley in a SHD (i.e. hedgerow) olive orchard, with about 60% of the incident PAR, will perform differently from the same crop placed under the trees, where radiation is much lower, even lower than in any position under the HD orchard, despite the fact that this latter orchard transmits less overall light than the SHD. Similarly, knowing the daily patterns of instantaneous transmitted PAR values allows better estimations of crop performance via crop models. In fact, for an equal amount of daily PAR transmitted by tree canopies, crop photosynthesis and radiation use efficiency are increasingly reduced with increasing variability of PAR patterns (Rosati et al., 2020).

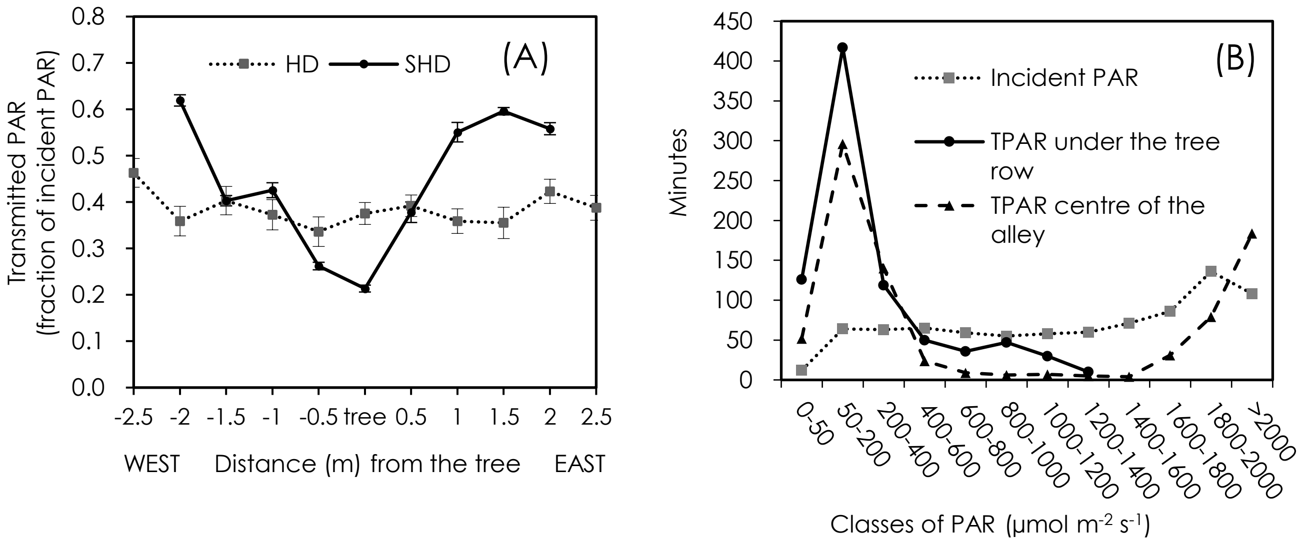

Figure 1. (A) Spatial distribution of seasonal (March – September) transmitted PAR (expressed as a fraction of incident PAR) along a transect, from the tree row to the centre of the alleys in both the west and east side on a high density (HD) and a super high density (SHD), or hedgerow, olive orchard. (B) Class Frequency distribution of incident (i.e. above the tree canopy) and transmitted (i.e. below the trees) PAR (TPAR) values, as measured at the centre of the alley (transmitted PAR = 0.62) and under the tree row (transmitted PAR = 0.21) during one clear day in May, in the SHD system.

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Aspects of the formation and management of a biodiverse agroforestry system: arrangement, organic matter contribution and food production

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Agroecology, low external input sustainable agriculture, ecology restoring

Abstract

Atlantic Forest suppression occurred in the Paraíba River Valley, located between the states of Rio de Janeiro and São Paulo, in Brazil due to 350 years of intensive monocultures what resulted in degraded soils and water resources. In areas that have undergone predations by economic cycles it is necessary to promote reforestation by combining homogeneous forests with ecological reforestation. In this context, agroforestry systems – AFS promote the productive use of agricultural crops with trees and shrubs. In Pindamonhangaba, the Regional Pole/APTA from Agribusiness Technology Agency of São Paulo Department of Agriculture and Supply has the project 'Agroecological Showcase' that promotes participatory research on AFS joining technicians and experimental farmers in task forces. The objective of this work is to promote implantation and management of a biodiverse AFS with low dependence on external resources, regarding the arrangement, management and performance of cultures and species. AFS was installed (Aug/2016) in 3,360 m² in no-tillage of Gliricidia sepium planted in an area of Paspalum grass. One year latter nine varieties of banana were planted in line between the gliricidia. The soil was stored between the lines with four grooves spaced 1.0m from each line, sowing on the outer lines a seed mixture of Crotalaria junceae and pigeon pea – Cajanus cajan (used as green fertilization) and in the inner lines the okra – Abelmoschus esculentus (Dec/2018). The crotalaria was pruned and the pigeon pea occupied the higher stratum between the lines at the end of the harvest of the okra (May/2019). The "juçara" palm – Euterpe edulis was planted next to the banana shrub and between the rows the "macaúba" palm - Acrocomia aculeata (used for pulp and bioenergy) every 10m interspersed with "araribá" - Centrolobium tomentosum (native wood), alternated with Myrtaceae family fruit and tree diversity in addition to the castor bean - Ricinus communis (green fertilization and bioenergy) every 5m (Mar/2018), fulfilling the space between AFS lines. In Mar/2019 the pigeon pea and castor bean were cut and gliricidia was pruned; the liana "cará-moela" – Dioscorea bulbifera was planted at the base of gliricidia and the pepper – Capsicum spp. next to the juçara palm (between gliricidia and banana shrub). Liana used gliricidia as a plant support wood to produce the aerial tubers in the sunny portion of the canopy. Pruning increased heatstroke in the sub-woods and added organic matter with different degrees of decomposition concentrated next to banana shrub and native fruits. Gliricidia lost the leaves in winter naturally increasing the luminosity in the AFS. Banana residues (pseudostem), rich in mineral sap, were cut in the form of tile and arranged surrounding native fruits. The banana and gliricidia consortium kept the environment fresh with moderate air current preserving soil moisture and protecting banana leaves from the fending by strong winds and frost in winter. The nine banana genotypes - BRS Platina, IAC 2001, Prata

Anã, Mel, Ouro, Maçã, Nanicão, Figo and BRS Conquista were grouped in two groups medium size and large size. BRS Conquista, Nanicão and Maçã stood out in productivity. Gliricidia landed on a dry basis 47 t/ha of organic matter rich in N. Among the positive aspects of agroecological management of the sap stand out: (1) Biological nitrogen fixation – FBN in native grass (live cover) (Doberëiner, 1966), legumes - gliricidia (green fertilizer, support live wood) (Franco et al, 2000), crotalaria and pigeon pea - and banana shrub, which also performs FBN (Weber et al., 1999); (2) Protection of soil biostructure with no-tillage and minimal cultivation; (3). Reduction of fossil fuels use; (4) Staggering activities that optimizes resources; (5) Association of species with different cycles and growth habits in space and time; (6) Selective cut conserving Eudicotyledons food and medicinal plants after the decline of grass Paspalum by shading; (7) Nutrient recycling with the continuous input of waste with different characteristics.

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Species	Spacing	Density	Dry mass	Product	
	m	Plant/ha	t/ha		Kg
Banana	2.5 x 5.0	800	7,850	fruit	12,818
Crotalaria	(1.0 x 0.3) x 3.0	11,111	0,600	grain	0,235
Gliricidia	2.5 x 5.0	800	47,030	cut	5,710
Pigeon pea	(1.0 x 0.3) x 3.0	11,111	2,880	grain	0,236
Castor bean	5.0 x 5.0	400	3,400	grain	0,180
Peeper	2.5 x 5.0	800	-	fruit	0,528
Okra	(1.0 x 0.4) x 4.0	6,250	1,800	fruit	0,405
Total			63,560		20,112

Table 1. Agroforestry production in the years 2018-2019 (Pindamonhangaba/SP/Brazil) (from Devide et al. 2018)

On-farm production of woodchip for use as a soil improver: practical implementation

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Abstract
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Theme: Agroforestry innovations towards innovative agroforestry systems

Keywords: Ramial woodchip, ecosystem services, hedges, agroforestry

Abstract

Agroforestry systems can deliver a wide range of ecosystem services and can help to mitigate some of the negative impacts of intensive agriculture. However, in the UK beyond the limited agri-environment scheme support there are currently few incentives for farmers to manage existing farm hedges and woodlands, especially in arable areas where machinery access is a priority. Identifying practical uses for these features could offer a solution as well as encouraging farmers to introduce more agroforestry onto their farms. One possibility is to use woodchip from agroforestry systems as a soil improver either composted or applied fresh as Ramial Chipped Wood (RCW). RCW is made from smaller diameter young branches; nutritionally the richest parts of trees, these branches can contain as much as 75% of the minerals, amino acids, proteins, phytohormones and enzymes found in the tree (Noel, 2006). A review documents evidence for increased soil biological activity and soil organic matter (SOM) with RCW use in agricultural systems (Caron et al. 1998). Chipping branch wood encourages rapid entry of soil microorganisms, enabling both nutrients and energy to be transferred to the humus complex (Lemieux, 1993). Ideally material should be spread in autumn/winter to keep the chip moist and provide optimum conditions for decomposition.

This paper reports on the practicalities of using woodchip produced from agroforestry systems as a soil improver. Replicated trials on three farms in Southern England compared the addition of uncomposted and composted woodchip (Table 1). The farms are all livestock-free, growing arable or vegetable crops, with fertility sourced from fertility-building crops, compost and/or mineral nitrogen. RCW, produced from coppiced hedgerows and short rotation coppice (SRC) agroforestry was applied in winter to a legume ley or overwinter stubble and compared against compost and a control with nothing added. As well as sampling the soils and monitoring crop yields under the different treatments, data were collected on the economics and practicalities of RCW use.

Results indicate that when applied to a legume ley or with mineral fertilisers, RCW has minimal or positive impact on yields and plant health with no indication of nitrogen lock-up (Westaway, 2020). The use of RCW had a negligible effect on most soil parameters measured, with the exception of phosphorus, with the addition of RCW increasing phosphorus availability across all trials. The farms all had relatively high SOM at the start of the trials and no significant differences were seen between treatments, however there was a significant increase in SOM with the increased RCW application rate at Wakelyns. The breakdown of woodchip, colonization by fungus and subsequent action on the soil is a long-term process (Lemieux and Germain, 2000) and ideally needs to be studied over a long period of time.

The three trial farms all operate at different scales and have used different methods to produce and apply RCW. The most efficient application method in terms of time was Tolhurst Organics, where material could be coppiced, then chipped straight into a spreader and applied in one operation. Cut coppice and woodchip are bulky and the more handling required the more costly the operation becomes. For example, the cost to move the woodchip at Down Farm was around £1.25/m^3. However, the biggest unforeseen cost at this farm was removal of wire from the hedge prior to coppicing. Nevertheless, without these additional costs, the larger scale mechanized coppicing and chipping operation at Down Farm

was the most cost effective at £10.75 per m^3 or RCW. The total volume of RCW from the hedge at Down Farm was 35m^3 per 100 m. This compares favourably with production figures of 21-29m^3 per 100m from previous research (Westaway and Smith, 2019). The trial field size is 14.6ha so to have enough RCW to apply to the whole field, even at the lower application rate of 40 m^3/ha,1.7km of hedgerow would be required. RCW produced from hazel and willow SRC at Wakelyns Agroforestry offers a solution; the alley cropping agroforestry system allows for arable crop production between SRC rows, and the SRC provides enough woodchip to heat the farmhouse with enough left over for soil fertility (Smith and Westaway, 2020).

RCW offers farmers an option where livestock are scarce or the raw materials for composting are unavailable. It is a way of integrating trees and hedges into farming systems, providing an incentive for management and a way of bringing fertility from the trees into the cropped areas. To use RCW at scale on larger arable fields, a combination of harvesting existing trees and hedges and planting fast-growing coppice species such willow, poplar and hazel either in an alley cropping system, as new hedges or in an unproductive corner is likely to be the most efficient and cost-effective method of using RCW. By providing motivation for farmers to value and manage existing woody features and establish new agroforestry systems, RCW will enhance the ecosystem service provision of the agricultural landscape.

Table 1. Farms participating in the trials and treatments used in the trials

Farm	Type	Treatments (3 replicates)	Application rate and timing
Tolhurst Organics	Organic vegetable production	1. RCW from mixed hedgerow 2. Composted woodchip 3. Control of nothing	T0: 70 m3/ha applied to 1st year of 2 year legume ley T1 & T2: 40 m3/ha applied to 1st year of 2 year legume ley
Wakelyns Agroforestry	Agroforestry alley cropping with organic arable rotation	RCW from: 1. Poplar SRC agroforestry 2. Willow SRC agroforestry 3. Hazel SRC agroforestry 4. Mixed hedgerow 5. Control of nothing	T1: 40 m3/ha applied to 1st year of 2 year legume ley T2: 80 m3/ha applied to 2nd year of 2 year legume ley (rate doubled and reapplied)
Down Farm	Conventional arable cropping	1. RCW from mixed hedgerow 2. Green waste compost 3. Control of nothing	T1 & T2: 150 m3/ha applied before sowing of spring crop (barley/ oilseed rape)

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Agroforestry innovation networks

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Theme: Agroforestry systems and innovations

Keywords: AFINET, dissemination, stakeholders, methodology, knowledge cloud, alive handbook

Abstract

Innovation is one of the key aspects to favour transition from conventional to more sustainable agricultural practices in developed countries. Europe is leading nowadays the development of a good knowledge infrastructure to move on this transition mainly related with the Thematic Networks. The Agroforestry Innovation Network, named AFINET, is a European project that integrated over 300 stakeholders in 9 different regions of Europe (Spain, UK, Belgium, Portugal, Italy, Hungary, Poland, France, and Finland) to foster the exchange and the knowledge transfer of agroforestry among scientists and practitioners in Europe. The AFINET stakeholders met every six months (5 meetings in total) to talk and discuss about agroforestry. The meetings had similar aims in all EU regions and they included a set of presentations by agroforestry experts (researchers and practicioners), discussion sessions, and farm visits. First two meetings were aimed at discussing agroforestry challenges and bottlenecks, and providing possible solutions or ideas to tackle them through a list of innovations. Main results of the challenges and bottlenecks to uptake agroforestry by practicioners in Europe where: technical, economical, education and communication and policy. In the third meeting, the list of innovations was presented, discussed and validated by the AFINET stakeholders to be used as a focus for AFINET dissemination materials to be produced. In the fourth meeting, synergies between the AFINET regions were established to guarantee a successful deployment of the vast reservoir of existing scientific and practical knowledge of agroforestry in an integral way. Finally, in the fifth meeting, the dissemination materials produced under the framework of the AFINET project (factsheets, technical articles, films,

innovations tutorials…) were presented to the AFINET stakeholders. The AFINET dissemination materials were produced in different languages in order to guarantee the knowledge exchange to farmers that are frequently not accounted with agroforestry concepts, advantages and most of all innovation opportunities. Most of the AFINET dissemination materials were collected in the AFINET website (http://agroforestrynet.eu/afinet/) and the AFINET knowledge cloud (https://agroforestrynet.eu/afinet/knowledge-cloud) which is a European reservoir of scientific and practical knowledge of agroforestry with an end-user friendly access. The AFINET knowledge cloud is connected with OpenAir and includes documents and information generated within the AFINET project but also information from secondary sources such as technical documents and contents coming from scientific and grey literature. An alive handbook (http://agroforestrynet.eu/) was also created under the AFINET project to help farmers to tackle the challenges and bottlenecks identified in the AFINET project. The alive handbook is translated to English, Spanish and Italian languages and explains the most relevant concepts of agroforestry and provides excellent innovations to implement. Therefore, AFINET's methodology has proven to be effective in gathering existing agroforestry knowledge that had not been available before. This methodology could be used as a start point in other innovation projects. Moreover, AFINET members confronted despair bottlenecks, such as economic, technical or policy-related, however they leveraged each other's strengths to work together for solutions.

Acknowledgements

We are grateful to the European Commission through the AFINET project from the European Union´s H2020 Research and Innovation Programme under grant agreement no 727872. The views and opinions expressed in this article are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

Comparing production systems - including agroforestry type - in organic vegetable production on the basis of soil properties, and climate.

EURAF 2020
Agroforestry innovations toward innovative agroforestry systems
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: agroforestry, soil properties, production systems, organic tomato production

Abstract

Introduction: Agroforestry systems have great importance in organic farming, especially in areas where climate (shortage of rainfall) and soil properties (sandy soil with H 1,5%) do not meet the optimal production requirements. Previous experiments of our research team demonstrated, that humus content and soil biological activity were higher in the soils of twenty-year-old hedgerows and eleven-year- old scattered orchards than in those of the intensively managed lands (Tóth et al 2018, Szalai et al 2019). Therefore we focused on investigating the role of trees in field vegetable production in an organic system, and on comparing different tomato production systems by different indicator traits.
Material and method: The experiment was set up in 2019 in order to compare different production systems of organic tomato production. The characteristics of different production methods are summarized in Table 1.

Table 1. Different characteristics of the investigated tomato production systems.

System code	Soil coverage	Supporting system	Nutrient replacement	Irrigation
1	plastic fabric	wooden frames	organic horse manure	-
2	straw	bamboo sticks	pelleted organic manure	drip irrigation
3	grass	willow trees	goat/sheep manure	-

Soil properties of different tomato production systems were measured by soil sensors (Parrot Flower Power Plant Sensor) at the Research and Experiment Field of Horticultural Faculty, Soroksár, Organic Farming Unit. Soil-physical-chemical parameters, nutrient content, and air temperature above soil, as well as enzyme activity and soil water content were measured from soil samples.

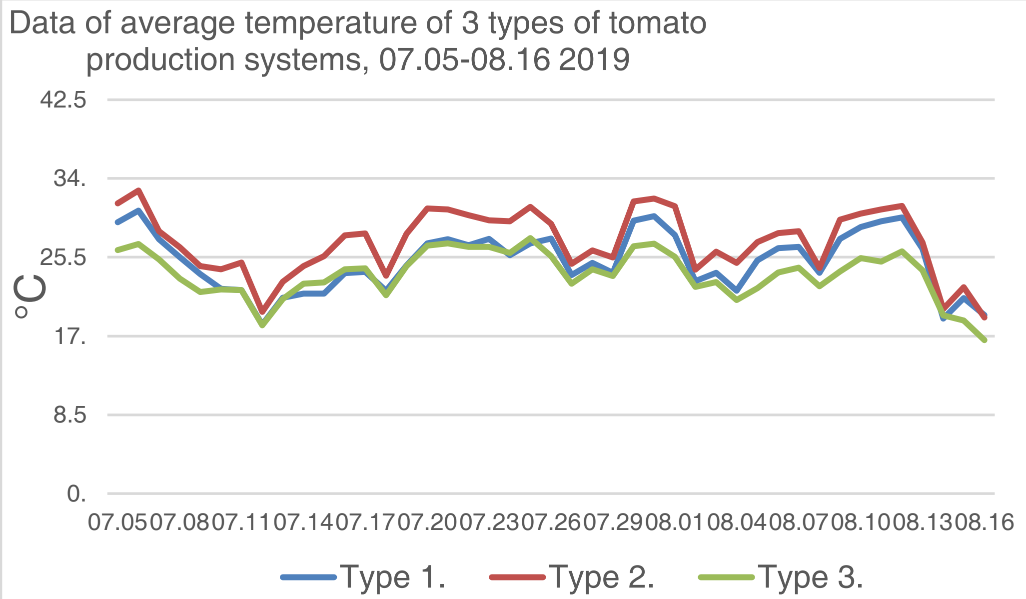

Figure 1. Daily average temperature of the 3 types of production systems measured by soil sensor 2019 at experiment field of Organic Farming Unit of Experiment Station

Results: Figure 1. shows that the highest temperatures were measured in case of production type 2 (soil covered by straw) and the lowest temperatures were recorded in case of type 3 where trees were used as supporting system of the tomato plants. Figure 1 shows that the period in question was a high temperature period of the vegetation season, sometimes the average temperature reached 32.7 °C on the plots covered by straw. Plots where trees were present the highest daily average temperature was 27 °C.

Soil water content was different in the case of both systems as irrigation was provided only in type 2. Type 1 had the highest soil water capacity because of the high amount of organic matter. However, the highest values of soil water content was measured at type 3 especially after rainfall. Data of soil water content were the highest for type 2 because of irrigation. Nutrient content measured by soil sensor through electric conductivity was the highest in type 3. production system where sheep/goat manure was applied with willow trees in the tomato rows.

Conclusion: Comparing the data measured by soil sensors we have found promising results especially from type 3. production system, where willow trees were used in the rows of tomato plants. We consider our results as preliminary achievements on the way to clarifying the best production system for tomato growing. This result proved the beneficial effect of planting trees in the rows of tomato plants, especially that to alleviate extremely high temperatures during the warmest times of the vegetation period.

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Testing "Greater Environmental Sustainability" poplar clones in silvoarable systems. A possible alternative to open field plantations

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: poplar clones, silvoarable, sustainability, timber production, fast growing trees

Abstract:

Veneto Agricoltura, Veneto Region Agency for the innovation in the primary sector, in collaboration with CREA – FL (Forest and Wood National Research Center of Casale Monferrato (AL) and with the support of Confagricoltura – Italian General Confederation of Agriculture, section of Rovigo, established since 2018 over its own pilot and demonstrative farm "Sasse Rami", in the municipality of Ceregnano (Rovigo), an experimental silvoarable system that integrate rows of poplar clones (Populus x euroamericana) with an ordinary rotation of annual crops (maize - soybean – wheat) under conservation agriculture.
The system is managed according to an eco-compatible cultivation standard model, characterized by particular certified poplar clones, signed as MSA (Maggior Sostenibilità Ambientale - Greater Environmental Sustainability", with the goal to produce high quality timber for the wood processing industry. These clones are characterized by high resistance to woolly poplar aphid (Phloeomyzus passerini) and to the main fungal diseases such as Marsonnina leaf spot (Marssonina brunnea), leaf blight (Venturia populina) and poplar leaf rust (Melampsora spp).

The experimental field is about 7.5 hectares large and consists of regular rectangular plots 38 m-wide and 190-long in the average, usually cultivated in minimum tillage.
The soil is completely flat, loamy, with good fertility and permeability, and an active limestone content of 3 %, optimum for poplar plants.
The aquifer tends to oscillate during the year with an average depth of 1.5 - 2.00 meters.
The experimental plots consist of 9 rows of poplar planted along one side of drain ditches, for a total length of 1460 m.
Along the row, 12 different MSA clones are arranged in subsequent blocks, with 6 meters one from each other. A total of 243 trees were planted (30 plants/ha).

Plant material consists of 2-year-old poplars straight cuttings (average height of 6 meters), with no root system. The 12 MSA clones used for experimental plantation are certified and regularly registered in the "National Register of Base Forest Materials" (RNMFB), former "National Registry of Forest Clones", as required by Legislative Decree 386/03, which transposed the EU Directive 1999/105 / EC.

The joint project main objective is to test the MSA clones in a silvoarable context, to evaluate their morphological and physiological adaptations out of the typical specialized open field plantations.
The specific goals are:

- To evaluate the yeld and economic investment return of timber and the associated crops
- To evaluate the competition between fast-growing trees as poplars and agricultural crops in these silvoarable schemes;
- To assess the positive effects of trees on a simplified agricultural environment (flora and fauna improving, microbial biodiversity in soil);
- Provide technical advertising to support the farmers in the management of the silvoarable system, with particular attention to tree pruning, mechanisation options, choice of most suitable MSA clones according to the soil and climatic profile of the site;
- To evaluate poplar wood characteristics of different MSA clones tested in a silvoarable pattern, compared to a conventional open field plantation.

	CLONE	VERNAL DEFOLIATION	LEAF RUST	MARSSONINA LEAF SPOT	POPLAR WOOLLY APHID	GENETIC SOURCE
	I-214	*****	***	**	**	*Populus x canadensis*
1	AF8	*****	****	*****	****	*Populus trichocarpa x Populus x generosa*
2	Aleramo	****	***	*****	*****	*Populus x canadensis*
3	Brenta	*****	***	*****	*****	*Populus x canadensis*
4	Diva	****	***	*****	***	*Populus x canadensis*
5	Dvina	*****	****	*****	*****	*Populus deltoides*
6	Eridano	*****	*****	*****	*****	*Populus deltoides x Populus maximowiczii*
7	Harvard	*****	*****	*****	****	*Populus deltoides*
8	Koster	****	****	***	****	*Populus x canadensis*
9	Lambro	*****	***	*****	*****	*Populus x canadensis*
10	Lena	*****	****	*****	*****	*Populus deltoides*
11	Lux	*****	****	*****	*****	*Populus deltoides*
12	Mella	*****	***	*****	****	*Populus x canadensis*
13	Moleto	****	****	*****	*****	*Populus x canadensis*
14	Mombello	****	****	*****	*****	*Populus x canadensis*
15	Moncalvo	****	***	*****	*****	*Populus x canadensis*
16	Oglio	****	*****	*****	*****	*Populus deltoides*
17	Onda	*****	*****	*****	****	*Populus deltoides*
18	San Martino	****	****	****	****	*Populus x canadensis*
19	Senna	****	****	****	****	*Populus x canadensis*
20	Sile	****	*****	*****	*****	*Populus deltoides x Populus ciliata*
21	Soligo	*****	*****	*****	****	*Populus x canadensis*
22	Stura	****	*****	*****	*****	*Populus x canadensis*
23	Taro	*****	****	*****	*****	*Populus deltoides x Populus x candensis*
24	Tucano	****	***	*****	*****	*Populus x canadensis*
25	Villafranca	****	****	****	*****	*Populus alba*

LEGENDA

*	highly susceptible
**	susceptible
***	tolerant
****	resistant
*****	highly resistant

Figure 1. In the red box, MSA poplar clones characterized by resistance or tolerance to the main biotic adversities, provided in the experimental silvoarable system (from Linee di indirizzo per una pioppicoltura sostenibile 2018 P. Corona, S. Bergante, G. Castro, P.M. Chiarabaglio, D. Coaloa, G. Facciotto, M. Gennaro, A. Giorcelli, L. Rosso, L. Vietto, G. Nervo)

Rapid tannin profiling of tree fodders using untargeted mid-infrared spectroscopy and partial least squares regression

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: condensed tannins; tree fodders; ruminant nutrition; chemometrics; silvopastoralism

Abstract

The tree foliage (leaves and twigs) of Oak (*Quercus spp.*), field maple (*Acer campestre*) and willow (*Salix spp.*), local tree species in Britain and Ireland, possesses a great potential to be included in silvopastoral systems as a nutritional supplement during certain seasons. Among other benefits, these tree species are rich in condensed tannins (CTs), exceeding 10% in dry foliage matter. The reduction of bloat incidence, antiparasitic properties, improvement of nitrogen utilisation and reduction of greenhouse gas emissions are the main properties that highlight the interest of livestock producers in these bioactive compounds; however, CTs may also be considered as antinutritional factors, especially when high concentrations are present in the plant material (Mueller-Harvey et al., 2019). Beyond the concentration of tannins, the size (mean degree of polymerisation – mDP) and structure (ratio of cis:trans and procyanidin:prodelphinidin - PC:PD flavan-3-ol units) are also decisive factors in the biological activity of CTs in ruminants. Therefore, a comprehensive tannin profiling is necessary to understand these compounds' mechanisms of action and support proper management of tree foliage for animal nutrition.

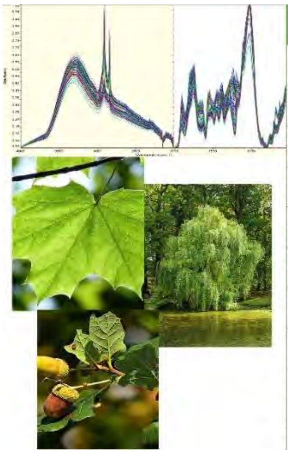
The time and resources requirements of standard wet techniques employed for the quantification and profiling of condensed tannins (HCl:Butanol; Thiolysis) are limited to effectively monitor changes due to climatological, seasonal and species variability. The combination of spectroscopic techniques with chemometric modelling is becoming a reliable alternative to rapidly quantify large numbers of samples to support decision-making. The present study investigates the suitability of Fourier-transformed mid-infrared spectroscopy (MIR: 4000-550 cm^{-1}) combined with multivariate analysis to simultaneously predicting the full CT profile (concentration, mDP, PC:PD and cis:trans ratio) of 120 samples of oak, maple and willow foliage (leaves and twigs) using HCl:Butanol:Acetone:Iron (HBAI) and thiolysis-HPLC as reference methods.

A single multivariate calibration model was developed based on partial least-squares regression (**Figure 1**). The fingerprint region offered the best results for model optimisation, with a RMSECV/RMSEC ratio ≤1.20 for all parameters, indicating suitable robustness. MIR showed an excellent prediction capacity for the determination of PC:PD (R^2P=0.94; RPD=4.07; RER=10.9) and cis:trans ratio (R^2P=0.94; RPD=3.39; RER=10.6), modest for CT quantification (R^2P=0.91; RPD=3.21; RER=11.3) and weak for mDP (R^2P=0.59; RPD=0.68; RER=1.69). Couture et al. (2016) already demonstrated MIR's ability to develop robust multispecies models to quantify tannins in tree foliage, similar to those obtained for individual species. However, this is the first study determining the full tannin profile by spectroscopic techniques in different tree species.

Regarding tannin quantification, wavelengths within the 1450-1430 cm-1 region were already correlated with the presence of tree tannins foliage (Jensen et al. 2008) and are linked explicitly to aromatic ring

stretching vibrations (Falcão and Araújo 2013). The prediction coefficient obtained for mDP improved the values obtained by NIRS in sainfoin samples (R^2P=0.49) (Mueller-Harvey et al. 2019), although not those of wine extracts by MIR (R^2=0.96) (Fernández and Agosin 2007). Nevertheless, foliage samples of oak, field maple and willow showed a small CT size within a relatively narrow mDP range (4.23-6.24). In this case, the PC:PD and cis:trans ratio is more relevant in determining CTs' biological activity (Mueller-Harvey et al. 2019). The estimation of PC:PD and cis:trans ratio obtained in the tree foliage by MIR showed higher predictive accuracy than those obtained previously in sainfoin samples by NIRS both for PC:PD (R^2P=0.77) and cis:trans (R^2P=0.84) (Mueller-Harvey et al. 2019). The regions 900-640 cm^{-1} (related to both OH oscillations of aromatic alcohols and out–of–plane bending of aromatic CH) and 1225-950 cm^{-1} (related to –CH aromatic in-plane bending) have been already used for CT discrimination purposes (Ricci et al. 2015), including differences between gallocatechins and catechins and cis/trans isomers.

The simultaneous and repeated screening of full CT profile from different plant species in a large number of samples represents a strong argument for the use of reflectance spectroscopy in silvopastoral systems. The information obtained would help understand better plant ecology aspects (genetic variation, response to weather conditions, grazing) and ultimately improve ruminant livestock's nutritional management. In contrast with previous NIR calibration models, the present study demonstrated the efficacy of MIR combined with chemometrics to accurately profile oak, field maple and willow foliage tannins. However, to maximise its potential for silvopastoral systems, *in situ-in vivo* field development using portable equipment would be required. Therefore, a broader range of samples should be included to obtain robust models that allow compensating the potential loss of accuracy related to measurements performed in fresh foliage.



	%CT (HBAI)	mDP	PC	cis
LV	8			
N	Calibration: 89 / Validation: 30			
Variables	550-1800 (cm^{-1})			
RMSEC	0.65	0.80	6.71	8.03
R^2C	0.91	0.59	0.94	0.94
RMSECV	0.76	0.96	8.14	9.62
RMSEP	0.81	0.85	7.23	8.82
R^2P	0.90	0.68	0.94	0.92
RPD	3.21	1.69	4.07	3.39
RER	11.3	6.49	10.9	10.6

Figure 1. MIR spectra of the oak, maple and willow foliage and PLS-R parameters for the full tannin profile analysed by a single model

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Augmented reality to support the design of innovative agroforestry systems

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Innovations toward innovative agroforestry systems

Keywords: augmented reality, web-based AR, marker-based AR, agroforestry system design, participative design

Abstract

Agroforestry is recognized as a way of developing a sustainable and resilient agriculture that can fight against climate change. However, the number of species combinations, spatial configurations and management options for trees and crops is vast. These choices must be adapted to the pedoclimatic and socio-economic contexts and to the objectives of the farmer, who therefore needs support in designing his system. Participative design workshops are a good way to integrate the knowledge of several experts in order to design such complex systems. The design of agroforestry systems should take into account both spatial aspects (e.g. spacing of trees within the lines and between lines, tree line orientation, tree-crop distance, species spatial patterns) and temporal aspects (e.g. crop rotations, tree thinning and pruning, tree planting in the case of successional agroforestry). Furthermore, the interactions between trees and crops evolve as the trees grow. However, agroforestry design workshops generally emphasize the spatial aspect only, through the use of static tokens to represent the different species when designing the spatial configuration of the system (fig. 1 A and B).

New technologies could remove this limitation. In particular, augmented reality (AR, the superimposition of digital objects on real-world images) makes it possible to visualize dynamic representations of trees and crops, and also their interactions, while at the same time retaining the possibility to physically interact with the system being designed (i.e. move trees, add or remove species etc.).

Our objective is to propose an ergonomic digital solution capable of assisting a group of agroforestry experts to design an agroforestry system. It should enable the group of experts to understand the dynamics and functioning of the system over time and to assess its landscape impact. Several digital technologies can be used to implement AR: marker-based AR (a specific marker, or pattern, existing in real life is used by the app to detect where the digital object should be displayed on the screen, figure 1C), geolocation-based AR (the app uses the telephone sensors, such as GPS and accelerometer, to compute where the digital object should be displayed) or markerless AR (the app automatically detects real-life objects, such as walls or the ground, through the camera to compute where the digital object should be displayed).

In this study, we investigated the use of marker-based AR to develop a digital tool able to assist in agroforestry systems design workshops. Since the workshops gathers people from different backgrounds, we looked for digital solutions that do not require specific hardware (apart from a smartphone), and ideally that would not even require installation of specific apps, so that all users could use their own

smartphones right out of the pocket. As a result, we turned to web-based AR tools, which use the phone's web browser to display the digital objects on the screen. Our first choice was to use AR.js, a lightweight library for Augmented Reality on the Web that is open-source and free of charge. We designed a first prototype that is able to detect around 20 different markers, although for now the prototype displays only two digital objects (a 3D model of a tree and blocks of wheat-looking crops, fig. 1D). The limitations and constraints of this tool in the context of agroforestry design workshops are being evaluated.

Current work concerns:

- the number of tree species available in the application : 3D digital models for walnut, poplar, wild cherry and other species used in agroforestry systems have been developed and are in process of being integrated in the prototype

- the representation of trees at various growth stages, to see the dynamics of trees as the system ages

- the possibility to have different tree generations, to be able to visualize successional agroforestry systems

Future work will focus on adding features to this prototype such as:

- analyzing the positions of objects to extract automatically the patterns and model the agroforestry system

- designing interfaces related to cultural practices, such as thinning or pruning

- representing tree-crop interactions. In a first step, we will focus on tree shade (light competition), although the final objective will be to be able to represent also below-ground competitions (water, nitrogen), or other variables of interest for the design of agroforestry systems (e.g. predicted crop yield).

Such a tool could be useful not only in agroforestry design workshops, but also as a pedagogical tool, and its use will be tested with farmers, agricultural extensionists and students in agronomical schools, to see how augmented reality contributes to the understanding of the complexity of interactions in agroforestry systems.

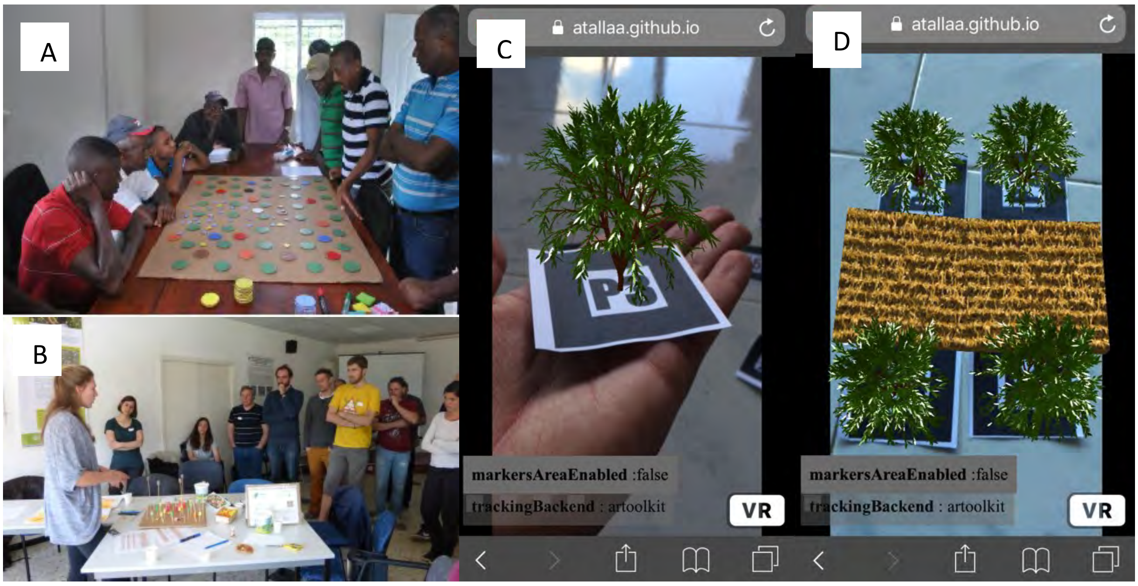

Figure 1. Different tree representations in agroforestry design workshops. A: coloured chips used to represent shade trees and understory crops in a cocoa agroforestry system. B: playmais® crafting toys on toothpicks used to represent fruit trees in an agroecological orchard. C: 3D model of a tree superimposed on a marker, as seen from the screen of a smartphone. D: 3D trees and crops superimposed on markers representing a simple agroforestry system.

How do chicken influence hazelnut production in a silvopastoral agroforestry system?

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: poultry, hazelnut production, mixed farming

Abstract

Introduction
As chickens are naturally forest animals that like to scratch and take dust baths, a free-range with a rich environment with sufficient vegetation to provide shelter for sun and birds of prey could meet the increasing demand for products from natural production systems (Stadig e.a., 2018, 2017). This vegetation could not only serve as a sheltering element, but also provide wood, biomass, nut or fruit production, or a combination thereof, and thus maximize land use efficiency.

There is a worldwide rising demand of fresh nuts as well (Fideghelli en De Salvador, 2009; Germain, 1994). Nuts, including hazelnuts, are a popular and healthy substitute for animal based proteins, the production of which is known to put pressure on ecosystems around the world. Besides, there is an increasing interest in local food production to reduce food kilometres. Nowadays hazelnuts in Flanders and other West European regions are mainly imported from Turkey, producing almost 65% of the total world production (FAO). Local production of hazelnuts is scarce, with a cultivation area of only 5.22 ha in Flanders (and 1.93 in Wallonia), and research and knowledge on productive cultivars in a more temperate climate compared to Mediterranean regions is scarce.Taking into account these two current trends, it was decided to plant eight different varieties of hazelnut trees (*Corylus avellana* cvs.) on a long-term experimental field at ILVO where interrelations between chicken behaviour, hazelnut production and soil conditions are being assessed. The following research questions are being addressed: (1) which hazelnut tree varieties are suitable for temperate agroforestry systems, (2) how does chicken presence influence health and productivity of hazelnut trees.

Materials and Methods
168 hazelnut trees (*Corylus avellana*) were planted at an experimental field at ILVO in Merelbeke (Flanders) on the two grassland plots in February 2017 at a density of 476 trees/ha. Eight cultivars were selected: 'Emoa 1', 'Hall's Giant', 'Corabel', 'Gunslebert', 'Kentish cob', 'Gustav's Zeller', 'Cosford' and 'Tonda di Giffoni' and planted in such a way that each cultivar was represented equally in both quadrants. The distance in the row (3 m) ensured that an optimal light and water supply is possible; the

distance between the rows (7.5 m) allowed machine mowing. The vegetation in the free-range is being monitored during three rounds of laying hens (2017-2021).
Both plots contained two fenced and thus chicken-free reference areas. Since it was observed that chicken often stayed nearby the stable, a weighted average distance ($\overline{d}$) of each tree to the stable was calculated wherein the variables time in number of days (*t*) were incorporated (Formula 1) and this distance was compared with hazelnut production. The distance of the tree to the stable was in other words used as a proxy for chicken presence.

Formula 1: $\overline{d} = \frac{\sum_{i=1}^{n}(d_i \times t_i)}{\sum_{i=1}^{n}(t_i)}$

With i = the number of the chicken round and n the total number of rounds at the time being (for the harvest of 2019, n = 2, for the harvest of 2020, n = 3.

The hazelnut variety was used as a random variable to assess the influence of chicken presence based on $\overline{d}$. Hazelnuts were collected, counted and weighed per tree in Autumn 2019 and 2020. Afterwards, a taste panel with either raw or roasted nuts was organized.

Preliminary results

The influence of the presence of hens on the growth, yield and quality of the vegetation appeared to be limited. The young hazel plant (February 2017) generated its first significant harvest in 2019. In total, 31.4 kg nuts were harvested. This amount didn't change significantly in 2020 (30.9 kg), although per cultivar, yearly differences occurred (Fig. 1). Both in 2019 and 2020, the hazelnut production (in gram) was highly correlated with the weighted average distance ($P < 0.001$). The higher the distance from the chicken stable, the lower the hazelnut production was per tree. Thus, the chicken seem to have a positive impact on the production of hazelnuts in a mixed system. Possible reasons might be: increased fertilization and/or impact on pest species such as the hazelnut weevil (*Curculio nucum*).

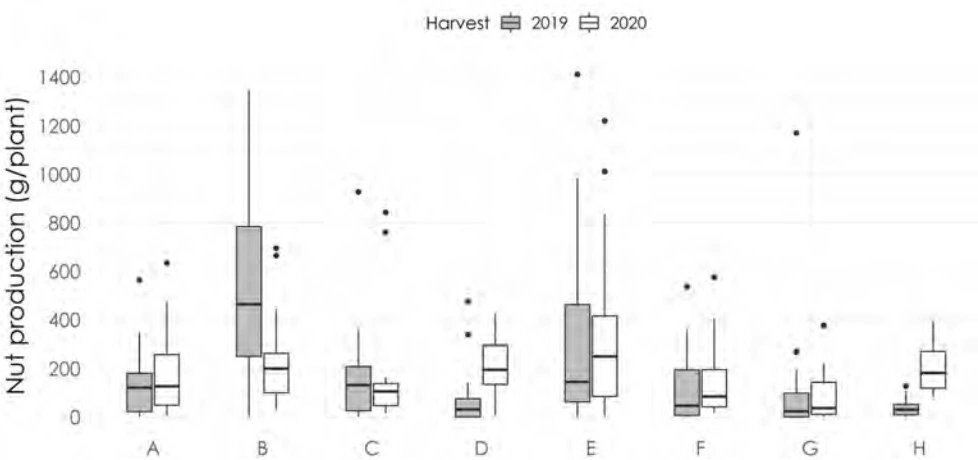

Figure 1. Total nut production in 2019 and 2020 in g hazelnuts/plant (A: 'Emoa 1', B: 'Hall's Giant', C: 'Corabel', D: 'Gunslebert', E: 'Kentish cob', F: 'Gustav's Zeller', G: 'Cosford' en H: 'Tonda di Giffoni').

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Successional Agroforestry Systems for the Mediterranean-Temperate transition: the Portuguese case

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Succession agroforestry, Syntropic agriculture, Agroecological practices, Ecosystems services

Abstract

Agroforestry is an agroecological practice with a long tradition in European countries and is recently getting more attention from both political and scientific communities (Mosquera-Losada et al. 2018). The recognition of Agroforestry importance can be found in the future "CAP strategic plans – Proposal for a regulation COM (2018)" and in the "Farm to Fork Strategy (2020)" and "EU Biodiversity Strategy for 2030 (2020)".

The concept of successional agroforestry systems (SAFs) has been developed and tested by Ernst Götsch since 1982 largely in Brazil. This agroforestry practice relies on ecological succession and stratification as a replacement for fertilizers and pesticides (Andrade et al. 2020).

The aim of our work is to try to identify and describe the most representative SAFs initiatives in mainland Portugal with the main purpose of understanding how these systems are being implemented in a Mediterranean-Temperate transition climate, what similarities they share with the designs from South-America tropical contexts and what solutions are being develop by farmers to adjust to Southern European edaphoclimatic conditions and social-economic reality.

From September 2020 to January of 2021, an update inventory of SAFs farms was attempted. An effort was made to try to seek for minimum representative features such as direct or indirect connexion with Ernst Götsh and an alley cropping design like. A total of nine farms were visited, field data was documented and additional information was collected using a semi-structured questionnaire.

Studied farms were distributed over Portuguese territory, with a bigger predominance in the centre and southern with a more Mediterranean influence. The oldest system was implemented nine years ago. The field areas ranged from 250m2 to 2ha with farms having a minimum of one and a maximum of four fields each. Indeed scalability has already been identified as a major limitation of this practice and labour costs and lack of specialized machinery was also pointed out by farmers as major difficulties. All farms adopted organic farming practices, with exclusion of synthetic agrochemicals from their practices, with four farms having organic agriculture certification and one being in conversion period.

Planned diversity was extremely high in most systems with an average of total 30 species per field of which 13 were trees. Tree densities were highly variable between systems with a median around 1500

trees per hectare. All systems have an alley cropping design like, with perennials, namely fruit trees, non commercial trees and shrubs densely planted in lines with minimum 2 to 8 m apart and the majority of systems having intense horticultural annual production between lines (Figure 1). Although horticultural annuals were present in almost all systems only one farm was considered by its responsible as profitable, based exclusively SAFs cultures with income coming from direct sell of grocery boxes. Interestingly almost all farms involved expected financial return with SAFs in the short or medium term.

Apart from agroforestry with timber, fruit or nut trees, other agroecological crop management practices such as organic fertilization, drip irrigation, intercropping, living cover crops or mulch and reduced tillage (Wezel et al. 2013), which are intrinsic to SAFs' concept, were also common to all study farms. Moreover some farms also included other agroecological practices such as the use of biofertilisers, crop choice and rotations and integration of semi-natural landscape elements at field scale. Consequently, the potential for provide enhanced ecosystems services are high. According with farmers' experience, less irrigation, decreased fertilization and almost no interventions to control pest and diseases were presented in comparison with conventional systems. These facts can be explained due to climate regulation, water flow regulation, enhanced nutrient cycling and natural pest control, also described by other authors in alley cropping systems in Europe (Quinkenstein et al. 2009).

Considering the expansion of SAFs throughout the world, Europe included, there is an opportunity to study and better understand these systems in order to optimize them to different climates and soil conditions. Additional financial return, either via the CAP measures, such eco-schemes, or other public or private initiatives such as carbon market could also be explored and be used as a model.

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Figure 1. A Successional Agroforestry System from northern Portugal (Photo by Ricardo Meireles, Santo Tirso, 2020)

Agroecological approach in soil management of apple organic orchards

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovation toward innovative agroforestry systems

Keywords: living mulches, herbs and medicinal species, soil biodiversity, weeds control

Soil management in organic orchards should provide adequate weeds and nutrient management, specific ecosystem services and sustain soil cover to reduce degradation processes. However, organic orchards are currently managed as intensive perennial systems that rarely allow for rotation or intercropping. Therefore, organic fruit production systems are characterized by 'conventional-like management' methods that are not fully in line with the basic principles of organic farming (Darnhofer et al. 2010). Biodiversity is reduced by intensive mono-cropping (Ratnadass et al. 2012) and soil fertility and plant protection in fruit orchards depend largely on external inputs (Granatstein et al. 2014). A possible break of the monoculture paradigm can be obtained with the introduction of new intercropping strategies using multifunctional living mulches to increase the sustainability and profitability of organic fruit orchards (Leary and DeFrank 2000) as well as the on-farm biodiversity and the provision of eco-services (Malézieux 2012). However, such systems often lead to new challenges due to constraints for efficient weed control or potential competition between the main and the cover crops (Wezel et al. 2014).

In an effort to design an agroecological approach for organic apple orchards, a trial was established to evaluate the feasibility of using living mulches for management of the soil on the tree row. The choice of species to be used for this purpose considered also the provision of the following additional characteristics: an additional source of income, and/or agronomical services (e.g. phytosanitary) and/or multifunctional services.

When considering the additional source of income, the main target was for officinal plants (e.g. *Alchemilla vulgaris*, peppermint) since there is a strong interest and market opportunity for such kind of plants at EU level. Species able to provide agronomical services were selected to support plant protection (e.g. *Tagetes* sp.) or soil bioremediation (e.g. *Cucurbita pepo*). *Fragaria vesca* and *Tropaeolum* sp. were among the multifunctional species since they can reduce weeds competition and provide additional income as fruit production or eco-services toward beneficial insects.

The impact of growing these species was assessed on soil (nematodes) and above-ground (weeds, beneficials arthropods) biodiversity as well as on the tree nutritional and health status. *A. vulgaris* and *C. pepo* induced a consistent increase in the population size of free-living nematodes, thus reducing plant parasite species. The same two species and peppermint reduced the incidence of weeds, but in general promoted an increase of species biodiversity (Figure 1). Such result was paralleled by a high biomass potential production for the herbal species, which can transform them in a second cash crop. *Tropaeolum* sp. was among the best promoter of beneficial mites on the apple tree leaves and at the same time reducing the impact of leaf rollers and some aphids. Concerning the nutrient status of the trees, the mineral content of apple leaves was not negatively affected by the living mulches.

The results are thus suggesting the possibility of using living mulches on the tree rows for organic apple orchard management. However, for the practical implementation of the technique it is necessary to consider also other agronomical practices (e.g. fertilization and water management) when selecting the species, envisioning their application within the framework of a whole cropping system rather than just as an alternative agronomical practice.

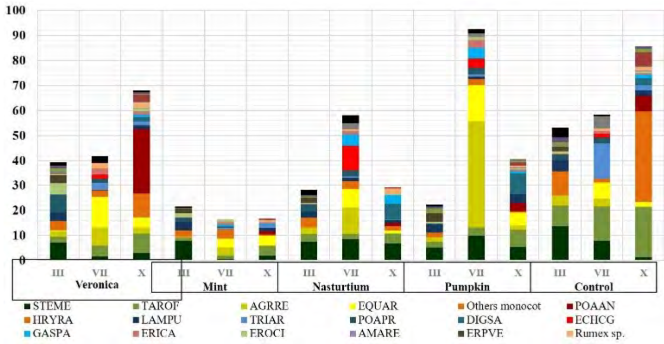

Figure 1. Soil coverage by weeds [%] in the tree rows where selected living mulches species were grown. Data collected on March, July and October 2020.

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The wonder of willow tannin-rich trees (Salix spp): A potential valuable tree fodder for ruminants

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: condensed tannins; willow; methane; ruminant; silvopastoralism

Abstract

Farm productions systems face multiple challenges as the consumer desire high quality animal products produced with less environmental impact without affecting animal welfare. Ruminants are important producers of greenhouse gases, (nitrous oxide and methane) and their potential impact on climate change is a major concern worldwide. Therefore, alternative sources are needed which could contribute to free up land for crop production for direct human consumption. Moreover, ruminal nitrogen use is relatively inefficient, as 55-95% of the ingested N is excreted via urine or faeces (Tedeschi et al. 2014). It is crucial, to improve feed efficiency and decrease emissions. One strategy is in the animal diet, condensed tannins (CT) which are polymeric phenolic compounds able to bind proteins, inhibit their ruminal degradation, resulting in lower ruminal NH_3 (Theodoridou et al. 2010). Studies demonstrated that use of tannins results in a pronounced shift in N excretion from urine to faeces whereas faecal N outputs are considered to be an environmentally less harmful form of N than urinary N (Misselbrook et al. 2005). Condensed tannins are also able to decrease methane emission by ruminants. Two modes of action of CT on methanogenesis: being a direct effect on ruminal methanogenic bacteria and archaea and, an indirect effect on fibre digestion to decrease production of hydrogen, which is a substrate for these bacteria. The protein binding effects of tannins are influenced by factors such as CT content, biological activity, mean degree of polymerisation, prodelphinidin and *cis* content. Willow is a tannin-rich tree fodder (Smith et al. 2012) and although it's great potential in animal nutrition, data on UK willows as animal feed are scarce. The aim of this preliminary study was to investigated, for the first time, the effect of willow variety on the structure and content of CT and the effect of their CT on methane production. Representative samples (n=15) from five willow varieties were collected from three replicate blocks in the cultivation area of AFBI at Loughgall, Co. Armagh, N. Ireland. Samples were freeze-dried and ground at 1-mm screen. Crude protein content in willow was calculated as Nitrogen x 6.25, and nitrogen was analysed by the Dumas method. In-Situ Thiolysis, using chromatography/mass spectrometry, used to assess mean degree of polymerisation (mDP), and ratio of procyanidins to prodelphinidins (PC/PD), and *cis*/*trans*-flavan-3-ols. CT content was measured with HCl-butanol acetone Free Flavanols analysis, using UV-Vis spectrophotometer. The *in vitro* batch fermentation system (Theodorou et al. 1994) was used to evaluate the effect of willow CT on methane production compared to lucerne, a non-CT legume. ANOVA Residual Maximum Likelihood analysis was performed using variety as fixed factor and tree as random factor using SAS (version 9.4) (SAS Institute, 2016). Results indicated that the crude protein content was similar among the varieties with average value 20.6% DM. The CT content (% DM) was 8.2, 8.0, 11.7, 10.9 and 3.9 for Beagle, Endeavour, Olof, Resolution and Terranova, respectively ($p = 0.009$). Prodelphindin, mDP and *cis* content was significant lower for Terranova ($p < 0.001$) compared to the other willow

varieties. The average methane production was lower ($p < 0.001$) for the willow compared to lucerne, a non-CT legume (**Figure 1**). These initial results provide evidence that willow could be a potential approach to help mitigate the adverse effects of climate change related to agriculture and improve the animal performance. However, further *in vivo* animal experiments are needed to confirm these results. The most suitable variety and harvest strategy should be selected to optimise the beneficial effect of introducing willow in ruminant nutrition.

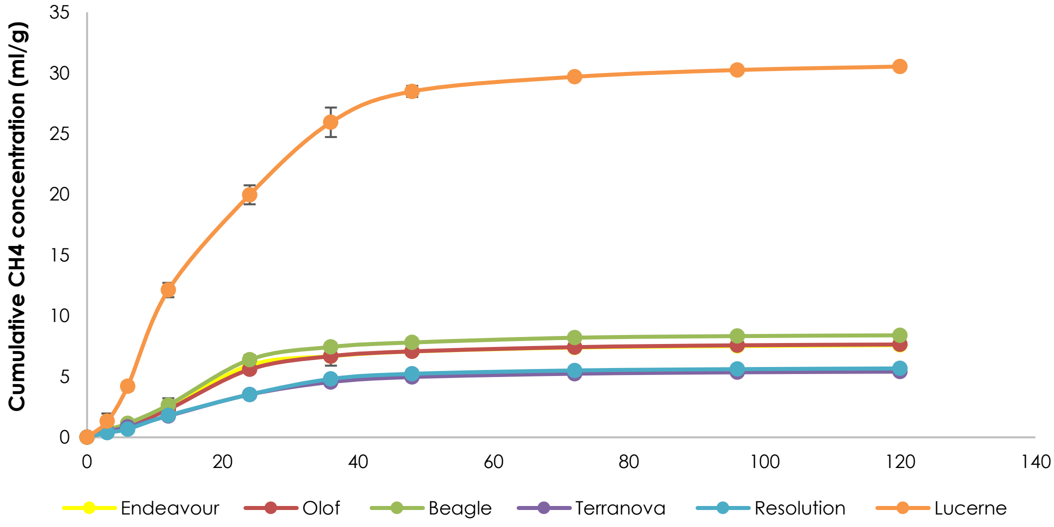

Figure 1. *In vitro* methane production of willow varieties and lucerne

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3.3

Managing Mediterranean agro-silvopastoral systems

What drives silvopastoral management in mid-Mediterranean mountain areas? Addressing opportunities, synergies and barriers of forest owners and livestock farmers for joint silvopastoral management

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Forest owners, livestock farmers, wood pastures, survey, attitudes

Abstract

Silvopastoral management has a long tradition in Mediterranean forests where multifunctional management led forage for livestock grazing and not wood to be the main product obtain from these forests (Fabbio et al. 2003). Historical evidence shows however how livestock grazing was banned from forest areas due to a number of reasons (e.g. afforestations that would impede local farmers' use to secure tree establishment) and conflict s between forest owners (either public or private) and livestock grazers are recorded (Vadell et al. 2016).

However, in a context of land abandonment and increased risk of wildfires, recovering silvopastoral practices may provide synergic scenarios for forest owners/managers and livestock farmers. Silvopastoral management may require from concerted action between forest owners (either public or private) and extensive livestock farmers.

This study presents the results of explorative face-to-face survey where close-ended interviews were undertaken to a sample of forest owners and extensive livestock farmers in two Spanish regions, Aragón and Catalonia, located in the northeastern part of the country.

The typologies of forest owners and livestock farmers in these two regions were previously devised based on expert assessment in each of the regions (Perrot 1990), so that selected individuals would represent the broad diversity of forest property and livestock farming in each of these regions.

Close-ended questionnaires were designed to separately characterize the type of forest ownership and livestock farming. Common questions addressing silvopastoral dimensions were included considering likert scales to assess the views of sampled individuals on silvopastoral management and to explore conflicts between forestry and livestock farming.

9 and 10 extensive livestock farmers were interviewed respectively in Aragón and Catalonia while 10 and 10 forest owners/managers were interviewed in each of the areas, respectively.

Due to the size of the samples, non-parametric approaches were employed. We employed Mann-Whitney U tests to assess whether significant structural differences exist between case study areas. We

assessed the influence of structural factors on the attitudes of the sampled individuals using Kruskal-Wallis and Mann-Whitney U tests. Finally, two-tailed Spearman correlation tests were employed to assess the relationship between management objectives and attitudes towards wood pasture grazing.

Preliminary results show the high relevance of the productive dimension for livestock grazers and high degree of agreement amongst livestock framers on the usefulness of wood pastures as a key resource for their farms. Policy measures to encourage forest grazing should acknowledge it in order to be successful.

The family heritage dimension is the main driver for forest owners to maintain their property. Their management objectives relate to improving the quality of their stands and favouring tree regeneration. The lack of profitability is the main threat signalled followed by the risk of forest fires. They all consider livestock browsing of vegetation as a key tool to reduce the risk of wildfires although initial vegetation reduction through mechanical browsing may be needed to make the work by animals more effective.

No conflicts between forest owners and farmers have been found in any of the two case study areas. Mutual benefits and synergies are identified that can be further stimulated by forest administrations.

In the Aragon case study, 40% of the forest land is public and the case study is located in the Natural Park of Cañones and Sierra de Guara. Our study reveals an abandonment process where pressure on the forest grazing resources is very low and where access to grazing areas is not an issue since the number of farms is decreasing. The grazing intensity is well under the carrying capacity and livestock grazers use of forest pastures is decreasing while the lack of forest management makes it increasingly difficult to access some areas due to vegetation encroachment. Still forest forage is considered by them as a valuable resource to increase self-sufficiency. Famers signal predators and wild animals as one the main risks for using forest pastures. The lack of CAP subsidies related to forest areas is not identified as a barrier for reduced use of the forest areas.

In contrast with the previous, the Catalan case study shows private forest ownership structure and a higher demand of land for farming. The provincial county is promoting agreements between forest owners and livestock farmers so that the former provide their forest pastures in exchange for biomass control by livestock browsing to reduce the risk of wildfires in their land. The fact that CAP subsidies penalize forestland, reduced its demand and makes it an affordable option for landless extensive farmers, some of them young ones for whom access to the land remains a key barrier. Therefore, there is a high interest in accessing wood pastures, being the main limiting factors the lack of water, high tree density or distance from farm.

Despite our study addresses a small sample, its explorative character amongst the diversity of farms and forest owners unveils the role that silvopastoral management may play and what research, management and policy directions should be pursued if this joint management is intended to be enhanced by regional authorities.

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Redesign and management of Silvopastoral systems in the South of France. Insights from agroecology.

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Theme: Managing Mediterranean agro-silvopastoral systems

In the Mediterranean region, more than 4 million hectares could be involved in silvopastoralism (Eurofor, 1994; Moreno and Pulido, 2012). However, many initiatives in silvopastoralism are limited at field level within a farmland - without significant farming system redesign. Other experiences replicate similar patterns on large areas, as in Dehesa and Montado (Rodriguez-Rigueiro et al., 2021), whereas the number of tree and grass species, as well as the shrubby understorey are limited. In this paper, we suggest an alternative pathway, considering various temporal and spatial scales. Our objectives are three-fold. First, we propose a functional approach of agro-silvopastoral systems, differing from a classical structural and determinist approach mostly driven by site conditions and timber production. We then develop a ten-year-on-farm-scenario with a dual purpose: differentiating pastoral resources for goats and producing firewood in evergreen oak coppices. Third, we discuss how the previous analysis can help understanding the transformative potential of agroecology to design dynamic agroforestry and silvopastoral systems. Accordingly, we address these objectives in three steps.

First, we depict the organisation of animal feeding at farm and annual levels as based on the functional analysis of feeding systems methodology (Guérin and Bellon, 1989). A function is characterized by an allotment in the farmland (spatial entities allocated to a function), a period in the animals' life cycle (growth, production, maintenance, welfare) and a stage in complementary feeding (the ration may or may not be totally obtained from grazing). As in permaculture (Mollison and Holmgren, 1978), every element of the system fulfils multiple functions (e.g. a legume supplies protein-rich feed and improves soil fertility; it can be grazed or harvested as hay or seeds…) and every function is performed by multiple elements (e.g. several plots can contribute to a specific function). The functions are linked together through utilisation patterns, since the same land unit can be grazed several times per year, and also differently across several years. One challenge is to manage interdependencies between feeding and cropping systems. They are connected within the functional approach, since both rangelands and crops can be used during the same period. Both biodiversity and agrobiodiversity are also valued for the functional redundancies they create and their beneficial effects. But cropping systems also follow another logic; it is determined by land use patterns and crop sequences, with carry-over effects or earlier crop and cultivation, and by evolutions in market outlets. Likewise, trees are also managed and ageing… Woodlands are often seen as areas on which a livestock farmer can build, according to the grazing practices that he/she implements in different seasons, diverse pastoral resources liable to confer flexibility and security to annual grazing schedules (Milestad et al., 2012). But they can also be considered in their development and management when combined with both an organization of grazing practices and annual economic returns. Secondly, focussing on the influence of sylvopastoral practices on vegetation dynamics, we develop a ten-year scenario with a dairy goat farm using evergreen oak coppices, following a dual purposes approach. One objective was to differentiate and care pastoral resources (grass, shrubs, sprouts, acorns) for goat maintenance during winter and summer, together with securing transition periods and increasing animal welfare. The other objective was to produce 50 steres (about 35 tons, for household heating) of firewood per year on 40 ha of holm oak coppices with an uneven density distribution, from clear to thick stands. The specific technical options were as follows: (i) structuring the coppice with linear clear-cutting, to facilitate firewood gathering and the establishment of fenced paddocks; (ii) gradual thinning in order to improve both summer and winter coppice utilization (increase in shoots and acorn production). In order to forecast the possible development of these woodlands, a simulation was designed for a ten years' time frame at the scale of the whole coppice (Bellon and Guérin, 1996). After clearing, the change in vegetation supplies various types of pastoral resources on a given plot. The privileged grazing periods vary accordingly over the years. The evolution of the level of utilisation of the arranged coppice as a whole was then assessed. Such simulations open the gate on dynamic agroecosystems, when thinning and pruning are widely used to create or regenerate resources and successions (Alejano, 2007; Campos, 2016). They also show that time is not opposing livestock farmers and foresters, since shared planning and time frames can be envisaged both for a better integration of ecological processes and for the definition of principles for action. Joining the knowledge of both forestry and pastoralism experts can serve as a basis for modelling and construction of support tools (Aubron et al., 2013).

Finally, we address how silvopastoralism can guide the design of agroecological systems. Rangelands are natural candidates for agroecology. In addition to the absence of external inputs and tillage, they are able to value solar energy 365 days/year, taking into account the permanence of multi-layered plant cover. Agro-ecological proposals concerning the enhancement of the photosynthetic capacities of multilayer vegetation find here a privileged field of application. Grazing is involved in the structure and functions of agroecosystems: animals are essential in energy flows, nutrient recycling, and the regulation of other organisms, especially plants and vegetation. Animals are (f)actors of environmental integrity and stability: shaping vegetation, influencing plant community dynamics, allowing energy flows, recycling nutrients, co-evolving with agriculture. They are considered in their diversity, including pollinators, beneficial insects, soil fauna, etc. Nutrient recycling is accelerated by the presence of grazing animals in a system; grazed resources are partially transformed into nutrients that are more soluble in faeces and dispersed in the land. Trees can also be arranged in a variety of patterns influencing animal behaviour (Gliessman, 2015). On the other hand, the relationship between agroecology and ecosystem services is still poorly informed, and silvopastoralism can be a fertile object in this direction. Taking advantage of diversity and successional development would enhance the production of goods and services, namely at territorial level (Bell & Bellon, 2021).

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Interaction between beef herd and olive grove in Lazio (Italy) organic farm

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems.

Keywords: grazing; beef herd; olive agroforestry.

Abstract

The use of soil with intercrops in olive grove is a landscape management that can give good results in Italy. This work describes the animal welfare, production and reproduction of herd beef composed of two genetic types (Limousine (LM) and undefined beef crossbreed (UBC)) raised in organic farm located in Central Italy (Lazio region). The beef was reared in olive grove and we describe the interaction between heard and olive tree with results and problem. The aim relieved that grazing of olive tree leaves constitute for animals a integration food of tannin, vitamin and mineral but also has anthelmintic ability. Indeed in two years of monitoring listed in paper, the farmer did not need any veterinary intervention for parasites. The reproductive data are very good; mean fertility is 102.5 and calf mortality is 5% on Limousine breed and 90.0 and 0% on UBC. Calving interval is 323 days and 346 days in average for LM and UBC respectively, with a 1 calf/years in both herds.

The olive grove has benefitted to grazing do to the natural manure, biodiversity of pasture and rainwater management. The problem of olive tree is that they require pruning a polyconic vase with high scaffolding because the animal feeding the low branches, thus cutting the production. The topics that need further analysis are the productions of olive grove in accordance with pruning, biodiversity of grassland and soil organic matter content.

Introduction

In the organic farm, primary goal is to promote the conservation of natural resources and use of sustainable farming practices. In Italy olive tree (Olea Europaea L.) is widely cultivated and has also a landscape value. The low profitability of olive grove and conservation of natural resources has opened the door to the possibility to intercropping with annual or perennial crops and the stakeholders want to introduce different crop/livestock species and varieties (Pisanelli et al. 2018). The presence of vegetative cover protects the soil surface, may increase the formation of organic matter, biological activity in soil and plant biodiversity. The use of livestock on olive grove enables soil manuring and weed control. This may affect olives production, as well as its management (Milgroom et al. 2007; Paris et al. 2019). The olive trees provide animals with shade during the summer and resting zone for rumination and sleep. The olive tree can be considered a natural-functional-feed (https://www.feedipedia.org/node/121) because for its high tannins content (7gr/kg DM). Tannins can be used in animal diets to reduce rumen methanogenesis with greenhouse effects reduction but also to improving diet efficiency (Yang et al. 2017). Moreover, it contains natural compounds with anthelmintic properties (Desrues et al. 2017). Synergy between livestock and olive grove meet the 10 elements of agroecology recommended by FAO (2018) and specifically: diversity, synergies and efficiency; these elements together create animal and plant welfare with decreased incidence of disease, higher yield per unit area and preservation of landscape.

The aim of this work was to describe the organic farm management of beef herd raised in olive grove in Lazio region.

Farm management

The farm is located in Lazio Region, near Roma (Italy) (41° 57' 50.495'' N; 12° 18' 27.948'' E) and is a multifunctional farm; It produces meat (beef and chicken), eggs, vegetable, olive oil and it has a guesthouse where is possible spend a relaxing time.

The beef herd includes three genetic types: Limousine (LM), Marchigiana and undefined beef crossbreed (UBC) amassing to a total of about 100 heads. All animals are reared on pasture but only LM and UBC are allowed grazing under olive trees. Productive and reproductive characteristics are listed in table 1. The herd management is based on groups consisting of cows, calves until 6/7 months and 1 bull together, according to numerosity showed in table 1. The bull stay in with cows all year long, while calves are removed from the herd 3 times/year. The grazing management is on a rotational stocking with of 4-7 days stocking period. Moreover period durationn is a function of climate condition (rain, temperature; grass growth; etc..). The Limousine herd has access to 23 ha of olive grove divided in 6 paddocks of about 3.5 ha. The stocking density is 1.7 LU/ha, while

the undefined beef crossbreed has access at 20 ha of olive grove and 12 ha of permanent pasture, divided in 6 paddocks of about 5 ha with a stoking density of 1.5 LU/ha.
Animal feeding is mainly constituted by grazing, but additional supplementation with hay is provided from July to January. We estimated a medium supplementation of 11 kg/DM/day.
The animal health is based on systemic approach. Health surveillance is daily performed by the herder and a scheduled monitoring plan with regular veterinary examination is in place. The farm uses natural medicine for illness prevention (Sepia officinalis, Capsicum annum, etc..) and a parasitology analysis on fecal pool for herd is done once per year; the analysis are performed in the laboratory of Istituto Zooprofilattico Sperimentale Lazio e Toscana using McMaster methods (Levecke B et al. 2012).
The animal Body Condition Score was 2.5/3 for both years analyzed in this work.
The total area of olive trees is 95 ha: 52 ha are seeded with intercropped forages, Graminaceae (barley and/or durum wheat) for feed and food and Leguminous (chickpea and/or lentils) for food in rotation crop; 43 ha are left for grazing. The planting system of olive grove is 10mx40m on the seeding area and 10mx40m and 10mx80m on pasture area. The olive varieties are chosen for the olive oil production.

Discussion

During the considered years the following disorders were observed: on Limousine herd 1cow showed vaginal prolapse and 1 cow ovarian cyst; on UBC herd 2 cows suffered vaginal prolapse. On calves a few neonatal diarrhea was observed, none leading to fatal consequences. The farm did not use antibiotics, the parasitosis cases have been limited to Strongyles (in very small quantities and no therapy was administered). The therapy for vermin is always harmful for the environment because it kills soil micro-organisms so, they prefer to monitor the parasites. The low incidence of parasites, probably, could be due to the tannins content in olive three leaves (Desrues et al. 2017).
This management is welfare-oriented and allows animals to fulfill their natural behavior. This is confirmed to reproductive characteristics. The mean fertility (102.5) and calf mortality (5%) of Limousine is high in comparison with bibliography data (Biancardi M and Sgoifo Rossi CA 2009). We have not compared data for UBC herd but there is not calf mortality and a very good fertility if one considers the average age of the herd. The productive goal is 1 calf per years and the data collected are very good because only UBC in 2017 is above 365 d.
The layout of olive grove is great for both pasture and crops because the distance of 40 or 80 meters enable the soil tillage, cattle movement and shaded areas for animal relaxation too.
In the olive grove trimmed using traditional vase, the animal are able to feed the lower branches, thus cutting the production. For this reason, olive groves used for cattle pasture can require a polyconic-vase-type pruning with high scaffolding. In the last years the farm has implemented polyconic vase on pasture In the future, the farm will implement the polyconic-vase technique in areas designated for crop production in order to gather and confront results from different olive oil production management routes.

Conclusion

The animal welfare, production and reproduction appear to be favored by pasture management probably because they can have a natural behavior connect with their ethology. Also a positive interaction human/animal promotes animal welfare and the presence of tree that provide shelter on the sun and winds. The grazing of olive tree leaves constitute for animal an integration food of tannin, vitamin and mineral.
In response of this results, in the future, the farm will monitor the productions of olive grove in accordance with its pruning method, biodiversity of grassland and soil organic matter content.

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Table 1. Herd characteristics

	Limousine		undefined beef crossbreed	
	2017	2018	2017	2018
Cows	26	28	36	35
Calf	28	30	36	30
Average age	7.1		11.5	
Prolificacy	1.08	1.07	1.00	0.86
Fertility (%)	107.7	96.4	88.9	91.0
Calf mortality (%)	0	10	0	0
Cow mortality (%)	3.8	3.6	0	0
Twins	0	3	4	3
Calving interval (d)	338	308	380	312

Figure 1. Beef heard in olive grove

Using quantile regression to evaluate the impact of different factors in the cork calliper of cork oak trees in montado agroforestry ecosystem

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: *Quercus suber* L., climate change, mapping productivity, cork stopper, cork growth index

Abstract

Cork oak (*Quercus suber L.*), is the species responsible for cork stoppers produced in Portugal. This is the most valuable industrial cork product and an important factor for farm profitability. The cork growth index is frequently used to characterize the tree cork caliper. It is defined as the value of the eight first complete cork growth years, measured in cork samples after boiling (Paulo et al 2017). It is known to be highly variable between trees located in the same geographical location, stand or even plot. Only a specific cork caliper range is suitable for this production. Estimating the amount of cork produced by one stand that is able to be used for cork stopper production had never been achieved. Quantile regression methodology was applied for the first time to a data set regarding cork caliper, sampled in more than 1000 trees located in 35 stands across the cork oak distribution area in Portugal. It proved to be a useful tool for researching the hypothesis raised: climate, management and tree variables affect individual trees, characterized by the production of different cork caliper, in different ways, even if they are located at same stand.

Results confirmed the hypothesis raised for climate variables. A negative parabolic relationship between cork caliper and annual average precipitation was determined for all quantiles, with optimum annual average precipitation value increasing for the trees characterizes by higher quantiles of cork caliper. Spring and Autumn precipitation showed a positive effect in cork caliper, but only for trees under the 80th quantile. Trees characterized by thicker cork (above the 80th quantile) do not seem to be responsive to the variation of the amount of precipitation in these two seasons. Maximum annual temperature showed to negatively affect cork caliper, but only of the trees under the 60th quantile. Trees characterized by thicker cork do not seem to be responsive to the variation of maximum annual temperature. The ratio between annual precipitation and average temperature, that define the Lang Index, showed a downward parabolic relationship with annual cork growth. Best cork growth conditions are found for Lang Index values around 60, corresponding for the transition between semi-arid climate and humid climate.

A final model was fitted including variables that previously demonstrated to be significant for the cork growth index. Debarking intensity variables were not included due to the lack of biological meaning of the parameters values (Paulo et al 2017). Thus, the fitting of the model included total annual precipitation,

Spring precipitation, Autumn precipitation, Lang index and maximum annual temperature. The application of the final model allowed the prediction and mapping of each cork caliper quantile, and thus the rollable cork percentage across the area of potential cork oak distribution (Palma et al., 2014) (Figure 1). It showed that higher values are expected in the Southern and Central coastal regions and along the Tagus River basin. The Northern coastal and mountain regions, characterized by Lang index values higher to 60 (humid climates), present lower estimated values for the percentage of cork suitable for natural cork stopper production. Higher values are expected in the southern coastal regions and along the Tagus river basis, a pattern similar to the one reported by Paulo et al (2015) for the site index distribution of the species.

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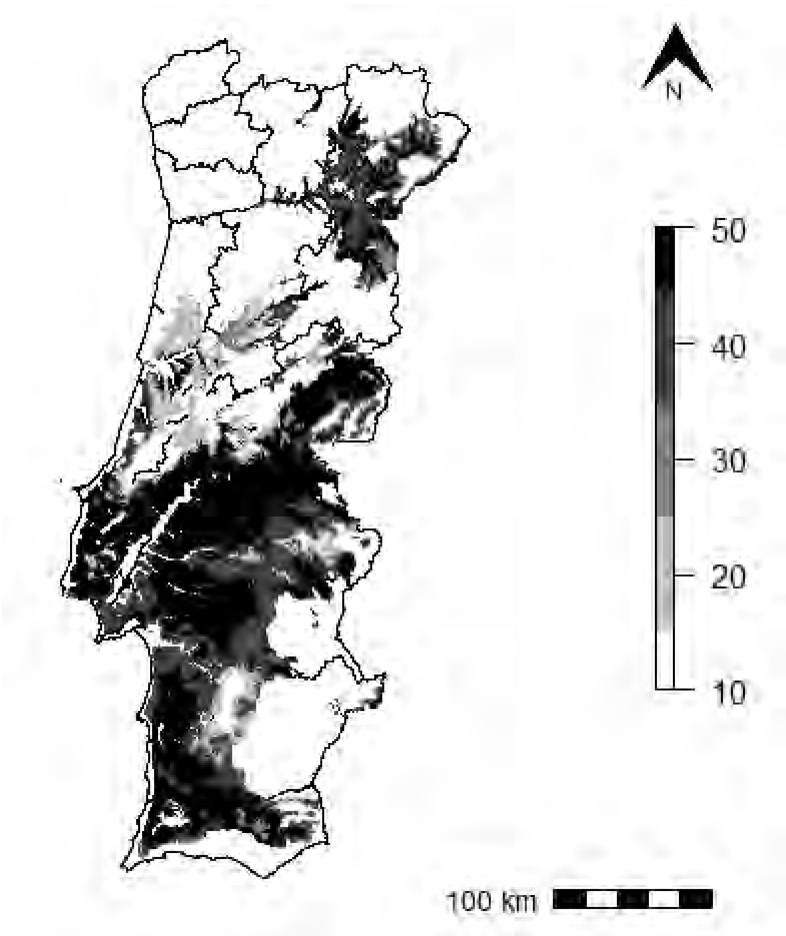

Figure 1. Map for the percentage of rollable cork production.

Assessing the long-term persistence of legume-rich mixtures sown in Mediterranean Dehesas through NDVI analysis

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Silvopastoral systems, Pasture improvement, Remote sensing

Abstract

Mediterranean silvopastoral systems are suppliers of ecosystem services (ES) as fodder production and biodiversity conservation (Moreno et al. 2018). These systems are under threat because of both abandonment and intensification trends (Mahyou et al. 2016; Rossetti and Bagella 2014). To pursue the long term ES provision, innovative practices and tools are needed in alternative to these diverging trends (Moreno et al. 2018). Pasture improvement by sowing legume-rich mixtures is gaining importance due to their contribution to the improvement of forage production and quality, soil fertility and C sequestration, thus turning grasslands into climate change-resilient ecosystems (Hernández-Esteban et al. 2018). However, the persistence of costly sown legume-rich pastures is always a concern and could make the practice unprofitable. The hypothesis of this study is built on the new insights on Remote Sensing (RS) that can contribute to the systematic collection of proxy data on pastures aboveground biomass production and quality. Furthermore, the combination of new software resources and big-data analytics for predictive modelling can provide cost-effective, integrated farm-level decision support tools for sustainable grassland management (Wachendorf et al. 2018). The specific objective of this study was to assess, through the analysis of NDVI dynamics, how long-lasting and intense are the impacts of pasture improvement actions based on sown legume-rich mixtures in Mediterranean silvopastoral systems.

The study was conducted in two dehesa farms (Atoquedo and La Villa) in Extremadura, Spain (Hernández-Esteban et al. 2018), where legumes-rich mixtures (*Trifolium subterraneum* ssp *brachycalycinum* and *yanninicum*, *Ornithopus sativus*, *T. incarnatum*, *T. michelianum* var balansae, *T. resupinatum*, *T. vesiculosum* and *T. glanduliferum*) had been sown over years (from 2003 to 2015) in distinct plots within each farm. In the first farm (Atoquedo), five plots were sown in 2010, 2011, 2012, 2013 and 2014, respectively, while in the second farm (La Villa), legumes were sown in three plots in 2003, 2005 and 2015, respectively. Within each farm, large unsown fields were identified as control areas.

The PNOA orthophotos of the study areas were processed with the eCognition© software (ver 9.0.1, Trimble Inc., Sunnyvale, California, USA) to create vectorial objects identifying trees and ungrazed areas. Starting from 4 year before the first sowing to 2019, at least three per year (from March 1st to May 31st) Landsat images (USGS, https://earthexplorer.usgs.gov) with less than 10% of cloud-cover were collected. The QGIS software was used to identify pixels with at least 90% of area covered by grassland by overlapping the Landsat image with the vectorial object identifying trees. The reflectances at Red and NIR bands of Landsat images were collected to calculate NDVI=(NIR-Red)/(NIR+Red). The average NDVI values were normalized with respect to the NDVI values observed in the control (unsown) areas. The effects of the year on the normalized NDVI before and after sowing was tested with linear regression analysis. The differences between the average normalized NDVI values before and after sowing and the reference

value in the control plots (normalized NDVI=1.0) were tested with one-tail t tests. The significance of statistical computations was evaluated at $P<0.05$.

The effect of the year on the normalized NDVI value was not significant in both farms and did not change before and after sowing (Figure 1). In the Atoquedo farm, the average normalized NDVI values before (0.92) and after (1.08) the sowing were significantly lower and higher, respectively, than the reference control value ($P<0.001$). At La Villa farm, the average normalized value before sowing (0.96) was different (but at $P=0.07$) from the control (1.00) and the average normalized NDVI value after sowing (1.22) was significantly higher from the control ($P<0.001$).

The lack of significance of linear regressions after sowing (9 and 13 years after, respectively) suggested that the effect of legumes enrichment in dehesa systems could be persistent for a long time. Whereas the NDVI is related to pasture quality, these preliminary results suggest that the impacts of the legumes enrichment could be effective as a strategy to improve the quality of the forage production and consequently to enhance ES in Mediterranean silvopastoral systems.

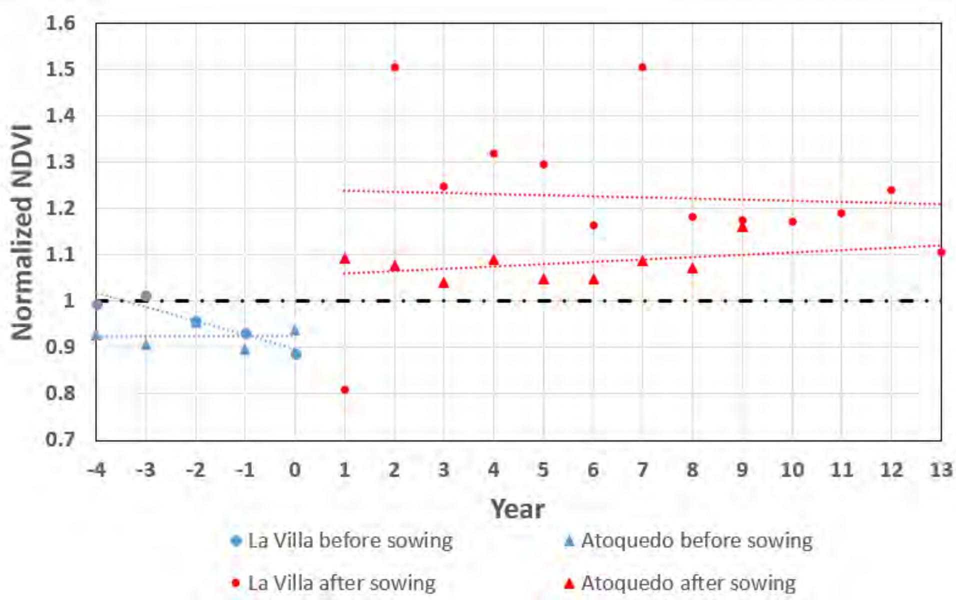

Figure 1. Mean of the normalized NDVI values before (blue) and after (red) sowing at "Atoquedo" (triangles) and "La Villa" (circles) farm. NDVI values were normalized by dividing mean values of the sown plots by mean values of the control plots.

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Shrub encroachment combines with drought and fire to decrease *Quercus suber* tree resilience in silvopastoral cork oak ecosystems

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: oak woodlands, shrub clearing, ungulates, drought, fire

Abstract

Shrub encroachment, i.e., the increase in biomass and density of shrubs is increasing around the world, particularly in systems with a lower density of trees such as the silvopastoral systems (Sala & Maestre 2014). As global change drivers seldom occur alone, shrub encroachment is expected to combine with other factors such as drought or fire to affect the functioning and resilience of ecosystems (Caldeira et al. 2015). Moreover socioeconomic changes such as land abandonment can also be drivers of shrub encroachment (Bugalho et al. 2011). In the Iberian Peninsula, both fire and drought intensity and frequency are already increasing and are expected to further aggravate. Mediterranean oak ecosystems that have a high socio-economic and conservation value may be particularly threatened by management practices mismatched from the current global change challenges. Shrub clearing, mechanically or through browsing, may have a critical role in the management of these ecosystems. Understanding how shrub encroachment and drought may combine to affect the functioning and resilience of these ecosystems is of particularly interest for the conservation of these silvopastoral systems.

To understand the effects of shrub encroachment on above ground C stocks, fire behaviour and resilience of tree water use and growth, we used two long-term experiments in a shrub invaded cork-oak (*Quercus suber*) woodland in South-East Portugal: 1) a 14- year long-term experiment, where five paired fenced and unfenced plots were established to exclude browsing by ungulates and enable encroachment by the shrub *Cistus ladanifer* where above ground biomass and C stocks were measured at 6 years and 14 years after fencing and fire behaviour modelled; 2) a 6 year long experiment, where three blocks with paired plots of *C. ladanifer* encroached were established and growth (band dendrometers) and tree transpiration and other physiological parameters were measured.

In 1) each of the paired fenced and unfenced plots was further divided into 40 subplots of 2 x 4 m. Eighteen of these subplots were then randomly selected for measuring *C. ladanifer* density and estimate biomass and C stocks, using plant biomass-volume allometric equations. We then estimated dry aboveground shrub biomass by cutting the shrubs to ground level and oven-drying samples at 60˚ C to constant mass. Carbon stocks of the above-ground biomass were estimated using the conversion factor of 0.51 g of carbon per g dry biomass determined for *C. ladanifer*. Fire behaviour was modelled using BEHAVE PLUS 5.0.5 model (Lecomte et al. 2019). In 2) six 25 x 25 m randomly selected plots paired by three sites were established in a cork oak woodland invaded by *C. ladanifer*. In each one of the paired plots the shrubs were cut in 2011 while the shrubs were left in the other paired plot. Sapflux density was measured in trees following the Granier constant heat method and the stem heat balance method in shrubs. Sapwood per ground area was determined for *Q. suber* by measuring diameter at breast height of all trees included in two circular plots with a radius of 14 m established randomly in each paired plots.

Fencing promoted shrub encroachment, by protecting the shrubs from the ungulates. The understory structure changed with shrub encroachment by increasing shrub aboveground biomass and overall C stocks. Simultaneously, shrub encroachment led to increased wildfire hazard. In a wildfire scenario, shrubs will change surface fires to crown fires and thus increasing the probability of tree mortality. These results are aggravated by drought occurrence. Our results also showed that shrub encroachment combined with drought to decrease tree transpiration and the resilience of the system. Tree transpiration in shrub encroached plots declined more sharply than in plots cleared from shrubs relative to a pre-drought year. Also, trees in shrub encroached plots were not able to recover from the drought year showing a lower resilience to drought. This was also reflected in a lower diameter at breast height growth in shrub encroached cork oak trees. Our results show that shrub management, under global change scenarios, can be critical for the conservation of these Mediterranean oak woodlands.

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Does livestock grazing affects soil properties in an oak silvopastoral system? Results from a traditional system in Western Greece

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: management, soil properties, grazing, local economy

Abstract

Valonia oak silvopastoral systems cover relatively large areas in Greece (about 30,000 ha) and constitute an important vegetation type with great economic and environmental interest (Pantera et al 2018). They are mixed systems composed of valonia oak trees with a crown density of no more than 40% and understory vegetation consisted of herbaceous and woody species (shrubs). The overstory species are used for the production of acorns and foliage to be fed to livestock while the understory vegetation is directly used by sheep and goats with grazing, rending them invaluable areas for livestock production. On the other hand, valonia oak systems play a significant environmental role because they protect the soil from erosion, ensure an increased biodiversity, regulate the carbon sequestration, and control mountain hydrology.

In this paper, the effects of grazing on certain soil properties of a *Quercus ithaburensis* subs. *macrolepis* silvopastoral system in combination with sheep, are investigated and discussed. The experiment was conducted in one of the largest valonia oak silvopastpral system, located in the prefecture of Aetoloarnania, w. Greece. It is one of the oldest and largest forests of this species that have in the past generously supported financially the local communities (Pantera et al. 2018). Nowadays its area continuously decreases as surrounding communities' habitants consider it solely as a fire-wood provider or as a future agricultural field. Its preservation is of great importance for numerous reasons and may be accomplished by subsidies or other financial incentives. In a recent investigation it was found that the area suffers from serious land use changes that are directly attributed to human interventions (Kaloudis et al 2019). Specific objectives of the study were: a. to compare the effect of tree crown on certain soil properties (pH, % SOM, and % mechanical composition), b. to assess the effects of grazing on certain soil properties (pH, % SOM, and % mechanical composition), and c. to determine the effects of protection from grazing on certain soil properties (pH, % SOM, and % mechanical composition).

The above parameters were evaluated in 9 paired plots (18 in total) in the valonia oak silvopastoral system, figure 1. Half of the plots are fenced since 2014. Soil samples were collected in December 2019 and were analysed for certain soil properties (pH, % SOM, and % mechanical composition), using standard procedures. Sampling points included five quadrates (0.50X0.50 m) located in a cross design.

Figure 1: One of the fenced plot in the valonia oak silvopastoral system

No statistical differences were found in any of the parameters tested. It appears that grazing had neither effect on the soil factors tested nor the presence of the tree crown. Based on the results, grazing had no effect on soil properties of a valonia oak silvopastoral system (Notis 2020).

To conclude, grazing may influence positively the ecosystems balance if applied under a management plan taking into account factors such as the uniform distribution of livestock over the grazing area. Actually, grazing plays an important role by preventing the build-up by removing the flammable biomass, which is even more important lately by the changing climatic parameters in similar ecosystems. This system should be preserved and protected through a number of measures including education as a living legend of Hellenic natural treasure.

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Adaptive Multi-Paddock model: a sustainable management practice for Mediterranean silvopastoral systems

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Grazing efficiency, Grassland production, Grazing management

Abstract

Silvopastoral systems have been proposed as a sustainable agricultural system over conventional agriculture and forestry, often having multiple land uses, of great importance for their environmental and socio-economic value (Castro and Castro 2019; de Albuquerque 2020). SilvopastoraL systems provide a wide range of ecosystem services, increasing economic benefits in different Mediterranean regions (Torralba et al 2016; Seddaiu et al 2018). In this view, the LIFE Regenerate project aims to enhance the providing of ecosystem services from Mediterranean silvopastoral systems, through the application of the Adaptive Multi-Paddock (AMP) management model. This involves rotational grazing with high instantaneous stocking rates and resting periods long enough to allow an optimal pasture regeneration. Within this framework, the hypothesis is that the AMP may be more effective than current grazing systems in the use of pastures in different vegetational conditions of Mediterranean agro-forestry systems. The aim of this study is to assess the impact of the grazing management within different typologies of land uses on the efficiency on grassland resources utilization by grazing animals.

The study site was a private farm located in the Central-western Sardinia, Italy (40°8'N,8°35'E), within which the main activity is the beef cattle and goats breeding. As a vertical transhumance from mountain (summer and autumn grazing) to valley (winter and spring) areas is adopted, since August 2018 an AMP grazing scheme was implemented within the farm, in two distinct areas located at 850 m (A) and 400 m (B) a.s.l.. In this areas, two land use typologies were identified: i) Wooded Grassland (WG) only at mountain area and ii) Permanent Grassland (PG) at both mountain and valley area. At the mountain area (Elighes Uttiosos, EU), 8 paddocks (4 for both WG and PG, size from 0.6 to 1.2 ha) were identified aiming to perform the AMP system, as well as a zone were animals grazed continuously, as control area (about 7 ha at WG and 2 ha at PG areas, respectively). At valley area (Sas Bogadas, SB), the AMP area was dived into 8 paddocks (size of about 0.3 ha) while the continuous grazing was performed within a control area of about 9 ha. In each paddock animal graze for few days with high instantaneous stocking (Livestock Units, LSU) rates (up to about 7 LSU ha^{-1}) followed by long resting periods, while in the control areas grazing will occur according to a continuous scheme with lower stocking rates (up to 1.2 LSU ha^{-1}).

The experimental set was a two-level nested design, with the grassland typology (EU-WG, EU-PG and SB-PG) as main factor, and grazing scheme (AMP and control) nested within the typology. At each level, the forage production was monitored the beginning and end of grazing periods by measuring the height using the HFRO sward stick, seasonally calibrated for strength and reliability regression equations (distinguished by botanical family) between sward stick height (m) and dry matter biomass (DM, kg ha-

[1]).The pasture utilization factor (UF, %) was calculated as the ratio between the herbage consumption and the herbage on offer.
The UF was significantly affected (P<0.001) by the grazing scheme (AMP vs control) within the grazing areas (EU-WG, EU-PG, and SB-PG).The UF was higher in the AMP within the EU-WG areas (Figure 1) than the AMP within the SB-PG and EU-PG (Figure1). The UF in control within EU-WG was not different between AMP in EU-PG, but higher than the UF in control zones within the EU-PG and SB-PG areas (Figure 1). The lower UF observed for both AMP and control at PG areas with respect to WG could be due to the high presence of less palatable species (e.g. *Pteridium aquilinum* (L.) Kuhn and *Cardueae* species) which furthermore could limit the access to palatable species. Nevertheless, the higher consumption observed in AMP than control areas suggest an higher consumption of less palatable species that would lead into an improvement of pasture quality over time (Probo et al 2014).

These results confirm the hypothesis that the pasture UF is affected by the grazing schem within the grassland typologies. The AMP allow to increase the grazing efficiency that could led into an improvement of pasture quality and productivity. These results suggest the AMP system can be consider an innovative model of grazing management maximizing the quantitative and qualitative value of native pasture resources.

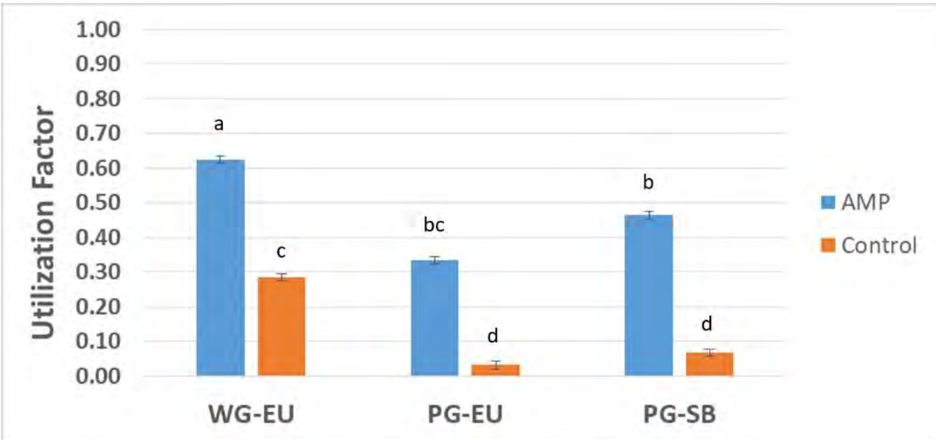

Figure 1. Average values of pasture Utilization Factor (UF, %) in Adaptive Multi-Paddock (AMP) and control areas within the WG-EU (wooded grassland at mountain area), PG-EU (permanent grassland at mountain area), and PG-SB (permenent grassland at valley area) zones. Different letters indicate mean significantly different according with the Student-Newman-Keuls test (P<0.05). Bars indicate the standard error of the mean (n=4).

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The agroforestry in the new Algerian forest strategy: state of art, socio-economic importance and future perspectives

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Abstract
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Theme: Agroforestry systems and innovations (Managing Mediterranean agro-silvopastoral systems)

Keywords: steppic areas, agroforestry, agrosylvopastoral systems

Abstract

Algeria covers an area of 2,381.740 km^2 and includes two important massifs, the Tell Atlas and the Saharan Atlas, running parallel from east to the west and separated by the High Plateau. In the south of the country, the Sahara Desert covers 80% of the whole territory, almost uninhabited. In terms of population, 87% of the total Algerian population is concentrated in the 36 Northern Departments (*Wilayas*), representing 11% of the territory.

Agriculture covers a surface of 8,5 million hectares of arable land (20% of the total agricultural area), of which 2,7% are irrigated (Bessaoud, 2019). According to the Algerian National Forest Inventory (NFI 2008), the forests cover 4,115,908 hectares (59% classified as Mediterranean scrub ecosystems while forests and reforested areas cover 41%) of which 16,7% localized in the northern part of the country. 68% of forests are represented by Aleppo pine, 21% by cork-oaks while a lower percentage (2-3%) is represented by Algerian oak and cedar. 1,974,018 hectares are classified as steppe grass dominated by alfa (*Stipa tenacissima*). Agroforestry systems are developed in the country and several analysis recognize their importance not only in the more populated and intensively exploited northern region (Abdelguerfi et al., 2012; Melle Hadj Ali, 2016) but also in the Algerian steppe close to the green barrier (Ben Salah, 2017) where climatic conditions do not permit other agricultural cultivation. In other pilot projects, new experimental agroforestry systems based on the water phytodepuration have been implemented in desert areas (FAO Project GCP/INT/059/ITA – Use of treated waste water in forestry and agroforestry). The traditional agrosilvopastoral systems are another example of agroforestry, very important for the social impact in the rural and marginal areas, but under surveillance for the high grazing pressures because of the lack of a significant program of development and management of pasture in Algeria (Abdelguerfi et al., 2012).

The new Algerian forest strategy, implemented by the Algerian General Directorate of Forestry (DGF) and currently underway, considers agroforestry as a strategical sector that can give a contribution to the development of forest production and non-timber forest products and that can play an important role in the fight against climate change, soil erosion and biodiversity losses (Baumer, 1997). The identification of a strategy for the valorisation of agroforestry is a major objective of the development of sustainable use of the forest resource that is the Component 1 of the Twinning project "*Appui au renforcement des capacités de la DGR dans la mise en oeuvre de la stratégie forestière*". This twinning between Algeria, France and Italy, started operatively in February 2020. Three project pilots have been regarded : (i) a plot

cultivated with *Pelargonium graveolens*, an aromatic and medicinal plant producing an essential oil, that can be considered in an agroforestry association able to improve the soil fertility; (ii) a plot cultivated with carob trees in a dry context; (iii) an agroforestry system (not yet defined) in a mountain areas, where agriculture is well developed. Further pilot project could be selected in growing-citrus and growing-olives areas, or in semi-arid context (oasis) representing the typical southern agroforestry systems.

The analysis is based on a participatory approach (information regarding the description of the plots, agronomic characteristics, production methods, etc. will be collected) and on a specific survey on the market or development opportunities of the systems in each selected local context.

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Maremmana breed, woodland environment and cattle behaviour

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Maremmana cattle breed, wood pasture, cattle behaviour

Abstract

The Maremmana breed descends directly from the Aurochs, Bos primigenius primigenius, and as such is considered an Italian native breed: it is widespread in regions of Tuscany and Latium with 11.138 heads counted in the Herdbook. Animals show a shaded grey coat, horns are long, halfmoon shaped in males and lyre-shaped in females. Thanks to their impressive structure this breed became an icon of the habitat, helping to make the landscape unique. Over the centuries, natural and artificial selection have jointly applied pressure towards resilience to environmental stressors and resistance to parasites and diseases. Recently, breeding schemes have posed a moderate pressure towards growth, type and muscularity, though the breed maintains its original traits of frugality and adaptability. Calves (born reddish to blend in with the forest, turning into grey around 3 months of age) are seldom treated against parasites. The semi-feral aptitude of this breed leads to a complex dietary composition, animals like to pasture grass but also browse woods, shrubs and leaves, enjoying autumn acorns. Such acorns are low in nutritional value but high in tannins: the large amount of astringent and cellulose tannic substances seem to balance the watery and laxative diet based on the late meadows. The early Autumn rainfall moisten and soften grass and shrubs lignin-rich, making them much more palatable. Acorn ingestion represents a timely "passive prevention" against internal parasites, which could be favoured by the fresh grass and leaves. Studying such behaviour could be an opportunity to learn more about the broader benefits of managing woodlands with livestock. Benefits to biodiversity could stem from reducing the presence of dominant plant species, decreasing excessive tree and scrub encroachment, maintaining open patches within the forest thus minimizing fire hazards (Hulbert, 2002). Small amount of behavioural data is available on the semi-wild Maremmana breed. Thus we collected 14 measures of group behaviour on a free-ranging herd of 52 heads of Maremmana cattle at different times of the day for 6 months. Pooled faeces samples for quantitative analysis of gastrointestinal *Strongyles* and *Coccida* were collected both in forest and in grassland for all seasons of the year. Forest occupied almost 85% of the estate area grazed by cattle and grassland covered the rest: tall tree woods were composed of Turkey oak (*Quercus cerris*) high timber forest passage in '70s with two thinnings in 2000/2001 and 2012/2013 (almost 100 trees per hectare) and of a typical undergrowth (briarwood - *Erica scoparia*, broom - *Genisteae dumort*, bearberry - *Arctostaphylos uva-ursi* and blackberry bush - *Rubus fruticosus*). The herd generally preferred to stay in woods and dense maquis, except in periods of hay consumption (34%), remaining hidden in dense vegetation, mostly while grazing, standing, resting and ruminating. Heads not detected in each observation were on average 23,7% of the cows and 41,9% of the calves: the preference of spending lot of time in the woods corroborates the close link between woodland environment and the Maremmana breed: some Authors underlined that Maremmana grazing behaviour has an interesting peculiarity with a real collaboration between conspecifics. It has been witnessed that some heads would bend the plants until the foliage is lowered to ground level, thus

allowing others to feed on it (AA.VV, 1984). Parasitic load remained very low for all seasons, confirming the resilience of the breed. The other main activities detected in the group of cows were related to feeding (34% for feeding hay and 16% grazing) and social interaction (approaching each other 14%), while for calves resting (33%) and rumination activity (16%) were the most common behaviours (Fig. 1). It appears that Maremmana can live in a forestry habitat all year round with forage supplementation in moments of vegetative stasis: the obvious rusticity and adaptability to forest resources of the breed are reflected in their diet, in which the dominant woody species seasonally predominate. This bond must be well considered in the herd management, in order to maintain both ethical husbandry and a high level of animal well-being. In addition, the peculiar attributes of Maremmana cattle here described suggest that other options are possible when the management of natural resources and landscapes are associated with free-ranging grazing animals. Ecosystem sustainability can be achieved with well-managed, well-grazed woods of Central Italy even if large herbivores are involved. Cattle grazing is a traditional use of woodlands that has persisted, and foraging activity probably affects the performance of some dominant plant species, so that type of animal could be an effective tool also for reducing fuel biomass in forests and could also help identify appropriate management regimes for woodlands that recognize the role of livestock and the conservation benefits that they confer.

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Activity	**Cows**		**Calves 0-3 months**		**Calves 3-6 months**	
	Mean (%)	*SD*	*Mean (%)*	*SD*	*Mean (%)*	*SD*
Decubitus - rumination	10.1	14.50	16.3	31.57	12.7	19.27
Decubitus - rest	7.7	10.80	33.3	41.33	23.4	35.28
Feeding - hay	34.4	23.40	2.4	7.52	22.2	31.57
Grazing	16.3	19.01	0.3	0.97	13.0	22.80
Drinking	2.0	3.09	0	0	0	0
Playing	0.3	1.15	1.2	3.88	4.2	8.91
Lowing	1.7	2.37	15.2	25.58	0.6	1.88
Suckling	1.0	2.30	9.5	16.73	1.9	4.47
Resting	6.8	10.25	15.0	33.04	9.5	30.08
Escaping	5.1	6.22	6.8	21.35	8.8	25.65
Approaching	14.5	18.38	0	0	3.7	8.26
Mating	0.1	0.36	0	0	0	0

Table 1. Values expressed as % of time spent by the different groups for each activity.

Simulating the effect of light availability reduction on grass and legume swards in a Mediterranean rainfed plot trial

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Intercropping, slats, shade, sulla, forage, transmittance, competition

Abstract

Agroforestry (AF) is defined as the integrated management of woody species on croplands or grasslands and it is indicated as one of the farming systems with the greatest potential for climate change mitigation and adaptation (Kay et al. 2019). In Italy, agroforestry systems cover an area of 1.4 millions ha mainly based on silvoarable system with high value trees and agro-silvo-pastoral systems (Paris et al., 2019). In Tuscany, a typical silvoarable system consists in silvoarable olive grove intercropped with a low-productive natural pasture, usually not grazed, until the early-summer period when shallow tillage is performed in order to decrease water competition between herbaceous plants and trees (Mantino et al., 2016). Growing legumes, and in particular perennials legumes, under the canopy of tree crops could be a practice to improve sustainability of Mediterranean AF systems mainly by increasing the Nitrogen (N) content in the soil through symbiotic N_2 fixation, thus reducing the reliance on mineral N fertilisers (Anglade et al., 2015; Hernandez-Esteban et al., 2019) and enhancing soil cover protection (Vallebona et al., 2016). The most important perennial legume crop in Mediterranean area is alfalfa (*Medicago sativa* L.). The effect of tree presence on legumes has been evaluated by several studies, reporting negative effects on yield, due to lower water availability (Nasielski et al., 2015), and reduced light availability (Gea-Izquierdo et al., 2009; Moreno et al., 2007), respect to an open field. Despite this, it was reported that the alfalfa nutritive value is not negatively affected by tree presence (Mantino et al., 2016). In Tuscany, the biennial legume Sulla (*Hedysarum coronarium* L.) could be interesting for its rusticity, productivity, and quality of the forage. Nevertheless, there is still a lack of knowledge on how the reduced light availability affects the development, the biomass accumulation and quality of forage species. Therefore, a rainfed plot trial was designed with the goal of investigating the effect of reduced light availability on Mediterranean legumes and grasses forage species. In October 2019, the plot trial was established at the Centre for Agro-Environmental Research "Enrico Avanzi" of the University of Pisa, San Piero a Grado (Pisa) (43°41'6.97"N 10°20'29.22"E), on a clay-loam soil with 2.5 % w/w of organic matter content in the topsoil (0 - 0.3 m) and 8.1 pH. Before sowing, performed on October 21st, 100 kg ha^{-1} of P_2O_5 were broadcast applied as triple superphosphate. The sowing was carried out on October 21th. The experimental layout complies with a two factor completely randomized block with four replicates (18 m^2 sizing each plot). One factor includes five levels assigned to five different swards: i) sulla cv. Silvan, (ii) ryegrass (*Lolium multiflorum* L. cv. Teanna), (iii) mix of sulla cv. Silvan and ryegrass, 50:50 (iv) mix of sulla cv Silvan, sulla cv. Chiara Stella and sulla cv. Avorio 33:33:33 and (v) alfalfa cv. Messe. Second factor has three increasing shading levels:

S0) the control representing full light availability, S25) and S50), corresponding to a reduction of potential light availability of 25 and 50% respectively. Shading was provided by woody slats, north-south oriented, 2.0 m long and 0.10 m wide, with a distance between each slats of 0.10 m for S50 and 0.20 m for S25, covering a total surface of 4 m^2. Slats were placed at 80 cm above ground level after the sowing (Fig.1). Light availability over and under the swards canopy is monthly measured by means of the SunScan (Delta-T Devices Ltd, Cambridge, UK) multiprobe sensor. Preliminary data showed no significant effect of shading treatments on seedling emergence for all the evaluated swards. Data about yield and nutritive value of herbage biomass, below-ground biomass and N_2 fixation will be evaluated for the next two years. This study received funding from the Tuscany Region Rural Development Plan, PINDARICO project - Measure 16.2 - 2017.

Figure 1. Slats placed immediately after sowing (Photo by L.G. Tramacere, 2019)

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Olive grove and livestock: Project on pasture management schemes for dry sheep

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Managing Mediterranean agro-silvopastoral systems.
Keywords: olive agroforestry; rotational grazing method; sheep.

Introduction

The use of pasture on olive grove is an ancient practice that was used when the understory was not cultivated. The animals, mainly sheep, controlled weeds and provided fertilization for the orchards (Vannucci S 2009). Grazing promotes animal health and the expression of the species ethogram. This agroforestry system also enables to increase soil organic carbon stock (Cardinael et al. 2017) and the presence of perennial crops helps controlling soil erosion (Paris et al., 2019). The idea of sheep grazing in the farm "Casorelle" derived from the concept of associating the two main activities of the farm: olive growing and sheep rearing, in an agroecological vision. The objective of the work is to illustrate a rotational grazing system applied to an agroforestry system, and to assess the environmental, economic and animal welfare benefits.

The farm

The farm "Casorelle", on Pistoiese hills (Tuscany,Italy) at about 200 masl, covers 27 hectars (43°49'34.0"N, 10°54'20.3"E). The farm produces olive oil and raises sheep of the "Assaf" breed, characterized by high milk productivity and adaptability to different climates. Sheep are stabulated, except in the dry period. Health management is systemic: clinical monitoring is carried out through laboratory analyses to implement prevention programs. the main therapies adopted are homeopathy and phytotherapy, avoiding the use of antibiotics and pesticides.

Project of pasture management in olive grove with rotational grazing method

The production block chosen for the management scheme covers 2 hectares with 500 olive trees, it seats at 145 m asl, and has south aspect (a part exposed to the south-west and a part to the south-east. The area has a slope from 2 to 20 degrees. The predominant wind blows from the east. The soil is silty and sandy. The floristic composition of pasture is very diversified: Graminaceae, Fabaceae (*Medicago sativa, Vicia sativa*), Cruciferae and Asteraceae (*Cichorium intybus*). This diversity contributes to make the pasture particularly resistant to the trampling and the pull of the sheep. The pasture, analyzed with NIR method in spring, had the following composition (expressed as % dry matter) 15.5% protein, 45.40% non-detergent fiber (NDF) and 39.98% acid detergent fiber (ADF). The ewes were fed with pasture, integrated with hay of different quality, dipending on the pasture quality. The evaluation of the efficiency of the system is evaluated by the Body Condition Score (BCS) methods (Kenyon et al. 2014) of the flock, and on detailed observation of the grass quality. The scheme was studied for 50 dry ewes with a maintenance-feed requirements of about 1,2 forage units (FU)per head and day, 180 g of crude protein, 3 kg of dry matter. The nutritional value of 1 ha of pasture was estimated in 600 FU in spring and autumn and 400 FU in summer and winter. The agricultural parcel (Fig.1) was divided into 4 paddock of about 5000m^2, with a central area equipped with canopy, water, hay, salt supplement, for the restoration of the animals when the pasture was not able to satisfy their nutritional requirements or was not optimal for grazing (strong rains, soil moisture). We used this scheme from February to June and from September to November for about 240 days. The time spent by animals in each paddock was about 6 days then, the re-growth period was 20-25 days. Each animal grazes 4 months on average.

Economics

The data were provided by the farmer for the year 2019. The grazing dry sheep consumed 0.5 kg head/day of hay, while they would have consumed 2.5 kg if stabulated., With 50 sheep the farm saved 100 kg of hay per day. Medium-quality hay costs 130 euros/tonne, so in 240 days of grazing the farm saved 3,120.00 €. The hourly cost for weed mowing in the olive grove is 40 euros/h, including labor, machine wear and fuel consumption, for a total of 56 hours in a year. In the grazed olive grove, no intervention is required for the management of spontaneous flora, thus saving annually 2,240.00 euros. The labor costs for the management of the grazing flock are around 1,650.00 euros/year, and the construction of fences and structures cost 9,600€, which, considering a duration of 10 years, produces an amortization of 950.00 euros per year. The maintenance costs of the grazing system (mowing grass under the fence and repairs) are around 600 euros/year. The economic savings from the sheep/olive association brought an economic benefit of 2,160.00 € (Tab.1).

Discussion

The farmer has obtained significant economic benefits especially in terms of feeding dry sheep and managing weeds in the olive grove. There are also other important advantages: the fertilization of agricultural land with manure from grazing sheep and optimal dry period management due to movement, sunlight and vitamin-mineral integrations from pasture. Grazing allows the animals to express their ethogram thus promoting well-being, leading to optimal health condition before the leambing and lactation.Nails are robust and digestive functions are favored by the 8.42% hemicellulose content, which is important for good ruminal fermentation efficiency. The problems encountered were wolf aggression and the sheep damage to the bark of small olive plants.

The management of pasture with the rotational method is an agroecological practice that allows to maintain a high pasture biodiversity, limiting the selective behavior of animals compared to grass feeding, avoiding soil degradation. The practice of orchard grazing provieds an important resource with a view to sustainability and multifunctionality, benefitting particularly farmers who do not have much grazing land or who cannot devote themselves to guided grazing to organize the farm.

Tab.1- Benefits from the introduction of sheep grazing in the olive area

	Economy[€]	Cost[€]
Hay	3,120.00	
Ground cleaning	2,240,00	
Flock management		1,650.00
Depreciation of facilities		950.00
Fence maintenance		600.00
TOTAL	5,360.00	3,200.00
SAVING	2,160.00	

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Grazed orchards in France: different forms of livestock integration and their implications for fruit growers' practices

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Orchard, sheep, livestock, integration, agro-silvopastoral systems

Abstract

Combining animals and crops in different forms of silvopastures has long been a traditional practice in Europe (Burgess et al. 2017). Today, in a context of moving agriculture towards more sustainable production systems, some fruit growers have chosen to re-introduce animals, in particular sheep into their orchard. They are mainly motivated by the intention to manage weeds in a different way and to improve pest and disease regulation (Mayr et al. 2007), while at the same time saving on phytosanitary treatments and fertilizers.

We carried out semi-structured interviews with 20 farmers in several regions of France (Provence and North-West). These interviews aimed to analyse: (i) farms structure (different productions and their respective area); (ii) the motivations of the farmers to integrate livestock and fruit trees; (iii) the technical adaptations that sylvopastoralism generated; and finally (iv) the services and disservices provided by animals in orchards.

The place of the animal in orchards is highly dependent on the fruit grower's expectations with regard to the provided services, his interest in livestock farming, but it is also closely linked to his ability to make his production system evolve and acquire new skills. We identified three possible organizations depending on the fruit grower degree of involvement into livestock farming:

(i) **Type 1: Farmers cooperation (*n=10*).** A fruit grower may use a flock from another livestock farmer. Thus, shepherds graze their large livestock from the end of the fruit harvest until budburst the following spring on dense orchard areas. This mainly informal arrangement benefits both parties: access to a grass resource for the herd and weed management for the orchard, thus eliminating at least one mechanical or chemical weeding.

(ii) **Type 2: Orchard-Livestock punctual integration (*n*=6).** When a producer aims to optimize the prophylactic action of the sheep against specific pests and diseases such as vole (*Microtus duodecimcostatus*), codling moth (*Cydia pomonella*), scab (*Venturia inaequalis*), he acquires a herd, often of limited size. The herd then grazes as quickly as possible after harvest in order to consume fruits leftovers and leaves, potential sources of inoculum. It then leaves the orchards as budbreak begins. In this configuration, the fruit grower has "fallback" plots: grasslands, mountain pastures or wooded plots, for grazing his herd during spring and summer.

(iii) **Type 3: Orchard-Livestock quasi-permanent integration (*n*=4).** Some fruit growers have opted to maximize the presence of their herd in orchards. A quasi-permanent pasture except during harvest and lambing periods provides more room for manoeuvre to increase the impact of sheep on the main pests and diseases in the orchard. In particular, by adjusting the frequency and the duration of sheep presence on a given plot.

Changes in the orchard and the fruit grower profession

Besides the collaboration with a professional shepherd, when a fruit farmer owns his herd, investments (fences, shelters, veterinary care...) and orchard improvements have to be considered, although they are partially compensated by livestock sales. In quasi-permanent integration (type 3), it may be necessary to raise the fruiting area to at least 1.10 m above ground, raising tree height.

Moreover, the presence of herds becomes an additional factor to be considered in relation to the nature of the normal management: pruning, treatments, harvesting. Because of copper toxicity towards sheep, it is essential to use an alternative to this active ingredient or to exclude the animals from the plot for 20 to 30 days after copper application. A large part of the extra work related to sheep farming is the management of fodder resource, by organising rotational grazing systems between tree rows, using mobile fences in order to move sheep regularly. Observing sheep's behaviour is also a crucial activity to detect any situation of insufficient grass resources, in order to prevent the risk of damaging tree bark.

Finally, sheep farming also involves more on-call duty, especially during the lambing period. New regulatory and sanitary constraints must be respected. It is also necessary to open up to new professional networks (veterinarians, shearers, slaughterhouses, etc.).

A flexible system for more sustainability

The main advantage of the livestock-orchard mixed system is its flexibility as it is compatible with all production methods (conventional, organic, biodynamic) and paves the way to numerous combinations between orchard and livestock (De Lacroix et al. 2011) depending on the objectives and socio-economic contexts of fruit growers (e.g. geese in peach orchards, hens in olive grove, pigs in apple orchards...). The example of sheep and apple orchard integration described here shows that there are many ways in which animals can be integrated, and that this degree of integration has a significant impact on farmers' management practices.

Moreover, through the reduction of the use of inputs, it has a positive environmental impact, contributing to practice changes and a shit of societal vision of fruit growers. Getting beyond the single model of the specialized and intensified orchard is not simple but can be done gradually. New orchard models will have to be designed, site-specific or 'tailor-made' in accordance with the objectives, needs, skills and constraints of each fruit grower.

Figure 1. Example of cherry orchard in Provence region corresponding to our Type 2 (credits: Compagnone M.).

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Observations on a livestock cattle system in a Mediterranean mountain pasture

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems (adaptation and mitigation)

Keywords: Mountain pasture feeding value, Sarda cows, carrying capacity, energy requirements

Abstract

In designing sustainable grazing management of suckler cattle production systems in less-favoured areas to determine the stocking density of animals and the available forage resources is of primary importance. Previous studies have reviewed the performance achievable on Mediterranean forest pastures by cattle on different physiological stages and in different seasons of the year (Casasus et al. 2007). Casasus et al., (2005) stated that lactating cows and their calves could not cover their requirements in autumn-winter period; in other work (Mayer et al. 2006 in Swiss sub-alpine wood pastures) cows with moderate energy and nutrient requirements were able to get an adequate diet. Henkin et al. (2005) concluded that a beef herd can support itself in a Mediterranean oak woodland throughout the year, with moderate supplementation during the summer and winter. The beef cattle livestock system in Sardinia is based on suckler cows system: the cattle normally graze pastures of medium-low nutritive value, often in medium-high mountain area, all year around. The calves follow their mothers at pasture until the weaning at about 6-7 months old, when they are sold mostly to the fattening centers of Po valley (Pianura Padana, in the North of Italy). To estimate the feeding value of a mediterranean mountain pasture, grazed by Sarda cattle, a study was carried out. The feeding value, expressed as MegaJoule of Metabolisable Energy (MJME), was indirectly estimated by the energy requirements of the herd grazing the pasture under study. This estimate could allow a better determination of the animal stocking rate, in order to better match the animals requirements and the biomass productivity of pastures. The research was carried out between 09/01/2015 and 09/01/2016 in the experimental farm of Agris Sardegna, located in North-West Sardinia (lat 39°N, long 9 °E), at 670 m a.s.l.. The study area is characterized by a vegetation cover dominated by Mediterranean trees (55% mainly Downy Oak *Quercus pubescens* L.), and *Pteridium aquilinum* (L.) Kuhn (24%), while the remaining patches are composed by rock (4%) and herbaceous cover. The climate is Mediterranean with hot, dry, sunny summers and mild and rainy winters with some days of snow (Tmax = 28.1°C; Tmin = 3.3°C; total annual rainfall = 905 mm). The area consisted of a mountain pasture (77 ha) managed under a continuous stocking system and grazed by a herd of 42 mature Sarda suckler cows 10 ± 3 years old (means ± s.d) at a stocking rate of 232 kg live weight/ha (approximately 0,5 cows/ha), in good agreement with that reported for similar areas and animals (Scotti et al. 2003). The total animal requirements are given by the sum of the maintenance, lactation and pregnancy requirements. This estimate also includes the suckled-calf requirements, included in lactation requirements. To this end the animals (cows and calves) were weighed monthly and the calving dates were recorded. The amount of supplement administered was also measured. The energy requirements of each animal, expressed in MJME, were estimated with Nicol and Brookes (2007). During the experimental period the total energy requirements of the herd was 1658566.5±13736.4 MJME, totally derived from the pasture. When referring

to grazing area, the feeding value was 21539.8±178.4 MJME/ha*year, 65% of which was represented by the maintenance requirements, 3% by the pregnancy and 32% by the lactation ones (Fig.1).

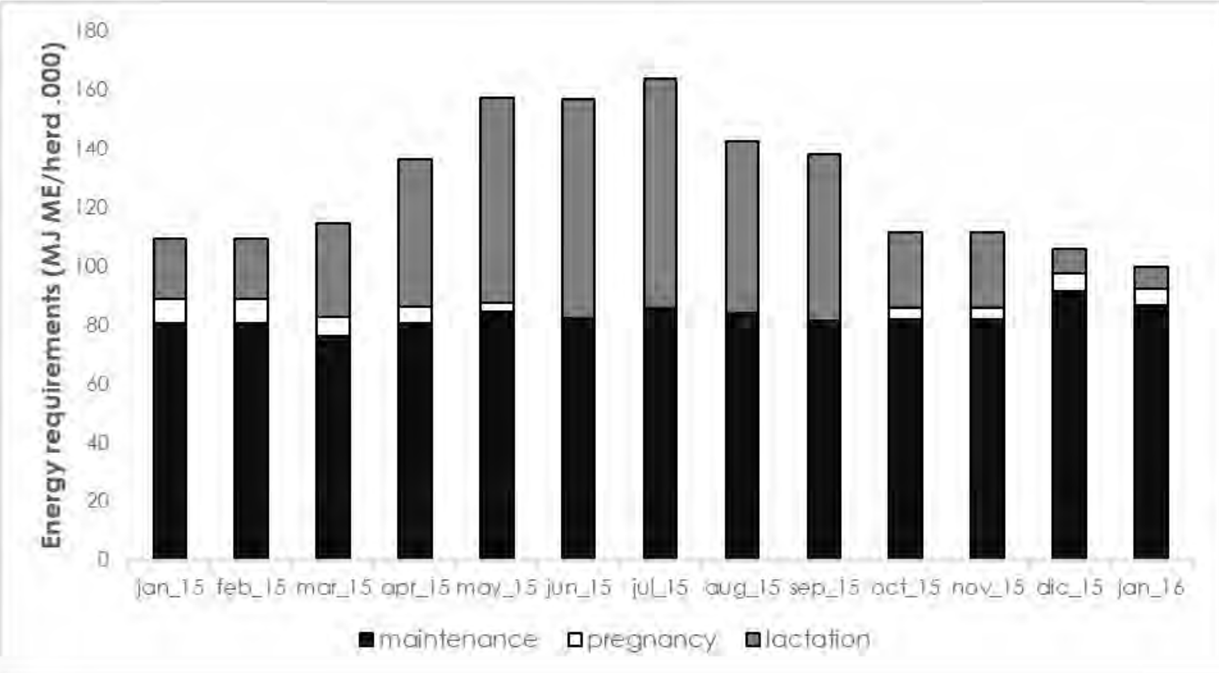

Figure 1. Monthly evolution of energy requirements (for maintenance, pregnancy and lactation) of 42 cows of Sarda breed reared, under a continuous stocking rate, on 77 ha of pasture in a mountain area in Sardinia.

The total energy requirements of the herd showed a peak in May-July, which corresponds to the higher lactation requirements, in turn linked to the average calving date (07/02/2015±47 days). In the experimental period the herd productivity, represented by the calves and expressed as kg live weight, was 6197 kg, (average birth and weaning weight of calves 29.5±4 and 196±30 kg/animal, respectively, herd fertility 88%). These results can constitute a starting point to assess the carrying capacity and the time of pasture shortage of Mediterranean mountain pastures grazed by an autochthonous cattle breed. Further research is needed for a better definition of key points (i.e. seasonal carrying capacity and stocking rate) for the management of a Mediterranean mountain pastures with grazing cattle.

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Selecting indicators for an integrative assessment of different land management in Iberian agro-silvopastoral systems

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: Soil quality; Water availability; Biodiversity; Pasture production; Tree health; Profitability

Abstract

The southwest of the Iberian Peninsula (Spain and Portugal) has a centuries-old tradition regarding the agro-silvopastoral use of its ancient Mediterranean forest converted progressively into both woody rangelands and treeless grasslands. Nevertheless, some socio-economic drivers of the 20th century (wars, autarkic dictatorships, rural migration and the European Union policies) have induced to significant changes in land management. Nowadays, extensive livestock husbandry is by far the dominant land use although a great sort of management strategies can be identified depending on both the local context of each farm and the aim pursued by each owner. Anyway, the positive or negative effects of the different types of land management that currently coexist have been partially studied so far being still necessary more integrative studies that allow assess them from different perspectives at the same time.

It is under this context that the research project *Development of an integrative spatially distributed assessment system for extensive livestock farms* (IB16052) arises. In it, five types of land management are being compared: [1] conventional woody rangeland (cattle, Iberian pigs, goats and hunting animals), [2] conventional treeless grassland (cattle within an area protected by the EU 2000 Nature Network and some irrigation water), [3] rangeland with organic livestock certificate (cattle near Tagus River), [4] holistic management (cattle rotating by several fenced areas of less than 5 ha), and [5] permaculture with recreational purposes (watering ponds designed by Sepp Holzer and partial grazing exclusion in order to attract endangered wild animals). Each one of them is represented by 5 representative farms, relatively comparable between them in terms of soil type, dominant lithology and climate conditions, selected after several meetings between the participants of the project and their PhD students.

The integrative assessment is being based on 6 key elements: [1] soil quality, [2] water availability, [3] biodiversity, [4] pasture production and tree health, [5] social and [6] economic profitability. Each one of them is being worked by the responsible scientist(s) following different research strategies according to their expertise. In the next paragraphs, the strategies used as well as the indicators that have been provisionally selected to form part of a future assessment system are widely described. This system pretends to develop a GIS tool, inspired in the SAFA system (FAO, 2014), that allow farmers to know the current state of the quality (from 1 to 5, i.e. from the lowest to the best quality) of these six elements abovementioned of their farms. For doing that, the users must introduce (when it is possible) a shapefile with the spatial limits of their farms and known values of a set of parameters (selected indicators) that the tool will ask in each step.

Soil quality is being addressed from both recent research of the participants (soil quality and degradation indicators proposed by Pulido et al. (2017)) and some newly lines of investigation focused on bacterial communities. Regarding soil quality it has been proposed as indicators the six variables already selected in previous research: cation exchange capacity (CEC), exchangeable potassium (K), soil organic matter (SOM), water content at field capacity (WFC), soil depth and the thickness of the Ah-horizon. As soil degradation indicators the penetration resistance (PR) has been added to the parameters: percentage of bare soil (erosion) and bulk density (compaction). Finally, referring to soil microbiology we have proposed some new indicators: number and diversity of bacteria and CO_2 quotient (soil respiration).

Water availability is being assessed by two approaches: the total amount of water that watering ponds, among other infrastructures, can store (livestock drink) and the availability of soil water necessary for pasture production (livestock food). Regarding water available for drinking we have selected the total surface area occupied by watering ponds (easy to quantify using aerial images), number of wells and other infrastructures and the total consumption per hectare. In addition, we are considering the possibility of adding some indicators related to water quality. Soil water is being assessed by climate indexes such as the aridity index (AI), the monthly content of water and the number of months that shows water deficit and saturated conditions (runoff).

As indicator of biodiversity we have proposed the number of species accounted by official inventories, gathered by the Global Biodiversity Information Facility (GBIF). I.e. by using the GBIF on-line tool the user (mostly thought for farmers) can know the number of species present in a buffering area of a radium of 1, 5 and 10 km from the centroide of each farm (the centroide and its geographical coordinates can be easily quantified through tools embedded in many GIS softwares). In addition, we are now working on mapping techniques through photointerpretation of the different habitats that can be observed in many agro-silvopastoral farms. In case a user can obtain information from inventories made ex proceso we have also proposed as indicators the number of species of mammals, birds, reptiles, invertebrates, amphibians and fishes.

Pasture production and tree health are being considered together because it pretends to be a good way of inform farmers about the productivity of their farm, i.e. if their pastures and trees are potentially strong to guarantee enough for animals (grasses, acorns, etc.). As indicators on pasture we have selected pasture production (kg of dry matter per ha), percentage of legume and grasses (natural composition) and percentage of protein and fibers (nutritional value). We are now testing the most efficient methods to determine easily these parameters. Tree health is being assessed by a great sort of variables: tree density, tree cover and a particular methodology that can enumerate and assess the damages of some representative trees (defollers, aphid, gills, pointed, pruning, mechanical damage, perforators and exudates).

The indicators proposed for the assessment of the social profitability are based on a methodology based on semi-quantitative questionnaires in which we are considering information (Likert-scale) about life quality, generational takeover, animal welfare, food and air quality and cultural legacy. Regarding economy efficiency we have selected annual expenses (regular vs. dry years) and inputs (livestock sale, EU subsidies and other inputs), expressed in percentage, and the number of stable jobs and labour days (wage) for temporary workers. These questionnaires have been answered (and corrected) by owners, managers and workers in the most of our study areas (a good example of participatory approach).

The scores and qualitative observations of every farm have been summarized in Table 1.

Table 1. Summarize of the 6 key element keys of every farm (preliminary results).

Farm	Soil quality	Water availability	Biodiversity (no. of species)	Pasture / Tree health	Social profitability	Economic profitability
Conventional rangeland	3.0	Not enough	76	3 / 1	1 worker	Efficient
Conventional grassland	3.2	Not enough	53	4 / no trees	No workers	Efficient
Organic farming	2.5	Not enough	57	3 / 3	No workers	Efficient
Holistic management	3.3	Enough	70	5 / 4	2 workers	Efficient
Permaculture	2.6	Enough	85	3 / 2	5 workers	Efficient

Selection of *Quercus ilex* acorns for reforestation of "dehesas" under climate change: experimental sowing of acorns of different provenances

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean Agro-silvopastoral systems

Keywords: provenance test, assisted regeneration, direct sowing

Abstract

The selection of suitable genetic material is essential for the short- and long-term success of assisted regeneration. This is particularly so in systems under risk of collapse due to climate change and lack of natural regeneration, such as Iberian "dehesas". Although the assisted migration of genotypes to better-suited areas under climate change remains a controversial topic, its feasibility and potential benefits for plant establishment and development need to be assessed prior to deciding whether to conduct such management. In this study, we analyzed the early development of the oaks [*Quercus ilex* L. subsp. *ballota* (Desf.) Samp.] emerged from acorns collected at ten provenances distributed across a broad aridity range in the southern half of the Iberian Peninsula. The study was designed to test the proportion of the variability in the response variables that is due to the population of origin, the maternal tree, the difference between individual acorns and the sowing place (four farms with six blocks divided in half for a treatment of irrigation), also controlling the effect of acorn weight. We sowed 4800 acorns, which were monitored for emergence and the survival of the plants and their growth before and after the first summer. The probability of emergence was more conditioned by the location of the sowing point (78% of the explained variance, of which the farm explained twice as much as the block) than by the origin of the acorn (22%, of which the maternal tree explained three times as much as the population of origin). The heaviest acorns and those coming from the most arid populations had a greater probability of emergence. The seedlings produced from the heaviest acorns also had a greater probability of survival; the sowing farm explained 74% of the variance in survival and the block another 19%. There was also a positive effect of acorn weight on all variables related to growth, such as the number of leaves, the height of the plant and the diameter of the root neck. For all growth variables, the variables related to sowing site explained a greater percentage of the variance than those related to the origin of the acorns. Irrigation increased the diameter and height of the plants, but not the

survival of the plants or the number of leaves, and it generally had a small effect. Our results suggest that the weight of the acorns and the proper selection of the sowing place are the main factors to improve the initial establishment of the holm oak via acorn sowing and that the effects of maternal variability are more pronounced than those of the variability between populations. This implies that early plant establishment would benefit more from the selection of proper maternal trees within a population of origin –primarily those with larger acorns– than from the selection of the most appropriate population of origin. Long-term monitoring would reveal if these patterns are maintained in later stages of plant development, and further studies should address the impact of different provenances on the genetic structure of the population.

Acknowledgements: This work is funded by projects AVA201601.19 (NUTERA-DE) and AVA2019.004 (NUTERA-DE II) co-financed (80%) by the EU FEDER program and the Andalusian Government, and grant RTI2018-096187-J-100 from FEDER/ Ministerio de Ciencia, Innovación y Universidades.

Seed mass and parent effects on the early response of Holm oak to different microclimatic tree shelters

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Theme: Managing Mediterranean Agro-silvopastoral systems

Keywords: Dehesa, acorn, tree shelters, assisted regeneration, *Quercus ilex*, Spain

Abstract

In the last decades the dehesa and other agroforestry systems in Europe have suffering strong impacts due to the intensive use of the land imposed by a change in technological and socio-economic conditions and the Common Agricultural Policy. There has been a significant decrease in the range of dehesas as a result of mechanization, and death of trees in aging stands. On the other hand, the loss of traditional agrosilvopastoral practices has increased soil erosion, the aging of stands and the loss of diversity. Two other major problems that have been developing after the dehesa crisis (late 1950s to late 1970s) are the intensification and extensification of land use. As a consequence of the intensification, there has been a progressive increase in livestock loads and mechanization, increasing the productivity and quality of the pastures as well as an excessive thinning of the trees. This has also led to a great shortage of oak recruitment in the dehesas. In fact, direct observation of most of them shows, in general, an aged woodland susceptible to pathogens and climate change, in which for at least a few decades, the installation of feet from seed has not compensated for natural or induced mortality. Therefore, human intervention (assisted regeneration) in this highly managed habitat seems necessary to ensure its environmental and economic sustainability, and preserve the ecosystem services it provides to society. It is necessary to find methods for the regeneration of trees with cheaper and quicker techniques to reduce costs and overcome the economic barrier that limits the application of traditional regeneration actions.

In this sense, the effects of microclimatic tree shelters on the early response of Holm-oak seedlings (*Quercus ilex* L. subsp. *ballota* (Desf.) Samp) coming from direct-acorn sowing are not well known since the most usual practice to restore oak agroforestry systems is outplanting one-year seedlings from forest nurseries. In this study we explore the performance of these seedlings to different microclimatic tree shelters (4 types plus control, Fig. 1) and the effect of the initial acorn mass and the maternal origin (6). The tree shelters consisted mainly in closed and plastic tubes (Tubex ®), mixed tubes, cork shelters, tiles. For this purpose 300 acorns were randomly sowed in 5 blocks (n=60), to monitor emergence, survival and growth (shoot height, RCD, number of leaves and stems) along the first growing seasons. Emergence was influenced by tree shelters (higher in plastic tree shelters) and by the maternal origin. In this

sense, higher emergence was found in mothers with higher acorn mass (mother 9 and 90). Survival after the first summer was also higher inside plastic shelters and for mothers with higher initial acorn mass (mother 9 and 90). Seedlings inside plastic tubes (Tubex®) showed higher shoot height, number of leaves and stems, but lower RCD, which could have been motivated by lower radiation inside the shelters. All growth parameters were positively influenced by acorn mass.

Acknowledgements: This work is funded by projects AVA201601.19 (NUTERA-DE) and AVA2019.004 (NUTERA-DE II) co-financed (80%) by the EU FEDER program and Andalusian Government.

Figure 1. Microclimatic tree shelters used in this study. From left to right side: Cork shelter, mixed tubes, tiles and plastic-closed shelter tubes.

FOR[m]AGE, BEES & FRUITS: bee-fruit synergies with forage farming systems in rainfed Mediterranean environment

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Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems

Keywords: agroforestry, bees, cover crops, fruit crops, natural enemies, organic agriculture, pests

Abstract

The 4APIFRUT project, acronym for "FOR[m]AGE, BEES & FRUITS": bee-fruit synergies with forage farming systems in rain-fed Mediterranean environment" has been financed by the Italian Ministry of Agricultural, Food and Forestry Policies. This project faces the present economic crisis of Sardinian traditional husbandry mainly due to the sheep milk price dropping and addresses climate and environmental actions of the Paris Agreement. In order to promote a greener, more resource efficient and climate-resilient productive model, this project is aimed at redesigning traditional productive systems where synergic interactions between animal husbandry and environment will also focus on the diffusion of 1) multifunctional legume species; 2) extensive fruit and 3) honey production. This model, shall promote agroforestry practices and organic agriculture, increase energy input efficiency and provide novel ecosystem services accomplishing environmental claims. Multidisciplinary knowledge will implement all project activities, involving the University of Sassari, the National Research Council and several pastoral farms (fig.1).

The hypothesis is that nowadays-neglected natural resources such as legumes biodiversity, wild pear rootstocks, and bee pasture plants might integrate the main products (milk, cheese, meat, etc.) of traditional agro-silvopastoral farms, arising incomes and competitiveness while supporting circular economy.

Project activities will cover three years (2020-2022), involving four representative farms located in Northern Sardinia. All farms operate extensively with dairy sheep, meat cattle, and donkeys in a typical Mediterranean environment distinguished by a remarkable presence of wild pear trees. In this context, project activities will: a) increase forage and grain yields to cover farm needs; b) extensively produce organic fruit by grafting wild pear rootstocks; c) produce high quality honey; d) handover protocols at low energy inputs, with high N fixation potential and CO_2 sequestration capacity; e) assure synergy between beekeeping activities, grain and fruit production, by increasing, stabilizing and extending pollen and nectar availability. Project activities include the following work packages

WP1 *Beekeeping as a tool to increase the productivity of the tipical agro-silvopastoral farms of Sardinia*.

The aim of this WP is to assess how beekeeping activity can affect the productivity of improved agro-silvopastoral systems, considering the honeys and pollens obtained and the increase in seed/fruit production due to pollination activity.

WP2 *Multifunctional evaluation of forage and grain legume species in new cultivation environments.*

Legume performances will be monitored for ground covering, phenological stages, grain and forage yields, bromatological composition, percentage of N derived from the atmosphere and fixed N.

WP3 *Make unproductive native wild pear rootstocks into extensive organic pear groves.*

Sardinian pear germplasm entities will be employed to turn unproductive elements of the agro-silvopastoral system (*Pyrus sylvestris*, *P. amygdaliformis*) into resilient-extensive groves offering organic food, fodder and pasture for bees.

WP4 *Investigations on legume and fruit crop entomofauna*.

The novel ecosystem enriched with forage and grain legume species and ancient pears *cvs* will be evaluated in terms of nectar and pollen sources for useful insects.

The multi-disciplinary scientific team will ensure tutoring and coaching along the project and warrant result dissemination.

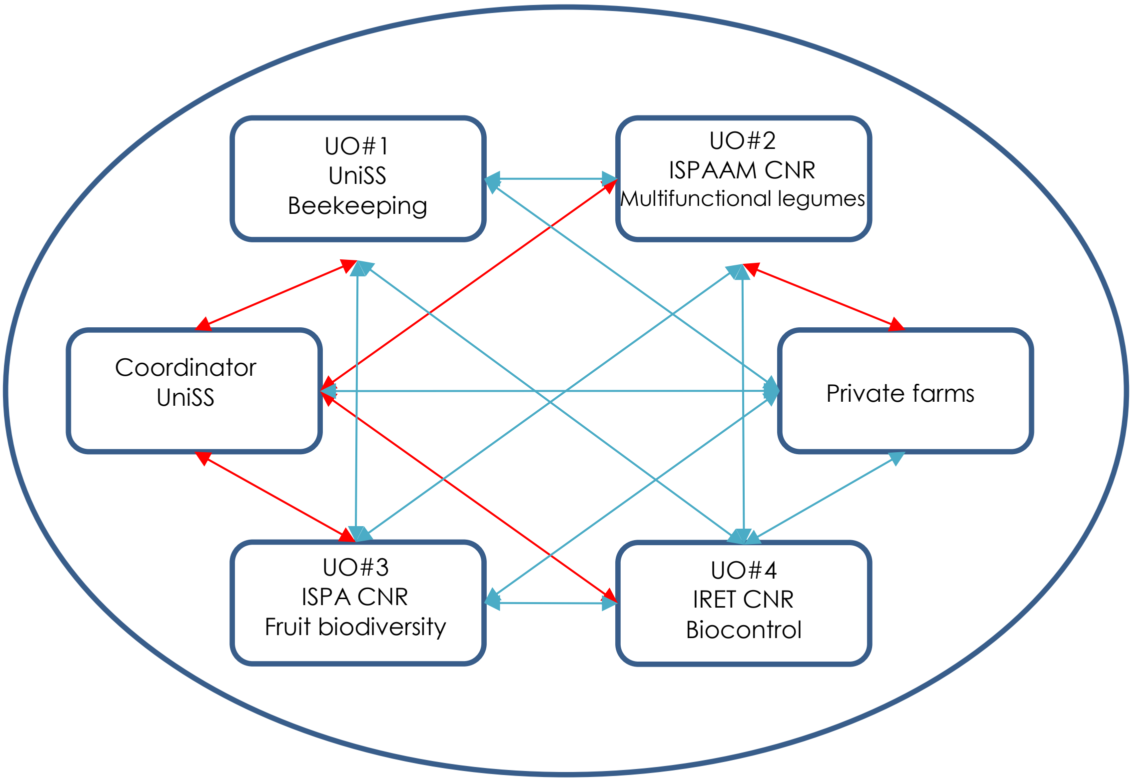

Figure 1 Partners involved in the 4APIFRUT project

Attractiveness of salt placement to cattle in the Mediterranean mountain areas

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Managing Mediterranean agro-silvopastoral systems (adaptation and mitigation)

Keywords: land abandonment, GPS tracking, Sarda cows, shrub-encroached grasslands

Abstract

Socio-economic changes occurred after World War II have resulted in a dramatic agro-pastoral abandonment with an extended shrub and tree encroachment of Italian mountain grasslands. This phenomenon has affected either the temperate and Mediterranean mountains, where invasion is the first step of the ecological succession towards the potential forest vegetation (Bagella et al. 2017). Biodiversity loss (Bagella et al., 2016; Orlandi et al., 2016), increase of wild-fires, erosion and avalanches over large areas (Pittarello et al. 2016) are the main effects of changing vegetation. As a consequence, the conservation and restoration of semi-natural grasslands have become important agri-environmental issues. Recent research show the benefits of the strategic placement of mineral mix supplements (MMS) to lure cattle into traditionally undergrazed areas and restore sub-alpine shrub-encroached grasslands (Probo et al. 2014; Pittarello et al., 2016). Due to the combined effects of grazing, trampling, seed transportation, and nutrient redistribution by cattle, these practices were effective in temperate grasslands in reducing woody species cover and in increasing the cover of herbaceous species characterized by good forage quality, while enhancing the diversity of plants and some insect taxa at the same time. The present work, which is part of in progress project iGral[1], has the ultimate goal of defining innovative options for the development of sustainable sylvo-pastoral systems. Here we report the first results on the strategic use of MMS in a sylvo-pastoral rangeland at Mediterranean mountains in Sardinia.

The study was conducted in the experimental farm of the Agricultural Research Agency of Sardinia (AGRIS Sardegna), located in municipality of Macomer (Nuoro, 600-700 m asl; lat.40°233N, long. 8°702E), as representative of sylvo-pastoral areas in Mediterranean mountains. The area is encroached mainly by downy oaks (*Quercus pubescens* Willd.) and shrubs of Pruno-Rubion and Cytisetea scopario-striati (Ruiu et al., 2017). Secondary grasslands are represented by communities referable to the classes *Poetea bulbosae* (habitat 6220*), *Molinio-Arrhenatheretea* and *Stellarietea mediae* (Bacchetta et al., 2007). The study area consisted of a pasture (40 ha) managed under a continuous stocking system and grazed by a herd of 12 mature Sarda suckler cows with their calves (16.7 AU - Allen et al., 2011), at a stocking rate of 208 kg live weight/ha. Nine MMS were supplied in 5-kg blocks (fosfatic salt blocks), which were placed on metal poles arranged along a line of 250 meters, in traditionally undergrazed and shrub-encroached locations. The linear arrangement of poles rather than a clustered one was used to help cows spread across these underutilized areas and find all the MMS sites (Pittarello et al., 2016). A paired control site

[1] Ager 2 Mountain Agriculture programme – project iGral "Innovative beef cattle Grazing systems for the Restoration of Abandoned Lands in the alpine and Mediterranean mountains"

without any supplement (C) with similar vegetation and topographic conditions was identified for each MMS site at a distance of 104±53 m (mean ± SD). Three randomly selected cows were tracked with Global Positioning System (GPS) collars during period 15- 25/07/2019. Knight GPS tracking collars, based on igotU Gt – 600 GPS units equipped with a large size rechargeable battery pack were used (Knight et al. 2018). The manufacturer reports an average accuracy of acquisitions within 10 m. Positions were recorded every 3 min. MMS and C locations were recorded with a hand-held GPS (Garmin Oregon ® 650t, Maps Trekmap ® Italia v4 pro). The use of sites by cattle was expressed as the time spent within a 50-m buffer area around MMS and corresponding C poles and it was calculated by counting the GPS fixes within each buffer area. Each fix was representative of a 3-minutes period. Then, differences in the time spent at MMS and C poles were assessed through linear mixed-effects model. The experimental unit was the 50- m buffer area. The model included site type (supplement or control) as fixed effect and animal as random effect. The analyses were performed using the nmle R package of R, version 3.6.1. (R Development Core Team, 2012).

During the experiment, a total of 17597 fixes was recorded, corresponding to 91% acquisition rate. The collared cows walked, on average, 6999±1771 m daily (mean ± SD). The MMS showed some ability to attract cattle, having the grazing cows spent more time at MMS sites than at C sites (Table 1). The cattle tracking lasted only 10 days and the time spent next to poles was small, consequently. Moreover, the results about the effects of cattle on vegetation will be available only after monitoring over a larger time span. However, preliminary achievements seem to confirm the results obtained in temperate grasslands under different vegetation conditions and with different cattle breeds.

Table 1. Time of cows spent to MMS and C sites from 15 to 25/07/2019

	MMS site	C site	P value
Time spent within 50- m buffer area per cow (min)	103.1 ± 16.3	57.6 ± 16.3	0.04

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Evaluation of remote sensing indices for characterizing insect defoliation in a Mediterranean agroforestry system

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Abstract
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Theme: Agroforestry systems and innovations (Managing Mediterranean agro-silvopastoral systems)

Keywords: spectral indices, NDVI, gNDVI, Mediterranean forests, *Quercus pubescens*, insect outbreaks, *Tortrix viridana*.

Abstract

Mediterranean forest and agroforestry systems are multifunctional systems that provide a range of ecosystem services and environmental benefits. However, these systems are affected by different environmental damages. An important factor of degradation is represented by the attacks of forest defoliators. Despite the impact of outbreaks of folivorous insects on forest management activities and the related losses there is a lack of information on the spatial and temporal patterns of outbreak distribution and severity of defoliations, whereas the availability of accurate monitoring data and maps could support the planning of pest management activities and policies. The data collected by the recent remote sensing platforms are characterized by spatial and temporal resolutions adequate for the monitoring of insect disturbances (Senf et al., 2017), and could support the development of pest management models and decision support systems in agroforestry.

The aim of this study is to investigate the suitability of spectral indices derived from Sentinel-2 imagery to assess the spatial and temporal consistency of insect defoliation on Mediterranean deciduous oak forests which are part of the silvopastoral systems located in central Sardinia, Italy.

We examined two forested study areas predominantly composed of deciduous oaks (*Quercus pubescens*) where the defoliations are caused mainly by the green oak leaf roller moth (*Tortrix viridana*), one of the most harmful pests of Palaearctic oaks. *T. viridana* is an early folivore, as the young larvae developed inside the flushing buds in spring and the mature larvae could completely defoliate the infested oaks in early summer, also in large areas and for several consecutive years when outbreaks occurs (Serra et al, 2002). We collected field data on defoliations during the period 2016–2019, in the Goceano and Gennargentu mountains. A set of 35 field plots were located within the forested areas where the degree of defoliation was assessed during June, when oaks shown the peak of leaf damage caused by the caterpillars. On each field stand we estimated the defoliation as mean loss of canopy cover, observed in a transect of 10 adult oak trees.

To evaluate the seasonal changes of oak leaf development and the disturbances caused in the late spring–early summer by moth defoliations, a set of remote sensing images were analysed and the following spectral indices were calculated: Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (gNDVI), and Chlorophyll Red-Edge (CLRE). For each field plot we derived the time series of the spectral indices and the relationship between the degree of defoliation and the amplitude of remote sensing signals were analysed using graphical methods (seasonal trend) and linear regression equations. Trends of spectral indices were analysed and summarised for each year, study area, class of defoliation, and forest stand.

The analysis of remote sensing indexes showed that the values of NDVI and gNDVI exhibited the better relationship with the severity of insect defoliations observed in field (Figure 1), with increasing accuracies observed during the 15 days following the peak of leaf consumption due to caterpillar attacks, when affected canopies are characterized by an increasing browning. Outcomes were also affected by the strong spatial variation of the canopy cover percentage in the different sectors of the two woodlands, where patches of open wooded pasture and grasslands alternates with very dense and close forested areas; this mosaic of vegetation types affected the accuracy of remote sensing indices, that was lower in stands with very scattered trees. The decrease of NDVI values observed during *T. viridana* attacks are in accordance with the work of Gooshbor et al. (2016), that derived NDVI values from Landsat 5, 7 and 8 imagery.
The method appears to be able to provide useful guidance in Mediterranean agroforestry systems for the assessment of moth defoliation and could be applied at large-scale in order to monitor the progress of outbreaks during the year. In addition, the maps of disturbance derived from remote sensing could provide useful data for development and calibration of modelling applications in pest management and large-scale survey.

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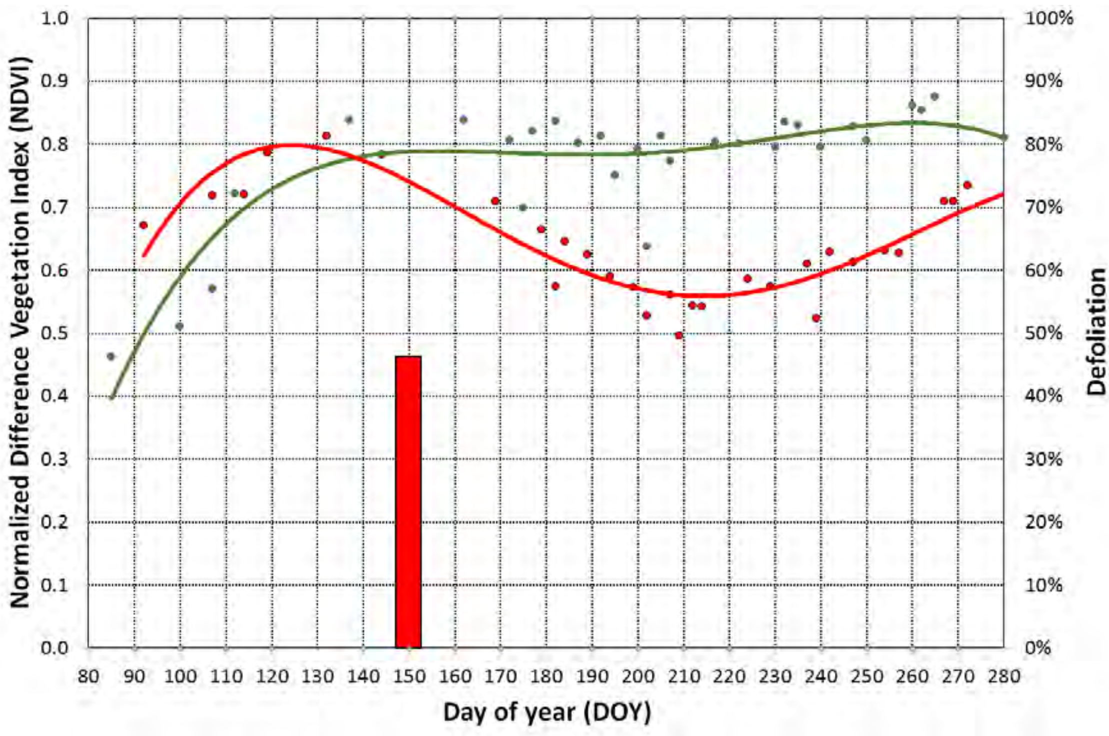

Figure 1. Seasonal pattern of NDVI values calculated for a set of undefoliated (green circles) and defoliated (red circles) oak stands of the Goceano Mountains forest area (Sardinia – Italy); the polynomial interpolations of NDVI values are also showed for undefoliated and defoliated stands. The maximum degree of *Quercus pubescens* defoliation caused by *Tortrix viridana,* observed at the end of May 2018 in defoliated stands, is showed by the red bar and the right y-axis.

4

Agroforestry, education, dissemination

4.1

Education, information sharing, and awareness raising in agroforestry

Hands-on tools for participative development of agroforestry implementation plans: the *Agroforestry Planner* and the *Adaptive Farm Plan methodology* as inspiring examples.

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: design, decision support tool, Adaptive Farm Plan, Agroforestry Planner, co-creation

Abstract

Agroforestry is all about deliberately integrating woody perennials (trees or shrubs) into crop and/or animal production systems. If properly adopted, it will create environmental, economic and social benefits. Agroforestry can increase farm profitability, help to conserve and protect natural resources and can help to meet the climate challenges of today and tomorrow.

However, correct advice and proper guidance in the development of an agroforestry implementation plan or plot design is key, since there are a lot of factors which will determine its functioning and impact in the future. A proper preparation is hence essential and most future agroforestry practitioners but also advisors and other stakeholders are eager to find and make use of hands-on decision support tools.

In this paper, we present two different hands-on decision support tools, i.e. the "Agroforestry Planner" and the "Adaptive Farm Plan" methodology.

The "Agroforestry Planner" was developed in 2019 by the partners of the Consortium Agroforestry Flanders (www.agroforestryvlaanderen.be) as a result of insights gained through research, during co-creative farm guidance activities and by organising collective trainings on agroforestry. This online tool helps farmers, advisers and other users with the development of a concrete plan for the design of an agroforestry plot. The user is guided step by step through the various choices and aspects that deserve attention, from overall objectives and tree species selection to the actual plot design, interaction with other production components and points of attention regarding tree maintenance and management. Particularly for the tree species selection, an extensive selection table is provided, which helps the user in choosing the suitable tree species or variety for his or her situation. In the end, a report is created with an overview of all choices made, a check against regulation and subsidy options, and the most important points for attention for the specific context of the designed agroforestry system. The tool is currently only available in Dutch and is designed with a focus on arable alley cropping systems, but the framework allows the development of new modules and adding new criteria and steps. It is considered a "simple", user-friendly and dynamic tool which can be updated and extended at any moment. The Agroforestry Planner mainly aims at helping the end user in asking the right questions, in thinking about the most relevant criteria and aspects to be considered and hence setting the right direction for an actual plan. It hence serves as a supplement to, but not as a substitute for, customized advice and guidance for specific farm and environmental conditions.

The first Adaptive Farm Plan (AFP) methodology was developed about 10 years ago by the Forestry Service Group (FSG), based on activities related to forest & nature management in more than 40 different

countries. The basic point of the AFP methodology is that prevalent global challenges do not stand alone. Climate change, land pressure, soil degradation, poverty, deforestation, biodiversity loss, social and environmental impact are all interrelated. And if these challenges are interrelated, so must be their answer. The AFP methodology does not make a choice between sustainability and productivity, or between social, economic and environmental benefits of land use. The AFP methodology is about including them all, mutually connected and represented in the right balance. And with no context equal to another, this balance of the '3 pillars' in the AFP methodology is customized to every site of application: in the AFP methodology global concerns meet local solutions.

The AFP methodology was first tested in its first rudimental form between 2012-2017 in the EU Life project Operation Co2. After that is was up-scaled, used, and further professionalized, in Life Montado adapt and in Life Desert Adapt. Now it is fine-tuned to North-western European circumstances in Life FarmLife.

Before the methodology starts, the baseline need to be set. We need to know what our starting point is, and where the weak points are at the farm. Weak points can be in any of the 3 pillars mentioned above, and have to be addresses to make sure the complete system will grow into balance. This usually means that climate scenarios will be developed and soil, biodiversity, biomass and water availability data will be collected.

After that the AFP methodology consist of easy (and easily adjustable) steps and is fully participatory; it is directly developed *with* the landowner. All main decisions are made while playing a '*card game*'. During the game the Goals and targets of the farm, Functions of farm & land use, Species and climate Adaptation Measures (AM's) will be selected. Goals & targets have to be selected in each of the 3 pillars. After that there are 49 Functions to choose from, separated in the 3 pillars, and a range of ecoservices is also included. A special species list is usually developed for a country or a group of countries. There are 54 potential AM's and many of these AM's are innovative. During the process a strong market research action is also executed to back up the decisions in the 'economic pillar' (and the species used).

The final results of the AFP methodology and the card game is a AFP model. This model also includes a budget, the complete planting plan, the nursery order list and maps etc. Maps are made fully digital and can even be consulted on your mobile phone in the field. After the plan is ready the farmer is ready to order all the required material and start implementing. Any developed AFP model is usually robust enough to be replicated to a much larger group of farmers in the project regions.

In conclusion, the Agroforestry Planner and the AFP methodology are two quite different tools which can complement each other. While the Agroforestry Planner was developed specifically for an agroforestry context and is rather a "first aid tool" to set the right direction for an actual plan, the AFP model is a more comprehensive and general, stepwise approach to increase economic, social and environmental (& climate) benefits from land in a balanced way. In the short term, we have the ambition to further optimize both tools and to screen opportunities for integration.

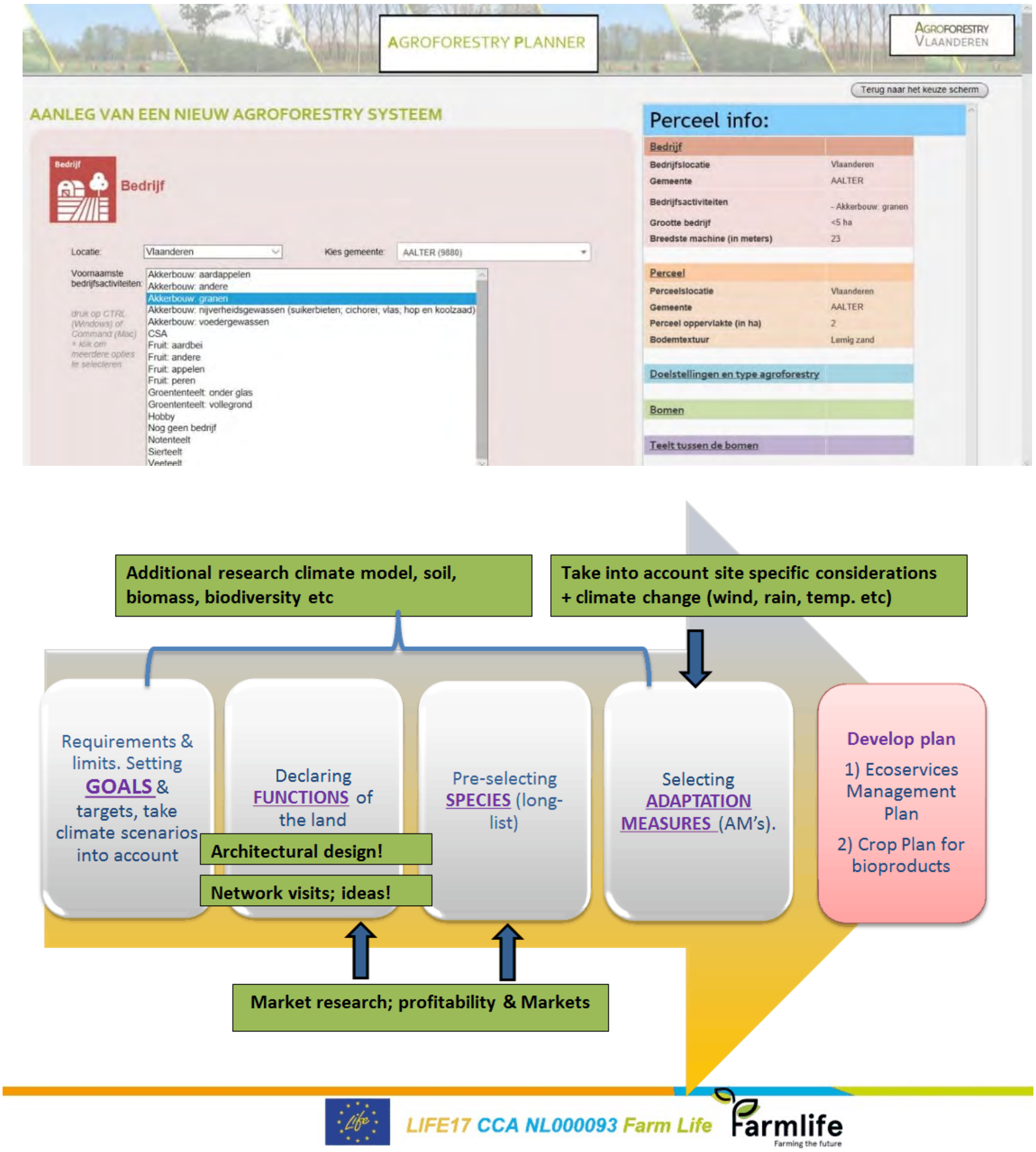

Figure 1. Top: The Agroforestry Planner (source: www.agroforestryvlaanderen.be). Bottom: the AFP methodology.

Linking scientific and empirical knowledge: an interactive web app to design agroforestry market gardening systems

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: agroforestry, intercropping, vegetables, fruit trees, decision-support tool

Abstract

Introduction

Among agroforestry systems, a particular form of intercropping has developed in recent years in Europe: the agroforestry market gardening system (Warlop, 2016). This particular form of professional agroforestry, where vegetables are grown in intercropping with fruit trees or berries, is found mainly in organic agriculture, on small areas (Fig. 1). Farmers combine a wide variety of crops and rely mainly on short food supply chains (Léger et al., 2018). Due to their highly agro-ecological nature, these systems seem able of addressing many of the specific challenges of developed European regions.

However, the great diversity of crops in terms of phenology (tubers, leaf, root or fruit vegetables, pome, stone or nuts fruits, berries, etc.), the number of combinations, the various biological interactions to take into account and the nature of these interactions make it very difficult to acquire references on these systems. While research is underway to understand the interactions between fruit trees and vegetables (Imbert et al., 2019), the nearly unlimited number of crop combinations makes this work very tedious.

In parallel, there is a substantial "grey literature" on this subject. This literature includes popular books, gardening books, websites and specialized magazines. It mainly compiles empirical knowledge resulting from the capitalization of site-specific experiments. The objective of the present work is therefore to combine scientific and grey literature in order to provide a decision support tool for farmers or new agroforestry practitioners.

Figure 1. An example of market gardening agroforestry system (pear – potatoes – peach intercropping)

Material & Methods

We carried out a review on horticultural intercropping systems in the scientific and grey literature. With regard to scientific literature, studies were identified from a search in the Institute for Scientific Information Web of Knowledge and Google Scholar databases. We requested the following terms: (inter-crop* OR agroforestry OR mixed crop*) AND (fruit* OR orchard OR vegetable* OR market gardening). 74 papers were analysed, resulting in 534 experiments (an experiment was defined by a unique crop combination in site and year). With regard to grey literature, books and documents were identified by search engines. 28 documents were analysed, resulting in 6525 combinations. A combination was defined as a unique data on an intercropping, either qualified as a "positive" or "negative" interaction.

Results

All the data from our literature review were combined in a web-based interactive platform. The user can choose one or more crops. Several forms of graphic representations are then available. When data is available in the scientific literature, Land Equivalent Ratio values are provided for the selected crop as well as all the other crops with which it can be intercropped. When it is available in the grey literature, the data is compiled and weighted. The platform also makes it possible to select several crops and generates a network representation (see Fig. 2 below). The web-based application is available at: https://paut-et-al.shinyapps.io/IC_review_en/ [1]

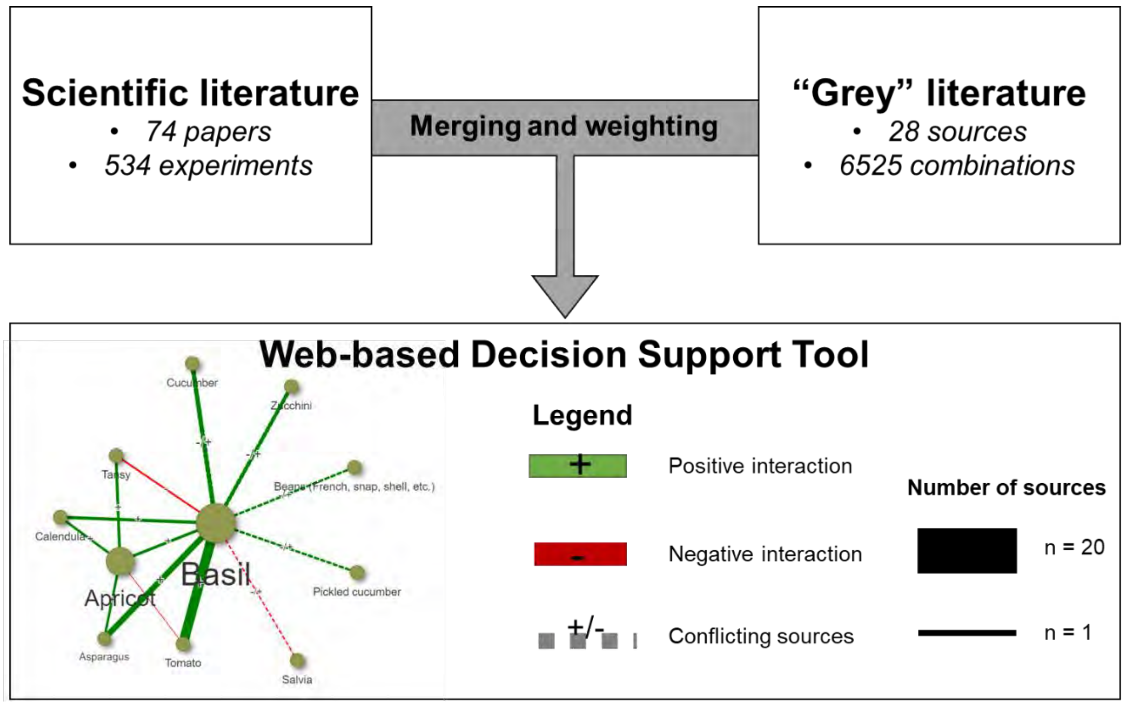

Figure 2. Screenshots of the web-based application

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[1] Contact the corresponding author if the platform is no longer available at the address provided.

Participative formats to promote agroforestry in Germany – insights, challenges, experiences and recommendations

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Regional governance, diffusion of innovation, participative planning

Abstract

In order to understand the complex processes in land use on a regional level, integrative approaches or system-scientific approaches are required (Vester and v. Hesler, 1980). Modern agroforestry systems are a promising form of climate resilient land use practices and are currently explored by a number of research projects and promoted by grass root initiatives. Still, its implementation and diffusion into the farming practice lags behind. Such implementation requires critical re-thinking established agricultural practices and requires a strong commitment by farmers and farming agencies. It also raises soil, water and nature conservation as well as legal concerns. Thus by its interdisciplinary nature its pros and cons are discussed by actors with respect to their particular interests and concerns.

Participative processes utilized by advocates of agroforestry pursue the goal of actively informing and involving actors in land use. Environmental NGOs, researchers, farmers associations, administrations involved in land use decisions and regulation as well as the public, represent the target audience.

We assume that with targeted information and participation, existing reservations to agroforestry could be identified, the implementation of such systems amongst farmers will accelerate (mutual exchange) and a positive perception in society can be strengthened. As Rogers (1962) stated, the characteristics of communication are decisive for the speed and scope of innovation. In the course of the participation process within a model region in Germany, varying participatory formats were developed and tested, which followed the overall framework of the Regional Governance approach by Hogl et al. (2008):

I. Participation of experts and lay people;
II. Intersectoral and multi-level coordination;
III. Adaptive and iterative planning;
IV. Use of democratic and accountable expertise;

Following the identification of the key players, the initial knowledge base on agroforestry practices was queried by interviews. Following the method of Patzelt (2013), responses were analysed with respect to their power, ideology, norms and ways of communication. The analysis of the model region based on initial interviews, the regional governance institutions present and the agricultural businesses and their practices determined the further conception of the participatory process. A main interest was the rendering of possible information deficits.

The extent to which the actors are interrelated and which possibilities of influencing them exist was analysed by means of social network analysis (SNA). Through the visual and mathematical analysis of the relations between each other (so-called sociogrammes), intersectoral and multi-level coordination can be better understood in relation to the second axis of the regional governance concept (Wasserman and Faust, 1999). The activities were primarily, but not exclusively, directed to local actors within the model region. A simplified SNA was also undertaken for the Germany.

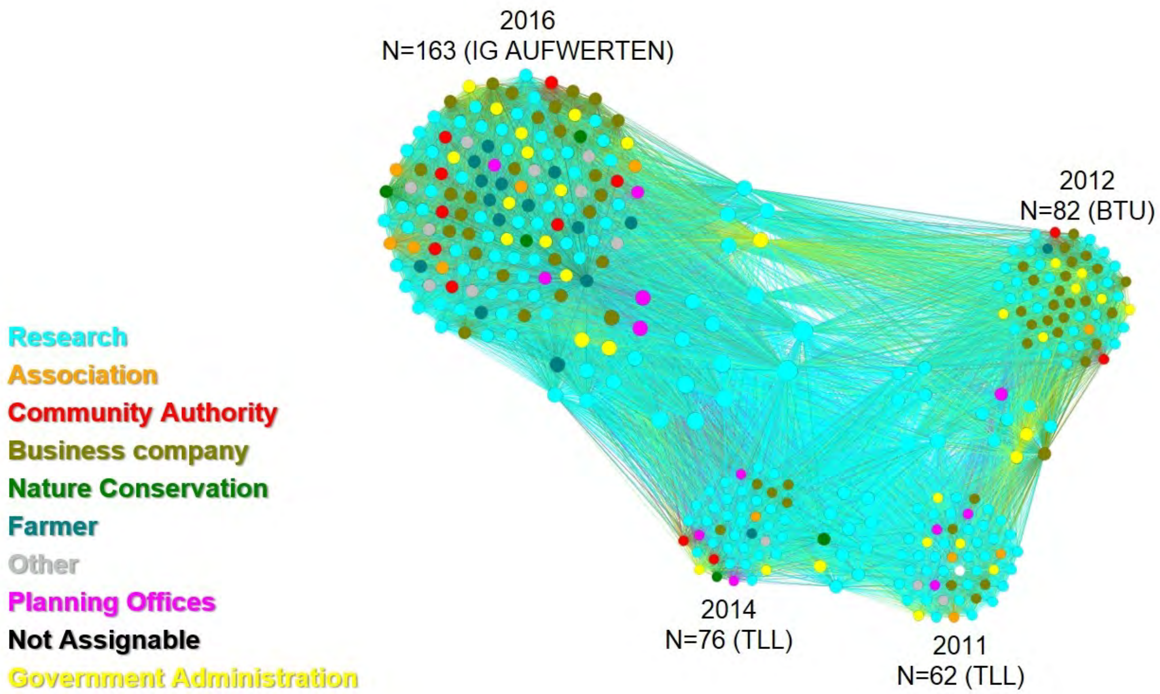

Figure 1. Evolved network of agroforestry advocates in Germany between 2011 and 2016

We conclude that

- the mix of methods enabled the capture of the connections, influences and early (potentially escalating) conflicts between the actors. It allowed working out and addressing the competitions between their goals;
- Through the timely and steady involvement of the actors, they became familiar with the others' perspective, which promoted and speeded up the mutual exchange.
- The information deficits were addressed in various formats of information and requested tools. Decision support systems, online planning tools, spreadsheet formats could be developed, tuned and tested with stakeholders.
- Mostly scientists but more recently farmers act as interface between different member types in the network (Figure 1). The Innovation Group AUFWERTEN is a crucial part of the actor network
- In all four fields of regional governance, participatory processes or concepts should be further explored to make agroforestry more widely known and to promote the further implementation.

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Green entrepreneurship and business skills needed for micro-entrepreneurs – case of Estonia

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, education, dissemination

Keywords: EURAF 2020, Green entrepreneurship, Business skills, Micro-entrepreneurship

Abstract

In the world of fast ecological changes and growing power of customer´s voice, companies must consider environmental aspects in all their actions and communication activities. Consumers are searching ways how to buy more environmentally friendly products to decrease their ecological footprint. For example, more than half of taxpayers in Germany are willing to pay for environmental improvement through agroforestry systems (Otter et al 2019). Therefore, there are business opportunities for entrepreneurs offering products and services that add value to customers without harming the environment. Small and micro entrepreneurs are often operating sustainably but are still struggling to compete on the field. The aim of this study was to map skills and competences micro entrepreneurs need to succeed in the fast-evolving field of green entrepreneurship.

A qualitative research methodology was used for the study, using secondary data analysis and empirical research. Authors first analysed the content of most relevant (n=12) sector specific reports (e.g. "Estonian eco-agriculture development plan for 2014–2020", "Analyses and suggestions for developing Estonian bioeconomy strategy" etc.) by looking keywords related to usage of natural resources in business activities and knowledge gaps of entrepreneurs. Since several documents noted that educating the entrepreneurs is needed, schools providing entrepreneurial education related to natural resources were mapped. In addition, 16 semi-structured interviews with micro sized entrepreneurs and organization representatives from the field of green entrepreneurship support organizations were conducted. Interviews were transcribed and the data received during interviews was inductively coded and analysed. Linneberg and Korsgaard (2019) say that inductive approach is relevant when doing an exploratory study where codes are completely loyal to the data. The approach allows to sort codes into labelled groups and later quickly access the data to conduct an analysis.

The secondary data analyses showed that the entrepreneurs should have a holistic picture about the environment, green economy, waste management and circular economy so the natural resources could be consumed sustainably. Businesses also need to have an overview of the sector and a strategy how to develop innovative products that solve customer´s problems. Renfors (2019) brings out that in Finland one of the most important things companies need to know is how to develop high value-added products reflecting green values and communicate them to the consumers. The results of current study indicate that in Estonia product development and marketing skills are also the fields, entrepreneurs want to know more about. Table 1 shows the main research results that were combined into 5 categories: (1)environment, green and circular economy; (2)sustainability in using natural resources and waste management; (3)trends in customer behaviour and marketing; (4)product development and topics related to natural materials; (5)diverse marketing activities, channels and practical skills. To compare current research results with a research conducted by Allen and Malin (2009), who learned from in-depth

interviews with green entrepreneurs, that there was rather low level of interest in economic success, high degrees of awareness about the business's environmental impact and concern for social justice, then the Estonian entrepreneurs acknowledge the fact that sector will gain importance and that the market is growing because customers demand more pure, ecological products, yet several will prefer producing and selling just enough to earn a decent living.

Table 1. Business competence categories needed for Estonian micro entrepreneurs using natural resources

Results from secondary data analysis	Results from empirical research
* developing quality plans * project writing skills * accounting, financial management, planning the budget	* sustainability in using natural resources (ability to see the big picture – how the whole supply chain is built up and what is entrepreneurs' role in it) * overall knowledge about environment, green economy, and circular economy * legislative advice and skills how to operate according to the laws * English skills
* sustainable principles, effective energy management, water usage and waste management * improving animal wellbeing	* waste management and from tourism entrepreneur's perspective: ecological toilets should be installed in natural environment
* marketing skills * how to get to know the customer	* how to get to know the customer * how to communicate your values to the customer going to international market vs customers coming to buy the products directly from them
* low added value * distributing the products and shortening the supply chain * use and implementation of scientific achievements in product development * using natural, historic, and cultural heritage in product development	* market needs natural and pure products * collaboration with the university to developed nature-based product based on a scientific research * asking directly from the customers and changing/developing the products according to the feedback
* differentiating from others and finding their USP * knowledge how to use latest IT solutions * problems regarding creation of synergy and collaboration	* best practices (what others have done, what went well, what went wrong) * with virtual marketing it is important to have a mentor or someone who would "hold their hand" and that something practical would be an outcome * contributing into wellbeing of individuals and local community

To produce green products or offer green services, there is a need to collaborate, so it would be possible to develop a transparent supply chain. Courses where micro size entrepreneurs can develop their skills and competences should involve an access to mentor, appreciated approach is also learning from other entrepreneurs on the field. Identified green entrepreneurship and business skills needed for micro-entrepreneurs were utilized in practice in collaboration with international partners, when a discipline-specific 8 module training program, "Business from Nature," was developed and handbook published. The research was supported by the European Union Interreg Central Baltic Program 2014–2020 [CB612].

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Public-private partnerships for agroforestry investment and adoption in the USA

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: alley cropping, silvoarable, non-governmental organizations, human dimensions, land tenure, beginning farmers

Abstract

Agroforestry is a robust natural climate solution with widespread potential across the USA (Fargione et al 2018). Nevertheless, adoption has been limited by barriers ranging from insufficiently developed tree germplasm and lack of optimized tree-crop-livestock integration to ill-equipped supply chains and underdeveloped investment infrastructure (Wolz et al 2018, Brainard et al 2019). The Savanna Institute's mission is to help overcome these barriers and catalyze widespread adoption of agroforestry in the Midwestern USA via strategic research, education, and outreach. Our goal is to achieve 50 million acres of agroforestry in the Midwest over the next 30 years.

To accomplish this, the Savanna Institute is establishing and coordinating a collaborative tree crop and agroforestry development pipeline in cooperation with universities and for-profit businesses. As a non-governmental, non-profit organization, the Savanna Institute is well-positioned to engage with the full breadth of necessary stakeholders and coordinate cooperative efforts. The work is organized into four stages: (1) breeding, (2) research and development, (3) pilot, and (4) scale-up (Fig. 1).

The first two stages take place primarily within the Savanna Institute and collaborating universities. Breeding efforts will include timber trees, nut trees, fruit trees and shrubs, and complementary herbaceous crops for use in agroforestry systems. Tree crops for food and fodder will be the main focus, as these are the species that have been most overlooked by existing university breeding programs and also have the most potential for rapid market expansion and adoption (Revord et al 2019). Initial species priorities include hybrid hazelnut (*Corylus americana x avellana*), Chinese chestnut and hybrids (*Castanea* mollissima & *C. mollissma x C.* sp.), walnut/heartnut (*Juglans* sp.), pecan/hickory (*Carya* sp.), honeylocust (*Gleditsia triacanthos*), pawpaw (*Asimina triloba*), persimmon (*Diospyros* sp.), elderberry (*Sambucus* sp.), mulberry (*Morus* sp.), and black currant (*Ribes nigrum*).

Research and development work varies in its focus depending on the needs of each particular crop or agroforestry practice. The first step in this work for a given crop or practice is to conduct a full supply chain analysis. This analysis identifies the central bottlenecks to widespread adoption, considers the competing priorities and the merit of various approaches to overcome these hurdles, and conducts an objective assessment and ranking of priorities for research or investment. The Savanna Institute has completed one such analysis for hazelnut in the Midwestern USA (Brainard et al 2019) and is currently conducting analyses for chestnut and elderberry. Once a plan is in place, research and development ensues around agronomic management, livestock integration, technological improvements, and environmental impacts.

The third stage—piloting novel crops, practices, technologies and supply chains at a commercial scale—is well-suited for joint efforts between public and private stakeholders. This stage synthesizes the development work around a given crop and/or practice and attempts to commercialize it in a

scalable enterprise. When applying these novel approaches at commercial scales, there is both a high risk for failure and an opportunity to learn lessons that cannot be gained at smaller scales. For example, commercial-scale harvesting and processing equipment can be tested only once ample yields are available, and these yields can further stimulate the development of the post-harvest supply chain. The riskier aspects of this stage may be housed with the Savanna Institute or within universities, funded by charitable or recoverable grants. However, high-risk investment capital may also be available from investors who target first-to-market efforts.

The final stage—scaling up trees, crops, and systems that are profitable—will be carried out by innovative for-profit businesses in cooperation with impact investors, public and private landowners, and farmers. These businesses and partnerships will scale up piloted systems by mobilizing investment capital to establish agroforestry in regionally-strategic processes. Critical to the success of these efforts will be aligning, facilitating, and de-risking partnerships of farmers, landowners, and appropriate capital. Land tenure will occur via either direct ownership or innovative long-term leases between landowners and farmers (Keeley et al 2019). The Savanna Institute is developing a brokerage platform to facilitate these partnerships, bundle projects in investment portfolios, and market ecosystem services. The scale-up stage will also depend on farmer learning networks stewarded by the Savanna Institute and others.

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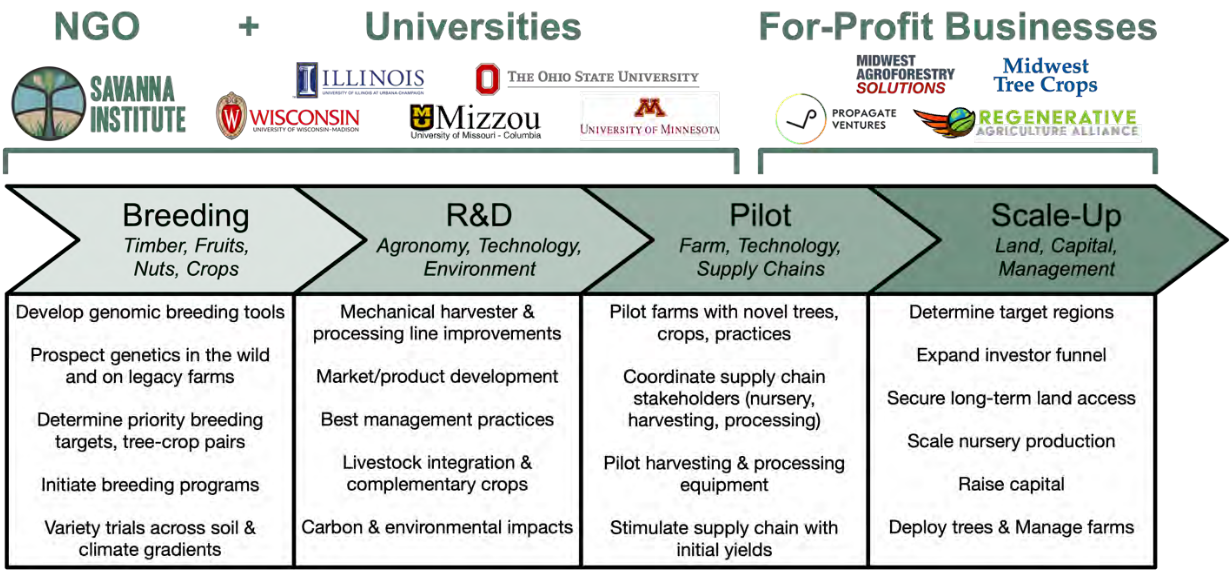

Figure 1. The tree crop and agroforestry development pipeline being established and coordinated by the Savanna Institute in the Midwestern USA.

The participative approach to promote innovations in agroforestry: the AFINET project in Italy

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Communication · Olive groves · Multi-stakeholders · Value chain

Abstract

Agroforestry practices have shaped key features of the rural landscape in Mediterranean countries, where trees have been traditionally and deliberately retained by farmers or included in cultivated or grazed lands (Paris et al. 2019). Global and European policies acknowledge the role that agroforestry can play to promote multifunctional agriculture providing different products and delivering additional, highly important, ecosystem services (Bateni et al., 2019). Nevertheless, it is also recognised that several constraints such as the lack of knowledge and expertise of farmers, land users and policy makers concerning agroforestry systems establishment and management hamper the adoption of such practices (Camilli et al. 2018). In order to fill this gap, a European research project, funded within the EU's H2020 research and innovation programme, started in January 2017: Agroforestry Innovation Networks (AFINET http://www.eurafagroforestry.eu/afinet). AFINET acted at EU level in order to take up research results into practice and to promote innovations to face challenges and resolve problems of practitioners. Through the improvement of knowledge exchange on AF practices among stakeholders, with a special focus on silvoarable and silvopastoral systems design, management, production and profitability, AFINET project collected solutions and promoted an intensive dissemination of information to end-users. To achieve this objective, AFINET proposed an innovative methodology based on the creation of a European interregional network, linking different Regional Agroforestry Innovation Networks (RAINs). RAINs are working groups of different stakeholders, created in nine strategic regions of Europe, interconnected and articulated through the figure of the Innovation Broker. RAIN in Italy was focused on multipurpose olive tree systems in the territory around Orvieto Municipality, Umbria Region, Central Italy. The network considered the extra-virgin olive oil value chain, from the olive production at farm to the olive processing at oil mill, including the waste management. The overall aim was to promote the improvement of the management of olive orchards through the adoption of agroforestry solutions and practices, and the identification of innovative uses of the bio-residues to improve the extra-virgin olive oil production process. This paper reports the results obtained during the AFINET project in Italy where about 90 stakeholders participated in 5 meetings organized during the project. At the beginning of this process, stakeholders were invited to highlight the bottlenecks of the value chain of extra virgin olive oil and the opportunity to overcome them through the implementation of agroforestry systems, based on their knowledge and experience. After this first step, the identification of key innovations was carried out during participative meetings. The Italian stakeholders retain that the olive oil value chain should be improved promoting: new process methods of the bio-products of the olive processing in order to create additional value products and reduce oil mill waste; the implementation of communication campaigns to demonstrate agroforestry systems sustainability and to educate consumers, in particular students; the identification of innovative policy instruments to promote cooperation among farmers; the identification of best

management practices to be adopted in the olive orchards. Finally, the Fuzzy Cognitive Map (FCM) survey was implemented (Figure 1) in order to validate the innovations according to the stakeholder perspectives. In fact, FCM can be used as a decision-making tool to help individuals and communities to understand the impacts associated with environmental, social and economic changes and to develop adequate policy actions and mitigation/adaptation strategies. The survey was performed to obtain: individual, combined and global cognitive maps to design possible scenarios. The extreme negative scenario, where the interaction among the most relevant FCM variables rated a particularly negative score, is dominated by combined overwhelming effects of climate change and policy weakness, with a remarkable worsening of influence by all the other variables. On the contrary, the most positive scenario, is dominated by the complex interaction among several variables, specifically involving: information, dissemination and public health related issues.

On the basis of the innovations identified, dissemination materials were produced and distributed to stakeholders and general public and were uploaded in the AFINET web site. In addition, the AFINET Knowledge Cloud has been developed to help stakeholders to find Agroforestry-related information. Factsheets, practice abstracts, video tutorials, newsletters, technical articles were produced to bridge the gaps disseminating knowledge on agroforestry at wide level among European stakeholders. It is desirable that through AFINET communication and dissemination channels, the barriers to implement agroforestry systems, will be partially removed favouring the adoption of agroforestry practices at European farm level.

These findings suggest the effectiveness of actions aimed to promote stakeholders' cooperation and knowledge dissemination for the adoption and sustainable management of Mediterranean agroforestry systems.

Figure 1. Stakeholders working together to develop a cognitive map of the multipliers category. The general Fuzzy Cognitive Map was obtained by combining the maps of each stakeholders' category.

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Linking scientific knowledge to management practices in Agroforestry: the pivotal role of higher education

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Master Course, Padova University, forest science, ecosystem approach

Abstract

In Italy silvo-pastoral management systems combining compound coppices and different grazers (e.g. ancient swine breed or goats) have been applied for centuries. They were managed for providing a set of multiple services and products such as fuelwood (small trees of the coppice), wood for furniture and construction (larger trees from the gamic regeneration) and livestock. According to the agroclimatic zone, a great diversity of historical silvo-pastoral systems are still the base for land conservation and the economic sustainability of large rural areas (Paris et al., 2019). Some examples are the semi extensive wood pasture grazed by cattle in the Alpine zone and the indigenous beef breeds of the Apennine silvo-pastoral systems. In the Mediterranean area, the dehesa-like agroforestry systems with scattered oak trees mixed with grasslands or intercropped with cereal and/or fodder crops, and grazed by livestock (mainly sheep and goat) are spread (Seddaiu et al., 2013). Silvoarable systems have also been integrated in the landscape over time with the typical association of trees, vines and arable crops, named promiscuous cultivation, as multifunctional agricultural system.

All these forms of managements, relying essentially on empirical experience, have showed, in the long term, to be relatively sustainable since the natural resources were not clearly depleted. However, the empirical approach cannot provide any prediction in case of change of the environmental or social conditions. Thus, a scientific-based approach is essential for predicting the effects of different agroforestry management systems on ecosystem functions and services. A recent study on the perception of agroforestry systems by local stakeholders in Italy highlighted the lack of information on specific agroforestry issues and management practices as the main limitation to the adoption and maintenance of agroforestry systems in Italy (Camilli et al., 2017). Scientific-based knowledge has been accumulated by scientists in many countries but it must be summarized and transferred to the farm managers. Higher education, especially at the Master level, is the pillar for connecting the scientific knowledge to technical dissemination through support to the farmers.

Here we present a new specialization planned by the University of Padova in ***Agroforestry systems*** within the MSc in Forest and Environmental Sciences from the Academic Year 2020-2021.

The specialization offers 5 different disciplines related to:

1) ECOPHYSIOLOGY AND MANAGEMENT OF AGROFORESTRY SYSTEMS;

2) AGROFORESTRY SYSTEMS AND SOIL PROPERTIES;

3) SILVO-PASTORAL SYSTEMS AND ECOSYSTEM SERVICES;

4) TREE PLANTATIONS;

5) EUROPEAN POLICIES AND MEASURES FOR SUPPORTING AGROFORESTRY.

During the MSc programme the students are encouraged to analyse the agroforestry systems by using an ecosystem view, that is taking in to account the system functionality, its complexity, the multiple interactions and the temporal dynamics. This approach is believed to be essential for correctly manage all natural or anthropogenic systems providing a multiple set of services and goods.

Thanks to the formal agreement with Veneto Region – Veneto Agricoltura, it will be possible to use experimental farms where to plan experiments, carry out measurements and test management practices directly in the field, that can be visited by the students and make practical activities (Figure 1).

Conclusion

There currently is large interest in alternative agricultural systems, capable to provide food and feed with low environmental impact. In this way the agroforestry system represent an environmental-friendly model, capable to combine high crop yield with additional advantages for climate change mitigation due to the presence of woody trees (carbon fixation; temperature mitigation; improved soil fertility, etc.). This requires to achieve deeper insight on functioning of this models and transfer information to the new generation. In this view, the new MSc programme represents an innovative educational stream in Italy.

Figure 1. Linear planting of poplar clone "MSA" ("maggior sostenibilità ambientale" – high environmental sustainability) in wheat fields at Sasse-Rami experimental farm of Veneto Agricoltura in Ceregnano (Rovigo, NE Italy) (left). Linear planting of alternate poplar and oak along drainage ditches in soybean fields at Masi (Padova, NE Italy) (right).

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Paraíba River Basin Agroforestry network: teaching methodology, participatory research and rural extension in Agroecology promotion

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information, sharing and awareness raising in agroforestry

Keywords: Agroecology, social inclusion, agroforestry joint effort, native seeds, biodiversity, family agriculture

Abstract

The present work aims to describe the methodology of collective work and quantify actions and experiences of the Agroforestry Network Paraíba River Valley, that acts in the valley located in São Paulo State in Brazil. The methodology consisted of systematizing a consolidated historical overview in a table that is analyzed by the network participants, for critical evaluation and support future planning. Implemented from the 'Agroecological Showcase' project, it was initially developed in the APTA REGIONAL Paraíba Valley, a research center from the São Paulo State and later introduced to peasants from rural areas. This dynamic brought together families of farmers, technicians, educators and academics and began to rapidly design, manage and evaluatetogether the impact of the technologies used in Agroforestry (AFS) areas (Devide et al., 2014). These actions resulted in the formation of the Paraíba River Valley Agroforestry Network and its community dynamics of agroforestry joined many technical representations and peasants in the dissemination work of successive AFSs areas implementation in the Paraíba River South basin that resulted in strengthening income generation through agroecological food production and recovery of degraded areas (emphasis on riparian forest). The adopted methodology has been continuously improved in the agroforestry joint efforts that occur continuously since 2012 and involved the induction of knowledge with the following steps: 1)Presentation of participant, background history of the property and farmers, beneficiaries of the task force day; 2) landscape study, aspects of natural characterization and impact, considering land use elements since the colonization of the region; 3) Identification of herbaceous, shrub and tree bioindicators of soil fertility status; 4)Study of the topography and processes involved in the formation of soils in highlands (deluviation) and lowlands (illuviation); 5) Strategies to be adopted in soil conservation (selective weeding, organic matter management, no-tillage and minimum tillage, tillage, tillage, green manureand others); 6) Recognition of functions of the species used in the implementation of the SAF; 7) Participatory

planning and adjustments for AFS implementation and management; 8) Division into working groups and task force activities; 9) Participatory assessment and recommendations; 10) fellowship and seed exchange. As a result of this process, the peasants themselves are becoming stronger with the rescue and expansion of creole seed conservation, seed and seedling production, selection and study of the adaptation in AFS concerning key crops such as banana (*Musa sp.*) and the native fruits of the Atlantic Forest, contributing to the rescue, dissemination, domestication (selection) and conservation According to Devide (2014) from 2010 to 2013 this work had 330 participants from 45 families and 41 properties. They met in 54 meeting days: 9 organized in the APTA REGIONAL and 45 in peasants properties for planning and plant days. The agroforestry network, social interaction and task force for AFS dissemination resulted in the plantation of 627 species where 322 were native species and 28 exchange activities such as lectures, workshops and filed visit day (Figure 1). These results reflected the different actors and their representations that strengthens the exchangeof experiences with the dialogue between the different realities, facilitates learning and brings collective reflections, especially on agroecological production, food and nutrition security and sovereignty andenvironmental conservation. These actions disseminate the techniques and knowledge with participatorymethods of great importance to overcome the limitations of agroecological production, technical assistance and rural extension and to propose public policies uniting education, research and rural extension and agrarian reform.

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Figure 1. Some pictures of meeting days and task force days for planning, discussing and planting areas with Agroforestry System, conducted by Agroforestry System Network of Paraiba Valley, Brazil.

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The network of AIAF demonstrative farms: the example of the "Casaria" farm

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Abstract

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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: EURAF, AIAF, Silvoarable system, Demo farm, Agroforestry network, information sharing

Abstract:

The Italian Association for Agroforestry (AIAF) is the organization that represents EURAF in Italy and promotes knowledge, implementation and the enhancement of both traditional and modern agroforestry systems at all levels.

Since its establishment in 2013, AIAF paid particular attention to the creation and recognition of a national network of demonstrative farms, with the following purposes:

- to show on the field, at a real scale, the countless examples of agroforestry models to involve farmers, technicians and public officers in their economic, environmental and social validity;
- to offer research sites and innovative transferable opportunities to research centers, public agencies, Universities, etc.

AIAF affiliated demonstrative farms can be both private and public, with preference for the first, due to the strong impact that their example has on other farmers. They are identifiable through a logo that also allows to enhance their role, products and services. AIAF is progressively identifying demonstrative farms in several Italian regions in order to achieve a full coverage on a national scale, connected to the European EURAF network (see http://www.eurafagroforestry.eu/about/agroforestry-map-europe).

There is an agreement between AIAF and the owners of the demonstrative farms that regulates mutual obligations:

AIAF is committed to: (i) transfer to farmers the best practices and the latest technical and scientific knowledge to set up and manage the agroforestry systems; (ii) encourage the participation of the demonstrative farms in various joint projects; (iii) promote the public image of the demonstrative farms.

The owners agree to: (i) maintain the agroforestry systems in the long term; (ii) manage the farm and the agroforestry land in a proper way and promote the distinctness and advantages of this agricultural model; (iii) host technical visits and educational activities; (iv) allow hosting research and innovation transfer projects; (v) promote agroforestry models in any other form.

The "Casaria" farm in Masi (Padua, Italy) is a private farm covering about 100 ha of agricultural land, and was the first AIAF demo-farm, still hosting the Association's official headquarter. Since its establishment (2012), the farm started to realize a first set of silvoarable system which has been gradually enlarged. At this time, the silvoarable covers over the 90% of the UAA.

The farm is located in the southern part of the Padua province, between the Adige and Gorzone rivers, in a stretch of plain reclaimed in recent times ('30s), characterized by loamy soils. The drainage of the waters is mechanical and the entire surface is covered with a regular system of drainage ditches, typical in the Po-Veneto plain. In the "Casaria" example, it consists of regular rectangular fields 40-m wide and 450-long. A large part of the cultivated area of the farm is covered with arable land (soybean, wheat, barley, sunflower, sugar beet) and alfalfa, in regular rotation under organic management. Rows of poplars (*Populus* x *euroamericana*, I214 clone) and oaks (*Quercus robur* L.) are planted along the ditches, regularly alternated every 5 m (10 m between each plant of the same species). Both species are grown for the production of high quality timber. The scheduled cutting time of poplars is 10 years while that of oak is 40 years. It is expected that after cutting, the poplars will be replanted along the same row for at least a second cycle, to leave only the oaks to grow.
The agroforestry system is integrated with a network of rural hedges that border the farm towards the Gorzone river to the north, and separating it from the neighboring farms.
The tree row-ditch system covers a strip of about 2 m in wide, managed with recurring mowing, supporting the establishment of a rich wild flora and fauna. A special focus is dedicated to the new establishment of honey plants as the farm produces organic honey too.
An intense teaching and demonstration activities take place periodically at the farm, also promoted by AIAF. The transfer of innovation is always supported by the active participation of the owner, who directly illustrates the reasons for their technical choices and the results of his activities to technicians and other farmers, providing technical details on the management of their agroforestry system.
The Casaria farm also hosts a rich research activity conducted in collaboration with Veneto Agricoltura (the Veneto Agency for Innovation in the Primary Sector), the CNR IRET of Porano, the Department DAFNAE of the University of Padua.
Different research activities conducted by the University of Padova (DAFNAE department) and CNR IRET aim to identify and quantify the multiple interactions between trees and intercrops and their effects on the crop growth and development in relation to available solar radiation and soil water and nutrient contents (Paris et al. 2017; Paris et al. 2018). Other research projects are focused on the stakeholder involvement in agro-forestry (Camilli et al. 2015).

The Casaria farm gives great emphasis to the fact that its products (honey, pasta, flour, etc.) come from a modern silvoarabile system that refers to the ancient system of the "Piantata Padana" (Ferrario 2019), translated into its motto "back to future" (see https://www.aziendacasaria.it/2019/07/02/back-to-thefuture-agroforestry-systems/).

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Syntropic agriculture and affective labour: the 'becoming' of environmental subjects through affects and example-based learning – Evidence from Brazilian farmers

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Human-nature relationship, subjectivity, syntopic agriculture, agroforestry, Brazil

Abstract

Agriculture, which began as a common subsistence practice, has expanded and industrialised to the point of becoming a global business network and a political instrument, all the while inflicting significant damage on the planet's natural resources. The United Nations has acknowledged that planetary boundaries stimulate dialogue among different disciplines and various approaches to alternative agricultures, as well as heighten the debate between scientific knowledge and other knowledge systems. The alternative agriculture that has been developed by Ernst Götsch, farmer and researcher, over a 40-year period in Brazil, offers a good opportunity to stimulate the type of dialogue called for by the United Nations (Pasini, 2017).
The concepts and practices underlying Ernst Götsch´s agriculture, now known as syntropic agriculture, is the subject of our presentation. We focus on the notion of affective labour, a concept we use to indicate the non-material outputs of labour (including knowledge, information, communication, relationships with nature, or emotional responses) and which is central for the creation of 'social life itself' (Hardt & Negri, 2004 p. 109). Syntropic agriculture fits into the realm of sustainable agriculture as a type of successional agriculture or agroforestry system, but with the peculiarity of being based on natural processes of building fertility. We consider natural succession as the process of natural regeneration, which presupposes changes in species composition in space and time with a view to increase the quality and quantity of life (Peneireiro, 1999).
Due to existing global environmental threats, it is fundamental that public policy further stimulates and enhances traditional sustainable activities developed by rural communities while promoting innovative forms of landscape management that combine food production with the restoration and conservation of natural resources. Moreover, the current environmental emergency and the advent of the Anthropocene present us with the fundamental challenge to radically transform our modes of involvement with nature. As argued by Milton (2002), it is necessary to devise a new approach to 'caring for nature'. Syntropic agriculture has a significant role to play in this since it offers strategies and novel ways of caring for nature and creating a diverse society. Affective labour is fundamental for this type of agriculture, yet the potential of this concept for nature conservation and sustainable agriculture has not yet been embraced by academic theorizers and policymakers (Singh, 2013).
In order to develop successful alternatives to intensive agriculture it is crucial to foster not only joint-action strategies but also 'alternative theorising'. Our contribution, therefore, aims to explore 'alternative imaginaries' by using sociological theories about affects and relations to analyse syntropic agriculture. To do so, we carried out in-depth, ethnographic research in three syntropic agriculture farms in Brazil, focusing specifically on the reasons why syntropic farmers invest their labour and care in protecting nature and biodiversity even when more profitable and stable work options were offered to them. We argue that economic motivations and dependence on nature by themselves are not enough to show how the environmental subjectivities and learning processes of farmers are shaped; rather, by looking beyond narrow economic, ecological and political motivations, we show that the concept of affective labour helps us to better understand how the subjectivities, learning processes and care practices of syntropic agriculture 'become' and positively influence cooperation, communication, and decision-making.

In syntropic agriculture, 'caring for nature' involves daily activities in which each seed and plant requires attention. On a daily basis, a syntropic farmer devotes time to plants and engages in a cyclical caring process. In such a context, the relevance of analysing syntropic agriculture through the lens of affective labour becomes evident. Indeed, these farmers form bonds with nature through this caring cycle. Consequently, passion and affects for nature are often the drivers of a personal decision to practice agriculture in this way. Some people choose this alternative because they care for ('love') the environment, and syntropic agriculture is a way of producing food while being part of nature as well as improving the life of the environment towards forestry systems. Even when the reason is of a more material and economic nature, the bonds created through time and syntropic activities are the motivators to continue practicing this agricultural method, as expressed by farmers. Therefore, daily care practices and relationships play an essential role in practicing syntropic agriculture: they are necessary to strengthen the farmers' motivation in doing what they do. Finally, farmers' ties with nature, in some cases, spur them to get involved in the formation and education of new collective environmental subjects.
Further developing the analysis of syntropic agriculture from the perspective of affective labour in different socio-political and geographical contexts will contribute to the debate over the relevance of affects and relationships versus rational and economic motives as drivers of human action for nature conservation. Our study suggests that we should go beyond political economic rationalities and consider how affective relations and syntropic embodied activities create new subjectivities and forms of involvement with the environment. In fact, our results show, firstly, how caring for nature through daily syntropic practices is essential in this process of shaping human behaviour and environmental subjectivities and, secondly, how sharing practical knowledge and lived experiences are essential strategies to promote farmers' learning process and awareness building.
Our analysis stresses the potential relevance of context-based policies grounded in affective labour research. In the context of the current environmental crises, new nature-human narratives are necessary to create alternatives to the oppressive dynamics of a fragmented society. Networks related to sustainable agriculture may play a significant role in organising and encouraging new visions and relations not only among multicultural societies but also with nature, land, and territories. Syntropic agriculture and agroforestry experiences can be relevant assets to create positive resistance to the current situation.
To empower local producers and to achieve the conservation and regeneration of their territories, public policy should be based first and foremost on the new human-nature relation discussed in this work. Our results show that farmers' rapport with nature can be *the* motivating factor to spur them to take care of nature and involve more people in this process of nurturing. To create and reinforce this novel relation among smallholders, public policy should be based on a bottom-up approach and on the creation of spaces for dialogue where farmers and local people can make their voices heard – expressing their opinions while 'using their own concepts' (Fasso, 2019).
Consequently, It is important to establish the groundwork and increase opportunities that give birth to local networks supporting sustainable agriculture and strengthening local knowledge so that these can influence wider policies. As our case studies show, these networks can favour the development of smallholders' awareness and learning about their possibilities as farmers and the importance of their knowledge for the rest of society.

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Combining agroforestry education and advice for the benefit of both students and farmers in Quebec, Canada

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Agroforestry for the transition towards sustainability and bioeconomy
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: education and training, information sharing, agroforestry advice, agroforestry design

Abstract

Agroforestry is still a marginal practice in Quebec, Canada. Its adoption faces contrasting challenges depending on local dynamics (Comité agroforesterie du CRAAQ 2017). In rural landscapes that are subject to agricultural intensification, trees, which are mostly absent from the fields, could help restore soil health, water quality and biodiversity. However, their planting is constrained by the high value of the land and the technical and financial difficulties associated with any change in the cropping system. In rural landscapes where agricultural activities are declining, agroforestry could help diversifying local economies, but its adoption is constrained by low market opportunities. Nevertheless, because of its capacity to provide private and public goods and services, a growing interest toward agroforestry is observable among farmers as well as among various stakeholders of the agricultural, forestry, environment and territorial planning sectors.

Recently, a document about the strategies to put in place in order to stimulate the adoption of agroforestry practices was drawn up by a working group stemming from a provincial agroforestry committee (Comité agroforesterie du CRAAQ 2017). Accessibility of practical knowledge, advice, and technical services was identified as an important constraint, as well as low training and education of both farmers and advisors. Thus, a course entitled *Agroforestry interventions*, which aims to train future agroforestry advisors while providing farmers with agroforestry advices, was created. Given three times so far, the course, conceived for small groups of students (up to fifteen), involved both university professor and agricultural technical college teacher as trainers, farmers (two to three per course) interested in adopting agroforestry practices on their farms, and students coming from a technical programme in agriculture as well as from various B.Sc. and M.Sc. programs (agroforestry, agronomy, forestry, biology, geography). Students of both technical and university levels were then able to interact among themselves as well as with trainers and farmers for comprehending various aspects of agroforestry interventions, from technical and biophysical ones to socioeconomical and policy aspects. Farmers, as for them, benefited from insights coming from both agroforestry experts and students bringing diverse perspectives in their diagnosis and design of agroforestry interventions responding to their needs, constraints, and values.

More specifically, after visiting different farms, collecting biophysical (soils, drainage, vegetation, climate) and socioeconomical information about them and meeting their landowners, students were asked to work in teams to propose various types of agroforestry designs. Their proposals went from windbreaks, natural hedges and riparian systems to intercropping and silvopastoral systems, but also included more original approaches such as permaculture. With the help of the diversity of their academic and technical

backgrounds, students were able to approach agroforestry in its overall complexity, in a multifunctional perspective, integrating adaptation to soil, water and climate, profitability, as well as ecosystem services, in accordance to environmental regulations. Their designs also included considerations such as the desire of a given farmer for food autonomy, animal well-being, recreational activities, agritourism, esthetics, relationships with the neighborhood, social engagement, etc. Following these proposals, farmers were able to adopt specific interventions and designs according to their needs.

Combining technical and university education to agroforestry advice thus appeared as a powerful means to both improve student expertise and stimulate the adoption of agroforestry designs adapted to the needs of farmers. It also helped to narrow the gap between technical and university students and to forge links between future advisors from the agricultural, forestry, environment, and territorial planning sectors, what could help the scaling-up of agroforestry in Quebec.

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EU habitats wooded pastures and meadows as nature based paradigm of sylvopastoral agroforestry systems - existing positive examples for promoting of agroforestry practice.

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing and awareness raising in agroforestry

Keywords: Nature based agroforestry systems, EU habitats, agroforestry promotion

Abstract

Agroforestry is well known and is becoming more popular as a sustainable farming method in Europe and Nordic countries. In Latvia there is agroforestry, but it is not defined in local legislation. Focus of this presentation is willingness to promote recognition of agroforestry and "legalization" of it.

From national heritage and traditional farming systems point - the most suitable agroforestry system for Latvia farming traditions seems to be silvopastoral systems. That is already adapted and listed as habitat (EC 2013a) 6530* Fennoscandian wooded meadows or (2013b) 9070 Fennoscandian wooded pastures. Both of them are a vegetation complexes consisting of amusement trees or groups of trees and shrubs as mosaics in open areas. Typical tree species are *Quercus robur*, *Tilia cordata*, *Ulmus laevis*, *Fraxinus excelsio*, also *Pinus sylvestris and Salix alba,* are presented in such systems typical for Latvian rural landscape, a small part of this habitat is managed. Traditional management has been a combination of several activities - hay harvesting, grazing and tree branches cutting for mineral nutrients. This is a species-rich vegetation complex with rare or endangered meadow species and rich epiphytic moss and lichen flora. Many endangered species occur on old, semi-cyclic trees. The habitat includes both currently managed sites and already overgrown sites with old trees formed as a result of traditional management. The habitat does not include abandoned and wooded open grasslands overgrown with birches, willows, alders and some small broadleaves characteristic to mentioned before habitat, but those areas has high potential to be transformed in juvenile silvopastoral system - having potential to became habitat in future. Because with special management and altitude to the trees, those areas have potential to became same as habitats – woody pastures and forest pastures. Educational activities focused on farmers and policy makers auditoria could improve the situation and raise awareness and promote visibility of agroforestry system.

Not only grazing, but also production of food -hay or other lignocellulosic animal food products could be organized as agroforestry system. Since 2011 Latvian State Forest research institute Silava and Institute of agriculture investigate development of first alley cropping agroforestry system initially designed for energy wood and grasses as well legume biomass and seeds production (Rancane et.al. 2014). Nowadays willow agroforestry system is operated as bee pasture, because additionally to sown plants natural meadow plants were ingrown in strips between trees (Pucka et.al.2016).

There are no available statistics how many ha of forest and bush land are used for grazing. The official opinion and message to society are that silvopastoral systems in Latvia have almost disappeared, but it is because valuable habitat survey is not finalized jet, till now some hundreds ha of forest pastures is

already counted. In Latvia there are around 45 farms dealing with cattle for meat. There is a huge potential for human made silvopastoral systems where fast-growing coppice trees (common for SRC systems) are used for shelter of cattle and older ones maintained for the same purpose. Shelter trees becoming more popular and important in terms of climate change as well – extreme weather conditions and as capturers of CO_2. There fore local agroforestry enthusiasts should made the concept more recognizable. First steps had been already done. LSFRI Silava in cooperation with Farmers Parliament started discussion "Between the forest and the countryside. Fast-growing trees - an additional ecological and economic benefit for the farmer". Agroforestry as option for bio-based rural economy is included in HORIZON 2020 project Bio-based strategies and roadmaps for enhanced rural and regional development in the EU (BE-Rural), which is European Union's Horizon 2020 research and innovation Programme under Grant Agreement No 818478. Activities are continuing thanks to in European Development fund support where set of Salix alba agroforestry systems will be established during next years, as well seminars for local farmers including visits of experimental demo fields -new ones as operated since 2011 will be organized as project "Installation of innovative white willow-perennial grassland agroforestry systems fertilized with mixtures of wood ash and less demanded peat fractions"(Nr. 1.1.1.1/19/A/112).

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Figure 1. Silvopastoral agroforestry in Latvia for cattle and bees.

From the tropics to the Mediterranean: A Functional Design Framework for Large-scale Successional Agroforestry Systems (SAFS) in different climates

EURAF 2020

Agroforestry for the transition towards sustainability and bioeconomy

Abstract

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Theme: Education, information sharing, and awareness raising in agroforestry *OR* Agroforestry innovations toward innovative agroforestry systems
Keywords: Successional Agroforestry Systems; Reflexive Interactive Design; function analysis; functional design framework; agroforestry systems design;

Abstract

Farming systems are globally urged to address the challenges posed by climate change and by the growing world population. A radical shift towards diversified and regenerative agriculture, that imitates the functioning of natural ecosystems, is urgently needed at all scales (IPES-Food, 2016). Complex agroforestry systems such as Successional Agroforestry Systems (SAFS) are one of the ways in which agro-ecosystems can be ecologically intensified, combining productivity and ecosystem services (Jacobi et al., 2014; Armengot et al., 2016; Schneider et al., 2017; Schneidewind et al., 2018). SAFS are agro-silvicultural systems that aim at mimicking the successional dynamics and the vertical stratification of native forest ecosystems, using productive and 'support' species. Processes are accelerated through pruning, with the resulting biomass used as green manure and mulch.

Despite the SAFS' productivity and ecosystem services provision, they have been adopted, so far, mostly on small-scale farms in tropical regions, and they have yet to be intensively studied. Moreover, there is a lack of distinct design tools that facilitate the replication of these complex agroforestry systems in contrasting environments and climates. Given the context-specificity of the flora and the consequent difficulty to replicate complex agro-ecological systems such as SAFS in different biophysical contexts, we propose in this study a functional approach, that allows to translate the 'structure', intended as the elements within the system, i.e. the plant species, to their 'function', that is the role that these elements fulfil in the system (van den Kroonenberg, 2002). Once functions are identified, they can be fulfilled by different plant species, with similar functional traits, in different biophysical conditions.

Therefore, this study aimed to: 1. Perform a function analysis of the elements in a case-study large-scale Successional Agroforestry System in São Paulo state, Brazil, and to identify plant traits linked to the functions' performance; 2. Create a Functional Design Framework for SAFS, based on the identified functions, applicable in different biophysical contexts.

Methods from Reflexive Interactive Design (RIO), a systematic approach for bio-systems design, were used, especially the design steps addressing systems requirements, functions analysis, morphological functions diagrams and the generation of solutions (Bos et al. 2009). The function analysis was carried out through

observations and semi-structured interviews conducted on the case-study farm and with other practitioners, and validated through experts feedback sessions.

A set of thirteen functions and relative sub-functions that need to be fulfilled in SAFS was identified (Figure 1). Plant traits allowing the performance of these functions, identifiable in different species in contrasting environments, were selected. A Functional Design Framework based on the identified functions was created, consisting of: a. the set of functions; b. morphological functions diagrams of possible solutions, consisting of the list of functions and the options of plants or practices that can fulfil them in a specific context; c. strata and successional stage matrices, that combine the plant's place in space (vertical stratification) and time (ecological succession) with the functions they perform, displaying the spatial, temporal and functional compatibility of the selected plant community.

The framework was tested with a theoretical SAFS design for the Mediterranean climate of Southern Europe, in which species fulfilling the chosen set of functions, compatible in space and time, were selected. The theoretical design demonstrated the framework's validity and usefulness in supporting the design process in contrasting biophysical contexts, proving that a functional approach to complex agroforestry systems design is useful and deserves further explorations with real-life trials.

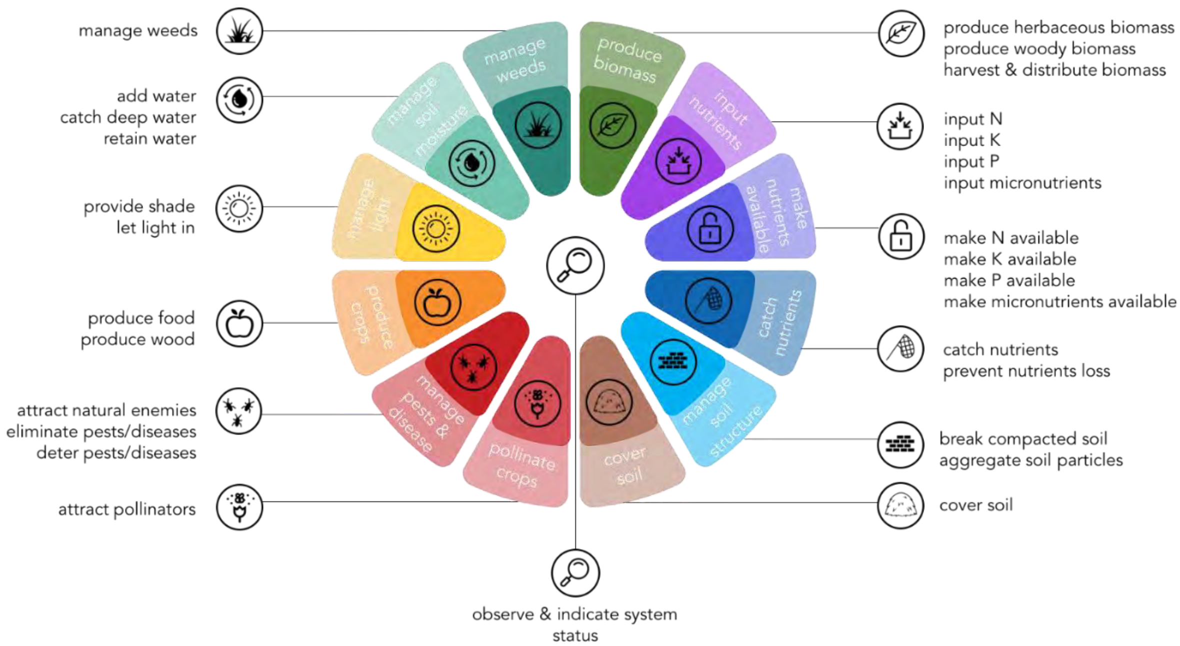

Figure 1. The identified SAFS functions and their relative sub-functions. Own elaboration. Source for icons: *www.thenounproject.com*

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EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract

Agroforestry system: Farmer at the heart of their projects

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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: agroforestry project, individual frame of references

Abstract

As an agroforestry specialist advisor, I am always trying to build an agroforestry project with the farmer, paying attention to the best technical aspects, but also to the person himself. This abstract will explain some characteristics of the individual to take into account.

Usually, an agroforestry system begins with a meeting between, at least, two people: a farmer, a neighbour, an advisor, an instructor … Yet, each individual has his own frame of references which play a key role in the project process. For instance, for an identical purpose (ex: shade) and the same context, one farmer will prefer hedges, another isolated trees, and the last one patches of trees. Therefore, the individual is really at the heart of the agroforestry project.

1. Firstly, managing space is fundamental in a farming system. To integrate trees means to change a farmer's space reference from a 2D system to a 3D system, even 4D. It also means redesigning circulation and pathways and taking into account landscape and perspectives.

2. Secondly, looking at a long-term perspective is essential. Yet it is not easy to think bearing in mind a thirty-year projection, especially as far as economic issues are concerned (ex: one month for breeding poultry, six for crops and forty years for growing trees).

3. Thirdly, the farmer's social environment is key. Actually, trees belong to their owners, but also, through the landscape, to the society. People are concerned by agroforestry projects at different scales and agroforestry offers a variety of socio-economic possibilities: children may sell timber; neighbours will notice the landscape evolution; a society could develop tourism linked to this designed landscape.

4. Finally, a farmer is a tree expert in the making. Training is needed to make an agroforestry system successful. In addition, AF advisors pass on their knowledge and adapt their language. As farmers are stronger together, they can be part of agroforestry groups (ex: "Club des agroforestiers" in Sarthe). Farmers' pride about their systems is also one of the most wonderful development levers.

To conclude, subjectivity, freedom of initiative, and creativity are part of the agroforestry project. If the human aspect is not included in the system's development, it will not succeed. To illustrate this note, we wish to propose farmer's testimonies at the 5th European Congress on Agroforestry.

Savoirs

Sèves d'Agroforestiers

... Et fiers de l'(H)Être

Lettre du Club des agroforestiers sarthois N°2

"L'arbre qui tombe fait plus de bruit que celui qui pousse" Proverbe Africain

VIE DU CLUB

Hiverner... pour mieux débourrer !

En hiver, les arbres semblent en repos..., en apparence. En effet, leurs cellules continuent à respirer, leurs racines à pousser, et ils activent des processus pour se protéger du froid, voire se réparer en cas de dommages.

De même, le Club agroforestier a hiverné en 2020, et recommence en 2021 avec plus de dynamisme et de souplesse afin de s'adapter aux conditions sanitaires.

En 2021, nous vous proposons 4 rencontres du Club des agroforestiers, et 4 Sèves d'Agroforestiers saisonières.

Prochaine rencontre : le 19 février 2021.

Débourrement de châtaignier

ARBRE, QUI ES-TU ?

Mûrier... l'Arbre des élevages

Le Mûrier blanc (*Morus alba*) est l'arbre de la culture des vers à soie (sériculture) qui raffolent de ses feuilles. Moins approprié pour cette culture, le Mûrier noir (*Morus nigra*) offre un fourrage très apprécié des élevages ovins, caprins et bovins. En têtard ou en cépée, sa masse végétale est importante et son ombrage également. Ses fruits de 2,5 cm, appelés mûres, sont rouge-noirâtres et comestibles. Le *Morus* est un arbre de 10 m de haut en moyenne. Ses feuilles sont lobées ou simples.
→ Vous souhaitez en savoir plus ? *Cliquez sur les liens à droite*

Mûriers
Telabotanica

« Dessine-moi »... le Fusain d'Europe

Le Fusain d'Europe (*Euonymus europaeus*) est connu pour son homonyme artistique le « fusain » créé par la carbonisation d'une jeune branche.

Figure 1 : "Club des agroforestiers" newsletter, a way to increase farmers'interest and enhance knowledge

AIAF, the Italian Association on Agroforestry

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Demonstrative Farms, CAP, Rural Developments Plans, Stakeholders;

Abstract

The *Italian Association of Agroforestry* (AIAF - *Associazione Italiana di Agro-Forestazione, www.agroforestry.it*) is a free and independent association open to all and currently mainly composed of agronomist, or forestry technicians, operators, agricultural entrepreneurs, scientists and academicians, as well simple enthusiasts, who take the opportunity to promote the rebirth of a healthier, more sustainable and liveable rural landscapes throughout the adoption of agroforestry systems. AIAF adheres to the *European Agroforestry Federation* (EURAF, *www.eurafagroforestry.eu*) in the belief that local commitment must be accompanied by a broad vision and by the exchange of experiences across international cooperation. For the membership, both public bodies, recognized or unrecognized private bodies, and natural persons may be members of the Association, provided that they are interested, in any capacity, in the pursuit of the aims of the Association itself. The bodies of the Association are: 1) the General Assembly of members; 2) the Executive Committee; 3) the President (Dr. Giustino Mezzalira); 4) the Scientific Technical Committee; 5) the Auditors.

The aims of AIAF are:

- promoting the adoption of sustainable agroforestry practices throughout Italy;
- supporting initiatives and actions aiming to develop awareness, knowledge, research and the development of policies for promoting the use, cultivation and diffusion of wood species within Italian farms, also inspired by experiences from other countries and by making use of all financial instruments at local, national and international level, especially at European Union level;
- promoting the conservation and restoration of traditional agroforestry systems present in Italy;
- favouring the economic valorisation of the products and services, direct and indirect, of the agroforestry systems, in particular by promoting their certification systems.

In order to better pursue and achieve the purposes referred above, AIAF will carry out, among others, the following activities: i) drafting of preliminary projects, of orientation projects on innovative and/or highly popular topics, as well as consultancy aimed at promoting agroforestation in Italy; ii) collection in a special "documentation center" of various types of documents (texts, drawings, photographs, conference proceedings, etc..), which have as their object agroforestry in Europe and especially in Italy; iii) financing, planning, coordination and development of research, promotion of conferences, lectures and exhibitions on topics related to agroforestry; iv) publication of studies, monographs and articles relating to agroforestry; v) management of a dedicated website, with the aim of sharing information, scientific results and political issues on agroforestry; vi) pursue collaboration with other agroforestry and not-agroforestry associations for the exchange of information and the organization of congresses, symposia and seminars, in particular with EURAF; vii) education, awareness and training activities aimed at the knowledge, protection and construction of agroforestry systems; viii) direct management of areas of agroforestry interest (or likely to be) aimed at achieving the aims of the Association.

AIAF is also organized across the national territory with Regional Delegates, along with Demonstrative Farms (Figure 1). Demonstrative Farms are selected thought-out a rigorous process of evaluation,

according to scientific, administrative and ethic criteria. The process is in development, and currently a total 13 demonstrative farms are under evaluation.

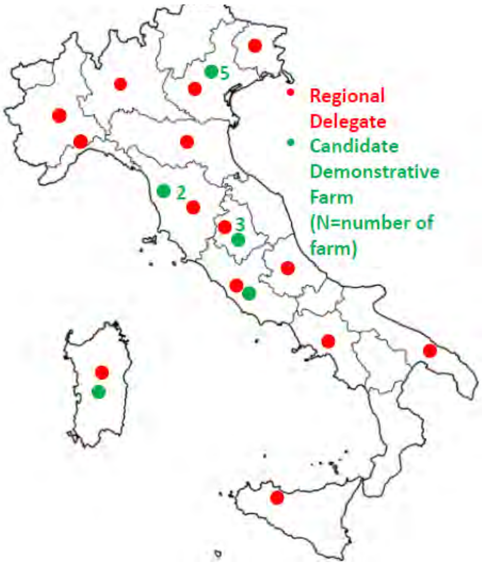

Figure 1. AIAF, distribution in Italy of regional delegates and demonstrative farms on agroforestry

AIAF is dialoguing with the Italian *Rete Rurale Nazionale*, the organization in charge for managing the *Rural Development Plans* (RDPs), for promoting agroforestry in the new RDPs, after the poor application of the agroforestry measure in Italy. Following the general indication of EURAF, and in accordance with the Sub-measure fiche (annex to the measure fiche "forestry"), agroforestry should be much more strongly promoted by the new *Common Agricultural Policy of the European Union* (EU CAP), with a wide range of scales, at plot, farm and landscape levels, also in agreement to the recent finding demonstrating the effect of agroforestry for mitigation of Climate Change (Kay et al., 2019). Within the CAP, It should be recognized five agroforestry practices: *silvopasture*, *silvoarable*, *hedgerows*, *windbreaks and riparian buffer strips, forest farming and home gardens*. Agroforestry should be promoted in both Pillar I and II. In Pillar I, agroforestry should be fully eligible for direct payments on every type of land use, arable lands, permanent grasslands and permanent crops (e.g.: woody fruit crops and short rotation coppices, forest plantations) according to an 'agroforestry options' and a management plan proposed by the owner/manager and approved by the local authority. Within the Pillar II, it was identified a strong segregation of agroforestry into 27 measures within the 2014-2020 RDPs (Mosquera-Losada et al. 2016). This high segregation should be encompassed with a single agroforestry measure in the post 2020 CAP, including both the establishment of new agroforestry systems on agricultural land, and the improved management and recovery of already existing agroforestry land that in Italy is estimated being ca. 1,2 Millions of hectare (Paris et al., 2019). Agroforestry should be promoted also on forest land, especially regarding the increasing risk of wildfires in Europe, promoting forest grazing. Agroforestry is an effective way for drastically reducing forest fire in Europe (Mosquera-Losada et al. 2020) throughout landscapes diversification and fragmentation. In all the above contexts, a much stronger support should be provided to cooperation amongst groups of farmers, breeders (of sheep, cattle and poultry) and owners of forestry area, in order to incentive climate-smart farming amongst different actors who can collaborate sharing resources. Additionally, because implementation of agroforestry is urgently dramatic for fighting Climate Changes and examples of application of best practices are key actions, specific funds to support demonstrative farms should be scheduled.

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NEWTON – Agroforestry Network in Tuscany: a regional Operational Group to spread agroforestry knowledge and innovations

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Multi-actor, participatory, EIP-agri, sustainable production, extensive livestock production

Abstract

Agroforestry is a cropping system in which trees and/or shrubs are deliberately combined with crops and/or livestock (Mosquera-losada et al., 2009). The Operational Group (OG) NEWTON "NEtWork per l'agroselvicoltura in TOscaNa" aims at the promotion of agroforestry practices in Tuscany as strategies for the sustainable intensification of agriculture (EIP-AGRI, 2017; Paris et al., 2019).

In the next years, the application of more sustainable cropping systems will be necessary to mitigate climate change and make agroecosystems more resilient to changing conditions. Such conditions concern also the need to support socio-economic and environmental sustainability, since sustainable agriculture strategies have also to contribute to the Paris Agreement - COP21 (ratified with: DDL S. 2568 - XVII Leg., il 27 ottobre 2016 dal Senato della Repubblica Italiana) –which fixes the objective of reducing by 40% greenhouse gas emissions by 2030 compared to 1990.

The OG NEWTON thanks to a participatory approach and promotes traditional agroforestry knowledge and innovative solutions among all the stakeholders, for the implementation of sustainable agroforestry systems.

This objective will be reached through the knowledge transfer from research to production sector. The specific objectives are: (1) to create a regional network of knowledge on local agroforestry systems, (2) to develop a network of innovations through stakeholder engagement in private or public pilot farms, (3) to disseminate information about agroforestry systems in Tuscany through a new web-platform (www.newton.eu) and (4) to valorise regional agroforestry products.

To achieve its aims, NEWTON identified a set of innovation transfer activities at each of the 4 pilot farms: (1) Centre for Agri-environmental Research "Enrico Avanzi", PI; (2) Tenuta di Paganico, GR, (3) Tenuta di Pietratonda, GR and (4) Il Rinnovamento Agricolo, Santa Luce, PI. In each pilot farm, environmental and economic parameters will be considered at field scale in order to assess the effects of the adoption of agroforestry systems and disseminate the results.

NEWTON project is based on 8 Work Packages (WPs), divided in two network pillars: knowledge network and innovation network (Fig.1). In particular, WP3 will be dedicated to the creation of the "Agroforestry school" in which seminars, meetings, courses and *study-visits* will be provided for farmers, advisors and extensionists.

Key activities related to the valorisation of agroforestry products are regrouped under the WP 4: (i) the preparation of a preliminary study for the certification of products coming from agroforestry systems, (ii) the application of an internal audit for the integration of different certification standards and (iii) the application of new PEFC criteria and indicators for sustainable agroforestry systems management.

The web-platform developed in WP7 will be aimed at: (i) visualizing informative maps on the presence of agroforestry systems in Tuscany, (ii) identifying suitable landscapes for new agroforestry systems establishment, (iii) favouring the interactive communication among project partners and stakeholders and (iv) disseminating project news.

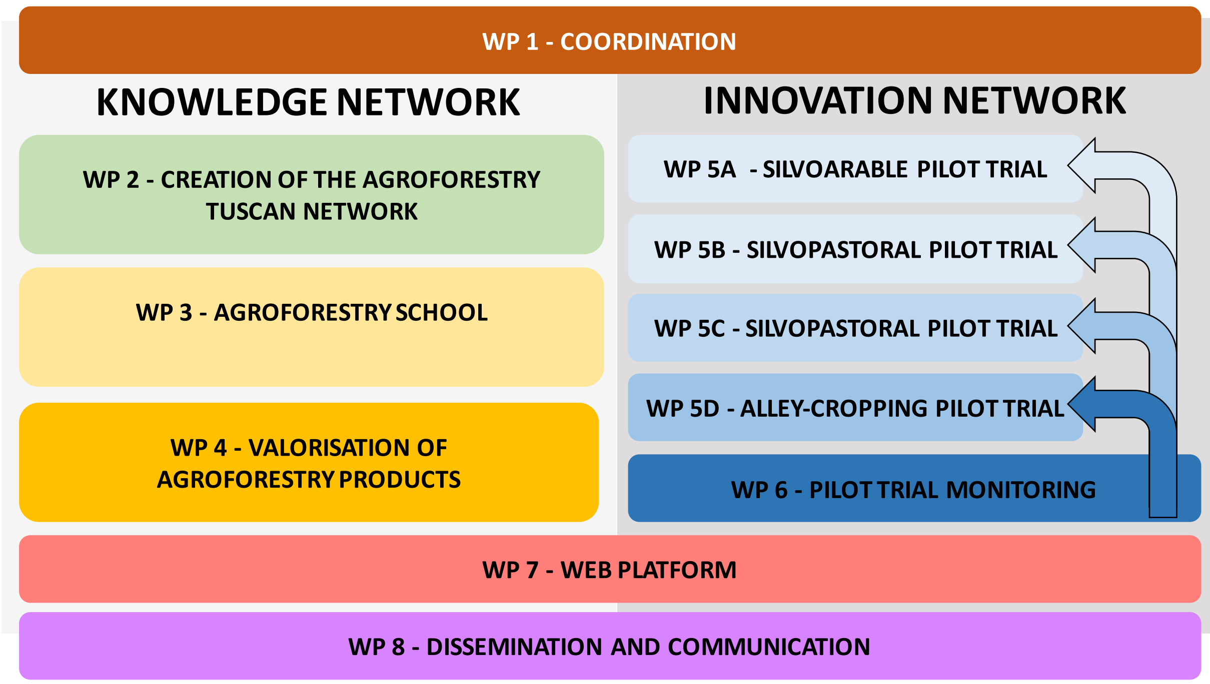

Figure 1. Graphical abstract of the project WPs

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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LIVINGAGRO

Cross-Border Living laboratories for Agroforestry

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Theme: Education, information sharing and awareness raising in agroforestry

Keywords: Agroforestry, Living laboratory, ICT Platform, Olive multifunctional systems, Grazed woodlands, Public-Private Partnerships (PPP), Innovation

Abstract

"*LIVINGAGRO – Cross Border Living laboratories for Agroforestry*" project is funded under the ENI CBC Med Programme 2014 – 2020, first call for standard projects, and refers to thematic objective A.2 "*Support to education, research, technological development and innovation*", priority A.2.1 "*Technological transfer and commercialization of research results*".

With a total budget of 3,3 Million Euros and a 2,9 Million EU-contribution through the ENI CBC Med Programme, LIVINGAGRO project involves 6 organizations from 4 different countries including the *Regional Forest Agency for Land and Environment of Sardinia* (Fo.Re.S.T.A.S.) in quality of Leading Beneficiary, the *Italian National Research Council*, Department of Biology, Agriculture and Food Science, through 4 Institutes ISAFOM, IRET, IBBR and ISPAAM (CNR - PP_1) and *ATM Consulting sas* (ATM - PP_5) from Italy; the *National Center for Agricultural Research and Extension* (NARC - PP_2) from Jordan; the *Lebanese Agricultural Research Institute* (LARI - PP_3) from Lebanon and the *Mediterranean Agronomic Institute of Chania* (MAICH - PP_4) from Greece.

LIVINGAGRO addresses the challenge of knowledge and technological transfer in Mediterranean agriculture and forestry systems for achieving and sharing good practices aimed at sustainable production, thus protecting biodiversity, enhancing innovation transfer, increasing rural incomes and profitability for all stakeholders involved. Using an open innovation approach for co-creating economic

and social values, improving interactions between the supply and demand of innovation, technological transfer and availability of research results, eliminating geographical and cultural barriers across involved Mediterranean countries, two Living Laboratories will be established focusing on *olive multifunctional systems* (Living Laboratory 1) and *grazed woodlands* (Living Laboratory 2).

Olive cultivation is widely representative of many Mediterranean rural areas, being often part of traditional agroforestry systems, in combination with cereals, fodder legumes and/or pasture. Grazed woodlands are major Mediterranean agroforestry systems that highly contribute to sustaining multi-functional local economies, supplying both plant and animal products.

The main project actions include the creation of two Laboratories (*Living Labs*) on the themes of multi-functional olive systems and grazed woodlands, whose activation phases include the localization and identification of relevant stakeholders, the establishment of Living Labs through specific agreements between public and private entities, the development of the dedicated *ICT platform*, the creation of a public-private community and the launch of experimental pilot actions.

What will be improved?
The identification and implementation of innovative value chains in agroforestry will create new opportunities for local communities in terms of sustainable farming practices and product diversification. In addition, food production stability will be improved over time, providing high quality agricultural products, while coping with limited resources and environmental constraints and increasing rural incomes. Finally, the project will lead to different innovations with high business potential in the field of agricultural machinery, food products, omics techniques, optimised uses of agricultural, forestry and breeding by-products and residues.

Who will benefit?
- Farmers and their organisations, extension services
- Consultancy firms, research centers, Universities
- Local authorities, public or private companies, SMEs, industry, policymakers
- Users of the developed innovations

Expected achievements
- 2 cross-border Living Laboratories established for innovation and technological transfer in agroforestry
- 4 research agreements between Universities/research centers and the private sector
- 8 enterprises cooperating with research institutions in innovation activities
- 6 training courses on business creation
- 10 new products/services developed in the agroforestry sector
- 10 science to business brokerage events for Researchers and SME's staff
- 20 technology transfer and intellectual property brokering services provided

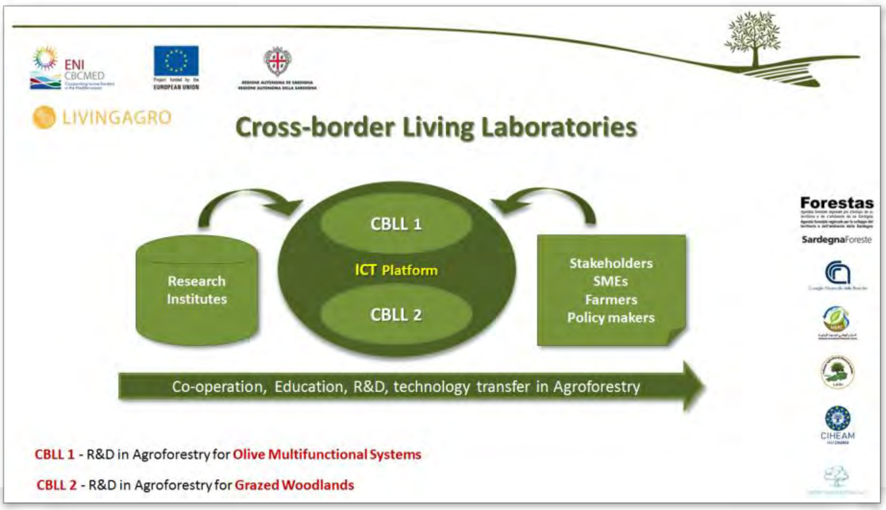

Figure 1. Cross-border Living Laboratory Model of LIVINGAGRO project.

http://www.enicbcmed.eu/projects/livingagro
https://www.facebook.com/Livingagro
https://enoll.org

Augmented reality for agroforestry system design

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Augmented reality, Agroforestry system design, Visualization

Abstract

In agriculture, thanks to the availability of mobile devices and the development of dedicated software, digital tools assist many tasks. Among digital technologies, augmented reality, the superimposition of virtual objects on views of the real world, is a powerful tool to visualize the evolution of a plot or to plan agricultural processes by interacting with digital representations of plants. This technology already helps for many works (Zheng and Campbell 2019; Janina et al. 2018; Katsaros et al. 2017). In this contribution, we propose a novel application case for agroforestry system design workshops.

Agroforestry system design workshops gather different actors (farmers, extensionists, local policymakers etc.) and aim at collectively decide the tree species to plant, the spatial organisation of the system and the tree and crop management options. Currently, such workshops use whiteboards, maps or physical mock-ups representing the system with tokens, pins or toothpicks. The result of these workshops is a model that represents part of the plot. Such workshops promote discussion between the different actors, but the participants cannot observe the impact of their choices and it is impossible to see the evolution of the plot over the years. Moreover, the model isn't a usable plantation map, an expert must adapt it to the whole plot and translate it into a usable plantation map.

In order to facilitate agroforestry system design and adoption, we propose to use augmented reality both for indoor design workshops and for outdoor field visits. For the indoor design application, our objective is to allow users to easily interact with a physical mock-up in order to facilitate user involvement and visualize quickly modification of the system by providing the users with information relevant to them: tree size, level of tree-crop competition, crop yield heterogeneity, etc. For example, a user could propose a specific tree species and visualize the consequences for the crops, as well as the agronomical or environmental performance of this system. For field visits, our aim is to visualise the impact of trees on the landscape, which would be useful for farmers to help them imagine their system, and for educational purposes, to foster discussions on the impacts of trees on crops, biodiversity, farming operations etc. Finally, the link between the indoor workshop and the in situ visualization, i.e. the implementation of the theoretical pattern in a particular plot of the farm to get the coordinates of the trees, could also benefit from augmented reality, thanks to automatic detection of the agroforestry pattern, replication of this pattern within field borders (with constraints) and generation of geographic coordinates of each tree.

Thus, we identified three steps, in which augmented reality could facilitate discussions, projections and help decision-making in the process of agroforestry system design:

- In the mock-up design stage, augmented reality allows visualizing the evolution of the plants and their constraints (tree growth, competition on light, spreading of diseases)
- In the mock-up implementation stage, the mock-up instantiation leads to the definition of a 3D scene, representing the future field. This implementation stage involves several processes such as pattern recognition, graph modelling, replication, and georeferencing
- At the in situ visualization stage, augmented reality is mobilized for realistic plants (trees, crops) visualisation in the plot including the possibility to simulate plant growth to see the impact on the landscape after 5, 10 or 50 years.

We get some results for the two first steps. Figure 1 shows, on the left, an image acquired by a smartphone or a webcam, of a (simplified) agroforestry system mock-up, with 6 "P" paper markers representing poplar trees, 2 "C" markers representing crops and one "TRI" marker defining the reference coordinate system(trihedron). Augmented reality allows to overlay, in real-time, on this image virtual representations of the trees (green points represent the canopy as the trunk cannot be seen from this viewing angle), crops (currently restricted to the marker surface but the objective is to fill the whole alley between trees) and the coordinate system vectors. On the right part of Figure1, the mock-up has been automatically translated into a 3D scene in the Unity visualisation environment for further analysis.

We propose here a methodology to move from the design stage to the mock-up implementation. It must integrate a complete description of the plot scene extracted from the image (which include to deal with the approximate marker positioning), and extract automatically relationships such as "the elements P2, P6 and P8 form a line" or "C1 is between the left line of trees and the middle line". We will then use them to infer the Ecosystem Service Functional Motif (ESFM) (Rafflegeau et al. 2019), which is the smallest pattern supporting all the ecosystem services targeted by the designers of the agroforestry system. During the instantiation step, the system repeats the EFSM automatically over the whole plot. An expert could correct, if necessary, to finalize the plantation map.

Further work will focus on: (i) predicting useful information (such as light or water competition) from the ESFM using simulation models and visualising them as augmented reality on the mock-up; (ii) formalising constraints in the implementation step (e.g. no trees in small corners of the plot) to replicate the ESFM throughout the map of the actual plot; (iii) visualising realistic-looking trees in situ, directly in the farmer's fields.

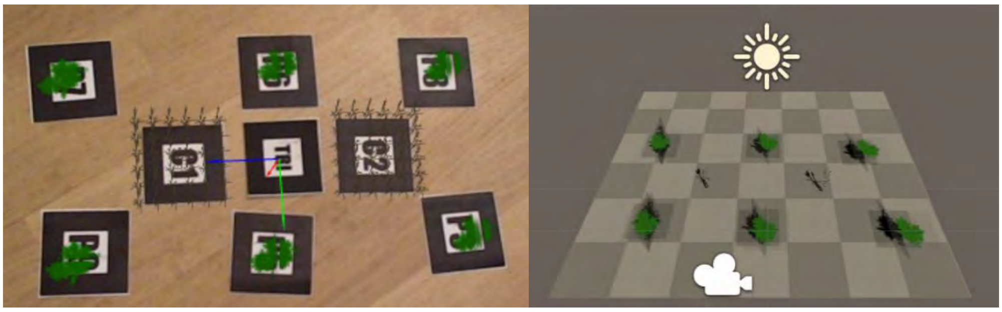

Figure 1. Example of mock-up (left) automatically convert into a 3D scene with a script and Unity software (right)

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Digital visualization of agroforestry practises in north-boreal forest

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: Agroforestry, North-boreal forest, Digital visualization, Virtual forest, natural products

Abstract

For the last 70 years, Finnish forests have been harnessed primarily for wood production. This dates back to the post-war period, when more extensive deforestation was started in Finnish forests to pay war compensation and employ men. Reconstruction of the land required large numbers of timber. To this day, the Finnish forest industry and timber exports have increased their share of wood production and are part of the Finnish Economy. The gross value of forest industry production in 2018 was over EUR 23 billion.

In order to increase the diversity of forest nature and forest industries, the diverse use of forests must also be increased in Finland. More than a third of Finland's endangered species are forest species. Forest biodiversity is most severely weakened by forest management practices, which has clearly reduced natural disturbances such as forest fires and the number of old trees and rotting trees. Finland has moved from a wood production-oriented way of thinking to emphasizing diversity and the ecologically, socially and economically sustainable use of forests. In addition to wood production, the multi-purpose thinking of forest use has grown in Finland. In ten years, regulations and organizations have changed, competition has liberalized, forest ownership options have increased and the forest owner has access to a wide range of digital services and there is a need for new information.

Agroforestry requires investments and / or acceptance of alternative costs to increase production efficiency. Intensified production of wild berries, mushrooms and wild herbs – forest farming - is possible provided that the forest is seen as a source other than wood raw material (Uusitalo, Peltola 2015). The concept of agroforestry is still quite unknown in Finland, although its methods are applied to some extent in Finland. The interest of forest owners in various alternative forms of production has increased, which can also be implemented alongside forestry. According to the forest owner survey, forest owners are interested in the production and collection of natural products on their forest farms. Three out of four respondents believe that forestry make sense to produce more than just wood and strongly believe that with active cultivation and recovery of natural products can increase forest income (Haveri-Heikkilä, 2018).

More information material on the benefits and applicability of agroforestry is needed for both teaching and forest counseling needs. Forest counseling and education needs more tools, applications and guidance on agroforestry in order to spread know-how to forest owners and diversify counseling. There are about 600,000 forest owners in Finland and Private Forest Owners own 60% of the forest land, so their decisions are very important. VirtualForest 2.0 helps forest owners, forest professionals and students to understand the principle of agroforestry and to see the significance and benefits of targeted production on different timelines.

VirtualForest 2.0 is a visualization tool developed in Lapland UAS. VirtualForest 2.0 is developed for forest engineering students for practicing different forest management operations and see the results in forest development in coming years. Simulation allows students to see how the forest would look like, i.e. 50 years after the operations. VirtualForest 2.0 can be used to visualize the effect of forest management operations for private forest owners and different organizations. VirtualForest 2.0 uses open QGIS geographic information system to generate changes in forest patterns or tree data, habitat data and terrain data in a 3D-visualization. Visualization is based on real world stratum data and can be generated by tree location point data. Visualization tool can also be used in landscape research and planning.

Agroforest visualization tool is an extension of VirtualForest2.0 where the focus is on forest undergrowth. Agroforest tool can be used to visualize different kinds of effects that forest care operations have on undergrowth tussocks. Visualization will demonstrate bilberry tussock growth in different time spans from year 0 to year 105. At the same time the program also offers information for forest owners about the effects of different forest care operations. At this seminar Agroforest tool will be used to present the differences in bilberry growth in research forests with forest management optimized for timber production and for joint production of timber and bilberry (Fig. 1).

Figure 1. Screenshot from visualization featuring bilberry coverage (dark green areas) in forest optimized for improved bilberry yields

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Building collaborative agroforestry landscape planning in times of socio-ecological crisis: the case of shade-grown coffee cooperatives in Mexico

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Abstract
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Theme: Education, information sharing, and awareness raising in agroforestry

Keywords: shade-grown coffee, collaborative research, sustainability, socio-ecological crisis.

Abstract

Agroforestry has a strong potential for climate change mitigation, strengthening local adaptation, mainstreaming biodiversity conservation into agriculture and fulfilling the Sustainable Development Goals (Plieninger et al. 2020). There are few value chains developed for agroforestry products. Coffee, when grown under the shade of a diversity of trees, can prove an example of agroforestry value chains that provide crucial ecosystem services. However, coffee producers face a series of challenges associated with climate change, increased vulnerability to pests and diseases, and fluctuations on the commodity market.

The ongoing COVID-19 pandemic has had devastating impacts on the global population and economy. The SARS-CoV-2 pandemic adds pressure to the pre-existing crisis of global environmental change and the challenges of feeding a growing population whilst at the same time reducing emissions. Its probable mid-term impacts serve to remind us of the need to recognize that sustainability and equity must go hand in hand (Leach et al. 2018). Restoring degraded ecosystems and transforming food systems by supporting sustainable practices are key to "building back better" considering the COVID-19 crisis (Pearson et al. 2020).

The call for recognizing the influence of context on outcome has received renewed interest in development studies (Chazdon et al. 2020). Agronomical extension services have emphasized the need for an "options by context" approach which will allow for local realities to dictate the specific research and scaling up and out initiatives in agroforestry (Sinclair & Coe 2019). An innovative approach to public research funding responding to local needs has recently been adopted by the Mexican Counsel for Science and Technology (CONACYT). The Counsel's National Strategic Program (ProNacEs) identifies specific problems in Mexico and proposes a new funding scheme to develop policy recommendations in the mid and long term by first funding collaborative research. For example, the specific program addressing the sustainability of social-ecological systems provides initial funding to bring together research capacities with local community needs to co-design a research and action program. These exercises in collaborative planning can afterwards compete for mid-term, public funding.

One of these projects brings together public universities (led by the Colegio de Postgraduados) with research centres (including the Mexican Carbon Program, a network of carbon cycle scientists) and organized coffee producers who produce shade-grown coffee for sale via organic, fair-trade and specialty markets. This alliance seeks to respond to the various challenges that shade-grown coffee producers face. Socio-ecological crises include losses to a fungal epidemic associated with climate change (Avelino et al. 2015), loss of coffee suitability due to changes in precipitation and temperature (Ovalle-Rivera et al. 2015), and uncertainty on the commodities and futures markets.

The project was designed before the COVID-19 pandemic broke out, and it has been forced to adapt accordingly to build spaces of discussion and collaborative planning while respecting the necessary safety measures. Producers' organizations in the Chiapas Sierra Madre have proved crucial leaders in responding to the multiple problems the COVID-19 pandemic presents to smallholder families. Coffee cooperatives have mobilized their experience and networks in providing access to information and credit in moments of need, while channeling demands for health and education services. However, organised agroforestry producers also face a series of additional challenges, such as accessing clear and concise information in the context of uncertainty, the lack of access to health services, and limits to personal mobility (rendering difficulties to safely access mountain coffee fields which can be far from the human settlements). Another concrete challenge deriving from the international crisis is a reduction in coffee demand considering consumption limits due to recommended lockdowns and safety protocols.

Although this innovative project is still in an early phase, it builds upon a history of collaborative research-action in the region. Learning lessons so far include the urgency to design innovative forms of participation and knowledge co-creation between agroforestry producers, community organizations and research centres. Facilitating participation implies pro-actively recognizing the gender inequalities that persist and the barriers to youth participation and generational renewal within rural producers' organizations. This also implies providing access and training in online communication and social networks, despite challenges in access to technology and internet in some regions.

This case in development in 2021 stands to highlight that public funding schemes for collaborative landscape planning can facilitate locally adapted proposals and further participation of agroforestry producers in promoting transitions towards sustainability. These alliances can push forward low-emissions development efforts promoting transformation to build new socio-environmental systems based on participation, localness, fairness and justice (Wezel et al. 2020).

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4.2

Agroforestry and rural tourism

Visual appreciation of tree-based intercropping systems by rural residents in Quebec, Canada

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry and rural tourism

Keywords: tree-based intercropping systems, visual appreciation, landscape, amenities.

Abstract

In Quebec (Canada), the implementation of tree-based agroforestry systems within areas of agricultural intensification or agricultural decline is seen by local stakeholders as a promising land-use option to face environmental challenges and increase landscape amenities and attractiveness for tourists (Laroche et al. 2019). Since landscape attractiveness and sustainability are intimately linked to the ecological and social coherence of its constitutive land-use systems, understanding how tree-based intercropping systems fit within the existing landscape socioecological system, and how their introduction is perceived by rural inhabitants in various agricultural contexts thus become a necessary preliminary step to ensure that the landscapes created remain attractive and significant for residents, and not only for tourists.
Our study scrutinized the visual appreciation of tree-based intercropping systems of rural residents from two contrasted agricultural regions of Quebec: Charlevoix-Est, a touristic region famous for its natural and picturesque landscapes but undergoing agricultural decline, and Les Maskoutains, a region where rural landscapes have been highly homogenised by agricultural intensification. Six tree-based intercropping system photo scenarios were created from the same baseline picture following a complete factorial design featuring two row spacings (15 m and 30 m) and three diversity levels: monospecific (M), mixed tree species (Mx) and mixed tree species with shrubs (MxS) (figure 1). In an online questionnaire, residents from the two regions rated these scenarios using a 10-point Likert scale, and answered open-ended questions on the reasons underlying their ratings. Repeated measure analyses of variance using mixed models in SAS software were performed to test the influence of region, diversity and row spacing on visual appreciation. Thematic coding was used to classify and reveal the main reasons underlying the appreciation of the tree-based intercropping system designs.

A total of 161 respondents (76 from the agricultural declining region and 85 from the intensification region) filled the questionnaire. The mean appreciation rating of the 6 tree-based intercropping scenarios varied from 6.330 for the M30 (monospecific, 30 m spacing) to 6,659 for the MxS15 (mixed tree species with shrubs, 15 m spacing). The analysis of the ratings revealed that the triple interaction region*diversity*row spacing was significant at a=0.05 level (F Value 3.39, Pr > F = 0.0362). This triple interaction indicates that row spacing and diversity have varying effects on landscape appreciation depending on their specific combination and from one region to another.
The comparison of the agroforestry design ratings by region confirmed that M30 is the less appreciated agroforestry design in both regions (6.3289 in the region facing agricultural decline and 6.3330 in the agricultural intensification region). In the agricultural decline region, the Mx30 (6.5921) and the MxSh30 (6.8040) are significantly more appreciated than the M30 design. However, the residents from the agricultural intensive region significantly prefer the Mx30 (6.6155) and the MxSh15 designs (6.6760) to the M30 design. The other design ratings were not found statistically different. These results highlight the complexity of visual appreciation and underline the need to survey local perceptions prior to implementation to optimize the diversity of the woody perennials and the row spacing according to the

residents' preferences. These results also support landscape appreciation theories stating that landscape global appreciation is more complex than the sum of the appreciation of its parts taken individually.
The main reasons underlying tree-based intercropping design appreciation were captured for the M30, the Mx15 and the MxSh30 designs. The reasons for appreciation were classified in four main categories (aesthetics, naturality, sense of place and functions) and the reasons to dislike the landscapes in four other categories (artificiality, darkness, lack of biodiversity and uselessness. In both regions, the aesthetics was the most often stated reason to justify the appreciation of the M30 (26.9 % in the declining region, 41.7 % in the intensification region) and the Mx15 (47.1 % and 30.3 %, respectively). The multiple functions of the MxSh30 were also frequently acknowledged in both regions (24.0 % of the comments in the declining region and 36.8 % in the intensification region), mostly because the presence of shrubs is associated to pollinators and biodiversity management.
Despite the globally positive effects of tree-based intercropping system features on aesthetics and visual appreciation, the "artificiality" of the designs, mostly related to the trees planted in rows, is stated for all the scenarios as the main reason of landscape unappreciation, ranging from 16.5 % for the MxSh15 in the declining agricultural context to 33.3 % and 33.7 % of the comments on the M30 and Mx15, respectively, in the agricultural intensification region. These results tend to show that trees are still highly associated to "wilderness" and nature, and that their spatial arrangement in geometrical, "unnatural" rows depreciates the landscapes.
In conclusion, tree-based intercropping system designs are appreciated by residents of very diversified agricultural regions, but this appreciation varies greatly with the context and the combination of multiple variables. Our results advocate for the implementation of policies, programs and landscape management strategies taking regional perceptions into account to increase landscape attractiveness for tourists while ensuring landscape sustainability and coherence for rural residents.

Figure 1. The six tree-based intercropping system scenarios

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Developing garden tourism and services – case of Garden Pearls Network in Estonia and Latvia

EURAF 2021
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Agroforestry, education, dissemination; Agroforestry and rural tourism

Keywords: garden tourism, development, special interest tourism, visitor's satisfaction, rural tourism

Abstract

Special interest tourism (including garden tourism) is becoming a popular trend in tourism. Visitors with special interest travel more often, they stay for a longer period, emphasize new knowledge and wish to learn, they have higher quality expectations, specific needs and they are more willing to spend money. That rises customer expectations for services and service providers. (Agarwal et al 2018, Benfield 2013, Kasriel-Alexander 2017) Due to urbanization many people search for an opportunity to reconnect with nature. As Paris et al. (2019) noted, integrating farming with agro-tourism activities may allow many farms an opportunity to attract visitors, who are interested in learning how the products have been made.

Garden tourism has been popular in England but getting more and more common elsewhere as well. There is information about garden tourism and garden tourist in Western Europe (Čakovská 2017, Bauer-Krösbacher et al 2012), however, there is a lack of information about opportunities in Eastern Europe. Some research has been done, but it concentrates on specific garden or target groups and does not give an in-depth overview of garden tourism situation, services, visitor's expectation, and satisfaction. The aim of this paper is to provide guidance for developing garden tourism and garden services in Estonian and Latvian private gardens that belong to the Garden Pearls Network (www.gardenpearls.eu).

Data was collected using the survey composed based on the modified THEMEQUAL model (Valcic et al 2015), Net Promoter Score (NPS) scale (Eger et al 2017) and using the literature of garden tourism. The gathered feedback contained the aim of the visit, visitors interests, information sources, findability, main services (garden visit), additional services (guiding, workshops, purchase plans, souvenirs and drinks), supporting facilities (parking, shelter, signs, garbage bins), price, satisfaction, suggestions, customer profile, etc. A questionnaire was sent to all private gardens in the network. Garden owners were asked to divided questioners to the visitors.

369 responses were collected. 287 answers were from Estonian and 82 from Latvian gardens, 317 were women and 36 men, in the age 30+ years. 202 of respondents marked their origin as Estonian, 106 as Latvian and 32 as Finnish. 308 of respondents had their own garden and 47 did not. Gardens were visited mainly with family or friends, but also with a group (more than 20 people). Most of the respondents visited the garden during a one-day trip (198 people) or 2–3 days trip (95 people) and they were repeat visitors (259 people). The information is primarily received from friends/relatives/acquaintances and Social Media. Overall, the garden visitors were satisfied. There is a slight difference in answers between those who have their own garden compared to the visitors who do not have a private garden, between men and women, visitors with children or those who travel with adults, first time or repeat visitors, group and private visitor's feedback. However, many of the respondents had difficulties to evaluate parking opportunities or give feedback to guiding and workshops. One reason was, that there were no workshops offered at the gardens. Almost half of the respondents were not able to purchase souvenirs and half of

the visitors explored the private garden by themselves. That result was common for visitors with a different profile. Results of NPS (recommendation to others using a 0–10 scale) reviled, that most of the visitors will recommend visited garden to friends or colleagues. However, Fins, younger visitors (under 40) and visitors with no private garden are detractors and they may speak negative things about their experience. See the results in table 1.

Results reviled strengths and weaknesses in garden tourism services in Estonia and Latvia. Several suggestions were made to improve visitor's satisfaction. Suggestions consider topics like information and information sources (including signs), workshops, additional services as drinks, souvenirs, toilets, shelters, cooperation, plans, etc. Additionally, research brought out a gap in service provider's knowledge about service design, marketing, a need for more in-depth cooperation, etc., that gave an input to compose criteria lists for Garden Pearls Network gardens and content for handbook for garden tourism providers.

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Respondents descriptive values	Possibility to purchase plants	Possibility to purchase souvenirs	Possibility to purchase water/coffee etc.	Possible to use a bathroom	Garbage bins available	Possibility to get shelter	Explored on my own	Possibility to have a guided tour
has a private garden	77%	30%	59%	85%	67%	71%	45%	76%
do not have a garden	45%	36%	55%	87%	68%	64%	53%	70%
Latvian garden	44%	56%	67%	91%	85%	57%	79%	49%
Estonian garden	82%	24%	56%	83%	62%	74%	37%	83%
visited alone	80%	35%	60%	75%	75%	75%	75%	80%
visited with friends	72%	29%	65%	86%	72%	75%	61%	65%
visited with a group	70%	30%	52%	89%	59%	69%	25%	88%
visited with a family	72%	36%	62%	78%	76%	57%	67%	64%
Estonian visitor	78%	17%	46%	80%	58%	70%	44%	81%
Finnish visitor	88%	41%	91%	94%	66%	78%	25%	94%
Latvian visitor	62%	56%	75%	94%	89%	74%	58%	63%
less than 20 years old	20%	40%	80%	80%	100%	40%	80%	80%
21-30 years old	33%	39%	67%	89%	83%	78%	83%	44%
31-40 years old	58%	38%	63%	88%	71%	58%	58%	63%
41-50 years old	80%	33%	61%	79%	68%	74%	57%	76%
51-60 years old	77%	26%	58%	87%	61%	74%	44%	77%
61-70 years old	78%	33%	63%	89%	72%	73%	40%	83%
over 70 years old	65%	26%	42%	81%	58%	52%	19%	81%
repeat visitor	72%	49%	69%	94%	85%	80%	62%	72%
first time visitor	73%	24%	55%	83%	61%	67%	42%	76%

Table 1. Evaluation of garden services by different groups of respondents

Agroforestry in the mountainous area of Evritania(Greece)

EURAF 2020
Agroforestry for the transition towards Sustainability and bioeconomy
Abstract
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Theme: Agroforestry and rural tourism

Keywords: agroforestry, sustainable water management, soil productivity, biodiversity

Abstract: Agroforestry represented a choice of survival and self-sufficiency for the inhabitants of small but dynamic communities in the Mediterranean mountainous region for thousands of years,. For centuries, households in the mountainous villages of Evritania, retained the characteristics that enabled them to make the most of the geophysical and hydrological characteristics of the mountains: smallholdings of arable land on terraces, conservation of local grain varieties of cereals and pulses, vines and fruit trees, community management of water resources and forests, solidarity, and exchange economy. These principles allowed agroforestry to flourish with livestock production creating a special mountainous culture. Nowadays the few permanent residents insist on utilizing this natural wealth by taking advantage of the coexistence of crops with trees (the dominant element of the systems for fruit or timber production), the shrubs and the forests, enjoying high quality agricultural and livestock products with local characteristics. At the same time they contribute to the conservation of soil, water and biodiversity (flora and fauna). Agroforestry practices represent a tangible answer to the urgent question and demand of today's societies for the preservation of soil, water and biodiversity (flora and fauna). Measure 8.2 presently reinforces these practices by supporting the establishment and maintenance of agroforestry systems (subsidy Rule 67 of Regulation 1303/13). This measure supports planting traditional varieties of trees that provide, at the same time, food for various birds species who also act as agents for spreading seeds in space, so necessary for the support of biodiversity under climate change. Equally important to science are the centuries-old trees (plane trees, oaks, firs, etc.) that have been specifically preserved by residents in the past, carrying interesting messages to us of the climate history. All these compose the most interesting framework for agrotourism and ecotourism in the mountainous areas of the Mediterranean.

Acknowledgement: This research has been funded by the M.Sc. program "Ecology and Natural Environment Management", General Department, Agricultural University of Athens

Figure 1. Terraces in the Tornos villages in autumn (Photo by V. Lappa)

Figure 2. The same terraces in the winter (Photo by P. Palios)

Olive trees and iris flowers in Tuscany: an agroforestry system to exploit rural tourism

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract

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Topic: Agroforestry and rural tourism
Keywords: Olive trees, iris flowers, agroforestry, tourism

Abstract
Nowadays, the need to provide a territory with an identity is more and more pressing. An increasing number of territories are working to highlight their cultural and environmental peculiarities to be more competitive, as it happens in the tourism sector.
Tuscany is characterized by a high variability of landscapes shaped, during centuries, by a successful integration of natural environments and culture. One peculiar scenery marking, in springtime, the hills of the Chianti and Valdarno countryside in the provinces of Florence and Arezzo is given by iris flowers blossoming in olive orchards. The light blue-violet of irises alternating with the grey-green of olive trees leaves offers the visitors a unique, harmonious and relaxing landscape (Fig. 1).
Such landscape, that could be defined as an agroforestry system, is, in fact, the result of an old agricultural tradition by which farmers used to cultivate the *Iris pallida* Lam. among olive trees. This flower, a perennial plant of the genus Iris, family Iridaceae, called *giaggiolo* (Italian common name of the flower) used to be cultivated as its rhizomes are rich in molecules utilized in the perfumery industry. The *giaggiolo* economy in Tuscany surged between 1700 and 1800 (Rombai, 2002) and iris rhizomes production (currently a niche production) increased thanks to the demand of French and Northern Europe cosmetic companies. The multipurpose uses of this flower are recorded in many ethnobotanical studies (Pieroni et al, 2004). Nowadays, the *giaggiolo* rhizomes are demanded also by the Italian market of alcoholic beverages.
The adaptive traits of iris species allow them to survive in particularly arid (or dry) conditions. The *giaggiolo* can be intercropped also with grapevines. As this crop is part of the Tuscan tradition for its historical and cultural value, agritourism farms are implementing its cultivation to increase the landscape value and profitability (Pezzarossa et al., 2016).

In order to understand if: i) the olive tree-iris, as an agroforestry system, is presented to visitors as a typical landscape; ii) the combination of the two species is well exploited in the description of the tourism offer, a preliminary text mining analysis has been performed on Italian websites. The study focused on online contents produced by economic operators and institutions that promote the iris and olive trees. Texts were retrieved from web sites provided by Google search engine with specifics queries identified to detect the relation between iris and olive tree ("Giaggiolo e olivo", "Olivo e giaggiolo" and "Giaggiolo e olivo paesaggio"). Google was selected because it is one of the main websites that generate the most upstream traffic to specific websites in relation to the tourism sector (Hopkins, 2008). The analysis is composed of search results on the first 4 Google pages emerged. The final sample included 33 webpages contents with more than 21,000 words. Computational text analysis was performed using the statistical software R. Several packages were applied to elaborate the data and perform analysis (i.e. dplyer, tidytext, rstem). The research adopted text-analysis techniques (Strapparava et al, 2006) to identify the main keywords associated by operators to iris and olive trees. The total selected keywords (n. 81 with total frequency=2078) mainly referred to the occurrence of certain concepts in the texts (frequency counts) were clustered. The percentage frequency (PF) was calculated for each cluster: "Flower" (36.3%); "Processing" (8.7%); "Territory" (12.6%); "Application sectors" (11.2%); "Colors" (7%); "Production" (6.3%); "Olive trees-oil" (2.8%); "Landscape" (5.9%); "Tourism- recreational activities" (4.4%); "Symbol" (2.9%); "Seasons" (2%).

The highest PF is shown by the “Flower” cluster in which “giaggiolo” and “iris” are the most cited keywords along with those belonging to the “Territory” and “Application sectors” clusters, followed by “Processing” and “Colors”. These data tend to indicate that most of the information is focused on the flower, the traditions linked to its processing to get the extracts from the rhizomes, but also to the different economic sectors in which the extracts can be applied, mainly perfumery and cosmetics. It is interesting to consider that the different concepts expressed by different types of clusters, though showing low PF, could be related to the multipurpose properties of the iris and its multifunctionality.
Since geographical references were not included in the search criteria, it is worth to notice that a high PF of the keyword “territory” as well as of names of places where the giaggiolo is grown (Florence, Tuscany, San Polo in Chianti,) were found. Probably, these locations are particularly emphasized because they can be widely recognized worldwide. Despite this, the “Recreational and tourism activities” cluster PF was not very high, even though it comprises also some emotional words such as, “bellissimo” (very beautiful).
Instead, the “Olive trees-oil” cluster comprising the words “olive tree”, “oil” and “oil mill” showed a low PF. This can be explained with the fact that the olive tree component of the system iris-olive tree is not very much perceived and highlighted in the description of the landscape and maybe it is evaluated as a component separated by the iris flower.

Figure 1. Iris flowers and olive trees landscape in San Polo in Chianti.
Source: Azienda Agricola Frantoio Pruneti

The results of this preliminary analysis show that, despite the landscape provided by olive-trees and iris flower is very characteristic, the economic operators seem to focus mainly on the flower, its traditional cultivation and applications.
Which can be the strategies to exploit the olive trees-iris as an agroforestry system?
Research on the visitors’ perceptions and opinions should be also performed, as well as studies on the ecological, economic and cultural relationships between the two plants.

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PASTORALP project: expected impacts of climate change on future distribution and development of alpine grasslands and wooded pastures

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Permanent grassland, wooded pastures, Alps, climate change, Random Forest, Day Cent

Abstract

Introduction

The climate conditions experienced by the Alps in the recent decades are highly increasing the vulnerability of high mountain grasslands (IPCC, 2014), in close link with the socio-economic changes affecting pastoral systems as a whole (Huber et al., 2013). As a consequence, we assist to an increasing encroachment of shrubs and trees in the former pastures (Targetti et al., 2010). Hereby, we present some preliminary results of the EU-LIFE project PASTORALP (2017-2022) on the analysis of climate change impacts on high altitude pastures located across the Western Alps.

Materials and Methods

The whole study area concerns high-mountain pastures located above 1700 m a.s.l. in two national parks (Gran Paradiso, IT and Des Ecrins, FR). Two tests sites were chosen for model calibration and validation, representative of well-managed pastures with mainly herbaceous cover (Entrelor), and of pasture with reduced utilization with high ground cover represented by woody species (Torgnon). For the study areas, two climate scenarios were developed, reflecting current (1990-2010), near (2011-2040) and mid-far term (2041-2070) climate conditions, referring to RCP4.5 and RCP8.5 scenarios, as predicted by ALADIN and CMCC Regional Circulation Models. The Random Forest machine learning approach (Breiman, 2001) was trained for the current period 1990-2010, and then applied to simulate future pasture distribution over RCP 4.5 and 8.5 scenarios. Predictive variables (harmonized at 1-km spatial resolution) were eight soil-topographic and specific climatic inputs (source: Harmonized World Soil Database and Worldclim), while current distribution of pastures, derived from local cartographies, were used as binary response variable. Afterwards, the biogeochemical model DayCent (Parton et al., 1994) was used to assess the expected future changes in snow cover presence and growing season length for the two pastures types after validation against observed data from the two study sites.

Results and Discussion

Climate conditions: RCMs projections indicate a general increase in temperatures up to 2-3 °C and 1-2 °C for min and max air temperatures, respectively. Precipitation and dry spells are also expected to increase. In particular, we anticipate an increased frequency of dry spells by 15% to 45%.

Random Forest: as predicted by CMCC, decreases of pasture suitability are expected up to -18% in the near future of RCP4.5 for both parks. Far future projections, as simulated by ALADIN, suggested reductions are up to -15%, particularly over P.N. Des Ecrins, coupled with an overall shift of pastoral suitable areas to higher altitudes (Fig. 1), with a possible expansion of wooded pastures as resulting in Dibari et al. (2015).

DayCent: Using the warmest scenario (i.e. RCP8.5), snow cover is expected to decrease in both sites by the end of the century, with predicted reductions up to 70% compared to the baseline. Accordingly, the length of the growing season is projected to increase in conjunction with snowpack reduction.

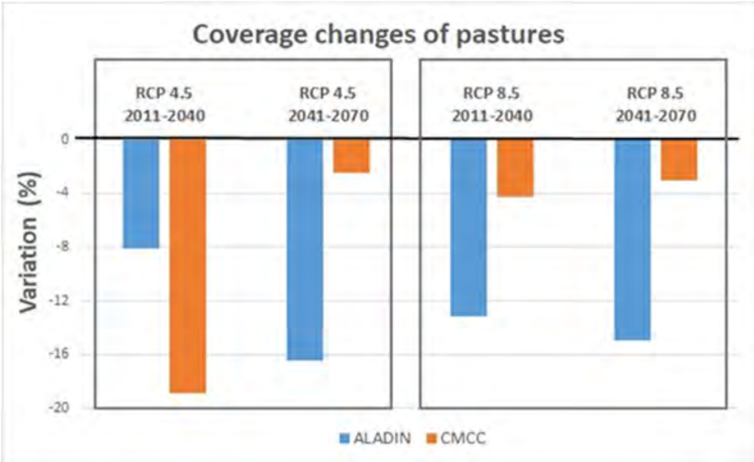

Figure 1. Variations in areas suited to grasslands for Gran Paradiso and Des Ecrins national parks, under RCP4.5 (left box) and 8.5 (right box) scenarios, in the near (2011-2040) and far future (2040-2070), as projected by ALADIN and CMCC regional circulation models.

Conclusions

Preliminary results indicated that future climate conditions (increases in temperatures and in rainfall variability) will affect high altitude pastures of Western Alps, with upward shifts of vegetation, decreases in snow cover, lengthening of the growing season, but without any relevant differences in the seasonal forage provision. These modifications will likely generate expansions of woody species, altering the sustainability of the traditional grazing systems in the Alpine region. This should be considered for defining proper adaptation strategies to cope with the projected climate.

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Spread wooded riparian buffer areas can increase significantly the phyto-depuration service.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Theme: Climate change (adaptation and mitigation)

Keywords: Buffer zones, phyto-depuration, CAP

Abstract

The intensification of land and water use and consequent the landscape modification have drastically reduced the surface of ecotones areas, as well as, their buffer capacity to reduce diffuse source pollution (Gumiero et al 2017). The large amount of water used for irrigation on one hand decrease the channel discharge and on the other promotes the transfer of Nitrogen from fertilized soils to water bodies though leaching and run-off. The Nitrogen phyto-depuration capacity of riparian ecotones and wetlands depends on denitrification process of anoxic water saturated soils. High nutrient load associated with lack or poor denitrification process impacted both surface and underground waters. Consequently, in river basins with intense urbanization and agriculture land use the nitrogen inputs exceed its own transformation and removal capacity. Wooded areas, like riparian buffer strip, can provide important "ecosystem services" beyond forestry.

Since 2000, the European Union with the WFD 2000/60 has set itself the general policy objective of achieving the availability of good quality water, in adequate quantities and ensuring the good ecological status of all European water bodies. The former Nitrates Directive has been included within this directive. Agriculture plays a crucial role in the sustainable management of water resources, both in terms of quality and quantity. For this reason the EU has often stressed the need to protect water resources also in the CAP. The importance of integrating water management policy with land management in order to achieve the goal of sustainable development is highlighted throughout the European legislation. To achieve the objectives of WFD the CAP used two tools: cross-compliance and the European agricultural fund for rural development (EAFRD). These tools should help to promote sustainable agriculture by encouraging good agricultural practices and by promoting the ecosystem recovery like vegetate buffer strips. Hydrology is the most important determinant of buffer zone conditions and dynamics, therefore water management is often the key driver to their restoration. Even in a very degraded area like low plain in Veneto Region where most of water courses are heavily modified with trapezoidal section can be restored and create a small floodplain that would become flooded during moderate water level rise (Fig. 1). Even if high denitrification rates have been observed also in deep moor soil, as a general rule, the most actives soil layers in term of biogeochemical processes are those in contact with the rhizosphere rarely deeper than 50–60 cm (Gumiero et al., 2011). This is due to the well known combined effects of uptake and availability of organic carbon which provide support for the metabolic activity of the microbial community.

The spatial distribution of riparian zones in agricultural areas has a great influence on capability to intercepts the diffuse Nitrogen flows. To achieve efficient removal of non-point source pollutants these systems must be widespread in the territory. For this reason, in recent decades, the Veneto Region has supported the increase of these linear infrastructures throughout the agricultural territory in the lowland areas, with the function of phyto-purification and increase of natural biodiversity.

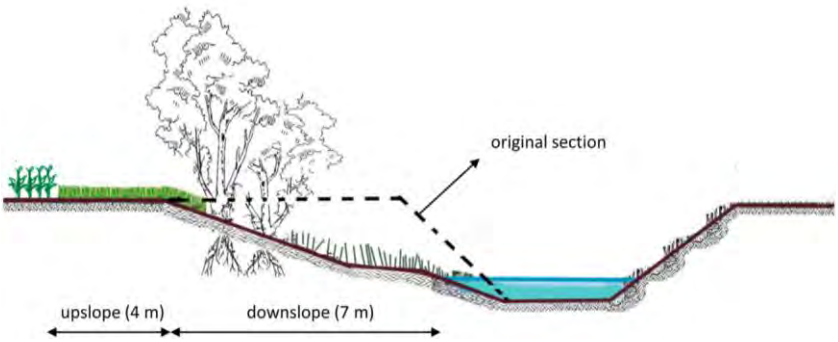

Figura 1 Section representing enlargement of the stream bank during restoration

To achieve these objectives, the Veneto Region Authority in the 2014-2020 planning period of Rural Development Programme (RDP) has funded projects focused on conservation and construction of both linear ecological infrastructures and small wooded areas in the plain. Overall, the length of the green infrastructures built - through collective projects coordinated by the Drainage Authority (Reclamation consortia) is about 5,330 Km. The agricultural area subjected to these agro-climatic-environmental actions was 3,542 hectares. The University of Padua (DAFNE) has been following for some years a study on the ecological infrastructures developed and preserved with the support of the projects funded thought the RDP. This study estimated the variation in the gross balance of nutrients (nitrogen and phosphorus) in the areas affected by land use change. The result of the applied studies led to estimate a reduction of the nitrogen load, in the intervention areas compared to the areas subjected to ordinary agronomic management, of 18.4 kg / hectare and a reduction of the phosphorus load equal to 13.8 kg / hectare (Dal Ferro et al., 2016).

The most important role of woody vegetation relates to its capacity to enrich in organic carbon deeper sub-soils, where it C_{org} is needed for denitrification in groundwater. Some researches (Bremer et al., 2009; Dandie et al., 2011), based on microbial communities analysis, open a new perspective on the role of vegetation, proving that the presence, as well as, the composition of different plants species affects the composition and the biomass of the denitrifiers' community. Finally, it should not be forgotten that, in addition to the phyto-depuration function, these systems are able to provide many ecosystem services to society (carbon sink, habitat diversity, ecological corridors etc..) which should always be evaluated in the cost and benefit analyzes.

Reference

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