EURAF 2024

EURAF 2024
28-31 MAY 2024
ABSTRACT BOOK

Mendel University in Brno

Editors: Bohdan Lojka, Šárka Hoffmannová

EURAF 2024
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Abstract book

2024

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Index

Theme 1: Agroforestry and Environment

Theme 2: Agroforestry Production – Quality, Safety and Sustainability

Theme 3: Economy and Policy of Agroforestry

Theme 4: Agroforestry in Society and Culture

Theme 5: Agroforestry in Practice

Welcome

Dear participant of the 7th European Agroforestry Conference,
In the name of the European Agroforestry Federation and The Czech Association for Agroforestry, we welcome you to the EURAF 2024 conference in Brno.

This year's conference is placed under the topic
Agroforestry – regenerating landscapes and diversifying production in Europe

European agriculture needs to evolve in the face of climate change, a reduction in the abundance of insects and farmland birds, pollution, and the need to improve human health. Greater and more effective use of agroforestry, the integration of woody perennials with livestock and/or crop production, is a proven means to maintain food production whilst addressing these issues. Agroforestry is an important regenerative agriculture practice which can achieve a greater diversity or quantity of outputs with fewer non-farm inputs, whilst improving a farm's resilience to climate change. Well-designed agroforestry systems, adapted to local conditions, can also enhance biodiversity and ecosystem services at the landscape level. Nevertheless, the re-adoption of agroforestry in Europe is currently challenging, despite the interest of both farmers and policy makers.

Czechia, at the heart of Europe, is an ideal place for us to come together to address these challenges. Here, we feel that agroforestry is gaining momentum now. It is the home of many intensive farms, where agroforestry can provide a cornerstone for progressive agricultural development and the creation and conservation of economic and environmentally beneficial landscapes. Hence, we are happy that you join us in the vibrant city of Brno. This timely conference will cover research and practical sessions that address the opportunities and challenges in promoting the integration of trees with farming. Discussions in plenary, thematic oral and poster sessions, and workshops will provide participants with new ideas to enhance the role that agroforestry can play in diversifying production, enhancing soil health and biodiversity, addressing climate change, creating profitable businesses, and regenerating landscapes in Europe.

EURAF 2024 conference will review recent research and practical results that address those challenges from various points of view, with all sorts of methodological approaches. Discussions in seven plenary keynote speeches and three panel discussion, 20 specific thematic oral presentation sessions (with more than 130 contributions), poster session (more than 100 posters), and several workshops will provide participants with new ideas to enhance our understanding of the potential capacity of the agroforestry approaches to face future crises, together with meeting the challenge of maintaining productivity of European agriculture.

We wish you an enjoyable conference, Vítejte v Brně!
Brno, May 2024

Bohdan Lojka,
Jakub Houška
and the organizing committee

Abstract
Book of abstract from the 7th European Agroforestry Conference 2024 placed under the topic Agroforestry – regenerating landscapes and diversifying production in Europe. Held at Mendel University in Brno, Czech Republic, during 28-31 May 2024.

Keywords
Agroforestry, Biodiversity, Carbon farming, Climate change adaptation, Climate change mitigation, EU policy, Farmers experiences, Landscape planning, Modelling, Silvoarable, Silvopastoral, Soil health, Trees

Keynote speeches

Agroforestry – How farmer experiences shape tomorrow's practise and policy

Mr Stephen Briggs[1]
1 Whitehall Farm, UK

5.1 Farmers Experiences and Adoption (II), Hall Q1, května 29, 2024, 15:45–17:15

The Common Agricultural Policy has shaped how we farm and manage land for more than 50 years. Agriculture and the way in which we manage land is having to change due to climate change, resource and land degradation. These are some of the greatest challenges of our time. Regenerative practices such as agroforestry offer farming and forestry routes to resilience and net zero with the opportunity to become part of the solution rather than being part of the problem.

In many parts of Europe, agroforestry adoption is increasing. Yesterdays climate issues in southern Europe are todays problems in middle Europe and tomorrow's challenges for northern Europe. There is an ever increasing body of research evidence that shows agroforestry can address many of these problems and challenges.

Farmer experiences across a range of diverse climatic and farming systems are invaluable in understanding the barriers to adopting and adapting agroforestry. Understanding what farmers technical, economic and market access needs and support requirement are will be key. Agroforestry requires long term, stable agricultural policy and the needs to address land tenure challenges in many locations. Importantly, mechanisms and approaches to de-risk change at farm level are critical, as are facilitating peer to peer knowledge exchange and creating networks of real-life, farm scale commercial examples of agroforestry, to provide the confidence to farmers, foresters and land managers to adopt agroforestry.

A number of country based and of EU wide programmes are now addressing these needs and building agroforestry into the new CAP and domestic policies is happening. EURAF's influence across agriculture, forestry, science and policy is growing from a niche player to one of increasing importance. Agroforestry is now in the ascendence, but more than ever, sharing, adapting and planting is for today not tomorrow.

"The best time to plant a tree was 20 years ago, the second best time is now"

Chinese proverb

When your kids are much smarter than you: a story of EURAF from the start

Dr Christian Dupraz[1]
1 INRAE, UMR Absys, Univ. of Montpellier, France

Opening ceremony, Aula, 28 May 2024, 10:00–11:00

EURAF, The European Agroforestry Federation, was founded in 2011, and already organised 7 European Agroforestry Conferences in Brussels (Belgium, 2012), Cottbus (Germany, 2014), Montpellier (France, 2016), Nijmegen (The Netherlands, 2018), on-line during covid times (2020), Nuoro (Italy, 2022) and Brno (Czech Republik, 2024). With an ever increasing number of European countries involved (25 countries so far, including Ukraine and Israel), EURAF has become a full player in the European agriculture lobbying scene. Twelve years of action is a short lapse of time, as the task was huge. Trees do not demonstrate on the streets, EURAF stands for them in all political arenas. Significant progresses have been achieved, both at the national policy level and at the European policy level. But the uptake of agroforestry by European farmers is desperately slow. The EURAF target (50% of –European- Farmers adopting agroforestry by 2025) will clearly not be reached. It is high time to reconsider it, and to set new objectives for the next decade.

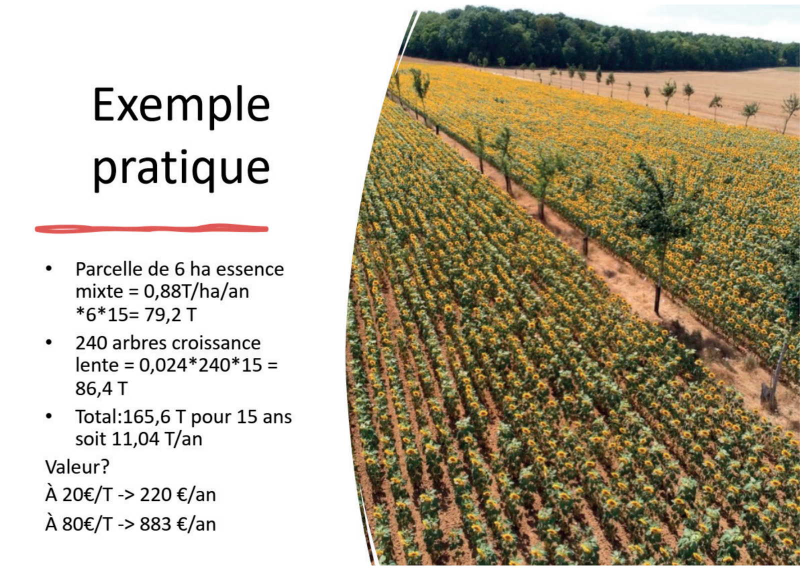
In some countries like France, AF is indeed progressing a lot. In the minds of the man and woman in the street, agroforestry is no longer a weird word. Farmers that adopt agroforestry systems now receive a very positive social recognition. The famous "Concours Général" organised during the "Salon de l'Agriculture" in Paris has now an agroforestry section. More than 1000 French engineers and technicians include agroforestry in their advisory work with farmers. Almost all agriculture high schools talk about agroforestry in their educational programme, and many have an experimental agroforestry plot on their farm. So, why is agroforestry take so slow? Why do we still have only about 10 000 ha of alley-cropping in France? Why do farmers keep destroying hedges? Allow me an hypothetical answer: because trees don't make fast money. Trees work for the future, the distant future. Mostly activist farmers adopt agroforestry. If we aim at a wider diffusion of AF, we cannot expect all mainstream farmers to become activists. The only farmer-driving solution is to make money with trees. In the short term.

This explains why many farmers focus on fruit trees in their agroforestry systems. Or favour hedges that produce significant returns as fire wood in the short term. Or manage hedges that provide a wind-break effect, that is now documented as a true money-earner. This is also why the payments for Environmental Services are so important for the future of AF. And among these payments, the Carbon market is probably the best option right now. Labelling procedures designed for agroforestry are now available in France, and could change the scene for agroforestry. Low C labels ensure higher prices on the Carbon voluntary market. They are now ready-to-use for both hedges and alley-cropping systems in France.

EURAF has a key responsibility in spreading the good news across the European countries borders, and also in pointing the bad news to avoid repeating mistakes. We could be at a tipping point on the way to mainstream agroforestry. But there are dark clouds hanging over: the recent call into question of the European green pact may jeopardize the current efforts. Linking agroforestry and the decarbonation of European farms is probably a smart way to bring back agroforestry at the top of the political agenda. This is more exciting job on the drawing board for EURAF.

Aditional Attachment I.

Awards ceremony for the best agroforestry projects in France (Salon de l'Agriculture, February 2023) with the French Ministry of Agriculture, Marc Fesneau.



Applying the Low C label and certification procedure to an alley-cropping system with slow growing trees.
Estimates of the farmer income at two values of C on the voluntary C market.

Source : RMT Agroforesterie, Patrick Cochard, pers. com., preliminary values, not for use.

Employing the Principles of Life in Dynamic Agroforestry Practice

Dr. Joachim Milz[1, 2, 3]
1 ECOTOP Suisse, Switzerland
2 ECOTOP Foundation, Bolivia
3 ECOTOP-D-UG, Germany

Plenary session: keynote speakers (II), Hall Q1, 28 May 2024, 13:00–14:30

In older translations of the Bible, "subdue the earth" was God's famous call to mankind in the story of creation, which still serves as the basis for interpretations advocating the unlimited exploitation of nature today. As early as the 1960s, the US historian of science Lynn White interpreted this "subjugation" as the root of the ecological crisis, suggesting that Judeo-Christian thinking perceives humanity as the ruler over creation.

The results are obvious, the majority of Earth's nine planetary boundaries (i.e., Climate change, Ocean acidification, Biosphere integrity, etc.), by human activities have now brought humanity well beyond a "safe operating space."

The question arises: How can humanity navigate out of this critical situation? A plausible answer lies in recognizing what distinguishes planet Earth in our universe - life. Understanding the principles of life and applying them to our actions and economic activities, rather than working against them, could provide a path forward.

Sustainability primarily entails ecological sustainability. The ecosystem we inhabit is dynamic, having evolved over three and a half billion years from simple forms to its current complexity. Preserving it is not merely about maintaining its current state but about safeguarding its capacity for development, vitality, productivity, elasticity, and robustness.

Ecosystems are dynamic systems capable of growth, creation, and complexity. Through "ecological succession," they shape their environment and determine their development within their own boundaries.

An extended holistic approach requires a deeper understanding of living systems' properties and contexts, as well as the principles of their functioning. The continuous increase in complex forms of organization and life, along with the conversion and storage of solar energy through photosynthesis, are fundamental principles of living systems.

Dynamic stability in ecosystems relies on a continuous energy supply, mainly through photosynthesis. This energy flow fosters self-organization, complexity, and dynamic stability, resulting in efficient biological energy and nutrient utilization, thus fostering a life-friendly biosphere.

If on the one hand entropy has brought the understanding that all concentrated energy in the universe tends to dissipate, simplify and dissociate, syntropy manifests itself by forming structures, increasing differentiation and complexity, as with life. That is, while the entropy disperses, syntropy concentrates and why life created and maintains the atmosphere on earth. As humans, we would therefore be well advised to integrate ourselves into the principles of life so as not to saw off the branch on which we ourselves are sitting.

Current agricultural and forestry practices often reduce highly complex dynamic systems to mere financial interests, disrupting their functionality. The pursuit of short-term gains leads to increasing instabilities, affecting not only agriculture and forestry but also other aspects of life.

A cultivation method aligned with sustainability criteria is "syntropic farming," also known as "dynamic agroforestry." This approach, developed by Ernst Götsch, is based on the principles of how living systems on earth are organised. Among other things, this means building production systems with species consortia that occupy different life cycles and layers, have a high biomass turnover by maximising photosynthesis, enable permanent ground cover and take into account a high biodiversity.

The overall result leads to a positive energy and life balance and requires no external inputs.

While very positive experiences have been made with this approach in tropical regions, adapting it to temperate latitudes requires, among other things, the development of suitable machinery and a legal framework that promotes agroforestry.

Another major challenge lies in creating production systems that can be adapted to our local agricultural structures.

In the smallholder context of tropical regions, where farming is essentially done manually and on smaller areas, such systems can be set up relatively easily and quickly, especially with permanent crops such as cocoa, coffee or oranges.

Götsch has also experimented with mechanisable forms of cultivation for the large-scale cultivation of soya in Brazil.

Based on experience with dynamic agroforestry in the tropics, there are also more and more promising pilot projects in temperate latitudes. Götsch advised on the development of syntropic cultivation systems at Gut &Bösel, which were implemented by Renke de Vries. Such pilot areas are necessary to develop machines for cultivation, especially pruning and shredding and to optimizing production processes.

ECOTOP financed by Halba/COOP Switzerland established with the Institut of Field and Vegetable Crops, Novi Sad, Serbia the first dynamic agroforestry rows.

Inspired by Götsch, the University of Giessen has also set up scientific trial plots on 8 ha of land.

However, the solution to the problems we have created for ourselves is not to simply plant trees in the landscape, but rather to create production systems that are orientated towards the functioning of living systems and counteract the second law of thermodynamics – entropy.

In other words, syntropic and dynamic farming

Aditional Attachment I.

Aditional Attachment II.

Is it too late to put Agroforestry back on the D&D track?

Mr Rowan Reid[1, 2, 3]

1 Bambra Agroforestry Farm, Australia

2 The University of Melbourne, Australia

3 Originator of the Australian Master TreeGrower, Australia

Plenary session: keynote speakers & panel discussion (III), Aula, 31 May 2024, 10:30–12:30

My own roots

In 1987, I purchased a small farm with the expressed purpose of making forestry, even the act of harvesting for timber, attractive to Australian farmers. 200 years of European settlement had caused widespread soil degradation and devastated our native wildlife. Our farming landscape needed trees and, to address the scale of the problem, they needed to pay their way.

I had just completed my postgraduate research in agroforestry and spent much of 1986 travelling overseas. This included a visit to ICRAF in Kenya. I knew I wanted to be involved in the development of this new discipline, but I hadn't yet found my pathway.

We called it the Bambra Agroforestry Farm and began grazing sheep and planting trees. Our farm would not be a demonstration of 'off-the-shelf' agroforestry options, but a personal story written on our landscape with trees. I hoped to inspire farmers to begin their own tree-growing journey.

The roots of Agroforestry Design

When we planted our first trees my theoretical understanding of the discipline of Agroforestry had been built on ICRAF's Diagnosis and Design model (D&D), as described a few months later by John Raintree in Agroforestry Systems (Vol 5, 1987). I had already rejected all the proposed definitions of agroforestry, including those from ICRAF itself, because they were framed around what the practice looked like or the values it provided. I knew what Raintree meant when he said that a "premature commitment to a particular idea of what agroforestry might be could severely prejudice the development of the field" (Raintree 1987). Looking back, it may have done just that.

Like agriculture, you cannot not define agroforestry by what it looks like, only by whom it involves: farmers. Not knowing is a strength: "from a diagnosis we could discover what it ought to be" (Raintree 1987) and then let agroforestry evolve. Because each farm, and every farming family, is unique, agroforestry will reflect the diversity inherent in that community. We need to focus on how trees might address the needs and aspirations of the farmers themselves. We need to build an agroforestry culture, not just the agro and the forestry.

What this means for Agroforestry Development

Knowing this, all my work–on our farm, within the local community, in the agroforestry subject at Melbourne Univesity and through the Australian Master TreeGrower (MTG) program–has been built on the idea that agroforestry is a process of design rather than adoption. Whilst this approach has been successful in engaging farmers and changing our agricultural landscape, I admit that the same cannot be said for other regions in Australia. The problem, as I see it, lies in the preconceived notions as to what farmers should plant and why, and the reliance on cost-share grants to entice farmers to commit to what the agencies, industry and NGOs now call "the right tree in the right place".

When we set up our Otway Agroforestry Network in 1993, we undertook to not provide funds to farmers to pay for their trees and fences. We would invest the money we were able to secure in building a culture of tree growing. We ran farm walks, mill tours, training days and local farmer education programs (including the MTG). When we saw the influence of peer networks on farmer decision making and their ongoing commitment to their trees, we began training, then paying farmers to talk to farmers about trees (our Peer Group Mentoring program).

The reliance on subsidies to entice farmers to plant the trees we think they need has failed to ignite and fuel a fire of spontaneous agroforestry investment, innovation, and adaptation. Likewise, the focus on the adoption of discrete agroforestry models has disenfranchised the very people who make the ultimate decision as to whether those trees will be protected or managed into the future.

What this might mean for your work

Agroforestry is not a suite of land management options that farmers can chose to either accept or reject. Agroforestry development is a dynamic process of engaging farmers in the creation, and ongoing management, of new landscapes that reflect their current needs and aspirations, and then change overtime in response to changing circumstances. These 'well-treed' landscapes are not created in research laboratories, industry boardrooms or government departments; they evolve from within farming communities. The extent to which the trees that farmers chose to grow deliver the environmental and commercial values sort by others depends on the rewards that reach those who provide them.

Whatever your position or influence, this view of agroforestry should highlight the role that you can play to help realise its great potential.

Aditional Attachment I.

Aditional Attachment II.

Fruit-tree-based silvopasture: potential and limitations

Dr. Adolfo Rosati[1, 2]
1 Council for Agricultural Research and Economics (CREA)
2 Research Centre for Olive, Fruit and Citrus Crops, Italy

2.2 Silvopastoral Systems (I), Hall Q3, 29 May 2024, 8:30–10:00

Introduction
Permanent crops, including fruit trees, are cultivated over about 150 million ha worldwide. The large majority of this area is managed as monocultures, and without livestock integration, unlike in the past. The removal of livestock from permanent crops brought about some drawbacks, such as lack of manure and thus a decrease in soil fertility and soil carbon stock, increasing costs for weed control, and reduced overall productivity of the land. These negative trends can be inverted by reintegrating livestock and permanent crops.

Potential of fruit-tree-based silvopasture
Permanent crops do not intercept all the photosynthetically active radiation (PAR), because of the necessary space between individual plants or plant rows, and/or because the trees are deciduous, thus leafless for part of the season. The PAR not absorbed by the permanent crop promotes weed growth, which is controlled mechanically or chemically, representing a cost, both economically and environmentally. Exploiting this biomass potential with suitable understory crops increases the overall productivity, providing crop diversification opportunities and therefore increasing farm resilience. The shade of the permanent crop could even be beneficial for some crops, especially with climate change and for shade-adapted crops. However, growing understory crops in an orchard presents many difficulties. Growing forages that can be directly grazed can be easier, as it does not require the passage of machinery for harvesting, which can be difficult or impossible amidst the trees. Additionally, tree shade can reduce yield and quality of the harvested part of crops, producing, for example, abundant straw (i.e. before the trees leaf out), followed by little grain, due to increased shade during grain filling. With forages, the whole aerial biomass is used, no matter how shade affects its partitioning into the different plant organs. Forages can be harvested at different times, including before shade becomes limiting. In many areas, green mulching of permanent crops is increasingly adopted to contrast soil erosion and the loss of soil fertility, carbon stock and biodiversity, and to promote soil structure and soil water infiltration and storage. Green mulching of permanent crops is now subsidized within the "eco-schemes" of the Common Agricultural Policy (CAP) of the European Union. The biomass produced by green mulches, whether sown or naturally occurring, can be used as forage.

Forage species can be managed in more flexible manner than most crops, as they can be terminated earlier or later, depending on the permanent crop needs and the seasonal weather: in dry springs the green mulch can be terminated earlier or grazed harder than in wet periods, when the green mulch can instead help against waterlogging and improve field accessibility. The large portfolio of forage species and varieties available provides an opportunity to choose the most suitable green mulch, compatible with the permanent crop needs and limitations. Annuals can be grown in the part of the season when competition with the main (i.e. permanent) crop is less. Perennials can have a dormant season or reduced growth at this time. Legume species can fix large amounts of nitrogen which can be used by the permanent crop: this is increasingly attractive given the increasing costs of fertilizers. Sown green mulches can suppress weeds and then dieback, leaving a dead mulch in the dry season, reducing soil evaporation, water stress, and weed development.

Direct grazing in the orchard can reduce costs for weed management and/or for forage harvesting. Different species have different impacts. Chickens can destroy weeds completely and till the soil superficially. Geese, sheep, and other herbivores can mow the vegetation. Goats and donkeys are better kept out as they usually do too much damage to the trees. Livestock grazing in the orchard also provides fertilization and, in some instances, pest control.

Trees improve livestock welfare and productivity. Tree shade reduces livestock heat stress, which strongly limits livestock productivity, and this is getting worse with climate change. Trees also buffer cold winds and rain. Trees can provide additional forages, with fallen and unutilized fruits, pruning materials, and by-products (e.g. de-pitted olive cake, fruit peels, etc.). Adding this forage potential to that of the green mulch amounts to an important, yet unquantified and mostly unexploited, forage potential from the orchard.

Conclusion

In conclusion, (re)integrating livestock and permanent crops can contribute towards ecological intensification, by increasing overall land productivity and farm resiliency, while reducing the use of external inputs and the environmental impact of agriculture. Agriculture is responsible for about one quarter of anthropic GHG emissions, most of which are related to producing feed for livestock. Using the permanent crop land to provide forage and pasture can help reduce the need for additional agricultural land to produce feed. While this is increasingly recognized, many difficulties persist, due to technical and cultural hindrances. This presentation will illustrate examples of permanent crop/livestock integration, discuss some of the hindrances to its adoption, and suggest ways forward.

Aditional Attachment I.

Sheep and cows feeding on olive pruning materials

What can biodiversity do for agroforestry?

Dr Jo Smith[1]

1 Moinhos de Vento Agroecological Research Centre (MVArc), Portugal

1.3 Biodiversity (II), Hall Q2, 29 May 2024, 8:30–10:00

The benefits to farmland biodiversity of integrating trees and agriculture is highlighted as one of the main selling points of agroforestry. Research comparing biodiversity in European agroforestry and conventional farming has been going on for decades now, leading to a good understanding of the overarching differences between agroforestry and monoculture systems (Torralba et al, 2016; Kletty et al, 2023), primarily reflecting higher system complexity. However, there are still some research gaps, with certain, more challenging, taxa underrepresented in previous research (e.g. bats, soil biota), and the influence of the surrounding landscape and temporal dynamics rarely considered, although recent research aims to address some of these gaps (see abstracts by Ido et al, 2024, and Olaves, 2024, in this book of abstracts).

With a strong evidence base that confirms the value of agroforestry for biodiversity, research is moving now towards a greater focus instead on what biodiversity can do for agroforestry, such as natural pest control, pollination, and nutrient cycling. This is particularly important to provide evidence to farmers who are under pressure to adopt more sustainable practices such as reduced usage of pesticide and synthetic fertilisers, while also facing higher prices for such inputs. Studies show higher abundances of natural enemies and pollinators and lower abundances of pests in some agroforestry systems, but it is more challenging to demonstrate how these differences translate to improved pest control and pollination (Staton et al, 2019). Knowledge on the role of soil organisms to support nutrient cycling, improved soil structure and plant health in European agroforestry systems is also sparse (Rolo et al, 2023), although studies report higher soil microbial biomass, a general indicator of soil health, in agroforestry systems compared with treeless systems (Beule et al 2023). The subsequent impacts of functional biodiversity, the services they provide, and potential trade-offs, on productivity and financial performance at the farm-level is currently lacking, although see Staton et al, 2022.

Going forward, there should be greater consideration of how the design and management of agroforestry systems can be optimised to support functional biodiversity and the delivery of these ecosystem services. For example, what is the best alley width that combines efficient mechanical harvesting of crops with foraging distances of pollinators or predators from tree understoreys? What combinations of tree species and understorey species would provide maximum flowering resources throughout the season for pollinators? Can we increase pest control services by providing nest boxes for birds and bats in new and young agroforestry plantings? What is the best way to manage tree understoreys to support pollination and pest control services? Work by Staton et al, 2021, showed that by reducing the cutting of understorey vegetation to allow flowering, apple trees had fewer aphid-damaged fruit which, combined with reduced mowing costs and additional income from government grants for flower rich areas, increased farm income compared with mown understoreys. Providing such evidence to both farmers and policy makers is key to making the case for agroforestry, not just as a practice that benefits biodiversity, but as a sustainable land use that, through enhanced ecosystem services provided by biodiversity, reduces the need for external inputs or interventions.

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Agroforestry innovation & adoption in the midwest USA

Kevin Wolz[1, 2]
1 Savanna Institute, Madison, United States
2 Canopy Farm Management, Champaign, United States

Plenary session: keynote speakers (II), Hall Q1, 28 May 2024, 13:00–14:30

Agroforestry is a robust natural climate solution with widespread potential across the USA. 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. Together, the Savanna Institute and Canopy Farm Management have been innovating solutions to help overcome these barriers and catalyze widespread adoption of agroforestry in Midwestern USA via strategic research, education, and commercialization. Our goal is to achieve 50 million acres of agroforestry in the Midwest over the next 30 years.

There are several key themes in our work that recently have particular momentum in scaling-up agroforestry systems in the USA:

Tree crop breeding & commercialization

Agricultural research on tree crops has seen systematic underinvestment for more than a century. The handful of major annual grain crops that dominate Midwest agriculture have achieved and maintained their level of ubiquity on the landscape in part through a diverse, well-funded, and long-term agricultural research effort.

The Savanna Institute's Tree Crop Improvement Team aims to level the playing field for perennial producers by investing in research that develops and steadily updates superior crop varieties and agronomic management techniques. This work will involve deep collaboration with universities and for-profit businesses.

We will initially focus on the breeding and genetic analysis of seven key crops selected for their viability and scalability for US markets:

- chestnut (Castanea sp.) & hazelnut (Corylus sp.) - high-value nuts
- elderberry (Sambucus sp.) & black currant (Ribes nigrum) - nutritious small fruits
- black locust (Robinia pseudoacacia), persimmon (Diospyros sp.) & mulberry (Morus sp.) - multifunctional timber/fodder species for silvopasture

Large-scale demonstration of agroforestry practices

Our network of demonstration farms are educational hubs for farmers and the public to learn about agroforestry. Comprising over 400 hectares across 10 locations, these farms also provide a place where our scientists collect tree crop germplasm repositories, conduct variety trials, and show how agroforestry can be practiced within different regions.

One of the newest and largest farms, Hudson Farm in Urbana, Illinois, features:

- A windbreak showcasing a variety of designs for wildlife
- Hardwood timber alley cropping with maize/soy, including a range of alley widths from 18 to 55 m.
- Elderberry, black currant & hazelnut varieties trials
- Pollinator habitat established using innovative methods for USDA cost-share

High-resolution crop suitability mapping

Canopy Compass (CanopyCompass.com) is our new web-based, crop suitability mapping and farm analysis tool built to support decision making in the array of perennial possibilities across US farmland.

Canopy Compass is the first of its kind, harnessing the most comprehensive and scientifically robust aggregation of suitability maps available today - all developed by Savanna Institute scientists and validated by crop experts across the country. More than 80 maps from over a dozen sources are completely free to explore on the tool. In addition, farm-specific reports generated by the site will empower US farmers and landowners with valuable data as a first step when considering new alternatives for their land, avoiding pitfalls, and more thoroughly exploring how to increase economic and ecological outcomes.

The suitability maps on Canopy Compass generate a 'suitability index' for each crop, considering factors like soil preferences, climate requirements, and landscape context. The tool removes the guesswork around: "Can I grow this crop on my farm?". Reports generated by the tool also include:

- Current and historical context of the land
- Environmental concerns
- Agroforestry opportunities
- Soil and climate factors

State-of-the-art tree establishment & management
Canopy Farm Management is our new, for-profit company that provides tree planting and management services to farmers and landowners in the Midwest USA. Canopy establishes perennial crops, timber plantings, conservation practices, and integrated agroforestry systems. It combines expert staff, thoughtful design, and a mobile fleet of farm equipment to cost-effectively establish and manage profitable, diverse, and resilient agroecological systems.

Canopy utilizes state-of-the-art tree establishment and management methods, enabling scale and efficiency in agroforestry adoption that have not been seen before. The tree establishment and management fleet is designed for:

- Safe & inclusive ergonomics
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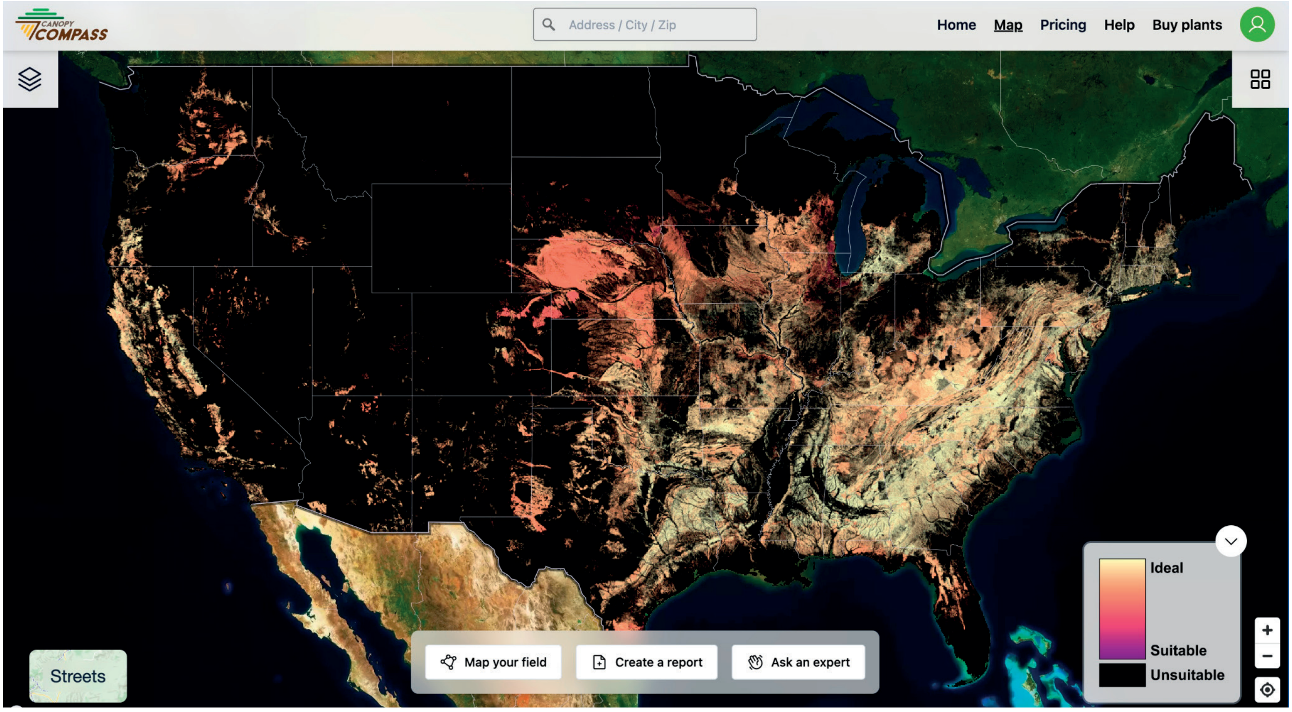
- Capability to plant/work day or night, maximizing the short spring planting season
- Organic & conventional establishment/management options
- Minimal soil compaction & disturbance
- GPS coordinates of each tree are logged for future monitoring/verification

Aditional Attachment I.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A Global Assessment of Carbon Sequestration Potential of Agroforestry and Increased Tree Cover on Agricultural Land

Dr. Robert Zomer[1, 2], Jianchu Xu[2, 3], Antonio Trabucco[1]

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2 Centre for International Forestry Research and World Agroforestry (CIFOR-ICRAF), East and Central Asia Regional Office, Kunming, China

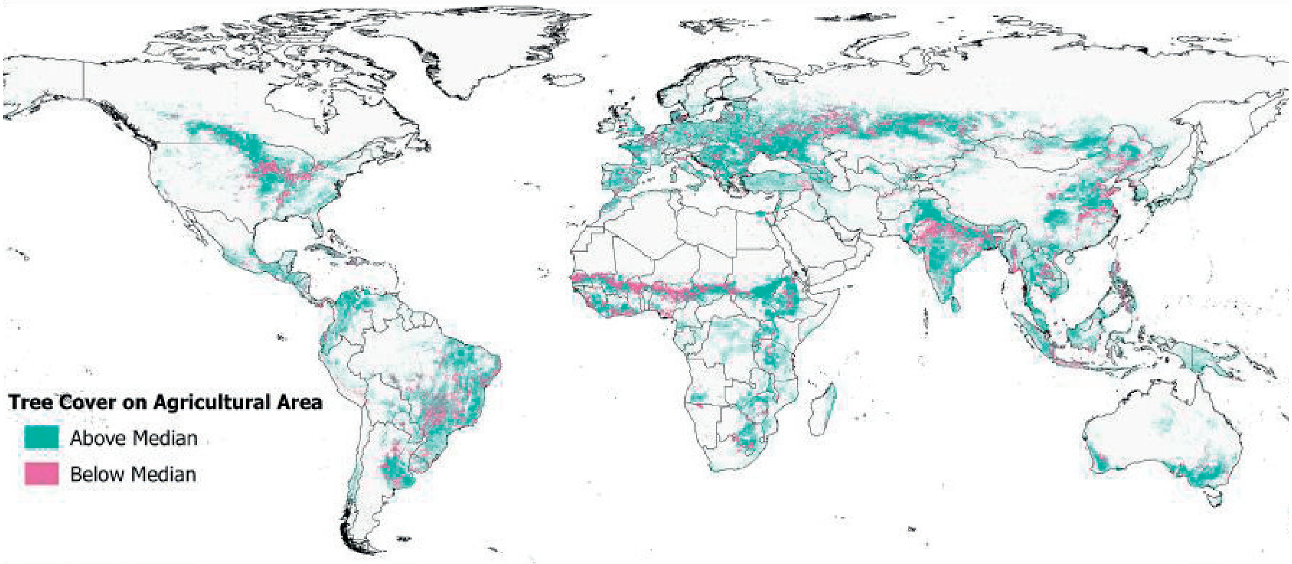
3 Center for Mountain Futures, Kunming Institute of Botany, Chinese Academy of Science (CAS), Kunming, China

Plenary session: keynote speakers & panel discussion (III), Aula, 31 May 2024, 10:30–12:30

Rapidly accelerating climate change in ecosystems and environments all across the globe are projected to have major implications on biodiversity, ecosystems, farming and pastoral systems, and protected areas, creating major challenges for global agriculture and food security. The need for a transformation of global food systems is now generally recognized. Positive opportunities for small farmers and agricultural communities are urgently required to develop climate change adaptation and sustainable development pathways while improving livelihoods and socio-ecological resilience. Among the many trade-offs that sustainable landuse systems must address and provide are included, notably, maintaining and improving food security and nutrition for urban populations and agricultural communities, conserving watershed functioning and slope stability for downstream users, improving soil health, increasing carbon sequestration for climate change mitigation, biodiversity conservation, and many other ecosystem services. Agroforestry systems seek to fulfill many of these functions through multi-functional approaches and the inclusion of trees for various roles and purposes into farming systems.

The recently released IPCC Mitigation report placed agroforestry as one of the top three Agriculture, Forestry and Other Land Use (AFOLU) mitigation pathways, noting that it delivers multiple biophysical and socioeconomic co-benefits such as increased land productivity, diversified livelihoods, reduced soil erosion, improved water quality, and more hospitable regional climates, concluding there is 'high confidence' in agroforestry's mitigation potential at field scale. As such, agroforestry is one of the most cited nature-based solutions in development strategies and in reporting of nationally determined contributions (NDC), both for its potential mitigation benefits, but not least for the adaptation, resilience and livelihood benefits it can provide, across scales from agro-industrial farming to small farmer holdings. Here we present global and regional estimates of tree cover, tree cover change trends, and above- and below-ground biomass on agricultural land based upon IPCC Tier 1 estimates (Zomer et al. 2016). Results are then compared with an updated carbon density map based on remote sensing and extensive ground-truthing, indicating that the methodology and initial estimations appear to be robust at the global scale. Two future scenarios are evaluated to estimate carbon sequestration potential of increasing tree cover on agricultural land: 1.) incremental change and 2.) a systematic change to a agroforestry system where trees are incorporated as central to the production system. Estimates of above- and below ground biomass carbon were combined with a previous remote sensing-based tree cover analysis (Zomer et al. 2022) to estimate the increase in biomass. Global increases (4-6 Pg C for incremental change; 12-19 Pg C for systematic change) highlight the substantial mitigation potential of increased tree cover on agricultural land. Increasing global tree cover on agricultural land by 10%, or 1% per year for 10 years, would sequester more than 18 Pg C over a decade. Regional analysis shows South America has the highest potential for increasing above- and below-ground biomass carbon on agricultural land, followed by Southeast Asia, West and Central Africa, and North America. Brazil, Indonesia, Philippines, India, the United States and China are among the top countries with the highest potential. Additionally, we provide an overview and analysis of the unique and significant contribution agroforestry can provide in mountainous regions and in reducing pressure on irrecoverable carbon and irreplaceable ecosystems (Zomer et al. 2023).

Aditional Attachment I.



Map of tree cover on agricultural land showing areas of above- and below- median values of percent tree cover in the year 2010, as estimated within 495 distinct above-and below-ground carbon strata globally, stratified based on eco-floristic and aridity zones.

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Theme 1: Agroforestry and Environment

1.1 Climate Change Mitigation

Oral presentations

Hall Q2, 29 May 2024, 14:00–15:30

Carbon balance of two beef cattle farms: integration of LCA methodology and offset tools in agrosilvopastoral system

Matteo Finocchi[1], Fabrizio Giuseppe Cella[1], Ricardo Villani[2], Alice Ripamonti[1], Jacopo Goracci[3], Alice Cappucci[2], Alessio Del Tongo[3], Roberto Tistarelli[4], Marcello Mele[1,5], Alberto Mantino[1,5]

1 University Of Pisa, Pisa, Italy
2 Tellus srl, Pisa, Italy
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4 Azienda agricola Aia della Colonna, Roccalbegna, Italy
5 Enrico Avanzi Agro-environmental research center, Pisa, Italy

Introduction

The necessity to reduce the environmental impacts of agriculture is underscored by its substantial contribution of 31% to total anthropogenic greenhouse gas (GHG) emissions (FAO, 2022). The GHG emission associated with ruminant productions can be mitigated through effective feeding, management, and genetic strategies. On the other hand, emissions could be offset by implementing farming systems able to sequestrate carbon, such as agroforestry. Currently, Life Cycle Assessment (LCA) is the standardized methodology for quantifying emissions based on specific metrics. Extensive livestock farming systems have higher emissions in terms of CO2 equivalent per kilogram of live animal body weight (LBW) compared to intensive systems (Bragaglio et al., 2018). On the other hand, agrosilvopastoral systems can generate several agroecosystem services (Torralba et al., 2016). The objective of the current study was to explore both carbon release and sequestration associated with agrosilvopastoral systems applied in two farms in a Mediterranean environment.

Materials and Methods

In the reference year 2022, we conducted an LCA analysis with a system boundary "from cradle to farm gate", focusing on beef cattle farming. The functional unit considered was 1kg of LBW of slaughtered animals. The study included two farms located in southern Tuscany, Italy, in the Maremma region: farm 1 adopt a cow-calves line for reproductive phase in an agrosilvopastoral system; the subsequent phase of calves fattening is pasture based with and integration mix self-produced composed by cereals (1% per 100kg LBW) and hay. The age of slaughtering is around 22 months with a final LBW around 450kg.

Farm 2 adopt a cow-calves line for reproductive phase in an agrosilvopastoral system; the subsequent phase of calves fattening is indoor until slaughtered age, 22 months and a final LBW around 550kg. In this farm the feeding strategy for fattening phase consist in self – produced forages and commercial concentrates composed by cereals and legumes grains.

In the year 2022, cows didn't been slaughtered due to an increase in reproductive heads in both farms.

The LCA methodology followed ISO 14040:2006 and 14044:2006 standards, along with PCR: Product Category Rules 2012:11 - "Meat of mammals," defining guidelines for Environmental Product Declaration (EPD) certification. A questionnaire was administered to collect data on the production process: herd composition, feed management, fuel and electricity consumption.

The data were processed with OpenLCA version 1.11.0 by Greendelta to assess the environmental impacts related to both farms. The equations used for the estimation of enteric fermentation estimation were based on the CNCPS (Cornell Net Carbohydrate and Protein System) dynamic nutritional model, while emissions from manure management were calculated using the equations proposed by IPCC (Intergovernmental Panel on Climate Change). The compensation phase was carried out utilizing the Italian national forest inventory (Gasparini et al., 2022) along with forest management practices.

Results

The results showed that farm 1, employing pasture-based fattening, had higher CO2 equivalent emissions per kg of LBW compared to farm 2, (27.79 kg CO2 eq kg LBW-1 and 16.78 CO2 eq kg LBW-1 for farm 1 and farm 2, respectively): this is caused by an higher methane production by animals, due to an high fiber content animal diets in farm 1 respect to farm 2 (Buccioni et al., 2012).

Given the management practices as high forest, localization and tree species present in both farms (Q. cerris, Q. pubescens, Q. ilex), the average annual carbon offset value accounted for 4.04 Mg CO2 ha-1 yr-1(Gasparini et al., 2022)). Considering the total impact of the two farms in terms of CO2eq, which was 575 and 285 Mg CO2eq, for farm 1 and farm 2 respectively, the amount of woodland required to ensure a complete offset of emissions, would be 142 and 71 ha, respectively. Considering the woody areas of the two farms, we can affirm the existence of adequate surfaces for carbon storage, effectively rendering CO2 emissions negligible. To accurately assess the carbon balance at farm level, further investigations are currently underway to evaluate the amount of carbon emitted by farms through the sale of timber and the impacts of forestry practice related to timber harvesting.

Conclusions

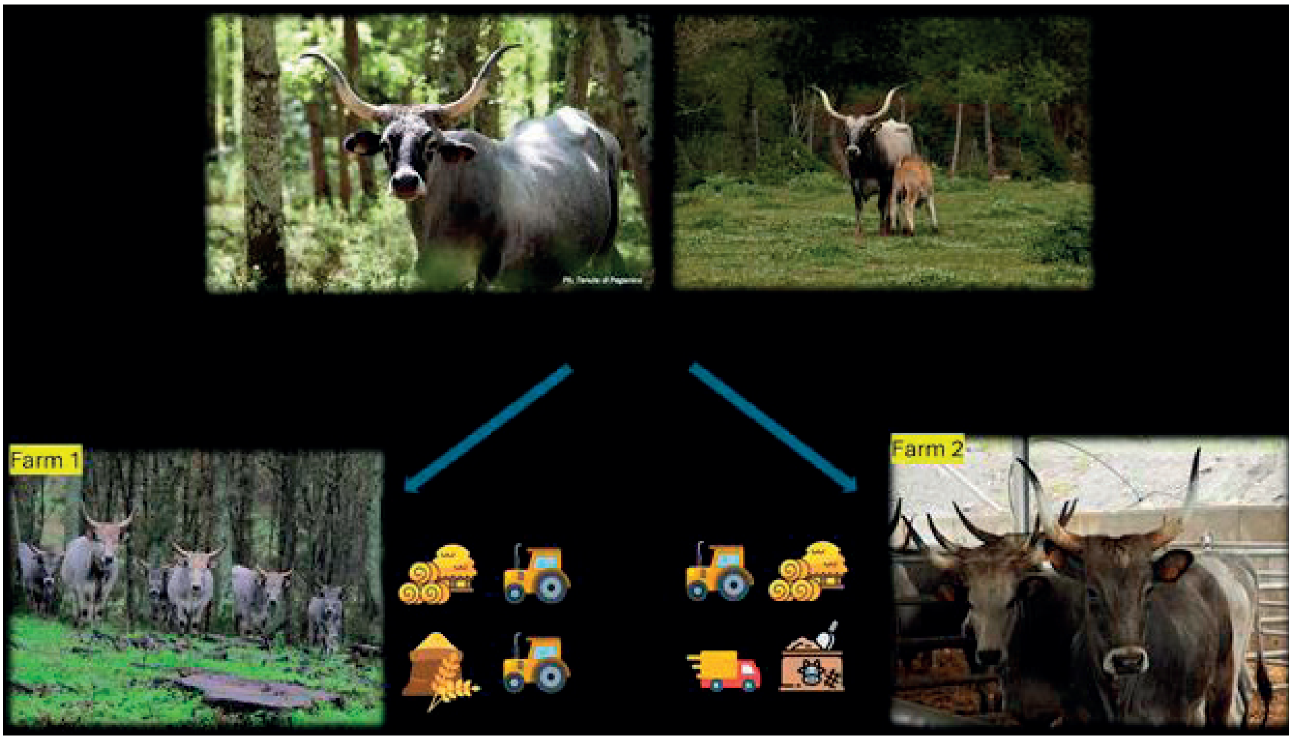
Based on our findings, we can conclude that in agrosilvopastoral farms, it is crucial to quantify both the carbon emissions and offsetting potential through grazed forest areas. Our results reveal substantial differences in terms of GHG emissions among the investigated farms but in line with Bragaglio et al., 2018 for an extensive system. Furthermore, grazed woodland areas play a key role in offsetting a significant proportion of GHG emissions. The results indicate that feeding strategies and woody areas utilized for animal grazing are crucial in both GHG emissions and carbon offsetting.

Preserving animal biodiversity and traditional knowledge are also key priorities for sustainable development of rural areas, and the rearing of Maremmana cattle in semi-extensive farms contributes to achieving these objectives.

Keywords

silvopasture, grassland, grazed woodlands, silvopastoral, Grassland with trees, livestock production, Living lab

Aditional Attachment



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Potential contribution of agroforestry to carbon sequestration in the LULUCF inventory of the UK: A case study in Northern Ireland.

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1 INTERRA Research Institute, Universidad de Extremadura, Cáceres, Spain

2 Agri-Food and Biosciences Institute, Hillsborough, United Kingdom

Introduction

During the past few decades, agroforestry (AF) systems have been recognised as more climate resilience system not only as an approach to sustainable land use practice owing to its production and environmental benefits, such as improving soil health and biodiversity, stabilizing slopes, reducing erosion, and increasing the overall resilience of farming systems to extreme weather events (Chemura et al. 2021), but also as a strategy to climate change mitigation.

In the context of climate change, the Land-Use, Land-Use Change and Forestry (LULUCF) sector in the UK Greenhouse Gas (GHG) Inventory reports (UK DESNZ 2023) uses broad definitions of six land use categories, like all Annex I parties to the Convention (UNFCCC 1992), which is based on IPCC reporting guidelines: Grassland, Cropland, Forest, Wetland, Settlement and Other Land (IPCC 2006).

However, the current reporting modalities do not credit agroforestry as a separate land use category. Instead, it is either not considered at all or included/accounted as part of forest land, cropland, grassland, or other land category. Where AF systems seem to have a different higher/lower sequestration rate than these categories. This contravene with the core principle of Good Practice Inventories (GPI), which states that GPI are "those contain neither over – nor under –estimates so far as far can be judged, and in which uncertainties are reduced as far as is practical" (IPCC 2019).

Objective

This study aims to investigate the potential contribution of AF systems to carbon sequestration as part of the LULUCF sector of the UK's GHG inventory to ensure that all local carbon (C) sequestration activities can be considered for future and accurate inventories of GHG emissions by source and removals by sink.

Methodology

The methodology (Figure 1) for the estimation of the potential contribution of AF systems to C sequestration in the LULUCF inventory in the UK was based on an experimental database obtained from two AF trials: one consisting of 3 silvopastoral plots (permanent grassland cover, 400 tree ha-^{1} and stocking rate of 12 sheep ha -^{1}) and 3 woodland plots (2500 tree ha-^{1}). The trials were established in 1989 in Loughgall (Figure 2), Northern Ireland, as part of UK's National Network Experiments scheme (Fornara et al. 2018).

Figure 1. Research framework for the estimation of the potential contribution of AF systems to C sequestration in the LULUCF inventory in the UK.

Figure 2. Location of the AF trials in Loughgall, Northern Ireland, UK.

Biomass figures calculated from tree height and diameter (1989-2017) were used to calculate AF carbon sequestration rates under experimental conditions according to the methodologies proposed on 2006 IPCC guidelines (AFOLU). These rates where then compared to other land-use categories reported in the LULUCF sector of the UK GHG inventory of the forest land, cropland, and grassland for the years 2010-2021.

Preliminary results

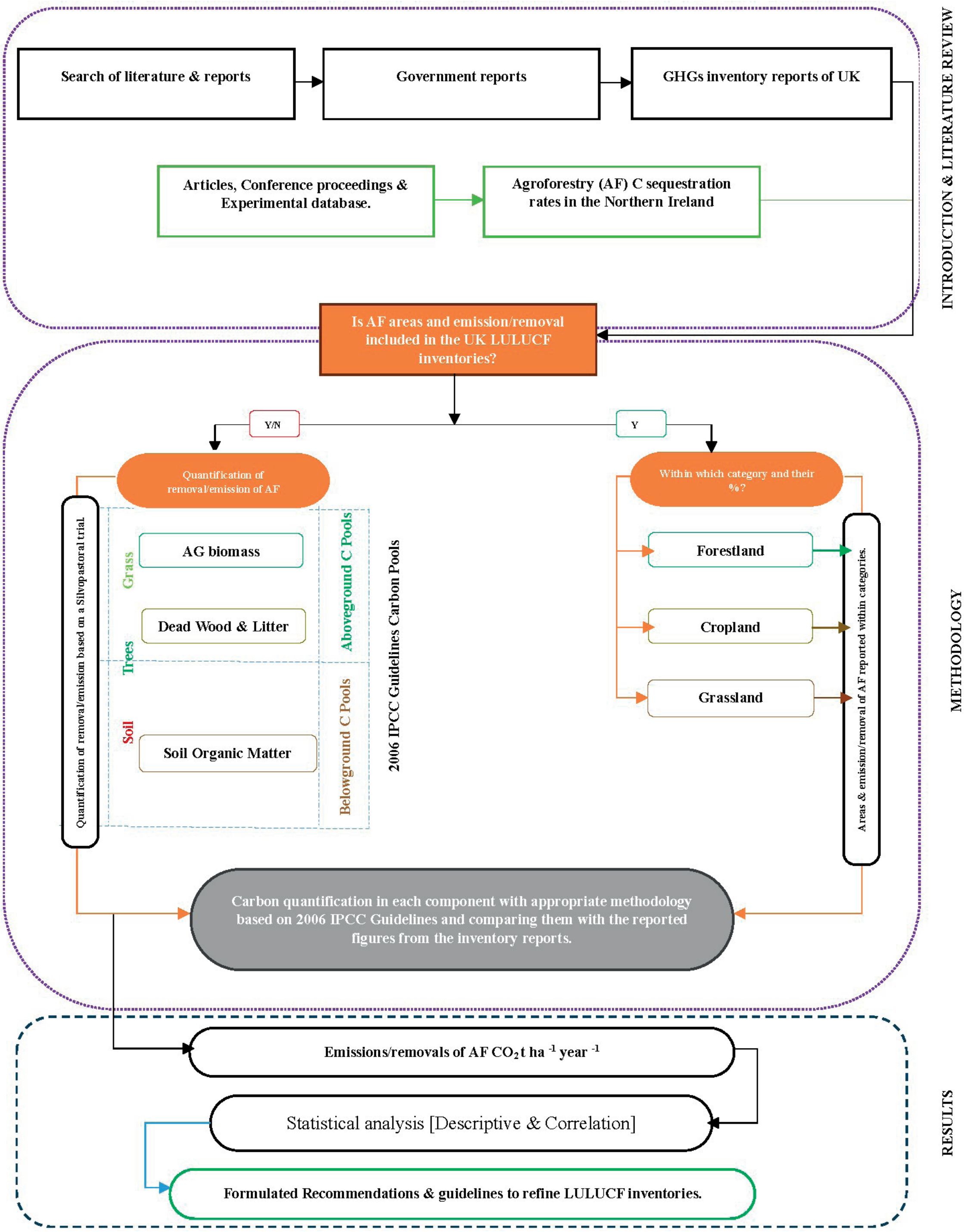
It has been indicated that the tree component of the silvopastoral and woodland trials alone (excluding C sequestrated by soil, grass and dead organic matter) could sequester up 3.1- 4.3 t CO_2 ha-^{1} year-^{1} and 8.7 -16 t CO_2 ha-^{1} year-^{1}, respectively. While C sequestration figures reported in UK's inventory reports (2010 –2021) of forest land were ranging from 4.8 - 5.3 t CO_2 ha-^{1} year-^{1} (Figure 3). These findings are in line with Bernal et al. (2018) who stated that planted forests and woodlands could have the CO_2 removal rate, 4.5 – 40.7 t CO2 ha-^{1} year-^{1} during first 20 years of growth.

Figure 3. Emissions and removals (in negative values) per hectare from the LULUCF categories, in the UK's GHG inventories, between 2010 and 2021: forest land, cropland, and grassland.

Conclusions
The sequestration rates measured under experimental conditions in Northern Ireland suggested that agroforestry act as a carbon sink, which has implications for the LULUCF sector of the UK GHG inventory. Furthermore, if the rate of C sequestration in the range of agroforestry ecosystems and scenarios of land use change are to be estimated, information on activities and net change in land use are inadequate to assess the implications of land use change on changes in soil carbon stocks.

Keywords
Agroforestry, carbon sequestration, GHG emissions, land use change

Aditional Attachment I.



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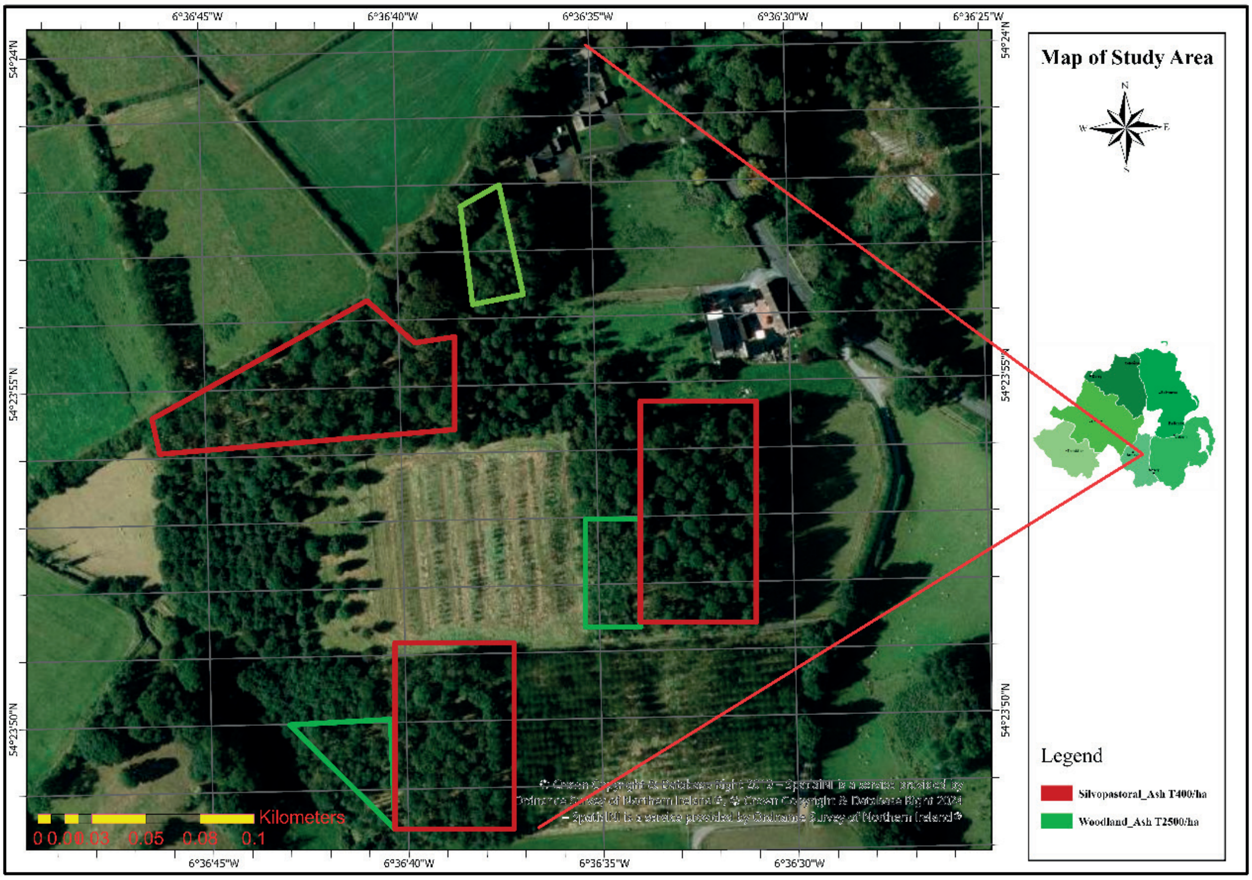

Figure 2. Location of the AF trials in Loughgall, Northern Ireland, UK.

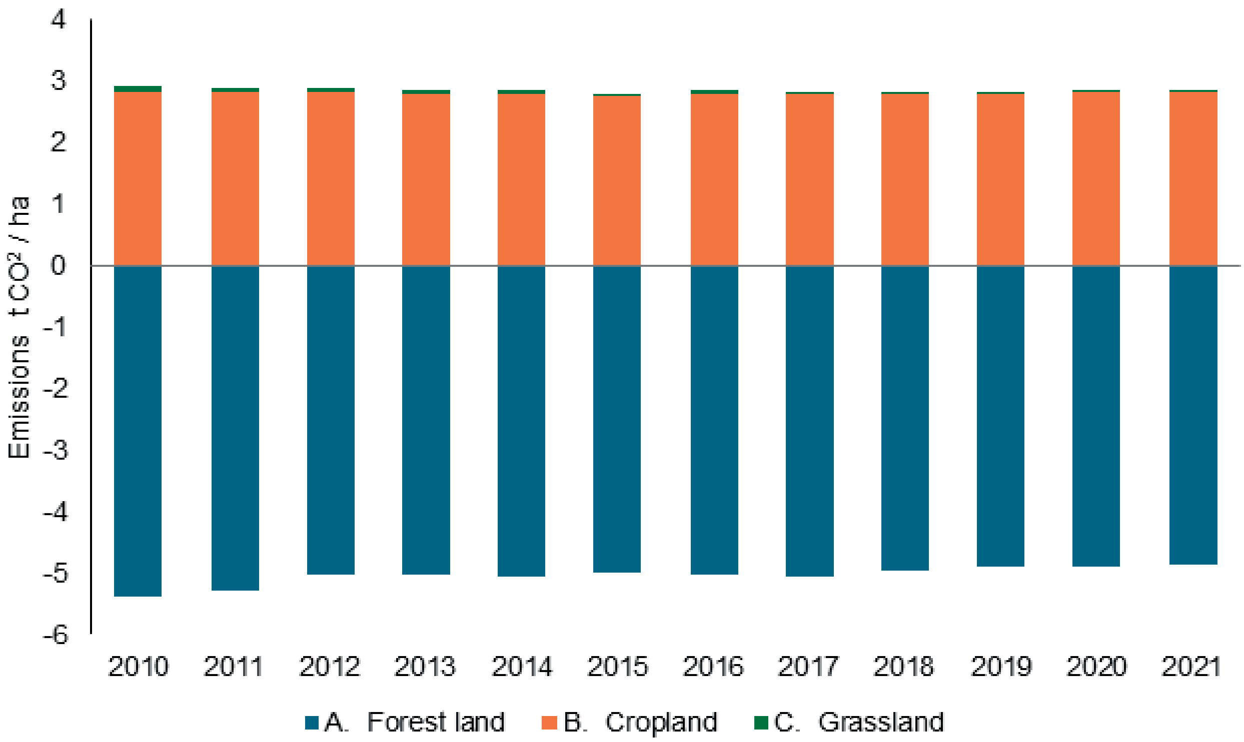

Figure 3. Emissions and removals (in negative values) per hectare from the LULUCF categories, in the UK's GHG inventories, between 2010 and 2021: forest land, cropland, and grassland.

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The extent of small woody features in German agricultural landscapes and their role in the national carbon budget

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Introduction

The land sector accounts for approximately a quarter of global greenhouse gas (GHG) emission, with around 50% arising from agriculture (Roe et al. 2019). At the same time, the intensification of food production systems has resulted in landscape simplification, with trees and hedges disappearing from agricultural land, principally in industrialized countries (Nerlich et al. 2013).

Within global efforts to reduce GHG emissions and enhance carbon sequestration, the German government aims to achieve carbon neutrality by 2045, e.g. by enhancing carbon sinks in soils and support forestry-related ecosystem services to combat global climate change (Cabinet of Germany 2022). Beside forests, also agroforestry systems and small woody landscape features (SWFs), e.g., hedgerows, woodlots, and scattered groups of trees, have a great potential to sequester carbon compared to agricultural production without trees (Zomer et al. 2016) and therefore contribute to reducing GHGs in the atmosphere while enhancing landscape ecosystem services.

Objectives

Our study was aimed to assess the extent of SWFs embedded within German agricultural landscapes, including cropland, grassland, vineyards and orchards, estimate their existing carbon stocks, and investigate the potential for increasing agroforestry cover to offset agricultural GHG emissions.

Methodology

We analysed open-source geospatial datasets (Copernicus Small Woody Features 2015 and CORINE Land Cover 5 ha CLC5 2015) for the extent of trees and shrubs in German agricultural area. SFWs were categorized in linear, patchy and additional characteristics. For all categories we estimated the carbon stored in above and belowground biomass (ABG C according to Wellbrock et al. (2017) and BLG C as a fraction of ABG C (Drexler et al. 2021)) and the corresponding soil carbon stock according to available literature values (see Golicz et al. 2021). Finally, we created scenarios of wide agroforestry adoption (according to the main temperate agroforestry structures, i.e. hedgerow, silvoarable and silvopastoral systems, orchards and vineyards) in 1%, 5% and 10% of the total German agricultural area to estimate the potential for carbon sequestration in biomass.

Results

We identified over 900,000 hectares of SWFs on agricultural land, equivalent to 4.6% of the total farmland. These were predominantly not agroforestry systems in sensu strictu, but groups of trees and hedgerow allocated beside and along cropland and grassland edges.

Cropland was found to have the lowest SWF density relative to their large coverage over Germany. Grassland, which contributes to the second largest area in German agricultural land, had the highest area of SWFs corresponding to more than half of the total area of SWFs. Linear features, e.g. hedgerows, were the most abundant type of SWFs.

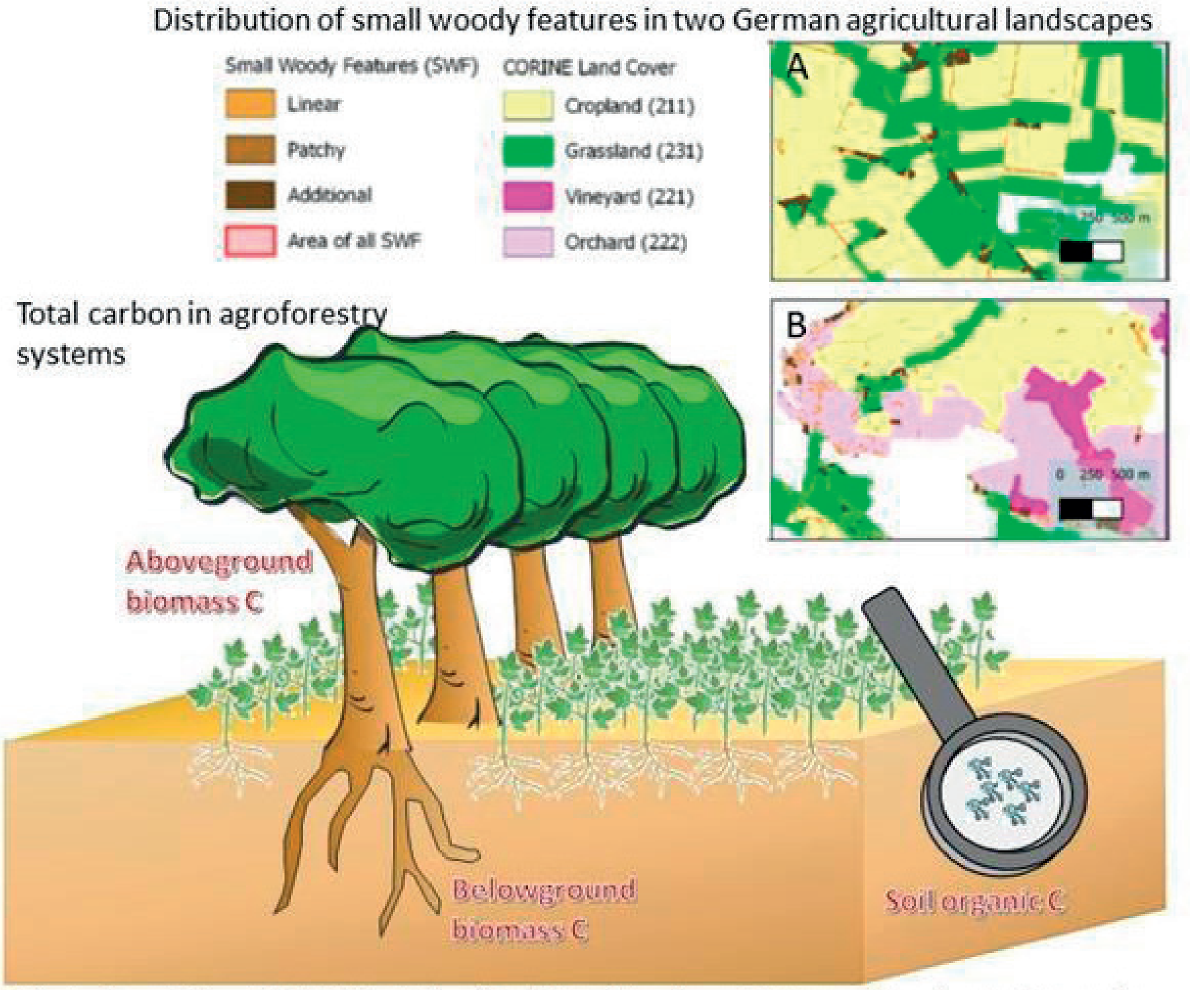
The total carbon storage of SWFs was estimated at 111.1 ± 52.5 SD teragrams of carbon (Tg C), which was previously unaccounted for in national GHG inventories. 67% of this C was stored in the soil and 33% in the total biomass of the SWFs, but still the biomass C was equal to 24% of the estimated annual cropland biomass carbon.

The implementation of agroforestry (silvoarable systems or hedgerows) in German agricultural land can result in a maximum C sequestration of 0.1 to 14.0 Tg C across their espected maturity cycle of 30 year. Installation of hedgerows was estimated to have to largest effect on additional carbon sequestration, followed by silvoarable and silvopastoral structures. Existing perennial systems (vineyards and orchards) were found to benefit only little from additional tree structures on a national basis. Annual sequestration rate were estimated between 0.005 Tg C (for hedgerows along vineyards in the 1% scenario) and 4.8 Tg C (for hedgerows implemented in cropland in the 10% agroforestry scenario).

Conclusion
The study highlights that country-specific data are urgently needed to refine existing C stock estimates and to improve GHG inventories and national budgeting. The large-scale implementation of agroforestry in Germany can increase carbon sequestration on agricultural land that has the potential to contribute to the national carbon budget, e.g. the adoption of hedgerows on 10% of German croplands can sequester carbon corresponding to around 7.5% of German 2019 agricultural GHG emissions. The reduction of annual crop production and potential leakage effects have to be considered. Calculated values base on literature values. Since data from German agroforestry systems' carbon sequestration is still limited and rely on heterogeneous agroforestry system design and pedoclimatic conditions, the uncertainty of the results remains high.

Keywords
carbon sequestration, carbon storage, wooded linear features, GHG emissions, aboveground carbon sequestration, soil carbon sequestration, climate change mitigation, hedgerows

Aditional Attachment II.



Adopted from Golicz et.al (2021) The Role of Small Woody Landscape Features and Agroforestry Systems for National Carbon Budgeting in Germany. Land 10:1028. https://doi.org/10.3390/land10101028

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Quantification of carbon in soil and woody biomass with the CARbon Agroforestry Tool “CARAT”

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2 Soil Service of Belgium (BDB), Leuven, Belgium, 3UGent Forest & Nature lab (Fornalab), Gontrode, Belgium

Introduction

The potential of agroforestry (AF) for carbon sequestration in both soil and woody biomass has been thoroughly shown in past research (Drexler et al., 2021; Mayer et al., 2022; Zomer et al., 2016). However, existing research simultaneously demonstrates the high dependency on a multitude of factors such as tree species, AF system design, soil conditions and climate (Mayer et al., 2022). This results in a broad range of observed and predicted amounts of sequestered carbon. To optimize the carbon sequestration potential of a specific AF field and to allow upfront financial compensation in case of carbon farming, a detailed field-level estimation of carbon stocks is necessary. This includes the spatiotemporal variation in woody biomass and soil organic carbon (SOC).

Objectives & Methodology

The CARbon Agroforestry Tool “CARAT” is an online tool developed by the Soil Service of Belgium (BDB), UGent and ILVO. It is implemented in the software program R, and developed as an interactive app using the Shiny package (R Core Team, 2023). The primary goal of CARAT is to aid famers, researchers, advisors and/or policy actors in quantifying above- and belowground carbon stocks of a specific AF field in temperate climatic conditions, and to predict how these stocks change over a period of 30 years. Thereto, the user can either define a rectangular field or select a field from the map integrated in the tool, the latter being based on the Flemish Land Parcel Identification System (Figure 1A). The resulting field is divided into a grid, whereby a tree can be positioned in each of the grid cells (Figure 1B). Given the small cell-size of $1m^2$, high flexibility is possible when designing an AF system to be simulated (e.g. orchard, alley cropping, boundary planted, …).

At present, the tool is aimed at simulating AF systems that consist of high pruned solitary trees. Choice between 20 different tree species is made possible, including a “standard” option in case the tree species is not yet known. For each tree in the simulation, the woody biomass and related carbon stock is modelled based on species-specific diameter at breast height (DBH) growth curves and allometric relations for solitary growing trees. Aforementioned DBH curves were developed by fitting a logistic relation to tree monitoring data extracted from literature. To estimate aboveground woody biomass, allometric relations for each of the tree species in the model were deduced based on the relations for similar tree species growing in AF conditions as described by McPherson et al. (2016), Shafer et al. (2019) and Hjelm & Johansson (2012). To account for the belowground woody biomass, a root:shoot ratio of 0.26 was assumed (Cairns et al., 1997).

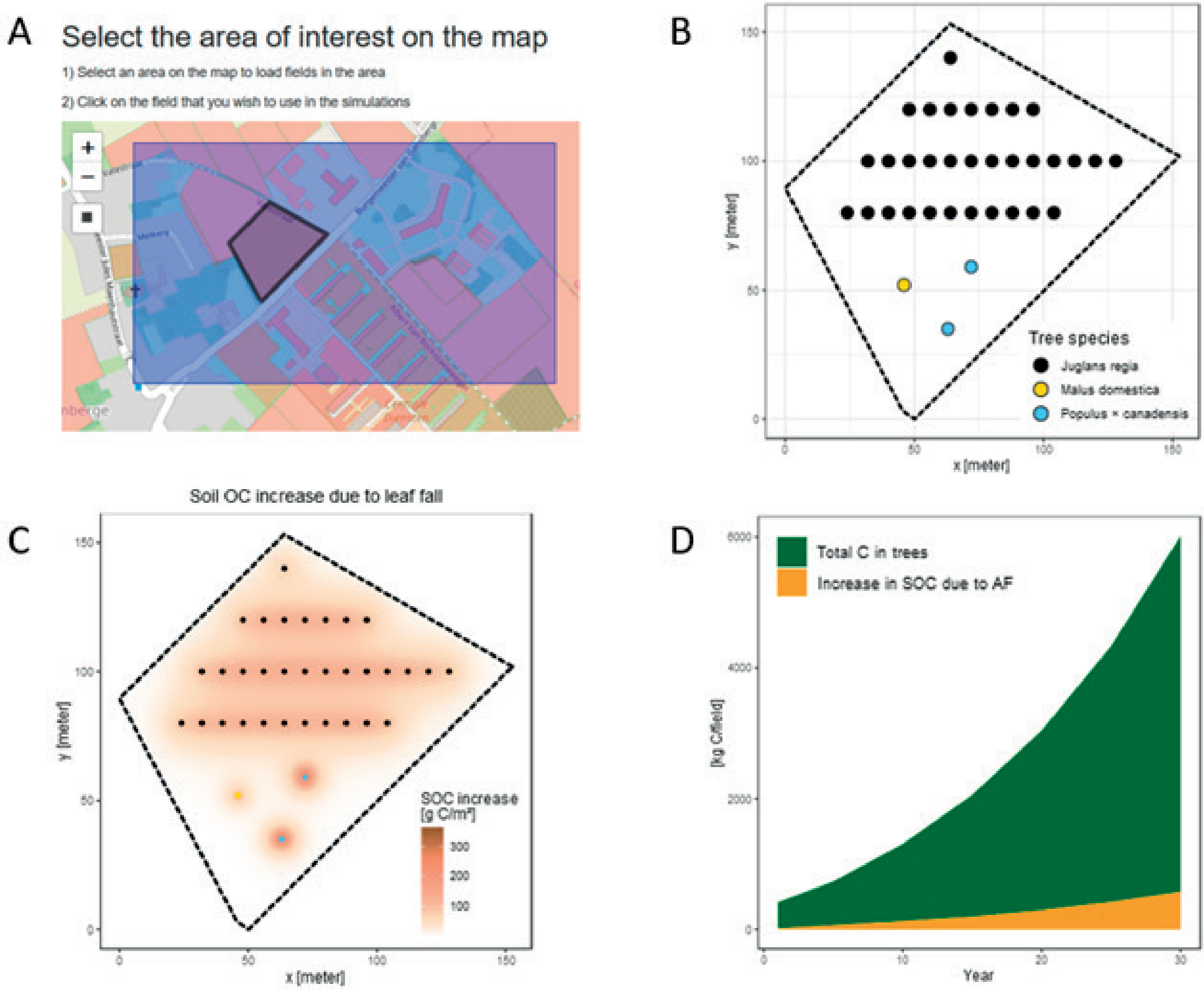
To estimate the evolution of soil carbon stocks in an AF system, the effect of tree leaf litter input to the soil is simulated for each grid cell and each year. The spatial pattern of leaf litter distribution is based on the model developed by Ferrari and Sugita (1996). Using the method of Peltre et al. (2012), the labile (fdpm), resistant (frpm) and humified (fhum) fraction is determined. Based on these fractions, a DPM:RPM ratio for each of the tree species in CARAT is deduced, which is then used as input to the RothC-model in order to quantify the transfer of organic carbon from the leaf litter to the soil. Field specific parameters (e.g. bulk density and initial SOC%) can be specified to improve the correctness of the simulation. At present, carbon fluxes originating from tree root decomposition and/or root exudates are not included in the model.

Output and future steps

The user is provided with a field-scale map showing heterogeneities in SOC owing to tree presence (Figure 1C), as well as an estimation of above- and belowground carbon stocks at field level and their evolution through time (Figure 1D). In addition to future improvements to the interface and user-friendliness of the tool, one of the main focusses will be increasing the number of tree species and of the types of AF systems that can be simulated, in particular the inclusion of systems with hedgerows and coppiced trees. Although at present not included, the effect of altered agricultural crop yields as a result of tree presence and their consecutive effect on SOC through the input of crop residues will be incorporated in the model. Finally, model parameters and outputs will be further validated based on comparison with field data of SOC, tree growth (DBH), leaf litterfall distribution and crop yield monitored in temperate agroforestry systems.

Keywords
soil organic carbon, R-shiny app, solitary high-pruned trees, carbon sequestration, temperate agroforestry, leaf litter, wood biomass, simulation model, species-specific

Aditional Attachment II.



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Dynamics of soil organic carbon in afforested land depending on stand age, soil type, and tree species

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Introduction

To ensure sustainable forest management and increase carbon sequestration and biodiversity protection, afforestation of agricultural land has gained importance in recent years (Bárcena et al. 2014; Nave et al. 2019; Mayer et al. 2020). Previous studies have shown the effects of afforestation on soil organic carbon (SOC) stocks, with varying results, including decreased, increased, or unchanged levels compared to previous land use (Guo & Gifford 2002; DeGryze et al. 2004; Smal et al. 2019; Strand et al. 2021). SOC accumulation depends on local climate conditions, soil type, texture, and tree species composition (Vesterdal et al. 2013). Short-term effects may lead to decreased SOC stocks, followed by an increase reaching forest levels several decades after afforestation. Lithuania, aligning with global climate change mitigation goals, prioritises afforestation of abandoned arable land, mainly those unsuitable for farming, to increase forest cover.

Objectives. This study investigated SOC stocks after afforestation in nutrient-poor Arenosols and nutrient-rich Luvisols, comparing them with croplands and grasslands in Lithuania, representing the European hemiboreal forest zone.

Methodology

SOC stocks in Arenosols and Luvisols were assessed in afforested agricultural land, grassland, and cropland in Central and Southern Lithuania. SOC stocks in afforested land were analysed across different age groups (1–10 years, 11–20 years, and 21–30 years) for coniferous and deciduous forest stands, including Lithuania's most prevalent tree species. According to the Lithuanian Statistical Yearbook of Forestry (2021), Pinus sylvestris L. covers 34.5 %, Picea abies (L.) Karst. 21.1 %, and Betula sp. 21.9 %). A paired-site design was used, and SOC stocks in afforested sites were compared with those in the control sites (grassland with permanent meadows and pastures or cropland with different crops like wheat, barley, oats, and rye) on the same soil types. In total, 254 plots were sampled from temporary sample plots. Control sites were selected in adjacent cropland or grassland.

To determine the mass and SOC concentration, the forest floor [layer of organic residues such as needles/leaves, branches, and bark in various stages of decomposition – annual litter, fragmented and humified litter, situated on the top layer of the mineral soil] and plant litter in perennial grassland were sampled within a 25 × 25 cm metallic frame. The mass was analysed according to the ISO 10694:1995. The mineral soil samples were analysed for bulk density (g cm–3) (ISO 11272:1998). Forest floor and mineral soil samples were analysed for SOC concentration (g kg–1) (ISO 10694:1995), and SOC stock (t ha–1). The SOC stocks in 0–30 cm mineral topsoil (0–10 cm and 10–30 cm) were calculated.

Results and Conclusion

The main findings showed that the forest floor mass and SOC stocks increased more in afforested Arenosols than in Luvisols, with coniferous stands showing double values in the forest floor mass and SOC stocks compared to deciduous stands after 2–3 decades. Afforested sites showed lower soil bulk density and higher SOC concentrations in the 0–30 cm mineral topsoil layer, especially in 21–30-year-old stands. In Luvisols, SOC stocks tended to increase with stand age. In afforested sites, summing up the forest floor and the mineral soil layer up to 30 cm, the total SOC stock was higher than in agricultural land. Encouraging afforestation of former agricultural land is recommended, but caution is advised for converting perennial grasslands to forests. In conclusion, the total SOC accumulation in afforested sites, obtained by summing the SOC stocks of the forest floor and mineral topsoil to a depth of 30 cm, was higher primarily due to the formation of the forest floor over the 30 years.

The results obtained in this study could be integrated into the agroforestry sector. Agroforestry practitioners can make informed decisions regarding tree species selection, considering the specific soil types and climate conditions of the region. By carefully selecting tree species, for example, incorporating coniferous species, they can enhance carbon sequestration over time. The integration of afforested plots with agrarian land has the potential to enhance SOC concentrations and stocks in the mineral topsoil layer. This combination not only promotes overall soil health but also reinforces the sustainable management of afforested lands, contributing to climate change mitigation efforts.

Keywords
species-specific, soil carbon sequestration, soil organic carbon, grassland, land use change

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1.1 Climate Change Mitigation

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

A slow development of agroforestry in hemi-boreal Latvia despite its multidimensional potential

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Evaluation of agroforestry (AF) practices across different climate zones highlights benefits of agroforestry systems (AFS) covering different ecosystem service groups. In the context of climate change mitigation and related international agreements (e.g. the Paris Agreement), special emphasis is placed on potential of AF to remove carbon dioxide (CO_2) from the atmosphere and to increase the long-storing carbon stock in tree biomass and soil. Considering the EU's climate policy aims of climate neutrality by 2050 and the recent (in December 2023) agreement of the UN Climate Change Conference (COP28) to transitioning away from fossil fuels in energy systems, the role of climate change mitigation actions such as tree introduction in agricultural land and simultaneously the demand for bioenergy is predicted to increase. In addition, AFS contribute to the promotion of self-supply with bioenergy. Although results of studies confirm that implementation of various climate-focused AFS can significantly increase CO_2 removals (e.g., Upson 2014) and climate change adaptive capacity (e.g., Quandt et al. 2023), as well as partially meet future demand for bioenergy (Kralik et al. 2022), there is a slow development of AF and lack of support in Latvia. In national legislation and policy planning documents in Latvia, the term agroforestry was mentioned for the first time only in the recent Latvia's Common Agricultural Policy (CAP) Strategic Plan for 2023–2027 (CAP Strategic plan 2023), stating that elements of AFS include trees that are grown as individual growing trees or as trees in groups, or rows, or strips with the aim of ensuring sustainable land use and preventing soil erosion, increasing carbon sequestration. These trees are considered eligible if the number of individually growing trees per hectare does not exceed 100 or if the total area occupied by tree groups, rows, or strips does not exceed 500 m^2. However, no specific national goals regarding AFS establishment have been set, as well as no special support for implementation of AFS in Latvia under the CAP is provided, so far.

In order to support the policy and decision makers, as well as to promote the development of AF in hemi-boreal zone of Europe, the objective of this study was to 1) synthesize the best available practices, technologies and scientific data to obtain new comprehensive knowledge on the climate change mitigation and adaptation potential, which can be provided by AFS in Latvia; 2) develop and test innovative technologies appropriate for cultivation of deciduous tree seedlings (for instance, beech Fagus sylvatica) suitable for local conditions; 3) develop and adapt technologies for mechanized management of AFS for biomass production.

Within the study, multidimensional aspects of AF practice were evaluated. We estimated the magnitude of soil-to-atmosphere greenhouse gas – CO_2, methane (CH_4) and nitrous oxide (N_2O) – fluxes in deciduous tree and willow coppice based AFS using an opaque chamber method for gas sampling in combination with gas chromatography method (Bardulis et al. 2023). Assessment of the suitable agricultural land for implementation of AFS in Latvia was conducted using geospatial methods (by overlapping spatial data layers from various sources); selected suitable agricultural land for AFS consists of agricultural land parcels with relatively low land quality value, excluding areas with forest cover and buffers (protection zones) around watercourses and roads (Bardulis et al. 2022). Also, recommendations for climate change mitigation targeted management of AFS were elaborated.

We concluded that implementation of various AFS would contribute to both the capture and storage of additional atmospheric CO_2, improve the adaptation to climate change, as well as increase supply of bioenergy and generally promote more effective land management. Implementation of various AFS is suitable for at least 351.5 kha or 14.1% of the total agricultural land in Latvia. Of this area, 306.6 kha are without underground drainage systems, which is one of the limiting aspects of establishment of AFS in agricultural land due to potential damage of drainage systems by tree roots (Bardulis et al. 2022). Measurements of soil-to-atmosphere greenhouse gas fluxes provide useful information to evaluate overall climate change mitigation impact of AFS. Furthermore, dominant vegetation type of AFS and type of used soil fertilisation practice are important determinants of soil-to-atmosphere GHG fluxes (Bardulis et al. 2023). Development of innovative technologies, for instance, for cultivation of beech, provides new alternatives for multifunctional AFS. We recommend to reduce legislative hindrances to the establishment of climate-, biodiversity-, bioenergy- and environment-focused AFS and to provide additional support under the CAP.

Acknowledgments: This research was initially funded by the ERDF's post-doctoral research project 'Evaluation of climate change mitigation potential of agroforestry systems with mineral and organic soils' (No. 1.1.1.2/VIAA/4/20/684) and EEA and Norway Grants project "Sustainable use of soil resources in the changing climate (SUCC)" (No. 1.4-6/19/2), continued within the research program "Carbon turnover in forest ecosystem" No. Nr. 5_5.9.1_0081_101_21_87.

Keywords
GHG emissions, Agroforestry, tree plantations, biomass, carbon sequestration

Aditional Attachment II.

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Can the adoption of a novel agroforestry system based on Dipteryx panamensis and pineapple help Costa Rican farmers transition to a more sustainable agricultural model?

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Introduction

Establishment of a new agricultural production system integrating indigenous traditional agriculture (Acuña Sossa & Umaña Gutiérrez, 2015) and modern agroforestry practices (Nair et al., 2021) may help farmers in Costa Rica's Caribbean and Northern Lowlands transition toward a resilient and sustainable agricultural system. Our experiment compares economic and environmental performance of two predominant agricultural systems — Chamugro, the traditional system employed by Bribri and Cabécar indigenous farming communities in Talamanca, Costa Rica (model 1), and conventional pineapple monocrop production (model 2) — versus a novel agroforestry system design incorporating foundational elements of Chamugro with Dipteryx panamensis, pineapple, and other cash crops, and employing modern agroforestry techniques and technology for enhanced management through mechanization (model 3). Participatory workshops with indigenous farmers from UCANEHU — an association practicing ancestral agroforestry methods — and comparative socioeconomic and technical analysis of the indigenous farms will identify how to effectively integrate indigenous farming practices into the new production system.

Our experiment will be tested in two biological corridor regions, each posing its own distinct environmental, socioeconomic challenges. The San Juan La Selva Biological Corridor and the Talamanca-Caribe Biological Corridor are respectively located in Costa Rica's Northern and Caribbean Lowlands. The agroecosystems' ecological performance will be measured based on conservation of bioindicator species (e.g., populations of Ara ambiguus, Dipteryx panamensis). Productivity and economic performance will be measured using viability analysis, including market and value chain analysis of specific products from the alternative systems (e.g., Dipteryx's almond) and scenario analysis of various market development strategies for the mix of crops produced.

Case description

Agricultural expansion is one of the main drivers of deforestation in Costa Rica's Northern and Caribbean Lowlands (Annex 1) and is occurring at an alarming rate (Girres et al., 2023). There is consensus in Costa Rica's environmental sector that alternative agricultural models which incorporate full-cost analysis and are aligned with the country's social and environmental goals must be developed for streamlined adoption. Recognizing the demand for specific knowledge about how to design and implement competitive alternative agricultural systems and their corresponding value chains, we intend to develop and test examples of such alternative systems which can be adapted to maximize performance across different contextual situations.

Dipteryx panamensis (colloquially, “Almendro”) is a fast-growing timber tree with promising silvicultural characteristics. Almendro produces a valuable non-timber forest product — its almond — traditionally employed in indigenous cuisine and containing nutritional and organoleptic qualities which suggest market potential. Almendro wood is considered one of the finest in the country which has led to high rates of deforestation during the last 50 years. The population density of Dipteryx panamensis has decreased from 8 individuals per hectare to 1 individual per hectare in one sector of the San Juan La Selva Biological Corridor (Tropical Science Center, unpublished data). The decline of this species has a ripple effect impact on another iconic species in the area, Ara ambiguus (the Great Green Macaw). Macaws nest and feed in Dipteryx panamensis. Decrease in the number of Almendro has reduced the population of Ara ambiguus to an estimated 500-700 individuals (Tropical Science Center, unpublished data). Another deforestation driver in this Corridor has been the rapid increase in monoculture pineapple production. Conventional pineapple production has well-documented negative environmental and socioeconomic impacts (Brown et al., 2020; Echeverría-Sáenz et al., 2012; Gansemans & D'Haese, 2020; Sherman & Brye, 2019); nevertheless, there is strong international market demand.

We propose to shift pineapple production from a dominant intensive, monocultural model to a production model that combines indigenous knowledge with modern agroforestry science to achieve maximum performance. We intend to demonstrate that this alternative production model is more beneficial socially and ecologically and equally as competitive economically. Developing successful agroforestry prototypes fosters the transition toward the ultimate establishment of complex and diversified agroforestry models, key elements in both the restoration of ecological corridors and in the movement toward more equitable economic development based on regenerative techniques. Evidence generated through our research will be transferred to local farmers and agricultural extension agencies via a series of workshops, training sessions, field trips to experimental sites, and on-line videos.

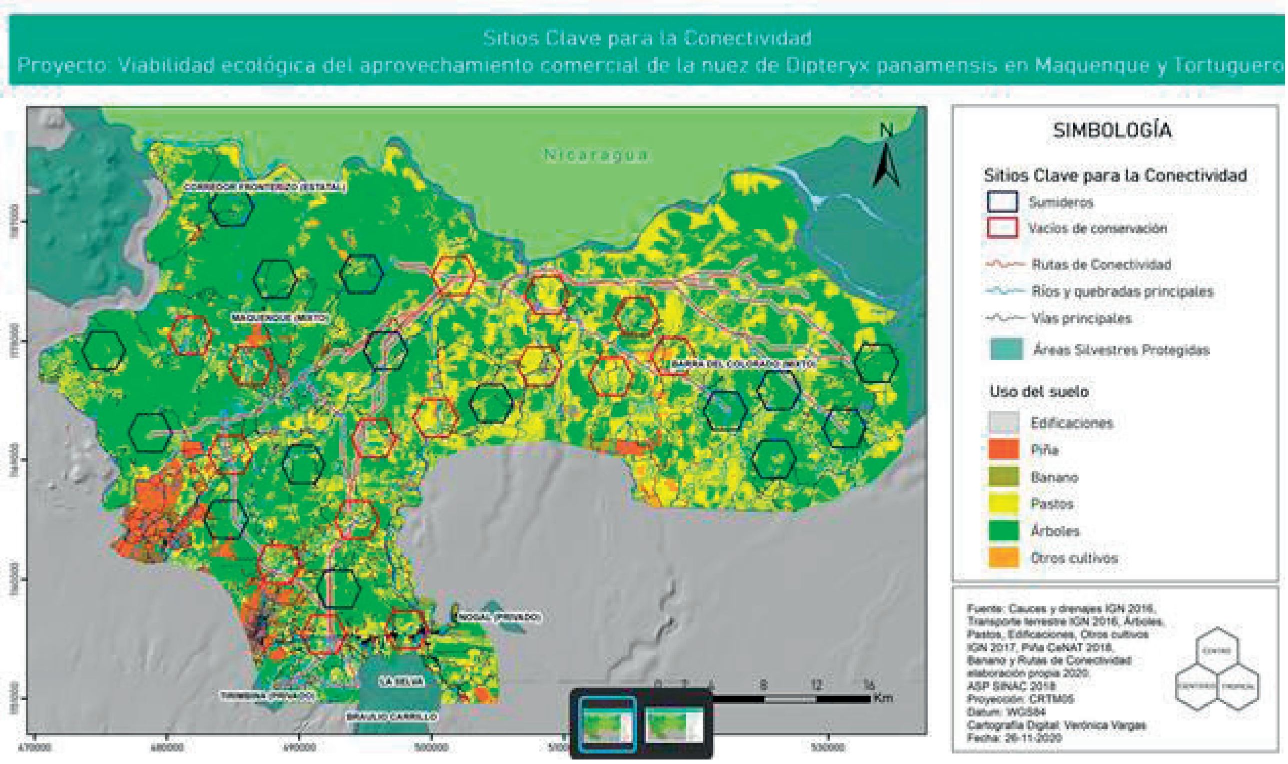
Conclusion

Indigenous cultures curate an invaluable body of knowledge on resilient food systems. Scientific knowledge offers tools to optimize and maximize the productivity of indigenous agricultural systems when employed in manners consistent with their underlying philosophical approach toward land management. This project promotes the adoption of agroforestry techniques as part of a strategic shift in food production toward a model that is regenerative for ecological systems and also generates greater well-being for people, especially farmers. We hope to offer farmers in these regions of Costa Rica a scientifically validated agricultural model that combines competitive economic performance with state-of the-art ecological resilience. We hope to offer farmers around the world a methodological approach which can be adapted and replicated using contextually appropriate species mixes.

Keywords

mixed farming, agroforestry practice loss, rural development, agri-environmental system, demonstration AFS, agroforestry value chains, Food security, circular economy, organic production, climate smart landscapes, Deforestation, Adoption, agriculture intensification, biodiversity conservation, intercropping agroecosystems, biological corridors

Aditional Attachment II.



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Modelling an Agroforestry System Using the Biophysical Hi-sAFe Model for Long-Term Prediction of Environmental Resilience: Loughgall, Northern Ireland, UK

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Introduction

Agroforestry systems have attracted considerable attention in recent years because of their potential in improving food security, enhancing sustainable land use practices, and mitigate climate change impact. Experiments in the field have been the primary approach to unravelling the complex relationships within these systems. However, models of agroforestry systems have the potential to advance ecological understanding while providing greater guidance for future experimentation as reliable tools for accurate predictions (Dupraz et al. 2019).

Objective

This study aims to model a 34-year old silvopastoral experimental site using the Hi-sAFe biophysical model for long-term prediction of environmental resilience by comparing three climate scenarios: Past, Present, and Future climatic conditions (Reyes et al. 2021).

Methodology

Study area

The model will be used to assess the behaviour of an ash silvopastoral system established at Loughgall (Northern Ireland). This site includes 3 replications of 3 land uses. The three land use types are: I) silvopastoral system with ash trees (Fraxinus excelsior L.), II) planted woodland with ash trees, and III) permanent grassland. They were established in 1989 as part of the UK National Network Experiments (NNE) at Loughgall, Northern Ireland (Figure 1). The silvopastoral and woodland plots were originally planted at 400 stems ha-1 (5 x 5 m2 spacing) and 2500 stems ha-1 (2 x2 m2 spacing) respectively (JH et al. 2018). The silvopastoral plots density was reduced with thinning to 265 stems ha-1 in 2004 and 170 stems ha-1 in 2009 with the stumps remaining in the ground. The woodland plots received minimal management except for thinning and pruning which were applied in 2009 to improve the quality of the trees, reducing tree density to an average of 1100 stem ha -1. In the period between 1989 and 2000 fertilizer application occurred at rates of 120 kg N ha-1 year-1 in silvopastoral and grassland plots and was thereafter reduced to 30 kg N ha-1 year-1. Sheep grazing at the rate of 12 ewes ha-1 occurred from April to November of each year in both grassland and silvopastoral plots. In 2015, the average DBH (diameter at breast height) of ash trees in the silvopastoral and woodland plots were 31.2 and 21.9 cm with average stand heights of 16.5 and 15.6 m respectively (Fornara et al. 2017).

The Hi-sAFe model:

Hi-sAFe (Version 4.2.19574) is a mechanistic biophysical model which was initially developed by an EU-funded project, (SAFE) Silvoarable Agroforestry for Europe (Dupraz et al. 2019). It is an exploration tool aimed at providing a better understanding of tree-crop interactions in a virtual environment and predicting the biophysical properties of agroforestry systems in temperate regions (Figure 2).

Expected results & Conclusion

A first achievement will be the satisfactory prediction of tree growth and pasture production in the past and present climate. With this validated model, it will be possible to explore the behaviour of key variables such as tree biomass production and carbon accumulation in the soil under the future climate. Simulation results are not yet available but will be included in the final presentation.

Keywords
Soil Carbon Stock Environmental Resilience.,Agroforestry, above ground biomass, soil organic carbon, AGROMIX, soil carbon sequestration, Hi-sAFe Modelling, silvopastoral, Hi-sAFe model

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Feasibility of expanding the agroforestry system for carbon sequestration in regenerative agricultural systems

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Introduction

Agroforestry is gaining attention in Europe as a method endorsed by global organizations to reduce greenhouse gas emissions. It involves the purposeful integration of woody vegetation with crops and/or animals for multiple outputs, promoting agroecology and carbon capture. Although agroforestry systems (AFS) store significant carbon, their environmental sustainability evaluation is challenging due to differences from conventional production (Tziolas et al., 2022). Slovakia's Government Regulation No. 3/2023, effective from January 1, 2024, supports non-project measures in the Common Agricultural Policy Strategic Plan, emphasizing assistance for agroforestry system implementation on agricultural land.

Slovakia holds promising potential for agroforestry, leveraging its diverse climate, rich biodiversity, and agricultural landscape to enhance sustainability, soil conservation, and economic diversification in the farming sector (Pastor et al., 2018). The farms try to embrace regenerative agriculture, a noteworthy achievement credited to the substantial adoption of extensive farming practices by a significant proportion of farms (Nowak et al., 2019; Dudek and Rosa, 2023). Promoting agroforestry into regenerative agriculture can increase environmental and economic benefits significantly. There are no local studies that objectively evaluate the impact/benefit of AFS that may occur after their application.

Research questions

1. What are the effects of creating agroforestry systems in regenerative agriculture in Slovakia?
2. What are the economic, environmental, and social benefits of creating agroforestry systems to improve the positive effects of agriculture?

Methodology

Life Cycle assessment (LCA) has been used. LCA comprises goal definition, inventory, impact assessment, and interpretation phases (Muralikrishna and Manickam, 2017). The study was conducted at the Krakovany-Stráže Agricultural Cooperative. We have considered the functional unit (FU) as 1ha (minimal area of established AFS) of regenerative agriculture for maize production. The first evaluation did not include AFS, the second one was calculated with the poplar wood production (as a representative sample of wood within this system). AFS has been designed in line with rules given by the Slovak Government Regulation No. 3/2023 that require planting of 100 trees per hectare using established planting methods and spacing. Poplars have been selected due to well-documented data for all inputs.

SimaPro Version 9.5.0.2 was utilized and the IPCC 2021 GWP-100 years method was employed.

Results

The system boundaries encompass the production of all inputs, including machinery, fertilizer, and pesticides derived from raw materials, as well as the cultivation of wood and crops (Fig 1).

Fig 1. System boundary of maize production accompanied by wood production (Photos are provided by regenerative farmers in Slovakia)

Our findings demonstrate the significance of regenerative agriculture when compared to traditional methods in terms of reducing greenhouse gas (GHG) emissions. GHG emission for 1 hectare of maize production is 532 Kg CO_2-eq. This amount regarding CO_2 uptake which is -37 Kg CO_2-eq would be 499 Kg CO_2-eq. Specifically, there is a noteworthy reduction in the usage of diesel fuels and electricity in key areas.

If we establish an agroforestry system exclusively for cultivating poplar wood on a 1-hectare plot, approximately 60 kg of CO_2 equivalent emissions will be generated. The results are comparable to the studies of Hafezi et al. (2021) and Krzyżaniak et al. (2019). The carbon storage for poplar trees will be 48 tons per hectare at 6 years of growth and 80 tons per hectare at 12 years of growth (Fang et al., 2007). This translates to (532*12) kg-CO_2eq in 12 years and 61 kg-CO_2 in 12 years for maize and poplar wood, respectively. As a result, agroforestry systems can sequester carbon, and negative GHG emissions can be offset in 12 years of agroforestry systems. Maize cultivation emissions will be offset by wood's carbon sequestration, mitigating negative impacts and adding economic value. Furthermore, Poplar wood effectively slows the increase in atmospheric carbon dioxide concentrations. This study suggests that biomass production and carbon storage potential are best when trees are planted for more years, respectively. (Main contributors to environmental hotspots will be detailed in the poster presentation. Short and long-term solutions will be highlighted accompanied by suggestions for the implementation of suitable agro-environmental systems).

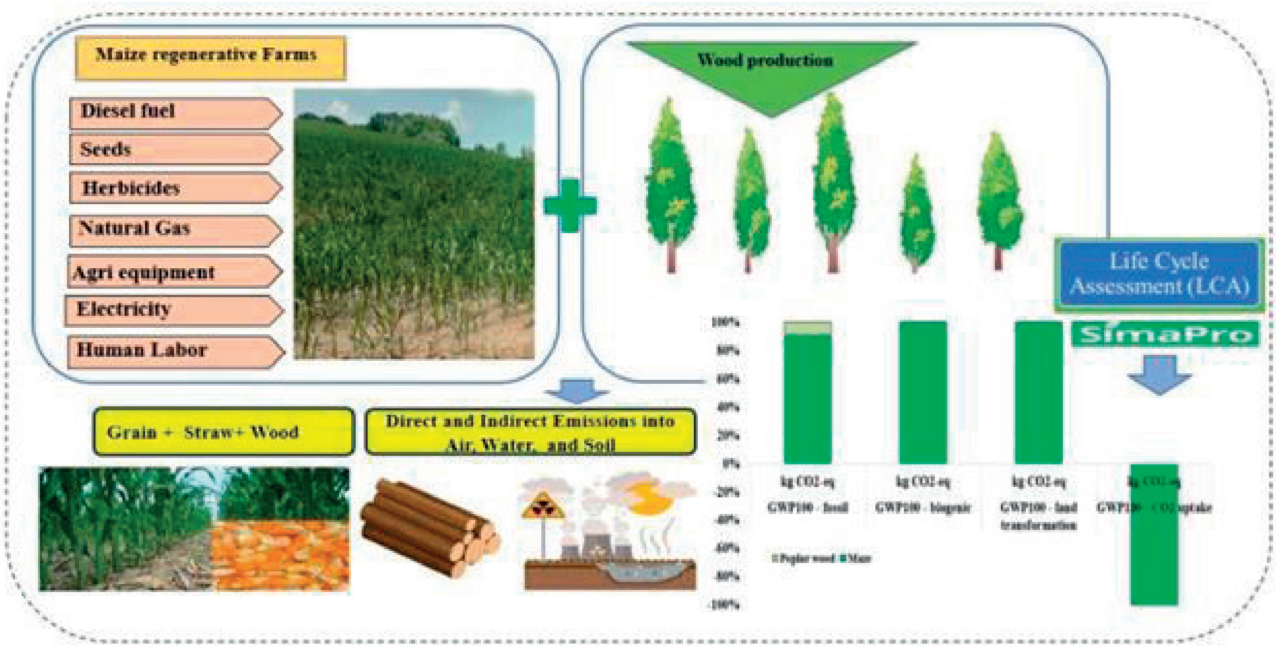
Conclusion

Agroforestry systems provide numerous agro-environmental advantages, but the profitability and adaptation of such systems in the local context are still questioned. Based on our results, creating an Agroforestry System (AFS) can ultimately improve all the benefits of agriculture and reduce GHG emissions. The authors hope that the presented results of the study will contribute to the expansion of the positive perception of implementing AFS not only in the conditions of regenerative but also in conventional management systems in particular.

Keynotes

Agroforestry, climate change, carbon sequestration

Aditional Attachment II.



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Agroforestry - a cooling system for heat islands in the agricultural landscape of Central Europe

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One of the important ways to preserve the productive function of the rural landscape and the ability of the ecosystem to adapt to ongoing climate changes is the introduction of agroforestry systems. It is a continuation of traditions that were respected in Europe until the 1950s. In the Czech Republic, by Regulation of the Government of the Czech Republic No. 140/2023 Coll. from June 2023, it is possible to farm either in the silvo-pasture way - woody plants are planted on the existing grasslands or in the silvo-tillage way - combining plant production on arable land with the planting of woody plants in rows so that the field can be managed with agricultural technology.

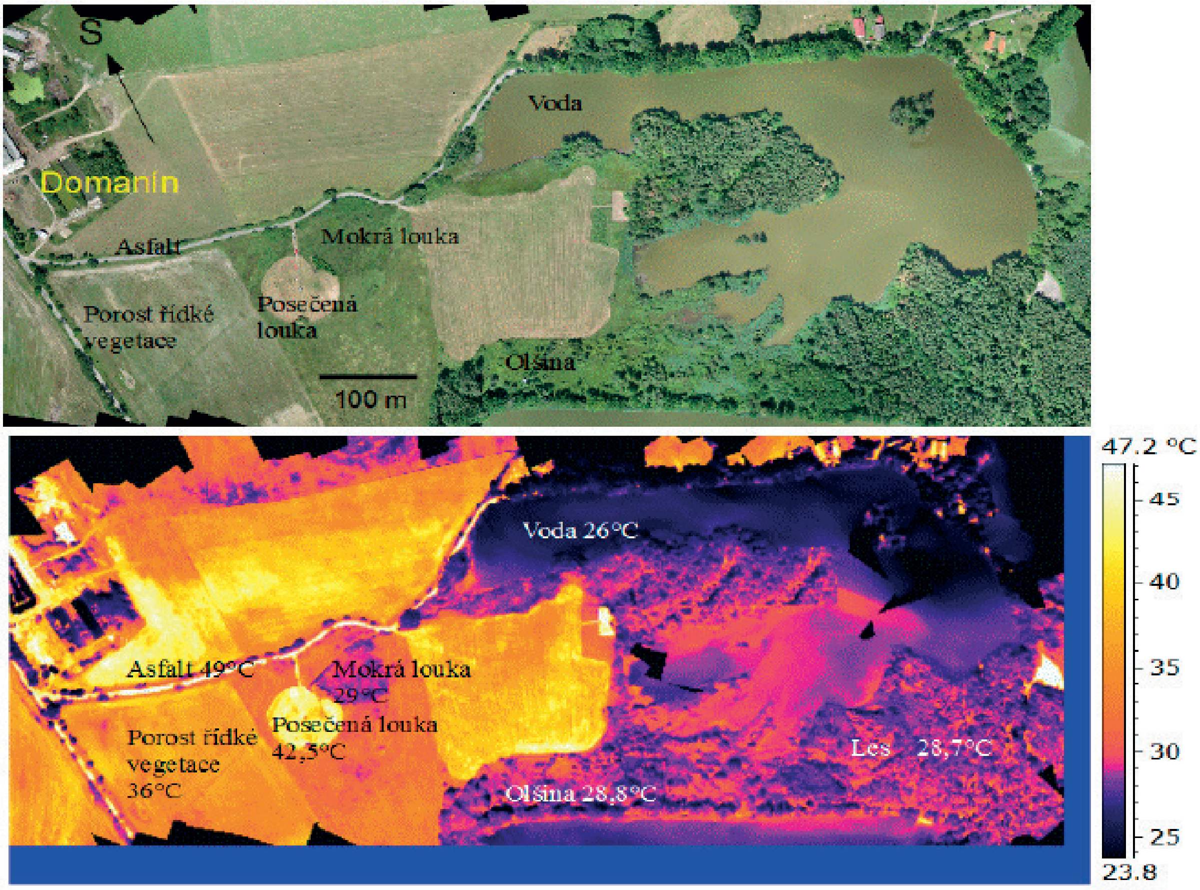
Woody plants in agroforestry systems perform important ecosystem services and non-production functions and actively counteract climate fluctuations. Last but not least, they significantly contribute to mitigating climatic extremes in heat islands of overheated areas of fields and settlements, where they can dampen extreme temperatures, episodes of drought and torrential rains. No more than 1% of the incoming solar energy is bound into biomass through photosynthesis. The largest part of the incoming solar energy, till 50%, is used for water vapor through the plant - for transpiration. If the tree is sufficiently supplied with water, it will evaporate more than 100 liters per day, and 100 x 0.7 kWh = 70 kWh of solar energy will be bound into the water vapor. 2.5 MJ / 0.7 kWh is consumed for the evaporation of one liter of water. So, in conversion, a tree in the area of its crown cools with an average power of 240W/m2 (Pokorný, Hesslerová 2019). In larger areas with sufficient tree greenery, fog and local cloudiness form, which provide shade and thus less solar energy falls overall, moreover, the formation of cloudiness is a condition for the attraction of moist air from the seas by the principle of the "biotic pump" (Makarieva, Gorshkov, 2010).

These findings, when trees function as powerful air conditioning units, need to be verified by comparative research in the agricultural areas of Central Europe in the territory of Lower Austria, South Moravia and South Bohemia, where climate change has a significant effect on the agricultural landscape. In the years 2018 – 2021, plantings were carried out in agricultural areas in these regions and research into the function of these and older plantings was started. Light, temperature and humidity conditions were measured in the field micro habitats of individual plants. The obtained data (Pokorný 2019, Gretz et Prähofer, 2019) on a small scale of micro habitats show that planting immediately changes the humidity, temperature and light conditions on the surface of the soil and in the airy shaded space under the tree. In the growing season, humidity rises by 5 to 15% in the air column and by 10-20% on the soil surface, temperature changes are even more pronounced by 10-40% in the air column and by 20-90% on the soil surface. Research also shows that trees, depending on their size, influence the wind conditions and water balance in the soil and create a competitive environment in a certain period (hot days), but only for a certain distance, but at the same time they provide a moisturizing and cooling effect for an area much larger (Gretz et Prähofer, 2019). The influence of agricultural heat islands on the drying of surrounding areas due to the formation of warm rising air currents is also evident (Pokorný, Hesslerová 2019). These results must be compared with other research and verified, among other things, using drones on medium and large scale soil blocks and landscape units of agricultural land, which is what the OP AT-CZ Plants for cooling project is focused on in the years 2023 – 2026. The results will bring more detailed data about the benefits of implementing ALS and will help increase the competitiveness and ecological resilience of our agriculture, which is increasingly affected by the effects of climate change.

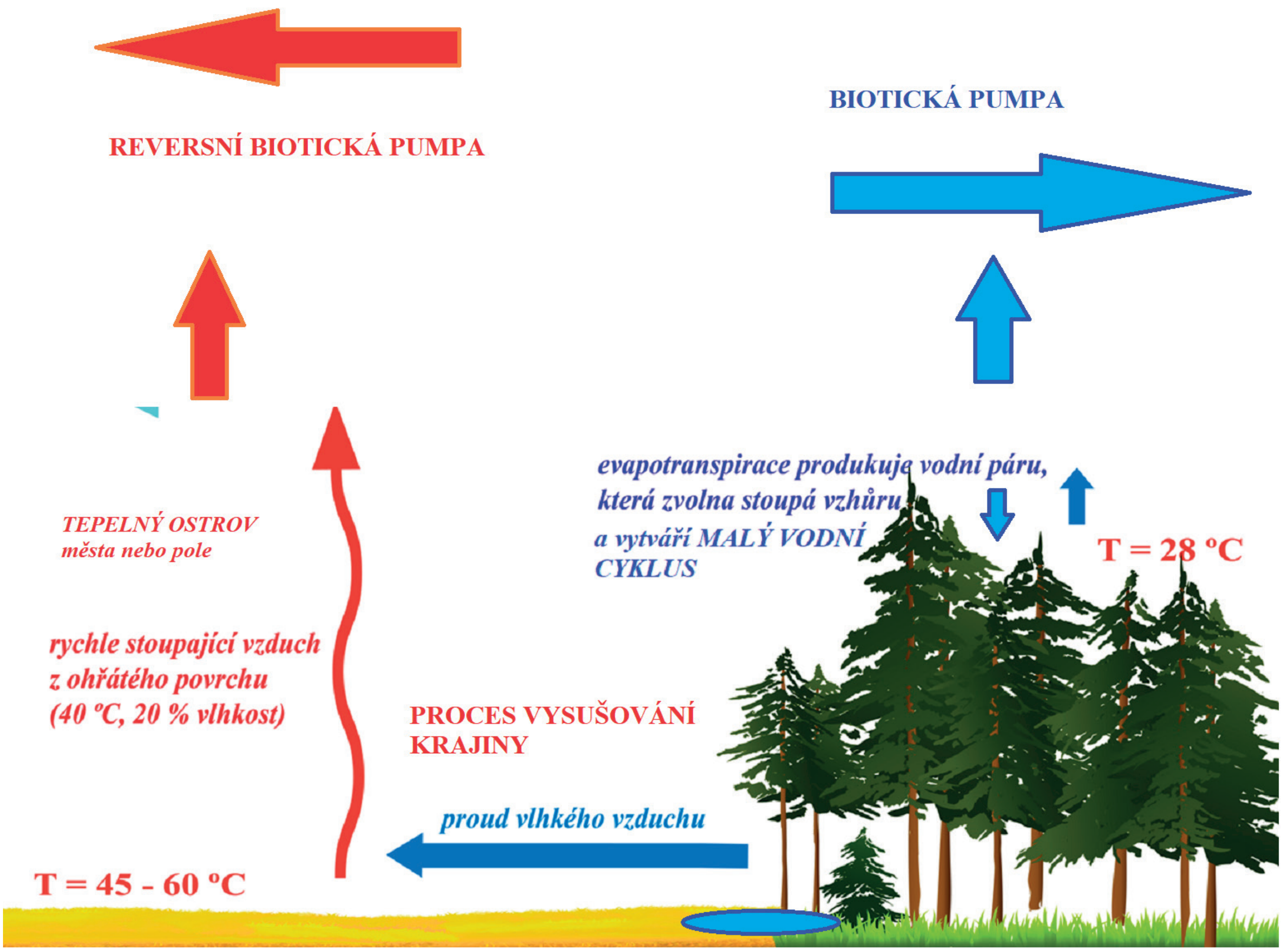
Keywords
drought adaptation, plant cooling efect, climate mitigation, resilience, agroforestry practices, ecological restoration, heat islands, active protection

Aditional Attachment I.

Agroforestry – a cooling system for heat islands in the agricultural landscape of Central Europe



Obr xx13: Za slunného počasí v létě se povrchové teploty v krajině pohybují mezi 26 °C (vodní hladina) 29 °C (les) až k teplotám nad 40 °C (asfalt, posečená louka) Hesslerová a kol. 2013



Heat island: Dry agricultural areas are heated by the sun and air is heated from them, which rises rapidly and draws in moist air from the surroundings. The surrounding forest, water bodies, vegetation, wetlands lose water held in a small water cycle (Pokorný, Hesslerová 2019).

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Describing the carbon accumulation temporal dynamics of agroforestry systems to harmonize the estimation of their climate mitigation benefit with other carbon dioxide removal (CDR) interventions

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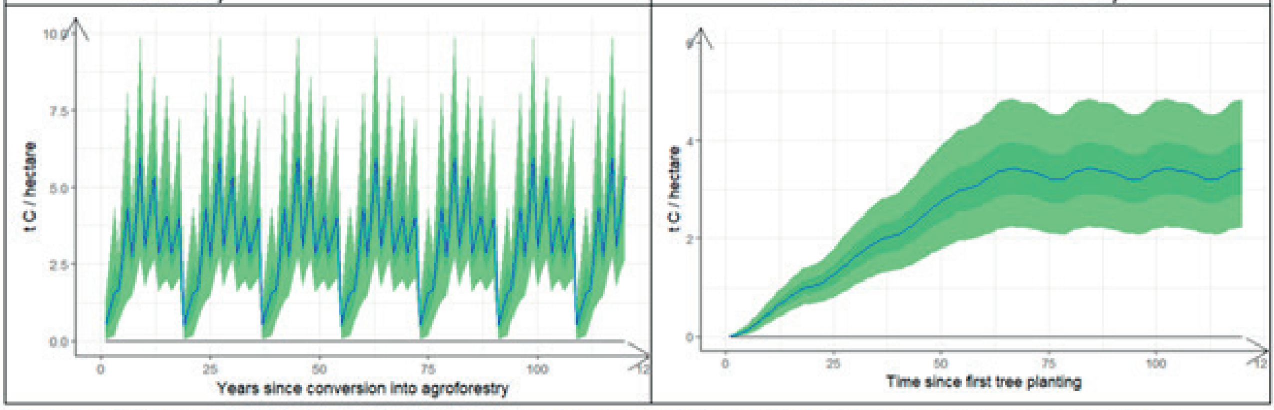
Existing proposed coefficients of carbon accumulation rates of agroforestry systems are presented as an annual average computed over a whole rotation period (Cardinael et al. 2020). This can be practical to calculate the carbon accumulation of options based exclusively on annual crops, with similar photosynthetic rates and net primary production every year. However, this is not valid for agroforestry-based interventions, whose main difference in comparison to other agricultural management interventions is the introduction of perennial vegetation stands, with a growth that follows a logistic curve and varying dynamics of the biomass carbon pool depending on the length of the wood rotation and whether regrowth develops from coppice or from plantation of new rootstock. Being explicit about such difference is not trivial. Climate policies tend to set absolute carbon sequestration targets over a whole territory at a specific reference time in the future. Figure 1a shows how difficult is to assign one single value to the contribution of one agroforestry stand to climate mitigation at any target time in the future. However, it must be noted that agroforestry upscaling processes do not take place by converting all lands on the same year. The adoption is gradual, at country level and even farm scales. Therefore, in order to provide quantitative estimates of the potential contribution of agroforestry climate mitigation targets, and how much land would be required for that, a temporally-explicit estimation of the carbon accumulation rates is necessary. We can do this if we theoretically assume that an equal amount of treeless agricultural land is converted into agroforestry every year, which results in a more stable depiction of the expected carbon gain resulting from agroforestry transitions (Figure 1b). The results show the dynamics of an alley-cropping short-rotation coppice as an example.

Keywords
carbon storage, coppice, timber, alley cropping, SRC

Aditional Attachment II.

Figure 1. Carbon content in the growing biomass of a short-rotation alley cropping system

a) Plot-scale (all trees are planted on the same year over the referred area = 1 hectare)	b) Landscape-scale (one new hectare is converted every year within the whole referred area = 20 hectares)



The lighter green area represents the 95% confidence interval, the darker green area the 50% interval, and the blue line the median.

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From forestry to agroforestry; adaptation and mitigation in drought-sensitive forest regions of Central Europe: A case study from the Masaryk forest

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1 Mendel University, Faculty Of Forestry

Introduction
Agroforestry systems have proven to be one of the effective climate adaptation and mitigation solution for Central European landscape. Particularly, in regard to increase of tree cover on agricultural lands. However, the adaptation and mitigation potential of agroforestry on forest lands is yet to be fully explored in our region. The shift of land-use from forestry to agroforestry seems to be one of the viable solutions in drought-affected areas.

Objectives
This paper discusses the question: What is the potential of agroforestry in tackling the challenges of drought-affected forest areas? And to what extent?

1. How does the ongoing climate change in the region limit the growth of trees and overall state of forests?
2. Are agroforestry systems more tolerant to drought than conventional forests?
3. What impacts can agroforestry have on social and economic sectors?

Methodology
This works is based on review deals with research questions, synthesis and practical recommendations.

For our study we choose Training Forest Enterprise (TFE) Křtiny, which belongs to the Mendel University of Brno. TFE Křtiny covers about 10 000 ha of forest located in the southeast part of the Czech Republic. Regarding to potential vegetation, the TFE Křtiny belongs to vegetation zone from oak to beech. On the other hand, the species composition is different compared to the natural one (e. g. beech 35 %, Norway spruce and oak about 15 %, Scot pine 8 %). From the year 2020, new adaptation strategy is practised in the TFE as a results of the change of the climate and socioeconomic demands.

Results
At the beginning of the 20th century, the average annual temperature in the TFE Křtiny ranged between 6.1 and 10 °C. At the end of the 21th century, the predicted annual temperature for this region will be four degrees higher (according to middle carbon scenario). For the same scenario, the annual average perceptions are expected to be more, less similar (klimatickazměna.cz).

Uncertainties in the range of the climatic change makes difficulties to predict the conditions for growing of tree species. On the other hand, there are similarities in the prediction of the

impact of climatic change on tree growth (Henewinkel et al. 2013, Thurm et al. 2018; Mette et al. 2022). In the region of Central Europe, the Mediterranean conditions and species are expected to prevail at the end of the 21st century. Mostly (or probably) for beech vegetation zone, the species as Quercus petraea, Carpinus betulus, Acer campestre, Sorbus torminalis are considered as the best choice. In the lower and drier conditions, the perspective species are: (i) European species Quercus cerris, Q. pubescens, Castanea sativa, Ulmus leavis or (ii) non-native Robinia pseudoacacia.

Improvements in the hydrological balance of forest stands are one of the keys to the successful mitigation of climate change. This task can be split into two fundaments: increasing the water yield or decreasing transpiration. The total water balance of open and closed forests in the same site is discussed nowadays. Trees are generally more water demanding than grassland. The reason for a high inspiration is aerodynamical roughness of their canopy which allows for the turbulent wind to carry the moist air away. At the same time, transpiration is a function of a leaf area index: the higher the leaf area, the more water is vaporized. High area of leaves and surfaces of the stems and branches brings along a high interception: roughly 0.2 mm from each rain event is captured on each square meter of leaves and branches. Therefore, decreasing the canopy cover may increase the resistance of forest to drought. Total transpiration from and interception of the silvopastoral system will be lower than in the forest. Therefore, the water yield may increase and the resistance of the ecosystem to drought may improve, as well. However, conversion of the forest to the silvopastoral system brings along some challenges. The trees growing in open canopy or as solitary trees have larger crown and roots, and are usually smaller in height. Increased illumination of the crown of the trees, which used to grow in a closed forest and did not develop an extensive root system would increase the stress load on single trees and eventually lead to their mortality. One of the challenges for agroforesters will be to develop the tools to convert existing forest stands into open forest systems with altered composition of tree species without making large-scale clear-cuts.

Conclusion

Utilization of drought-tolerant woody tree species under rapidly changing conditions is oftentimes linked to lower yields compared to recent forest stands. Drought-tolerant species are usually slow growing and provide lower quality wood assortments. Change of one single-wood product forestry to the multi-product forestry is a viable solution and agroforestry systems, such as silvopastoral or edible forest gardens, are one of the feasible approaches. The land use change should be systematic, following certain principles, such as: new drought tolerant species should be introduced during forest regeneration process; strong continuous thinning should focus on individual trees, their vitality. In conclusion, the drought-adaptation focused silviculture will result in open forests which comes with great uncertainty in various aspects. Although, this situation also offers a wide range of opportunities to be explored.

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1.2 Climate Change Adaptation

Oral presentations

Hall Q2, 28 May 2024, 14:45–16:15

How resilient are European agroforestry systems to climate change? What experts think

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Introduction

Agriculture is the most vulnerable sector to climate change due to its strong dependency on weather parameters (Malhi et al., 2021). Predicted yield losses related to climate change range from marginal decreases up to drastic yield losses (Schlenker und Roberts, 2009). The development of future agricultural systems in the face of rising temperatures, varying precipitation and increased frequency of weather extremes must increasingly incorporate the aspect of resilience to maintain food security (Azadi et al., 2021). Agroforestry systems are seen as a promising agricultural practice for maintaining productivity while being more resilient (Smith et al., 2013).

Objectives

Quantifying agricultural benefits in agroforestry in the context of resilience to current and future climate change is a challenge. An online expert survey was conducted in 2023 to capture the experts' assessment of the resilience of agroforestry systems to climate change and to develop new approaches to enhance agricultural resilience. Are agroforestry systems in the present more resilient than their respective woodless systems or is this expected for the future? Are there differences between silvoarable and silvopastoral systems and systems with hedgerows, riparian buffer strips or windbreaks – and in different climate zones? Do the experts' backgrounds influence their assessment?

Methodology

Experts within the European agroforestry networks were invited to participate in the online survey. The online questionnaire was conducted via the Swiss platform SurveyHero (enuvo GmbH). Respondents were asked anonymous questions on the impact of climate change on yield, yield variability and the quality of saleable products, as well as on the effects of environmental services and proposals to strengthen resilience to climate change. Statistical analyses were carried out with R version 4.3.2 (2023-10-31).

Results

From 613 people viewing the survey, 60 participants completed the questionnaire, where 55% were experts for silvoarable and 27% for silvopastoral agroforestry systems, respectively, and 18% for agroforestry systems with hedgerows, riparian buffer strips and windbreaks. 50% participants were experts for Central and Eastern Europe, 23% for the Mediterranean region and 13% for Northwestern and Northern Europe, respectively. 57% of participants came from research, mostly from the Natural Sciences (53%). The second biggest group of experts came from practice (32%). Other work sectors included Advising and Administration. Concerning their field of expertise, the great majority of participants were experts for plants (83%). Nearly two-third of participants had more than 10 years of work experience in their field, a quarter up to five years.

The change in yield (defined as the amount of total saleable produce) under current climate change, averaged across all agroforestry systems and climate zones, was assessed as 0% in agroforestry as compared to -6.5% in the corresponding woodless agricultural systems. This difference was considerably higher for the assessment of expected future climatic changes, with a constant 0% for agroforestry systems and -20% for the woodless reference systems.

Experts assessed presently observed and by 2050 expected effects of climate change variables on a five--level Likert scale from -2 (severe reduction) to +2 (big increase). A severe yield reduction due to climate change in general was presently observed by 3% and 2% and by 2050 expected by 63% and 5% in non-agroforestry and agroforestry, respectively; a minor yield reduction was observed by 65% and 27% and by

2050 expected by 15% and 48%, respectively; no effect by 12% and 46% (present) and 2% and 12% (future); a small yield increase by 15% and 20% (present) and 7% and 19% (future); and a big increase by 2% (present) and 10% (future) in both non-agroforestry and agroforestry.

Work experience influenced the estimation of changes in yield. In particular participants with less than five and more than 10 years of work experience expected more severe yield reductions for non-agroforestry systems. The work sector in which the participants were active also influenced the assessment of changes in yield, though the general observation that agroforestry systems were expected to show less yield losses and more yield gains compared to non-agroforestry was reflected in most sectors. "Exclusive" practitioners, however, more often expected big yield increases for non-agroforestry systems and small increases more often for agroforestry systems. "Exclusive" natural scientists reported higher yields for agroforestry and non-agroforestry systems more or less equally frequently, and small yield increases more frequently for agroforestry systems.

42% and 28% of experts think that environmental services can buffer the effects of climate change much and very much, respectively. Compared to other measures to improve agricultural resilience to a climate, 87% of the experts rated agroforestry to be more effective.

Conclusion

Collecting assessments of the resilience of agroforestry systems to climate change from experts in science and practice allows merging knowledge from different perspectives and comparing systems, climate zones and time horizons, and understanding of experts' opinions. Backgrounds of education and work experience may influence opinions and be an important point to consider for agricultural policy.

Keywords

Socioeconomic status, ecosystem services, climate change, agriculture, adaptation, Europe, knowledge gaps, agri-environmental system, Climate smart agriculture, buffering climatic extremes, climate resilience, Agri-Environment-Climate

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Contribution of agroforestry to climate change adaptation and other ecosystem services: Understanding the drivers, underlying processes and relevancy for policy targets

Msc Lennart Fuchs[1], Maureen Schoutsen[1], MSc Isabella Selin Norén[1], MSc Maria-Franca Dekkers[1], MSc Sanne van Leeuwen[1]

1 Wageningen University & Research, Lelystad, Netherlands

Agroforestry can make positive contributions to a multitude of ecosystem services. Think of effects on climate adaptation, biodiversity, carbon sequestration, soil and water quality, relevant for ecosystem services and policy targets. For many reasons it is interesting and relevant to quantify these effects. However, making generic quantifications for agroforestry is impossible. First of all, because there is a wide variety of agroforestry systems, with different designs and configurations leading to different effects. Secondly, the local landscape context influences the supply (and need) of the specific ecosystem services. This often leads to over- and under expectations or estimations of these effects, which is undesirable. As researchers, we should be able to share the correct insights in this to support decision making on the implementation of agroforestry.

To be able to get better insights and make valid estimations, it is necessary to understand the processes and working mechanisms behind these effects. We analysed a diverse range of literature, where we mainly looked into effects on climate change adaptation, carbon sequestration, nitrogen dynamics, (functional) biodiversity, and water quality. Our goal was not to find very specific or complex relations, but to translate our findings into logical and understandable outcomes that support decision making. This has resulted in the publication of a series of factsheets (in Dutch).

Climate change adaptation: Trees contribute to a good soil structure with macropores, which will improve infiltration of excess water to reduce water logging (flat areas) and soil erosion (hilly areas). A good distribution of trees over the field and choice for deep-rooting species will optimize this effect in an agroforestry system. Trees can also help to cope with heat and drought. Direct shade of tree canopy will buffer direct sunshine and thereby heat with a large canopy giving the most shade, but this can also negatively impact crop growth. When trees are implemented as windbreaks, wind speed can be reduced leading to lower evaporation of crops. In such systems a negative effect on crop yield is expected close to the tree row (1-2x tree height) and a higher yield from 2-15x tree height. Research will have to proof how significant this effect will be in different regions and contexts.

Carbon sequestration: A broad range of expected C sequestration in agroforestry systems in the Netherlands is 1-10 t CO2/ha/yr, of which about 75% will be in tree biomass and 25% in soils. From the tree biomass about 75% is expected to be stored in aboveground parts, and the other 25% in root biomass. The fastest sequestration rates are obtained with high growth rates (high number and fast growing trees). To foster long-term sequestration, the purpose and use of the biomass after its lifecycle as a living tree is key and this should therefore be considered in the design process. When wood can be used as e.g. building material, the C can be stored for long-term.

Water quality: Trees can contribute to a better water quality as deeper roots can uptake nutrients from deeper soil layers and reduce soil erosion and surface run-off, which will reduce nutrient losses to water bodies. At the same time trees can act as a physical barrier and reduce drift from chemical crop protection, reducing the contamination of water bodies. To optimize these effects, a good distribution of trees with deep-rooting systems over the field is desired, as well as placing trees in such a way to protect water bodies.

Biodiversity: Trees, shrubs and the understory vegetation offer a diversity of habitats, which benefits the general biodiversity in agricultural landscapes. This can also benefit functional biodiversity, like pollination and pest control. Botanical, structural and spatial diversity of the agroforestry system will contribute to this, as well as a good integration into the existing landscape.

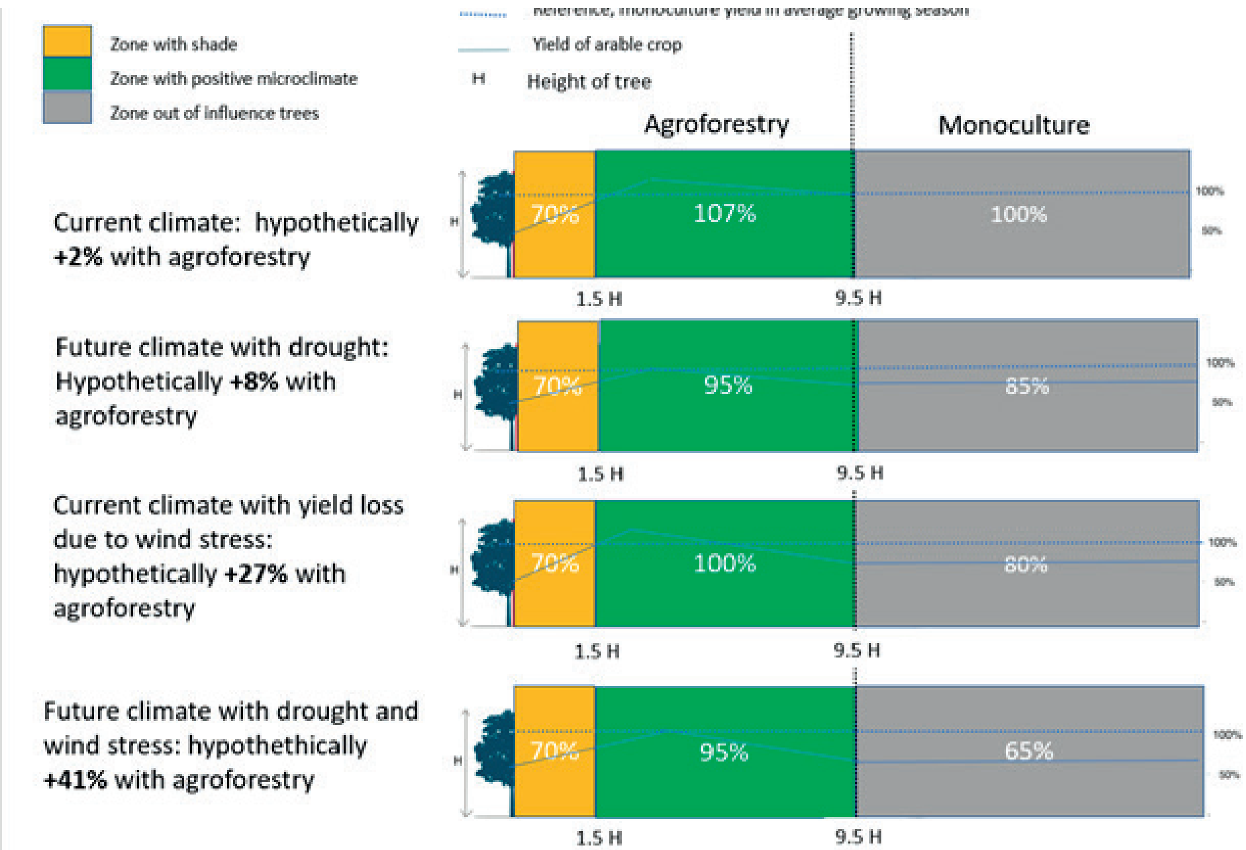
Nitrogen dynamics: Trees can improve N cycling and efficiency of the agricultural system as they can take up N from deeper soil layers and recycle it to the system through litterfall. N-fixing trees, like alder and robinia, can also be sources of extra N to the system. Trees can also take up N from the atmosphere, but this effect is rather limited.

In short, trees in agroforestry systems have the potential to make a positive contribution to a wide range of ecosystem services. However, these basic descriptions show that each service functions best within a specific design (tree spacing, distribution, shape, diversity etc.). This might give conflicting requirements and means that not all services can be optimised simultaneously in each agroforestry system, certainly if farm production and labour are also accounted for.

This knowledge will help to: a) make choices in the design of agroforestry systems to optimize for certain ecosystem services and find synergies, and b) understand which type of agroforestry systems are most relevant in certain areas to contribute to specific policy targets on ecosystem services.

Keywords
biodiversity, carbon sequestration, Policy, ecosystem services, Water quality, water management, adaptation, landscape, nitrogen use efficiency

Aditional Attachment I.



Schematic representation of the hypothetical effects on crop yields at different distances from a windbreak under different climatic circumstances. The numbers are based on assumptions and literature and it is assumed that the effects are additive, there is no irrigation and water shortage causes yield decreases, also with agroforestry:

1. 70% yield loss up to 1.5 H, 7% yield increase between 1.5 and 9.5 * H (Van Vooren et al., 2016).

2. 15% yield loss due to drought, whereby agroforestry hypothetically gives an increase of 10% between 1.5 and 9.5 H compared to the monoculture.

3. 20% (hidden) yield loss due to wind stress which is countered with a woody hedgerow meant as windbreak.

4. 35% yield loss due to drought and wind stress which is partly countered and overcompensated in the agroforestry situation).

Bibliography

Facsheets (in Dutch):
Factsheet on climate adaptation: https://edepot.wur.nl/580732
Factsheet on nitrogen dynamics: https://edepot.wur.nl/638797
Factsheet on policy targets for nature, water and climate: https://edepot.wur.nl/640442
Factsheet on carbon sequestration: edepot.wur.nl/501459
Factsheet on biodiversity: edepot.wur.nl/495298
Report on effects of agroforestry on water management and functional agrobiodiversity (English summary): edepot.wur.nl/580955

Predicting the effect of climate change and increased carbon dioxide concentrations on grassland, woodland and silvopastoral yields in an Atlantic Climate

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Introduction

Approximately 22% of global emissions are associated with agriculture, and land use and land-use change including deforestation. "Farming with trees" is one method that farmers can use to mitigate against and adapt to the impact of climate change. The objective of this study is to use the Yield-SAFE model, to predict the possible effects of future climate scenarios on the tree and grass yields in a grass-only, tree-only, and silvopastoral agroforestry system at Loughgall in Northern Ireland.

Method

The Yield-SAFE agroforestry model was modified to include the effect of increases in atmospheric carbon dioxide (CO2) on the radiation use efficiency and hence yields of trees, grass, and crops. This was incorporated by applying a multiplier to the radiation use efficiency, as the CO2 concentration increased, up to a maximum 28% benefit at a CO2 concentration of 800 ppm. Data from published research on tree and crop responses to current and future atmospheric CO2 concentrations were used to develop the multiplier. The tree-only system comprised ash (Fraxinus excelsior) planted at a density of 2500 trees ha-1 with thinning to 1100 trees ha-1 in year 20. The silvopastoral system comprised ash planted at a density of 400 trees ha-1 with thinning to 265 trees ha-1 in year 15 and to 170 trees ha-1 in year 20. The site has a mild Atlantic climate with generally even rainfall distribution. For the baseline scenario (based on modelled climate for 1989-2029) the mean air temperature was 10.0°C and the mean annual rainfall was 794 mm. Representative concentration pathways (RCPs) for either 4.5 or 8.5 W m-2 of extra warming by 2100 were modelled and split into early and late stages corresponding to 2020-2060 and 2060-2100 respectively. The RCP 8.5 is predicted to result in a mean air temperature of 12.0°C and a mean annual rainfall of 945 mm in 2060-2100, and a CO2 concentration of 1142 ppm by 2100.

Results and discussion

The Yield-SAFE model predicted that the annual baseline yield of the grass crop for the period 1989-2029 was 9.2-9.6 t ha-1 with a slight benefit when accounting for the CO2 fertilisation effect in the model (Table 1). The calculated harvested and standing timber volume at 40 years was 409-420 m3 ha-1. In the baseline situation, the mean grass yield in the silvopasture system was 4.1 t ha-1 and the predicted harvested and standing timber volume at 40 years was 265-275 m3 ha-1.

Assuming the RCP 8.5 scenario, grass yields in the pasture system were predicted to decline to 8.9 t ha-1 (2020-2060) and 7.7 t ha-1 (2060-2100) without the CO2 fertilisation effect. However including the CO2 fertilisation effect, grass yields were predicted to increase to 11.0 t ha-1 (2020-2060) and 12.7 t ha-1 (2060-2100). For the woodland system, without CO2 fertilisation, the predicted woodland tree biomass in the RCP 8.5 scenario (391-398 m3 ha-1) was similar to the 409 m3 ha-1 in the baseline scenario. Including the CO2 fertilisation effect led to higher wood production to either 450 m3 ha-1 (2020-2060) or 506 m3 ha-1 (2060-2100).

Within the silvopastoral system, in the absence of a CO2 fertilisation effect, the trees reduced the relative decline in grass yields with the RCP 8.5 scenario as demonstrated by the increasing contribution of grass to the land equivalent ratio. By contrast, the inclusion of the CO2 fertilisation effect led to greater tree growth which in turn suppressed relative grass growth.

Conclusions

The results demonstrate that the Yield-SAFE model predicts that the relative balance between tree and grass growth in a silvopastoral system in an Atlantic climate will be affected by climate change. However, the nature of that impact is altered by the inclusion of a CO2 fertilisation effect. In practice, the overall balance between tree and grass growth can also be overridden by management choices such as the timing of thinning. In this analysis, combining the trees with grassland increased the overall land productivity as demonstrated by a land equivalent ratio greater than one. In addition, the timber volume per tree in the agroforestry system would be higher than in the woodland.

Keywords
Agroforestry, above ground biomass, AGROMIX, modelling, timber, RCP

Aditional Attachment II.

Table 1. Predicted grass and tree yields over 40 years for the baseline and the representative concentration pathway of 8.5 W m^{-2} of extra warming by 2100 over two periods, with the effect of CO_2 fertilization excluded or included.

Scenario	Time period	CO2 effects	Monoculture grass yield (t ha^{-1} yr^{-1})	Woodland standing+ harvested timber (m^3 ha^{-1})	Silvopastoral grass yield (t ha^{-1} yr^{-1})	Silvopastoral standing+ harvested timber (m^3 ha^{-1})	Predicted land equivalent ratio (grass + tree)
Baseline	1989-	No	9.2	409	4.1	265	0.44+0.65=1.09
	2029	Yes	9.6	420	4.1	275	0.43+0.65=1.08
RCP 8.5	2020-	No	8.9	398	4.2	256	0.47+0.64=1.11
	2060	Yes	11.0	450	4.6	305	0.42+0.67=1.09
	2060-	No	7.7	391	3.9	252	0.51+0.64=1.15
	2100	Yes	12.7	506	4.9	369	0.38+0.73=1.11

Agroforestry in viticulture - A case study in Switzerland

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Introduction
In the backdrop of accelerating climate change, the frequency of extreme weather events, such as droughts and heat waves, is on the rise. This climatic shift is influencing grapevine phenology, accelerating ripening towards the warmest months of the season and inducing discernible alterations in grape and wine composition (Rienth et al., 2021). Elevated temperatures during the ripening phase result in increased sugar levels, diminished total acidity, and modifications in the phenolic makeup of grapevine berries, potentially compromising wine quality and eroding the distinctive characteristics of wines from traditional viticultural regions (Santos et al., 2020).

In tandem with rising temperatures, water deficit stress is emerging as a critical concern in numerous winegrowing areas. More frequent drought periods pose a threat to both yield and quality, jeopardizing the sustainability of vine cultivation in traditionally esteemed regions.

While various mitigation strategies exist, some necessitate substantial changes, such as cultivar adaptation, while others, like irrigation, may lack environmental sustainability. Consequently, agroforestry has emerged as a compelling, multi-faceted solution, offering potential benefits such as microclimate regulation, improved water and nutrient availability, and enhanced soil fertility and activity. The simultaneous cultivation of trees and grapevines could improve biodiversity in vineyards, but also holds promise for mitigating the adverse impacts of climate change on viticulture.

Despite the growing interest in agroforestry systems, scientific understanding of their application in viticulture remains limited, primarily due to the absence of robust, long-term experiments. Initial studies have yielded promising results, albeit with considerable variability and a lack of consistency. Addressing this knowledge gap is crucial for harnessing the full potential of agroforestry as a sustainable and effective strategy in the face of climate-induced challenges in the wine industry.

The objective of this study is therefore to study the impact of the presence of trees in the vineyard on grapevine physiology, berry quality and environmental parameters such as microclimate, soil quality and diversity of fungal communities of an established vitiforestry system in Switzerland.

We hypothesize that the integration of trees within the vineyards can reduce stress regarding increased temperatures and dryness, lower water availability and reduced nutrient supply.

Methodology
The study takes place in an eleven-year-old vitiforestry system in the region of lake of Genève, planted with the variety Garanoir. The west-east facing has a size of 0.4 ha with 20 trees (Salix spp.) planted within two vine rows separated by 9 vine rows and a distance of 20m. Trees are planted at a distance of 6m and are cut each year in spring as pollarded willows.

For the sampling design, measurement were taken at four distances with trees as center and with eight replicates each. The influence of shading was investigated by collecting samples on the west and east side of the tree row, within in the tree row itself and at a control point outside the tree radius.

The canopy microclimate is characterized by air temperature and humidity probes installed in the bunch zone. Infrared imaging was performed by drone at three time points during the growing season to calculate the NDVI (normalized difference vegetation index). Water availability was measured by assessing four times the stem water potential and additionally berry samples were analyzed of stable carbon isotope composition (d13C) of the must sugars by elemental analysis-isotope ratio mass spectrometry (EA-IRMS). The nitrogen supply of vines is measured by chlorophyll leaves index using an N-tester apparatus (Yara, Nanterre, France) at flowering. The nitrogen content (yeast assimilable nitrogen, YAN) as well as other berry quality parameters (sugar, organic acids, pH) are analyzed with near-infrared (NIR) spectroscopy. Vine physiology was assessed by gas exchange measurements during three time points using a Ciras 3 system, furthermore, pruning weight as a proxy for vigor was determined in winter.

Results

Preliminary results indicate no difference in water availability or water stress during this first year between the four sampling locations. The stable carbon isotope composition shows overall no to mild water deficit for all vines. Even though there was no difference in the chlorophyll index of leaves detectable, must analysis revealed tendencies of reduced nitrogen content (NH4), also lowered yeast assimilable nitrogen content for vines growing within tree row or on the north faced side of the tree row. A similar trend was observed for malic acid concentration. In the months of May, July and August no significant effect of the trees on air temperature was detectable. However, in June and September, a statistically significant temperature reduction of 0.5 to 0.9°C can be recorded due to trees.

Conclusion

The season 2023 was remarkably wet and cold in springtime and summer with heatwaves around June and August. This first year provides insight into the impact of trees on nutrients and water availability, as well as air temperature in the vineyard. Nevertheless, the following years will show the extent to which these results will be confirmed.

Keywords

temperate region, Wine, NDVI, Agroforestry, vitiforestry, soil biodiversity, silvoarable, soil water availability, microclimate, climate resilience

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Long-term winter crop yield dynamics in temperate agroforestry under drought conditions - a case study from southwest Germany

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In the face of climate change European agriculture is faced in dire need for adaptation options. Especially warm season droughts peaking in summer are getting more frequent in central Europe (Markonis et al.), causing severe yield losses among cereal crops (Brás et al. 2021). Agroforestry is widely regarded as a key adaptation measure in the face of increasingly extreme weather events due to climate change (IPCC 2019; van Noordwijk et al. 2021).

While there is an increasing body of literature investigating yield dynamics in temperate agroforestry (Kanzler et al. 2019; Pardon et al. 2020; Swieter et al. 2022), in respect to the limited availability of long-term time series data, assessments of yield dynamics in temperate agroforestry rarely allow for assumptions on the effect of inter annual variability in water availability during growing season on crop yields. Thus, there is little knowledge on the influence of agroforestry on yield performance comparing between dry and wet years.

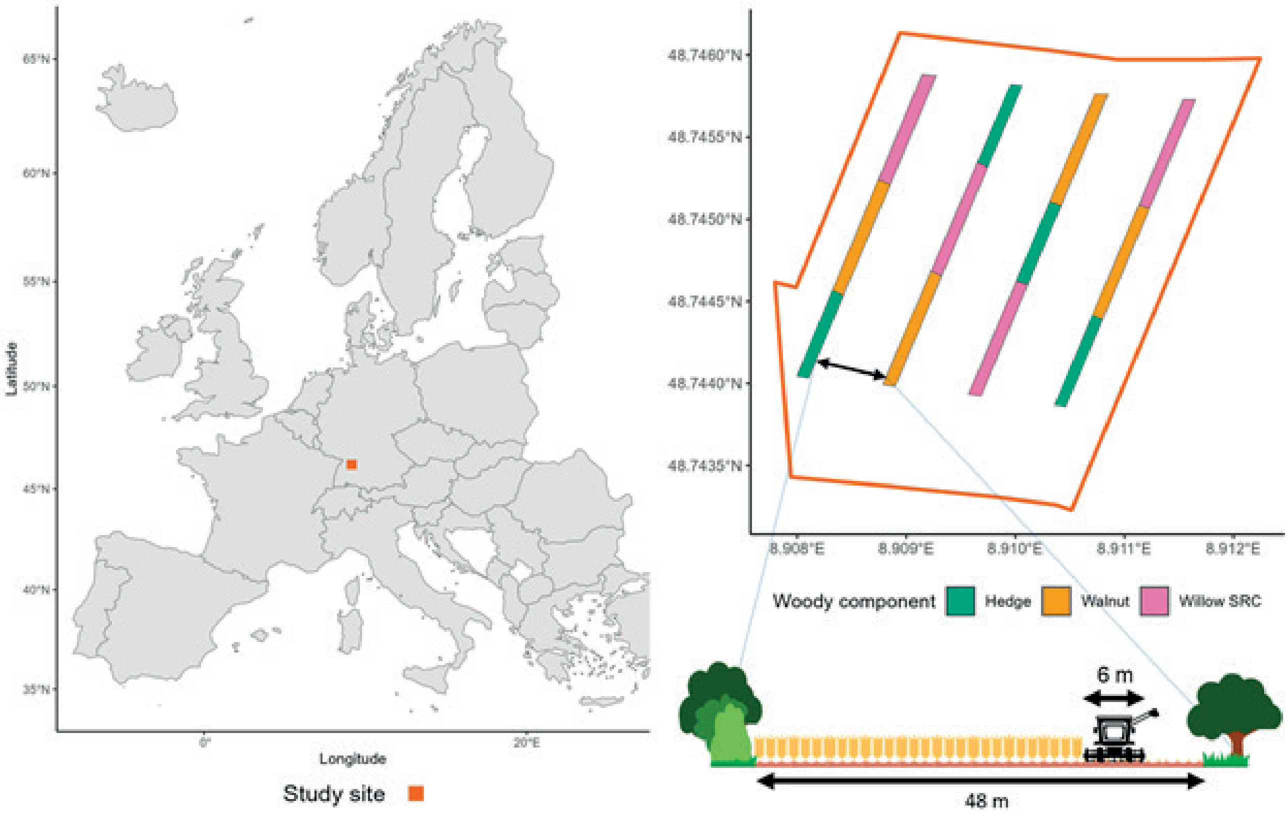
We analyse winter crop yields on the agroforestry trial site at the Agricultural Experiment Station Ihinger Hof. The 16-year-old trial site features three variations of agroforestry practice 1) willow short-rotation coppice (SRC), 2) high value walnut trees and 3) diverse hedges, established with four repetitions each. To analyse yield dynamics over time we used yield data of the 5 winter crops in the period of 2012 – 2023. The assessed crops are winter wheat, winter barley, triticale, oil rape and winter pea. We used linear mixed effects models (LMM) to analyse the effects of the proximity to tree rows, aspect and their interaction on grain yields. Moreover, we assessed the relationship of agroforestry induced yield effects and water availability using the climatic water balance (CWB) during spring and summer months for the characterization of weather induced water surpluses or deficits. CWB was calculated as the difference between precipitation and potential evapotranspiration. Incorporating water – energy interactions, water-balance-based variables are proposed as meaningful estimates of the the hydrologic and energetic environment experienced by plants (Stephenson 1990; Fisher et al. 2011).

Significant effects of tree rows on crop yields were occurring for all agroforestry practices from the start of the time-series in the fourth year after establishment of the agroforestry site. This is an earlier onset of significant effects of tree row proximity on yields compared to findings in other studies (Ivezić et al. 2021). Depending on year agroforestry practices had varying effects on winter crop yields. We show, that climatic water availability alters yield responses across different alley cropping practices. Across all winter cereals assessed, yields between willow SRC rows benefitted from the lee effect and proximity to tree rows with decreasing climatic water balance in Spring and Summer. Proximity to hedge rows showed most beneficial effect on crop yields among woody components.

Our results contribute towards the understanding of yield dynamics in agroforestry practices under inter-annual variability in water surpluses or deficits, informing decision making when applying agroforestry as a measure of adaptation to climate change induced weather extremes.

Keywords
windbreak, temperate agroforestry, drought adaptation, climate resilience, climate change, crop production, SRC, Cereal Crop, silvoarable agroforestry, hedgerows, willow, alley cropping, walnut

Aditional Attachment II.



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Reaching consensus on the resilience of agroforestry to climate impact drivers in Europe: a Delphi study

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The Intergovernmental Panel on Climate Change (IPCC) identifies agroecological systems, including agroforestry, as highly effective adaptation options that enhance resilience to climate change (Bednar-Friedl et al., 2022). But what are the particular characteristics or mechanisms of these agroecological systems that enhance their resilience, i.e., reduce their vulnerability to climate change, compared with conventional systems? While there has been considerable research on the mitigation and adaptation potential of agroforestry systems (Hernández-Morcillo et al., 2018; Kay et al., 2019; Reyes-Palomo et al., 2022), the resilience potential of agroforestry, particularly in a European context, has not been well addressed, perhaps due to the complexity and diversity of these systems and the challenges of measuring or modelling resilience. An iterative expert knowledge-based Delphi study was undertaken to contribute to filling this knowledge gap and contribute to the development of an interactive map for policy makers and farmers.

The objectives of the study were:

1. To reach consensus on the resilience of agroforestry types to climate impact drivers and associated impacts compared with baseline scenarios (i.e. annual crops/livestock/orchards/forestry).
2. To identify key mechanisms and properties of agroforestry types that impact resilience.
3. To reach consensus on the implementation, management and economic implications of a change in land-use towards a more climate change resilient land use model.
4. To identify knowledge gaps.

Hugé et al. (2010) describe the Delphi technique as "a method of structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problem". The Delphi study consisted of three rounds of structured questionnaires and ran from October to December 2023; there were separate Delphis for Northern Europe, Southern Europe and Western & Central Europe, climate change regions defined within IPCC. The questionnaire contained seven questions relating to resilience of each of the agroforestry types (Table 1) to climate impact drivers and their associated impacts, compared to the baseline. Each question was divided into three subsections; the first subsection focused on agroforestry types compared with an annual crop (arable/vegetable)-only baseline, the second on agroforestry types compared with a livestock-only baseline, and the third on agroforestry types compared with a tree-only baseline (i.e. orchard or forestry). The questions had a five-point scale answer ranging from 'Much lower resilience' to 'Much higher resilience', as well as options to choose 'I don't know' or 'There is no evidence'. Participants were asked to suggest the mechanisms or properties of the agroforestry type that determines the level of resilience, with references where possible (in any language), plus the opportunity to add notes, limitations or caveats. They were also asked to assess the agroforestry types with regards the costs of implementation, ease of management and financial performance (with and without subsidies) compared with the agricultural or tree-only baseline.

After each Round, responses were aggregated and anonymous feedback provided to the participants. Participants were asked to review and confirm or amend their previous responses, considering the opinions and elements that were suggested by the other participants during the preceding round. Consensus was reached when at least 70% of participants have agreed on the same level of resilience for a particular agroforestry type. To identify key mechanisms and properties of agroforestry types that impact resilience, thematic content analysis was carried out on the participant comments.

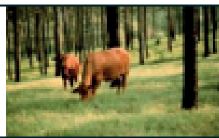
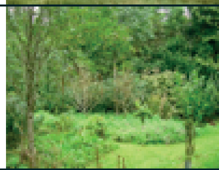
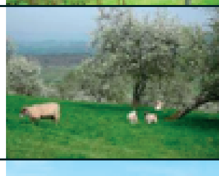
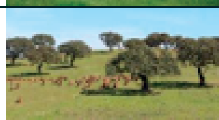
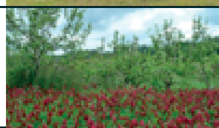
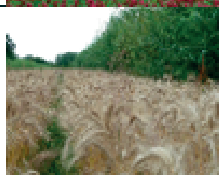
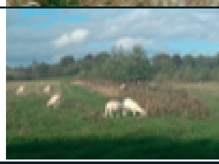
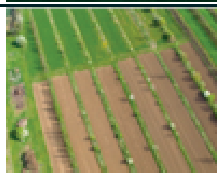
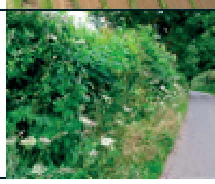
There were a total of 45 experts engaged through to the end of Round 3. A consensus was reached, in most cases (88%), that agroforestry land use models have higher resilience to climate impact drivers than annual cropping and livestock-only baselines. The main exception was for the climate impact driver 'reduction in cold extremes' where consensus was not reached for the majority of land use models.

For transition from a tree-only (i.e. forestry or orchard) baseline, consensus was much lower (10%) or the resilience level was unknown (11%), suggesting much less is known about the impact of introducing livestock or cropping into existing forestry or orchards systems. However, in Southern Europe, there was consensus of higher resilience of agroforestry systems compared with tree-only baselines, to increases in droughts, decreases in mean precipitation, and increases in heat extremes and mean temperatures. Thematic content analysis identified key mechanisms and properties underpinning the resilience of agroforestry systems and these will be presented. The resulting themes, along with the references cited by participants will form the foundation of a structured literature review.

Regarding the implementation, management and economic implications of a change in land-use towards a more climate change resilient land use model, there was a strong consensus that most of the agroforestry models are harder to manage than the baseline systems. By contrast, there was an almost complete lack of consensus regarding financial performance of the land use models, both with and without subsidies, in comparison with baseline systems.

Keywords
buffering climatic extremes, adaptation, climate resilience

Aditional Attachment II.

Agroforestry type	Description	Illustration
Forest grazing	Livestock incorporated into woodland or forests.	
Forest farming	Cultivation of high-value crops under the protection of a managed tree canopy.	
Grazed orchards	Permanent woody crops (top fruit, nuts, vines, olives) with livestock.	
Wood pasture	Livestock with scattered trees. The trees can be productive (e.g. fruit, timber, cork, fodder) or not.	
Intercropped orchards	Permanent woody crops (top fruit, nuts, vines, olives) with temporary crops (arable, vegetables).	
Alley cropping - arable	Within-field linear systems with temporary crops (arable, vegetables) grown in alleys between tree rows. Trees can be productive (e.g. fruit, timber, short rotation coppice) or not.	
Alley cropping - livestock	Within-field linear systems with pasture or forage grown in alleys between tree rows. Trees can be productive (e.g. fruit, timber, short rotation coppice, fodder) or not.	
Agrosilvopastoral	Combination of trees, livestock, and temporary crops (arable, vegetables) within the same system, usually on a rotation. Trees can be productive (e.g., fruit, timber, short rotation coppice, fodder) or not.	
Hedgerows, riparian buffers, and shelterbelts	Linear systems of shrubs and trees around field perimeters or adjacent to streams, rivers, lakes, or wetlands. Trees can be productive (e.g., fruit, timber, short rotation coppice, fodder) or not.	

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1.2 Climate Change Adaptation

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Olive trees and the impact of land management in ecosystem services production. A case study in Crete, Greece

Mrs Nicole Cecchinato[1], Georgios Koubouris[2], Oumaima Hrameche[2]

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The Mediterranean Basin faces climate change challenges, including increased droughts, reduced water resources, and higher temperatures (Fraga 2020). These changes impact not only crop yields, yet also the ability of agroecosystems to provide ecosystem services (Michalopoulos 2020). Olive trees (Olea europaea L.) are key elements of the Mediterranean agricultural landscape (Maldonado 2016), due to their suitability to the climate and their high adaptability in stress conditions, such as water scarcity (Gomez 2003; Vossen 2007).

This research explores how the design of agricultural practices influences the multifunctional role of olive trees in supporting and regulating ecosystem services (i.e. nutrient cycling and water content) in olive groves, aiming to address existing knowledge gaps and assess the potential of these practices in agricultural systems.

The present study was conducted in Chania, Crete (Greece) in four experimental olive groves of ELGO-DIMITRA (Institute of Olive Tree, Subtropical Crops and Viticulture) during spring and summer 2022. Per each olive grove, three fifty-year-old trees belonging to the cultivars 'Kalamon' were selected for monitoring. Each olive grove was observed under different treatments, including the type of land management (i.e. abandoned or managed; n=12 for tree measurements; n= 24 for soil measurements), the tree density (i.e. low density or high density; n=12 for tree measurements; n= 24 for soil measurements), and the closeness to trees (i.e. under the tree canopy or outside of the tree canopy; n=24 for soil measurements), analysing the data using statistical tools (i.e. SPSS 23 software).

In the managed olive groves, plant nutrition needs were covered through chemical fertilisers (N-P-K, B, Mg and Zn) applied each winter according to soil and foliage analysis. Moderate tree pruning was implemented every 3-4 years. Weed control was done every spring by superficial mechanical mowing. Pest control was realised according to Integrated Pest Management principles using commercial agrochemicals. 3-5 bait-sprays were realised every summer for controlling the Olive fruit fly (i.e. B. oleae) and 1-2 sprays in autumn and spring for fungal diseases. In the abandoned olive groves, no fertiliser, pruning or pest control was applied for 3-10 years.

Results showed that abandoned olive groves present better conditions for olive trees' ecosystem services support and regulation, when compared with managed olive groves, both in relation to soil variables (i.e. pH, SWC) and tree variables (i.e. LAI, B in leaves, tree volume). Tree density has not shown any significant effect. The closeness to the tree presented a positive significant effect towards soil water content (SWC), yet negative significant effect towards soil nitrate (NO3-), manganese (Mn) and copper (Cu). Interactions of the type of management and the tree density showed strong positive effects on soil water content (SWC), soil organic matter (SOM) and magnesium (Mg), thus significant negative effect on pH, phosphorous (P). The interaction between tree density and the closeness to the tree positively affects zinc (Zn) in soil, whereas the interaction between the type of management and the closeness to the tree showed positive effects on pH and electrical conductivity (EC). Correlations were also found mainly in relation to leaf nutrients.

This study provides a first evidence of the effects of design in olive tree ecosystem services provision and contributes to filling the knowledge gap regarding the effects of these woody crops in combination with specific types of management and density. Generally, more research is needed to understand the contribution of olive trees in providing ecosystem services, both in managed and abandoned olive groves. Specifically, further research on the interaction between types of management and density is highly recommended due to a lack of data regarding different densities in olive groves.

Keywords
Environmental Services, Olea Europea, soil analysis, soil properties, oive trees, land management, Mediterranean agroecosystem modules, Tree Crops, fruit orchards, orchards, Field abandonment, experimental site, multifunctional olive systems, Mediterranean resilient agriculture, ecosystem services, agri-environmental system, case study

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Monitoring the influence of agroforestry systems on the microclimate of small watercourses in agricultural landscapes in Saxony and Brandenburg/Germany

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1 City Of Dresden, Dresden, Germany

2 TU Dresden, Dresden, Germany

Only 7 % of Saxony's watercourses currently have a good ecological status. However, implementation of the EU Water Framework Directive must be stepped up throughout the whole Germany (Wagener 2023). Woody strips with fast-growing tree species along watercourses can be part of the solution, as they can be an economically profitable cultivation method for farmers for the production of energy wood. In addition to the natural vegetation, riparian wood strips provide many ecological benefits alongside small watercourses in agricultural areas. They reduce the input of substances to the water and also reduce the water runoff by intensifying the rooting of the riparian zones (Hübner 2023). Through their shading effects, agroforestry crops also contribute to the stabilization of water ecology, especially through cooling during heat periods. Last but not least, an improved microclimate through agroforestry can have a positive effect on crop yield and stability, depending on the local conditions (Böhm 2018).

In the OLGA project (https://urlsand.esvalabs.com/?u=https%3A%2F%2Fwww.projekt-olga.de%2Fen%2F&e=7da38bd4&h=b5ed429f&f=y&p=n), studies were carried out on two agroforestry systems in the German regions of Saxony and Brandenburg. The aim was to investigate their influence on the microclimate of the adjacent watercourses.

Data on air and water temperature, humidity, pressure (for dew point determination), wind speed and solar radiation were collected at both sites during the vegetation periods 2021 and 2022 in order estimate the influence of the wooden vegetation on the microclimate - especially water and air temperature - of neighboring watercourses and agricultural areas.

Measurements by means of five sensors located in shaded and unshaded areas of the Peickwitzer Mühlgraben (Brandenburg test site) show that the shading of bank areas in a stocked section of 350 m length can generate a temperature reduction of up to over 4 °C at low water discharge at an average flow velocity of approximately 0.08 m/s. This reduction is possible during low water conditions in summer, when shading becomes particularly important. Statistically, the contribution of bank shading was confirmed by a multiple regression analysis when comparing individual stream sections. None of the other climate parameters investigated had a similarly significant influence on the water temperature reduction.

Hemispheric photos were taken at the Wiesengrundbach in Colmnitz (Saxony test site) to determine the shading capacity of watercourses by riparian vegetation. The images represent the canopy cover and allow the heat radiation entering the water body by determining the sun's path. The direct and diffuse global radiation is calculated under a cloudless sky. This value could be reduced at the Wiesengrundbach in the summer months of May to September 2022 from an average of over 200 watts/m² for unshaded conditions to approx. 48 watts/m² due to the bank vegetation. The change of water temperature was analysed over 100 m flow length for areas with different canopy openings. It can be seen that a low canopy opening leads to a temperature reduction in the water body, while a high canopy opening increases the temperature by up to 1° C per 100 m at an average flow velocity of approximately 0.2 m/s.

In order to assess the effect of the agroforestry system on the ambient temperature at the Brandenburg site, additional measurements of radiant heat were carried out using globe thermometers at various locations inside and outside the stand. Three measurements were carried out within the stand of trees, at the edge of the riparian buffer strip in the immediate vicinity of the watercourse and in the middle of the adjacent harvested arable land. The air temperatures show a clear gradient. In 2022, there was a temperature difference of up to +1.9°C between the interior of the riparian buffer strip and its edge to the watercourse, and up to +11°C between the interior of the stand and the surrounding harvested arable land (compared to 10° C in 2021).

With reference to the parameters of water and air temperature investigated at both test sites, it can be summarized that woody features in the form of extensive agroforestry systems with fast growing tree species have a positive influence on the microclimate of adjacent watercourses and arable land. In particular, the shading effects of woody vegetation on small watercourses and ditches with low water runoff in agricultural landscapes with little riparian vegetation can significantly reduce the water temperature - in our case by more than 4° C on some days. Riparian buffer strips also have a cooling effect on their immediate surroundings of a few meters, but they quickly lose their effect, especially during increasingly frequent periods of heat. Fast-growing trees are therefore an alternative to near-natural riparian design with regional trees if the economic interests of the landowner have to be taken into account.

This study shows that agroforestry systems, in this case in form of woody vegetation along watercourses, improve the local microclimate of agrarian landscapes. The extent of climate benefits depends on various local conditions, such as soil, vegetation, arable crops, weather, water quality, planting design etc. In general, it will be important to communicate the economic, ecological and, in particular, climatic advantages of agroforestry systems for agricultural production and water management in an integrated manner in order to achieve adequate management processes with regional value creation and, at the same time, sustainable use in cooperation with all stakeholders involved.

Attachment

Peickwitzer Mühlgraben (Brandenburg test site) left, Wiesengrundbach (Saxony test site) on the right

Keywords

fast-growing tree, microclimate, Shading Effect, climate, microclimatic parameters, Poplar, adaptation, Heat stress, silvoarable, ecosystem services, Agri-Environment-Climate, Water quality, climate change, air temperature, climate resilience, Germany, water scarcity

Aditional Attachment II.

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The effect of the silvoarable alley cropping system on the soil moisture and temperature regime at Amálie farm, Czech Republic

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Introduction

Agroforestry, a sustainable land use system that combines tree cultivation and crop production on the same field, can enhance water management and improve microclimatic conditions during weather extremes caused by climate change. In autumn 2022 we have established an experimental and demonstration alley cropping agroforestry plot at the university farm Amálie in Central Bohemia. The design follows the rules of the new measure to support agroforestry in Czechia (100 trees per ha in alley cropping scheme, trees in double row at a distance of 5 m, at least 50% of forest trees, the tree alley covered with grass/legume mixture), which started in 2023. The objective was to test and demonstrate the feasibility of the agroforestry measure, but also monitor, collect, and evaluate a number of valuable research data about the development of this agroforestry systems in the future.

Objectives

This research aims to evaluate the effect of the silvoarable agroforestry system on the soil moisture and temperature regime during the first year after its establishment. The research question is whether the planted trees can effectively decrease the soil moisture and temperature extremes in the field.

Methods

During the 2023 vegetation season, we monitored the soil moisture and temperature regimes of silt loam soil using 35 microclimatic stations (TMS Tomst). These stations were installed at two different depths within the soil profile within tree alleys and surrounding open crop fields with sorghum, as depicted in Fig 1.

Results

We observed that the temperature amplitudes, both at surface and subsurface levels, were lower in the tree alleys. During the August heatwaves, the maximum temperatures at the soil surface were nearly 7ºC cooler than those in open crop fields. Surprisingly, this pattern was also seen 8 cm and 25 cm beneath the soil surface, where the maximum temperatures were almost 4ºC cooler (see Fig. 2). Furthermore, results showed that tree alleys had a more intense response to heavy rainfall, with the immediate increase in soil moisture being 7% higher than that of open crop fields. However, the recharged soil moisture in tree alleys was rapidly depleted during the two weeks, falling below the levels in open crop fields. This is likely attributable to the high transpiration rates of trees in the alleys, particularly within the understory vegetation.

Conclusion

The tree alley system implemented in Amálie farm demonstrated a more pronounced soil moisture depletion. However, it also exhibited a more effective recharge mechanism after heavy rainfall due to improved infiltration caused by enhanced preferential flow. The promising soil temperature data show the ability of agroforestry systems to prevent landscape overheating. It is important to note that this study only covers the initial stages following the establishment of the system. Therefore, it is important to continue monitoring the temperature and soil moisture regimes in upcoming years, given the system's potential to evolve into a more resilient system that can better withstand the adverse effects of climate change.

Acknowledgment

This research was supported by the State Environmental Fund of the Czech Republic (Norway Grants, RAGO, project no. 3211100014, Amálie Pilot Farm—application of the Smart Landscapes concept), and by the Technology Agency of the Czech Republic (project no. SS02030027, Water Systems and Water Management in the Czech Republic in conditions of climate change).

Aditional Attachment I.

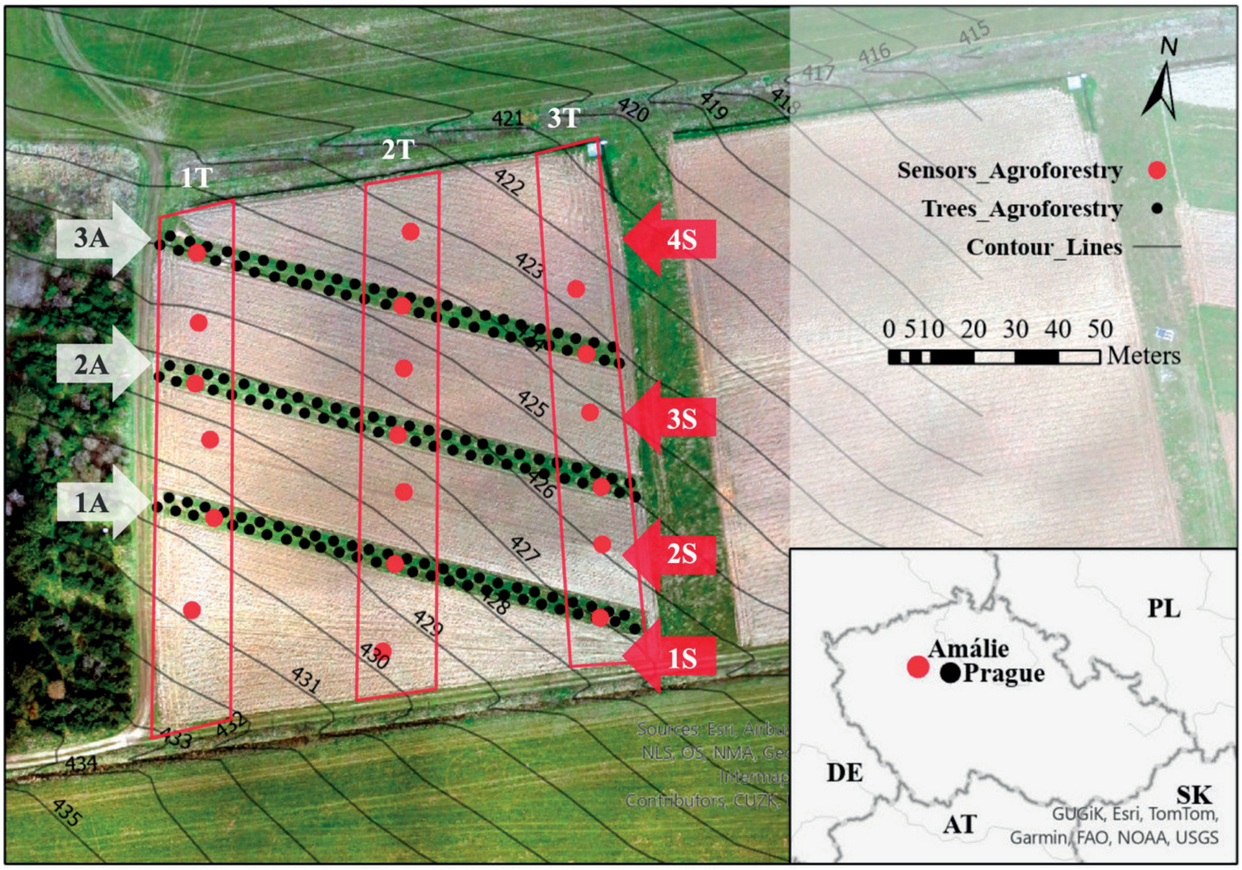

Fig. 1. The locality of the examined agroforestry system. Red points mark the TMS microclimate stations. Black points mark trees. The tree alleys are indicated by white arrows labeled with an "A". Open field strips are shown by red arrows labeled with an "S". Boxed areas labeled "T" represent transects perpendicular to forested alleys and open fields. The contours are in black.

Aditional Attachment II.

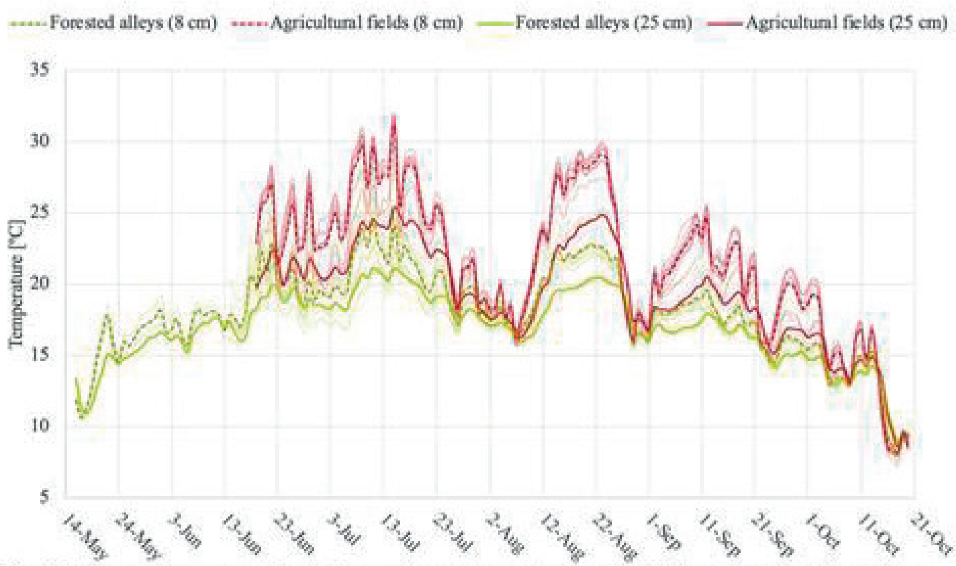

Fig. 2. This graph compares the daily maximum temperatures recorded by microclimatic stations within the forested alleys and open agricultural fields at the depths of 8 (dashed line) and 25 cm (continuous line) below the soil surface. The green lines denote the forested alleys, while the red lines correspond to the agricultural fields. The bold lines indicate the mean value of all sensors, while the fine transparent lines show data from individual sensors.

Farming agroforestry weeds: turning a negative into a positive – a case study from southern Portugal

João Palma[1], **Ana Tomás**[1], **Jo Smith**[1]
1 MVARC, Mértola, Portugal

Introduction
Curralões, the farm where MVARC is established, covers 240 ha near Mértola in Baixo Alentejo, in south-east Portugal. It is in a landscape dominated by game management and extensive livestock/arable production on marginal land. The climate normals are characterised by hot dry summers with an average annual rainfall of 548mm (although in the last 15 years, the average has dropped to 273mm) falling in the winter months. As elsewhere, climate change impacts are a concern with drought a frequent issue in recent years.

Case Description
In 1994, over 130,000 stone pines (Pinus pinea L.) trees were planted on 160 ha of the farm under an afforestation measure in the CAP Pillar 2, with the aims of increasing carbon storage, fighting greenhouse gas effects and improving forestry resources. The pines have very slow growth (4 metres high, 15 cm diameter after 25 years) and low productivity (low yield of pine cones).

The land area with pines is classified as an orchard (for pine nuts) and therefore eligible for direct payments under CAP Pillar 1. The understorey is dominated by a shrub layer composed primarily of 'rockrose' (Cistus ladanifer L.), a species highly resistant to drought and heatwaves; this shrub layer must be removed from agricultural land to comply with the CAP conditionality of "good agricultural and ecological conditions" (GAEC), i.e. shrubs should be no more than 20% cover nor higher than 50cm. Like other farmers in this area, this conditionality has been maintained by using an offset disc harrow every four to five years. This leaves the alleys between tree rows clear of vegetation, with natural regeneration of grasses and forbs, and within a year or two, re-emergence of shrubs. As well as being costly for farmers, harrowing destroys soil structure, releases soil carbon, exposes soil to evaporation and leads to soil erosion, either by water or wind.

Triggered by concerns about the level of soil degradation, a new approach to shrub management has been implemented. Rockrose is an aromatic shrub, producing a highly valuable, although low yielding (~0.01-0.05%) essential oil (EO). Local artisanal essential oil producers currently wild harvest by hand to produce small amounts of the oil. The idea was to initiate a shrub management plan in the alleys between the trees to produce essential oil – but to scale the process through mechanisation. After an extensive search, an appropriate machine that would cut and collect the shrub was found and purchased in 2022. This mulcher cuts the rockrose at 30-50cm above ground, thus encouraging bushy re-growth with a higher proportion of oil-containing leaves, while maintaining eligibility for CAP payments by keeping the shrubs below 50 cm in height, at least for the first year.

The essential oil is extracted from shrub biomass by steam distillation, and a 2 x 1000 litre still was installed in 2021. Water is heated using woodfuel harvested from pine tree prunings and thinnings and there is potential for using the post-distillation shrub biomass for fuelling the boiler. Other uses of the biomass are also being investigated, including as a soil improver, weed control mulch, and as livestock feed. Water is recycled through the system, with the only water leaving the system being the 'floral water' or hydrolate from the condensation process while recovering the essential oil. This hydrolate also has a value in its own right as a product from the process, and the key to making this venture successful financially, is to secure buyers for the hydrolate.

Although research is undergoing to estimate the carbon balance of this farming system, it is highly likely that the essential oil and hydrolate are carbon negative products from this farm (i.e. more carbon is stored than emitted) due to the carbon being stored in the growth of the agroforestry system that hosts the rockrose and avoiding emissions by not harrowing the soil thus keeping the standing carbon in coppiced shrub biomass and roots. This could be further enhanced by returning post-distilled biomass to the alleys to increase soil carbon.

Conclusion
However, to unlock the potential of this shrub as a resilient and adapted crop to this environment, there is an urgent need to make the case to the European Commission that actively managed Cistus ladanifer shrubland should be classified as an aromatic crop (similarly to rosemary or lavender). A distinction should be made as to when rockrose is kept between 50-100 cm (coppicing to harvest leaves every two years) and

abandoned land (i.e. non-eligible for CAP payments) where the shrub is more than 100cm high. In this way coppicing would avoid harrowing, with all associated ecosystem benefits, where the farmer could opt to shred the coppiced material as an soil organic matter improver, thus keeping soil covered, or harvest the material to sell to essential oil distilleries.

Figure 1. Top left: Coppicing the shrub in the alleys. Top right: The shrub harvester/mulcher in action. Bottom left: Re-growth from coppiced shrub, also storing carbon and keeping soil structure. Bottom right: packing the shrub biomass into the still.

Keywords
case study, agroecology, essential oil, Organic Farming, aboveground carbon sequestration, hydrosol, alleys, carbon storage, adaptation, aromatic, hydrolate, floral water, demonstration AFS, landscape policy, alley cropping, agricultural policy, antioxidant activity, carbon sequestration, agricultural revenue diversification, landscape transformation, arable weeds

Aditional Attachment II.

Figure 1. Top left: Coppicing the shrub in the alleys. Top right: The shrub harvester/mulcher in action. Bottom left: Re-growth from coppiced shrub, also storing carbon and keeping soil structure. Bottom right: packing the shrub biomass into the still.

Planning approaches for temperate silvoarable agroforestry systems for soil erosion and water management at the local and regional level

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Introduction

Climate change intensifies the hydrological cycle and may cause an increase in extreme weather events like droughts or heavy precipitation associated with increases in potential soil erosion on arable fields (Borelli et al., 2020; IPCC, 2021). Albeit precipitation-related projections are engrained with uncertainty, it seems wise for farmers to prepare for such events as in the past, single heavy rainfall events caused severe soil erosion and flash floods at many locations in Europe (StMUV, 2021). Our work focused on silvoarable agroforestry systems for preventing soil erosion and enhancing water management in arable agriculture in temperate regions. It provided planning approaches for sustainable agroforestry on the regional and local levels based on a study area in the county of Rottal-Inn, Lower Bavaria, Germany, with partly steep terrain.

Research Questions

The thesis was divided into four research questions oriented towards local and regional scales. The first question aimed to asses the framework and objectives of stakeholders in the study area regarding silvoarable agroforestry. Secondly, how must temperate agroforestry systems be designed to achieve these objectives? The third questions investigated which arable fields in the study area show – potentially overlapping – priorities for the objectives, and which agroforestry systems would be suitable to achieve these. Finally, how could a silvoarable agroforestry system be designed on one of the high priority fields?

Methodology

Objectives and the natural and socio-economic frameworks in the study area regarding the potential establishment of agroforestry were assessed using expert interviews. Planning and design factors for temperate agroforestry systems targeting the stated objectives (soil erosion, water balance and microclimate) were presented based on a literature review. To match suitable fields with the objectives and derive agroforestry designs in the study area, filter steps and decision trees were applied and developed integrating the results from before, and map data was classified and allocated in QGIS. An exemplary agroforestry planning process included an initial interview with the landowner and rounds off the study. The silvoarable agroforestry system was planned in QGIS in the masterline design.

Results

Priority fields for implementing silvoarable agroforestry in the study area presented themselves based on the combination of allocated objectives to the arable fields, visualised by 3D matrices and maps. High priority for erosion control (52 %), water retention (30 %) and/or wind protection (4 %) was allocated to 66 % of the arable land. Based on a hierarchical cascade of filter steps, establishing silvoarable agroforestry would be suitable and recommended on 94 % of the arable land. Planning factors derived from studies, supplemented by practical recommendations, resulted in four basic design approaches for silvoarable agroforestry systems. These designs were assigned to the fields of the study area using a decision tree, including the priority of stated objectives, site characteristics and crop rotation. The literature findings confirmed the dependence of design factors for soil erosion, microclimatic and water balance effects. Agroforestry systems targeting soil erosion reduction and water retention on 92 % of the arable land with slope gradients > 3 % were characterised by smaller crop alleys and wood strips covered with vegetation. In contrast, the orientation, height and porosity of the wood strips were crucial for agroforestry systems targeting wind (erosion) protection and microclimate enhancement on 43 % of the arable land with < 6 % slope gradient and low to medium water erosion risk (cf. Figure 1). Based on the potential area and expected effects at the field scale, hereafter, initial assessments can be made of how implementing agroforestry systems can contribute to the stated objectives. Field-scale studies reported reduced surface runoff (n=3), wind speed and erosion (n=7), water retention (n=7) and modification of microclimate variables (n=5) for short rotation systems. Reduced surface runoff and erosion (n=5) and wind speed (n=1), as well as water retention (n=12) and microclimate (n=7), were measured in timber and fruit systems, compared to arable cultivation.

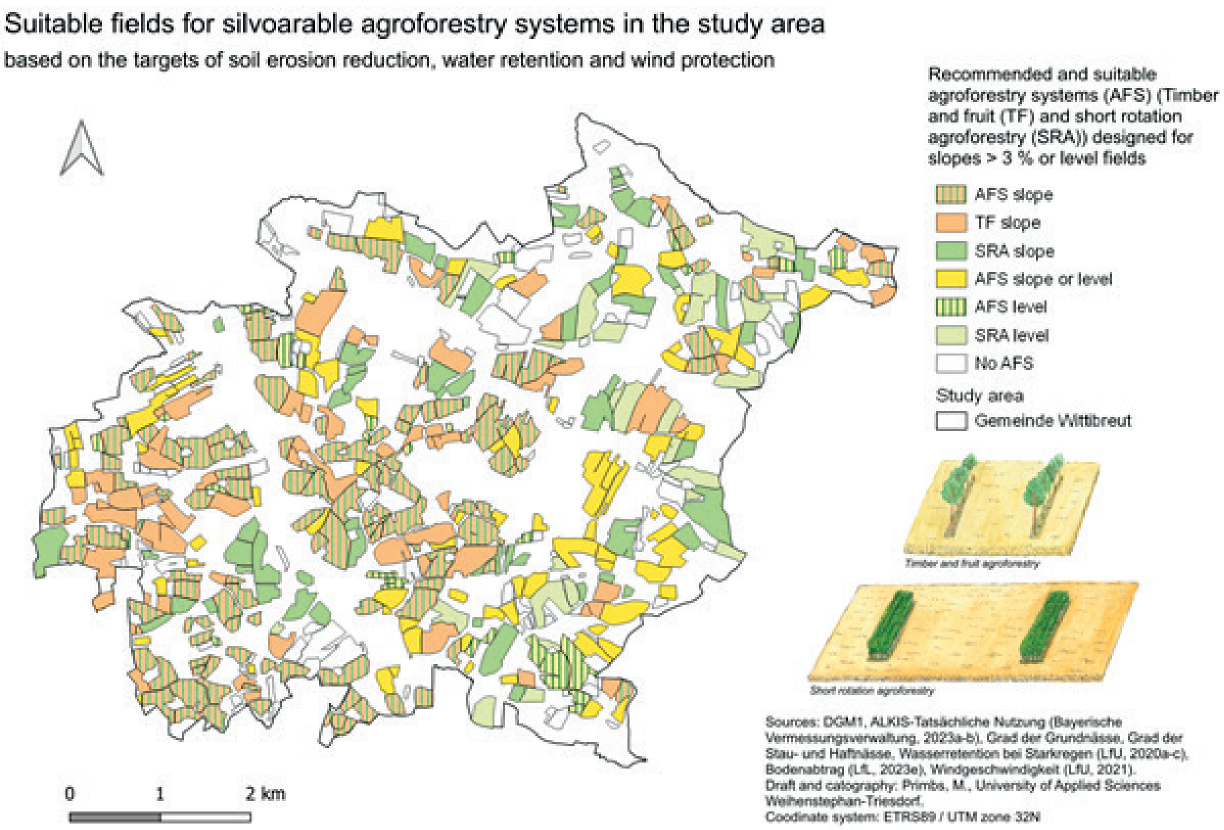
Conclusion

The planning approaches merge scientific and practical planning factors for aided decision-making for agroforestry planning inspired by practitioners' needs but always founded in science. The agroforestry designs for soil erosion and water management serve as planning recommendations on the local scale for temperate regions. The developed planning approach on the regional level can provide a simplified method for municipalities and regions to get an overview of the suitability of fields for agroforestry regarding set objectives, thereby facilitating the establishment of such systems and enhancing climate change resilience of arable agriculture. Expert interviews confirmed that economic viability, legal security, and consultation are fundamental to removing barriers to its implementation. Future research should investigate the automation of simplified planning approaches on the regional scale and extend the scientific basis for field-scale effects depending on system designs and site specifics, as well as for landscape-scale effects.

Keywords

agriculture, Agroforestry, silvoarable agroforestry, microclimate, soil erosion control, alley cropping, adaptation, agroforestry system planning, spatial planning, water management, soil conservation measures

Aditional Attachment II.



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Master Thesis

Primbs, M. (2023) Development of planning approaches for temperate silvoarable agroforestry systems for soil erosion and water management at the local and regional level. Master thesis. Department of Landscape Architecture, Dep. of Forestry, Dep. of Sustainable Agriculture and Energy Systems, University of Applied Sciences Weihenstephan-Triesdorf.

Study of microclimate influencing effect of hedgerow in organic tomato production system

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Introduction

Agroforestry systems, including hedgerows have great importance in field vegetable production, especially in regions where climate and soil properties (sandy soil with 1,5% humus content or lower) do not meet the optimal production requirements.

Hedgerows, and shelterbelts decrease harmful effects mainly by reducing wind speed. The reduction of wind speed by hedgerows can be achieved by appropriate structural composition and orientation. The efficiency of reducing wind speed is about 10–15% on the windward side, and can reach 60% on the leeward side (Boskovic et al 2010). By the reduction of wind speed, the microclimate can be modified in terms of relative humidity and temperature. Microclimate manipulation has the ability to optimize the microenvironment for crop plants.

This research aims to evaluate the microclimatic modulation effect of a hedgerow in an organic tomato production system, by comparing the performance on windy and protected sides. The results can contribute to revealing the effects of hedges in organic vegetable production.

Materials and methods

The experiment took place in the vegetation season 2023 at the Experimental and Research Farm, located at the Hungarian University of Agriculture and Life Sciences (MATE), Organic Farming Unit (47.394557 N, 19.147419 E). Plots were set up on two sides of a hedgerow, that orients to NW-SE and consists of three lines of trees in the middle and bushes on two sides. The hedge is considered as narrow, with 5m width and 6m average height (Gál 1972). The hedge was established using local species and varieties in 1999-2000. The experimental plots were set up at five different distances from the hedge at both sides. Distances were gradually increased with three-three meters, (R1, R2, R3, R4, and R5) with R1 being the closest and R5 the farthest from the hedgerow. Temperature (oC) and humidity (H%) data logger sensors were positioned in the middle of each plot in steadily increasing distances from hedge on both sides in a straight line. Three tomato genotypes (Roma VF, Ace 55, and Szentlőrinckáta local landrace) were applied in the experiment in both side × distance combinations. Plots were aligned in a random block design, consisting of five replicates of tree varieties on both sides resulting 2*15 plots in 3*5 blocks. The spacing between plants and rows was set at 60*70 cm.

Air humidity and temperature was measured by Voltcraft DL-121TH and DL-210 TH sensors, wind speed was measured by AkiNET DL-Anemometer on both sides. Sensors were positioned in the center of each block in 90 cm height from the soil; sensors were protected from direct sunlight by custom plastic shading containers, the sides of which were perforated and the bottom was opened. Although the applied temperature/humidity sensors used are medium level measurement methods, the obtained results are appropriate for the detection of obvious tendencies. Wind sensors were positioned on both sides of the hedge, at the outer edge of R5 blocks (W=windy, P=protected position). Data logging was set to 30 min intervals; datasets were averaged for calculating daily data.

Results: Considerable differences were found between the average temperatures of the windy and the protected sides. Using the average temperature of the hedge as a reference value throughout the period of 30 May-6 September, the average deviance of the windy side is +2.49oC, while that of the protected side was +3.54oC measured in 15 m distance (W5 and P5) from the hedge. It shows, that in 15 m distance from the hedge, the protected side can benefit an average of +1.04oC from the establishment of a hedge. This advancement was also measured in the closest measurement points (W1, P1). In the case of the windy side, the average difference from the average air temperature inside the hedge was +2.07oC, while it was +2.45oC on the protected side. (Figure 1) Comparing the amount of healthy red fruit harvested, the side variable (windy or protected) had a significant effect on the number and weight of the harvested fruits, with the protected side producing significantly more healthy red fruits compared to the windy side.

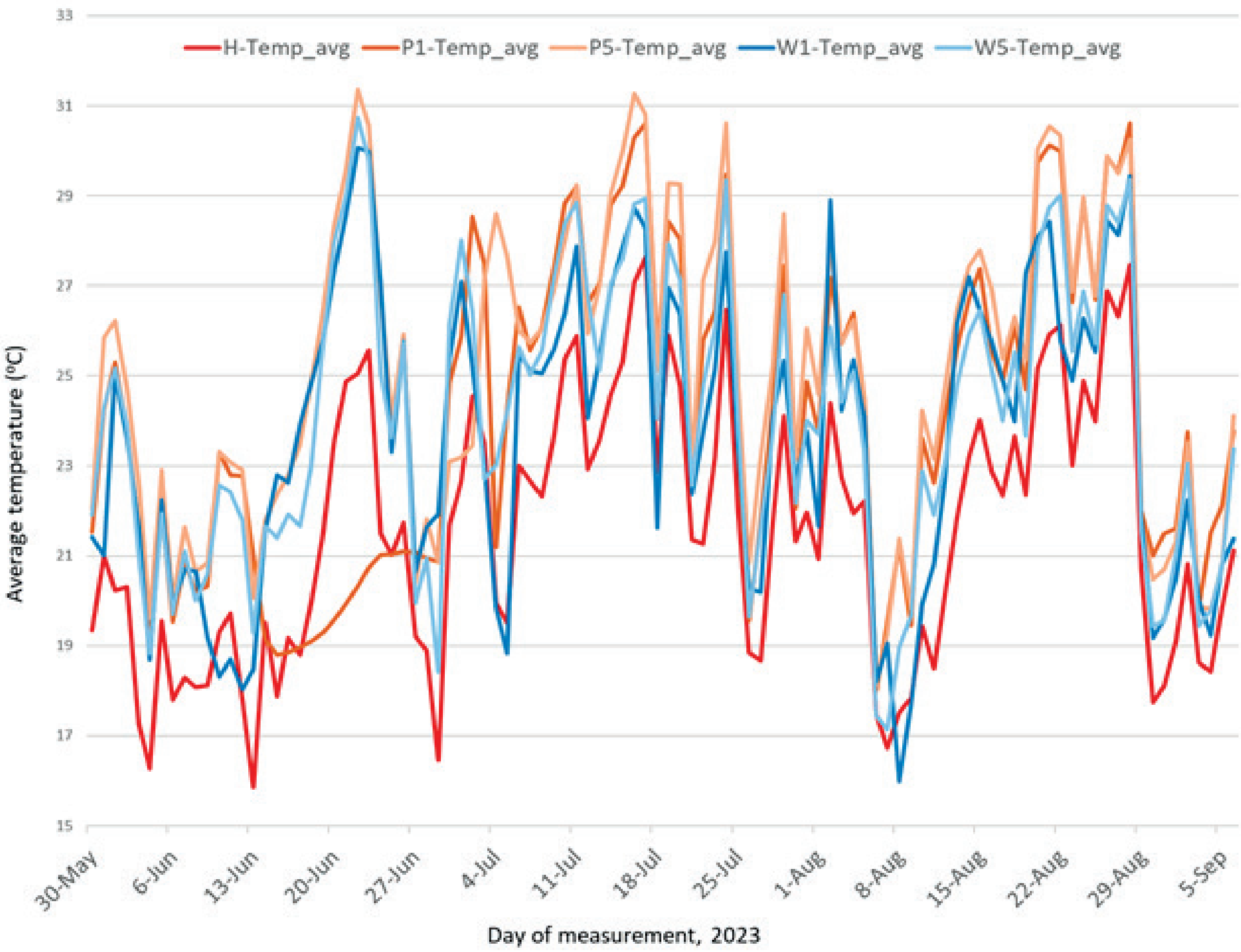
Conclusion

The results show that the average temperature of the protected side is +0.38oC higher compared to that of the windy side related to the vegetation season. The less pronounced effect of temperature modulation in the case of lower distance might be accounted to the shading effect of the hedgerow. The overall influence of the hedge on the air temperature might be explained by its ability to break the momentum of the wind. The tomato fruits harvested on both sides of the hedges show higher percentage of healthy fruits in the case of protected side. The overall influence is beneficial in terms of increasing earliness of vegetables on the protected side and in providing less moist microclimate within the canopy of crops which might decelerate and reduce pathogen infections on the windy side.

Keywords

climate mitigation, shelterbelts, temperate region, hedgerows, air temperature, organic tomato production

Aditional Attachment II.



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3 year-monitoring of microclimate in an maize-poplar short rotation alley-cropping system in a Mediterranean coastal area

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Introduction

Heat waves, drought and exceptionally strong winds are posing significant risks to agriculture (Van Meijl 2017), affecting evapotranspiration, thus, plant responses with effects on soil fertility (Awazi and Tchamba 2019; Tsufac et al. 2019). Alley cropping systems, such as short rotation coppice (SRC) in the temperate zone, combine fast-growing trees with annual crops. Such agroforestry systems can mitigate climatic events since the tree component can act as a windbreak and they can also work as a shading barrier to reduce to certain extent soil heating and evaporation although often arranged in alternating alleys with North–South orientation to minimise shading (Beule et al. 2022).

Therefore, it is important to understand how wind and shade variables change depending on the size of the trees and, to what extent, can affect crop ecophysiology and growth.

Objective

This study aims to assess the microclimatic conditions in an alley-cropping system and their effects on the soil and the crop water status.

Methodology

The study was carried out at the Centre of Agri-environmental Research "Enrico Avanzi" Research (University of Pisa, Lat. 43.68, Long.10.34), located in the Arno River plain, close to the coastline. The alley-cropping system design comprised two rows (at 13.5 m distance) of hybrid poplars managed as SRC 3 year-cycle and maize within the rows. Micrometeorological monitoring was carried out from 2021 to 2023, from maize sowing to harvest (approximately from May to September). The maximum poplars' height and canopy density was in 2021 (H3 = 4.5-7.0 m); poplars were cut and harvested in winter 2022 (H1= 0-2.0 m) and in 2023, poplars were at the 2nd year of the cycle (H2 = 2.5-4.0 m). Parameters were recorded in an open field (control) and in the central part of the alley. Wind speed and direction were measured by bidirectional sonic anemometers; air temperature and humidity were detected hourly approximately 1 m above the canopy, by lifting up the sensors during the vegetation growth. Over three days of the maize growth period (June-September): i) shade projection on the ground by poplars within the alley was calculated hourly, according to the 3-D solar and the tree geometry, ii) soil moisture was measured continuously at a depth of 0.2 m along a transversal transect within the alley, iii) the water status of the maize was assessed by measuring the leaf water potential (ψ) from pre-dawn to late afternoon during 3 days.

Results

Shade within the alley ground was negligible during H1, reaching a shade length up to 2 m inside the crop area (max 15% of the surface) only from August. When poplars were at H3, shade affected the maximum part of the crop area: in June-September, the total shade increased from 23% to 41% covering, either in the morning or in the afternoon, the external thirds of the alley.

A strong NW-W sea breeze from 12:00 till the late afternoon characterised the whole area. Concerning the upwind reference point, the main effects on the wind reduction were observed when poplars reached H3. The first and second row of poplars reduced the wind speed by approximately 20% and by 50-70%, respectively. After the poplars' cut, the wind reduction was very limited.

In 2022 weather conditions were rather extreme: average temperature between 21 and 29 °C and average maximum temperature was over 30 °C for most of the period. However, compared to the control, the temperature within the alley was generally lower.

Soil moisture was higher in the central part of the alley when poplars were high (H2-H3). During the summer, following the poplars' cut, soil moisture was lower in the central part of the alley, and within the alley it was on average lower than in control.

When poplars were H1, maize ψ during the central hours of the day showed similar values in the control and within the alley. Instead, during the poplars' growth (H2), ψ showed lower values in the control and in the central part of the alley compared to the two external sides (about 0.4 MPa lower), as well as at the maximum height of poplars (H3). Poplar shadow in the afternoon contributed to the plants' water status recovery later in the day, starting from the west side of the alley. However, the external sides of the alley resulted in scarce crop soil cover.

Conclusions

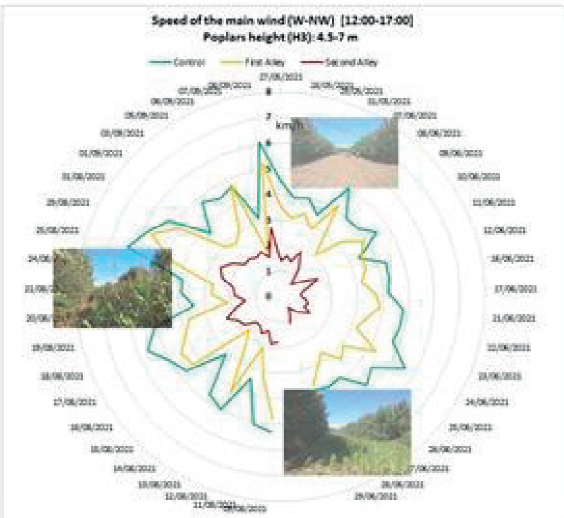
Poplars of the SRC reduced wind speed, affected soil moisture and up to certain extent shading aided crop's water status recovery. However, tree height and distance from maize must be accurately planned due to the likely competition for water and light which in turn affect crop density and growth (data not shown). Therefore, tradeoffs should be taken into consideration to identify the most effective decisions on management.

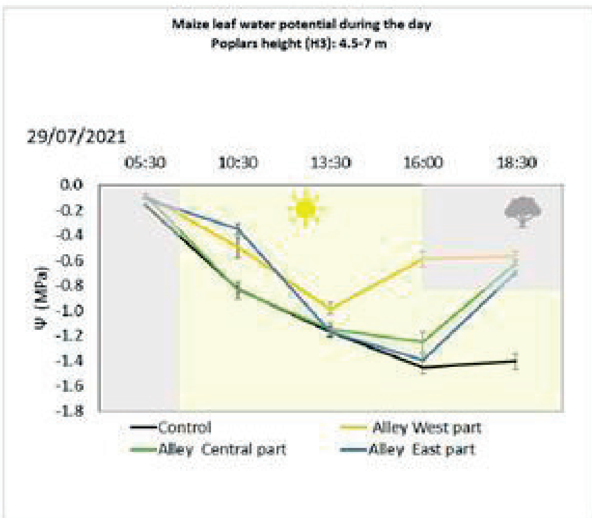
This work is part of the EIP-AGRI Operational Groups (Tuscany RDP 2014-2022) "PS GO NEWTON NETWORK PER L'AGROFORESTAZIONE IN TOSCANA".

Keywords

alley cropping systems, wind attenuation, alley cropping, agriculture, abiotic disturbances, poplars, soil moisture, agroforestry monitoring, microclimate, adaptation, Agroforestry system, climate change, maize water status, air temperature, microclimatic parameters

Aditional Attachment II.





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Microclimatic functions of trees stand with different densities - short rotation coppice and agroforestry systems - in agricultural landscape

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Introduction

The importance of trees in agricultural systems - as a source of local woody biomass and an efficient provider of multifunctional environmental benefits - is growing. Trees, especially stands of them in short rotation coppice (SRC) and agroforestry systems (AFS), are often recommended as tools for solving multilateral tasks and goals which our societies and landscapes are facing due to current human and environmental crises, e.g. climate change, economic and energy poverty, biodiversity loss, soil erosion and depletion (Lojka et al., 2020; Weger et al., 2022).

Objectives/research question

Our work aims to evaluate and quantify how trees (fast-growing and others) and especially the density of their stands influence (micro) climatic conditions and mitigate climatic extremes in the landscape.

Methodology

We have monitored microclimatic conditions in three growing seasons (1. May to 30. September) from 2020 to 2022 in three sites with different densities of trees: SRC (0.5 ha with 10000 trees/ha), silvoarable AFS (0.7 ha with 440 trees/ha) and FIELD (45 ha with no trees). In SRC, poplars were harvested (coppiced) in March of the first year of our monitoring, and they reached heights of 1.7 – 3.5 – 4.6 meters after growing seasons 2020-2022. In AFS, 18-20 year-old linden and rowan trees were 7.9-12.1 m tall during the monitoring period. The FIELD and the AFS (10-15 m wide) sites were farmed with conventional food crops - annually alternating wheat, pea, and wheat crops from 2020-2022. All three sites are in the experimental station Michovky (N 49°59.52107', E 14°34.70347') in the Central Bohemian Region of the Czech Republic - at a maximal distance of 500 meters from each other and with identical soil-climate conditions.

We have monitored the following parameters in all three sites: air temperature and humidity at 1 m, soil temperature and moisture at depths of -1 cm, -30 cm a -60 cm, photosynthetically active radiation (PAR) at 4 m and wind speed at 4 m. Rainfall was measured in FIELD and throughfall under trees in AFS and SRC with under-crown rain gauge. All parameters have been measured by the automatic monitoring system, which records data every 10 minutes (http://www.emsbrno.cz/p.axd/en/Pole.VUKOZ.ALS.html). The interception of rain by/under trees was calculated as the difference between the sum of rainfall in the FIELD and the AFS or SRC.

Results

The most significant differences in measured parameters were between SRC and FIELD; AFS results were intermediate. For instance, in SRC with a fully developed canopy (since 2021), the average air temperature was up to 1°C lower, the average soil temperature at -60 cm was up to 2°C lower, and the photosynthetically active radiation was 4.5x lower than in the FIELD site. Similar differences continued also in 2022. However, in SRC, after trees were harvested (March 2020), a process carried out every 3-4 years, the air and soil temperatures and soil moisture were higher and air humidity lower than in the FIELD site.

In AFS, the average air temperature was slightly lower than in the FIELD site by 0.05 °C in 2020 and 0.36 °C in 2022, while average air humidity was nearly the same as in FIELD during all growing seasons. Surface soil temperature (-1 cm) in AFS was lower than in FIELD only in crop strips during all growing seasons. Rain interception under tree crowns was, on average, 38%-48% in AFS and SRC during all growing seasons.

Conclusions

The results show that dense tree stands with closed canopy (SRC) are the most efficient in reducing air and soil temperatures and increasing air humidity. The "cooling-ability" in AFS is lower than in SRC. Still, AFS is more favourable for maintaining higher and long-term soil moisture in crop strips, probably due to the lower tree density (water uptake) and less interception of rainfall than the fully developed SRC. AFS, therefore, can be recommended for buffering climatic extremes, especially heat and droughts, thus lowering the stress conditions of cultivated crops in AFS. Well-designed and managed AFS can offer balanced sun radiation, temperature, and moisture conditions for producing conventional food crops and ecosystem benefits missing in our landscapes with intensive agriculture. We have also correlated these differences to yields of annual crops grown in AFS and FIELD (another conference contribution of our team).

Keywords
climate mitigation, tree spacing, fast-growing tree, coniferous trees, Socioeconomic status, microclimate, deciduous trees

Aditional Attachment II.

Figure 1: Sites with monitoring systems from left: FIELD (no-trees), AFS (440 trees/ha) and SRC (10000 poplars/ha; late spring 2020 - after harvest)

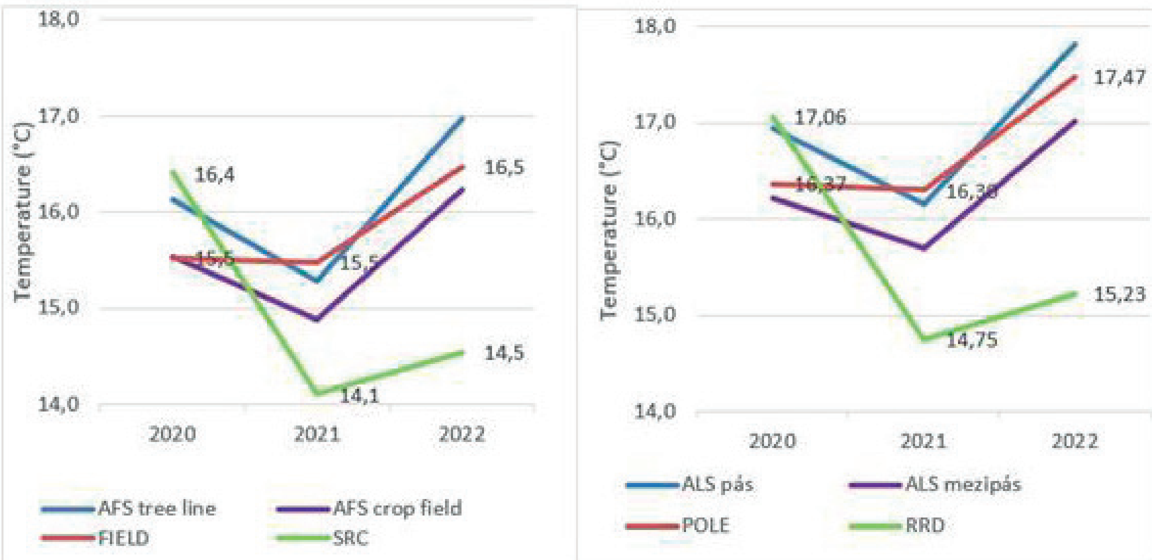

Figure 2: Average soil temperature at -30 cm (left) and -60 cm (right) in AFS (in tree line and crop field), FIELD (POLE) and SRC (RRD) in the growing seasons from 1/5 to 30/9 in 2020 – 2022

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AFS-1 (Experimental Agroforestry System Michovky – VÚKOZ Průhonice) http://www.agroforestrysystems.eu/en/michovka-2

1.3 Biodiversity (I)

Oral presentations

Hall Q3, 28 May 2024, 16:30 - 18:00

Monitoring of biodiversity effects of agroforestry: Start of a long-term experiment in Hesse, Germany

Prof. Dr. Miriam Athmann[1,2], Dipl.-Biol. Harald Haag[2], Dr. Rüdiger Graß[1]

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Introduction

Agroforestry systems have the potential to promote biodiversity in agroecosystems, but effects are complex and not all species profit from the integration of woody structures. At the Hessian State Domain Frankenhausen, an 18 ha long-term agroforestry experiment with alley cropping of walnut (Juglans regia), hazelnut (Corylus avellana) and black currant (Ribes nigrum) was established in 2022 on two experimental fields at a site where positive effects for biodiversity had been generated already during the past 25 years, both via conversion to organic agriculture in 1998 and via integration of various nature conservation measures including elements of agroforestry, mainly hedges, fruit trees and field margins, in 2008-2010. A biodiversity increase is expected from both the newly established woody structures and the diverse grassland that has been established underneath.

Objectives

The integration of structural elements in 2008-2010 was accompanied by three years of farmland bird and butterfly monitoring. With the implementation of the agroforestry system, this monitoring of butterflies and farmland birds was reestablished at and around the two experimental fields (in total: 70 ha) with the objective to generate data on the initial status at the sites at the time of initiation of agroforestry.

Methodology

Farmland birds were monitored via territory mapping on 7 dates between March and June each year, butterflies were monitored via transect counting at four transects along field margins. Both bird and butterfly numbers were compared with data generated with the same methods in 2008-2010 to measure the impact of conversion to organic agriculture and of hedges, fruit trees and field margins established in 2008-2010.

Results

First results show that the total number of farmland birds nearly doubled between 2008-2010 and 2022-2023, with 3 species that were not found any more and 12 new species as compared to 2008-2010. A total of 38 butterfly species was detected in the transects in 2022-2023 (vs. 18 in the 2000s), with 4 species that were not found any more and 7 new species. 7 species are classified as rare or endangered on the red list for Germany and/or the state of Hesse. Particularly, the species spectrum in the field margins was complemented by species associated with marginal site conditions.

Conclusion and Outlook

The site has seen a clear increase in abundance and biodiversity of farmland birds and butterflies in the past 12 years, including some protected species. Future monitoring planned for 2026-2028 will reveal first effects of the integration of alley cropping.

Keywords

alley cropping, Agroforestry, agroforestry monitoring, temperate agroforestry, biodiversity, agroecology, agroforestry landscapes, farmland bird, Birds

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Agroforestry systems are significantly increasing biodiversity of ground beetles (Carabidae)

Ing. Ph.D. Jan Weger[1], Bc. Jaroslav Bubeník[1]

1 Výzkumný Ústav Silva Taroucy Pro Krajinu A Okrasné Zahradnictví, V. V. I., Průhonice, Czech Republic

Introduction

European landscapes are heavily affected by industrialized agriculture. This intensive management is in many regions responsible, among other harmful impacts, for dramatic loss of biodiversity and increase of soil erosion (Kletty et al., 2023). These negative trends have been worsened by extreme enlargement of farmed fields during transformation of agriculture from state owned to market driven in Central and Eastern European states – for instance average farm size is over 250 ha in Czech Republic in comparison with 35-45 ha in EU. One of the possible measure to stop these negative effects is implementation of agroforestry, which diversifies farm fields and agricultural practice. An increase of biodiversity has been often reported as one of the positive environmental effects of modern agroforestry systems (AFS).

Objectives/research question

To verify and quantify positive effect of AFS on biodiversity in conditions of czech agriculture practice we have established experiment where we have compared composition and amount of ground beetle (Carabidae), which are important indicators of biodiversity, in agricultural monocultures, agroforestry systems and "close to the natural habitats".

Methodology

To study ground beetles we have chosen five localities (Michovky – Průhonice close to Prague in south-eastern direction, Miskovice by Kutná Hora, south-bohemian Nová Olešná, moravian Šardice by Kyjov and Úholičky close to Prague in northern direction). Two are silvopastoral, two silvoarable and one "non productive" AFS. To collect beetles we used pit-fall traps filled with solution of water and ethylene glycol. Five traps were installed in variants representing 3–4 biotopes/habitats per location. There were agroforestry, natural, mainstream agricultural fields and mainstream agriculture ecotone habitats. Traps were emptied three times per year, in spring, summer and late summer time. After analyzing trap's content, ground beetles were stored in ethanol and sent to entomologist expert for description. When each beetle was identified, we divided them into categories R – rare, A – adaptable and E – eurytopic according to methodology by Hůrka, 1996 and Veselý, 2002. Degree of anthropogenic influence (DAI) was calculated.

Results

We have collected 11 550 individual beetles and described 99 species of which 53 species were eurytopic 45 adaptable and one was rare. 10 730 beetles were eurytopic, 750 were adaptable and 69 rare. One ground beetle Harpalus albanicus was not placed into any of categories. Rare beetles were found only in Šardice location. After summing up the data from all five locations DAI indexes were 0,38 in agroforestry variant whereas 0,088 in mainstream agricultural and 2,858 in natural variants.

Conclusions

Field results of ground beetle composition indicate the transitional character of agroforestry element in countryside, something between natural biotops and land strongly influenced by human activity. It seems, that based on DAI index value, agroforestry systems attract ca. 4 times more adaptable as well as eurytopic groups of ground beetles, what can cause enhancement of biodiversity in comparison with mono-cultural industrial agriculture management.

Acknowledgement

Our research was possible thanks to grant no. TH04030409 of TAČR program Epsilon.

The authors would also thank the following experts and collaborators for their help in processing the results: Doc. Jan Farkač, Ph.D. (ground beetle taxonomy), Ing. A. Mazouchová, Ph.D. (GSM models), and owners/managing farmers of the ALS research stands: Ing. J. Miller, Mr. and Mrs. Bartoš, doc. Dr. P. Marada, B.Sc. Josef Nedbal, Ing. Radim Kotrba, Ph.D.

Keywords
Agroforestry, Carabidae, biodiversity

Aditional Attachment II.

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Agroforestry systems to support bat conservation in Europe

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As a consequence of agricultural intensification and landscape homogenization, semi-natural elements such as hedges, woodland patches and scattered trees have been removed from many agricultural areas. The resulting habitat loss has led to the decline of the diversity and abundance of many taxa including bats, which are highly dependent on linear elements in their habitats as foraging areas and commuting corridors. By combining trees with crops (silvoarable systems) or livestock (silvopastoral systems), agroforestry re-integrates structural diversity into agricultural areas and can have beneficial effects on biodiversity. However, to our knowledge, the effects of such systems on bats have not yet been investigated.

In this study, bat activity was recorded with autonomous sound recorders at seven silvoarable and thirteen silvopastoral sites located in seven European countries. The bat activity measured at these sites was compared to nearby forests, orchards and cropland (in case of silvoarable systems) or pastures (for silvopastoral systems). We predicted positive effects of the presence of trees and grazing animals, both contributing to a stronger structural heterogeneity and a higher insect prey availability. Moreover, we expected the benefits to bats to depend on the type and age of trees.

We found that bat activity, but not species richness, was significantly higher in silvopastoral systems than in pastures, cropland, and forests. In addition, social calls and foraging rate of bats were highest in silvopastoral systems. Contrary to our expectations, we measured no differences in bat activity and species richness between silvoarable systems and cropland. Tree characteristics affected total bat activity, with activity increasing with tree age and being significantly higher in sites associated with broad-leaved trees compared with coniferous trees.

Our results show that the combination of trees and livestock in silvopastoral agroforestry systems is highly beneficial for bats. The implementation of extensively grazed silvopastoral systems across Europe could support bat conservation in agricultural landscapes and, thus, promote the important ecosystem services such as pest control that are provided by bats.

Keywords

bats, biodiversity, silvoarable agroforestry, silvopastoral systems, conservation

Acoustic bird monitoring in 20 Swiss agroforestry systems: Challenges and opportunities

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Introduction

Modern agroforestry is emerging in Switzerland. One example is the project Agro4esterie, which aims to promote agroforestry in four cantons of western Switzerland. Farmers are supported in the establishment of new agroforestry systems. Starting in 2020, with around 100 farmers participating, both new silvoarable and silvopastoral agroforestry systems were installed. From 2020 to 2027 a biodiversity monitoring is being carried out on 20 sites (Roberti 2023).

Trees and shrubs in open farmland can provide additional habitats for breeding birds, and thus agroforestry systems may help in restoring farmland bird diversity, especially in temperate Europe (Edo et al. 2023). Our research focuses on monitoring methods for this species group using digital audio recorders and deep-learning-based tools. These techniques of analyses are emerging as a new way to perform monitoring (Pérez-Granados 2023). Passive acoustic monitoring is the deployment of audio recording devices to capture, in this case, vocalizations of birds. These sounds can be analysed by the deep-learning-based tool BirdNET, which is able to detect more than 6000 species worldwide (Kahl et al. 2021). BirdNET output consists of timestamps, with species names and a confidence value indicating the certainty of the model with its prediction.

Research questions

The technical and ecological aspects encountered in the ongoing monitoring lead to two key questions:

- How good is the quality of the automated detection with audio-recording techniques in combination with BirdNET?
- Can we already find patterns in breeding bird diversity in young agroforestry systems after two years of monitoring?

Methodology

We used the AudioMoth recorder (Hill et al. 2019) for our audio recordings. As part of the monitoring on 20 sites, passive acoustic monitoring in combination with a semi-automatic analysis workflow is being used to quantify breeding bird diversity. During three weeks per year (April, June, August), daily recordings are made (2h each day, starting at sunrise) and subsequently audio files are analysed using the application BirdNET.

On a subset of 28 recording sequences, five different procedures for filtering of the BirdNET output data are applied, using a combination of species lists and confidence threshold. The confidence threshold filter excludes detections below a value of 0.5 (in a range of 0 to 1), and the species list filter excludes species not represented in an expert species list. The same 28 recordings were annotated by an ornithologist for comparison.

For the analysis of the entire recording dataset, a combination of a confidence threshold of 0.5 and a local species list is used. Manual verification of detections is performed in uncertain cases.

Results

The comparison of the five analysis procedures shows that procedures using a confidence threshold have a high number of false negative detections, but a very low number of false positives. On the other hand, species lists have the reverse effect (little false negatives, high number of false positives). True positives are high using species lists, and low for confidence value procedures. Looking at the F1-Score, using a local species list without confidence threshold, performs best (F1 of 0.3)

The dataset from the initial years of the monitoring gives some insight into breeding bird diversity in emerging agroforestry systems. On average, 8.5 species were found on the monitoring sites. Bird diversity correlates with the amount of bird habitats expressed as a habitat score (Kaeser 2009) in the vicinity of the site (see appended figure). However, no clear effect of farming intensity (organic vs. conventional farming) nor type of agroforestry system (silvopastoral vs. silvoarable) on bird diversity was observed. Since the trees are still very young (<5 years) the environmental effects of the agroforestry systems might not be very strong yet.

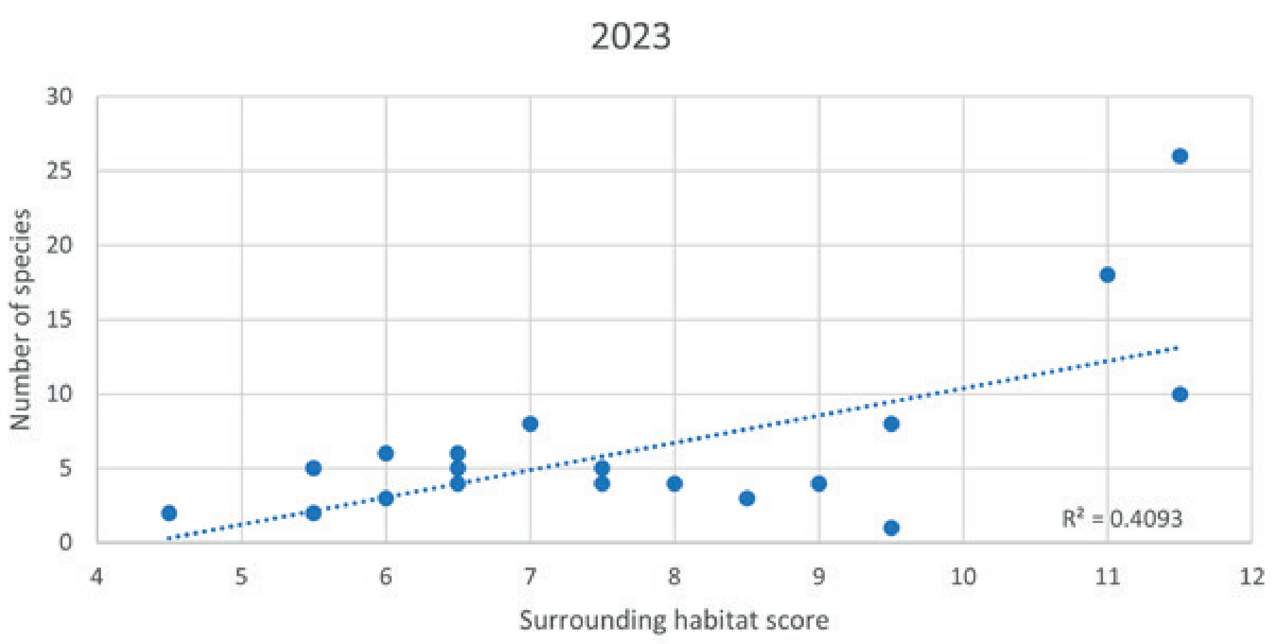
Conclusion

In conclusion, passive acoustic monitoring seems to be a suitable and effective method for assessing bird diversity in agroforestry systems. The analysis workflow allows for a time-efficient monitoring, but some challenges in regards to reliability and technical complexity remain. The data from the environmental monitoring reveals interesting correlations and can help to understand the impact of Swiss agroforestry systems on birds. However, further monitoring is needed to get a clearer picture on the longer-term effects.

Keywords

Birds, Agroforestry system, agroforestry monitoring, deep learning, passive acoustic monitoring, agri-environmental system, biodiversity, Audio recordings

Aditional Attachment II.



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Plant community response to solitary trees in traditional wood pastures of Southern Transylvania (Romania)

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Traditional wooded pastures are characterized by modest productivity and represent semi-natural ecosystems. These traditional agroforestry systems are often considered biodiversity hotspots and have a high significance for landscape structure and services. However, large areas of these ecosystems have been lost throughout Europe in the last century due to land-use intensification, urbanization, land abandonment, and declining management. Several studies have assessed plant species richness and diversity in wood pasture systems. Nevertheless, the influence of solitary tree canopy areas on plant species richness and diversity, along with their impact on plant functional groups such as grasses, forbs, and legumes have not been addressed yet. This study addresses this gap by investigating the influence of solitary tree canopies on southern Transylvania's wood-pasture agroforestry system in Romania. We employed a stratified random sampling at 30 sites with 360 plots. Data on solitary trees, vegetation, and environmental variables were collected. To test the effects of tree canopy area on species richness and diversity, we applied analysis of variance (ANOVA) and Tukey's post-hoc test. To examine the effects on species composition, we employed analysis of dispersion (Betadisper), analysis of similarity (anosim), and indicator species analysis (ISA). In total, we found 239 plant species. Species richness and species diversity were positively correlated with distance from tree canopy, emphasizing the role of lighter conditions. Furthermore, functional group analysis revealed a substantial influence of the tree canopy distance on legumes and forbs, with no marked variation for grasses. This research underscores the significant influence of the distance of solitary tree canopies on vascular plant species richness and diversity, primarily driven by variations in light conditions. Our findings provide valuable insights into the plant community in the studied traditional wood pasture system, with implications for both research advancements and management strategies in biodiversity conservation.

Keywords
Agroforestry, biodiversity, Agroforestry system, Socioeconomic status, grazed woodlands, oak, functional groups, solitary tree, Grassland with trees, vascular plant diversity, traditional wood pasture, plant diversity, grassland

Vegetation Diversity and Weed-pressure in Alley-cropping Agroforestry in Switzerland

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Introduction

Alley-cropping, the integration of tree-lines in arable fields, is a practice with positive ecological, economic, and social effects (Torralba et al., 2016; Thiesmeier & Zander, 2023). However, the understory vegetation (spontaneous or not) in the tree-lines may act as a reservoir for weeds and increase the pressure (spillover) on the arable crops. Therefore, many farmers sow species-poor seed mixtures, containing mainly grasses, to avoid the potential spillover-effects. This results in simple floral communities in the tree lines with limited benefits for biodiversity (plant richness, feeding and nesting resources for insects).

However, the relationships between tree-lines species-richness and weed pressure in arable fields are still unclear. Boinot et al. (2019) showed that the spillover effect is generally weak and limited to the area near the tree lines. But do agroforestry systems with higher species richness also suffer from increased weed pressure? And are problematic weeds more present in species-rich vegetation communities in the tree lines?

This study aims to examine whether increased weed-pressure is restricted to the arable areas close to the tree lines (1-2m) and whether there is a relationship between species richness and weed pressure and which.

Research questions

- Is there an increased weed-pressure in the arable field-zones near to the tree-lines, compared to more central zones of the fields?
- Do agroforestry systems with higher species richness in the tree-lines suffer from increased weed-pressure (spillover) in the arable crops?

Methods

The data collection has been conducted in 2022 and 2023 in 20 silvoarable agroforestry systems (organic and conventional) in Switzerland. Vegetation surveys (recording of all plant species and their relative coverage) of the tree-line vegetation were carried out. All species in six 1m x 1m plots and their relative coverage were recorded. In the arable-fields, surveys of the weed-cover in three different distances from the tree-line (0.5, 2 and 8 m) were carried out. All species in 0.25 m2 have been registered, together with their relative coverage and the crop-coverage.

Results

In total 210 plant species were found in the 20 agroforestry systems. 90 of them were also found at least once in the arable-fields. The maximum number of species found in one system was 70 and the mean number of species per square-meter 10. In the arable fields, the mean weed-cover was 5% for conventional and 14% for organic systems.

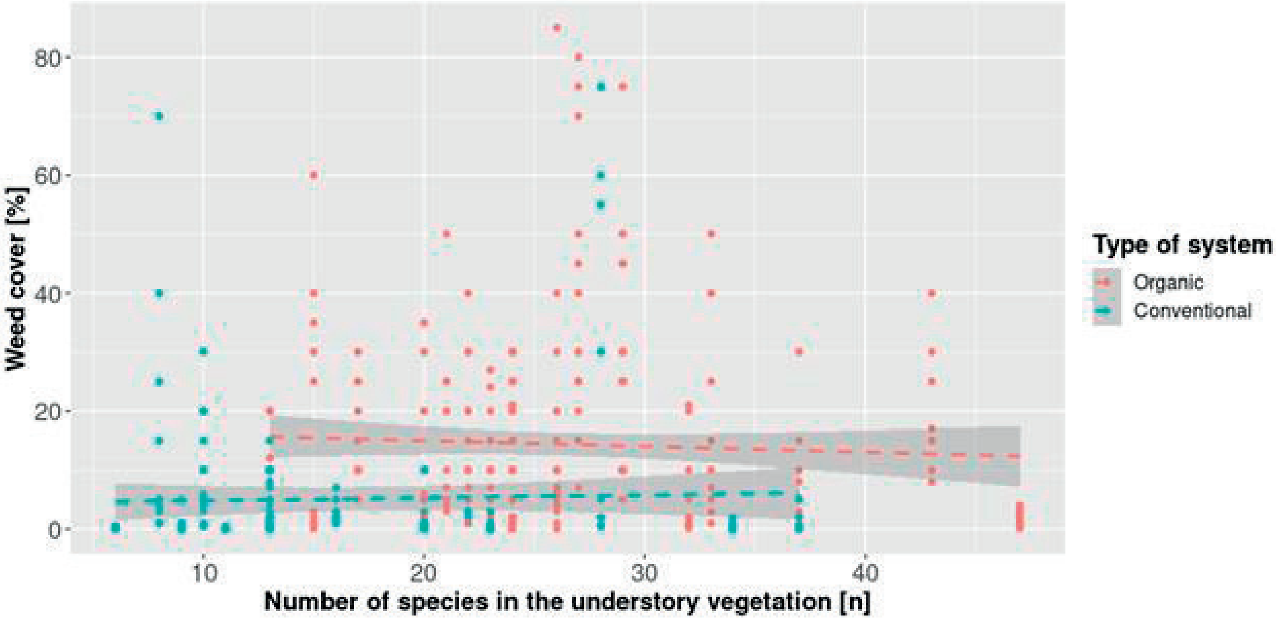
The results do not show any significant difference between weed pressure near the tree-lines (distance of 0.5m) in comparison to the central zones (distance of 8m) of the arable-fields. This indicates that the spillover-effect is marginal and does not increase the weed-pressure significantly. Also, the species-richness of the tree line vegetation did not have any effect on weed pressure, indicating that sowing species-poor mixtures does not have any beneficial effects. The main differences are explained by the farming-system, with organic farming suffering from more weed pressure than conventional farming. This effect is not related to agroforestry, but observed in any type of agricultural practice.

Conclusions

This study clarified the relationships between species-richness in the tree line vegetation and the weed pressure in arable zones. It indicates that agroforestry does not significantly increase the weed-pressure, even in systems with a high species richness in plant communities. However, since the analyzed system are very young, the study should be repeated in the future, in order to confirm the result

Keywords
alley cropping, plant species richness, biodiversity

Aditional Attachment II.



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1.3 Biodiversity (II)

Oral Presentations

Hall Q2, 29 May 2024, 8:30–10:00

Arthropod Community Extraction from Soil Samples using a MACFADYEN Extractor in a Silvopasture

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Introduction

Trees and shrubs exert positive effects on both above- and below-ground biodiversity in agroforestry systems as they provide nutrients, building materials, a microclimate, and microhabitats (Marsden et al., 2020; Mupepele et al., 2021). By increasing species richness and the relative abundance of soil organisms such as ground-dwelling Arthropods, agroforestry systems can indirectly improve soil health. For example, earthworms, ants and other so-called ecosystem engineers, alter the physical structure of soil, influencing nutrient and energy flow rates (Coleman & Wall, 2015). Smaller arthropods, also called litter transformers, fragment decomposing litter and improve its availability to microorganisms. Thus, by modulating and complementing the activity of saprotrophic microorganisms, ground-dwelling arthropods play a pivotal role in shaping soil health, influencing carbon transformation, nutrient cycling, soil structure maintenance, and biological regulation (Barrios et al., 2012; Pamminger et al., 2022). Despite the critical role of ground-dwelling arthropods, there remains a gap in our understanding of how different agroforestry systems and agricultural practices in temperate regions impact soil fauna and their functions. Therefore, there is a clear need to implement effective methods for assessing the influence of trees and shrubs on soil fauna, particularly ground-dwelling arthropods. Through the application of the described non-invasive method for extracting and quantifying soil fauna, our research aims to explore the spatial distribution of the arthropod community in a temperate silvopastoral system over time.

Methodology

The experimental site is a flat, 3.4 ha silvopastoral system situated in canton Aargau, Switzerland. Various tree and shrub species were planted in single or double rows in winter 2022, spaced approximately 30 meters apart, resulting in a total of eight rows. These trees and shrubs are categorized into sections and serve various purposes, including standard trees, cut hedges, or stock hedges. Soil sampling was conducted along a transect with seven sampling points per transect. The central sampling point was located within a stock hedge double row, with three additional sampling points orthogonally spreading out on both sides (east and west) of the row at distances of 1, 5, and 10 meters. Three transects were sampled, yielding a total of 21 soil samples. Shrub species at the central sampling point of the three transect were 1.) Salix daphnoides (violet willow), 2.) Sorbus aucuparia (rowan), and 3.) Corylus avellana (hazel). The soil samples were collected using HumaxTube® insert sleeves (Humax® Soil Sampling Technologies, GreenGround AG, Switzerland, 2020), typically used for bulk density determination, to obtain undisturbed cylindric soil cores with a height of 14 cm and a diameter of 5.8 cm, resulting in a volume of approximately 370 cm3. For transportation, samples were sealed with parafilm and stored in plastic bags inside a cooler box. Soil cores were weighted and randomly placed upside down in the MACFADYEN Extractor (MACFADYEN High-Gradient-Extraktor, ecoTech Umwelt-Messsysteme GmbH, Germany), a modified version of the Tullgren funnel (Berlese, 1905; Hassall et al., 1988). Collection vessels were fastened afterward to prevent contamination with soil particles. A temperature ramp was initiated, commencing at 25°C and gradually increasing to 60°C over the span of 7 days. During the temperature ramp, topsoil gradually dried out causing the organisms to move downwards into a cooler section until falling through a grid into the vessels. The soil organisms were then counted and identified up to class level. For each Sampling point, Shannon index (H') was calculated:

$$H' = -\sum pi * \ln(pi)$$

H'= Shannon index
pi= n individuals of specific species at location/n individuals of all species at location

A one-way analysis of variance (ANOVA) was conducted to assess whether there were significant differences in the means (n = 3) of the Shannon index across sampling point distance and direction (n = 7). The assumptions of normality, homogeneity of variances, and independence of observations were checked.

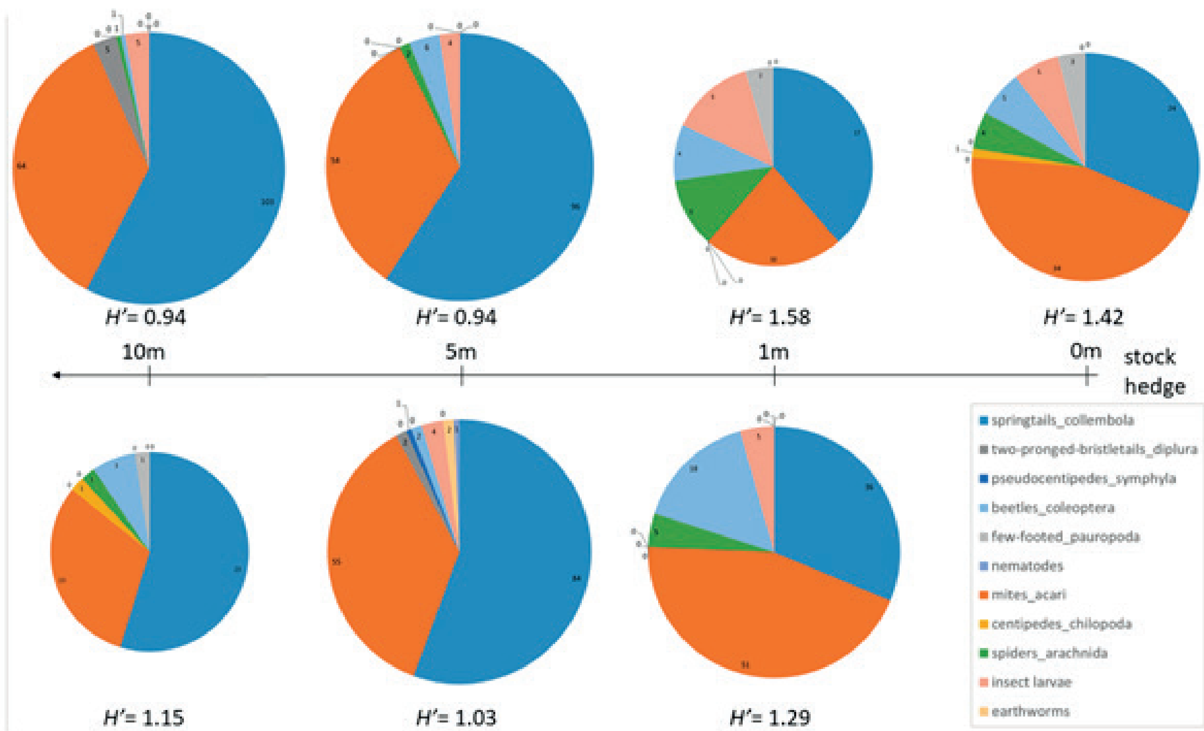
Preliminary Results and Conclusion

A total of 768 individuals were collected from eight different classes of arthropods as well as earthworms, insect larvae and nematodes. Shannon indices did not differ significantly across sampling point distances and directions; however, they tended to be higher near or within the stock hedge (Figure 1). Even though the total amount of individuals was smaller near or within the stock hedge, a higher number of large arthropods (spiders and beetles) was found, resulting in the higher Shannon indices. These findings may be associated to microhabitat preferences, resource availability, and interspecific interactions. So far, no statement on change over time can be made as it is the first year of this study. Further investigations are necessary to track species richness and abundance to comprehensively understand the factors driving the distribution pattern and the effect on the agroforestry system and related functions.

Keywords

arthropods, Transect sampling, silvopastoral, biodiversity

Aditional Attachment II.



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Effect of intercropping of Paulownia and buckwheat on soil microbial biodiversity and enzymatic activity

Dr hab. Anna Jama-Rodzeńska[1], Dr habilitowany Marek Liszewski[1], dr Małgorzata Woźniak[2], dr Elżbieta Gębarowska[1]

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Introduction

The main objective of today's intensive agriculture is the urgent need to find solutions that contribute to the sustainability of agriculture while at the same time increasing crop yields needed to feed the world's growing population. Intercropping is the practice of growing two or more crop species or genotypes simultaneously in the same field for a period of time. Such a cropping system can affect microbial diversity and alter the content and distribution of soil aggregates, thereby improving the physicochemical properties of the soil, increasing the abundance and diversity of the microbiome, and increasing the total carbon, available potassium, and phosphorus content of the soil. The abundance and diversity of soil microorganisms are significantly higher in agroforestry systems. Paulownia spp. is a species of fast-growing deciduous tree with high tolerance to variable soil and climatic conditions and low water requirements. Buckwheat (Fagopyrum esculentum Moench), on the other hand, is a crop that is in high demand around the world for its multiple uses. To ensure food security in a global climate change scenario, this pseudo-cereal is an alternative to other crops.

Objective

The aim of the study was to determine the feasibility of growing paulownia and buckwheat (in the inter-rows between paulownia) in the same field, and to capture changes in the soil environment in terms of microbiology (microbial biodiversity and abundance).

Methodology

A field experiment with buckwheat (Fagopyrum esculentum Moench) and paulownia (Clon in Vitro 112 - Oxytree; P. elongata × P. fortunei) was established in 2019 at the Wroclaw University of Environmental and Life Sciences, using the randomized block method. The factor studied was the intercropping of buckwheat with paulovnia in rows against the control. Plots of buckwheat without oxytree were treated as control plots. In the experiment, biodiversity analysis of the biome was performed through microbiological analyses including DNA extraction, PCR and Illumina amplicon sequencing. To determine the colony forming units of bacteria and fungi in the studied soils, we performed dilutions on medium according to Bounta-Rovira (Bunt and Rovira, 1955) and Martin (Martin, 1950), respectively. Dehydrogenase activity (DHA) was analyzed according to PN-ISO 23753-1 and the concentration of total glomalin-related soil proteins (T-GRSP) extracted from soil samples according to the method described by Wright and Upadhyay with modification. Results: In the studied rhizosphere soil, 10 types of bacteria were found to be dominant: Acidobacteriota, Proteobacteria, Acidobacteriota, Chloroflexi, Gemmatimonadota, Bacteroidota, Firmicutes, Myxococcota, Verrucomicrobiota and Planctomycetota. The NGS analysis showed that Actobacteria, Proteobacteria and Acidobacteria dominated the microbiome in each variation of the experiment, regardless of the crop. In all combinations tested, Actobacteria were the largest group, accounting for up to about 45%. Proteobacteria were also a key group in all combinations (about 20-30%), depending on the combination studied. The dominant fungi were again 4 species: Ascomycota, Basidiomycota, Mortierellomycota, Mucoromycota. In all combinations studied, Ascomycota were the largest group with up to about 65%. Dehydrogenase activity was higher in the intercropping system compared to the control, but statistically significant differences were observed at the first sampling date (T1). The highest DHA activity was observed in the intercropping system in 2022 at the first sampling date.

Conclusions

Intercropping paulownia and buckwheat changed the abundance of soil bacteria and fungi. Intercropping not only improves soil quality in agricultural ecosystems, but also provides insight into the relationship between soil microbial diversity and ecosystem functions. Intercropping is a potentially useful land use system for increasing the sustainability of agricultural production and the efficiency of using available land. Our research indicates that, as a rule, the system of intercropping with Paulownia and buckwheat trees

had a positive effect on soil microbial properties, which are a sensitive indicator of soil quality. Both the mycobiome and the TBI microbiome are rich in microorganisms belonging to the group of plant growth promoting microbes, which positively affect plant growth and yield. Temporal variation is a key factor affecting the biological properties of the soil, given the seasonal and annual trend of each parameter analyzed. The research presented here can provide a basis for the development of innovative management strategies for growing bioenergy trees. In addition, they aim to provide scientific arguments for the implementation of TBI systems based on Paulownia trees in temperate climates.

Keywords
intercropping system, intercropping, buckwheat, Socioeconomic status, oxytree, biodiversity, alley cropping, agriculture

Exploring food forest soil biodiversity: from microbes to earthworms

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Introduction

The past decades it has become increasingly clear that while achieving high agricultural output, the post-war, high-input agriculture is an important driver of above- and belowground biodiversity loss. Soil biodiversity is, besides being intrinsically valuable, crucial for the functioning of agroecosystems (e.g. for nutrient cycling and soil aggregation) (Bardgett and van der Putten 2014) and important for future food security (FAO, 2020). The incorporation of trees in silvoarable and silvopastoral agroforestry systems has been found to improve biodiversity and soil health compared to their monocropping counterparts (Dollinger and Jose 2018; P. Udawatta et al. 2019). A strongly diversified and more complex type of agroforestry that has recently seen a surge in public attention in Europe, is food forestry (Albrecht and Wiek 2021). Food forests (or forest gardens) are multi-strata food production systems that emulate young woodlands or forest edges in their complexity and interaction patterns and consist of a high diversity of mostly perennial plants (Nytofte and Henriksen 2019). In Belgium and The Netherlands alone, more than 300 food forest projects have been planted in the past twenty years (Roodhof, in press; Moereels, manuscript in preparation). The functioning of these systems is still far from understood, and this holds especially true for what happens belowground. While the body of evidence for beneficial effects on biodiversity from silvoarable and -pastoral agroforestry practices and (sub)tropical food forests is growing, this has not been thoroughly evaluated for food forests in the temperate zone. Two of temperate food forests' defining characteristics, namely their high perennial plant diversity and the limited disturbance of the soil have however been shown to enhance soil biodiversity in other systems (Tsiafouli et al. 2015; Isbell et al. 2017) and suggest temperate food forest soils could harbor diverse soil communities.

Objectives/research questions

With this study we provide the first thorough assessment of belowground biodiversity (richness, abundance and community composition) of soil micro, meso- and macro-organisms in temperate food forests and how soil biota communities differ between the food forests and local reference land use types (permanent grassland, cropland and mixed forest). Our first hypothesis was that abundance and diversity of most soil organisms would be higher in food forests compared to the reference land uses. Our second hypothesis was that the community composition of most soil organism groups would be distinct between food forests and grasslands and arable fields.

Methods

We studied 15 food forest systems spread across The Netherlands and Flanders and compared soil biodiversity attributes in these systems to those in reference sites managed as a permanent grassland, cropland (mainly cereals and corn) or mixed forest. The reference sites were located less than 2 km from the food forest and on the same soil type. The food forests displayed a gradient in age, ranging from 6 to 29 years old and were located on diverging soil types. All food forests were planted on land that was previously used as cropland or grassland. In each study site a composite soil sample of the upper 25 cm soil was collected in 6 stratified random plots. On these composite samples phospholipid and neutral lipid fatty acid analyses were conducted to estimate microbial biomass and DNA sequencing was used to identify soil fungi, bacteria, archaea and protist species composition. In 3 out of 6 plots, earthworms, nematodes, mites and springtails were collected and counted. Earthworms were microscopically identified to species level, whilst DNA sequencing was used to obtain nematode, mite and springtail species composition.

Results

Contrary to our hypothesis, we did not find higher biomass estimates for the bacteria and fungi or higher nematode abundance in the food forests than the reference land uses. For mites and springtails, we found that abundances in the food forests were intermediate between those in grasslands and forests, as expected. Earthworms had the highest abundance and biomass in grasslands, except for epigeic earthworms that had higher abundance and number of species in food forests. Results on the microbial, nematode and mite and springtail diversity and species composition are still in progress but will be presented at the EURAF conference as well.

Conclusion

Patterns in the difference in abundance and diversity between food forests and grasslands, croplands and forests differ between groups of organisms. For some groups, like mites, we found higher abundances in food forests than croplands and grasslands, indicating a shift towards a more forest-type ecosystem, whilst for other groups such a shift was not yet observed. This points towards a partial shift in the soil food web, but further analyses of the data will give a more complete picture of which species find a habitat in food forests and what role food forests could play in restoring agricultural soil biodiversity.

Keywords

nature-based solutions, soil biodiversity, food forest, Land Use, temperate agroforestry

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Effects of land use change on soil microbial functioning in a long-term agroforestry system

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Introduction

Agroforestry is an agricultural land use management practice that can be described as the integration of trees with livestock and/or crops and has been demonstrated to provide multiple ecosystem service benefits such as improvements to soil, water, and air quality, as well as benefits to agronomic and livestock production. However, it is uncertain how historical changes in land use and land management within these systems can affect wider soil microbial community composition, abundance and functioning and therefore the potential impact on regulating processes such as soil nutrient cycling and carbon sequestration. This study tested the hypothesis that a change in land management will fundamentally alter soil processes and the ability of the ecosystem to deliver specific biological functions.

Methods

Shotgun metagenomic characterisation of soil samples from a long-term agroforestry site in the United Kingdom, that had experienced transitional management over time, were compared to i) permanent grassland and ii) woodland control plots to assess both variation in microbial taxa and potential functionality of microorganisms with a view to assessing ecosystem sustainability and resilience. The taxonomic and functional profiling as well as the relative abundance in each experimental plot were quantified at the phylum level. DNA data quality was evaluated using Nanodrop, Qubit and Gel electrophoresis. Minimum read length was 20bp. Microbiome functional capacity was then profiled across soil samples using KEGG Orthology (KO) modules and EC (Enzyme Commission) numbers for "carbon metabolism" and "nitrogen metabolism", grouped by type of compound they metabolise.

Preliminary Results and Discussion

5500 unique species were detected in total across the different land uses: 160 Archaea, 5259 Bacteria, 75 Eukaryota and 8 viruses. Of these 3967 have a mean relative abundance of less than 1%. Proteobacteria and Actinobacteria can be considered dominant species in all land uses.

Figure 1. Relative abundance of enzymes associated with carbon cycling functions in agroforestry relative to grassland and woodland control plots, Loughgall, UK

Initial results show clear differences between the abundance of enzyme functions associated with the macronutrient cycle in agroforestry plots relative to grassland and woodland plots. For enzymes related to carbon cycling functioning, enzymes related to the breakdown of hemi-cellulose (beta-glucosidases) are most abundant; and have significantly higher abundance in grassland and forest plots relative to agroforestry ($P<0.01$; Figure 1). In general, it is to be noted that there is a greater abundance of functional enzymes in the grassland system relative to the other habitat plots. This may be due to differences in management activities and practices such as inorganic fertiliser, grazing livestock excretal returns and liming additions.

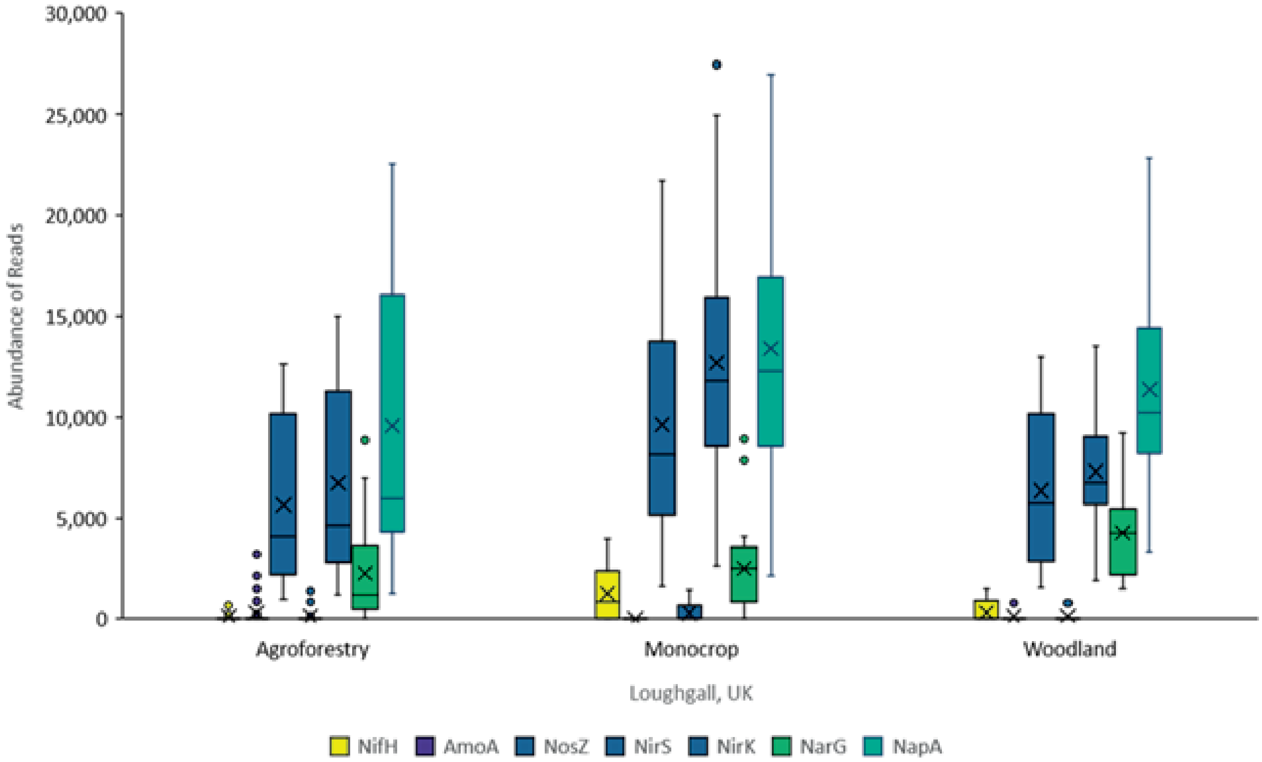
Enzyme functions associated with nitrogen cycling functions including nitrate reduction and denitrification (NosZ, NirS, NirK) appeared to be most abundant, with a trend of greater abundance in monocrop grassland habitat plots relative to the other land uses. However, the greatest range of total abundance reads were found in the agroforestry plots. Nitrogen fixation (NifH) was highest in the grassland and woodland habitats relative to agroforestry.

Overall, it appears that management practices, such as higher inputs of nutrients in the monocrop grassland system have influenced the soil microbiome community composition, abundance and function and therefore potentially macronutrient cycling rates. Drivers of enzyme functional abundance is still being explored in the context of soil biogeophysical and chemical parameters and ecosystem vegetation to ascertain how land use change affects long-term ecosystem sustainability and resilience in these agricultural systems.

Keywords

Land Use, biodiversity, soil microbiome, climate change, Agroforestry

Aditional Attachment II.



What can biodiversity do for agroforestry?

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The benefits to farmland biodiversity of integrating trees and agriculture is highlighted as one of the main selling points of agroforestry. Research comparing biodiversity in European agroforestry and conventional farming has been going on for decades now, leading to a good understanding of the overarching differences between agroforestry and monoculture systems (Torralba et al, 2016; Kletty et al, 2023), primarily reflecting higher system complexity. However, there are still some research gaps, with certain, more challenging, taxa underrepresented in previous research (e.g. bats, soil biota), and the influence of the surrounding landscape and temporal dynamics rarely considered, although recent research aims to address some of these gaps (see abstracts by Ido et al, 2024, and Olaves, 2024, in this book of abstracts).

With a strong evidence base that confirms the value of agroforestry for biodiversity, research is moving now towards a greater focus instead on what biodiversity can do for agroforestry, such as natural pest control, pollination, and nutrient cycling. This is particularly important to provide evidence to farmers who are under pressure to adopt more sustainable practices such as reduced usage of pesticide and synthetic fertilisers, while also facing higher prices for such inputs. Studies show higher abundances of natural enemies and pollinators and lower abundances of pests in some agroforestry systems, but it is more challenging to demonstrate how these differences translate to improved pest control and pollination (Staton et al, 2019). Knowledge on the role of soil organisms to support nutrient cycling, improved soil structure and plant health in European agroforestry systems is also sparse (Rolo et al, 2023), although studies report higher soil microbial biomass, a general indicator of soil health, in agroforestry systems compared with treeless systems (Beule et al 2023). The subsequent impacts of functional biodiversity, the services they provide, and potential trade-offs, on productivity and financial performance at the farm-level is currently lacking, although see Staton et al, 2022.

Going forward, there should be greater consideration of how the design and management of agroforestry systems can be optimised to support functional biodiversity and the delivery of these ecosystem services. For example, what is the best alley width that combines efficient mechanical harvesting of crops with foraging distances of pollinators or predators from tree understoreys? What combinations of tree species and understorey species would provide maximum flowering resources throughout the season for pollinators? Can we increase pest control services by providing nest boxes for birds and bats in new and young agroforestry plantings? What is the best way to manage tree understoreys to support pollination and pest control services? Work by Staton et al, 2021, showed that by reducing the cutting of understorey vegetation to allow flowering, apple trees had fewer aphid-damaged fruit which, combined with reduced mowing costs and additional income from government grants for flower rich areas, increased farm income compared with mown understoreys. Providing such evidence to both farmers and policy makers is key to making the case for agroforestry, not just as a practice that benefits biodiversity, but as a sustainable land use that, through enhanced ecosystem services provided by biodiversity, reduces the need for external inputs or interventions.

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Effect of cropping system on soil mesofauna diversity and abundance: An olive alley agroforestry

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Soil is the largest habitat for many species where geo-bio-chemical processes are interconnected and constantly active. Globally, 25% of soil biodiversity is composed of soil organisms, approximately 85% of them are arthropods. Soil arthropods drive its functioning by organic matter translocation, particle fragmentation and decomposition, nutrient cycling, predation/biocontrol, and the facilitation of microbial activity. Agricultural intensification, expansion, and mechanization have been shown to reduce soil biodiversity and its functioning. However, agricultural practices aiming at the conservation of soil functioning - hold potential to support ecosystem services of soil fauna. Soil conservation include practices such as minimum tillage and allowing vegetative cover within the crop. We study the effect of vegetative cover in agricultural systems on the diversity of soil mesofauna aiming to explore the links between soil conservation practices, and soil fauna diversity, as an indicator of its functioning. Our hypothesis suggests that allowing vegetation in an orchard or vineyard will support richer diversity of fauna as compared to bare soil practice between the crop lines. To study the impact of vegetation on soil fauna we will compare agricultural fields covered with vegetation to the same system with bare soil. To evaluate soil fauna diversity, we will extract soil cores (approximately 1000cm3 in size) from the covered and uncovered agricultural soils. Mesofaunas will be extracted in a Berlese-Tullgren funnel and observed under a stereomicroscope at low magnification (usually 20–40×) to classify them at order/class level. Then, they will be assigned by ecomorphological index (EMI) based on their level of adaptation to the soil for computing the soil biological quality index (QBS-ar). In addition, Indicator Species Analysis of the different treatments will be compared. Preliminary results showed that QBS-ar values did not significantly differ in soils with and without vegetative cover (n=5, p= 0.354). However, the mean QBS-ar values of samples with vegetative cover showed slightly higher value than without vegetation, after herbicide application (70 and 56 respectively). In addition, the community composition did differ (n = 5, pv = 0.0092). This led us to predict that vegetative cover, in olive-alley agroforestry field, will be positively linked to soil mesofauna diversity and abundance. Hence, the impact of vegetative cover on soil mesofauna diversity and abundance could be evaluated as an indicator for soil fauna functioning.

Keywords

Mesofauna, Agroforestry, alley cropping, soil fauna, soil functioning

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1.3 Biodiversity

Poster presentations

Poster session, Building Q - Foyer, 29 May 2024, 12:00–13:00

Service tree, suitable tree for agroforestry systems

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Abstract

Service tree (Sorbus domestica L.) is a scientifically little-studied species (abbrev.SD) belonging to the original (endemic) forest fruit trees of Europe. More recently classified for its genetic uniqueness as Cormus domestica (McAllister, 2005), it is the original species of the light oak forests, which are suitable for restoration as ecosystems resistant to climate change. In the years 2002 – 2021, a gene pool of different types of SD was obtained from most of the extension area, and the properties of this species are being monitored in new agroforestry plantings established in 2008, 2011, 2014, 2018 and 2021 in SE Moravia. Here, SD appears as a fast-growing, long-lived tree, fruiting after 7-10 years. Seedlings of large-fruited types carry the quality of the fruits of the mother plant quite significantly. Agroforestry plantings are mixed and SD characteristics are compared with other drought tolerant trees. The drought resistance is similar to the oak Quercus robur (Schmucker, 2023) and Q. pubescens, and is higher than Pyrus pyraster (Paganová, 2010). Growth capabilities and space and soil requirements correspond to oaks (Schmucker, 2023). When planted in a clip larger than 5 m, there is a similar increase, without the influence of light competition, as with winter oak and pollince pear (Pyrus pyraster), and it is lower than wild cherry (Prunus avium) and, on the contrary, taller than S. torminalis. Due to the rapid vertical growth in the first 10 years, without good support, the species is not suitable as a solitaire for windy positions (ridges, slopes with prevailing winds). As part of the monitoring of plantings, a species Classifier was created, which describes the morphological, phenological and partly also organoleptic variability of the species, and according to it, its quality can be monitored in other agroforestry plantings within the range of the species.

Keywords

multi species, non-forest woody vegetation, wild food, biodiversity, plant diversity, Socioeconomic status, Sorbus domestica, research-action approach, fruit trees

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The beekeeping value of buckwheat (Fagopyrum esculentum MOENCH) in intercropping with oxytree (Paulownia elongata x P. fortunei)

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Introduction

Intercropping is the practice of growing two or more crops in the same field at the same time. A special form of intercropping is alley cropping. It makes it possible to avoid monocultures, which lead to the appearance of agrophages, nutrient depletion and an increase in the abundance of certain weed species. The system of intercropping allows the use of ecological factors to protect the soil from erosion, excessive drying, reduce the number of pests and the occurrence of some weeds. The intercropping of trees and melliferous plants contributes to increasing the biodiversity of the agroecosystem, brings additional income to the farm, supports the development of biological life in the soil, reduces water loss, prevents the growth of weeds and the penetration of nitrogen from mineral fertilizers deep into the soil profile. Inter-row shading by oxytree trees can protect melliferous plants from strong sunlight during the flowering period, thus preventing deterioration of nectar quality (nectar dehydration). Nectar dehydration makes flowers less attractive to pollinating insects, resulting in a decrease in seed yield.

Objective: The objective of the study was to determine the feasibility of Paulownia and buckwheat in the same field (in the interrows between trees) and to estimate the apicultural value of buckwheat in terms of the amount of nectar produced, the concentration of saccharides in the nectar, and the weight of sugar per 10 buckwheat flowers and per hectare.

Methodology

In 2019, a field experiment was conducted with buckwheat and oxytree (Clon in Vitro 112 - Oxytree) using the randomized block method. Buckwheat cultivation in the alley (A1) was the factor studied. Plots with buckwheat cultivation without Oxytree were treated as controls (A2). Oxytree seedlings were planted on May 30, 2019. In the spring of 2020, the trees were technically pruned and the main shoot (future stem) was selected. Buckwheat was sown in the interrows between the trees on May 11, 2021; May 04, 2022; April 20, 2023 at the rate of 250 seeds per square meter. The area of the buckwheat plot was 30 m2. The trees were planted in rows, 5 per plot, with a row spacing of 5 m and a tree spacing of 4 m.

Buckwheat nectar was determined by the pipette method according to Jablonski (2003) on eight dates in 2021 (from 28.06. to 14.07.), eleven dates in 2022 (from 13.06. to 14.07.) and ten dates in 2023 (from 07.06. to 28.06.). Flower samples (from at least 10 isolated plants) were collected from the center of the canopy of each plot. The nectar collected in the laboratory was weighed and then the concentrations of sugars in it were determined in an Abbe refractometer and the sugar mass was calculated according to the formula: sugar mass = (nectar weight x % sugars)/100. The result obtained was then recalculated for 10 buckwheat flowers. On each day, the number of developed flowers was also counted on 10 plants, which was recalculated according to the plant density per 1 m2 and then per 1 ha. For each day of observation, the number of insects visiting the plot (block) was determined (from 7:15-7:30).

Results

It should be concluded that the intercropping of buckwheat with oxytree did not cause a deterioration of parameters important for the apicultural value of buckwheat in terms of its attractiveness to pollinators. It also did not contribute to a significant change in yield and deterioration of buckwheat nut quality. The statistical analysis performed did not show the significance of the differences between the two groups (A1 and A2) for the three-year period, in the parameters presented. The observed differences between years are mainly due to the effect of weather conditions during the growing season of buckwheat.

Conclusion: The intercropping of buckwheat with Paulownia allows an efficient use of the land between the oxytree rows. Strip (alley) cultivation does not deteriorate both nectar and yield conditions for buckwheat.

Keywords

intercropping system, flowering, oxytree, honey plants, buckwheat, beekeeping, agriculture, alley cropping, Socioeconomic status, intercropping

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The impact of buffer tree strips on diversity of different groups of Arthropods in organic arable land

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Structure of arthropod communities depends on the type of a cropping system, especially on such its elements as share of perennial crops, reduced tillage, organic farming or agroforestry. At the same time any type of landscape diversification has a potential to increase biodiversity. In this study we assessed the impact of buffer tree strips of different age on the diversity of arthropods in organic arable land. Three sweep net samples have been collected in 3 distances in the experimental plots in Juchowo biodynamic farm (north-western Poland) in 2021-2023. For the old of 10 m high trees samples were taken in distances of 10, 20 and 30 m. For the young trees of 5 m high, distances were: 5, 10 and 15 m. Spiders, Araneae were the most numerous in proximity of the trees and Araneidae, Linyphiidae and Thomisidae families dominated there. Beetles, Coleoptera were also more numerous in the closest proximity to the trees and for this group Anthicidae, Coccinellidae and Curculionidae families dominated. Flies, Diptera, were evenly distributed in all distances, however, some families were found in higher numbers near to trees, like Chloropidae and Cecidomyiidae, and other at the maximum distances from the trees, like Muscidae. Most of bugs Hemiptera were found in distance of 5 and 10 meter from the trees, depending on the family. Aphids, Aphididae family picked at 15 m from the trees, whereas number of leaf hoopers Cicadellidae was highest at 5 m from trees. Miridae and Pentatomidae were most represented at the distance of 15 and 20 m. Wasps, Hymenoptera were abundant on proximity to the trees at 5 and 10 m, especially in case of families Crabronidae, Trichogrammatidae and Braconidae. Number of thrips Thysanoptera increased with the distance from the trees at 15, 20 and 30 m. The presence of the trees affected both beneficial arthropods and the pests. This research was carried out in the framework of the MIXED project (Multi-actor and transdisciplinary development of efficient and resilient MIXED farming and agroforestry systems) that received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862357.

Keywords
microarthropods, Organic Farming, tree-bordered field, insect, biodiversity

Tree diversity in German alley cropping research and praxis

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Numerous studies have documented the benefits of agroforestry systems for diverse ecosystem indicators (Chapman et al. 2020; Jose 2009; Seserman et al. 2019; Udawatta and Gantzer 2022). These benefits result from a higher structural and species diversity in agroforestry systems compared to farmland without trees and may even be increased by enhanced tree species diversity as suggested by research in forests with increasing complexity (Augusto and Boča 2022; Brassard et al. 2013; Sanaei et al. 2021). However, a research gap exists for the temperate climatic zone, regarding the impacts of different levels of tree diversity on ecosystem indicators in agroforestry systems.

To address this research gap, we compared the diversity of tree use types and tree species of alley cropping systems in German agroforestry practice and research. We drew on information from a) the largest database of existing agroforestry systems in Germany, b) a systematic search of peer-reviewed literature and c) interviews with German agroforestry researchers.

We found that German alley cropping practice is characterized by a large share (58%) of systems with three or more different tree species. In contrast, agroforestry research in Germany has had a strong focus on alley cropping systems with only one or two tree species (84% of systems). With regard to the intended tree-use, biomass systems dominated research (65%) but appeared only in 24% of the cases in agroforestry practice. In contrast, fruit systems were only analysed in 19% of the studies but account for 51% of the systems in agroforestry practice.

The fact that, in general, the agroforestry systems analysed in research were on average less complex than the systems in German agroforestry practice may have implications for the development of agroforestry. Among others, this discrepancy may lead to a distorted perception of the state of agroforestry in Germany and biases concerning the development of suitable financial support measures. However, interest in tree diverse agroforestry systems is growing in the German research community. At various German universities, new agroforestry research sites have recently been installed or are in the planning phase. For all these sites, systems with multiple tree species are of interest (Rüdiger Grass, Lucie Chmelíková, Julia Schneider and Claudia Kammann, personal communication in February and March 2023).

With regard to quantifying the impacts of agroforestry systems on ecosystem indicators, we identified three major research gaps for agroforestry research in Germany: 1) Agroforestry systems with a high tree species or tree-use type diversity remain understudied. 2) Further research on fruit tree agroforestry systems is needed as this is the main tree-use type in German agroforestry practice. 3) Empirical studies testing the assumption that tree species diversity in agroforestry systems can improve ecosystem indicators are needed.

Keywords

Socioeconomic status, trees, biodiversity, tree diversity, Germany, ecosystem services, alley cropping

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1.4 Landscape Planning (I)

Oral presentations

Hall Q2, 28 May 2024, 16:30–18:00

PrioSilvAra and PrioSilPas: new tools for prioritising target areas for silvoarable and silvopastoral systems

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LIFE AgroForAdapt project (2021-2026 - www.agroforadapt.eu) aims to promote agroforestry systems (silvoarable and silvopastoral) as a measure to adapt the Mediterranean agriculture and forestry sectors to climate change. With 8 Spanish and French partners, the project covers Catalonia and Castilla y León (Spain) and Occitanie and Provence-Alpes-Côte d'Azur (France), where we have installed and/or manage 76 demonstration systems, totalling more than 850 ha.

One specific project objective is to develop innovative tools to promote agroforestry adoption. A key aspect of this is to identify the areas where the promotion of agroforestry systems would be particularly beneficial, considering the ecosystem services they provide. This would make it possible for land planners to optimise the use of private and public resources (including subsidy policies) allocated to agroforestry deployment, as well as to define climate change adaptation plans at local and regional levels.

In this communication, we present the rationale, methodology and conclusions of a pilot application of two tools developed in 2023-24 within LIFE AgroForAdapt project to prioritise the areas where to install silvoarable (PrioSilvAra tool) or silvopastoral (PrioSilPas tool) systems. These tools combine up-to-date GIS data and techniques, advanced geo-statistics and expert knowledge, to produce prioritisation maps that can be fine-tuned for specific contexts or decision factors. These two tools can be used alone or in combination to facilitate integrated landscape planning.

PrioSilvAra: tool to prioritise areas for the installation of silvoarable systems

The main objective of this tool is to identify the areas currently under agricultural or pastoral use where the addition of woody vegetation, forming silvoarable systems, would be particularly beneficial to increase land resilience: adaptation and mitigation of climate change; protection of biodiversity, soil and water. In particular, we focus on ecological connectivity (i.e. improving the network of natural and semi-natural landscape features), landscape diversification (i.e. promoting woody structures in treeless landscapes), prevention of soil erosion and water pollution and potential soil carbon sequestration. The classification is based on land use, soil characteristics, topography, tree cover, nitrate leaching risk and landscape homogeneity. This information is processed through a GIS-based Analytical Hierarchy Process (AHP), which allows structuring a multi-criteria problem in a visual form. The prioritisation is done through a hierarchical model based on the selection and weighting of the evaluation criteria. The graphical output is a map with a resolution of 100 m pixels, showing the level of priority for the implementation of silvoarable systems.

We conduct a pilot test of this tool in 7,500 km2 of arable and grassland areas in Burgos province (north-central Spain), which hosts very diverse landscapes and most bioclimates of inland Spain, which will facilitate the replicability of the methodology.

PrioSilPas: Prioritisation of Silvopastoral Systems for forest fires prevention

The main objective of this tool is to identify forest areas where silvopastoral systems would be particularly strategic to achieve and maintain a landscape with low vulnerability to large wildfires. This tool consists of two sub-tools:

- Critical areas for wildfire management: landscape classification from a fire ecology and fire suppression perspective. This classification is based on variables of forest structure (fuel model, fuel continuity, timber stock, shrub cover), topography, infrastructures and accessibility, complemented by wildfire simulators. The resulting classification is validated by a panel of experts in fire ecology, silviculture and land planning. This process allows us to identify those forest areas where the application of

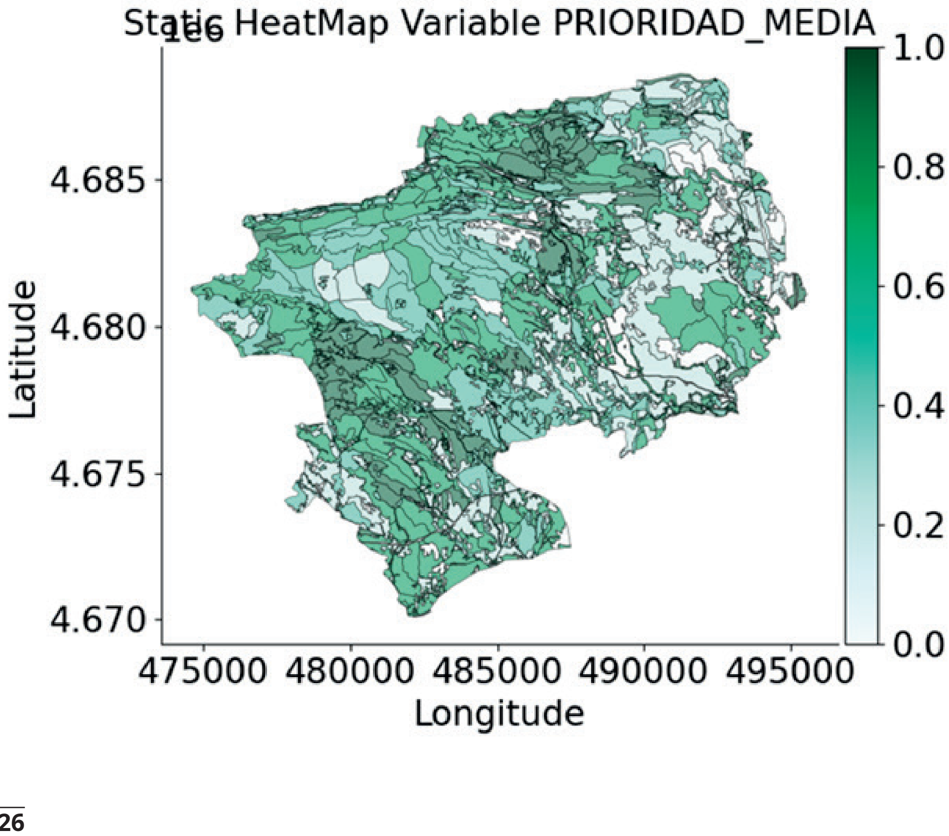
fire-preventive silviculture would have a more decisive effect in modifying fire behaviour and thus allow the prevention of large wildfires. The outcome is a land classification ranging from 0 (minimum relevance to wildfire management) to 1 (maximum relevance).
- Feasibility of silvopastoralism: landscape classification according to the technical and economic viability of silvopastoralism. It is based on the identification of areas where silvopastoralism, including forest grazing, can be a sustainable and productive system without compromising biodiversity and soil conservation values. This assessment is based on forest structure (species composition, timber stock), pasture value (typology, forage capacity, traditional use, suitability for different - yet compatible - livestock species), pre-existing livestock in the area, pastoral infrastructures (troughs, shelters, fences, water points), accessibility, topography and connectivity of areas with similar feasibility. The resulting classification is validated by a panel of experts in livestock, silvopastoralism and land planning. The outcome is a map with values ranging from 0 (minimum feasibility for silvopastoralism) to 1 (maximum feasibility for silvopastoralism).

These sub-tools make up PrioSilPas, which classifies land (1:25,000 scale) giving maximum priority to areas that are most critical from a wildfire management perspective and where silvopastoralism is more feasible. Within the project, we conduct a pilot application of this tool in Catalonia, which hosts a large part of the South European bioclimates.

LIFE AgroForAdapt project (LIFE20 CCA/ES/001682) is funded by the LIFE programme of the European Union.

Keywords
multifunctional landscape, soil improvement, decision-making, modelling, precision grazing, Fire protection, Mediterranean resilient agriculture, burn probability, European project, climate change, alley cropping, restoration, GIS, landscape planning, simulation model, silvopasture, Land Use Policy, agroforestry landscapes, agroforestry practices, forest management, sustainable soil & water management, trees, silvoarable agroforestry, grazed woodlands, resilience, climate smart landscapes, ecological restoration, Trees Outside Forest, Decision, crop-livestock-forestry systems, temperate agroforestry, Policy support, livestock, Landscape ecology, biodiversity, silviculture in agroforestry, Wildfire, soil carbon sequestration, carbon sequestration, silvopastoral systems, agroforestry system planning, climate resilience, ecosystem services, wildfire risk, research and development, Sustainable management, Remote Sensing, decision analysis, Water quality, landscape, silvopastoral, tree farming, decision tool

Aditional Attachment II.



Country-Wide Remote Sensing Approach to Agroforestry Identification: Case Study of the UK

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Agroforestry, a sustainable land use practice combining agricultural and forestry systems, is an important tool for enhancing ecosystem services and mitigating climate change whilst minimising land use change of agricultural lands. Traditional remote sensing methods have been successful in identifying agricultural lands under agroforestry by combining the use of satellite imagery and supervised classification techniques, which are heavily reliant on extensive training data for successful results. However, an analysis by den Herder et al. (2017) revealed that over half of the European Union (EU)-27 countries at the time had less than 5% agroforestry coverage, posing a significant challenge to the identification of agroforestry in these countries through conventional methods. This is evident in the CORINE Land Cover map, where the 'agro-forestry areas' class is defined as almost exclusively applicable to Mediterranean systems. With the increased interest in agroforestry from industry, landowners, and governments, there is a need for accurate and large-scale identification of agroforested lands that is applicable to all countries, including those that currently have sparse levels of agroforestry.

Our work introduces a novel approach for identifying agroforestry in countries and regions with low agroforestry percentages, using the United Kingdom (UK), a country with approximately 3.3% agroforestry by agricultural area and the majority of which is in silvopastoral systems, as a case study. We address classification challenges in low-coverage agroforestry areas, offering a more adaptable workflow for land use identification in regions where conventional methods fall short. We aimed to understand the influence of base land cover map, tree cover map, as well as the resolution and the heterogeneity statistics of the aforementioned inputs, on agroforestry identification accuracy, with the final goal of creating a country-wide map of areas under agroforestry in the UK.

We analyse the freely available EU Land Use/Cover Area frame Surveys (LUCAS) from 2012 to 2018 using broadly the same classification rules as Rubio-Delgado et al. (2023) on a county level in the UK to understand changes in agroforestry prevalence and select robust training points to distinguish agricultural, agroforested, and forested areas. We chose to follow LUCAS classifciations from Rubio-Delgado et al. due to the non-overlapping agroforestry sub-classes, compared to those of Den Herder et al. Using these points, we test the accuracy of number of global, European, and UK specific land classification maps as well as resolutions of the COPERNICUS tree cover map. Using the highest accuracy augmented resolution COPERNICUS tree cover map we sub-classified points into two classes: no significant tree cover (agricultural) or significant tree cover (agroforestry and forestry). We tested several FRAGSTAT heterogeneity metrics for accuracy of further sub-classification of regions with significant tree cover into either agroforestry or forestry. At the end of this workflow, we identify the optimum land cover map, tree cover resolution, and statistical metrics to identify regions of agroforestry. We finally validate this workflow through its ability to identify agroforestry sites outside of the LUCAS dataset, specifically sites from the Farm Woodland Forum dataset of agroforestry experiments and farms in the UK, selecting only mature sites.

Through this workflow, we create a complete map of agroforestry in the UK, similar to that of Zomer et al. (2016) but with better alignment with agroforestry sites identified through LUCAS. We identify a number of maps with good accuracy as base land classification maps, many of which have European-wide coverage, as well as a number of statistical metrics with a high potential for distinguishing between lands with significant tree density that are actively utilised for agricultural and those that are not. We further find that tree cover datasets with resolutions between 100-180m are optimal for separating forested and non-forested agricultural lands.

We conclude that with carefully selected input datasets and statistical metrics, it is possible to identify agroforested lands through a simple stepwise workflow, even when there is a limited availability of training data. Our method utilises only freely available programs and datasets with European-wide coverage and shows good alignment with LUCAS. Our methodology allows for the identification of agrorested areas outside of LUCAS point samples, as well as potentially higher temporal resolution depending on input data. The implications of our research extend beyond the United Kingdom, serving as a valuable framework for other European countries facing similar limitations in agroforestry data availability. Our workflow has the potential to be applied to regions across the continent to better understand the prevalence of agroforestry in Europe, as well as changes over time through imputing various versions COPERNICUS tree cover datasets from past and future.

Keywords
Remote Sensing, Europe, Copernicus, land cover, Land cover change, Land Use, agroforestry landscapes, land-use classification, land use change

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Extent and relevance of small woody feature agroforestry in Europe compared to other agroforestry systems

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Introduction

In the agricultural landscapes of Europe, small woody features (SWF) are often overlooked landscape elements. SWF are naturally occurring or planted trees or shrubs that frequently serve as field boundaries, hedgerows, riparian buffers, or single trees. When SWF are found in combination with agricultural land uses, the result can be considered an agroforestry system (AFswf). These differ from other agroforestry systems, such as silvopastoral, silvoarable, or grazed permanent crops, defined as combinations of tree and shrub cover with grazing or cropping use, which have been studied by Den Herder et al. (2017) and Rubio-Delgado et al. (2023). In order to differentiate these systems from AFswf they are referred to as common agroforestry systems (AFc). The spatial coincidence or divergence of these different AF systems is currently unknown, and knowledge about the geographical distribution of these different systems may have implications for agricultural policies, biodiversity conservation and productivity management.

Objectives

This study aims to address the knowledge gap by determining and comparing the extent and spatial distribution of different AFswf and AFc categories across 28 European Union Member States in 2015 (EU-28) using the 2015 Eurostat LUCAS dataset.

Methods

To achieve this, various categories of agroforestry systems were determined. For AFc five categories were identified: silvopastoral, silvoarable, grazed permanent crops, intercropped permanent crops, and kitchen gardens (see Table). The classification criteria were based on the combination of land covers such as woodlands, shrublands, grasslands with sparse tree cover, or permanent crops, with arable crops or grazing activity. Kitchen gardens were also included as an AFc category as they combine arable crops, permanent crops, and sometimes shrubs and grass. For AFswf, four categories were established based on arable or permanent crops and grazed or ungrazed grasslands within agricultural areas where at least one SWF was present (Table). The LUCAS survey provides the sequence of SWF and other elements along transects that extended 250 m eastwards from each LUCAS sample point. The survey considers as SWF those woody features that have a width between 1 and 3 m and a minimum length of 20 m. The SWF types are heaths and shrubs, single trees and shrubs, avenue trees, conifer hedges, managed hedgerows, unmanaged hedgerows, and groves and woodlands margins. AFc systems can also include SWF; however, the LUCAS points where this combination was identified were not considered in the group of AFswf, as the main criterion for classification was the combination of different land covers and not the presence or absence of SWF. Therefore, both types of systems, AFc and AFswf, were mutually exclusive. Finally, a density map was produced to analyse the spatial distribution of AF systems in Europe.

Results

The total agroforestry area (AFswf and AFc) encompassed 576,087 km² representing 12.9% of the total EU-28 surface area and 35.6% of the utilized agricultural area (UAA) (Table). Of this extent, 132,317 km² was identified as AFc, and an additional 443,770 km² corresponded to AFswf systems, representing 23% and 77% of the total, respectively. Areas classified as AFc systems where SWF were also identified covering 29,466 km² and representing 22.3% of the total AFc surface area. Therefore, by comparing the extent of AFswf to that of AFc, we found the former occupying 3.3 times more land than the latter. Furthermore, as shown in the Table, arable crops with SWF were the most extensively represented system, covering 196,175 km², which represents 34.1% of the total agroforestry area. It was followed by silvopastoral systems, ungrazed grasslands with SWF, grazed grasslands with SWF, permanent crops with SWF, kitchen gardens, grazed permanent crops, silvoarable, and intercropped permanent crops. The area covered by arable and permanent crops with SWF (232,138 km²) was 38 times greater than the area of AFc with permanent crops (grazed or intercropped) or silvoarable systems (6,110 km²). In contrast, the extent of grazed grasslands with SWF

(103,238 km²) was slightly lower than that occupied by silvopastoral systems (113,717 km²), which encompass grazed woodlands and shrublands as well as grasslands with sparse tree cover. Additionally, each type of agroforestry system exhibits different and segregated spatial distribution patterns. AFc systems were found particularly concentrated in the Mediterranean region, showing higher densities in countries such as Spain, Portugal or Greece. In contrast, AFswf were more widespread in Atlantic and Continental countries such as Ireland, United Kingdom, France, Denmark, and Germany.

Conclusions

This research provides novel insights on the different categories of AFswf and AFc, and their spatial distribution in the European Union. The findings also contribute to a better understanding of the agroforestry systems and offers a baseline for future monitoring and management. This underscores the necessity for policy incentives and increased awareness among farmers to foster a deeper understanding of the impacts of small woody features on productivity and biodiversity.

Acknowledgements

This work was funded by EU Horizon 2020 project AGROMIX (862993).

Keywords

Europe, AGROMIX, woody landscape features, spatial evaluation, agroforestry landscapes, Agroforestry systems

Aditional Attachment I.

Table. Extent (km²) of different categories of common agroforestry (AF_C) and small woody features agroforestry systems (AF_{SWF}) in 28 EU Member States in 2015 using the 2015 Eurostat LUCAS dataset. Areas included within AF_C are not double counted in AF_{SWF}. The percentage of the extent of each category is presented in relation to the total agroforestry systems extent (% of total AF), the total surface area of the EU-28 (% of EU-28), and the total extent of the Utilised Agricultural Area in the EU-28 (% of UAA-28) in 2015.

AF systems	Categories	Surface area (km²)	% of total AF	% of EU-28	% of UAA-28
AF_C	Silvopastoral	113,717	19.7	2.5	7.0
	Kitchen gardens	12,490	2.2	0.3	0.8
	Grazed permanent crops	4,953	0.9	0.1	0.3
	Silvoarable	591	0.1	0.0	0.0
	Intercropped permanent crops	566	0.1	0.0	0.0
	Total AF_C extent	132,317	23.0	3.0	8.2
AF_{SWF}	Arable crops with SWF	196,175	34.1	4.4	12.1
	Ungrazed grasslands with SWF	108,394	18.8	2.4	6.7
	Grazed grasslands with SWF	103,238	17.9	2.3	6.4
	Permanent crops with SWF	35,963	6.2	0.8	2.2
	Total AF_{SWF} extent	443,770	77.0	9.9	27.4
Total AF surface area		576,087	100.0	12.9	35.6

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Co-designing a resilient future for an agroforestry farm in southern Portugal

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Introduction
The MVArc farm, Curralões, covers 240 ha near Mértola in Baixo Alentejo, in south-east Portugal. It is within a landscape dominated by game management and extensive livestock/arable production on marginal land with poor, easily eroded soils. The climate is characterised by an average annual rainfall of 548mm falling in the winter months, and hot, dry summers. In the last 15 years, the average rainfall has dropped to 273mm, and as elsewhere, climate change impacts are a concern with drought a frequent issue in recent years. Farming in the area is heavily reliant on subsidies and in chasing those subsidies, land management practices in the region are often antagonistic to the need to increase resilience to climate change.

Formerly an extensive livestock production farm, in 1994 over 130,000 Pinus pinea trees were planted on 160 ha of the Curralões farm under an afforestation measure in the CAP Pillar 2, with the aims of increasing carbon storage and improving forestry resources. The pines have very slow growth and productivity.

Objectives / research questions
There is an urgent need to develop a new approach to land management on the farm, with the dual aims of reducing reliance on subsidies and increasing resilience to climate change. Recognising the value of involving local farmers in this development process, to learn from their experience and understanding of the local context, a co-design approach was initiated in 2022, as one of the co-design pilot farms in the AGROMIX project. The objective of this study was to use a co-design method, the Reflexive Interactive Design (RIO) method, to co-create new scenarios for the farm.

Methodology
The RIO method is a participative design approach that leads a group of actors through a process of thinking, designing and acting to co-design scenarios of transition (Bos and Grin, 2012). Applying it in the Portuguese context, two workshops were held in Spring 2023, attended by five local farmers and hosted by the Curralões farmer and the pilot facilitator and ambassador. The first workshop focused on the ‘thinking’ stage of the RIO; this involved discussing and developing a vision and goal for the farm, as well as identifying key challenges that would need to be overcome to reach the goal. The second workshop moved onto the ‘designing’ stage; identifying potential scenarios as solutions to the challenges and then classifying these within a framework of feasibility.

Results
The first workshop developed and agreed on a Vision and Goal for the farm:
- Vision: “Resilient system independent from subsidies”
- Goal: “Introducing productive AND profitable functions to the farm”

The key challenges that were identified by the group were water shortages and staff shortages. As the second challenge could not be addressed by actions solely on-farm, the focus of subsequent discussions was on solutions to water shortages. Solutions suggested could be grouped under two main themes (Fig. 1). The first focused on ensuring water security through practices aimed at improving water storage, water retention and water input and distribution. The second focused on approaches that promote the adaptive and diversification capacity of the existing system, by developing new income streams, and promoting new policy and support mechanisms.

Two scenarios have resulted through this co-design process. The first is based around the development of essential oil and hydrolate production from a shrub species, Cistus ladanifer, that grows as a weed on the farm (and in the surrounding landscape) and is usually controlled through harrowing. This scenario is proposed to increase farm productivity (essential oil and hydrolate) and income (sale of EO and hydrolate, maintenance of direct payments), and improve soil health (reduce cultivation, addition of organic matter via post-distilled biomass).

The second scenario combines keyline implementation for improved water retention and distribution with diversification of the tree component of the system, by introducing other fruiting tree species. Compared with the current system, this co-design scenario is proposed to increase farm productivity (tree crops) and income, spread production risk (by diversifying crop production) while improving soil health and water conservation (through keyline), and potentially increasing biodiversity (tree diversity).

Conclusion

The co-design process has been a useful approach to developing new scenarios for the farm, building on knowledge and experience (and enthusiasm) from local farmers. The two scenarios identified will be gradually implemented on the farm in the coming years. As well as working towards the goal of introducing productive and profitable functions to the farm to make it independent from subsidies and more resilient to climate change, it is hoped that the farm will also provide a practical demonstration for other farmers of applying the co-design process.

Keywords

AGROMIX, design, Mediterranean resilient agriculture, agroforestry system planning, agricultural revenue diversification, climate resilience

Aditional Attachment II.

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Traditional management of 'Knicks': stakeholder perspectives on the drivers and barriers of agricultural hedgerows in Schleswig-Holstein, Germany

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Hedgerows as a traditional landscape management practice have been established by human activity and developed into landscape structures with ecological, economic and social value. 'Knicks' are a particular type of hedgerow in the northern part of Germany, with woody and herbaceous plants growing on a ridge. Temperate hedgerows provide biosecurity, crop protection, pollination, and demarcation of land ownership (Montgomery et al. 2020). In addition, 'Knicks' provide food, timber and fuel (provisioning services), soil protection and carbon sequestration (regulating services), human well-being and identity (cultural services), as well as biodiversity, nutrient cycling and landscape connectivity (supporting services).

'Knicks' were widely established in the 18th century to mark land ownership boundaries (Baudry et al., 2000) and often persist as the last remaining semi-natural woodland habitat in intensified agricultural landscapes. In Schleswig-Holstein, a total 'Knick' length of 54,196 km remains, representing 68 % of the total length from the 1940s (Lütt et al. 2022:23-24), resulting in the reduction of an average 'Knick' density from 116 m/ha to 62 m/ha (Litza & Diekmann 2020:1189-1191). Species-rich hedgerows have become rare, and a study by Litza & Diekmann (2017) found an overall decrease in 'Knick' biodiversity, particularly for shrubs and herbaceous forest species. Recent 'Knicks' contain significantly fewer forest species than ancient 'Knicks' but, if managed traditionally, can be transformed over time into valuable habitats similar to ancient 'Knicks' (Litza & Diekmann 2019).

This case study aims to identify the drivers and barriers for the establishment, maintenance and care of 'Knicks' perceived from different perspectives. The following questions create a framework for the qualitative research approach:

1. How are the establishment and maintenance of 'Knicks' viewed from an agricultural perspective?
2. To what extent can ecological forest management and nature conservation play a cooperative role in the establishment and maintenance of 'Knicks'?
3. What potential is there in communities and administration for the establishment and maintenance of 'Knicks'?
4. In what way can science and education make a supportive contribution to the establishment and maintenance of 'Knicks'?

Therefore, expert interviews explore insights from stakeholders in the area of agriculture, forestry, nature conservation, community, administration, science and education. Interview questions deal with the awareness, functions, maintenance, use, policies, and problems of 'Knicks' and their maintenance. Focusing on overcoming barriers, cooperation and synergies between different stakeholder perspectives could be a key for the future development of hedgerows in Schleswig-Holstein, including a variety of supporting measures to foster the traditional 'Knick' care and maintain, restore, and establish hedgerows with valuable positive effects.

Without regular maintenance, 'Knicks' grow into sparse rows of trees, which means that their diverse functions will decrease or be lost. The benefits of hedgerows can only be fulfilled if they are properly managed and maintained in their traditional form (Drexler et al. 2021). Today the traditional hedgerow management consists of a 'Knick' care, in which the shrub-like trees and shrubs are cut down to the stumps at 10-15-year intervals. In 2023, the UNESCO has declared the maintenance of 'Knicks' in Schleswig-Holstein an intangible cultural heritage. For centuries, 'Knick' care has been practiced through voluntary commitment. Farmers pass on their knowledge over generations to the present and future carrier groups of the cultural form, thus safeguarding the tradition of 'Knick' care (DUK 2023).

Since the end of the 20th Century, there has been a shift in 'Knick' maintenance and care from traditional knowledge to legal regulations in Germany. Since 2010, hedgerows are considered as protected landscape elements by the Federal Nature Conservation Act (§ 30 BNatSchG), with additional details on the 'Knick' care in the State Nature Conservation Act of Schleswig-Holstein in 2016 (§ 21 LNatSchG). Further implementation regulations on 'Knick' conservation were issued in 2017 by the Ministry for Energy Transition, Agriculture, Environment and Rural Areas of Schleswig Holstein. In general, the establishment of hedgerows in Europe is associated with a permanent obligation from the landowner through European Cross Compliance Regulations (Regulation (EU) No 1306/2013).

Nowadays, the 'Knick' conservation focus is based on preserving their landscape character, maintaining their function in the ecosystem and thus contributing to the preservation of biodiversity. Despite an improvement in the 'Knick' quantity and quality through legal regulations, there are still considerable deficits in the 'Knick' care of single central elements of the applicable 'Knick' implementation regulations (BUND SH 2017). This study therefore intends to outline cooperative strategies for the sustainable development of 'Knicks' and their care.

Keywords
agroforestry landscapes, Regenerative communities, landscape policy, case study, forest management

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1.4 Landscape Planning (II)

Oral presentations

Hall Q2, 29 May 2024, 15:45 - 17:15

Potential for enhancing environmental resilience in Finnish farmland through increasing the adoption of new and traditional agroforestry practices

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Agroforestry is not a very well-known and common practice in Finland, but it nevertheless has a long history. Some examples of traditional agroforestry practices, which might be as old as agriculture itself, include reindeer husbandry in northernmost Fennoscandia, slash-and-burn cultivation which led to the existence of the typical Fennoscandian wood pastures, and the collection of non-wood forest products (Mattila 2023). In this study, we will assess the potential environmental benefits of agroforestry in Finland, if it would be adopted on a larger scale. In addition to traditional agroforestry practices, there would be many opportunities for more novel practices too (Mattila 2023). For instance, alley cropping is a practice which is currently very uncommon in Finland but could offer large opportunities for instance for climate change adaptation, as an erosion prevention measure, improving quality of surface water, or enhancing biodiversity in monoculture cropping areas.

As forest cover is already high in Finland (more than 75 % of the land cover, Natural Resources Institute Finland, 2023), priority areas for new agroforestry should be identified carefully. In addition, not all practices are suitable for the whole country due to harsh climatic conditions. In this study, we will identify which practices are suitable for different parts of the country. For instance, forest grazing in combination with commercial forestry or management of (semi-) natural and traditional rural areas would be suitable in forested areas in central, eastern and northern Finland. Forest farming such as the cultivation of wild herbs and mushrooms in forest would be possible in most parts of the country. Linnear agroforestry systems such as alley cropping, riparian buffer zones, windbreaks and hedgerows would be suitable in southern and western Finland, as these areas are much less forested. Intensive agriculture and large fields without tree cover are much more common in these areas, and consequently erosion, wind and drought damage are not uncommon. Therefore, in these areas there would be opportunities for arable agroforestry.

The work will use a landscape design approach to assess where it would be most beneficial to implement new agroforestry systems. This prioritization approach will include the assessment of the following factors: erosion risk, water quality, and tree cover density. Areas with a high erosion risk, low water quality or low tree cover density will be identified using existing data sources through a GIS approach. As the second step in the analysis, we will assess the potential for additional carbon storage, benefits for ecosystem services and biodiversity if new agroforestry areas are established in these priority areas.

The benefits of agroforestry in Finland have never been properly assessed and currently agroforestry is not well supported by the Finnish agricultural policy. This approach will enable farm advisors to demonstrate the benefits of agroforestry to the practitioners, as well as it will enable researchers to demonstrate the benefits of agroforestry to decision and policy makers.

Keywords

aboveground carbon sequestration, agroforestry practices, Water quality, Agroforestry, carbon farming, adaptation, wind erosion, agricultural policy, GIS, soil erosion, agroforestry landscapes, Trees Outside Forest, biodiversity, Carbon Balance, agroforestry system planning, riparian buffer

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Analyzing the spatial distribution of environmental pressures across agricultural landscapes for introducing mixed farming and agroforestry in Europe.

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Agricultural land in Europe is facing several challenges due to climate change and the intensification of agricultural practices since several decades. The aim of our analysis is to define target areas where the introduction of mixed farming (MF) or agroforestry (AF) could provide environmental benefits and increased resilience to climate change.

The methodology for the definition of target areas was based on a spatial approach, which is an adaptation of the one used by Kay et al. (2019) for AF systems. It consisted of five steps: (1) selection of suitable potential areas from the total agricultural area in the European Union member states (EU27), United Kingdom and Switzerland, excluding nature conservation sites and MF/AF areas already identified in the land cover cartography, (2) analysis of environmental pressures in the potential areas, (3) definition of target areas (4) analysis of the socio-economic context and, finally, (5) evaluation of small woody features.

For the estimation of the total agricultural area, the land cover map from the Land-Use based Integrated Sustainability Assessment (LUISA) of 2018 (Batista and Pigaiani 2021) was used. The total agricultural area was 1,722,866 km^2, including non-irrigated arable land (59.1% of the total agricultural area), permanently irrigated arable land (2.3%) and rice fields (0.4%), as croplands; vineyards (2.0%), fruit trees and berry plantations (1.5%) and olive groves (2.6%), as permanent crops and, finally, pastures (26.0%) and natural grasslands (6.1%), as another group.

A total total of 11 environmental indicators were identified as pressures in relation to soils (soil erosion by water and wind, soil organic carbon stocks), biodiversity (potential threats to soil biodiversity, pest control index, pollinator potential), water (irrigated areas, nitrogen surplus), and climate change (annual mean temperature, aridity index, drought frequency, heavy precipitation). To evaluate the effects of those pressures, threshold values were defined for each indicator, identifying the limits beyond which sustainability is compromised in potential areas.

After combining the environmental indicators, heat maps were produced to highlight areas that have a high concentration of risks and determine priority areas to introduce MF/AF. Additionally, an analysis of the socio-economic context aimed at the characterization of areas with varying needs of policy support was undertaken. A total of 6 social and economic indicators related to demography (ratio of young to elderly farmers, degree of urbanisation), education (training of farm managers, number of organic farming holdings) and economy (economic size and unemployment rate) were analyzed for NUTS 2 regions within the study area.

Finally, the small woody features, described by Schnabel et al. (2022) using the Land Use/Cover Area frame Survey (LUCAS), were used to detect these features allowing to fine-tune the selection of target areas, as agricultural land may include woody vegetation, such as hedgerows, windbreaks, riparian vegetation, and these are widespread in many parts of Europe (Mosquera-Losada et al. 2018).

Although the basic approach follows the one of Kay et al. (2019), our study varies in several ways. Firstly, we do not only consider agroforestry as an alternative agricultural system but also mixed farming. Secondly, potential areas are agricultural areas that exclude those areas that are either protected nature reserves or are already MF/AF systems. Thirdly, regarding suitable potential areas, Kay et al. (2019) differentiated between arable areas and pastureland. In our case, we divide arable areas into cropland and permanent crops because the starting conditions for transformation into either MF or AF, are different. Finally, once the target areas were defined and the socio-economic context was characterized, a separate analysis regarding the existence of woody elements was undertaken to prove whether the environmental risks in these areas are different from agricultural land without woody features.

Our preliminary results indicated that the potential area affected by climate change and biodiversity-related pressures was greater than the potential area affected by water or soil-related variables. The geographic distribution of pressures also varied by country, finding hotspots in countries such as Spain, where a total of 9 environmental pressures affected more than 75% of the total potential area, whereas Belgium, Germany, France, Ireland, Italy, Netherlands, and Romania showed a total of 6 pressures affecting more than 75% of their territory simultaneously.

Among agricultural land covers, rice fields, permanently irrigated arable land, vineyards, and olive groves, showed higher environmental pressures, with average values exceeding 6. Conversely, non-irrigated arable land, fruit trees and berry plantations, pastures, and grasslands, reported lower pressures with mean values below 6.

Finally, the analysis resulted in the definition of locations exhibiting high environmental pressures, that could constitute areas where MF/AF should be introduced. Although a large proportion of agricultural land in Europe was affected by a variable number of environmental pressures, the most prevalent was the group of climate change variables. Therefore, more resilient practices such as mixed farming or agroforestry should be introduced as a means of adapting to climate change.

Keywords
climate change, land-use, land cover, agroforestry system planning, agri-environmental system, spatial planning, mixed farming

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The establishment of forest shelterbelts in the Romanian Plain and the Dobrogea Plateau in the last three decades – an overview

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The forest shelterbelts are the most widespread and well-known agroforestry systems in Romania, having a history of over 100 years, even if the evolution of their development also experienced periods of decline (Lupe 1981, Neșu 1999, Ianculescu 2006, Popov et al. 2017). This problem concerned both agriculture and forestry specialists, as well as farmers, for the prevention of crop losses (Lupe, 1951, Vasilescu, 2015) due to unfavorable climatic conditions, characterized by extreme temperatures, strong winds, low precipitation (Costachescu et al 2010) and obtaining stable agricultural productions.

The study aims to promote this type of agroforestry system, encouraging farmers to establish it. A knowledge of the situation of the forest shelterbelts established in the last three decades can serve as an argument for the further stimulation of their establishment on the largest possible surfaces and can convince the national or European authorities to support their establishment through funding programs for agroforestry systems.

The Romanian Plain, located in the south of Romania, is the main agricultural area of the country, occupying an area of 21% of the territory, and the Dobrogea Plateau, in the south-east, 6.5% of the country's area (INS). Due to the geographical location, but also due to the small percentage of areas occupied by forests, around 8%, these are the most exposed areas in the country from a climatic point of view.

In the last 30 years, climatic excesses, correlated with other factors, have determined the appearance of areas with a tendency to desertification (MMAP), so the concerns regarding the forest shelterbelts have intensified. Specifically, from 2003 to 2022, various research and development projects were carried out, within which the design of the networks of forest shelterbelts for the agricultural lands in the south and south-east of Romania were carried out. The design of forest shelterbelts networks was carried out in the GIS system, at the commune level, using high-resolution geospatial data. Regarding their establishment, it was done on small areas, mainly due to funding difficulties and the fact that farmers lose the agricultural subsidy for the land occupied by the forest shelterbelts. However, some farmers, using their own resources, have established forest shelterbelts consisting of a minimum number of rows, most frequently (4) 5 rows, the species used being black locust. Their width varies from 6 to 10 m, and the length varies according to the size of the plots (1000-1200 m x 500-600 m). At the national level, the total area occupied by the forest shelterbelts established by farmers on agricultural land is not precisely known. It is estimated based on Google Earth examination, that they cumulate an area of approximately 1500 ha.

Also, forest shelterbelts were established to protect the field on land owned by the state, within some stud farms and on agricultural land belonging to the Romanian Academy. The first ones are made up of 7 rows of trees, spaced 2 m apart, and are made up predominantly of black locust and occasionally of honey locust and Siberian elm. They delimit the agricultural plots and the area occupied by these shelterbelts is 187 ha. Those established on the grounds of the Romanian Academy cover an area of 157 ha and are made up of 5 - 7 rows of trees, spaced 2 m apart, including a wider range of species such as: oak, flowering ash, wild pear, Siberian elm, honey locust.

20 years ago, a program was started to establish forest shelterbelts to protect road and highways from heavy snowfall that disrupts economic activities. These shelterbelts also fulfill the function of protecting the related agricultural land. Thus, 85 km of forest shelterbelts were established along the A2 highway and 22 km along some national roadways, with a total area of 320 ha (RNP). These forest shelterbelts are 30 m wide and consist of 15 rows of trees and shrubs. Depending on their ecological requirements and the microsite conditions, the following species were used: silver lime, field elm, European white elm, mahaleb cherry, field maple, mulberry, and shrubs such as: common hawthorn, wild privet, dog rose, blackthorn, smoke tree. In certain areas black locust was also used.

Since the climatic evolution has become more and more unfavorable in the last three decades, the concerns regarding the creation of forest shelterbelts intensified, planting more than 2000 ha of forest shelterbelts in the Romanian Plain and Dobrogea Plateau. Established to improve climatic conditions and ensure the safety of agricultural products, they also perform other functions, the most obvious being the increase in biodiversity and the areas occupied by forest vegetation.

Acknowledgements
This study is funded by the national project PN23090203: New scientific contributions for sustainable management of watersheds, degraded lands, forest shelterbelts and other agroforestry systems in the context of climate change and PN23090204: Scientific Foundations for Digital Forestry through the Integration of Geospatial Solutions and Technologies.

Keywords
shelterbelts, Agroforestry systems, biodiversity, forest shelterbelts establishment, trees

Aditional Attachment II.

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Establishing Agroforestry Research in Israel - Challenges, Opportunities and First Steps

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Intensively grown crops are commonly farmed in monoculture systems; though evidence shows that this uniformity exposes food systems to vulnerability. The major objective of our research team is to introduce links between dimensions of diversity and the functioning of agroecosystems. We focus on field design by orchard intercropping, as a focal dimension of agricultural diversification. The main challenge of establishing Agroforestry research is that constructing field systems with trees lasts decades. To face the challenge of this long timeframe, we established different research agrosystems, where different aspects are studied. 1) Alley cropping in a Mediterranean dryland. We hypothesize that a major mechanism for climate mitigation in dryland agroforestry is the impact of the tree- and herbaceous-crop interactions on microclimatic conditions, which are formed by the system components and interactions. In these alley-cropping systems, we track the dynamics of abiotic conditions, aiming to facilitate long-time ecological research in an agroecosystem, to foster sustainable agriculture. We will present initial results from these alley cropping systems in a recently established Olive-Field-Crop system and in a setup of Citrus-Cereals; 2) Preliminary results show that introducing sheep grazing to Pomegranate-Cover Crop suggests advantages of multiple component intercropping without negative effect to the pomegranate yield. In this project we evaluate the potential to scale up the integration of multiple uses in the same field; in addition to the major first research systems, we will relate more briefly to 3) Fast-growing willow trees as a riparian buffer – first results show that integrating perennials to a flooded area is possible. We are examining if the willow trees can mitigate floods and support agro-biodiversity; 4) Isolating shade impact on intercropped vegetation. Our study showed interesting impacts of shade on plant performance and yield quality; Overall, we aim to suggest that diversification of agriculture by integrating trees within the field can support the sustainable intensification of food systems. Studying Agroforestry is challenging, and our way of coping with the challenges suggests studying simultaneously different aspects of tree integration within a variety of agrosystems. We are developing a holistic evaluation of the agrosystem, its productivity, and support of self-reliance on ecosystem services. To establish long-time studies with relevance to farmers, we are using the advice of our domestic extension services, we use established crops and common practices, we establish experiments within commercial agricultural fields with the local farmers, and last but not least – many of our research students are farmers who are constantly studying the dynamics in their field, now with a scientific attitude.

Keywords

nature-based solutions, agriculture intensification, agroforestry system planning, natural resources, agroforestry systems establishment, agroecology, farm-scale sustainability assessment, agrisilvicultural systems, agri-environmental system, abiotic disturbances, intercropping agroecosystems, Agroforestry system, above ground biomass, soil fauna

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Wood pasture social ecological networks. A transdisciplinary approach for the development of collaborative environmental governance systems

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Wood pasture social ecological networks. A transdisciplinary approach for the development of collaborative environmental governance systems.

Wood pasture is a neutral designation that, following a geographical approach, indicates a type of landscape with trees where grazing is the main driver. From a socio-ecological perspective, wood pasture systems vary depending on the interactions between ecological components, stakeholders involved, management systems, and governance systems. As a practice, wood pasture takes on multiple forms, including traditional, contingency-driven practices based on the economic and land availability of the shepherd/farmer, and innovative practices within agroforestry activities. What distinguishes practitioners' activities is primarily the approach with which a land management plan on the company's territory is or is not designed. In all cases, in Italy, wood pasture practices are regulated by multiple sectoral regulations, which, by not directly considering silvopastoralism, do not facilitate its diffusion and tend to cause the informal execution of practices. In this landscape, an experimental representation of wood pasture practices is proposed as complex socio-ecological systems composed of intersectoral interactions to analyze their characteristics. The hypothesis is that existing relationships are often unstable, non-reciprocal, and conflicting, increasing the distances between different types of practitioners and hindering the diffusion of agroforestry silvopastoral practices. Social-ecological network analysis offers a detailed examination of how various stakeholders within wood pasture landscapes, like shepherds, farmers, regulators, and environmentalists, interact with each other. Through mapping these interactions, the network analysis identifies key actors, communication patterns, and areas of collaboration or discord. This comprehensive understanding aids in enhancing cooperation, addressing conflicts, and advancing sustainable management approaches.

The research's objective is, therefore, to understand how socio-ecological systems of woodland grazing are structured, specifically answering the questions: i) who are the main actors constituting the socio-ecological systems of wood pasture? ii) What are the interactions between the actors? iii) What externalities do these interactions produce? The study context was chosen regionally to have a common regulatory framework regarding forest regulations, measures of activated common agricultural policy, and landscape plans. Data were collected through semi-structured interviews with shepherds, farmers, and public officials. Data processing was done through network analysis, allowing the representation of the interaction system of individual practitioners and connecting systems, assessing the degree of collaboration between parties (among shepherds, between shepherds and the political and regulatory system, between regulatory and political sectors). The analysis creates a network composed of nodes and edges, where nodes represent social and ecological actors, while edges represent various types of relationships, whether conflicting or not, between actors. The representation is obtained by calculating three centrality indicators: degree centrality, betweenness centrality, and closeness centrality. The first measures a node's involvement through the number of connections, the second identifies the probability that a node is on the shortest path between two others, highlighting key actors and ecological components in the network, and the third is used to evaluate the average closeness of actors in the network.

Keywords

collaborative governance, traditional landscape, silvopastoral systems, Policy, agricultural policy, wood pasture

Sustainable Nexus: A Mixed Approach to Climate-Resilient Landscape Planning in The Egyptian New Delta Mega-Agricultural Project

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Transitional and climate-resilient landscape planning and management in arid regions must be considered in Mega-agricultural horizontal expansion projects. One of Egypt's horizontal expansion strategies is the New Delta mega project, a significant initiative in the country's long-term plan for transformational evolution, aiming to boost the projection of Egypt regionally and globally. The project is considered a significant development initiative that has the potential to transform the country's agricultural landscape. The New Delta is of substantial scale, covering an area equivalent to Puerto Rico, and is expected to increase Egypt's agricultural land by 23% in multi-faces, which is 42% of the old Nile Delta area. The cost of 9.7 billion USD makes it the largest agriculture project in Egyptian history, focusing on establishing industrial complexes based on integrated agricultural production, including the latest mechanisms. Despite its impressive size and potential for a positive impact on food security and the economy, careful planning and execution are crucial to maximize the project's benefits while minimizing any negative impacts. The project seeks to reclaim 1.2 million acres of land west of the Nile Delta, relying on treated agricultural wastewater and underground water resources for irrigation. The case report outlines an environmentally integrated planning framework for a large-scale agricultural project, pioneering climate-resilient strategies facing emerging food security issues crossing the geo-political scale and intersecting with the increasing environmental challenges. The New Delta Agricultural Mega, project planning initiative, exemplifies a comprehensive land and water resource management approach, ensuring sustainability and optimizing production in a changing climate. The core planning framework lies in creating a resilient and diverse agricultural landscape. The plan utilizes a combination of land-resources surveys, remote sensing, and climate models to inform land-use optimization and assess future water demands for each crop in an open field or under a greenhouse. One of the critical features of this planning approach is the incorporation of mixed strategic crop rotations, introducing a dynamic agricultural system that enhances soil health, reduces the risk of pests and diseases, and promotes biodiversity. Meanwhile, scarce water and harsh conditions limit traditional agriculture in arid regions. Agroforestry and mixed farming offer a game-changing approach to new landscape planning by creating favorable microclimates, improving soil health, and promoting diversification. The establishment of an olive trees corridor not only adds economic value through olive production but also creates a mosaic of ecological niches that serve as a natural windbreak, contributing to climate resilience and soil conservation. Notably, olive cultivation thrives in these regions from the west bank of the Nile River to Siwa Oasis at the Egyptian western border with Libya, but in a monocultivation system due to its deep root and drought tolerance. Integrating olives with the proposed crops and cropping system leverages these synergies, enhancing overall productivity, reducing risk, empowering arid communities to adapt to a changing climate, and improving their economic dependence and resilience. The power of the terrain planning alignment to the WEFE-Nexus approach and for minimum trade-offs, dedicated areas with environmentally optimized greenhouses employing geothermal energy (Sub-Soil Temperature) technology minimize energy consumption and water use, setting a benchmark for sustainable production. In addition to optimizing energy consumption within the greenhouse areas, the conceptual plan strategically allocates rocky lands for the development of solar energy production. This dual-purpose land use maximizes agricultural productivity and contributes significantly to renewable energy generation, aligning the project with broader sustainable development goals.

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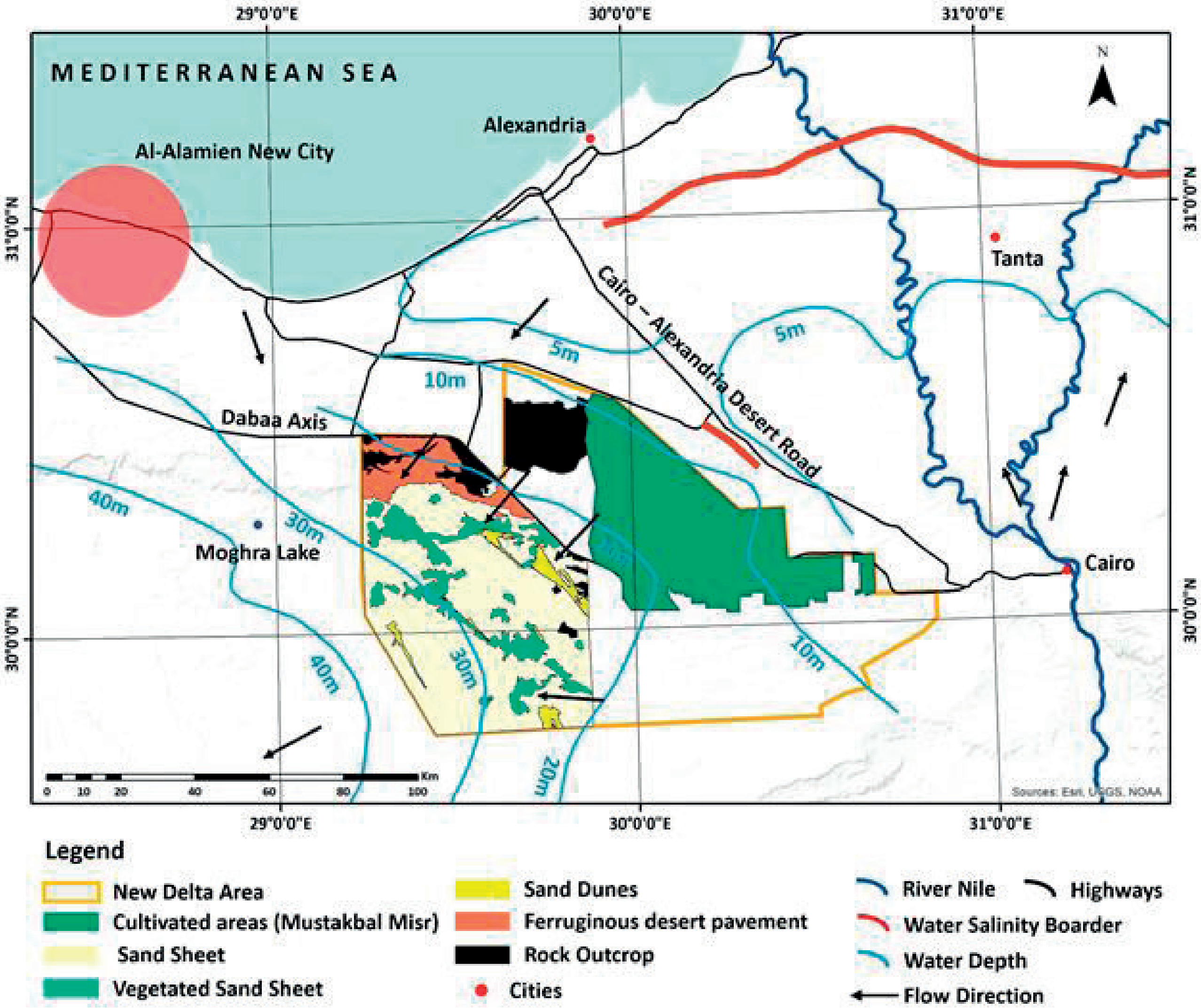
The Authors acknowledge the Informatics Research Institute (IRI) Data Center team, City of Scientific Research and Technological Applications (SRTA-City) for providing resources through the ENHPCG grid, an Academy of Scientific Research and Technology (ASRT) funded project.

Keywords
Climate smart agriculture, Agri-Environment-Climate, Sustainable management, climate resilience, agricultural policy, agri-environmental system, climate variability, agriculture, e-learning, microclimate, mixed farming, sustainability, spatial planning, GIS

Aditional Attachment II.



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1.4 Landscape planning

Poster presentations

Poster session, Building Q - Foyer, 29 May 2024, 12:00–13:00

Livestock species distribution and its drivers at regional scale: The case of Extremadura (SW Spain)

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Introduction

Livestock plays a significant role in feeding the world's population and as an activity that drives land use in many agroforestry areas, particularly in the Mediterranean. It contributes to soil fertility and promotes biodiversity (Bowman et al. 2013), as well as provides public goods (Ryschawy et al. 2017). Conversely, livestock causes impacts as greenhouse gas emissions (Cerutti et al. 2023), demands of land surface and agricultural production (Cassidy et al. 2013), water use and pollution or biodiversity loss (Li et al. 2022). In the EU, livestock grazing is contributing to land and water footprints (Vanham et al. 2023), and also in Spain. As a result, livestock systems face unprecedented pressure to alleviate negative impacts on the environment. Understanding the influence of livestock on ecosystems requires knowledge of their spatial distribution and driving factors. Several studies have been carried in this sense at global or continental scales. Nevertheless, little efforts have been done at smaller scales, as regional or lesser (Ej. Nicolas et al. 2016). Within the EU, Extremadura is one of the regions with the highest presence of extensive livestock farms, spatially dominated by silvopastoral agroforestry areas grazed by cattle, sheep, goats, and pigs.

Objectives

The aim is to study the combination of influencing factors that lead the presence of the different livestock species: cattle, sheep, goats, and pigs in the region of Extremadura (SW Spain).

Methodology

Random Forest (RF) spatial models were developed that predict the spatial allocation of livestock species as related to several physical and socio-economic variables. The influence of the variables on the models was interpreted as factors leading livestock pressure. The calculation of Livestock Units (LU) and the rest of the variables was treated in QGIS software and Google Earth Engine (GEE). A massive regional query of 250 m grid nodes (404,185 points) was constructed. RF models were generated with a limit of 100 trees, using 80% and 20% of the data for training and testing purposes using JASP® software.

The dependent and explaining variables used in models are listed in Table 1:

Table 1: Variables used to build RF models.

Results and discussion

The results underscore the significance of underlying physical variables and human population as factors influencing livestock pressure. These findings suggest that both environmental conditions and population density have a substantial impact on the pressure exerted by livestock. The variables used in the analysis were enough to predict the allocation of livestock pressure in the region, showing high performance in general (R^2 higher than 0.9 in all the four cases). Mean absolute errors were higher for sheep and goats (83.06% and 70.98%) compared to cattle and pigs (31.62% and 23.16%). As preliminary results, a set of influential or explaining variables were obtained. The main explaining variables corresponded to climate (temperature and precipitation derived metrics), distances to populations and population density. For cattle, annual and diurnal temperature range, standard deviation of temperature, mean temperature of the warmest month and human population density were the main drivers. For sheep, mean temperature of the warmest month, annual and diurnal temperature range, human population density and SD of temperature were the main factors. For goats, human population density, distance to cities with more than 10,000 and 5,000 inhabitants·km-1, SD of the temperature and distance to cities with more than 1,000 inhabitants·km-1 were the main drivers. Finally, for pigs, isothermally, precipitation seasonality, human population density, diurnal temperature range and precipitation of the wettest month were the main drivers.

Understanding how these variables interact and their implications for livestock sustainability and management is crucial. Such insights can inform more effective strategies to address livestock-related challenges such as grazing management, water provision, biodiversity and overall animal welfare, as well and promote sustainable practices in agriculture and animal husbandry.

Keywords
climate, modelling, livestock, Mediterranean socio-ecological systems, silvopastoral

Acknowledgments
This study was supported by MCIN with funding from European Union NextGenerationEU (PRTR-C17.I1): 'Environmental heterogeneity and habitat diversity at different spatial scales in a gradient of land use intensity: Agroforestry and mixed systems versus abandoned or intensified ones' (2022/00362/005).

Aditional Attachment I.

Variable	Units	Source and characteristics	
Livestock density of cattle, sheep, goats, or pigs (Dependent variable)	LU·ha-1	National Statistics Institute (INE)	Livestock numbers per municipality
Limits of municipalities		Information System on Land Occupation in Spain (SIOSE AR), 2017.	Used to establish the correspondent livestock density in livestock units (LU) per municipality. Expressed as LU·ha-1
Land use and cover		Information System on Land Occupation in Spain (SIOSE AR).	Livestock presence in municipalities was spatially corrected by previously allocating livestock according to selected SIOSE land use/cover categories that avoid the allocation of livestock to areas not suitable for grazing.
Worldclim bioclimatic variables		WorldClim V1 (Hijmans et al. 2005)	19 bioclimatic variables derived from monthly temperature and rainfall values in order to generate more biologically meaningful variables.
Topographic variables	m, degrees	National Plan of Aerial Orthophotography PNOA DTM05.	Altitude, slope, aspect, and curvatures
Normalized Difference Vegetation Index (NDVI)		Sentinel-L2A satellite images	Sentinel 2 based annual and seasonal NDVI values.
Enhanced Vegetation Index (EVI)		Sentinel-L2A satellite images	Sentinel 2 based annual and seasonal EVI values.
Bare Soil Index (BSI)		Sentinel-L2A satellite images	Sentinel 2 based annual and seasonal BSI values.
Distance to populations	m	IGRP (2020).	Tree variables of distance to populated areas exceeding 1,000, 5,000 and 10,000 inhabitants were calculated as human influence variable
Population Density	persons·km-1	GPWv4 (2020)	Estimates of human population density.
Distance to protected areas	km	UNEP-WCMC and IUCN	
Distance to watering points	m	Unpublished data	Distance to livestock watering ponds

Table 1: Variables used to build RF models.

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Design of agroforestry systems: a modular concept as a decision tool for agroforestry

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Introduction

As a multifunctional land use form, agroforestry offers a wide range of design options and the potential for more climate resilience in agriculture. At the same time, agroforestry systems can be used to produce a variety of products that, depending on the orientation of the business and its integration into (regional) economic cycles, can contribute to increasing added value.

For the successful incorporation of agroforestry into the agricultural sector it is essential that the positive impacts on the landscape are really effective in the long term. This requires the choice of a suitable system well adapted to the landscape and the farm managing the agroforestry system, as well as a good planning and establishment in general. Due to the large number of usable trees and shrubs, there is, in principle, no limit to the diversity of agroforestry systems. However, the decision on which one is mostly suited for a farmer depends very much on the site conditions as well as on the objectives for producing a specific product or for fulfilling one or more environmental services with agroforestry.

As a guide for the decision in favor of a specific agroforestry system, a new decision tool was developed in the frame of the project AgroBaLa, which focuses on the potential of agroforestry for circular economy, climate resilience and new added value potential in Lusatia, South Brandenburg in Germany.

Case description

With the variety of design options, agroforestry sytems can be described by referring to a modular concept, which allows for deciding on characteristics and functions that the specific systems should fulfill. Corresponding to this principle, a practically oriented decision-support tool, the “plant construction kit” (in German “Planzenbaukasten), compares the respective objectives of a farm with the agroforestry systems that can be used for this purpose. This means that certain aroforestry measures are “translated” into concrete crop production tools in the form of certain agroforestry systems. In this way, questions can be clarified step by step that should be answered in advance when making a decision for a specific agroforestry system.

The “plant construction kit” is a result of the research project AgroBaLa (Agroforestry circular economy as a basis for structurally rich and climate-resilient agriculture with high added value potential) and is based on studies in agroforestry systems in southern Brandenburg, Germany. The aim of the project is to develop and disseminate land use based on agroforestry, which strengthens climate resilience and at the same time reveals new economic potential. To do this, the “plant construction kit” establishes a reference to concrete added value options.

The tool, which can be printed out and will also be available as a digital version, provides a a flexibly adaptable knowledge pool and is oriented along three types of categories: Based on ten categories of each, environmental performance and production goals, the user is guided to one or more agroforestry systems that match the needs of the specific farm. For this, altogether ten so-called “agroforestry tools” have been elaborated or rather formulated such as windbreaks, tree-shrub hedges and individual trees. Each of these tools offers four varieties as examples of how this tool can look like in practice so that the user has an orientation of the different characteristics. At the end, these specific tools and a number of exemplary tree and shrub species are described in more detail in the form of detailed fact sheets.

Conclusion

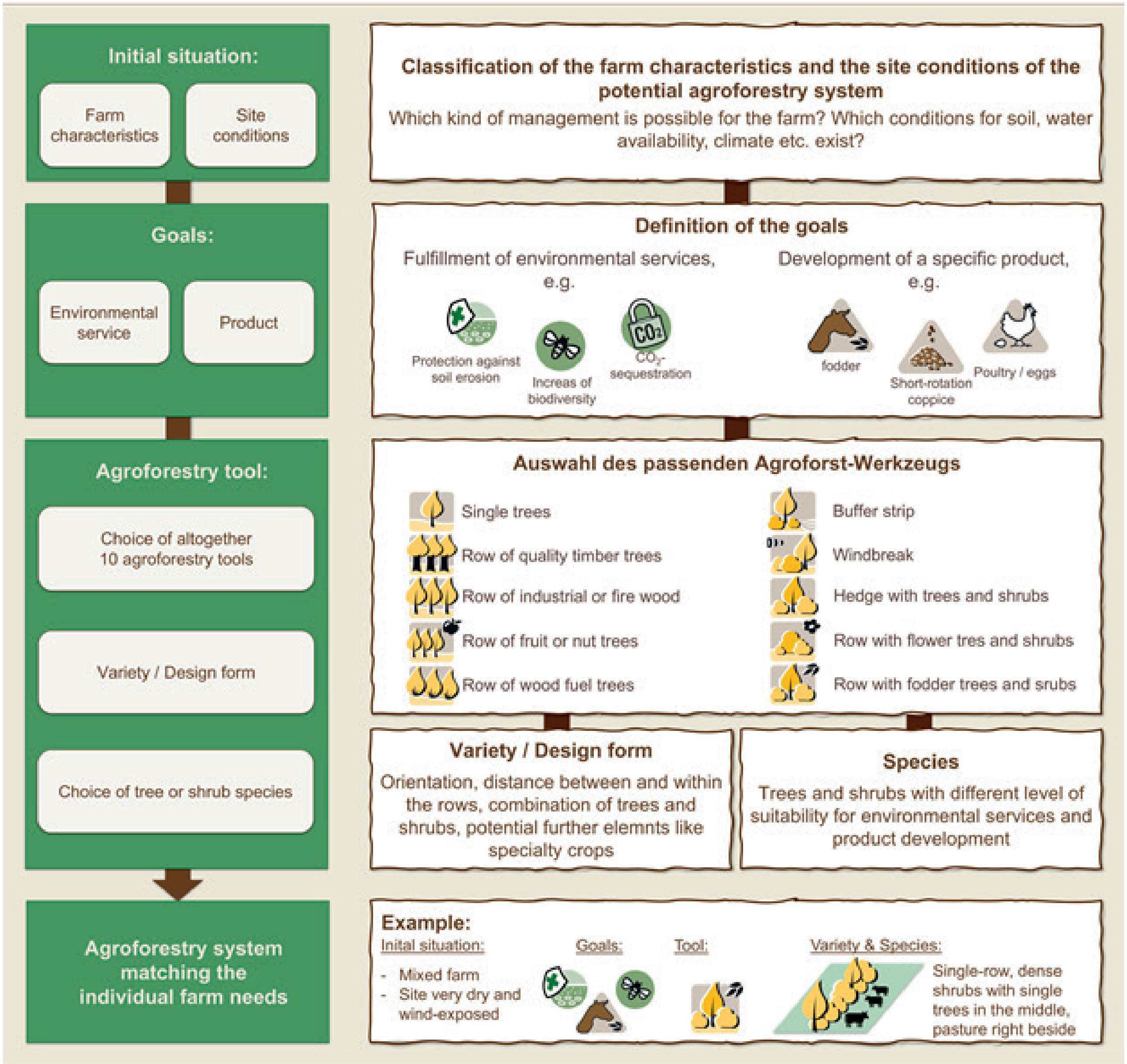
With the “plant (construction) kit” an initial knowledge collection on the diversity of agroforestry systems, its elements and functions has been created, which can flexibly be updated and adapted in the long term. As the tool is available in a printed and digital version, the accessibility is easy accessible so that many target groups can easily use it. Due to a graphic design using a variety of pictograms, colours and icons the tool is furthermore easily understandable and comprehensible.

Acknowledgment

The project AgroBaLa (FKZ 03WIR3006) is funded by the German Ministry for Education and Research (BMBF) in the frame of the WIR-programme in the Initiative “Land-Innovation-Lausitz”.

Keywords
decision tool, Germany, know-how transfer, decision-making, farmers' decision making, design, agroforestry system planning

Aditional Attachment II.



Agroforestry as a perspective for ensuring connectivity of wildlife populations and maintaining biodiversity in the human fragmented landscape of Central Europe

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Changes in land use and associated landscape fragmentation caused by anthropogenic activities (such as expansion of linear infrastructure, human settlements, logistics centres, large-scale units of monoculture fields and forests, intensification of land use, etc.) are observed not only in Central Europe but also worldwide. These fundamental anthropogenic changes in the landscape go along with sudden changes for ecosystems and land use, which have been shaped over long periods of time far ahead of human existence. In addition to the targeted benefits for human society, changes in the landscape bring a number of significant problems such as changes in ecosystems and related loss of ecosystem services, loss of biodiversity, loss of habitats, impaired resistance of ecosystems to stresses, an increase in the number of wildlife-vehicle collisions, interrupted connectivity of wildlife populations and related genetic inbreeding, etc. According to the European Environment Agency (2022), almost a third of the land in the European Union and the United Kingdom is highly fragmented, which results in average sizes of unfragmented habitats of less than 0.02 km2. In order to preserve the sustainable use of land in Europe's landscapes as well as to preserve the integrity of biodiversity, ecosystem services and the connectivity of wild animal populations, it is necessary to support mitigation measures and a responsible management approach within those landscapes. In this manner agroforestry in particular seems to be a suitable tool to promote biodiversity in the landscape (P. Udawatta et al. 2019).

Through monitoring of ecological corridors in Austria for the duration of an entire year, we sought to answer questions related to permeability and the influence of vegetation on maintaining connectivity of wildlife populations.

At selected ecological corridor sites in open landscapes in Austria (almost 50 sites), wildlife monitoring was carried out using automatic photo traps capturing wildlife activities for the whole year of 2022. The obtained monitoring data were evaluated in terms of species and number of mammals and subsequently were correlated with the surroundings of the monitoring site. To compare the influence of the surroundings, a layer of landscape cover (EUNIS 2018) and a buffer with a radius of 500 m were used. The vegetation layer included landscape features such as habitat complexes, heathlands, scrubs, grasslands, woodlands, forests and other wooded land. The size of the buffer was chosen with regard to the presence and recommendations for the minimum configuration of international corridors (Birngruber et al. 2012). Subsequently, the effect of the distance from the forest and the coefficient of ecological stability (CES; the ratio between stable i.e. dominated by vegetation cover and unstable areas i.e. built-up and industrial areas, regularly or recently cultivated arable and other land) in the vicinity of the monitoring sites on wildlife activity as well as species richness of mammals was compared through spatial analysis.

The results indicate that the distance between forest complexes and the value of the ratio of the coefficient of ecological stability in the vicinity of the monitored localities (in favor of vegetation and landscape features) have an effect on the biodiversity of mammals in the landscape. Positive correlations were noted for the activity and number of mammal species in the landscape.

Based on the findings in the Austrian landscape, we support the establishment of agroforestry systems that can significantly contribute to the remediation of the current landscape and the provision of ecosystem services, while promoting biodiversity and connectivity of wildlife populations. The presence of vegetation and landscape features has a significant impact on biodiversity in the landscape. As part of the spatial planning process, the establishment of agroforestry systems (with the selection of appropriate configuration and tree species composition) should be encouraged along the routes of ecological (migration) corridors and their buffer zones. The combination of agricultural and forestry management through agroforestry systems on agricultural land can contribute to sustainable and responsible landscape management and at the same time act as a mitigation tool for the impact of landscape fragmentation caused by human activities. Agroforestry can help maintain connectivity for sensitive forest-bound animal species across human-altered landscapes. In order to clarify the impact of agroforestry systems on biodiversity and connectivity of wildlife populations in fragmented landscapes of Central Europe, further research on this issue is desirable.

Keywords
vmonitoring fauna, agroecology, trees, restoration, adaptation, Land fragmentation, wildlife monitoring, biological corridors, green infrastructure, landscape architecture and planning, Landscape biodiversity, Landscape ecology, biodiversity, spatial planning, Agroforestry

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Agroforestry systems in Estonia

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Introduction

Agroforestry (AF), 'the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions' (Burgess and Rosati, 2018), has a long tradition in Europe. Agroforestry is encompassed in recent European agricultural policies and support measures. According to the AGROMIX project (https://agromixproject.eu/), these practices promote the transition to more resilient land use. Rubio-Delgado et al. (2023) estimated the extent of different AF systems for the European Union Member States using the Land Use/Cover Area frame Statistical (LUCAS) 2018 survey dataset. They determined five categories: grazed permanent crops, silvopastoral (i.e., combining tree and shrub layers with grazing), silvoarable (i.e., combining tree and shrub layers with arable crops), intercropped permanent crops, and kitchen gardens (i.e., small orchards combining arable and/or permanent crops with shrubs and grasses). Additionally, according to Mosquera-Losada et al. (2018), recognising the significance of small woody features (SWF), which are often present in agricultural areas, as AF systems, is crucial. These features, eligible for subsidies in some European countries like Estonia, contribute to ecosystem services. However, in Estonia, where the term 'agroforestry' is not widely known, the absence of a unified dataset underscores the need to enhance awareness and understanding of systems that could be classified as AF.

Objectives

The objectives of this work are twofold: 1) to analyse current datasets and classifications related to the agroforestry elements in Estonia; and 2) to compare the extent of these agroforestry units with the corresponding agroforestry area estimated by other authors.
Methods - First, the composite map of ecosystems of Estonian Environmental Board ELME project (Helm et al., 2021) was used to estimate the extent of silvopastoral systems in Estonia. The dataset compiles spatial data from multiple national sources. Among the 49 distinguished classes of ecosystems, four could be assigned as AF. Areas were calculated using GRASS GIS raster software (r.report in QGIS), whereas the corresponding raster classes were explained in Helm et al. (2021). The ELME composite map includes different semi-natural habitats that can be subject to silvopastoral AF systems, such as Fennoscandian wooded meadows (Habitats Directive Annex I code no 6530*), Fennoscandian wooded pastures (those with the code 9070), Juniperus communis formations on calcareous grasslands (traditionally grazed, and identified with the code 5130), and other wooded pastures outside agricultural areas similar to Fennoscandian wooded pastures. Second, a dataset of the Agricultural Registers and Information Board (ARIB) was used to assess the extent of small woody features (SWF). This dataset categorises features into various types: field copse, hedge, trees in line, ditch, forest strip. Of the ditches, 50% were included due to their wooded status, the approximate estimate obtained using the canopy height model, CHM.

Results

In this work, two categories of AF systems could be determined based on the available data, silvopastoral systems and small woody features. The total area covered by silvopastoral systems in Estonia was estimated at 214 km^2 using the local datasets. From this surface area, 91 km^2 corresponded to wooded meadows, 78 km^2 to wooded pastures, and 45 km^2 to Juniperus communis pastures. By adding the total area of 54 km^2 of SWF in agricultural land, the total AF area in Estonia is roughly 268 km^2. These datasets did not allow the identification of other types of AF systems - silvoarable, grazed or intercropped permanent crops are hardly practiced in Estonia, while kitchen gardens are common but not unified into dataset. Rubio-Delgado et al. (2023) estimated a total surface of AF systems of 289 km^2, which represents 2.9% of the Utilised Agricultural Area (UAA) of the country. Only silvopastoral systems (170 km^2) and kitchen gardens (119 km^2) were identified using LUCAS data. Total areas of AF systems could not be compared because the different analysis did not include similar categories, except for the silvopastoral systems. The extent of this category showed a slight difference depending on the dataset used to estimate the surface area, i.e., local dataset or LUCAS data, which could be related to differences in the data gathering methods. LUCAS survey considers grazing activity as a criterion. However, it is important in Estonia to preserve silvopastoral systems for ecosystem services, and if animal husbandry is lacking, wooded meadows are managed by haymaking.

Conclusions

This study contributes to the clarification and standardization of terms used to describe various agroforestry systems in Estonia. The results highlight the importance of silvopastoral systems, which were the most extensive, followed by kitchen gardens, and small woody features. Silvopastoral systems result from centuries of mild, extensive grazing and haymaking, in less fertile or marginal forest areas not suitable for crops. This is often combined with selective cutting of trees/shrubs. The formation of semi-natural or 'heritage' habitats, such as wooded meadows, wood pastures, floodplain meadows, alvars, etc., is the outcome of these practices.

Keywords

AGROMIX, ecosystem services, silvopastoral systems, LUCAS survey, small woody features

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Unlocking the environmental impact of rail traffic: insight and remediation potential of black locust linear systems

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Introduction

Railway networks constitute a vast and intricate infrastructure system that connects various environments, exerting a significant impact on them. Nonetheless, our comprehension of railway ecology remains limited, encompassing issues such as habitat loss, surrogates and low connectivity, and the effects of pollution (Barrientos et al. 2019). Studies have drawn attention to elevated soil contamination levels along railway infrastructure, demonstrating a wide spatial reach of influence, extending up to 50 meters from the tracks (Burkhardt et al. 2008; Wilkomirski et al. 2012; Mętrak et al. 2015; Brtnický et al. 2022). As time progresses, this pollution accumulates, presenting a plausible long-term ecological threat (Jiasheng et al. 2020). To address this concern, buffers, as permanent vegetation strips, assume a pivotal role in mitigating the mobilization and transportation of pollutants towards fields through natural processes, filtering and reducing water runoff, and reducing bank erosion (Dosskey 2001). Regrettably, the potential and actual environmental pressures stemming from rail traffic are overlooked in landscape planning. Agroforestry, a practice that reintegrates tree planting or spontaneous tree growth into agricultural systems, offers a balanced approach to addressing environmental challenges while considering both productivity and protection (Smith et al. 2013). The black locust (Robinia pseudoacacia L.), a widespread invasive non-native tree in Europe found alongside railway tracks (Cierjacks et al. 2013; Pfeiffenschneider and Ries 2014; Sitzia et al. 2016), has been widely planted along railways and gained attention in agroforestry systems for biomass and honey production. Consequently, there is a pressing need for further research into its remediation capabilities.

Objectives

The project seeks to achieve two primary goals: first, to advance our understanding of soil contamination resulting from rail traffic; second, to investigate the remediation potential of black locust linear systems as farmland or riparian buffer strips by examining their functional and structural characteristics in relation to soil contamination levels alongside railway infrastructures.

Methodology

Exploratory analyses were conducted in the north-eastern Po plain to investigate the influence of rail traffic on the quality and quantity of heavy metals. We selected two railway lines characterized by differing traffic intensities for our study. Each line had two transects perpendicular to the tracks, and we collected soil samples at various distances from the tracks (at 3, 8, 13, 18, 25, and 40 m) at two different depths (0-10 cm and 10-20 cm). The selection criteria for the study areas were designed to minimize variables, except for track distance, ensuring homogeneity in topsoil and the absence of recent earthmoving activities, among other factors. The concentrations of total Cd, Cr, Cu, Ni, Pb, Tl, V, Zn, As, Hg, Sb, and Sn were determined using inductively coupled plasma spectroscopy.

Subsequently, a characterization of black locust linear systems was conducted alongside electrified railway infrastructures. Forty-two sampling units were chosen along various railway lines with differing traffic intensities and functional segments. The sampling units were defined with a fixed length of 10 meters along the tree linear system, running parallel to the rail track. The width of each area varied according to the width of the tree system's crown projections. Within each unit, data on general attributes, tree size, and understory composition were collected. Soil and black locust leaves were sampled for the analysis of heavy metal concentrations using the same method as mentioned earlier.

Results

The analyses conducted along the distance gradient from the railway infrastructure revealed a significant increase in heavy metal content near the tracks, followed by a rapid decline in metal content beyond distances of 8 to 13 meters from the tracks. When comparing data collected from different train lines characterized by varying levels of rail traffic, it becomes evident that there is a correlation between contaminant levels and the intensity of traffic.

The investigation concerning the black locust linear systems and their relative contamination levels highlighted a wide range of heavy metal content across various sampling units. The metal with the highest concentration was copper often exceeding the Italian environmental regulatory threshold for industrial sites, and lead, zinc, nickel, and tin, which surpass the regulatory thresholds for green areas. Preliminary analyses confirmed existing evidence that black locust tree systems do not appear to be negatively influenced by the level of soil contamination (Sitzia et al. 2016).

Conclusion

The preliminary findings of the study underscore a significant level of contamination along the railway infrastructure, with high concentrations of heavy metals in the soil frequently exceeding regulatory threshold values. The analysis of the black locust linear systems structure and allometric relationships appears to support the notion that these systems exhibit high tolerance to soil contamination. Further research is required to compare the distribution gradient of heavy metals at increasing distances from the tracks under various conditions, including: i) with and without the presence of tree linear systems, ii) with different types of tree linear systems, and iii) across different land-use types and farmland areas.

Keywords

Black Locust, agroforestry system planning, buffer strips, non-forest woody vegetation, phytoremediation, fast-growing tree, landscape planning

Aditional Attachment II.

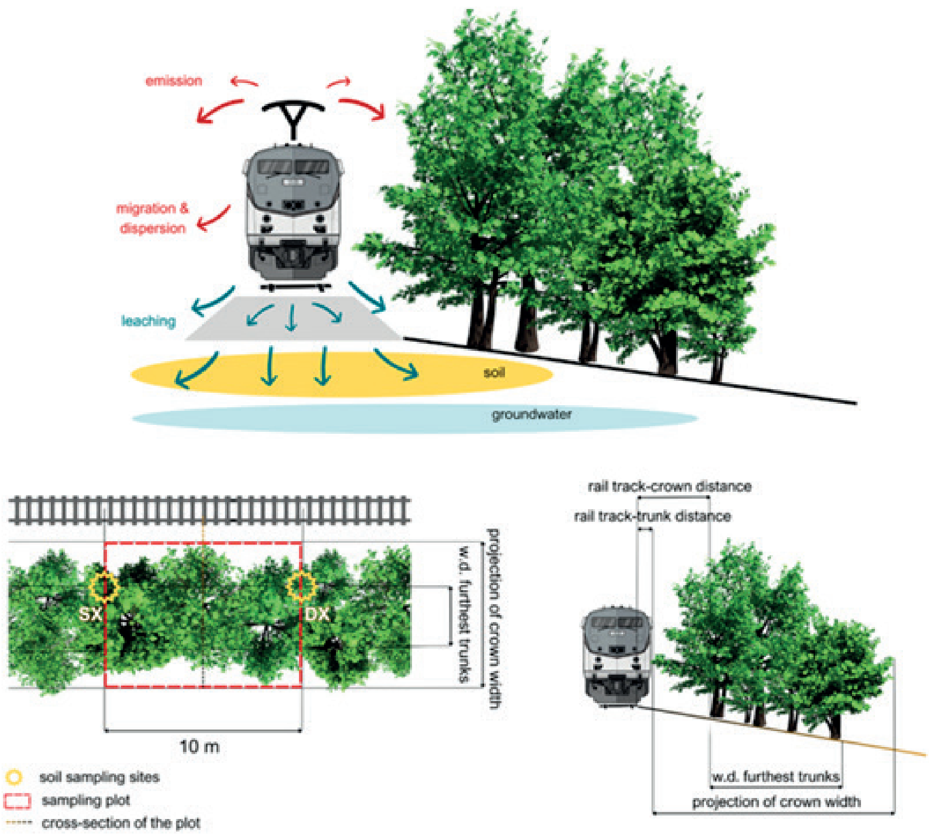

Figure 1 – Railway traffic processes source of heavy metals (at the top) and design of the sampling units with identification of the projection of the crown width, the width distance from the furthest trunks and the distances from the rail track to the closer crown and closer trunk respectively (from left to right, at the bottom).

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Silvopastoral landscapes in north-Italian perifluvial areas: new perspectives and traditional practices

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Introduction

Today, we inherit historical landscapes, often unaware of their origin and how they were managed in previous centuries. This is the case for the valley floors of the Alps and the Appennines along the watercourses in the plains, where flocks of sheep once transhumed and which are now marginal lands for agriculture and poplar cultivation. Due to the presence of coarse sedimentary materials, ranging from sands to pebbles to river boulders in mountainous areas, these environments have always been highly draining and less conducive to cultivation or forage production. In the depressed areas of the plains, they also had the characteristic of having some swampy and waterlogged zones, making their cultivation problematic. With mechanization, the labour power produced by earthmoving machines has overcome these difficulties, and the increasing urbanization in the second half of the 20th century has further reduced their surfaces. Today, these areas are undergoing partial transformation due to processes of neo-colonization by woody species, while various sectors proximal to agricultural enterprises appear strongly ruralized. The black poplar (Populus nigra) often characterises these landscapes and proves to be one of the key species for the silvo-pastoral enhancement of these semi-natural habitats. Studies with a sectorial approach (phytosociological, agronomic, pastoral, historical, silvicultural) rarely adequately highlight such perifluvial mosaics, allowing the complexity of the situations to be probed and providing appropriate management indications at the agro--silvo-pastoral level. What innovations or new practices are possible and sustainable in these contexts? Is it possible to restore a traditional use, updated and in step with the times, of some silvo-pastoral practices?

Case description

After a bibliographic analysis of studies carried out in similar European contexts, our interdisciplinary work is based on the spatial analysis of the various landscape patterns and some application examples related to (a) selective grazing experiences to counter the advancement of invasive exotic species; (b) the traditional treatment of woody species rows in mosaic with hay meadows in areas with more active agro-forestry management; (c) a possible silvo-pastoral treatment of newly formed stands of poplars and other broadleaved species in areas currently characterised by a lack of management. Specific insights are mentioned in some Alpine and Appennine valleys regarding the role of the different woody species in the production of foliage as complementary fodder to herbaceous production, as well as their supply of other products (biomass and other wood products) and services (carbon storage and habitat for biodiversity).

Conclusion

Two key lessons need to be kept in mind for the future: the first is that win-win agreements and active synergies between the different public and private estates along river corridors are needed more than ever to overcome land fragmentation and management inertia. The second is methodological: in a landscape mosaic that includes interconnected and patchily fallow lands, ruderal stands, little woods, areas of forest recolonisation and xeric alluvial grasslands only an interdisciplinary approach can lead to interesting perspectives that the individual disciplines of agronomy, forestry and nature conservation cannot do separately.

Keywords

non-forest woody vegetation, silvopastoral systems, weeds control, Landscape biodiversity, heritage, grassland, fodder trees, poplars, restoration

Aditional Attachment II.

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1.6 Healthy Soil and Water Management (I)

Oral presentations

Hall Q2 29 May 2024, 17:30–19:00

Earthworms and arthropods abundance in an alley-cropping system with poplar and the effect on yield of common wheat and maize intercrops

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Introduction

A comprehensive understanding of the interactions influencing crop and tree growth is crucial for implementing high-productivity alley-cropping systems. While aboveground interactions, such as microclimatic variations related to shade intensity and windbreak, have been extensively studied for their potential to enhance climate resilience, research on belowground tree-crop interactions, mainly focusing on water relations, is limited1. Soil biological fertility, particularly the abundance and diversity of pedofauna, plays vital roles in nutrient cycling, soil structure, and biodiversity2,3, influencing the long-term sustainability of agroecosystems4,5. However, this aspect remains relatively unexplored.

Objectives

This study investigates the impact of an alley-cropping system with poplar trees (i) on earthworms (e) and arthropods (ar) biodiversity through Soil Biological Quality Index QBS-e and QBS-ar; (ii) on soil humidity and (iii) on the yield of common wheat and maize intercrops.

Methodology

The trial took place in 2022-23 at the “Sasse Rami” pilot farm of Veneto Agricoltura (VA) in Ceregnano (Rovigo, NE Italy). It involved an alley-cropping system and a specialized plantation with five-year-old poplar trees. Common wheat (sown on 21/11/22, harvested on 30/06/2023) and maize (sown on 28/04/23, harvested on 12/09/2023) were cultivated in the inter-rows of N-S oriented rows of poplar trees spaced 40m apart and planted along drainage ditches, with 6 meters between trees along the row. The specialized poplar plantation with a 6×6 m design was used as a control (Figure 1).

The QBS-e index values were carried out using the earthworms sampling protocol proposed in Paoletti et al.7 with hand-sorting of 30x30x25 cm monolith without using attractive solution. Specimens collected were classified by ecological-functional categories8 and preserved for taxonomic identification and QBS-e calculation8.

Sampling occurred twice in 2023, in June and September. For both crops, the soil was sampled along three transects (n=3) perpendicular to poplar rows at distances of +6m and +12m on both east and west sides and in the center of the alley (+20m, Controls). For poplars, earthworms were sampled along the tree row in the alley-cropping system and the poplar plantation.

QBS-ar index was determined by collecting soil samples (1 dm^3) later subjected to mesofauna extraction (Berlese-Tullgren method) and microarthropod identification4. Soil organisms are classified into biological forms based on their morphological adaptation to soil environments. The degree of adaptation depends on specific morphological traits, with each form associated with an Eco-Morphological Index (EMI) score ranging from 1 to 204. The final QBS-ar score was derived by summing EMI scores. Sampling occurred in June (wheat and poplars) and September (corn and poplars) at the same QBS-e sampling plots.

At crop harvest, wheat and maize were sampled on a 1-m^2 area for each position and threshed to determine grain yield and quality (NIRS technology). Statistical significant differences were detected by R studio (Tukey’s HSD test, $P \leq 0.05$).

Results

In wheat and maize, the QBS-e index generally decreased towards the tree row, though not significantly. In June, the highest QBS-e values were at the alley center (346 in wheat, 439 in maize), except for +12m East in wheat, with the lowest at +6m West (Figure 2). In September, variations were slightly lower than in June, with greater QBS-e decreases in the wheat field. For poplars, a lower QBS-e was observed along tree rows in the alley-cropping system compared to the poplar plantation, though not significantly.
In wheat and maize, QBS-ar showed a non-significant increase in the interaction zone with poplars, at +6m in wheat and +12m in maize (west side). For poplars, QBS-ar was significantly higher in the alley-cropping system than in the control plantation (+56 in June, +80 in September, Figure 2). Additionally, the QBS-ar value in the row grass exceeded that in the cultivated field.
Wheat yield remained unaffected by tree proximity, with consistent values at all distances, approximately 7 tons per hectare, and a slight increase at +6m East (+10% vs. C; $p \geq 0.05$). Maize yields were similar at +12m East and C (approximately 14.7 t/ha), but a significant reduction was observed at +6m (-35% vs. C).

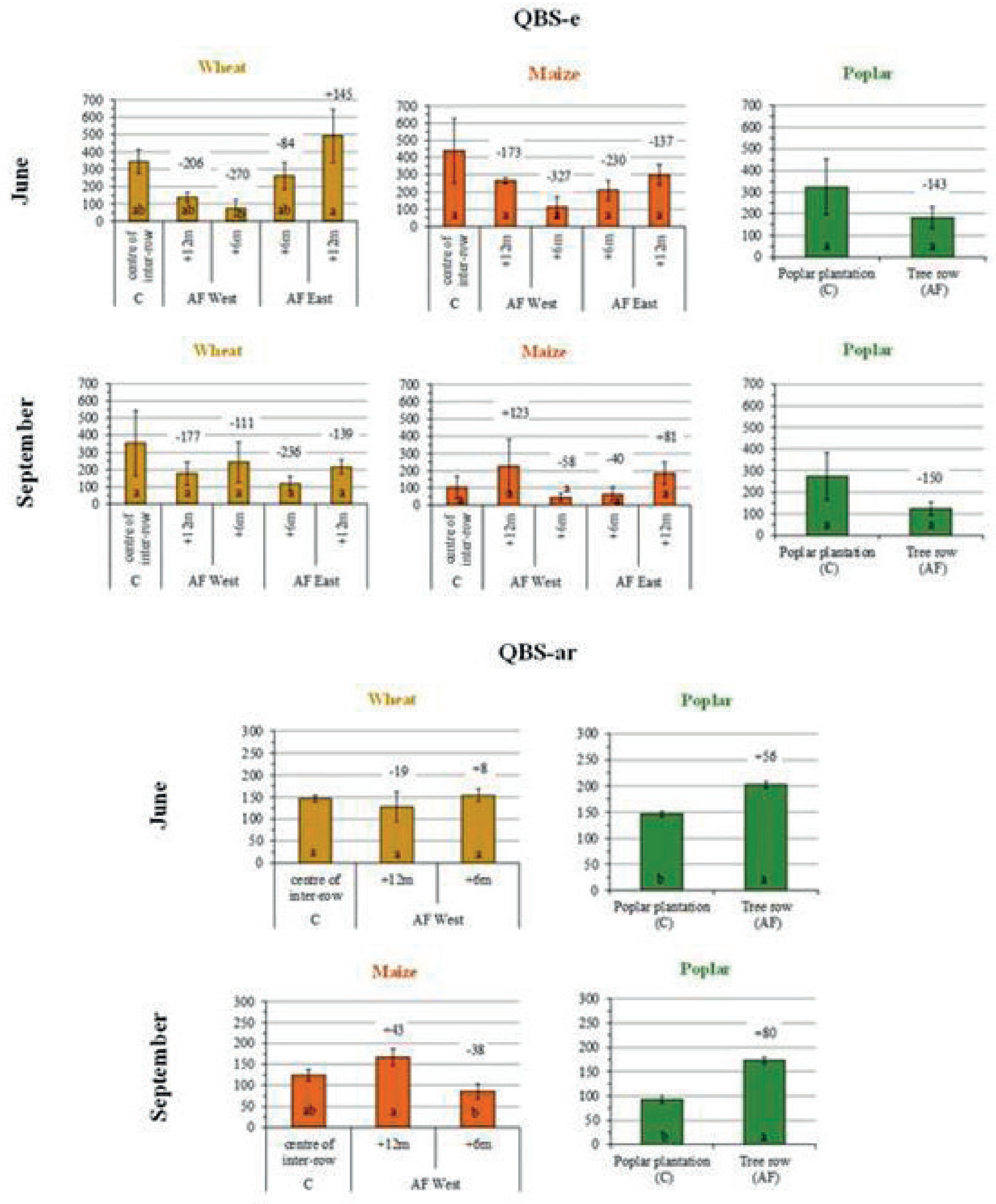
Conclusion

Earthworms generally decreased while arthropod abundance increased near the tree rows in a silvoarable system with widely-spaced poplar rows and trees at half commercial life span. Poplar rows covered with grass showed the highest QBS-ar values, indicating that diverse habitats enhance biodiversity protection. A positive correlation between earthworms and soil water content was observed in the alley-cropping system, peaking at the center of the inter-row. The positive correlation between crop productivity, particularly in maize, and earthworm density suggests that QBS-e could serve as an informative index for crop yield. Despite higher soil water content, tree rows exhibited lower QBS-e than the arable field, indicating a potential inhibitory effect of poplar on earthworms. However, further research is required to corroborate these preliminary results and possibly clear the role of these agroforestry features (organisms and soil structures, crops, water management, tree species, and ditches).

Keywords

earthworm, soil fauna, soil biodiversity, silvoarable agroforestry, soil moisture, crop production, Mesofauna

Aditional Attachment II.



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Use of superabsorbents in agroforestry in tropical and subtropical regions

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As the frequency and intensity of droughts escalate due to climate change, innovative strategies are imperative for the preservation and revitalization of indigenous species in natural environments. This article explores the use of superabsorbent polymers (SAPs) in agroforestry, focusing on their potential to address water scarcity challenges. SAPs, known for their remarkable water-absorbing capacity, offer a promising solution to enhance soil quality and foster optimal plant growth.

The incorporation of hydrogel into soil structures has shown significant improvements, creating a controlled and porous environment. This controlled release mechanism regulates water, promotes efficient water infiltration, and ensures uniform distribution of nutrients, ultimately providing an ideal foundation for robust root development. The use of SAPs, particularly hydrogel, mitigates root desiccation, facilitates nutrient absorption, and supports seamless assimilation, reducing stress on seedlings and resulting in lower mortality rates.

Two case studies are presented to illustrate the practical application of SAPs in agroforestry. The first trial, conducted on Socotra Island, addresses the preservation challenges faced by Boswellia species in harsh climatic conditions. An organic hydrogel, primarily composed of potassium polyacrylate, is employed in a nursery in Hadibo. The trial aims to optimize planting material production for Boswellia aspleniifolia, Boswellia dioscoridis, and Boswellia elongata, contributing to the conservation of the island's unique biodiversity.

The second trial, situated in Mongu, Western province of Zambia, focuses on the planting of Moringa oleifera and Gliricida sepium in three selected areas. Two types of organic superabsorbents, one based on potato starch and the other on an organic polymer of potassium carbonate, are tested alongside a control group. The trial follows a consistent planting pattern, evaluating the impact of superabsorbents on seedling growth and development. This research provides valuable insights into the practical implementation of SAPs in diverse agroforestry settings, offering a sustainable approach to mitigate the adverse effects of climate-induced droughts.

Keywords
soil water availability, soil moisture, climate change

Evaluation of beneficial effects of agroforestry system on soil properties compared to conventional wheat production system in Denmark

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Introduction

Alley cropping is an agroforestry practice, where crops are grown in alleys between rows of trees or shrubs, which aims to optimize resource use, enhance productivity and promote agro-ecology

Objective

The objective was to investigate the beneficial effects of agroforestry system on soil properties compared to the conventional winter wheat.

Methodology

A combined food and energy (CFE) alley cropping system was established in 1995 to develop carbon-neutral production system for food, fodder and energy production. The alley cropping system constitutes alleys, bordered by the biomass belts (BB). In 2023, alley crops grown were clover (CFE clover), oat (CFE oat) and winter wheat (CFE WW). One biomass belt was not harvested since the establishment of the CFE system in 1995 and regarded as natural forest (NF) (Porter et al. 2009). The CFE system is managed as organic farm without using chemicals and fertilizer inputs. Nearby CFE, a conventional winter wheat field (CWW) is the reference treeless control system, managed with inputs of nitrogen, potassium and phosphorus fertilizer and chemicals in accordance with standard Danish practice.

Soil samples were collected from six different production systems (Fig. 1&2), out of which 4 production systems were components of the CFE system viz. CFE WW, CFE oat, CFE clover and BB and other two production systems were NF and CWW. The soil properties were compared either among the six production systems or between NF, CWW and CFE systems (CFEmean) viz. mean of CFE WW, CFE oat, CFE clover and BB. Earthworm counts were taken from 25 cm x 25 cm x 25 cm soil volume.

Soil moisture was monitored in CFE WW, BB, NF and CWW at six soil profile depths viz. 10 cm, 20 cm, 30 cm, 40 cm, 60 cm, and 100 cm depths during the months of June, July and August in 2023.

Results and discussions

Bulk density (BD) was significantly ($P<0.01$) different when compared between CFEmean, NF and CWW. The BD was highest in the CWW (1.74 g cm-3), followed by CFEmean (1.48 g cm-3) and lowest in NF (1.01 gcm-3) (Table 1) in congruence to another field study in the same site (Ghaley et al. 2014). The soil organic matter content (% OM) was highest (6.61% OM) in NF followed by BB (4.44 OM%) and the lowest in CWW (2.48 % OM). The total soil nitrogen (TN%) was highest in NF (4.14 % TN), followed by CFEmean and CWW (1.47 % TN) and the same trend was recorded for exchangeable K, potentially mineralizable nitrogen (PMN mg kg-1) and cation exchange capacity (CEC) with highest in NF, followed by CFEmean and CWW. These findings of improved soil properties in the agroforestry system is in agreement with other field studies (Kho et al. 2001; Akoto et al. 2020). Earthworm count was significantly different between CFEmean and CWW with highest earthworm count in CFEmean (N = 449) followed by NF (N = 363) and lowest in CWW (N = 128) in consonance with other studies (Cardinael et al. 2019; Insfrán Ortiz et al. 2023; Mettauer et al. 2024). The data demonstrated beneficial effects of agroforestry on soil properties for improved soil health in agroforestry system (CFEmean) compared to CWW.

Soil moisture content was significantly different between the BB, NF, CFEWW and CWW (Table 2). In 2023, we experienced extreme drought with only 9.8 mm precipitation in June compared to 5-year average of 29.4 mm whereas July and August received a record high rainfall of 95.3 and 136.1 mm respectively compared to 5-year average of 49.8 and 103 mm respectively. During the dry spell in June, BB maintained significantly higher soil moisture followed by NF compared to ploughed systems viz. CWW and CFEWW due to high OM content and low BD that help conserve moisture. In contrary, during the wet spell in July and early August, the soil moisture was significantly higher in CWW and CFE WW compared to BB and NF, indicating that the excessive rainfall in July and early August lead to saturation of soil in CFEWW and CWW due to low infiltration into soil caused by soil compaction (high BD) whereas reverse was true in BB and NF.

Conclusion

The study demonstrated that CFEmean and NF had lower bulk density compared to CWW indicating that the CFEmean and NF had higher soil porosity, less compaction and increased soil moisture retention. The higher soil fertility in CFEmean compared to the CWW demonstrated that the agroforestry system had beneficial effects on soil properties. BB and NF maintained higher soil moisture during the dry spell due to high OM and converse was true in CFEWW and CWW.

Acknowledgement

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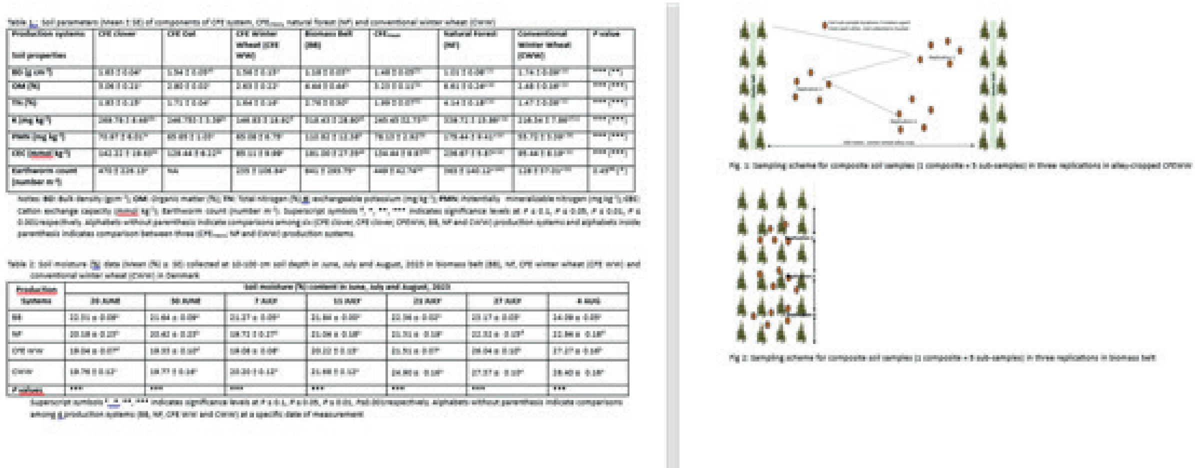
Keywords

hazelnut, microclimate, alley cropping, wheat, soil improvement, grass clover, Soil Organic Matter, water infiltration, willow, soil moisture, Agroforestry, Denmark, production systems, soil depth, Living lab, Agroforestry system, temperate agroforestry, soil analysis, trees, shelterbelts, soil characteristics, barley, Climate smart agriculture, silvoarable

Aditional Attachment II.



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Systematizing transect sampling for soil carbon accounting in alley cropping systems

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Agroforestry systems have great potential for soil carbon sequestration (Cardinael et al., 2017; Mayer et al., 2022), offering an essential approach for climate change mitigation. The presence of perennial woody plants and the exclusion of soil tillage in tree strip zones are key contributors to this potential. However, the diversity in designs, management practices, and environmental contexts across agroforestry systems poses challenges in obtaining reliable and comparable data (Feliciano et al., 2018; Golicz et al., 2022; Nair 2012). Defining suitable locations for soil sampling, among other considerations, presents a considerable challenge.

One promising approach to estimate soil carbon stocks in alley cropping systems is the use of a transect soil sampling approach (Cardinael et al., 2017; Golicz et al., 2023). Here, samples are systematically collected along transects in both tree strips and adjacent arable or grassland strips, allowing for the consideration of internal heterogeneity within an alley cropping system with varying levels of tree influence. However, the wide variation in transect sampling methodologies has been compromising comparability across studies and their integration in meta-analyses (Cardinael et al., 2018; Chatterjee et al., 2018). Additionally, some of the sampling approaches may result in biases, leading to over- or underestimation of tree influence for the entire system.

This presentation outlines the findings of an evaluation of 48 studies considered in a recent meta-analysis on soil organic carbon sequestration in temperate agroforestry systems. Our assessment identified and quantified six potential biases associated with transect soil sampling in alley cropping systems (Minarsch et al., 2024). All 23 case studies examined in detail exhibited at least one of these biases. For instance, ten studies did not include soil sampling in the tree strip, potentially leading to an underestimation of tree influence. Conversely, an overestimation may occur when tree and arable strips are not weighted by their respective area shares, a consideration in only three case studies.

To address these biases and enhance the accuracy and comparability of soil carbon analyses, we propose a standardized guideline for transect soil sampling in alley cropping systems (Minarsch et al., 2022; 2024). Practical examples demonstrating the implementation of this guideline will be introduced, building on experiences from Gladbacherhof, a research farm of the Justus-Liebig-University Giessen, Germany, and farms involved in a citizen science agroforestry monitoring project led by the University of Münster, Germany. This work aims to provide agroforestry researchers and practitioners with a tool to ensure methodological consistency, fostering a more robust understanding of the role of agroforestry in soil carbon sequestration and contributing to the advancement of sustainable land management practices.

Keywords
design, soil carbon sequestration, Analysis, spatial planning, agroforestry monitoring, alley cropping, Transect sampling, soil analysis

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Impact of age and diversity of Swiss agroforestry systems on soil health

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Introduction
Although traditional agroforestry systems are found across Europe (Dupraz et Liagre, 2008). So-called modern, silvoarable alley cropping systems (ACS) are rather scarce, especially in Switzerland (Jäger, 2019). ACS could be one of the solutions to the major challenges facing agriculture, such as biodiversity loss, climate change adaptation and mitigation (Terasaki Hart et al, 2023; Jacobs et al, 2022; Torralba et al. 2016). ACS offer high potential for improving soil health by reducing erosion, increasing carbon inputs and nutrient availability or enhancing soil life compared to conventional systems (Rolo et al. 2023). Moreover, ACS were shown to increase resource use efficiency and agroecosystem resilience (Sauter et al. 2015). However, under certain circumstances, the presence of intercropped trees may increase competition for nutrients, water and light (Lawson et al. 2019). Furthermore, setting up ACS represent substantial financial investment, as well as a high workload in the first years (Jäger, 2019). Thus, the balance between the advantages and disadvantages of ACS is intrinsically linked to location, as well as to the system design and management practices.

In past years, ACS started to be implemented with increasing frequency in Switzerland. Switzerland has a highly diversified, often hilly landscape, and farmers cultivate rather small fields. Therefore, farmers design specific ACS adapted to their site, resulting in highly diversified ACS. Tree strip orientation and width, cropping alley width and use differ between farms and plots. Among all ACS, trees are used for a variety of purposes, such as the production of fruit, nuts or timber. Additionally, some wild tree species are grown solely for biodiversity purposes. The diversity of systems also varies: some ACS consist of a single tree species, others combine several tree species or uses. Furthermore, farmers grow several crops in their rotation and sometimes grow different crops simultaneously in each cropping alley of the same ACS. This huge diversity increases the challenge to study and compare ACS.

Benefits of ACS for soil health are well established (Beule et al. 2022, Ivezić et al. 2022, Nagba et al. 2023). However, little is known on how different ACS characteristics such as age or diversity affect soil health in temperate regions. Furthermore, individual case-studies focusing on few particular soil properties in topsoil are the most common method of studying ACS. The aim of this study is to conduct an on-farm survey at various sites throughout Switzerland to compare soil health of whole ACS and tree-less arable plots and to shed light on how different ACS implementations and pedoclimatic conditions affect soil health – assessed using biological, chemical and physical soil health indicators. This may give us inferences on: at which (i) age, (ii) density and (iii) diversity level an ACS can have an impact on soil properties.

Material and Methods
Soil sampling protocol (carried out in Feb-March 2024)
We have identified around 30 farms practicing silvoarable agroforestry in Switzerland. For each site, pedoclimatic information and agricultural management data will be collected. ACS's ages range from 1 to 30 years. In order to cope with the ACS diversity, we plan to collect soil sub-samples in 5 transects between two tree strips, each transect being 4 meters apart. Transect sub-samples will be mixed to get representative composite sample for each site. Composite samples will be collected in triplicate at each farm: one in a control tree-less plot, one in the cropping strip of the ACS and one in the ACS tree strip. This allows to weight the effect of the trees according to the dimensions of the cropped area and to compare ACS with each other. In addition to the composite samples, undisturbed soil cores (5 replicates) will be collected at each site. Composite and undisturbed samples will be collected in topsoil (0-20 cm) and subsoil (20-60 cm).

Soil health assessment – Selection of indicators (carried out in Mar-Aug 2024)

The assessment of the soil health will be based on biological, chemical and physical soil properties. For this purpose, the following indicators were collected and evaluated with regard to their relevance and feasibility.

Soil penetration resistance and infiltration capacity will be measured on site using a penetrometer (Sol Solution) and mini disk infiltrometer (Meter group GmBH), respectively. Soil cores will be used to determine soil bulk density and soil structure by visual estimation (Core VESS). Composite samples will be sieved at 2mm and split in two: one part will be stored at 4°C, the other will be dried. Composite cooled samples (4°C) samples will be used to measure soil microbial biomass, soil respiration and composition of soil biota functional community. Composite dried samples will be used to determine texture, pH, cation exchange capacity, total N, available P, K, Mg, Ca, soil organic carbon.

Preliminary results of the physical soil health will be available in spring 2024. The biological and chemical analysis of soil properties will take longer.

Keywords
climate resilience, soil organic carbon, climate change mitigation, soil properties, Age-dependent, alley cropping, Temperate climate, silvoarable agroforestry

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Development of regenerative agroforestry-based cotton production in Italy

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Introduction
Cotton is a very old and the most used fiber found in many parts of the world. With the return of the First Crusaders, cotton was brought back to Europe as a novelty item, and European demand for cotton began. Cotton consumption, cultivation and production were practiced all over the Mediterranean Basin. The cotton production in Italy declined in the last half of the 16th century owing to decline price with emergence of syntenic fibre, and high input costs of cotton framing. In effect, European Forest Institute under Circular Bioeconomy Alliance (CBA) has initiated the 5 years cotton regenerative agroforestry project experiment in the CREA-AA Experimental Farm in Rutigliano (BA), Southern Italy as a show case for the Mediterranean region.

Objectives
The overall objective of the research is to restore and scientifically assess regenerative agroforestry-based cotton production systems in Italy. Specifically, objectives of the study are: (1) to test alternative agroforestry and regenerative farming practices to produce sustainable cotton (on one ha); (2) to apply precision agricultural techniques to match irrigation and soil fertility in cotton crop management; and (3) to monitor the provision of agroforestry ecosystem services.

Methodology
The one-year experiment was conducted on regenerative monocropping cotton (MC) on a plot of about 0.7 ha and cotton regenerative agroforestry (CAF) on a plot of 0.3 ha where cotton was grown in intercropping with a 7-year-old peach orchard of late ripening.

Results
Preliminary results of the experiment showed that the seasonal irrigation volume was 3604 m3 ha-1 for MC and 1662 m3 ha-1 for CAF. Stem potential (Ψs) in CAF had significantly higher values (and therefore the plants were more stressed) than in MC (2.9± 0.94 and 2.27± 0.56 Bar respectively). At peak plant development, cotton had Leaf Area Index (LAI) of 4.41 and 2.38 for MC and CAF, respectively. The aboveground dry biomass of cotton plant was estimated to 5.49 t ha-1 for MC and 1.47 t ha-1 for CAF. The seed fiber cotton yield was 3.58 (±0.34) t ha-1 for MC and 1.72 (±0.30) t ha-1 for CAF. The proportion of incidence of seeds was about 55%. There was no difference in water productivity (WPi) in the two treatments ($p>0.05$). The WPi was 0.96 and 1.03 kg m-3 respectively for MC and AF. It should be noted that the lower production of seed fiber cotton in CAF treatment is due to the presence of the peach orchard planted at a very dense width to adapt it to an agroforestry system for cotton. Other ecosystem services that are being monitored during the overall duration of this 5-year long experiment include Carbon sequestration in soil and biomass, other greenhouse gases yearly budget (utilizing eddy covariance approach), and landscape impact of the agroforestry crop.

Conclusions
The study will be further continued to validate the production impacts of regenerative cotton production system in the study region while a certification scheme for regenerative agroforestry will be applied, capitalizing on the experimental observations being conducted.

Keywords
Cotton, Regenerative agroforestry, Italy, Mediterranean, biodiversity, Agri-Environment-Climate, soil organic carbon, soil water availability, Agroforestry

1.6 Healthy Soil and Water Management (II)

Oral presentations

Hall Q2, 31 May 2024, 8:30–9:15

Agroforestry as a key to improve water management and adaptation to extreme weather events in Germany, Belgium and the Netherlands

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Introduction

In most parts of Central Europe, the advancing climate change is leading to a reduction in precipitation during the vegetation period (drought in summer), an increase in winter precipitation (risk of flooding and erosion) with a generally increased risk of heavy rainfall events. Such climate dynamics impact hydrological processes at local, regional and global scale.

The scarcity of water during dry periods and an increased surface runoff due to the intense rainfall events affect particularly agricultural activities, which result in loss of fertile top soil and crop yield decline mainly in hilly areas. Extreme weather events and deviation from normal conditions, coupled with human-driven factors – such as land use change, increased surface sealing, intensive use of machinery for farming – exacerbate the disruption of hydrological processes. These factors hamper rainfall infiltration and elevate runoff; consequently, they increase the risk of soil erosion on the one hand and drought on the other – both at the farm and at catchment level.

Sustainable water management practices such as green infrastructure and nature-based solutions are crucial for mitigating these challenges (Haase 2021; Miralles-Wilhelm 2021). The flood occurred in Belgium, Germany and the Netherlands in July 2021 (Koks et al. 2022) showed the urgency to take measures to improve water management. The practice of agroforestry is less common in Central Europe (Mosquera-Losada et al. 2018) and its effects on water related processes are generally not well understood.

Case Description

Agroforestry integrates trees and shrubs into agricultural landscapes (EURAF 2022), creating a system that mimics natural ecosystems while supporting both agricultural productivity, environmental sustainability and diverse societal benefits (Pavlidis and Tsihrintzis 2018; Rigueiro-Rodríguez et al. 2009). As illustrated in figure 1 (attached), agroforestry plays a crucial role in water management in different ways. Trees decrease surface runoff through their canopy by intercepting rainfall and reducing the impact of raindrops on the soil surface (Zabret and Šraj 2019). Trees improve soil structure through their litter and root system. Roots and litters create pore spaces and channels for water to infiltrate and increase water storage in the soil often far below the root horizon of crop plants (Anderson 2009; Udawatta 2002). Enhanced infiltration of water not only reduces soil erosion by runoff but also improves ground water recharge and sustainable supply of water for crops as well as the ecosystem. Agroforestry systems may also serve as a windbreak and shading, mitigating the rate of evapotranspiration from both soil and plant surfaces; thus, they create a microclimate with lower temperature and higher humidity that helps to maintain soil moisture (Brandle 2004).

These effects contradict the increased water consumption by trees. Nevertheless, the project partners in AFaktive assume that the positive effects of AF on water management predominate. Studies of alley cropping systems in eastern Germany have shown that the positive effects outweigh the negative effects. In order to quantify these effects, numerous measurements and investigations on a practical scale are planned as part of AFaktive.

To increase the recognition and understanding of the role of agroforestry in Europe for sustainable water management under extreme weather events, new examples for demonstration of innovative agroforestry-based water management practices at farm and regional level are needed. The recently started LIFE Climate project 'AFaktive' aims to demonstrate and promote agroforestry systems as a key for water management and adaptation to extreme weather events in three EU countries, Belgium, Germany and the Netherlands. AFaktive applies agroforestry with the objective to support environmental adaptation, socio-economic benefits and to create knowledge-based best-practice examples. To reach these objectives, AFaktive has designed a 3-step procedure: 1) use pioneer farms with already existing, mature agroforestry systems to quantify the effects and calibrate models for runoff/flood and erosion prediction; 2) build up new agroforestry systems on both pioneer and expansion farms as demonstration of improved agroforestry with regard to water management. These farms will serve as incubators for further steps; 3) plan and implement agroforestry and water management projects to demonstrate the effects at regional scale – this can be e.g. watershed or municipal level.

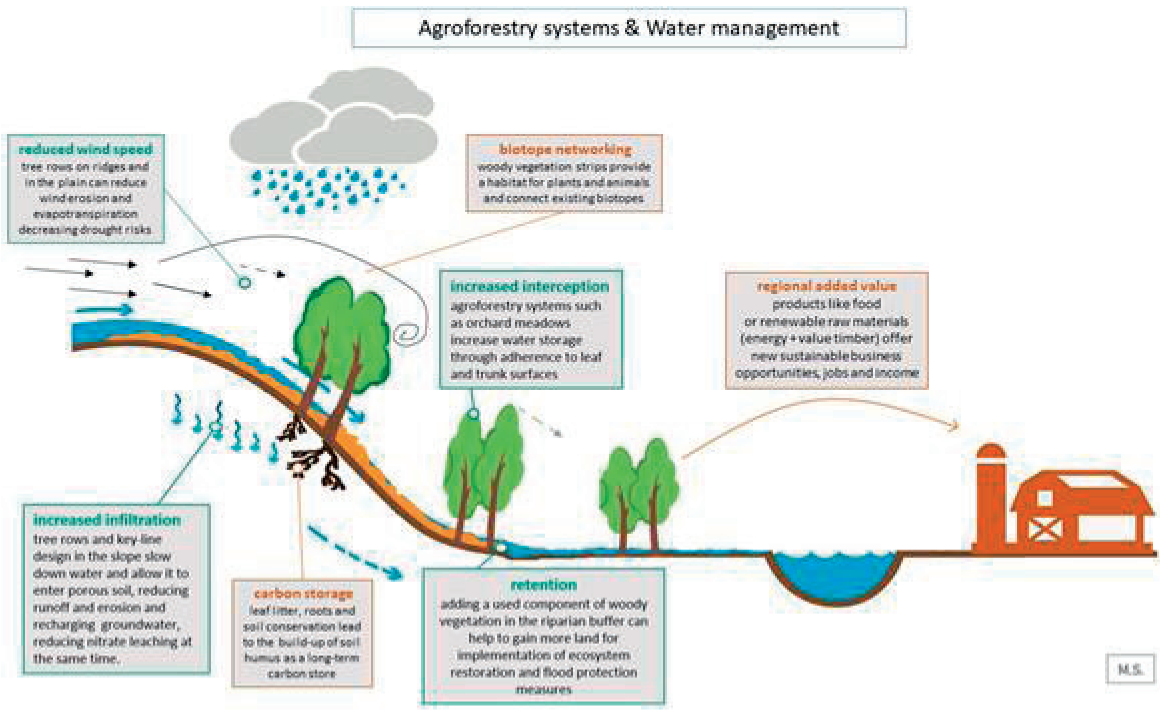
Conclusions

AFaktive will lay the foundation for a targeted introduction of agroforestry as a tool for water management in Central Europe. In addition to the practical implementation described above, the project will develop different tools for planning, collect knowledge and experience and bring them together in educational materials, events for practitioners, administration and science. The growing interest in collaborating and support for agroforestry system expansion in Europe will have a great impact on the implementation of AFaktive project. At present, field works both for the assessment of the effects of agroforestry practices on water management and the selection of farms for the establishment of new agroforestry are underway.

Keywords

drought adaptation, flood prevention, business models, agroforestry system planning, buffering climatic extremes, Climate smart agriculture, nature-based solutions, Agroforestry, soil erosion control, green infrastructure, water management, agri-environmental system, water retention, water infiltration, water scarcity, land management, ground water recharge, agroforestry landscapes, adaptation

Aditional Attachment II.



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Impact on windbreak addition on the forms of soil organic matter and associated soil organisms in the field: results from South Moravia

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Introduction

Windbreaks are added at the field edges to protect crops from negative climatic conditions. In addition to this microclimate effect, they also provide a high input of organic matter in the field (leaves and root system). Though this has been shown to positively affect global soil organic C content, the stability of this C and the impact on the communities of soil organisms is less studied or shows contrasted results.

Objectives: We investigated whether the presence of 20-year-old poplar windbreaks significantly affects a large variety of soil organism communities (microorganisms, nematodes, meso and macrofauna) as well as the forms and amount of soil organic matter in the field (labile C in particulate or dissolved form, C protected in aggregates, mineral-associated C) and some soil chemical properties (nutrient content and pH).

Methods

We sampled 5 fields bordered with windbreaks and 5 control fields bordered by a grass strip only near Brno, in South Moravia, Czechia. Sampling took place in the margin (windbreak or grass strip), and into the field at different distances from the margin. We extracted and identified the faunal communities, measured microorganisms biomass C and PLFA, and separated different forms of organic matter by density-fractionation.

Results

First results showed that though the free soil particulate organic matter and the dissolved organic C content (labile fractions of the organic matter) were particularly high in the windbreak, they did not differ according to the margin type in the field, and did not vary with the distance to the margin. At the opposite, the partially occluded particulate organic matter content (less labile as protected in soil aggregates) was increased in the presence of windbreak both in the margin and in the field, and significantly decreased with increasing distance from the margin, no matter the margin type. Microbial biomass of bacteria was particularly high in the windbreak, but decreased with the distance from the margin no matter the margin type. At the opposite, the biomass of fungi did not present any clear variation.

First conclusions

These preliminary results show that the strong effect of windbreaks in the field margin is not always associated to a strong effect in the field properties, and that taking into account the forms of organic matter is important when considering the C additions to the soil. In the windbreak, a high amount of labile C addition probably promotes high bacterial biomass. In the field, the added labile C is probably either quickly used by copiotrophic microorganisms, or protected very quickly in a more stabilized form due to soil disturbance.

Keywords

biodiversity, soil characteristics, soil analysis, soil fauna, soil biodiversity

Effects of tree features on hydrophysical soil properties in European temperate agroforestry systems - systematic review

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Introduction

Soil is a non-renewable natural resource that plays important environmental, economic and social functions. Conventional industrial agriculture is driving our soil-depended food systems to disaster. Agroforestry represents an alternative able to regenerate soils and adapt them to fast changing conditions, both economically and environmentally. However, research on the effects of woody-vegetation on various soil properties in the region still has some gaps to fill. Therefore, in this systematic review, we focused on identifying quality/existing knowledge for different types of agroforestry systems, different factors of soil physics and soil water. Furthermore, we explored research gaps and shortcomings in current methodological approaches.

Research questions

1. What are the effects of tree features on hydrophysical soil properties in European temperate agroforestry systems (ETAFS)?
2. Do effects of tree features on hydrophysical soil properties vary in different types ETAFS? If yes, how?
3. What methods are the most used to study the effects of tree features on hydrophysical soil properties in ETAFS?
4. What are the research gaps in the effects of hydrophysical soil properties in ETAFS?

Methodology

Two main databases of worldwide relevance were used for systematic review of scientific literature to outline the current scientific knowledge about effects of tree features on hydrophysical soil properties in ETAFS and to identify its main approaches and shortcomings. The selection and review process of the papers consisted of two main phases: First screening and Systematic ranking and data analysis (Fig. 1).

The search was restricted to articles as they usually present complete research results, and reviews. We further restricted the scope to temperate European countries according to the Köppen-Geiger climate classification (Kottek et al., 2006) and papers in English language only. We did not limit the search to any time period. Irrelevant disciplines such as Science Technology, Energy Fuels, Biotechnology, Food Science Technologies were excluded. Retrieved data were exported in .csv and .txt format. After combining and adjusting the databases, removal of duplicates was performed. The first screening phase resulted in 1050 papers. Following systematic ranking (relevance) and screening was done by five reviewers based on the titles and abstracts, finally, by analysing the full texts. Bibliometric analysis of papers ranked 1-4 was performed using Bibliometrix software.

Results

Results revealed that the majority of the studies was focused on silvopastoral systems (e.g. Wairiu et al. 1993; Carroll et al. 2004; Sanchez and McCollin 2015). Tree features in ETAFs proved to increase hydraulic conductivity resulting in higher infiltration rates (e.g. Carroll et al. 2004). More intense capillary reach was observed (e.g. Wairiu et al. 1993; Ghazavi et al. 2011), associated with the presence and dynamics of tree roots (e.g. Inurreta-Aguirre et al. 2022). Tree roots also explored deeper soil layers than annual crops whilst creating a "safety net" for excess nutrients and pesticides. This effect was attributed mainly to older systems but could be noticed as early as five years after the establishment (e.g. O'Connor et al. 2023). The driest soil conditions in ETAFs were identified in close proximity to trees (e.g. Sanchez and McCollin 2015). It is important to mention that majority of studies stem from the Mediterranean region, with dissimilar precipitation regimes (e.g. Rolo and Moreno 2019). In all regions respectively, the main limiting factor, in effects of tree features on hydrological and physical soil properties, was the groundwater availability (e.g. Forey et al. 2021). Generally, the topsoil reaching up to 20 cm in depth was well documented. Yet limited number of papers dealt with the deeper soil layers over 50 cm, including the hydrological and physical soil properties, soil carbon stock and root dynamics (O'Connor et al. 2023). Detailed information on soil temperature regimes in ETAFS vs control plots is scarce for all soil layers. Moreover, only few papers dealt with water balance differences between conditions of ETAFS and forest control plots. Retrospective studies, especially in relation to assessment of land use change, are one of the identified research gaps.

Our review also addressed the methodological approaches of studies. We identified the main methodological shortcoming to be the lack of coverage of the soil water dynamics, especially in terms of seasonality. The complexity of the issue was not adequately reflected in data collections and measurements.

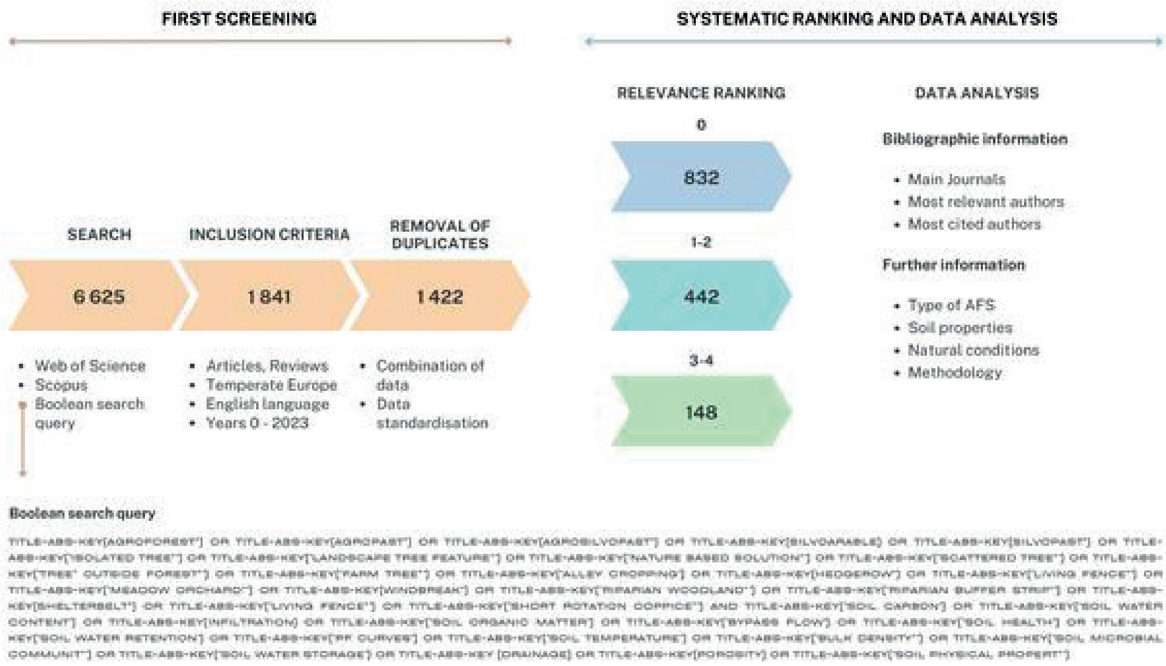
Conclusion

In terms of soil hydrophysical properties of agroforestry systems, topsoil was studied the most. Studies that in detail examine soil depths below 50 cm are scarce. The research gap extends to climatic subregion and soil type specificities, tree density per hectare, tree species and is especially lacking in retrospectivity.

Keywords

systematic review, Soil Organic Matter, soil water availability, soil moisture, temperate agroforestry, soil water content

Aditional Attachment II.



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1.6 Healthy Soil and Water Management

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Soil microbial diversity in silvoarable agroforestry system in Czech Republic

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Introduction

Soils represent the most biologically diverse and important ecosystem on the planet. There is tremendous number of the soil biological processes, which are crucial for the maintenance of ecosystem services associated with sustainable agricultural production. The functions performed by soil biota have large, direct, and indirect effects on crop growth, soil quality, crop disease incidence, nutrient, and water cycling. As such, soil biodiversity is therefore highlighted in the Soil Thematic Strategy of European Union.

Nevertheless, soil degradation currently affects nearly half of the land on Earth and poses a risk to future food security. Current Czech agriculture is based on large blocks of generally homogeneous agricultural landscapes, characterized by low biodiversity and high vulnerability to soil erosion and degradation Thus, sustainable agricultural practices which sustain food production while maintaining or improving soil quality, biodiversity, and ecosystem services, are urgently required. Agroforestry (AF) is regarded as a sustainable agricultural practice that enhances and diversifies farm and forestry production while conserving natural resources. Despite it was a common land-use system in the past, it currently occupies less than 1% of utilized agricultural area of Czech Republic. However, the reintroduction of woody perennials on agricultural land has drawn attention recently, owing to its potential to reverse soil degradation and biodiversity loss while increasing the overall productivity. In recent years, research has already shown that the temperate AF practice affect both microbial abundance and function in soil. Particularly, the increase of soil fungal abundance and affection on the assembly of soil fungal communities has been observed (Beule & Karlovsky 2021).

Objectives

The objective of our research was to describe potential impacts of selected agroforestry systems on soil microbial and macrofaunal diversity and linked soil properties. More specifically, examine the soil microbial communities and linked soil properties within the agroforestry system in relations to the distance from the tree lines and comparison of the agroforestry systems (AFS) to conventional field.

Methodology

The experiment was conducted in an experimental silvoarable plot located in Průhonice, Central Bohemia region (Figure 1). This plot was founded in 2019 from tree nursery where five tree species were left in forest rows (maple, linden, ash, rowan, and Turkish hazel). Soil samples were collected at distances 0.0 m, 2.5 m, 5.0 m and 7.5 m from the tree lines, from the enclosed woodland, and the adjacent conventional field. Diversity of soil bacteria and fungi was established using the next generation sequencing methods. DNA was extracted from the soil samples by the DNeasy PowrSoil Pro Kit (Qiagen), and it was sent to SeqMe for metagenome analysis. The fungal internal transcribed spacer of the rDNA was amplified using primers gITS7ngs and ITS4. The bacterial 16S rRNA gene (V4 region) was amplified from the same DNA extracts using primers 515f and 806r49.

Results

Our preliminary results indicate relatively low effect of tree presence on both bacterial and fungal species diversity but clear impact on species distribution and evenness and this effect is opposite in case of bacteria and fungi. The highest Simpson' evenness and Pielou index of bacterial species were detected in the conventional field. On the contrary, agroforestry system (and the open alleys between tree lines in particular) was represented by the highest evenness of soil fungal species. Furthermore, species diversity of soil fungi was also found higher in agroforestry than in woodland or conventional field.

Conclusion

We observed a greater species distribution and evenness of soil fungal species in agroforestry system compared to the conventional field, whilst the opposite effect in case of bacteria. This finding aligns with previous research that fungal populations are encouraged by the diversity of the plant community. The transition towards fungal dominance within the microbial community is believed to foster the accumulation of organic carbon and reduce its turnover rate through enhanced fungal-mediated soil aggregation. Furthermore, fungal communities contribute to plant growth enhancement through mutualistic interactions, pathogenicity, and increased nutrient availability, ultimately bolstering drought resistance. Consequently, our findings suggest that agroforestry systems exhibit greater resilience in addressing global challenges, including climate change, when contrasted with conventional field production.

Keywords
soil biodiversity, sustainable food production, Agroforestry

Aditional Attachment II.

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Soil moisture dynamics in silvoarable alley cropping systems – Learning from a soil moisture sensor network

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Introduction

With the expected increase in the occurrence of prolonged droughts and extreme rainfall events in continental Europe, it is crucial to increase the resilience of agriculture to climate change. Alley cropping, i.e., the inclusion of linear rows of trees on cropland, is considered a promising pathway to achieve this (Wolz et al. 2018). Shading, lower temperatures, higher relative humidity and reduced wind speeds could create a beneficial microclimate that reduces crop evapotranspiration and therefore water losses (Jacobs et al. 2022). Furthermore, tree roots and changes in physical soil characteristics could enhance infiltration, whereas the tree lines help to reduce soil erosion during rainfall events (Akdemir et al. 2016). However, trees also have higher evapotranspiration rates than annual crops, which could lead to reduced soil water availability and crop yield.

To better understand the role of trees in regulating soil water availability, both temporal (throughout the year) and spatial (distance to the trees, hillslope position) data on soil moisture are required. Here we present the design of a soil moisture sensor network installed in a 4-year old silvoarable alley cropping system at the research and teaching farm "Gladbacherhof" of the Justus Liebig University Giessen (Hesse, central Germany).

Objectives

The objectives of this contribution are (1) to demonstrate how a network of soil moisture sensors can be used to investigate spatiotemporal soil moisture patterns in a silvoarable agroforestry system, and (2) to highlight the challenges of the implementation and maintenance of such network.

Methods

Three transects with18 sensors each (Teros 11 and 12, Meter Group Inc., Pullman WA, USA) were installed perpendicular to a tree row in 2021. The tree row has a 1.5 m wide grass-clover strip on both sides (i.e. 3 m in total). Crop alleys are 18 m wide. Along each transect, sensors are deployed at 1 m (within the grass strip), 2.5 m (in the crop alley at 1 m distance from the edge of the grass strip), 6 m (quarter width of the crop alley) and 10.5 m (middle of the crop alley) distance upslope and downslope of the tree row (Figure 1). Sensors are placed at 40 and 60 cm depth with additional sensors in the grass strip at 10 cm depth where no soil management takes place. Sensor cables run through plastic tubes at 50 cm depth to the solar powered data logger (ADCON Radio Telemetry Unit A723, Vienna, Austria) to avoid damage from soil management activities and fauna, such as mice. The data logger transmits the data wirelessly to a base station located 300 m away, which is incorporated in the university network and allows almost real-time visualisation of the data from the office.

Results

Preliminary data from summer 2022 demonstrate that the data can be used to identify differences in soil moisture dynamics between soil depths, distances from the tree row and topographical position. Soil moisture in the crop alley decreased faster than in the grass strip, suggesting faster drying in the absence of rainfall. The difference between soil moisture upslope and downslope of the tree row was on average <2%, except in the centre of the crop alley, where soil moisture upslope was up to 42% lower than downslope. Recharge following rainfall was fastest at 10 cm depth in the grass strip. Deeper layers responded more slowly to rainfall across all transects, especially closer to the trees. During wet weather, soil moisture at 2.5 m upslope was 11.4±24.9% higher than downslope, possibly due to the grass strips acting as barrier for the downslope movement of soil water.

Soil moisture sensor networks come with challenges. The installation is labour-intensive and causes major disturbance of the soil and potentially destruction of annual crops. Care must be taken that the sensors are installed in undisturbed soil. The use of protective tubes for cables is highly recommended to prevent damage from soil fauna and management activities (including mowing of grass strips). However, they should not cause preferential flow towards the sensors. Finally, the selection of sensors, a compatible data logging and transmission systems and power supply is crucial for a well-functioning network. Particular attention should be paid to the placement of solar panels among the trees due to shading. Finally, such networks generate large amounts of data and require a dedicated person to check the incoming data for irregularities and to perform quality control.

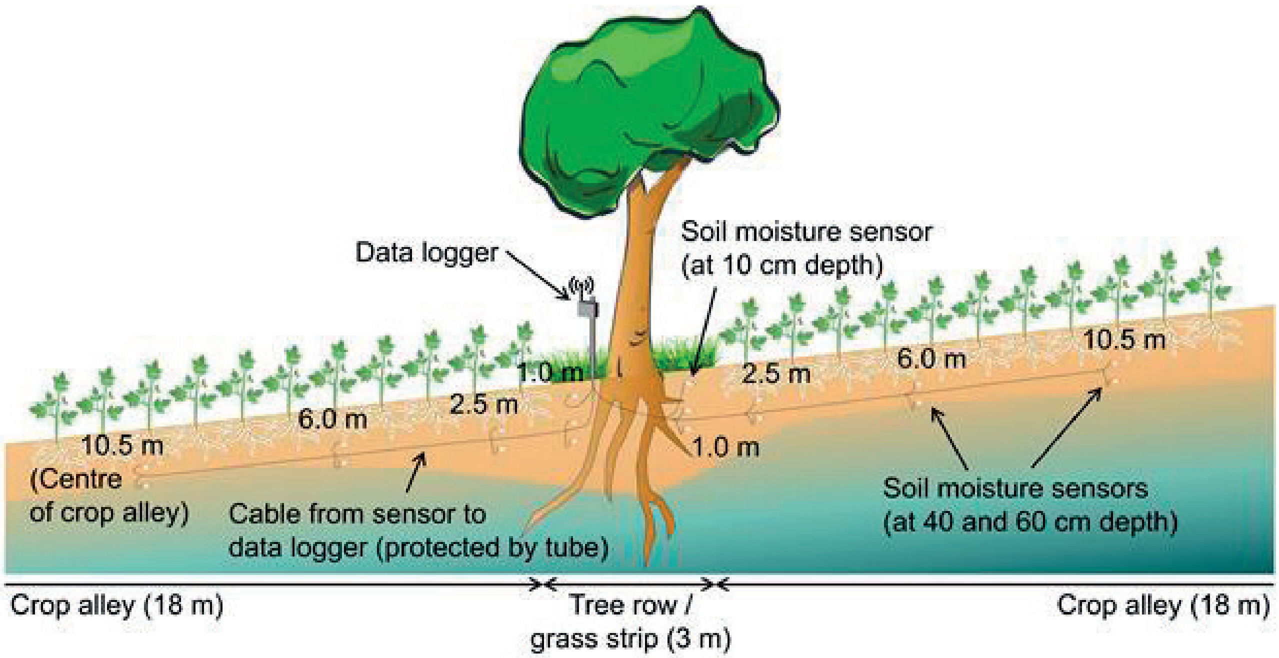
Conclusions

Due to the relatively recent installation of the sensor network at the research site, no conclusions about the role of trees in regulating water availability for crops can be drawn yet, nor can recommendations be made regarding optimal field design for alley cropping systems. However, it is clear that properly designed and maintained sensor networks can help to increase our understanding of spatiotemporal soil moisture dynamics and support the assessment of the drought resilience of such systems.

Keywords

light and water competition, temperate agroforestry, Germany, water resources, soil water availability, soil moisture, silvoarable agroforestry

Aditional Attachment II.



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Nitrogen-fixing Woody Perennials for Agroforestry Systems in Germany

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Integrating nitrogen-fixing woody perennials (NWP) into agroforestry systems has the potential to improve nutrient cycling while promoting the growth of neighbouring crops. An innovative strategy is crucial, especially for organic farming in Germany, to minimise the risk of nutrient deficiency due to sole reliance on nitrogen-fixing cover crops. NWP can address these challenges by increasing the nutrient and carbon accumulation at the soil surface level. Long-term and short-term studies in tropical plantations have shown that mixed-species plantations with NWP have positive feedback on adjacent and succeeding crops.

The literature review was conducted to explore the potential species for agroforestry systems in Germany. NWP species were selected from available literature and screened based on several characteristics: (1) species origin, (2) frost tolerance, (3) German Negative List, (4) probability of nodule formation, and (5) plant height and shade tolerance. The screening process resulted in nine species of NWPs from the genera Alnus and Elaeagnus, namely Alnus cordata, Alnus glutinosa, Alnus hirsuta, Alnus rubra, Alnus alnobetula subsp. alnobetula, Elaeagnus angustifolia, Elaeagnus umbellata, and Elaeagnus multiflora.

All of the mentioned species, with the exception of Alnus alnobetula subsp. alnobetula, are suitable for coppicing management – cutting the tree to ground level. While the impact of coppicing and pruning – removing branches, on nitrogen fixation performance remains unclear, coppicing facilitates the regeneration of new shoots and pruning remains essential for nutrient cycling. Additionally, each species offers unique ecological and economic benefits for agroforestry systems. The literature review also highlighted the potential benefits, risks, mechanisms, and drawbacks of integrating NWPs into agroforestry systems in Germany.

Aditional Attachment II.

UNIVERSITÄT HOHENHEIM

Species Name	Common Name	Nitrogen Fixing Capacity (kg ha^{-1} year^{-1})	Height (m)	Recommended Management	Value Added
Large/Medium Trees					
Alnus cordata (Loisel.) Duby	Italian Alder	60-360[a]	25	SRC & P[g]	Bee plant.
Alnus glutinosa (L.) Gaertn.	European Alder	185[b]	25	SRC & P[h]	Dye, bee plant, tannins, fodder, medicinal plant.
Alnus hirsuta (Spach) Rupr.	Manchurian Alder	56.4 [c], 60[d]	18	SRC & P[i]	Dye.
Alnus rubra Bong.	Red Alder	130[e], 62[f]	20	SRC & P[i]	Sap, dye, medicinal plant.
Small Trees/Large Shrubs					
Elaeagnus angustifolia L.	Russian Olive	240[a]	7	SRC[j] & P[k]	Edible fruit, edible seed, bee plant, medicinal plant.
Elaeagnus umbellata Thunb.	Autumn Elaeagnus	236[b]	4.5	P[k]	Edible fruit, edible seed, bee plant, soil stabilizer, medicinal plant
Medium/Small Shrubs					
Alnus alnobetula subsp. alnobetula	Green Alder	60-360[a]	3	P[i]	Dye, medicinal plant.
Elaeagnus multiflora Thunb.	Cherry Silverberry	240[a]	3	n.a.	Edible fruit, edible seed, bee plant, medicinal plant.
Elaeagnus latifolia L.	Oleaster	240[a]	3	n.a.	Edible fruit, edible seed, bee plant, ground cover.

Green highlight: European origin
Yellow highlight: Full-shade tolerant
SRC: Short-rotation coppice
P: Pruning

[a]Crawford (1995), [b]Paschke et al. (1989), [c]Tobita et al. (2013), [d]Lee & Son (2005), [e]Binkley (1981), [f]Tripp et al. (1979), [g]Ducci &Tani (2009), [h]Daugaviete, et al., (2022), [i]Wilson et al., (2021), [j]Wilcox (2003), [k]USDA (n.d.)

Methods of programming and optimizing air phytoremediation processes using the potential of plant structures of row- alley agroforestry systems

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One of the most important values of agroforestry systems is multifunctionality which, in addition to provisional benefits, allows to provide bunch of regulating ecosystem services, creating the paradigmatic model of sustainable land use.

Alley cropping system, in which trees/shrubs and crops are arranged in a strip structure, can be used successfully as a passive method of improving air quality at the local-level, using natural abilities of plants to remove or biostabilize environmental pollution.

The presentation shows the stages of programming the air phytoremediation process in alley cropping system structure, enhancing its ability as a passive air quality control measure.

The fundamental recognition on which the programming process is based is the bipolar nature of air phytoremediation, according to which the reduction of particulate pollution occurs as a result of deposition and aerodynamic effects. In the presentation we discuss the case study, where we analyze the interaction between plants community and stream pollution of fine particles, discussing the case of PM 2.5.

The optimal configurating a phytoremediation-efficient plant community requires recognizing many variables, including the specificity of the plant material, their arrangement, meteorological parameters, and the morphological conditions of the area.

To intensify the phytoremediation processes in the dispersion-deposition model, it is necessary to apply both an appropriate species with a high depositional potential and with an appropriate spatial structure. It is needed to recognize both the individual morphological properties of plants and of the group structure, which have a significant impact on the mechanisms and processes that occur between plants and the pollution stream.

In the study the numerical experiments have been carried out using micrometeorological Computational Fluid Dynamics model (ENVI-met software), where the dispersion process efficiency has been estimated quantitatively.

The results showed the efficiency is dependent on characteristics of individual plants, including the parameters of structure and of crown density (Leaf Area Index and Leaf Area Density) and the plants configuration in the group. The use of different values of these parameters leads to significant differences in the efficiency of the dispersion process (9-20%), therefore they should be classified as key variables in phytoremediation efficiency of plant groups.

The statistical study of the most efficient scenarios using ARCD [δARDC] and RC [%] parameters confirms the correlation between the efficiency of the phytoremediation process and the adopted parameters of the plant community. the results are presented in boxplot and Tukay test analysis for different zones formed depending on the distance from the source of pollution.

The study provides methods of improving crops productivity, important in a field-scale for a farmer, however, by stimulation the phytoremediation processes, broadens as well perspective pointing agroforestry as an efficient tool for air pollution mitigation objectives.

Assessment of acid phosphatase activity in soils from the cerrado biome of Minas Gerais - Brazil in an agroforestry system using Cratylia argentae

PhD Elaine Teixeira[1], PhD Iran Dias Borges[1], Student Raul Paredes Ferreira[1], Student Vinicius Sanchez Amara[1], Student Giovanny Batista Garbaccio[1], Student Lucas Braga Freitas[1], PhD student Isabela Figueiredo de Oliveira[1], PhD student Yara Da Costa Guedes[1]

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Introduction

The growing demand for agricultural means of production with lower environmental impacts and in sustainable ways, which allow such activities to be combined with greater biodiversity and use in which natural resources such as soil and water are perpetuated. Thus, the use of legumes, in so-called agroforestry, tree-shrub systems, allows the afforestation of pastures, providing shade for livestock, favors nutrient cycling and can produce additional products such as wood, fruits, among others. Among these, there is an emphasis on cratylia (Cratylia argentea), in which there is interest in soils in tropical biomes, such as the Brazilian cerrado. This species has great tolerance to acidic soils with a high aluminum content, but it also has resistance to water deficit, in addition to biological fixation (FBN). Another point to highlight concerns the availability of phosphorus in Brazilian soils, which can be influenced by the action of soil microorganisms. The importance of the microbiota stands out in the solubilization of the nutrient phosphorus (P), protection against pathogens and the release of enzymes.

Objective

The present work aims to understand, through the quantification of acid phosphatase, the effect of the presence of cratilia on the solubilization potential of phosphorus in soil typical of the cerrado biome in Minas Gerais (MG), Brazil (BR).

Methodology

The experiment was carried out by the Federal University of São João del-Rei (UFSJ), at the campus of Sete Lagoas (CSL)-MG, BR (latitude 19°28'37.32"S longitude 44°11'46.99"W). The experimental design was in randomized blocks in a 2X3 factorial scheme (2 locations: Experimental fields of UFSJ-CSL and experimental fields of the Agricultural Research Company of Minas Gerais (EPAMIG) in the municipality of Prudente de Morais (latitude 19º45'38.43''S, longitude 44º15'97.48''W), MG, BR and 3 vegetation conditions: areas with presence of cratilia, area of native forest Cerrado stricto sensu and area of bare soil). Soil samples were collected from 0 to 10cm from the surface in two locations (Experimental Fields of UFSJ-CSL and Experimental Fields of EPAMIG. The soil of the experimental regions is classified as Dystrophic Red Latosol (Embrapa 2013). For each location and vegetation condition, three replications were performed randomly. The determination of acid phosphatase activity was performed according to the method recommended by Alef et al. (1995). The method is based on the analysis of the concentration of pnitrophenol resulting from the enzymatic hydrolysis of pnitrophenyl phosphate. Buffer pH 6.5 was added to 0.15g of soil for acid phosphatase analysis. All analyses were performed using the R statistical analysis software (R CORE TEAM, 2022). The data were evaluated when the assumptions of normality and homoscedasticity were met by the test de Shapiro-Wilk e Bartlett respectively. Comparisons between the means for enzymatic activity based on the "acidic" method were performed using Tukey's test ($p<0.05$).

Results

In general, the EPAMIG site has higher values of acid phosphatase levels compared to the UFSJ site, regardless of the area collected (bare soil, native cerrado or cratilia). This superiority is evident in bare soil. There was no significant difference between the sites for the native forest and cratilia areas (Table 1).

The presence of cratilia, regardless of the location, always provides lower values of acid phosphatase, however, at UFSJ-CSL, cratilia and bare soil were like each other and inferior to the area of native forest.

Studies such as Govarthanan et al. (2018) and Adhikari and Pandey (2019), argue that the release of acid phosphatase is directly related to the production of organic acids, and consecutively to the reduction of pH, through the release of protons, and thus, being considered the main mechanism employed in the solubilization of phosphorus in the soil. . Furthermore, this manifests the nutritional condition of the plant in the soil, because as phosphorus deficiency increases, its activity increases (Ascencio, 1994).

Conclusion

The evaluation site influenced the phosphatase values, so that the EPAMIG site provides higher acid phosphatase values. The presence of cratilia provides lower acid phosphatase values when compared to the forest and bare soil.

Different values in acid phosphatase activity suggest that phosphorus mobilization by plants will have a different behavior through the action of these enzymes in the different areas evaluated. Analyses of the P content in the different plants of the system, as well as the relationship with the microbial activity of the soil in phosphate uptake will elucidate the role of Cratylia argentea in agroforestry systems.

Keywords

Socioeconomic status, sustainable agriculture, crop-livestock-forestry systems, legumes, bioma cerrado Brasil, shrub legume, fodder trees

Aditional Attachment II.

Table 1. Average acid phosphatase activity in 2 locations (UFSJ-CSL and EPAMIG) and 3 vegetation conditions (areas with presence of cratília, Cerrado stricto sensu native forest area and bare soil area)

Local	Vegetation Conditions			Average	p- valor		
	SC	MNC	CRA		*L	*C	*LxC
	μg *p*-nitrofenol $g^{-1}solo^{-1}$				0,011	0,007	0,004
EPAMIG	1315,99 aA	949,99 aAB	595,91 aB	953,97 a			
UFSJ	529,15 bB	980,99 aA	573,27 aB	694,47 b			
Average	922,57 A	965,49A	584,69 B				

Averages followed by distinct lowercase letters compare vegetation condition within the site and uppercase letters compare vegetation condition by orthogonal contrasts $p<0.05$

p-value – probability values; *L Local; C Vegetation Condition; LxC Interaction

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Evaluation of different agroforestry systems as measure for soil conservation against water erosion

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The aim of our work is to evaluate efficiency of silvoarable agroforestry systems (AFS) for reduction of water erosion in agricultural land conditions of the Czech Republic, which are characteristic with hilly terrains and large fields with cereals, rape seed, but also corn and root crops (potatoes, sugar beet). More than half of the agriculture land in the Czech Republic is evaluated as endangered by water erosion and this risk is expected to grow as predicted impacts of climate change include among others an increase of torrential rains.

For our experiments, we have used combined AFS with different parameters of the tree component established on field with slope declination 7-12% at research station Michovky in 2020-2022. Soil type is brown soil with high proportion of loess. AFS consists of one coppiced tree belt (CTB, 6.5 m wide) with triple-row of fast-growing trees (poplars Max-4, 'Kaktu', willow 'Rokyta'; 2x2x0.5 m) and two single rows with maple, wild cherry, chestnut and wild service tree (1.7 m wide, trees planted in 2 m distance) all planted along contour lines of the slope. Total area of agroforestry system is 1 ha (12% tree lines and belts and 88% conventional crops) and distances between tree lines and belts are 26 m. In 2021-2023, we have conducted 4 simulated erosion experiments with two types of devices: i) field rainfall simulator and ii) overflow simulator of concentrated runoff.

The principle of simulated rain experiment was based on water sprinkle on an area of 10.5 m2 of AFS from which surface runoff flowed away together with soil particles. Each experiment consisted of two simulated rains which lasted 30 minutes with 15 min break between them. Rain had intensity 1.2 mm/min (total rainfall 390 l/30 minutes; 72 mm/m2).

The simulated surface runoff experiment used a slurry pump with a reported maximum output of 680 l/min (reduced by pipelines to 625 l/min, a flow rate 10.42 l/s) which pumped water into the Prashall flume to simulate overflow irrigation which would create gully erosion. The distance of the Prashall flume from the agroforestry tree strips resp. CTB was always 10 m. The duration of the testing was set at 16 minutes. The fallow land was used as a control experiment in both types of experiments.

In experiments with simulated rains, no surface runoff was observed in coppiced tree belt while in the fallow land surface runoff and soil loss were 496 l and 6.95 t/ha in June and 41 l and 0.58 t/ha in October. In the experiment where the overflow simulator of concentrated runoff was used, the total surface runoff was 7.0 m3 for the control (fallow land), and only 2.4 m3 and 1.3 m3 in the case of agroforestry systems, depending on the width of the tree strip. In agroforestry systems, there was observed also a significant slowing of surface runoff and increased sedimentation of soil particles at the same time.

The experiments proved very good soil conservation efficiency of coppiced tree belts. We will continue with erosion experiments in different conditions in coming years

Keywords
water infiltration, water management, soil erosion control, sustainable soil & water management, Socioeconomic status

1.7 Pests, Diseases and Weeds Control

Oral presentations

Hall Q2, 31 May 2024, 9:15–10:00

Cover crops in almond orchard - supporting their services and avoiding competition by adjusting fertilization.

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Introduction

Conventional chemical control of weeds in almond orchards grown in the Mediterranean region can deteriorate soil quality over time. The practice of cover crop (CC) intercropping in orchards is viewed as a cost-effective and alternative method for promoting sustainability by improving soil fertility, effective weed suppression, and supporting the beneficial functions of soil organisms. Despite the perceived benefits, some literature reports yield reductions in orchards utilizing cover crops. Our initial findings indicate that incorporating CC in and out of the tree lines of almond orchards may result in a substantial (37% in 2021 and 45% in 2022) reduction in yields.

Objectives

This work aimed to enhance the positive services of CC intercropping in almond tree lines by increasing the annual fertilizer load and compensating for their potential disservices.

Methodology

This study was carried out at the Model Farms of the Neve Yaar research station in the Yizre'el Valley, Israel. A self-fertilized almond "Matan" cv was planted in January 2019. We used a two-factor factorial design, including twenty individual plots (eight trees each), with five replicates per treatment. Ryegrass CC was planted on the tree line, while the non-cover crop (NCC) line was treated with herbicide. The second factor we investigated was fertilization levels. We used two distinct levels of fertilization: the common best practice rate (F1, 100%) and 20% more than the common best practice rate (F2, 120%). Our experiment consisted of four distinct treatment groups, each with a unique combination of CC presence and fertilization level (CC + F1, CC + F2, NCC + F1, and NCC + F2). The soil at the site is classified as clay grumusol (Vertisols), pH 7.5-8.3, EC 0.39-0.99 ds/m, soil organic carbon 0.58-1.08%, total nitrogen 200-500 mg/kg, K 245-519 mg/kg, and P-PO4 15.6-56.3 mg/kg. We used ammonium sulfate nitrate (12%) and Sarit liquid fertilizer with NPK and micronutrients. The soil was sampled prior to the initiation of the fertigation season (March) and at its end (November). Monthly stem water potential measurements were recorded from April to September. April and July leaf samples were analyzed for total nitrogen content (TN). Yield was analyzed from 20 individual trees (5 per treatment) and from each plot.

Results

The results revealed that cover crops increased nitrate, mineral nitrogen, total organic carbon, total nitrogen, and organic matter levels compared to plots without cover crops at 20cm soil depth. Fertilization rates did not significantly impact nitrogen, organic carbon, and organic matter levels at a depth of 20 cm in the cover crop plot. Notably, the interaction of cover crops and fertilization rates significantly increased soil nutrient levels in CCF2 compared to no cover crop plots, suggesting potential nutrient provision to cover crops, thus reducing competition. While NCCF1 had low nitrate, mineral nitrogen, total organic carbon, total nitrogen, and organic matter levels, no significant variations were found in pH, EC, C/N, or K at any soil depth. Almond leaf nutrient analysis indicated no statistical difference in leaf N content between April and July, though content decreased in July compared to the April sample in all treatment. Leaf water potential measurements showed no significant differences among treatments from April to August, but in September, the stem water potential was lower in the CCF2 treatment. While cover crops had no negative impact on almond leaf status, they aided in retaining soil water and preventing evaporation, resulting in a lower soil water potential than NCCF1 and NCCF2. We observed significant yield variations among different groups ($p<0.0068$). NCCF2 had a higher yield, while CCF1 had a lower kernel yield. Interestingly, there was no statistical difference between CCF2 and NCCF1. Despite applying new fertigation, the yield remained lower in CCF2 compared to NCCF2, although CCF2 had a relatively higher yield than CCF1. The adjustments made to fertigation during the 2023 growing season may not have impacted that season's yield. Almond trees rely on stored nutrients from the previous year (2022) to support their growth and fruit production. Therefore, the yield in 2023 may have been influenced by the nutrients stored from the previous year.

Conclusion

Based on observations, there was no competition for water, but there appears to be nutrient competition in CCF1 between the cover crop and almond trees, potentially leading to a decrease in yield. However, it's crucial to note that these conclusions are based on one season, and it cannot be conclusively stated that adjusting fertigation levels has no impact on almond yield, as improvement was observed in CCF2. Furthermore, we conclude that any impact from the new fertigation in the 2023 growing season may manifest in vegetative growth rather than yield, with the effects potentially visible in the next growing season.

Keywords

tree-crop competition, compensation, leaf water potential, agricultural revenue diversification, fertilization, almond, intercropping

Aditional Attachment I.

Treatment	Depth (cm)	NO3-N mg-Kg	NH4-N mg-Kg	NO2-N mg-Kg	Min N mg-Kg	TOC %	TN mg-Kg	C/N	OM %	pH (1:2)	EC dS/m	K mg-Kg
CCF1	0-20	70.36a	14.55a	1.84	86.75a	1.32a	798a	17.36	2.27a	7.75	0.64	815
CCF2		64.86a	15.47a	1.86	82.18a	1.39a	758a	18.53	2.40a	7.69	0.65	723
NCCF1		43.83c	14.84a	2.04	60.71c	1.01b	480b	21.23	1.74b	7.80	0.47	739
NCCF2		52.39b	14.63a	2.16	69.17b	1.18ab	630ab	19.09	2.03ab	7.70	0.49	978
CCF1	20-40	68.63b	18.44a	1.79	88.85a	1.24	688a	19.07	2.13a	7.74	0.87	877
CCF2		79.21a	14.21b	1.9	95.32a	1.20	590a	20.93	2.06a	7.64	1.00	861
NCCF1		59.24c	14.27b	1.95	75.47b	0.93	416a	23.11	1.61a	7.74	0.85	846
NCCF2		76.25a	18.32a	2.31	96.87a	1.09	534a	20.48	1.88a	7.71	0.89	976
CCF1	40-60	76.36a	19.17a	2.32	97.85a	0.93	414a	22.76	1.61a	7.79	0.90	773
CCF2		83.17a	16.50ab	2.37	102.04a	0.99	420a	24.14	1.70a	7.75	0.96	802
NCCF1		54.51b	14.30b	2.05	70.85b	0.85	336a	26.06	1.46a	7.78	0.72	706
NCCF2		81.44a	13.45c	1.95	96.84a	0.96	430a	22.36	1.65a	7.63	0.86	826
				ns				ns		ns	ns	ns

Table 1. Soil chemical results at the end of growing season (November 2023) (similar letters indicates no statistical difference between the groups, p=0.05, ns indicates no significance level of p = 0.05 between the groups in all depths.). CCF1, cover crop with 100% farmer recommended fertigation rate, CCF2, cover crop with 20% more than the farmer-recommended, NCCF1 no cover crop with 100% farmer recommended fertigation, NCCF2, no cover crop with 20% more than the farmer-recommended.

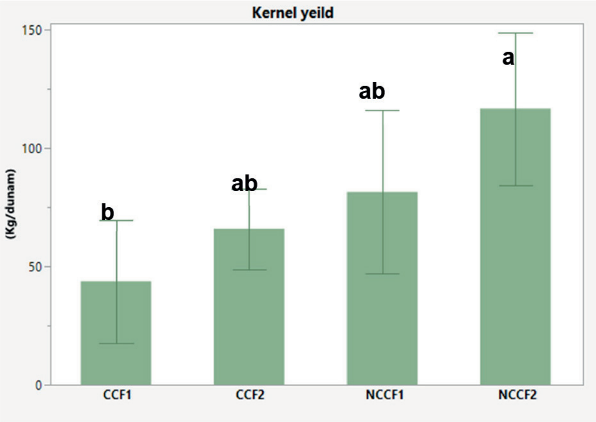

Figure. 1. Almond kernel yield 2023, (the bar with similar letters indicates no statistical difference, p=0.05). CCF1, cover crop with 100% farmer recommended fertigation rate, CCF2, cover crop with 20% more than the farmer-recommended, NCCF1 no cover crop with 100% farmer recommended fertigation, NCCF2, no cover crop with 20% more than the farmer-recommended.

Aditional Attachment II.

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What factors affect the incidence of coffee leaf rust in agroforestry plantations in Peru?

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Introduction

Coffee leaf rust (CLR), caused by Hemileia vastarix, is one of the most serious diseases of coffee plantations and causes great losses in coffee production (Kushalappa 1989; Prakash et al. 2004; Wintgen 2004). Coffee is traditionally grown under the shade of trees, forming a typical agroforestry system. The influence of the tree shade on CLR is the subject of controversy (Avelino and Rivas 2013). The increase in CLR incidence with increasing shade (Monterroso 1999) was one of the reasons for shade elimination in numerous plantations in South and Central American and Caribbean countries in the 1990s. We aimed to examine the effect of shade, coffee variety, age of coffee shrubs, and coffee plant density on CLR infection.

Methodology

This study was conducted in the Villa Rica (10°44’ S; 75°16 W) district, Pasco region, Peru, which is located in the foothills of the Peruvian Andes in the tropical humid mountain forest zone. The majority of coffee plantations in the district are using agroforestry (Greenberg et al. 1999). CLR is a serious problem in this region: in December 2013, about 33% of coffee shrubs were infected with it (JNC 2014). We established a total of 75 plots in three agroforestry coffee plantations and we gathered data there in 2011 (dry season) on the presence/absence of CLR, coffee variety, age, density of coffee plants, and canopy openness. In 2014 (wet season), we again gathered data on the same variables. Hemispherical photographs to assess canopy openness were taken looking upwards from the centre of each coffee measurement plot, above the coffee plant at the height of 1.6 m (using a Canon EOS 550D camera with Sigma 4.5mm f/2.8 EX DC lens) at the same time that data about CLR were collected. Photographs were then classified using the IsoData method in ImageJ vers. 1.48v. Finally, two canopy openness values were calculated from each photograph, both employing CIMES vers. 9 (Gonsamo et al. 2011). The first, with a 10° zenith angle, was calculated to assess the openness directly above the coffee plant, while the second, with a 75° zenith angle, was intended to characterize the overall situation (Fig. 1)

Results

At all plantations, coffee variety had a significant effect on CLR incidence, with the Catimor variety infected less frequently than Caturra. Coffee plant age had a significant positive effect on CLR incidence. With increasing age, CLR incidence increased for both studied varieties. In particular, we found that the critical age at which CLR infection increases substantially even for the resistant Catimor variety seems to be between 15 and 20 years. Increasing coffee density also increased CLR incidence for some of the studied plantations/seasons. Comparing those plots from which data were collected in the dry and wet seasons, we found that CLR presence was significantly higher in the wet season. The effect of shade on CLR incidence was not clear. Catimor and Caturra varieties showed opposite trends of CLR incidence in response to shade quantity in most cases (Caturra variety CLR incidence decreased with shading increase and Catimor CLR incidence decreased with decreasing shading). The results are displayed in Table 1.

Conclusion

Our general recommendation for coffee growers is to use resistant coffee varieties and to replace coffee plants when they become too old to be resistant to CLR infection. In the context of our study, it is important to mention that approximately 70 % of the coffee plantations in Peru are older than 20 years (JNC 2014) and hence the risk of CLR epidemic is large. On the other hand, conversion of agroforestry to monoculture plantations is not recommended to reduce the CLR presence, as the relationship between the amount of shade and the CLR presence remains unclear, moreover, such a transition would result in the loss of the various benefits provided by agroforestry.

Keywords
coffee, Tree Crops

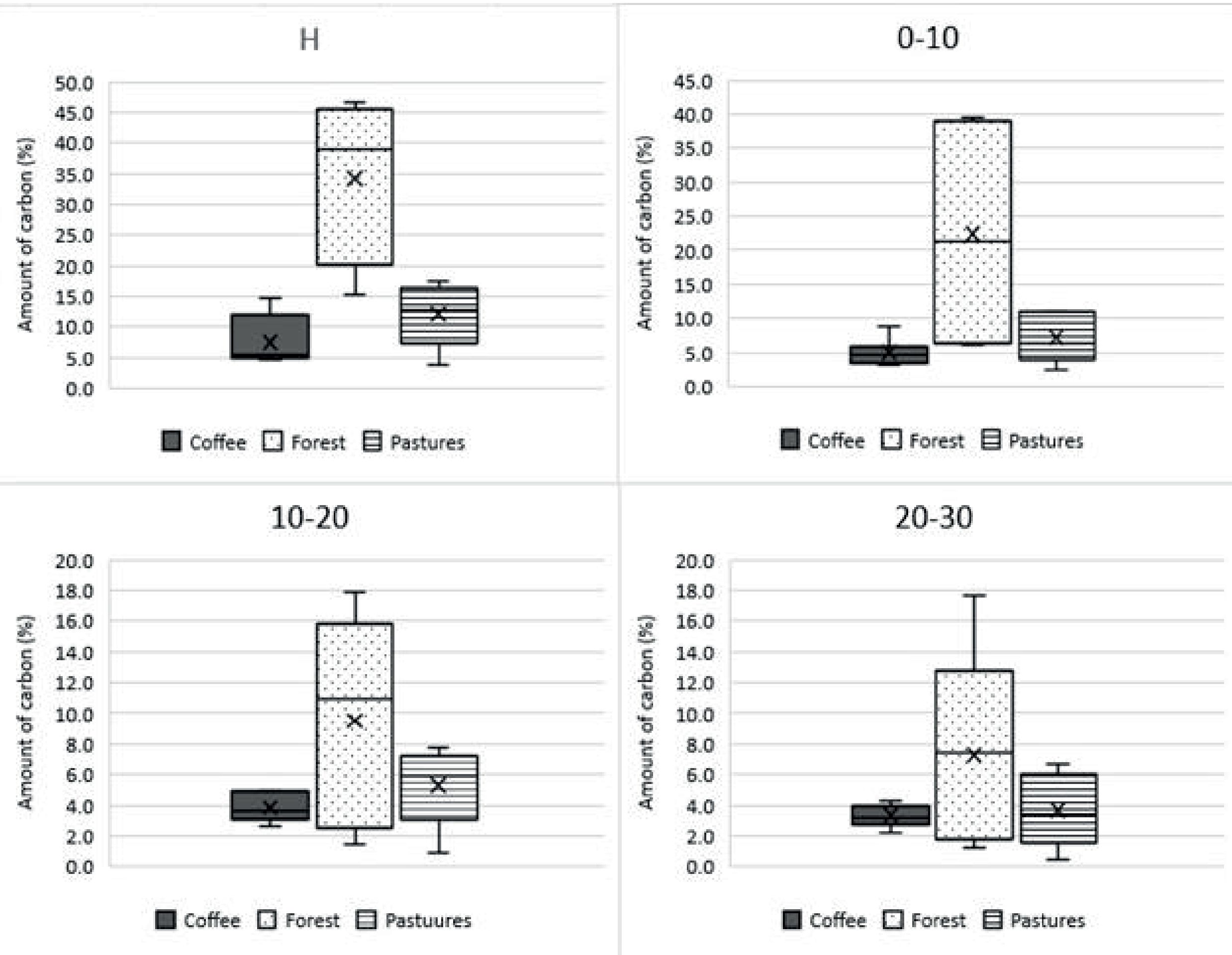
Figure 1. Location of the camera for the hemispherical photographs, showing marked zenith angles of 10° and 75°. The depiction of coffee plants (below the trees) also illustrates the systematic coffee pruning described in the text.

Table 1. Overview of the effects of studied variables on CLR incidence shown for traditional Caturra and resistant Catimor coffee varieties and for different plantations and seasons. Codes: '++' strong positive effect (i.e., CLR incidence increase); '+' positive effect; '.' non-significant effect; '(-)' negative effect (i.e., CLR incidence decrease); '--' strong negative effect. Plantations with very narrow gradient for the particular variable and variety are indicated by a grey background.

Aditional Attachment I.

Season	Plantation	Age		Openness10		Openness75		Density	
		Catimor	Caturra	Catimor	Caturra	Catimor	Caturra	Catimor	Caturra
2011	Ave Fenix	+	+	.	.	-	--	+	-
2014	Ave Fenix	-	+	-	+	.	+	.	.
2011	Santa Rosa	++	++	.	.	-	+	+	+
2014	Santa Rosa	++	.	+	-	.	.	(-)	+
2011	Carrillo	.	.	.	.	+	+	.	.
2014	La Tore	.	.	-	+	.	.	.	+

Aditional Attachment II.



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Biotic stress and yield stability in English organic silvoarable

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Introduction

In-field trees are thought to buffer arable crops from climate extremes through the creation of microclimates that may reduce the impacts of heat, wind, and cold (1). Much less is known about how trees and their biotic associations (e.g., with natural enemies of pests and wild understory plants) impact crop yield stability to biotic stresses such as crop pests and disease.

Methods

Modelling these interactions using conventional approaches is complex and time consuming and we take a simplified approach, representing the agroecosystem as a Boolean regulatory network (2) and parameterising Boolean functions using expert opinion. This allies our approach with decision analysis (3), which is increasingly finding applications in agriculture.

Results

Despite the naivety of our model, we demonstrate that it outputs complex and realistic agroecosystem dynamics. It predicts that, in English silvoarable, the biotic associations of in-field trees boost arable crop yield overall but they do not increase yield stability to biotic stress in the form of short perturbations of crop pests and disease. Sensitivity analysis shows that arable crop yield is very sensitive to disease and weeds and insensitive to natural enemies.

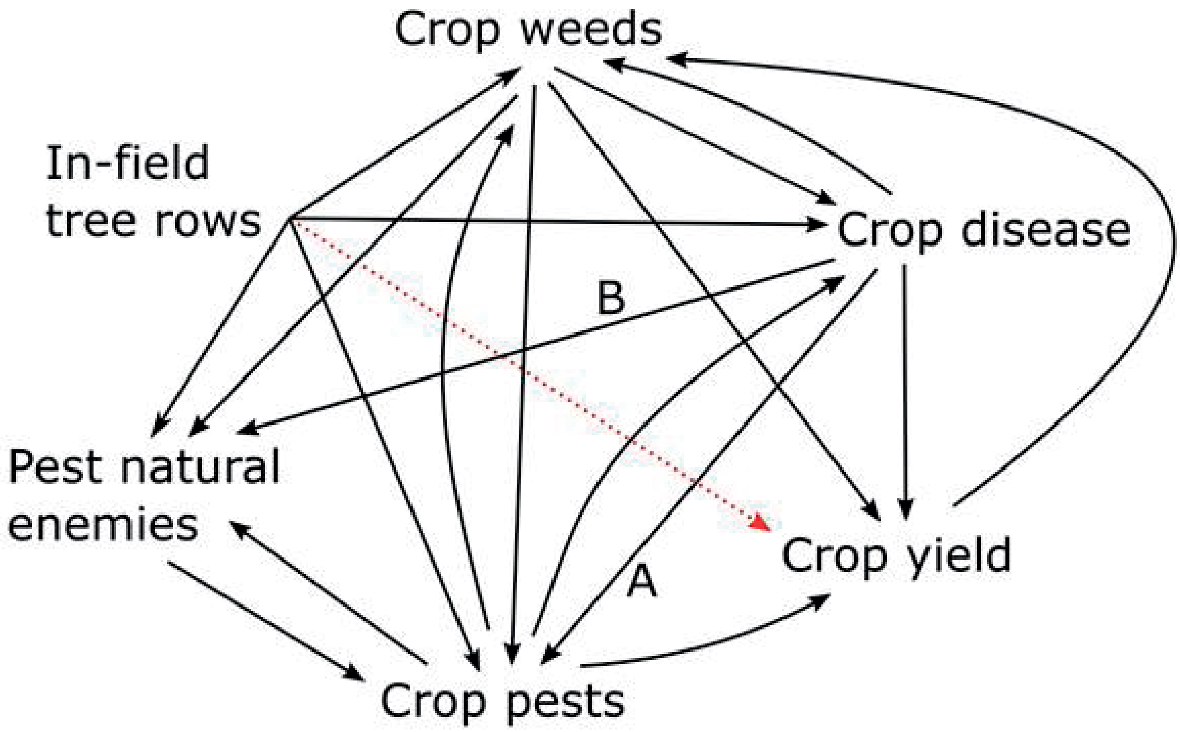
Discussion

We suggest that the focus of studies and debate on ecosystem service provision by English agroforestry needs to shift from natural enemies and pests to these ecosystem components. We discuss how our model can be improved through validation and parameterisation using real field data. Finally, we discuss how our approach can be used to rapidly model systems (agricultural or otherwise) than can be represented as dynamic interaction networks.

Keywords

Socioeconomic status, yield, natural pest control, Agroforestry, disturbance, agroecology, biodiversity, biotic interactions, modelling, resilience, pollination, ecosystem services, silvoarable

Aditional Attachment II.



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1.7 Pests, Diseases and Weeds Control

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Is market gardening agroforestry favorable to higher natural biocontrol ? A case study in France

François Warlop[1], Dr Maxime Jacquot[1], Boiron Lucie[1]

1 Grab, Avignon, France

Introduction

Agroforestry is now acknowledged as a relevant tool for agroecological transition. It can provide multiple services to soil, crop, biodiversity... Systems associating diversified vegetables and fruit trees (so-called market gardening systems) in France are increasingly interesting farmers. Fruit trees can provide multiple services, beside the productive one which is in many cases not the main one for farmers. In this study, we investigated if biological control on vegetable and fruits could be improved by associating both types of crops.

We formulated two hypotheses concerning these cultivated systems:

- The combination of fruit trees and vegetables under market gardening provides better predation service than when these crops are grown independently;
- In such market gardening systems, there are differences in the predation services provided for both fruit and vegetables crops.

Material & method

We worked on 9 farms and 3 kinds of plots (vegetable/orchard/agroforestry) with 4 categories : Vegetables (V), Fruit Tree (T), Fruit Tree in Agroforestry (AT), Vegetables in Agroforestry (AV).

From 2019 to 2022, we measured predation rates and diversity in these plots by using sentinel preys (lure caterpillars and predation cards with Ephestia eggs) between april and july (4 to 5 sessions per year).

Predation cards (with Ephestia eggs) and plasticine caterpillars were exposed respectively 2 and 7 days per session. Sentinel preys were placed in at least 5 locations per type of « systems » and plot, and 3 repetitions were placed per location.

After exposition, predation rate was measured on cards and plasticin caterpillars. In addition, we distinguished the predators leaving traces on caterpillars (arthropods, birds, mammals or unidentified ones). Several indicators are calculated for predation : (i) Intensity and frequency of predation on sentinel eggs, and ; (ii) diversity, frequency and richness of predation on plasticine caterpillars.

The statistical analysis of the differences between types of system was carried out separately for each indicator using linear mixed models taking into account the year and the farm. The analyses were carried out using R v 4.2.2.

Results

See tables in annex for detail of results and statistical data.

For plasticine caterpillars, the analysis over the 4 years (Table 1, see annex) shows that :

(i) Predation frequency did not differ between the 4 types of system ;
(ii) Predation intensity by birds is higher in AT than in V and AV ;
(iii) Predation intensity by arthropods is higher in AT than in AV ;
(iv) Predation richness is also higher une AT than in AV.

For sentinel eggs, overall analysis (Table 1) shows that :

(i) Predation frequency is lower in T than in AV ;
(ii) Predation intensity is lower in T and AT than in AV ;

Pluriannual statistical analysis show that market garden orchards do not provide higher predation service than untreated monocultures in our study (no significant differences were found between : T and AT, V and AV).

Analyses done year by year for predation intensity of sentinel eggs (Table 2) show some evidence of a benefit of agroforestry (AV > V in 2020, AT > T in 2022), better than overall analysis.

Additional analyses are necessary because the results may vary from one year/session to another.

Discussion

Concerning our hypothesis on differences in predation in market garden, our results show that predation services on plasticine caterpillars are more important in fruit trees than in vegetable crops. Conversely, predation services on Ephestia eggs are more important in vegetable crops than in fruit trees. As highlighted by the high R-squared (0,29) of the statistical model on predation intensity of caterpillars by birds, it seems that birds play an important role in the predation on fruit trees, perhaps underestimated in orchards but underlined here by the association with an annual crop.

Furthermore, this partial conclusion should be hampered with a methodological consideration : orchards and vegetables plots considered as control systems in our study are also very extensive, untreated and diversified systems, therefore also very much favorable to natural predation.

Keywords

agroecology, Agroforestry, temperate agroforestry, fruit trees, organic production, biodiversity

Aditional Attachment I.

Annexe

EURAF

How about biological control in market gardening agroforestry ?

Sentinel Preys	Indicator of predation	Fruit trees				Agrof trees				Vegetables				Agrof vegetables				AIC	R^2 model (R^2 types of system)
		mean	±	se	group	mean	±	se	group	mean	±	se	group	mean	±	se	group		
Caterpillars																			
	Frequency	6,07	±	1,65	a	9,22	±	1,61	a	8,17	±	1,68	a	9	±	1,61	a	967	0,43 (0,04)
	Intensity by birds	4,64	±	0,61	ab	3,51	±	0,59	a	6,4	±	0,75	b	5,33	±	0,6	b	1929	0,71 (0,29)
	Intensity by arthropods	3,62	±	0,83	ab	2,61	±	0,83	a	2,86		0,86	ab	2,83	±	0,83	b	6887	0,97 (0,03)
	Richness	0,91	±	0,38	ab	1,24	±	0,39	a	0,83	±	0,39	ab	0,87	±	0,38	b	916	0,39 (0,02)
Eggs																			
	Frequency	0,81	±	0,18	b	0,55	±	0,17	ab	0,52	±	0,17	ab	0,39	±	0,15	a	2047	0,19 (0,02)
	intensity	2,18	±	0,46	b	1,83	±	0,45	b	2,05	±	0,46	ab	1,66	±	0,45	a	2592	0,95 (0,03)

Table 1: Summary of linear mixed models for the predation service indicators monitored in the 4 types of system between 2019 and 2022. Each line corresponds to the results of one model, with predicted marginal means, standard error and statistical group for each type of system. The Akaike information criterion (AIC) is an estimator of prediction error and thereby relative quality of statistical models for a given set of data. R^2 model is the proportion of variance explains by the entire model (taking into account types of system, years and farms) and R^2 types of system is the proportion of variance explains by types of system only.

Year	Fruit trees				Agrof trees				Vegetables				Agrof vegetables				AIC	R^2 model (R^2 types of system)
	mean	±	se	group	mean	±	se	group	mean	±	se	group	mean	±	se	group		
2019	3,52	±	0,49	a	2,91	±	0,47	a	4,04	±	0,65	a	3,13	±	0,47	a	632	0,86 (0,11)
2020	1,08	±	0,14	ab	0,99	±	0,11	a	1,53	±	0,14	b	0,87	±	0,66	a	545	0,68 (0,40)
2021	1,73	±	0,42	ab	1,8	±	0,4	b	1,61		0,42	ab	1,37	±	0,4	a	655	0,94 (0,04)
2022	2,09	±	0,21	b	1,63	±	0,19	a	1,44	±	0,21	a	1,49	±	0,19	a	674	0,78 (0,21)

Table 2: Summary of yearly linear mixed models for predation intensity of sentinel eggs monitored in the 4 types of system. Each line corresponds to the results of one model, with predicted marginal means, standard error and statistical group for each type of system. The Akaike information criterion (AIC) is an estimator of prediction error and thereby relative quality of statistical models for a given set of data. R^2 model is the proportion of variance explains by the entire model (taking into account types of system, years and farms) and R^2 types of system is the proportion of variance explains by types of system only.

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Theme 2: Agroforestry Production – Quality, Safety and Sustainability

2.1 Silvoarable Systems – Crop Production

Oral presentations

Hall Q1, 28 May 2024, 16:30–18:00

Productivity and crop physiology of an olive - cereal agroforestry in the Mediterranean

Dr Sebastiano Corinzia[1], Antonella Iurato[1], Salvatore Cosentino[1], Giorgio Testa[1], Giuseppe Mancini[1]

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Introduction

Agroforestry is a viable alternative to conventional monocropping in the semi-arid Mediterranean environment due to the sustainable intensification of land and water use [1,2]. Winter cereals and olive are respectively among main herbaceous and tree crops in the Mediterranean environment.

Solar radiation is one of the limiting factors in both cereals and olive yield, therefore the optimization of solar radiation interception by the agroforestry systems comprising olive trees and winter cereals has a considerable importance to enhance the system efficiency [3–6].

Objectives / research questions

The study aims to evaluate the productivity and the solar radiation interception of an agroforestry systems comprising olive trees and herbaceous crops, namely durum wheat (Triticum durum), common wheat (Triticum aestivum) and rye (Secale cereale).

Methodology

The field trial was carried out during the 2022-2023 growing season in a 4-year-old olive grove with trees spaced 5.5 m between the rows and 5 m along the row located on a mountainous site (970m a.s.l.) in Sicily (Italy). The rows of trees are along the East-West axis.

The winter cereals used for the trial were a durum wheat (T. durum) landrace (Timilia) a common wheat (T. aestivum) evolutionary population (Mixwheat) and rye (S. cereale) variety (Irmanu).

The herbaceous crops were sown on a 4.5 m strip between two adjacent rows of tress and in an adjacent field as monocropping control. The sowing of the herbaceous crops took place in January 2023.

The amount of photosynthetically active radiation (PAR) intercepted by the trees and the crops has been measured using the ACCUPAR LP-80 PAR/LAI Ceptometer at two different heights above the ground (below the tree canopy and below the herbaceous crop canopy) in several positions between the rows of trees, described by two factors: position and strip.

The positions are

- on the North side of a tree (position Under) or
- on the North side of the inter-row gap (position Between).

The strips are

- the 1.5 m wide strip on the South side of the row of trees (Strip 1),
- the middle 1.5 m wide strip (Strip 2),
- the 1.5 m wide strip on the North side of the row of trees (Strip 3).

Grain yield has been measured for all the combination of position and strips.

Results

PAR interception by the trees was higher in the positions on the North side of a tree (position Under) and along the strips on the North side of the row of trees (Strip 3). The middle strip (Strip 2) was the least affected by the shadow of the trees. Rye reached the highest values of PAR interception in the middle strip, while it was highly affected by the shadows of the trees in the side strips (Strip 1 and 3). Timilia was the least affected by the shadow of the trees in all the positions.

Rye was the most productive winter cereal with a grain yield of 2.5 t ha-1 in monocropping and 1.7 t ha-1 in intercropping. Common wheat population Mixwheat had a mono and agroforestry production of 1.2 t ha-1 and 0.9 t ha-1 respectively. The lowest yield was achieved by durum wheat landrace Timilia with a production of 0.75 t ha-1 in monocropping and 0.6 t ha-1 in agroforestry.

The amount of PAR intercepted by the crop and the grain yield were positively correlated and the highest values of grain yield for each species were achieved in the position with the highest values of PAR interception.

Conclusion

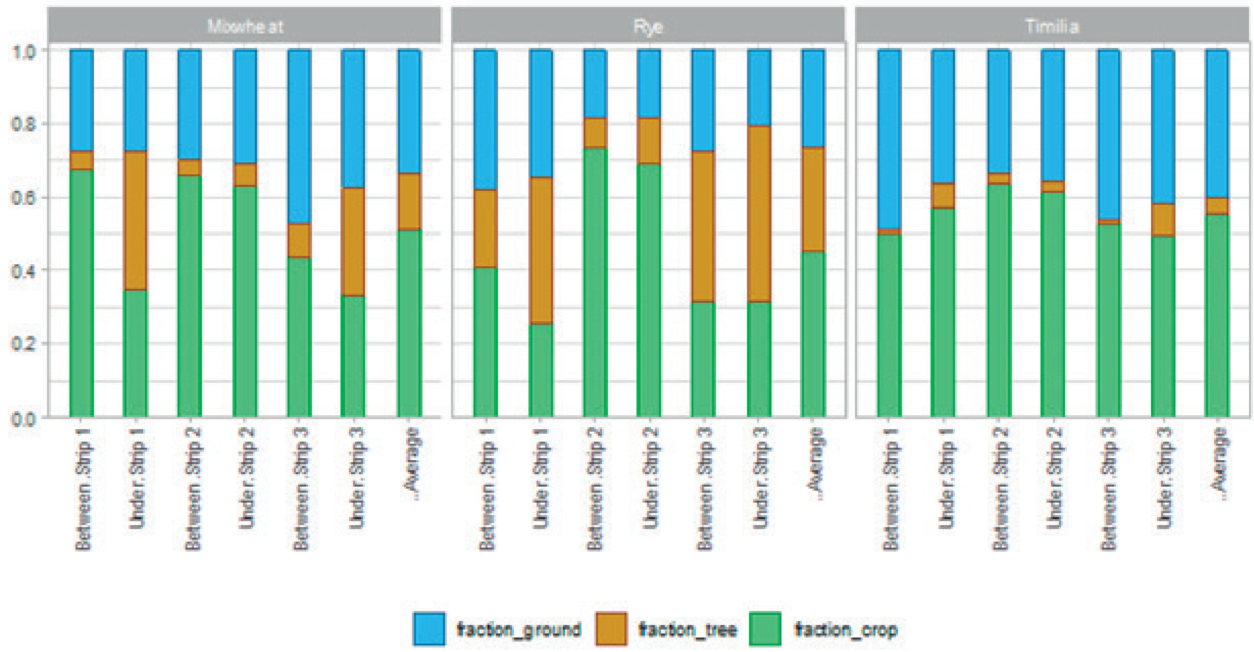
The herbaceous crops produced lower yield in the agroforestry system in comparison with the monocropping system. Rye achieved the highest yields been able to intercept the highest amount of PAR due to the high leaf area index. The yield of the herbaceous crops varied significantly according to the sampling site between the rows of trees.

Rye proved to be the most suited winter cereal for olive tree agroforestry in the condition of the experiment (Mediterranean mountainous environment).

Keywords

multifunctional olive systems, wheat varieties, wheat, Rye

Aditional Attachment II.



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How does a winter wheat composite cross population perform in temperate agroforestry? A Swiss case study

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Introduction

In agroforestry systems, where environmental conditions are highly variable at small spatial scales, the use of uniform genetic material of a single cultivar commonly grown in monoculture cropping might not be optimal. Breeding for maximum and/or stable yield in competitive, heterogeneous and low-input environments should ideally be undertaken under exactly such conditions. The dynamic gene pool of a composite cross population (CCP) provides the potential of adaption to locally heterogeneous environmental conditions as they are found in agroforestry (Smith, Pearce, and Wolfe 2012, Vollenweider et al. 2020). A CCP is obtained by the reciprocal inter-crossing of genotypes and mixing of the progeny and is a particularly plastic and adaptable culture (Knapp et al. 2020).

Objectives and research questions

In a one-year field experimentation at two temperate agroforestry sites in Switzerland, the potential of CCPs for improved yield (stability) and quality of wheat under agroforestry conditions in different spacing to tree rows was assessed. It was hypothesised that a wheat CCP will outperform a commercial cultivar in terms of yield and quality in particular in proximity to the tree row. Furthermore, it was assumed that quality traits (such as protein and mineral content) of CCP would be improved, especially near the tree.

Methodology

A common winter wheat variety ('Wiwa') and a winter wheat CCP ('CC-2k') were grown from autumn 2021 to summer 2022 at two organically managed agroforestry systems with standard fruit trees in Switzerland. CC-2k is a composite cross obtained as a cross of 20 wheat varieties and breeding lines from Switzerland and from Europe, its development started in 2000 at the Agroscope site in Changins (Nyon, Switzerland).

The experimental fields lay on the North side of plum and apple tree rows in Feusisberg (705 m a.s.l.) and Wollerau (620 m a.s.l), respectively, to include the effect of shade cast by the 4 to 6 m high trees. Wiwa and CC-2k were planted in two 1.8 x 9 m strips in a "split-plot" design with three replicates per site. Within each long plot, four observation and sampling plots of 1 m^2 were defined at 1.0, 2.4, 3.8 and 7.0 m distance from the tree-row border (Fig. 1).

Measurements included leaf chlorophyll content, stomatal conductance, plant height, total grain weight, grain mass, number of grains, thousand grain weight (TGW), protein and mineral contents.

Results

CC-2k outperformed Wiwa in terms of yield at one of the two sites, Wiwa outperformed CC-2k in terms of quality. Variety and the interactions of site and distance and site and population/variety significantly affected wheat yield ($p < 0.05$). Yield of CC-2k (1.9 ± 0.8 Mg ha^{-1}) was significantly higher than yield of Wiwa (1.4 ± 0.9 Mg ha^{-1}) across both sites and all distances. Mean CC-2k yield was identical for Feusisberg and Wollerau while mean Wiwa yield in Wollerau was only 35% of mean Wiwa yield in Feusisberg. The coefficient of variation was 40% for CC-2k and 64% for Wiwa across the two sites.

Yield was highest and lowest at 3.8 m in Feusisberg and Wollerau, respectively, and similar at 1.0, 2.4 and 7.0 m distance to the tree row. The interaction of population/variety and distance varied with CC-2k having higher yields in proximity to the tree row in Feusisberg but lower ones in Wollerau compared to the reference yield at 7.0 m distance.

TGW was significantly affected by distance ($p < 0.05$), differences between Wiwa and CC-2k were not significant. Distance influenced plant height significantly ($p < 0.001$), with plants being higher close to the tree. Protein content was significantly affected by population/variety ($p < 0.01$) and marginally significantly by site ($p = 0.06$). Protein content was significantly higher in Wiwa (12.7 ± 1.0%) than in CC-2k (11.1 ± 0.6%) and in Wollerau (12.2 ± 1.3%) than Feusisberg (11.5 ± 0.9%). Potassium, phosphorus, calcium, magnesium, iron and zinc content significantly depended on population/variety. Some nutrients showed effects by site, distance and interactions of site and population/variety, site and distance and distance and population/variety.

Chlorophyll content was significantly affected by month, site and distance. Volumetric soil moisture was significantly affected by month and the interaction of distance and population/variety.

Conclusion

CC-2k was more apt to grow well under the heterogeneous and low-input conditions at both agroforestry sites and outperformed the commercial organic variety Wiwa in terms of yield but not in terms of grain quality at one agroforestry site in this year. As variety-/population-specific yield was independent from the distance to the tree row, it may be concluded that shade-induced reductions in yield-related characteristics must not have been decisive or might have been outweighed by positive interactions or a beneficial microclimate in the agroforestry systems of this experiment.

Keywords

crop variety, Genetic resources, alley cropping, Organic Farming, understorey growth, adaptation, silvoarable agroforestry, Temperate

Aditional Attachment II.

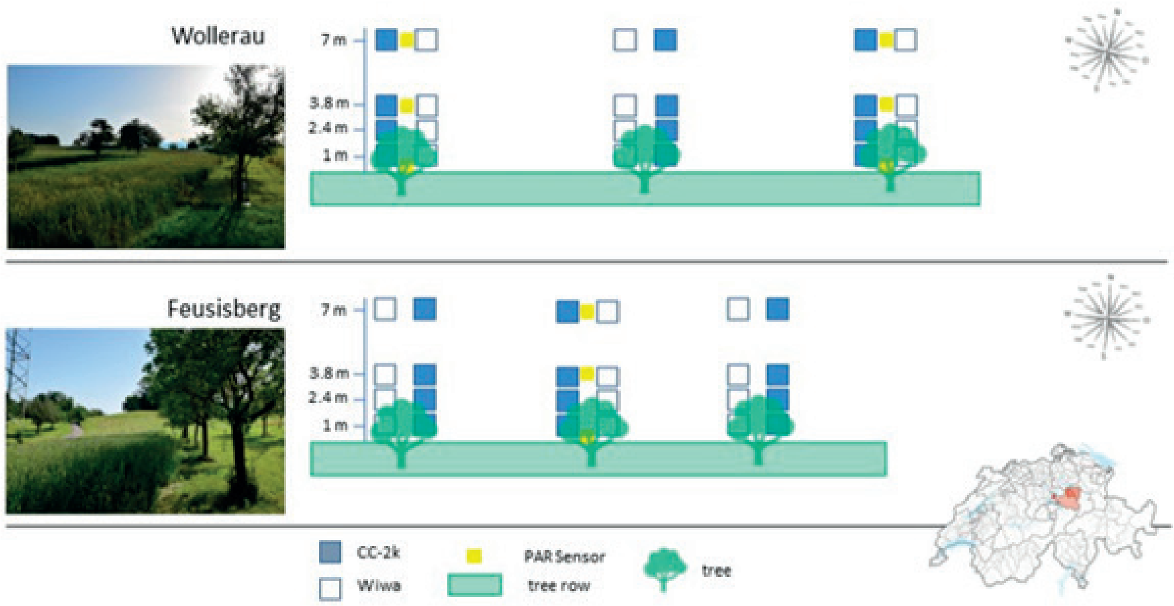

Fig. 1: Experimental design at two Swiss agroforestry systems in Feusisberg and Wollerau, respectively. Each replicate consisted of a strip ("long plot") with the composite cross population "CC-2k" and commercial variety "Wiwa". Physiological and yield parameters were collected from 1 m² plots at four distances (1.0, 2.4, 3.8 and 7.0 m) from the tree row.

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Large-scale silvoarable agroforestry experiment in the Netherlands: Experimental design, monitoring choices and first results

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Agroforestry, the combination of woody perennials with arable farming, vegetable cultivation or grassland, can offer multiple ecosystem services, while maintaining economic viability. It can play a major role in future proofing our farming systems and addressing societal issues. However, research on agroforestry in the Netherlands, especially in combination with Dutch cash crops like potato, onions and carrots, is lacking. Two long term agroforestry experiments were set up in 2021 on a sandy loam soil at the research facilities of Wageningen University & Research near Lelystad, NL. The focus is on testing the practical implementation and economic viability of an alley cropping agroforestry system in an open and windy Dutch landscape. In addition to the yields of the trees and arable crops, the effects on ecosystem services such as biodiversity, carbon sequestration, microclimate and buffering against extreme weather events are monitored. Because the trade-offs and choices made in the design of the facility may also be of interest to other researchers (starting a new Long Term Experiment), we want to share and explain the background, design and data collection of the facility. With this, we hope to increase the understanding and interest in this trial and also to contribute to well-thought-out designs of agroforestry systems elsewhere. The agroforestry facility is also available to external parties to carry out research. Suggestions and collaborations are welcome.

The most important starting point for the design of this generic agroforestry system is the relatively strong and ever-present wind in the Dutch polders. This challenge provides opportunities for silvoarable agroforestry; the trees can reduce the wind speed and thereby change the microclimate on the fields. Additionally, the increase in weather extremes such as (extreme) heat and drought is an important starting point for almost all Dutch regions. Therefore the design of the agroforestry experiment focuses on improving the microclimate for the annual crops. An alley cropping agroforestry system was chosen for these experiments since it fits the contemporary large-scale landscape and the current level of mechanization. The direction of the tree rows in both experiments is north-south, so that the light distribution on the crop is even on both sides, which is important for a homogeneous development of the arable crop.

With the main experiment, an alley cropping agroforestry system, with tree rows at various spacing, we can answer research questions concerning the effect of alley cropping on the cultivation, yield and quality of arable crops and on soil quality, climate adaptation, carbon sequestration, biodiversity, pest control and farm economics. We look at when, how and where these effects occur. We hypothesised a negative effect of the tree rows on the arable crops up to a distance of approximately 1.6 times the tree height and a positive effect between 1.6 and 9.5 times the tree height, with an average additional yield of 7% in this zone (Van Vooren et al., 2016). Distances between the tree rows (50 and 100m) and the points of measuring within the experiment are based on this. The tree rows consist out of a windbreak of fast growing native trees (interrow spacing of 1m) and a row of hazels (interrow spacing of 3m). As each year, different annual crops are grown within this experiment, this will give insight into the extent of the effect per crop type. Other criteria for the design of the experiment were scalability, realistic in terms of market and labour requirements, scientific set-up and international relevance. Both trees and annual crops are managed with realistic farm scale machinery. The experiment also had to be consistent with the design and cultural identity of the landscape. Organic management was chosen as it allows for a better mapping of the full effect of the system on biodiversity and natural disease and pest control.

In an additional experiment, various pruning strategies, tree shapes for hazels and a varying number of tree rows are further investigated to answer questions concerning their effects on labour requirements and hazel productivity. This will help to investigate how hazelnut cultivation can be practically incorporated into the arable farming system, so farmers can adopt this system more easily.

Already in the first years we saw increased levels of biodiversity near the tree rows. In the first 2 years after establishment, no clear positive nor negative effects on crop yields were found. In the 3rd year we saw the first indications of a positive effect of the tree rows on the productivity of the arable crop (faba bean and soy bean) due to changes in microclimate and reduced pest pressure. As the project continues and the trees develop further, more (scientific) results on the effect of this system will be obtained and can be shared.

Factsheet describing the experimental set-up: edepot.wur.nl/650895

Keywords
natural pest control, carbon sequestration, microclimate, alleys, hazelnut, windbreak, silvoarable, biodiversity, crop production

Aditional Attachment I.

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Factsheet describing the experimental set-up: edepot.wur.nl/650895

Insights into biomass belt effects on crop yields and comparative assessment of crop yields in agroforestry and conventional wheat production system in Denmark

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Introduction

Alley cropping is an agroforestry practice, where crops are grown in alleys between rows of trees or shrubs, which aims to optimize resource use, enhance productivity and promote agro-ecology

Objectives

The objective was to assess the combined effects of management and biomass belts on agronomic yields in alley-cropped winter wheat (CFE winter wheat) in agroforestry system compared to the conventional winter wheat with chemical and fertilizer inputs.

Methodology

A combined food and energy (CFE), production system i,e alley cropping system was established in 1995 with objective to develop carbon-neutral production of food, fodder and energy without any fertilizer or chemical inputs. The CFE system is managed as per organic principles without input of fertilizers and chemicals. The alley cropping system constitutes alleys where food and fodder crops are grown, bordered by the biomass belts consisting of 5 double rows of trees. The CFE winter wheat was sown in 200 m alley and the crop cuts were carried out in 2023 at distances (H) from the biomass belt. H is the ratio of ground distance from biomass belt (m)/height (m) of biomass belt. Biomass belt can have positive and negative effects on alley crops and to quantify the effects on CFE winter wheat, crop cuts were taken at H values (0.5, 1.0, 1.64, 3.6, 9.52 and 12.0) from the biomass belt. Crop cuts in 3 replications, were taken at 3.3 m, 6.6 m, 10.82 m, 23.76 m, 62.83 m and 79.20 m (Fig. 1) from biomass belts. The conventional winter wheat field was located nearby and fertilized with nitrogen, phosphorus, potassium, two applications of weedicides and insecticides and three applications of fungicides. Crop cuts were taken in 3 replications in 2023.

Results and discussions

The mean yields of grain, straw and aboveground biomass in CFE winter wheat and conventional winter wheat are provided in Table 1. Except grain yields, there were significant differences in straw ($P \leq 0.09$) and aboveground biomass yields ($P \leq 0.1$) between conventional winter wheat and CFE winter wheat (Table 1). CFE winter wheat grain yield was higher by 3.1% whereas straw and aboveground biomass yields were significantly higher by 21.9% and 39.7% respectively compared to conventional winter wheat. The study demonstrated that CFE winter wheat recorded higher grain, straw and aboveground biomass yields with no chemical or fertilizer inputs compared to conventional winter wheat with inputs of fertilizers and chemicals. Our findings on beneficial effects of agroforestry systems on alley crops are in congruence with other field studies (Van Vooren et al. 2016; Khan et al, 2023).

The mean yields of grain, straw and aboveground biomass at H = 0.5, 1.0, 1.64, 3.6, 9.52 and 12.0 in CFE winter wheat and mean yields of conventional winter wheat are provided in Table 2. CFE winter wheat grain, straw and aboveground biomass yields were significantly different between H=0.5 and H= 9.52 with lowest at H=0.5 and highest at H=9.52. The negative effects on grain, straw and aboveground biomass harvest were recorded only at the nearest sampling point to the biomass belt (H = 0.5) in CFE winter wheat with relative grain yields of 76.5% compared to the conventional winter wheat (Table 2). The grain, straw and above ground biomass yields increased steadily in CFE winter wheat as the distance from the biomass belt increased at H = 1.0, 1.64, 3.60, 9.52 with relative grain yields at 107%, 101%, 111% and 122% respectively compared to the conventional winter wheat. The same trend was recorded for straw and aboveground biomass yields. However, at H= 12, the relative grain yield was 99.8% in CFE winter wheat compared to conventional winter wheat indicating that the biomass effects were non-existent or negligible at H= 12 (79.2m). The data provided evidence of negative and positive effects of biomass belts on annual crops grown in the alleys depending on the H values and such benefits are reported in several studies (Jose et al. 2004, Borin et al. 2010 and Van Vooren et al. 2016).

Conclusions

The study demonstrated that CFE winter wheat yielded higher grain, straw and aboveground biomass yield compared to the conventional winter wheat with chemical and fertilizer inputs, providing evidence that agroforestry systems support higher yields. The biomass belts had negative effects on grain, straw and aboveground biomass yields at the nearest fields from the biomass belts and yields equaled or increased in the fields further away from the biomass yields with maximum yields at 62.83 m away from biomass belt. These findings provided robust field evidence on agroforestry effects on alley crops as a basis for investigating the agroforestry benefits under different pedo-climatic, social and economic contexts.

Acknowledgement

We are grateful for the financial support provided by the REFOREST project funded by the European Union's Horizon Europe research and innovation programme under grant agreement number [101060635].

Keywords

food, energy crop, willow, organic production, carbon farming, hedgerows, Europe, silvoarable, wheat, alley cropping, Cereal Crop, grass clover, biomass, climate resilience, crop production, wood biomass, Denmark, above ground biomass, tree-crop competition, windbreaks, agroecology, Agroforestry, forage

Aditional Attachment II.

Table 1: Grain, straw and aboveground biomass yields in CFE winter wheat in combined food and energy (CFE) system and conventional winter wheat

Production systems	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	Aboveground biomass ($kg\ ha^{-1}$)
CFE winter wheat	5037 ± 55^{a}	5698 ± 34^{a}	10735 ± 58^{a}
Conventional winter wheat	4885 ± 331^{a}	4673 ± 411^{b}	7681 ± 377^{b}

Values are mean ± standard error (SE); superscript alphabets indicate significant differences at $p \leq 0.1$.

Table 2: Grain, straw and aboveground biomass yields at H= 0.5, 1.0, 1.64, 3.6, 9.52 and 12.0 in CFE winter wheat in combined food and energy (CFE) system in Denmark

Parameters	H1 = 0.5 (3.30 m)	H2 = 1.0 (6.60 m)	H3 = 1.64 (10.82 m)	H4 = 3.60 (23.76 m)	H5 = 9.52 (62.83 m)	H6 = 12.0 (79.20 m)
Grain yield ($kg\ ha^{-1}$)	3740 ± 169^{b}	5235 ± 237^{ab}	4971 ± 209^{ab}	5444 ± 503^{ab}	5960 ± 430^{a}	4875 ± 414^{ab}
Straw yield ($kg\ ha^{-1}$)	4705 ± 114^{b}	5472 ± 374^{ab}	5536 ± 248^{ab}	5644 ± 438^{ab}	6981 ± 208^{a}	5849 ± 392^{ab}
Aboveground biomass ($kg\ ha^{-1}$)	8445 ± 312^{b}	10707 ± 583^{ab}	10507 ± 457^{ab}	11088 ± 923^{ab}	12942 ± 291^{a}	10724 ± 336^{ab}

Values are mean ± standard error (SE); superscript alphabets indicate significant differences at $p<0.1$. H1, H2, H3, H4, H5 and H6 represents the sampling points from biomass belt.

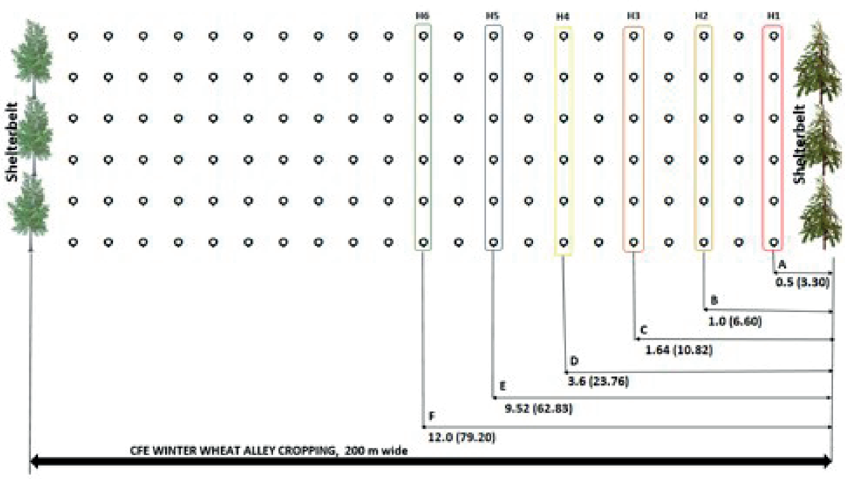

Fig 1: Schematic layout of crop cut samplings in alley-cropped CFE winter wheat at different H values (0.5, 1.0, 1.64, 3.6, 9.52 and 12.0) from biomass belt in the combined food and energy system

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Screening hard varieties of common wheat for their implementation in efficient alley-cropping systems with poplar

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Introduction

Crop yield reduction in the neighbouring of trees remains one of the main obstacles to large scale adoption of silvoarable agroforestry in Europe. In North-Western Europe, solar radiation is likely to be the most limiting resource for understorey crops, with grain yield worsening as shade increases [3 4 6]. On the contrary, in Southern Europe there is evidence that water is likely the main limiting factor, and crop yield can be either improved, when adequate rainfall occurs and/or tree-crop root competition is low, either reduced, when water is limiting [1 5]. The implementation of high-productive alley-cropping systems can be achieved through a deeper knowledge on the multiple tree-crop interactions that affect growth and yield of herbaceous plants, with particular attention to variety choice. Up to date the genetic variability within field crops has been poorly explored for these pourposes, and mainly in pot trials with artificial shading [2 3].

Objectives

This study aimed at investigating (i) the impact of an alley-cropping system with poplar trees on the microclimate, and (ii) the growth and yield response of five hard common wheat varieties at different distances of the tree row, at both east and west sides.

Methodology

The trial was carried out during 2022-23 at the “Sasse Rami” pilot farm of Veneto Agricoltura, at Ceregnano (Rovigo, NE Italy). Wheat was sown in the inter-row of an alley-cropping system with N-S oriented, 40-m apart rows of 5-year old poplar trees planted along drainage ditches (Figure 1). At the beginning of the trail, trees were 15 m high, with 23.4 cm of trunk diameter at breast height. Five hard common wheat (Triticum aestivum L.) varieties were cultivated, i.e., ACA 360, Aurelius, Criterium, Garbino, and Rebelde.

Wheat was sown on 21 November 2022 at a rate of 230 kg ha-1 of seeds, 15 cm apart rows. Wheat plots where 40-m wide (E-W) and 38-m long (N-S), with 1,520 m^2 per variety. For each variety, 1-m^2 area of wheat was sampled along three transects (n=3) orthogonal to the poplar rows, at distances from trees of +3m, +6m and +12m, both at east and west sides of the tree rows, and in the centre of the alley (C, +20m, Controls). Microclimatic sensors were placed at +6m and +12m, and C. Photosynthetic active radiation (PAR) at 1-m height and soil volumetric water content at 0-30 cm soil depth were measured from April 2023 until harvest.

Leaf chlorophyll content (SPAD-502, Minolta), NDVI (Greenseaker), and aboveground biomass were measured at flowering. At harvest (30 June 2023), plants sampled on a 1-m^2 area for each replicate × variety × distance were threshed to determine grain yield, and quality (NIRS technology). Statistical significant differences were detected by R studio software (Tukey’s HSD test, $P \leq 0.05$).

Results

From April to June, PAR daily mean was reduced by 8% and 4% at +6m and +12m respectively, as compared to C. Despite abundant seasonal rainfall (702 mm vs. 496 mm of the 10-year historical mean), volumetric soil water content was reduced by 8% and 2% vs. C, respectively at +6m and +12m at the east side of poplars, and by 17% and 10% at +6m and +12m at the west side.

From the beginning of May (flowering) until half June, a higher leaf greenness (NDVI) and chlorophyll content (SPAD) vs. C were measured in the interaction zone with poplars, significantly at +6m and +12m. At flowering, aboveground dry biomass showed similar values as C on the west side, whereas an increment of +23% at +6m and +12m East, and the lowest value (-21% vs. C, $p \leq 0.05$) at +3m East. The leaf-to-culm DW ratio was increased by 17-23% vs. C ($p \leq 0.05$), except for +3m East.

Grain yield was slightly improved, except for +3m East, with the major increments at +6m and +12m on the east side (+11% vs. C, $p \leq 0.05$). As regards varieties, the largest yield increases in the interaction zone with trees were observed in Aurelius and Criterium, with respectively +13% and +17% vs. C (Figure 2). In particular, Criterium showed yield improvements between +9% and +27%, significantly at +12m East.

Protein and gluten content of grains were increased in all the sampling positions in the neighbouring of poplars, except for +3m East, i.e. ~+8% vs. C.

Conclusion

In a silvoarable system with widely-spaced and N-S oriented poplar rows with trees at half commercial life span, PAR reduction for a winter crop such as common wheat seems less relevant than water availability. There is reasonable scope in screening common wheat varieties for agroforestry within hard type that are increasingly requested by baking industries for high-leavened products. While ACA360 and Rebelde showed yield reduction in the interaction zone with poplars, Aurelius and especially Criterium revealed to be suitable to agroforestry, with equal or higher yield and improved quality.

Keywords

grain protein, crop production, leaf senescence, silvoarable agroforestry, shade

Aditional Attachment I.

Figure 1. View of the alley-cropping system at wheat maturity.

Aditional Attachment II.

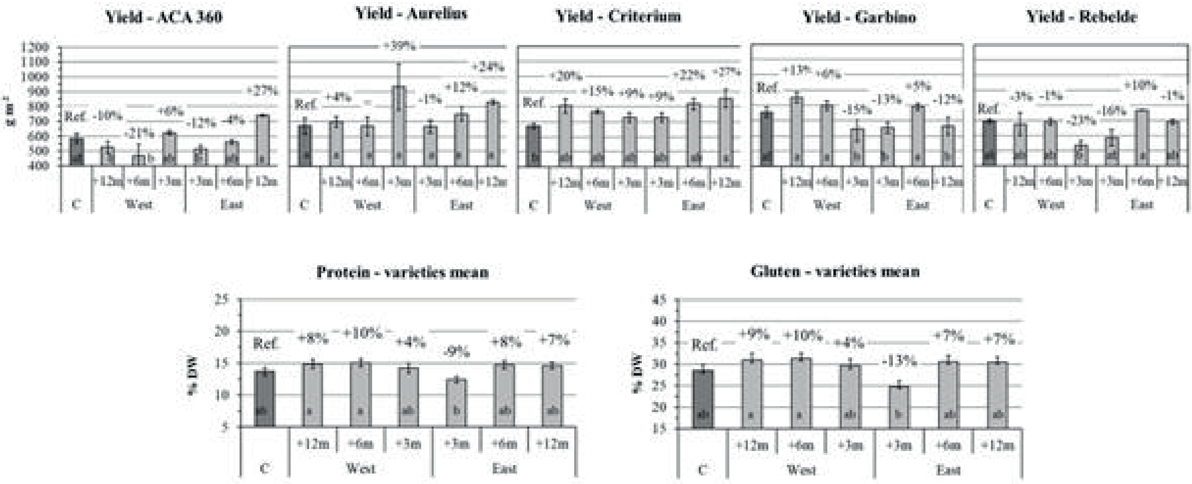

Figure 2. Grain yield and qualitative parameters (means ± S.E.; n=3) in five wheat varieties. DW: dry weight. Differences for Tukey's HSD test at $p \leq 0.05$.

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Can we optimise feed production in alley cropping systems by adapting grass-herb composition based on distinct shade responses? First results of an artificial shade experiment

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Introduction and research objectives

To further increase the adoption of silvoarable agroforestry in Europe, system optimisation to improve productivity and performance is key. This starts with disentangling and characterising the wide range of processes at play, including both competitive and facilitative interactions occurring above- and below-ground between trees and crops. Furthermore, system optimisation also encompasses improved tree-crop combinations, selection of adapted crop and tree varieties and smart design.

In North-Western Europe, light is likely to be the principal limiting resource for understorey crops, with trees strongly influencing the fraction of Photosynthetically Active Radiation (PAR) received by the annual crop. Hence, most agronomic studies show a systematic reduction of final yield as shade increases 2,6. This effect has been thoroughly assessed in previous research for a range of arable crop species through both empirical studies and modelling works 2,4,5,9. Recent meta-analyses across temperate climate suggest contrasting responses to shade according to crop species, with (i) winter crops being less affected than summer crops6, and (ii) forages, berries and fruits revealing a more tolerant response than C3 cereals, grain legumes and maize 8. However, studies comparing the performance of multiple species are less abundant and mainly restricted to the Mediterranean region 1,3,7. At the variety level, studies become even more rare 1,6. Arenas-Corraliza et al. (2019)1 assessed the effect of artificial shade on multiple Mediterranean wheat and barley varieties. They found significant differences between cultivars in terms of grain yield increase, leaf mass area decrease and total chlorophyll content increase under shade conditions. Additionally, Panozzo et al. (2020)7 found a clear difference in shade response between old and modern Mediterranean durum wheat varieties.

These studies indicate that varieties can respond significantly different to shade, which allows optimisation of variety choice. Context specific climate conditions but also other aspects such as soil conditions, nutrient availability, pest and disease risks need to be considered in this search for adapted varieties.

In this context, in 2021 ILVO set up a program to start field screening of crop species, varieties and mixtures for agroforestry conditions typical for temperate climate. The overall objective of this setup is to gain further insight in crop responses to shade under varying weather conditions and different orientations, and for a range of crop varieties, in order to work towards precision solutions in terms of (spatially differentiated) crop and variety choice and management.

Methodology

An artificial shade construction was installed at the ILVO agroforestry research site, mimicking a mature system through the use of military camouflage netting to provide discontinuous light through the day (based on Artru et al. 2017 2). The construction is made of concrete poles with a height of 3.5 m and with a metal crossbeam of 3 m long attached on the top of the poles. The structure is approximately North-South oriented, with the camouflage netting fixed on top of the crossbeams. In the alleys East and West from this construction, nine crop plots of 12 m long (along the row of poles) and 12 m wide (perpendicular to the row of poles) were installed, enabling us to have three crop treatments with three replicates per season (see Fig. 1- left). An aerial view of the construction can be seen in this short video (https://youtu.be/k8xinMvH0og).

The light reduction is monitored at 3, 6 and 9 m East and West from the row of poles, using pyranometers. At the same positions, also air humidity and temperature, soil water content, soil temperature and soil water potential are assessed.

During the two first growth seasons of 2022 and 2023, we evaluated the impact of the dynamic shade conditions on crop productivity and quality for three different grass-herb mixtures, i.e. (1) Lolium perenne + Trifolium pratense, (2) Festuca arundinacea + T. pratense and (3) F. arundinacea + T. pratense + Plantago lanceolata.

Research questions, results and perspective

The main research hypotheses are:

1. There is a significant effect of the plants' distance from the shade construction, with all mixtures performing best under moderately shaded conditions, as compared to severe shading (too much light competition) or full light (higher drought stress) conditions.
2. There is a difference in shade response of the plants on the East versus the West side of the artificial shade construction, hence plants respond differently to morning vs. afternoon shade.
3. During the growing cycle of the plants, the weather conditions and soil moisture content significantly affect the responses to shade, with the shading effect being beneficial during long/severe periods of drought.
4. Adding P. lanceolata to the grass-clover mixtures further increases drought resistance but also productivity and feed quality in shaded conditions.

The insights gained over the first two years of monitoring in this trial will help us to deal with these hypotheses, and will be presented, together with a perspective towards future research at the same site.

Keywords

Agroforestry, alley cropping, silvoarable agroforestry, grass clover, shade tolerance, crop production, Belgium, above ground biomass, forage, Shading Effect

Aditional Attachment II.

Figure 1. Artificial shade construction at the ILVO experimental site (Merelbeke, Belgium). Left: Field view with light sensors and three treatments of grass-clover mixtures along the length of the construction. Right: Harvesting activities with the Haldrup and manual collection of samples for further analysis.

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2.1 Silvoarable Systems – Crop Production

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Alley cropping with walnut, hazelnut and blackcurrant: planting an agroforestry experiment

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2 Hessian State Domain Frankenhausen, Grebenstein, Germany

Introduction

Long-term research on alley-cropping systems in the temperate climate zone is underdeveloped (Lovell et al. 2018). However, interested farmers need research findings in order to be able to assess the long-term effects on yields, economic returns, soil and the environment and thus the ecological and economic development of their own farm (Thiesmeyer & Zander 2023).

For this reason, an AFS experiment with arable crops, walnut (Juglans regia L.), tree hazel (Corylus colurna L.) and blackcurrant (Ribes nigrum L.) was set up in November 2022 at the Teaching, Research and Transfer Centre for Organic Farming Hessian State Domain Frankenhausen on a Haplic Luvisol from loess.

Objectives

The experiment is intended to investigate the following questions:

1. ecological and economic effects of AFS compared to arable farming and plantation farming: walnut and arable crops in alley cropping compared to arable crops without the influence of woody plants and walnut in plantation farming
2. ecological and economic effects of increasing diversity in AFS: alley cropping with walnut compared to alley cropping with walnut and hazelnut as well as with walnut, hazel and currant.

Both questions are analysed for two different walnut varieties (cv. Moselaner 120 and cv. Franquette).

Methodology

The experiment was established as a randomised block design with a total of three (2+1) field replicates on two spatially close fields (10 + 7 ha). Plot size is 3,200 m² (40x80 m) with 36 m wide arable strips and 4 m wide tree strips as well as 15 m distance between the walnut trees in the row in the alley cropping variants. In the plantation variant, the distance between individual trees is 15 m in the row and 13 m between the rows. Tree hazel trees are spaced 7.5 meters apart between the walnut trees, while currants are planted with 3 plants each at 7.5 meters between walnut and tree hazel. The tree strips and the grassland in the plantation variant are sown with a diverse meadow mixture. On the arable land, a customary crop rotation of cereals and legume-grass mixtures is planned. The experiment is largely managed organically. Fig. 1 shows the experimental plan for the first two field replicates.

Expected results and impacts

In the first years, the status quo will be recorded with a focus on soil biology (earthworms, microbial biomass), physics (pH, bulk density, soil texture) and chemistry (carbon, nitrogen), as well as biodiversity (butterflies, farmland birds). Growth and yields of arable crops and woody plants is recorded annually, and successive investigations of other soil parameters is planned, as well as continuous biodiversity monitoring focusing on soil microbiology, insects, butterflies and birds. With time, the experiment is expected to provide sound data on crop and tree yields including measures on the performance of mixtures vs. sole crops such as a leaf area ratio, as well as on ecosystem services delivered by agroforestry.

The project is funded by the state of Hesse, represented by the Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection.

Keywords

agroecology, Agroforestry, temperate agroforestry, alley cropping

Aditional Attachment

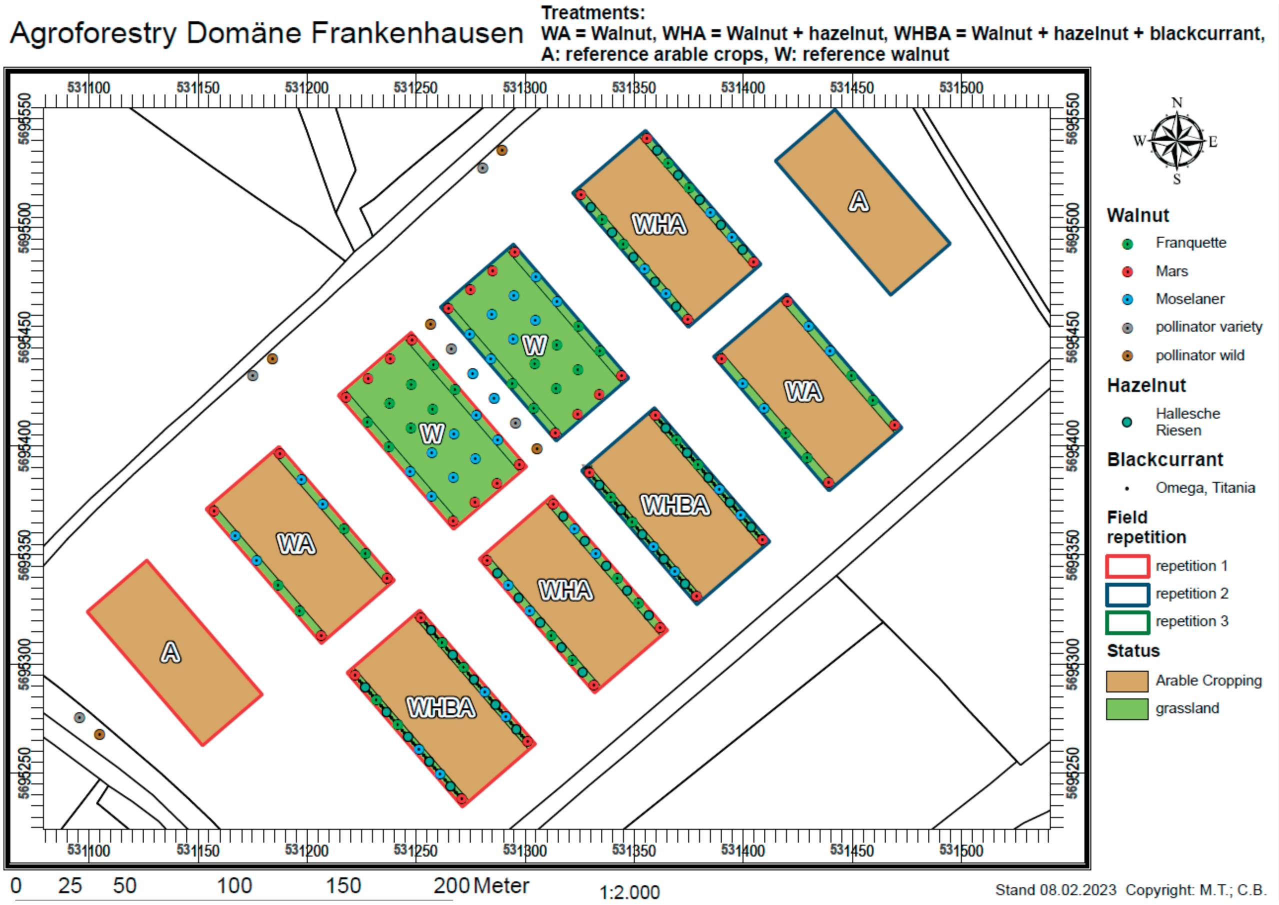

Fig. 1: Plan of field repetition 1 + 2 of the experiment at Frankenhausen.

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The state of alley cropping and windbreak systems in Croatia

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Introduction

As part of the ERASMUS+ project „Agroforestry practices in West Balkan: weaknesses and strengths – AGFORWEB" we investigated the scope of agroforestry practices in Croatia. Most of the agroforestry practices in Croatia refer to silvopastoral systems while silvoarable agroforestry is poorly represented. The state of silvoarable agroforestry refers mainly to devastated windbreak systems in the Mediterranean part of Croatia and some experimental sites in the continental part (picture 1).

The objective of this abstract is to overview the existing situation regarding the silvoarable practices in Croatia.

Methodology

The investigation was conducted by reviewing papers and summarizing the information on silvoarable practices from publications but also personal communications.

Results

Silvoarable practices in Croatia are extremely rare as well as publications containing examples of silvoarable practices in Croatia. Most of it refers to windbreak systems in the Mediterranean part of Croatia (Tomašević, 1996; Ljubenkov, 2012; Kisić, 2017; Barčić et al., 2021). Winds in the coastal part of Croatia often can reach up to 100km/h, mainly during the winter months, which can result in soil degradation due to wind erosion (Ljubenkov, 2012). Large agricultural areas in Mediterranean Croatia are affected by it and as an instrument of protection, windbreak systems with trees have been established. The most common examples are "Čepić Polje" in Istria and "Sinjsko polje" in Dalmatia (Ljubenkov, 2012; Kisić et al. 2013; Kisić, 2017). Sinjsko polje is an arable area of 6190 ha where winds during winter are between 60-100km/h. Between 1950 and 1970 around 42000 poplar trees were planted in windbreak systems that stretched throughout 140 km of protective belts. In 1989 only 18000 trees remained which were further devastated in the last 30 yr. (Ljubenkov, 2012). Windbreak systems in Croatia have been neglected and today they provide poor protection from wind. There is a need to revitalize these windbreak systems and to consider using more appropriate tree species than poplar (Populus spp.). In windbreak systems of Mediterranean Croatia, mostly poplars are used however during winter months they provide poor protection. Coniferous species such as Cupressus spp. would provide protection all year round and as such are more appropriate in coastal Croatia.

At the Faculty of Agrobiotechnical Sciences Osijek field trials of alley cropping systems with tree rows of short rotation coppice (SRC) have been established (picture 1.). The alleys between tree lines are 24m wide and within the alleys, microclimatic parameters such as temperature, humidity, wind direction, and wind strength are observed. These experimental sites serve as a baseline for the future possibility of using SRC in an agricultural field. As of 2019 establishing SRC stands on poor agricultural soils is supported by governmental subsidies. This financial support can result in an increase of SRC stands in Croatia. The field trial aims to investigate the full potential of such stands. However, since it was established only a few years ago the effect of this system on soil improvement is not visible yet. It is expected that soil improvement will occur after 10-20 years of practicing alley cropping. Crop yields are not expected to change much as the tree lines are quite far from each other and the trees are managed in short rotation. The yields of trees might provide some additional income. During this period the economic aspects will be evaluated as well.

Conclusion

Silvoarable systems in Croatia are scarce although there is a huge demand for wind protection in the coastal part of Croatia. The state of windbreak systems in that area is devastated. With new agricultural policies where some forms of agroforestry systems have been subsidized there is a potential to revitalize the devastated windbreak systems but also establish new alley cropping systems in continental parts of Croatia where the necessity is soil improvement as well as production diversification.

Keywords
alley cropping, crop production, Eastern Europe, soil improvement, erosion phenomena

Aditional Attachment II.

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Crop productivity in two Danish agroforestry systems

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It is well known, that agroforestry systems - under the right circumstances - can deliver a range of ecosystem services including carbon sequestration (De Stefano & Jacobsen 2018), reduced nitrogen leaching (Kim & Isaac 2022) and increased biodiversity (Bentrup et al. 2019). Modern, large-scale agriculture is often associated with problems with regard to these ecosystem services (Martínez-Dalmau et al. 2021; Secretariat of the Convention on Biological Diversity 2020, IPCC 2023). Many Danish organic farmers have shown interest in using agroforestry systems to reduce their environmental footprint (Innovation Center for Organic Farming 2024). There is a long history in Danish agriculture of reducing wind erosion and improving agricultural productivity through large-scale shelterbelt establishment schemes. However, in recent decades the extent of shelterbelt establishment has declined (Fritzbøger 2002). Today's organic agricultural methods in Denmark include artificial irrigation, heavy mechanization and the use of modern crop cultivars. In this agricultural setup, the crop productivity may interact differently with shelterbelts, compared to earlier times' agriculture which was affected more by climatic fluctuations. For organic farmers to allow more tree-based systems on their farm, there is a need to document the effect of trees on the yield of grain and fodder grass.

We present results of biomass and grain productivity assessed on two organic farms on sandy soils in a windy climate characterized by strong westerly winds. Field productivity was assessed in 2021, 2022 and 2023 within 2x2m plots at four distances (replicated 3 times) on each side of North-South oriented, mature shelterbelts. The following factors were quantified to explain the productivity patterns: Crown coverage, precipitation and irrigation, soil moisture, soil carbon, nitrogen, pH, temperature, and wind speed and direction.

We model and discuss factors controlling the interaction between shelterbelts and field productivity. We discuss the implications of these interactions on the design of agroforestry systems on temperate organic farms in the future.

Keywords

trade-off, Growing season, Soil Organic Matter, hedgerows, crop production, Grassland with trees, Growth functions, agroforestry landscapes, shelterbelts, windbreak, Organic Farming

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Agroforestry-Trial Grottenhof / Graz - First experiences with silvoarable agroforestry systems in Styria

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Experiment question

- Is the concept of agroforestry a strategy against long-term climate change?
- What effects are there on soil condition, plant growth, management, biodiversity and overall yield?

Test site: LFS Grottenhof / Thal operating area

Experimental procedure:

The experiment is intended to be a long-term experiment, as the effect of the planned tree population, in the specific case in the form of rows of trees, only occurs after several years. The installation took place in spring 2016. In the so-called Preineracker, seven rows of trees with the red oak and birch tree species were planted in a north-south direction. The distance between the rows is 20 meters, red oak and birch are planted alternately in the rows at a distance of 5 meters.

The arable land is cultivated in the company's usual crop rotation.

The growth success of the trees can now be described as assured. During the last assessment in autumn 2022 one oak and two birch trees are classified as failed, which corresponds to a growth success of 98%.

Since 2021, surveys on harvest results, soil parameters and weather data have been carried out continuously.

Keywords

agri-environmental system, silvoarable agroforestry, crop production, research and development, Land cover change, biodiversity, agriculture, Agroforestry, valuable wood, Socioeconomic status, Heat stress, oak, timber, Trees Outside Forest

The effect of the trees and previous legume forage crops on the grain sorghum production under rainfed conditions in the Mediterranean area

Dr Lorenzo Gabriele Tramacere[1], dr Daniele Antichi[1,2]

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Introduction

The integration of nitrogen-fixing crops between trees presents a promising solution to enhance land productivity and reduce dependence on external inputs. This approach increases nitrogen (N) availability, promoting the growth of both trees and crops, thereby improving the sustainability of agricultural systems (Tramacere et al. 2023). Intercropping perennial legumes with trees offers additional benefits, such as contributing to year-round soil cover reducing N losses, and accumulating it in stable forms through biological N_2-fixation (BNF) and N root compartmentation (Hernández-Esteban et al. 2019). Moreover, the N derived from BNF in perennial legumes can surpass standard N-fertilization rates in conventional agriculture (Unkovich et al. 2010). In the Mediterranean basin, alfalfa (Medicago sativa L.) and sulla (Hedysarum coronarium L.) are commonly cultivated for their hardiness, productivity, and high-quality forage, and traditionally cropped in agroforestry systems (AFS) (Tramacere et al. 2023, Mantino et al. 2021). In Italy, poplars (Populus spp.), are significant sources of wood, known for their rapid growth and favorable wood technological features, often used in the plywood industry, and used also in alley-cropping (AC) AFS (Chiarabaglio et al. 2018). After the forage legume cultivation the choice of the right herbaceous grain crop is crucial in AC systems to maximize facilitation (e.g., to exploit residual N in the soil) and minimize competition with trees. Warm-season crops, for example, can benefit from reduced potential evapotranspiration by leveraging the windbreaking function of tree rows, especially in rainfed systems (Mantino et al. 2023). Previous studies have shown the viability of intercropping sorghum (Sorghum bicolor L.) with poplar in AC under rainfed Mediterranean conditions (Pecchioni et al. 2020).

Objectives

The aim of this work was to assess the beneficial role of a poplar based silvo-arable system that includes different perennial forage legumes like alfalfa and sulla, in terms of nutrient aivalability, when cropped before a cash crop like grain sorgum, a summer crop typically cropped in the Mediterranean area under rainfed conditions for its rusticity and drought tolerance.

Materials and Methods

In 2020, a rainfed plot field experiment was established at the Centre for Agri-Environmental Research "Enrico Avanzi" of the University of Pisa (CiRAA), San Piero a Grado, Pisa, Italy (43°41'07.6" N 10°20'32.2" E, 1 m above sea level and 0% slope) (Tramacere et al. 2023). In November, the plot trial was established on a loam soil with pH of 8.1 and 1.69 % w/w of organic matter content. Before sowing, 100 kg ha^{-1} of P_2O_5 were applied. The experiment complied with a two-factor randomized complete block design (RCBD) with three replicates (each plot sizing 56 m^2). The first factor (CROP) included three different swards: (i) sulla (SUL) cv. Silvan, (ii) alfalfa cv. Messe (ALF), and (iii) ryegrass (RYE) cv. Teanna, i.e., a grass species as control. The second factor (SYSTEM) included two different cropping systems: ARABLE, i.e., forage crops grown without intercropped trees, and a SILVO-ARABLE system with poplar clone I-214 (Populus × euramericana (Dode) Guinier) tree rows planted in February 2021. After two growing seasons of the forages, all plots were muldboard ploughed in February 2023 at 0.3 m depth and then, on 8th May, sorghum was sown on the entire field. In post-emergence, 0.4l of Banvel 480s were applied and then one pass of hoe was carried out for the weed control. On 4th September, sorghum was sampled at harvest to measure the above ground biomass production and its partitioning between grain and residues on two sampling areas of 1 m^2 each per two distances from the side border of the plot, i.e., 1-m and 4-m apart, to test whether there were differences in plant production related to their distance (factor AREA, Ar) from the ditches or from the tree rows, respectively for ARABLE and SILVO-ARABLE systems. Crop production was measured as follows: total above-ground biomass (g m^{-2}), dry grain yield (g m^{-2}), and residues (g m^{-2}). Samples were fresh weighed and sub-samples were oven dried at 60 °C for dry matter content determination.

Results and Conclusions

The statistical analysis reported no significative differences between the factors tested. However, as showed in the Figure 1, it is possible to observe a slow increment in the production of sorghum on the legume plots compared to the RYE, especially at 1-m of distance from the border in both systems tested. Consequently, it is possible to think that a slight residual effect of the legume crops occurred, but further studies are needed to verify this observation in replicated trials, intensifying the level of investigations and even assessing grain quality and the nutrient uptake.

Moreover, no differences in the productivity was highlighted comparing ARABLE and SILVO-ARABLE systems, suggesting the suitability of the sorghum cultivation in the AFS under rainfed conditions, avoiding yield losses due the competition with trees.

Acknowledgements

This work was supported by European Union's Horizon 2020 research and innovation programme, Grant Agreement 862993, project AGROMIX (AGROforestry and MIXed farming systems - Participatory research to drive the transition to a resilient and efficient land use in Europe).

Keywords

sorghum, sulla, legumes, yield, poplars, previous crop, forage, residual nitrogen, alfalfa, agroecology, alley cropping

Aditional Attachment I.

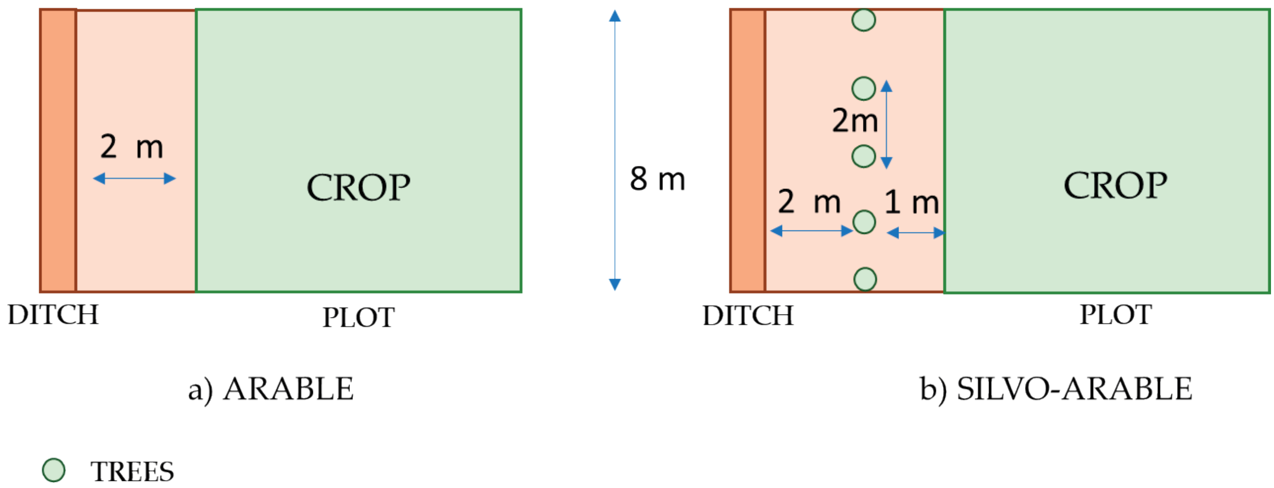

Figure 1. Plots layout of the system ARABLE (a) and SILVO-ARABLE (b), respectively. System SIPAST: Five 1-yr old poplar trees have been planted in February 2021, North-South oriented, between the ditch and the forage crop. on the row every 2 m along one side of each plot (plot length: 8 m), 2 m away from drainage ditches, and 1 m apart from the first row of the forage crop.

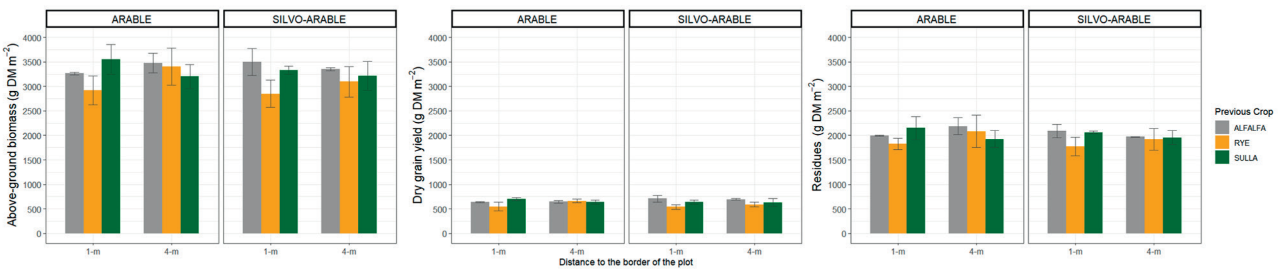

Figure 2. Average values of the above-ground biomass, grain yield and residues of the sorghum as affected by the previous crop, the system and the area of sampling. Vertical bars indicate standard error of the mean. Treatments are not significantly different at p≤ 0.05 (Tukey's HSD test).

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Quantitative and qualitative parameters of cereals grown in adult experimental agroforestry systems - first results and experience in Czech Republic

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2 Mendel University in Brno, Brno, Czech Republic

3 Czech Agroforestry Association, Prague, Czech Republic

Introduction

Current agriculture in the Czech Republic and many other EU countries and regions can be characterized as large-scale, industrial farming of agricultural land oriented towards high yields and economic profit, which brings many negative impacts - on the environment, but also on the social situation in the countryside. Modern agroforestry systems, which combine tree cultivation and some form of conventional agricultural management on one piece of land, can fundamentally contribute to improving the sustainability of Czech agriculture and its resistance to the effects of climate change (Lojka et al., 2020, Weger et al., 2022). According to the results of research and practice (Lehmann et al., 2020), it is possible to maintain or increase productivity per unit area (LER) in appropriately established and cultivated agroforestry systems. For farmers additional significant benefit may represent a diversification of production and reduction of risks related with lower external inputs of tree components of AFS. Knowledge about the cultivation of cereals in agroforestry systems and their possible yield and quality is essential for development of agroforestry and searching for suitable varieties.

Objectives/research question

The aim of our work was to evaluate quantitative and qualitative parameters of cereals grown in experimental agroforestry system with semi-closed canopy of older trees and compare them with cereals grown on field with standard conditions.

Methodology

The alley cropping agroforestry system (AFS-1; 0.6 ha) was established at research station Michovky for experimental purposes in 2018-2019 by transforming an over-aged tree nursery (15 years) into a silvoarable system consisting tree lines of maples, linden, ash and rowan in NWW–SEE direction. Tree crowns have created closed canopy as tree density has been relatively high (440 trees / ha) as well as their height (8-10 meters) during experimental period. Width of crops strips (fields between tree lines) are 10 and 15 meters. Since 2020 arable soil has been farmed by an agro-cooperative with the same annual crops and similar their management practices as on a neighboring field (FIELD: 45 ha, 50 m from AFS). The agroforestry system and the conventional field have been equipped with monitoring system of climatic, soil and hydrological parameters as well as for measuring eco-physiological parameters of trees (sap flow, diameter growth; FAR). Three varieties of cereals - RGT Reform, Patras (winter wheat) and Bojos (spring barley) - were grown in the experimental agroforestry systems (AFS-1) and in the adjacent field in 2020, 2022 and 2023. Multiple samples of cereal plants (>80, each 0,5 x 0,5 m) were taken to evaluate their quantitative (yield, height) and qualitative parameters in different parts of AFS and field each year. In the agroforestry experiment, 3 transects (TA, TB and TC) were marked, which pass rectangular to tree lines across the entire experimental area. At the FIELD site, 3 transects (T1, T2 and T3) were marked, which were parallel and at a distance of 10 m, the second 30 m and 110 m from the field edge.

Quantitative parameters measured in cereal stads samples include: total weight (fresh/dry), number of stems, number of ears, weight of ears and straw, height of stalks, number and weight of grains. Quality assessment of cereal grains s were performed by Agricultural Research Institute Kroměříž, Ltd. and they include standard parameters including gluten index, crude protein content, sedimentation index, weight of 1000 grains and grain bulk density etc.

Results

Our analyses show that quantitative parameters of cereals in experimental AFS Michovky were mostly lower/worse than in the field monoculture e.g yield of grains were lower by 30-50% depending on site, variety and year. In AFS, samples closer to the tree lines had often lower biometric and yield parameters compared to the samples harvested in the middle of crop strips. The main limiting factors for quantitative parameters were dense spacing of trees in and between tree lines which limited water availability for crops and also efficient use of agricultural machinery (ploughing, seeding close to trees).

On the contrary results of qualitative parameters of wheat in 2020 and 2022 were often better in AFS than in FIELD, especially in the parts with higher shading typically with lower gluten content and other parameters. Analyses of barley from 2023 are currently in process.

Conclusions

Our results show possibilities for quality production of cereals in AFS and also give ideas for improvement of AFS in adult growth period so that they better meet the production conditions of field crops and at the same time preserve the environmental benefits of agroforestry in conditions of Czech agricultural practice.

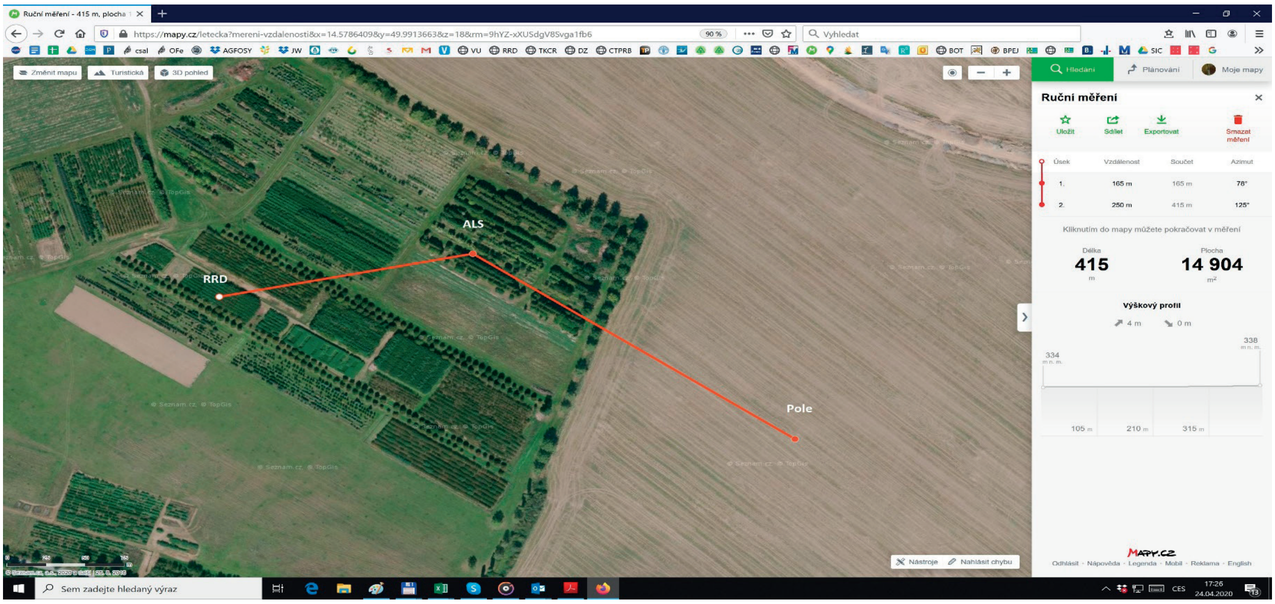
Acknowledgement

Our research was supported by the institutional funding of VUKOZ (VUKOZ-IP-00027073) and project TACR Epsilon (TH04030409).

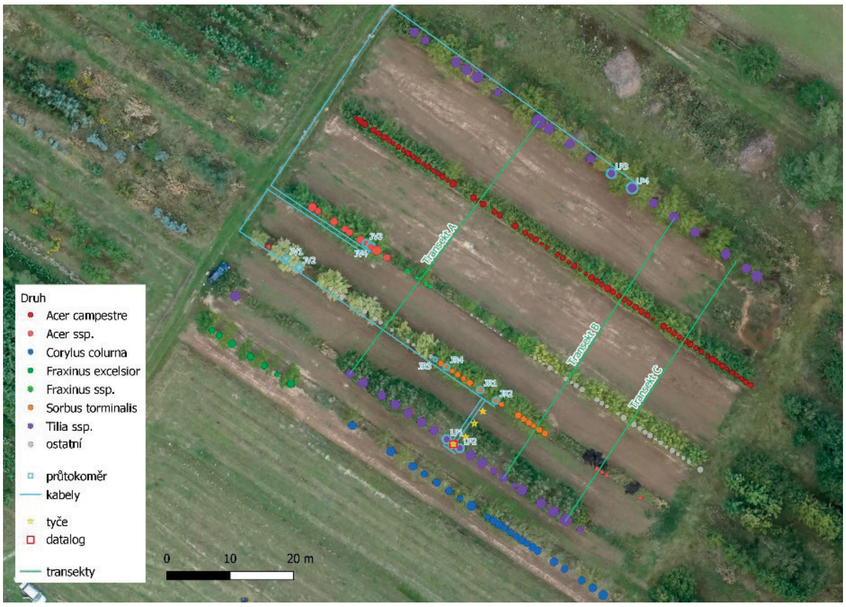
Keywords

alley cropping, wheat, barley, silvoarable agroforestry, yield, quality

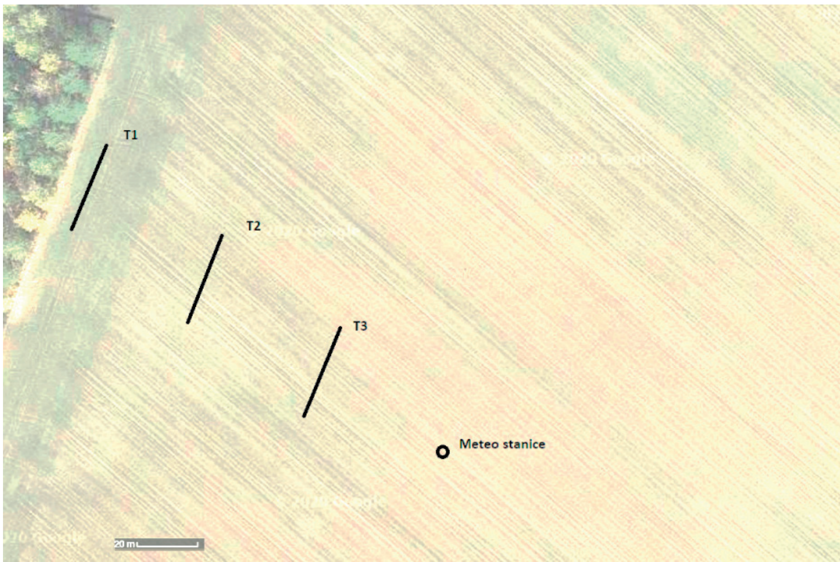
Aditional Attachment I.



Aireal view of the experiemntal site Michovky with Agroforestry system Michovky -1 (ALS) and conventional FIELD (Pole) as control site.



Scheme of experimental Agroforestry system Michovky -1 with sampling transect A, B, C of cereals



Scheme of FIELD site Michovky with sampling transect 1, 2, 3 of cereals

Figure 1 Collection of wheat samples for analyzes from the control FIELD and mechanised harvest of wheat in ALS-1 Michovky 2020

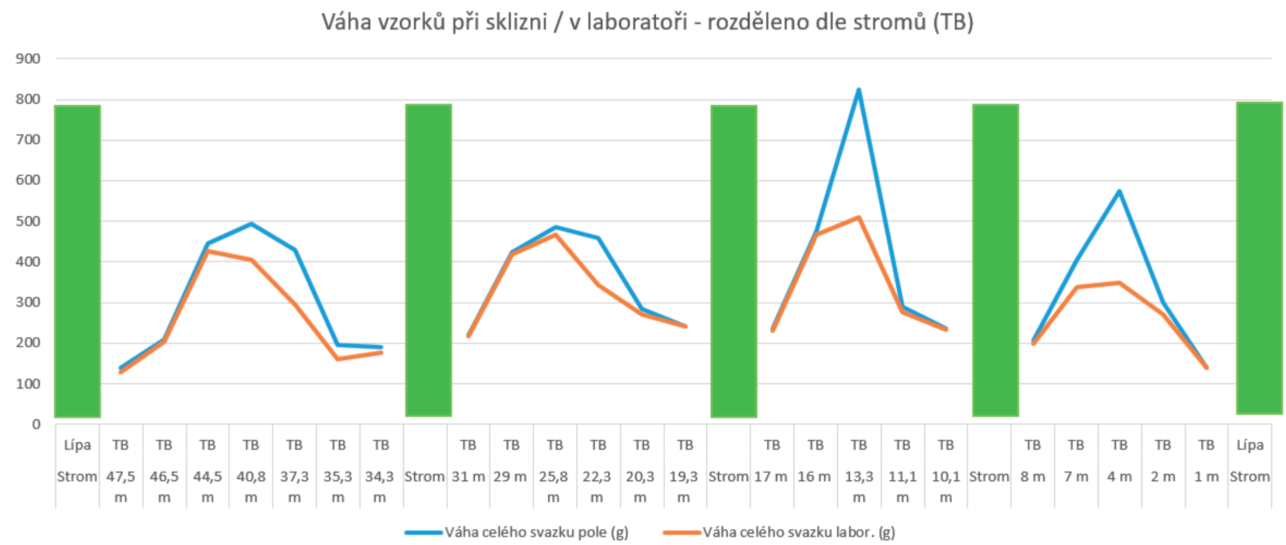


Fig. 2: Sample weight [g] of whole wheat sheaves in the ALS-TB transect– on site and laboratory (2020) (tree lines are green, 2020)

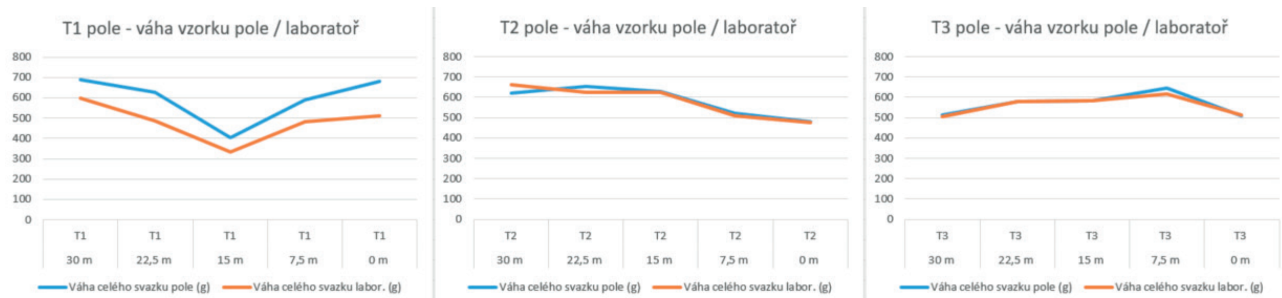


Fig 3. Weight of wheat samples in the FIELD in transects (T1-3) – on site and in the laboratory (2020)

Fig. 4 Results of winter wheat (RTG Reform) quality assessment in 2020

Parameter	ALS 1 shade	ALS 1 sunny	FIELD 10	FELD 30-110
Density	82,9	80,8	81,6	84,3
Decline number	388	390	382	384
Sedimentation index	34	30	33	33
Content of nitrogenous substances	13,1	10,3	13,1	11,7
Wet gluten content	33	23	32	28
Gluten index	58	95	63	92
Weight of a thousand grains	45,1	44,4	38,5	44,9

Content of nitrogenous substances

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AFS-1 (Experimental Agroforestry System Michovky – VÚKOZ Průhonice) http://www.agroforestrysystems.eu/en/michovka-2

2.2 Silvopastoral Systems (I)

Oral presentations

Hall Q3, 29 May 2024, 8:30–10:00

Land-use diversification on intensive dairy farms: agroforestry as a complementary feeding source for dairy cattle

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Introduction

European crop and livestock farms produce large yields of safe and high-quality food, but this production depends on the use of many off-farm inputs and the associated greenhouse gas emissions, loss of soil nutrients and other adverse environmental impacts (Burgess et Rosati, 2018). The agricultural and forestry sectors are currently facing the dramatic challenge of producing food, energy and wood for a growing world population, while preserving the environment at the same time. Several strategies can be adopted to address this issue: among these, the integration of crop and/or livestock systems with woody perennials on the same land unit, can promote an ecological intensification and the synergic use efficiency of resources and inputs (Paris et al., 2019). Moreover, fodder trees and shrubs in dairy cattle farms can provide additional feed rich in macro and micro-nutrients. Livestock agroforestry covers about 15.1 million ha, corresponding to about 3.5% of the EU territorial area, which is by far the predominant use among the areas dedicated to agroforestry (den Herder et al, 2017). Historically, trees have played an important role for livestock feeding worldwide and are still an important source of fodder in developing countries. Currently, dairy farming practices in Europe rely on high input grassland and fodder crops with the goal of maximizing production. In Lombardy, a northern Italian region, where about 33% of the Italian dairy cattle are bred, farms are predominantly intensive, with an average of 214 head per farm (AIA, 2022). In these farms, maize which covers about one third of the regional utilized agricultural area, represents the main feed for cattle.

Objectives

The DairyMix Project (www.dairymix.eu), among the other objectives, aims to study the potential of adapting agroforestry systems to the dairy Lombardy context as a complementary feed source for dairy cattle and a way towards land-use diversification.

Methodology

The DairyMix Project involves six dairy farms from Lombardy with an average herd size of 473±365 cows and an annual milk production of 9.12±2.38 t milk/cow. Within the case studies, the tree species present were identified. The most promising species were selected on the basis of nutritional traits (Crude Protein, CP; Neutral Detergent Fibre, NDF; organic matter digestibility) (Luske et al., 2017). Leaf samples from the 5 species, namely black mulberry (Morus nigra L.), black locust (Robinia pseudoacacia L.), weeping willow (Salix babylonica L.), common ash (Fraxinus excelsior L.), field elm (Ulmus minor Mill.), were collected manually from the lowest branches of selected trees at three different times during summer 2023. On the samples, bromatological and mineral content analyses, in vitro digestibility with ruminal fluid and gas production analyses were carried out. Net Energy for Lactation (NEL) was calculated (Menke and Steingass, 1988). Data were analysed with the statistical software SAS® using general linear model (GLM) analysis.

Results

The dry matter (DM) increased slightly throughout the summer with the lowest value recorded at the first harvest in black mulberry (24.3%). The average CP content decreased from 18.8±3.67% of DM at the first to 17.2±3.12% at the third harvest. The highest CP value was recorded in black locust at the second harvest (23.4%). The lowest and the highest average Neutral Detergent Fibre (NDF) values were observed in black mulberry (33.7±3.14% of DM) and in field elm (56.6±3.00%), respectively. Black locust registered the highest average Acid Detergent Lignin (ADL) content (20.1±1.26% of DM). The average bromatological results of the 5 tree species are showed in figure.

The GLM analysis showed a highly significant species effect (P <0.001) for nearly all the analysed parameters with the exception of EE (NS) and SS (P<0.05) and an effect of harvesting period on SS (P <0.05) and EE (P <0.05). A wide variability was observed for the nutritive value expressed in terms of NEl (MJ/kg DM). On average, NEL was estimated at 5.64±1.49: the lowest value was observed for black locust (3.90±0.55) and the highest for black mulberry (7.72±1.60). NEL showed a significant effect of harvesting period (P<0.05).

Conclusion

Especially in intensive farming system, it would be useful to restore, valorise and enhance the multifunctionality of trees. The observed differences among tree species show higher nutritive value and better chemical composition for the mulberry samples making it an interesting feed option for ruminant diets. In particular, based on the preliminary results, we expect to obtain high organic matter digestibility values correlated with elevated gas production for the mulberry samples. These results are encouraging and represent a good starting point for exploring the effective implementation of agroforestry practices within dairy intensive systems.

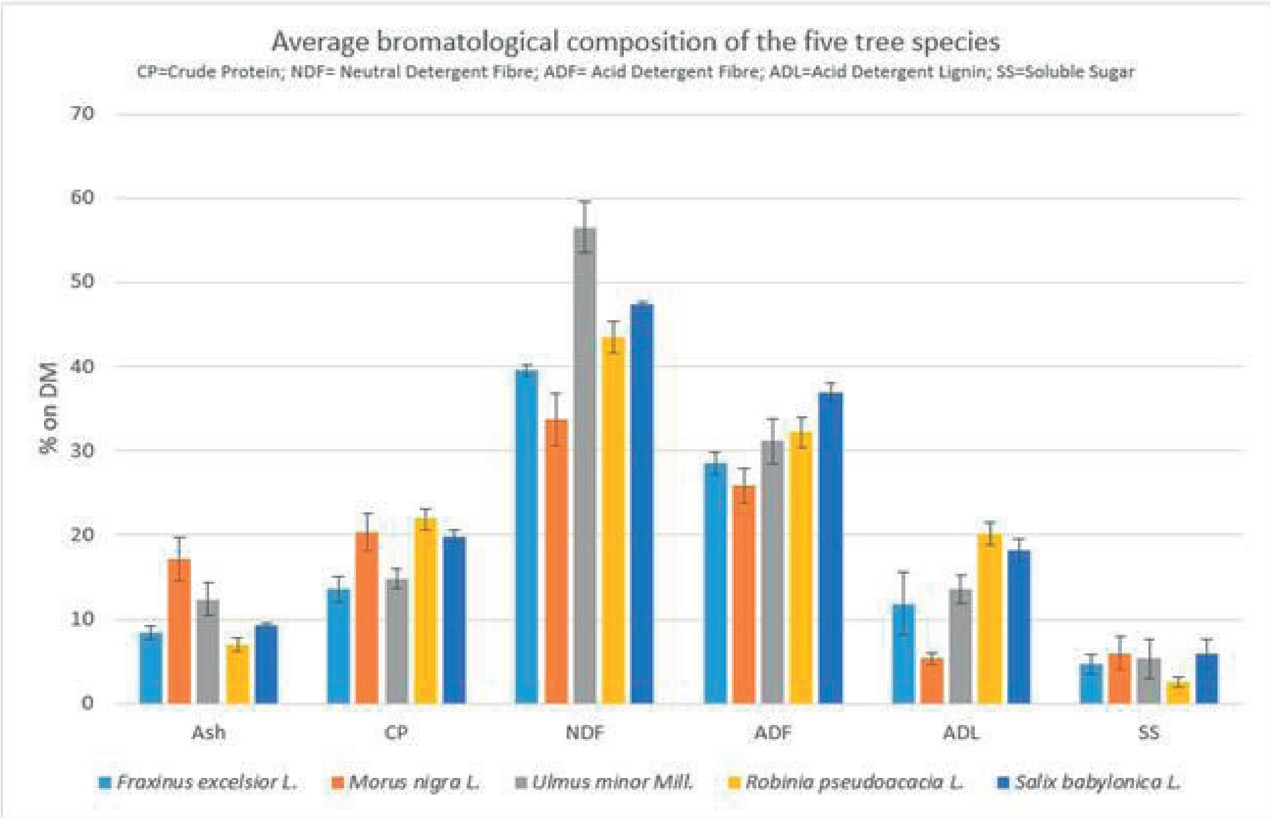
Acknowledgements

Project funded by national funding agencies under the Joint Call 2021 ERA-GAS, ICT-AGRI-FOOD, SusCrop and SusAn on "Circularity in mixed crop and livestock farming systems, with emphasis on greenhouse gas mitigation". Project coordination is funded by the German Federal Ministry of Food and Agriculture through the Federal Office for Agriculture and Food.

Keywords

dairy cows, silvoarable agroforestry, intensive dairy farms, circularity scenarios, crop-livestock-forestry systems, Italy, Socioeconomic status, sustainable food production, livestock, Case studies, milk, fodder trees, Agroforestry system, farmers' decision making, resilience, ruminants, tree-crop-soil interactions, mixed farming, tree diversity

Aditional Attachment II.



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Monitoring and assessment of daily sheep grazing routes in two representative grazing pastures of Evrytania Prefecture using GPS devices

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3 Department of Agriculture, School of Agriculture, University of Ioannina, Arta, Greece

The study was carried out in the Regional Unit of Evrytania (Region of Central Greece), at the southern end of Pindos. Evrytania has an area of 1,870 km2 and a population of 17,461 inhabitants. Evrytania has the characteristics of a mountainous Mediterranean climate with cold and wet winters and mild summers. According to official data (Veterinary Department of the Regional Unit of Evrytania 2021), in 2021 there were 56,534 sheep and goats in Evrytania reared in extensive and semi-extensive conditions.

The grazing behavior of sheep is the combined effect of many factors such as breed, pasture composition, pasture production and air temperature (Zygogiannis 1999). However, the grazing positions are more related to the characteristics of the landscape, the plant community, and the individual meadow sections (Papachristou 2018). The behavior of sheep during grazing is an important factor affecting the condition of different parts of the rangeland and ultimately the sustainable management of rangelands (Loridas et al. 2011). In addition, the distances traveled by the sheep, the slopes and the elevation differences of the pasture are related to the energy balance and therefore to the quality of the meat and especially the fat content of the carcass (Fisher et al 2000, Ramirez-Retamal et al 2014).

The objective of the study was to investigate the grazing behavior of two flocks of extensively reared sheep in two pastures of Evrytania, a semi-mountain (altitude 282-450 m) in Fragkista (Fra) with a pasture production of 310 kg/1000 sqm and a mountainous one (altitude 1080-1597 m) in Miriki (Mir) with production of 150.96 kg/1000 sqm. The characteristics of the rangelands are shown in table 1. The first flock (Fra) consists of 60 sheep of a local not official breed, called “tsipurisia” or “tsipia”. These are animals with low yields in milk and meat, but with very good adaptation to the local ecological conditions. The second flock (Mir) consists of 300 crossbred animals of the Chios and Karagouniki breeds. They are relatively large animals, with high milk production and greater requirements in terms of nutrition (Ministry of Agricultural Development and Food 2023).

Collars with an integrated GPS device were placed on six female sheep from each flock and distances traveled and elevation differences were measured, while grazing positions were imaged. Ultimately, only four devices in each flock yielded sufficient data for statistical processing.

Animals of both flocks were found to travel long distances daily to find food, with the animals of the mountain pasture herd reaching up to 16 km per day. It was found to stay in the tree-covered parts of the pastures mainly during the hot hours. The main results are shown in the table 2.

The greater daily distance traveled by the animals of the “Mir” flock compared to the animals of the “Fra” flock could be due to several factors. An important factor is the lower pasture production recorded in the mountain pasture (Mir). This leads to the rapid depletion of grazing material in the area around the shelter, forcing the flock to travel longer distances. Another critical element is the genetic material and phenotypic characteristics of the livestock of the two farms. The larger animals of the “Mir” flock are forced to travel longer distances to meet their greater nutritional needs. An important factor is the different grazing techniques applied as well as the lower thermal stress in the mountain meadow (Mir) compared to the semi-mountainous one (Fra).

This research is part of a comprehensive study aimed at evaluating the ecosystem services provided by the meadows of Evrytania.

Keywords
GPS livestock tracking, grazing livestock, grazing behaviour, GPS devices

Aditional Attachment I.

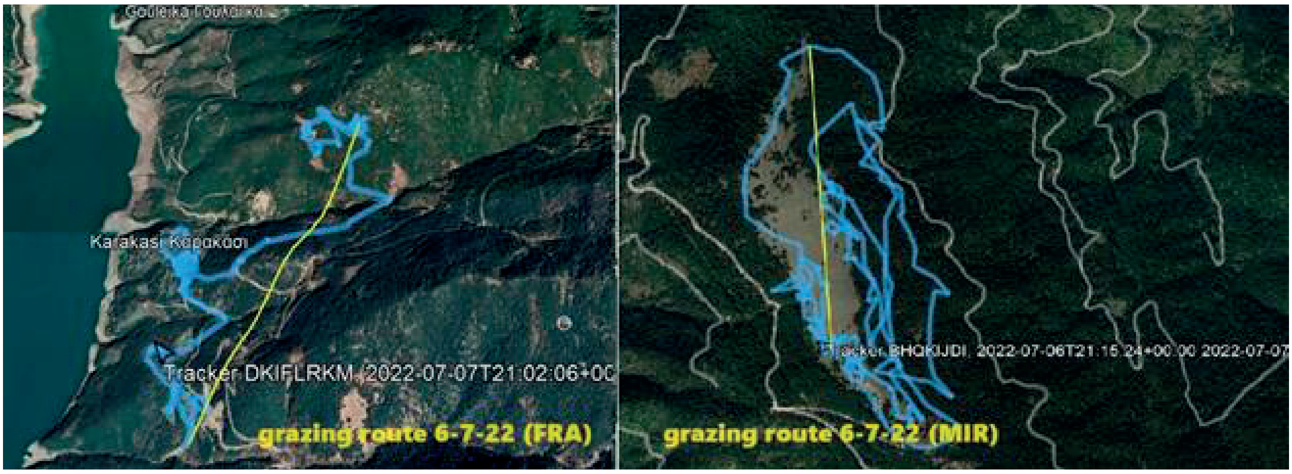
RANGELAND	AREA (X1000 sqm)	PERIMETER (km)	MIN ALTITUDE (m)	MAX ALTITUDE (m)	PRODUCTION 2022
Fra	727	4,71	282	450	310 kg/1000 sqm
Mir	302,4	3,93	1.080	1.597	150,96 kg/1000 sqm

Table 1. Characteristics of the studied rangelands

	Grazing distance (avg)	Radius of grazing	Elevation differences/day	Grazing in the shade
Fra	8,3 km/day	0,4 – 1,4 km	29-95 m	impossibility of assessment
Mir	11,95 km/day	1,34 -1,74 km	61-176 m	During the hot hours

Table 2. Daily routes and grazing places of the two flocks of sheep

Aditional Attachment II.



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The impact of poplar (Populus) leaves and stems supplementation on ewes' milk yield and quality

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Introduction

Climate change, increased production costs, and the lack of extension services are having a negative impact on sheep rearing for milk production in the Mediterranean (Aguilera et al., 2020). Consequently, land abandonment has become a widespread phenomenon in marginal and rural areas, with adverse effects on both the environment and local economies (Pardini et al., 2011). In semi-intensive dairy sheep farming, severe summer droughts compromise the availability of pasture biomass, reducing feed resources for milk production. Despite these challenges, a scientific approach to valorizing local traditional farming practices, such as using trees as fodder for sheep, could offer a potentially sustainable solution to this problem. Silvopastoral practices used to be widespread in Mediterranean contexts, and livestock could benefit from the presence of trees due to shade, shelter provisioning, and fodder availability. Particularly during dry seasons, tree fodder used to be provided to animals as a source of fresh biomass instead of pasture. Besides being beneficial to livestock, trees also prevent soil erosion, improve carbon sequestration, and provide a wide range of other ecosystem services, preserving biodiversity (Paris et al., 2019).

In this study, we aim to investigate the contribution of poplar leaves and stems as ingredients in the lactating ewes' diet, exploring their effects on milk production and animal welfare through an on-farm trial.

Material and methods

In March 2021, seven poplar clones (Stura, Brenta, Orion, I214, Imola, Jean Portet, Tucano) were planted on two farms to establish a long-term agrosilvopastoral system.

In June 2022 and June 2023, six lactating ewes were selected from the flock of one of the two farms, placed in individual boxes, and divided into two groups: for 14 consecutive days, three ewes were fed with a conventional diet (control group) based on oat-clover hay, alfalfa hay, and concentrates, while the treatment group, composed by the other three ewes, was fed with the same diet as the control group, except for the substitution of 0.5 kg DM of alfalfa with 0.5 kg DM of fresh poplar leaves and stems. Each day, all the diet ingredients were weighed, including the leftovers, to measure the individual total intake. In the morning, poplar stems were cut and provided to the treated group. Animals were milked twice daily, in the morning and evening, and individual milk production was measured (kg) for each milking session. Milk samples were taken every two days and analysed.

Statistical analysis on milk yield and quality was performed using R software. Intake, and FPCM yield were analysed in order to assess the differences between treatment and time (days). The effect of treatment and time was determined using a linear mixed-effect models with factors treatment and day as fixed effects and animal nested in treatment as random effect. Data transformation was not necessary.

Results and Discussion

Encouraging results were obtained from the analysis of data collected during the feeding trial in both years of the experiment. The production in terms of corrected milk for fat and proteins (FPCM, 6.5; 5.8) was not significantly different between the treatment and the control group in both years. During the first year the individual average daily FPCM production was 1149 g for the control and 1103 g for the treatment group. On the second year of the trial, FPCM production was 1366 g per sheep per day for the control and 1584 g for the treatment.

The daily total intake also showed no significant difference between groups for both years. In 2022, the daily intake for control and treatment group has resulted in 2218 and 2341 g DM, respectively. In 2023 the daily intake for control and treatment group has resulted in 2567 and 2801 g DM, respectively.

Conclusions

This study contributes to increasing knowledge about the utilization of fodder trees in the Mediterranean and demonstrates the feasibility of incorporating poplar leaves and stems into ewe diets during the summer when pasture mass is unavailable. Poplar leaves and stems have successfully been integrated into the diet of lactating ewes without compromising production. Further studies on the conservation of fresh biomass of trees could be useful for exploring the possibility of including it in the ewes' diet.

This study was founded by the Horizon 2020 project AGROMIX (GA n 862993).

Keywords
silvopastoral systems, Mediterranean resilient agriculture, Heat stress, sheep

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Multiple benefits of feeding willow leaves to ruminants may include reduced greenhouse gas emissions

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Introduction
Trees are increasingly valued in grazing livestock systems for the provision of shade and shelter. Tree leaves also provide a supplementary source of minerals such as zinc and cobalt (Kendall et al. 2021). We have carried out small scale replicated experiments at the Allerton Project research and demonstration farm in central England (Stoate, 2023) to investigate potential benefits of feeding the leaves of goat willow (Salix caprea) to lambs that had been weaned two weeks previously. In each case, 200 – 300g (fresh weight) of willow leaves per lamb were fed daily to groups of 6-8 lambs over a two-week period in late summer. Lambs had unlimited access to pasture and fresh water.

Minerals and gastrointestinal worm control
We have documented that cobalt availability in grazed grass at the site is lower than the requirement for growing lambs during much of the summer (Lee et al. 2017). In one study we demonstrated that lambs that had been fed willow had a blood cobalt concentration that was twice that of lambs that were not fed willow and this was reflected in vitamin B12 concentration which was 2.8 times higher in willow-fed lambs (Walker et al., 2022).

We also investigated willow as a potential anthelmintic (Hany Elsheikha et al., unpublished). In an in vitro assay, mortality of larval gastrointestinal nematodes increased with concentration of compounds extracted from willow leaves. We conducted an in vivo experiment along the lines of that carried out for mineral supplementation, but with high (1kg/lamb) as well as the low (200-300g/lamb) rates of willow leaves in the diet, and a control group that was not fed willow. At slaughter at the end of the fourteen-day experiment, we found that faecal worm egg counts were significantly (>70%) lower in the two groups fed willow than in the group that was not fed willow.

Greenhouse gas emissions
Associated with the experiments described above, we used a Gasmet multi-gas analyser to measure nitrous oxide emissions from nine fresh urine patches in a willow-fed group of lambs, and nine in the group that was not fed willow, as well as randomly selected patches of pasture without urine. We repeated daily measurements for two subsequent weeks. Nitrous oxide emissions were significantly lower for the willow-fed group than the group that was not fed willow for the first three days after urination (average 56% reduction), with lowest emissions from the pasture control patches without urine (Stoate, 2023). There were low emissions from all sampling patches beyond three days after urination.

We subsequently collected urine samples from ewe lambs in the experimental protocol with high, low and no willow feeding at the end of the two-week feeding period. This enabled us to apply a known 30ml volume of urine to pasture under controlled conditions. This provided four samples from the high willow feeding group, two from the standard willow feeding group, and two from the group that was not fed willow. Results of monitoring nitrous oxide emissions reflected those from the earlier work, with lower emissions from the groups fed willow than from the group that was not fed willow for the first four days following urination. There was no apparent difference between high and low fed groups and emissions from all groups were low one week after urination (see graph).

Although these results were not statistically significant because of the small sample sizes, the consistent results across two years with slightly different approaches implies that willow feeding may reduce nitrous oxide emissions from urine in this red meat production system.

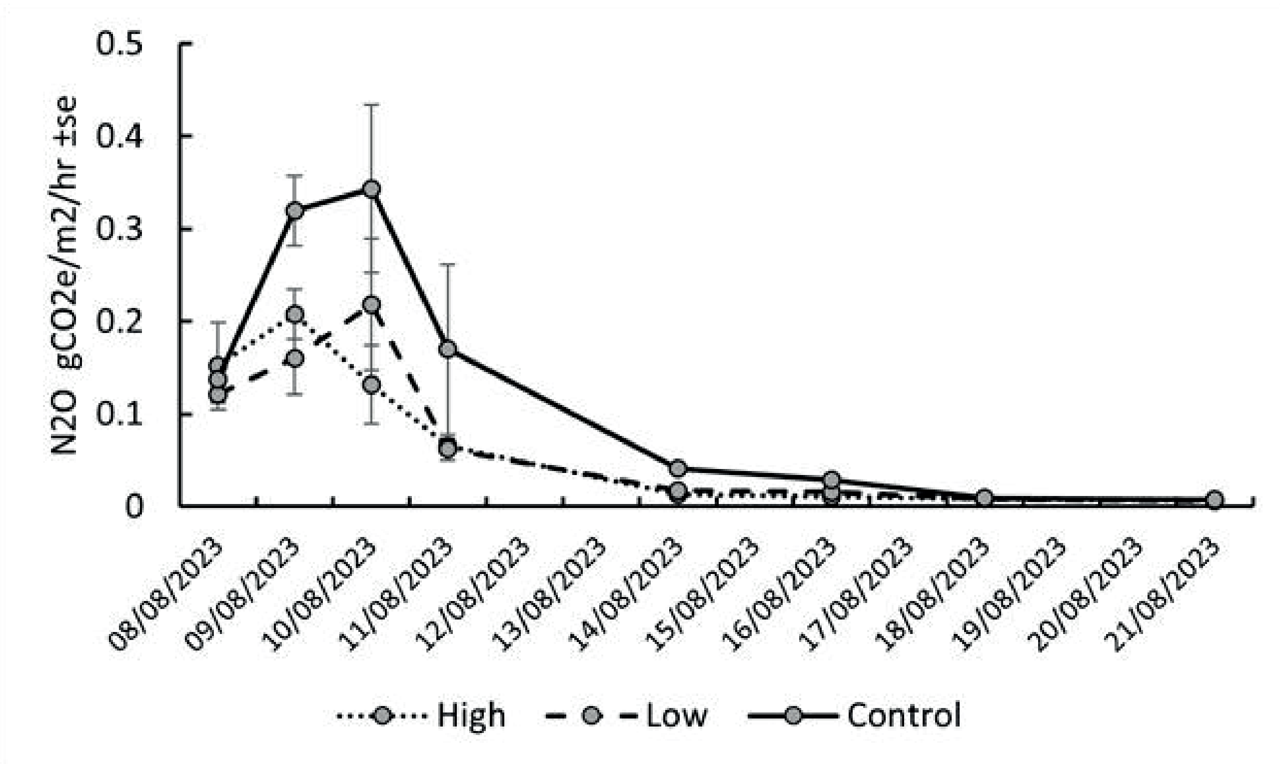
Discussion
As well as provision of shade and shelter, benefits of integrating willow trees into grazing ruminant systems include mineral supplementation and associated vitamin B12 elevation, and control of gastrointestinal worms. The use of leaves for mineral supplementation reduces the need for commercial supplements, while associated control of worms reduces the need for synthetic anthelmintics, with considerable ecological benefits to grassland ecosystems, including dung beetle communities (Manning et al., 2017).

With an increasing need to reduce contributions to climate change across the food production sector, it becomes increasingly important to establish an evidence base for management practices that reduce greenhouse gas emissions from ruminants. Recent UK research suggests that feeding willow to sheep can reduce enteric methane emissions from sheep by 50% (Katerina Theodoridou et al., unpublished).

Our own monitoring of nitrous oxide emissions from urine also suggests that emissions of this more potent greenhouse gas can be halved by feeding willow leaves, contributing to a reduction in the climate change impacts of red meat production. However, although consistent across our two studies with differing approaches, our samples are small and unbalanced. There is a need to conduct a simple but robust experiment to test this further.

Keywords
silvopasture, Grassland with trees, climate change mitigation, GHG emissions, fodder trees

Aditional Attachment II.



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2.2 Silvopastoral Systems (II)

Oral presentations

Hall Q3, 29 May 2024, 10:30–11:15

Designing credible forage agroforestry schemes for ruminant breeders

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One of the main challenges for ruminant farmers is to ensure the forage autonomy of their farm, especially in the face of summer droughts, which are more and more frequent and which force them to consume their winter forage stock. A growing number are considering the opportunity to use new forage resources, complementary to conventional forages (Legendre, 2018). Some breeders cut the branches of trees around their plots or give access to hedges to be grazed by animals (Penn, 2018). This was a common practice in Europe prior to grassland planting, maize development and mechanization (Sigaut 1987).

The work carried out with breeders' networks in the French projects PARASOL (2015-2018) and ARBELE (2015-2018) shows that visions of the forage tree are changing: they are no longer used only occasionally as a supplement during droughts but as a more regular resource in the farm's forage system. In order to improve this practice, the types of development are diversified: forage hedges, single intercrop lines, double or triple combining different woody species. The challenge for research is to support this dynamic and to offer farmers the knowledge necessary for the design and management of these tree schemes for optimal integration into their forage system. This is the aim of the RAME project, led by Agroof, in partnership with the Institut de l'Elevage, the Chamber of Agriculture and INRAE (2021-2024).

The forage resource derived from trees is still little studied and raises questions about the range of their food value, their acceptability by animals, and production ways. Scientific studies on the nutritional value of woody leaves (trees, shrubs or lianas) are still scarce in Europe (e.g. Smith et al., 2014; Novak et al., 2020; Luske and Van Eekeren, 2018). Research has so far focused on woody forages characteristic of pastoral systems in the Mediterranean area (Meuret, 1986; Mosquera-Losada et al., 2004; Papanastasis et al. 2008, Mebirouk-Boudechiche et al., 2015) or tropical (Alonso-Diaz et al., 2008; Vu et al., 2011). The lack of references on the nutritional value of tree species in temperate environments is a barrier to the development of their use (Hermansen et al., 2015). The first results obtained in the PARASOL and ARBELE projects and presented in Emile et al. (2017) on the total nitrogen content (MAT), fibers, condensed tannins (TANc) and in vitro digestibility of the leaves were thus supplemented by including new essences and considering not only the leaf but also the young stems or twigs also consumed by animals.

Surveys of breeders allowed us to approach some notions of productivity and input to animals. Thus, mulberry trees in the south of France can provide supplements after summer pastures in late August and autumn (between 10 and 20% of the ration). However, there are no production tables for trees that are regularly reclaimed or topped, for example, and for the multitude of woody species that can be grazed. The RAME project proposes to integrate the tree as a full-fledged forage production workshop, and not as a supplement.

Various tree schemes have been evaluated, with several species including white mulberry or common ash. During the first two years, performance measures declined by management mode were carried out (aligned pollarded trees, inline coppice with different densities, short pruning or goblet driving). Measured production per hectare ranges from 1 to 4 tonnes of DM/ha/year, without the additional herbaceous production. This production is found to be rich in Total Nitrogen Materials (between 10 and 15%) and mineral elements, with digestibility rates sometimes higher than conventional forages (above 80%). These results show that well designed and managed agroforestry systems are a credible solution to address climate change adaptation challenges for livestock producers.

Based on the study of the forage potential of trees, the project has launched co-design workshops at the farm level, involving researchers, advisors and breeders, to imagine agroforestry schemes for the production of a tree fodder resource to increase the climate and technical-economic resilience of ruminant livestock systems (sheep, cattle, goats).

The challenge now lies in the large-scale launch of forage analyses of agroforestry systems, like any conventional forage crop, to account for the impact of pedoclimatic contexts and practices, on the quality and yields of leaves based forage. In parallel, initial progress is being made to facilitate the integration of the tree workshop into the forage management of the farm (leaf harvesting, mechanization, optimization of costs and working time).

Keywords
Fraxinus, fodder trees, milk, Mulberry, herbivores, small ruminants, adaptation

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The Effect of Tree Presence on Forage Nutritive Value: A Systematic Review to highlight Water, Light, and Nutrient Competition and Livestock Management within Agrosilvopastoral Systems

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Livestock systems are essential to provide agroecosystems services and livelihoods for numerous families and communities worldwide. However, when not managed correctly, livestock systems can negatively impact the environment. In particular, greenhouse gas (GHG) emissions contribute to global warming, highlighting the need for sustainable management practices. In this context, feeding management and feed nutritive value play a crucial role in limiting the GHG emissions of livestock (FAO 2023). The challenges lie in advancing current knowledge on the environmental sustainability of livestock production in agroforestry systems.

The main aim of this study is to provide a general overview about the effect of limiting water, light, and nutrient availability in agroforestry systems on forage nutritive value in studies carried out around the world through a systematic review of the literature. To perform this systematic review, PRISMA checklist was applied (Page et al. 2021), and the information was obtained from the selected 5 reviews, 4 meta-analyses, and 123 research articles that consider forage quality and production.

Firstly, the existing literature on the impact of light availability on forage quality in agroforestry systems has been thoroughly reviewed through meta-analyses and reviews. In summary, existing reviews and meta-analyses provide valuable insights into the effects of light availability on forage quality, while controlled and landscape-level studies underscore the complexity of these interactions, emphasizing the need for considering both production and quality aspects in diverse environmental conditions.

Research studies conducted in continental climates have predominantly employed a combination of grass and legume forage species, such as Trifolium spp., Lolium spp., Dactylis glomerata, Bromus inermis, and Festuca arundinacea. Investigations into silvopastoral systems involving walnut and honey locust reported a positive impact of up to 40% shade on forage production and quality (Pent et al. 2020). However, excessive shading has been observed to enhance nitrate levels in grasses, influencing animal performance, so management practices like tree thinning are necessary to increase light availability. Generally, silvopastoral systems have demonstrated comparable forage nutritive values to conventional systems.

In Europe (Ehret et al. 2018), studies including L. perenne and Trifolium spp. mirrored USA findings, with 80% shade halving biomass but no significant effects on forage quality within the first three years when the light is not a limiting factor. Livestock studies emphasized shade benefits in temperate climates for animal welfare, suggesting a positive role of silvopastoral systems within rotational grazing management. Bromus inermis and Dactylis glomerata were deemed suitable for shade conditions, while the use of legume alone, like Medicago sativa, proved less favourable. Management practices, including tree thinning and the use of fertilizers, were crucial for the long-term profitability of silvopastoral systems.

The systematic review unveiled diverse research priorities worldwide. In South America, studies mainly focused on a few grass species in agroforestry systems, emphasizing profitability and animal performance. African research centred on understanding tree-grass interactions to enhance soil fertility and restore dry rangelands. North America, Europe, and Australia, with temperate or continental climates, not only studied tree effects on forage quality and production but also considered animal welfare, acknowledging the positive impact of shade on animal performance. Notably, there was a lack of research from Asia indicating potential gaps.

Future research questions emerged from distinct climatic areas. In tropical regions, there's a need to explore the potential use of local tree species, assess the benefits of intercropping legumes with grasses, and investigate the consociations of other tree species with forages. In dry savannas, research could focus on fertilization and grazing management to enhance forage quality under shade conditions. In temperate and continental climates, long-term studies are crucial to understanding optimal management practices for sustained profitability. The challenge lies in managing rotational grazing to maximize benefits from shade use.

In conclusion, the systematic review often identified a neutral or positive impact of trees on forage in agrosilvopastoral systems. In some cases, forage biomass reduction was attributed to light availability, competition for nutrients, and, in arid climates, exacerbated by drought. Nitrogen and protein content increased in grasses, while legumes experienced a decline in crude protein under shade. In agrosilvopastoral systems, planning and grazing management are pivotal, and tree orientation, thinning, and pruning were identified as critical factors for long-term success. Consideration of shrubs and tree leaves and steam as fodder in future reviews could further enhance the understanding of global forage availability and quality in agrosilvopastoral systems.

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Keywords
forage, light and water competition, grazing, grazing livestock, forage production and quality, Forage monitoring

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Nutritive value of Alnus viridis leaves and nitrogen translocation by Highland cattle in Alnus viridis-encroached pastures

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Introduction

Alnus viridis is a shrub species that has been increasingly spreading in many European mountain chains. This nitrogen-fixing species has triggered negative agro-environmental impacts, such as a loss of agricultural land and biodiversity, as well as an increase in nitrogen (N) leaching and soil acidification. Targeted livestock management systems have been recently investigated to reduce its encroachment, since some robust livestock breeds are able to feed on A. viridis leaves, thus reducing its cover and creating a mosaic of pasture and shrub patches. Among cattle breeds, Highland cattle can feed on a higher proportion of woody species compared to production-oriented breeds. Moreover, other studies have shown that N balance across pastures can be actively affected by livestock grazing through N ingestion and excretion.

Objectives / research questions

The aims of this study were to assess: 1) the temporal variation of A. viridis leaf feed value along the grazing season and 2) the pasture use by Highland cattle and their N translocation from A. viridis-encroached areas to adjacent open pastures.

Methodology

A. viridis leaves were collected three times during the grazing seasons of 2020 and 2021 (in June, July and August), in four highly encroached sites across Italy and Switzerland, at similar elevations and with varying pedo-climatic conditions. Based on the data collected by meteorological stations, the sum of temperatures was calculated for each site. We measured the functional traits (specific leaf area and leaf dry matter content), nutritive value (macro- and micro-elements and fibre content) and phenolic content of the leaves. The in vitro organic matter digestibility (IVOMD) and related gas emissions (CO2 and CH4) were also investigated using a ruminal incubation system, with a diet composed of A. viridis leaves and hay in 1:4 ratio in the DM.

In 2019 and 2020, two Highland cattle herds equipped with GPS collars were placed in four A. viridis-encroached paddocks, which were representative of an A. viridis cover gradient. Using cattle GPS locations and collar activity sensors, livestock activity phases (grazing and resting) were discriminated. From 11 to 24 herbaceous samples for each paddock were collected in multiple homogeneous vegetation patches before grazing. Cattle dung pats were also sampled throughout both seasons every 10 days. The N content of all vegetation and dung pat samples were then measured.

Direct observations were carried out to explore the diet composition of Highland cattle. Based on these data, N ingested by cattle was estimated considering a diet characterized at 88% by herbaceous vegetation and 12% by A. viridis leaves from vegetation patches that were visited and grazed by cattle during 24 hours before dung sampling (N24H). Finally, the N translocation produced by cattle was estimated as a N flux in each vegetation patch through the estimations of N ingestion and N excretion (urine and dung) during the season. The estimation of urinary N excretion was made using literature data from studies carried out in similar environmental conditions and with similar cattle type.

Results

Leaf functional traits and all macro- and micro-elements significantly varied during the season, with similar decreasing patterns in leaf N, P, and K values. Contrarily, leaf Ca and Mn significantly increased through the summer. Leaf N and P were on average of 32.1 ± 0.36 g.kg-1 DM and 2.3 ± 0.07 g.kg-1 DM, respectively. On the other hand, leaf neutral detergent fiber, acid detergent fiber, and acid detergent lignin significantly increased during the season. Phenols did not show a significant seasonal trend except for condensed tannins, which slightly increased along the season. Including A. viridis leaves in cattle diet reduced OM digestibility and CH4/digested organic matter (dOM) emissions compared to a control diet of 100% hay.

The N content of herbaceous vegetation was significantly higher in A. viridis understory areas compared to adjacent open pastures, due to the nitrophilous habitat created by soil N accumulation. The average N content in Highland cattle dung pats (31.2 ± 3.4 g kg-1 DM) was higher than average values from literature on grazing cattle under crude protein rich diets. The N dung content was marginally affected by N24H, with higher dung N values when Highland cattle grazed in the most N rich areas. Finally, most of this N (29.5 ± 10.3 kg ha-1 yr-1) was redistributed across the pastures, and actively translocated from A. viridis-encroached and steep areas towards resting areas, which generally occurred on flat open pastures.

Conclusion
These results highlighted 1) the potential of A. viridis leaves as a valuable forage resource and identified the beginning of the summer season as the ideal grazing period and showed that 2) Highland cattle can effectively translocate part of the ingested N from A. viridis-encroached towards open areas. Therefore, they could help defining targeted management strategies for silvopastoral systems to increase beef cattle productivity, while reducing greenhouse gas emissions and controlling A. viridis-encroachment.

Keywords
grazing livestock, silvopastoral systems, fodder trees, forage production and quality, silvopastoral grazing impact

2.2 Silvopastoral Systems

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Sheep and Wool – Implications for Europe's Farms, Land and Livelihoods

Jeannette Cook[1], Ms Dalena White[1]
1 International Wool Textile Organisation (IWTO), Brussels, Belgium

Around the world, sheep supply meat, milk, and wool. Wool sheep are often a choice for land on which more profitable crops like wheat, rice or maize cannot be grown.

Although wool us only 1% of the overall global fibre market, sheep and their wool are extremely important to the livelihood of small farmers and rural communities.

Sheep also have an important role to play in the environmental health of farms and pastures. Sheep have the potential to contribute to positive carbon sequestration (50% of the weight of clean wool is biogenic carbon), improved soil (through regenerative agricultural practices) and increased biodiversity.

These benefits can be brought to European agricultural systems, including agroforestry and silvopasturage.

Sheep Traditions:
Traditional agroforestry with sheep can be found everywhere where you find heather landscapes in Europe. The „Lüneburger Heide" is famous for the heather landscapes and shepherds are being paid for to maintain it.

Elsewhere, across the Mediterranean countries, recognition for systematic grazing of sheep and goats in forests, for the prevention of wildfires, is growing.

Innovation: Sheep for Sustainable Forest Regeneration
A new approach to a familiar challenge brings sheep into reforesting harvested areas. Traditionally, herbicides are used to control unwanted grasses, but these methods raise concerns about environmental impact.

Young trees can struggle to survive, choked by fast-growing grasses. Recent studies show a decline in reforestation success due to this competition.

A 5-year pilot project launched in 2020 in partnership with the University of Alberta and a silviculture forester with Weyerhaeuser (a lumber company), is currently collecting data involving 5,000 sheep who graze harvested areas, called cutblocks. The sheep control grass growth, enabling young trees to flourish.

Experienced shepherds, accompanied by trained dogs, guide the sheep through the cutblocks in a rotational grazing system. This ensures the sheep don't overgraze or trample saplings.

Animal welfare is paramount. All necessary precautions are taken to keep the sheep healthy and safe. This includes using guardian dogs to protect them from predators, providing clean and comfortable resting areas, and maintaining a buffer zone from wild sheep populations to prevent disease transmission.

The benefits: reduces reliance on herbicides, creates new jobs for shepherds, contributes to the local economy.

The project is collecting data to evaluate the long-term effectiveness. However, the initial results are promising.

The project builds on a previous study: Effectiveness of sheep grazing to control competing vegetation in white spruce reforestation (2021). Here, sheep grazing was shown to offer good-to-excellent control of both herbaceous and woody vegetation, provided certain conditions are met: (1) the dominant vegetation must be palatable to the sheep, (2) the large- and small-scale topography must be relatively even, (3) the treatment must be carried out before the crop trees become severely suppressed or damaged and (4) the animals must be effectively supervised.

Innovations: Wool as a Substitute for Substrates
In New Zealand, sheep's wool is providing a solution to supply chain challenges for indoor growers and nurseries. Due to its biodegradability properties and the advantage of having a local supply, New Zealand wool is being used as a substitute for substrates. Fleecegrow developed a successful research prototype

with tomatoes and strawberries. Fleecegrow aims to design a product line and investment opportunities to launch in 2025.

Related: A study from the University of Guelph (Canada) on benefits of sheep grazing cover crop ahead of corn in rotation and the benefits to the soil and corn crop.

Sheep Grazing at Solar Farms

Farmers Janna and Ryan Greir's of Whispering Cedars Ranch in Strathmore, Alberta use sheep to maintain the land around solar energy panels. Their ranch now runs 400+ sheep to maintain the vegetal growth around the solar panels and provide wool. More information, including data, is forthcoming.

Land management with Sheep

Ecopaturage Le Biquette is a not-for-profit organization which grazes sheep in public parks in Montreal. Sheep are turned out in rotational grazing daily and brought into a barn at night. A senior supervisor guides volunteer shepherds.

Here, sheep not only tend the land but provide an educational opportunity. The parks where the sheep graze are urban and it can be many people's first exposure to sheep and wool.

We are currently researching more examples which integrate sheep into agroforestry and silvopasturage.

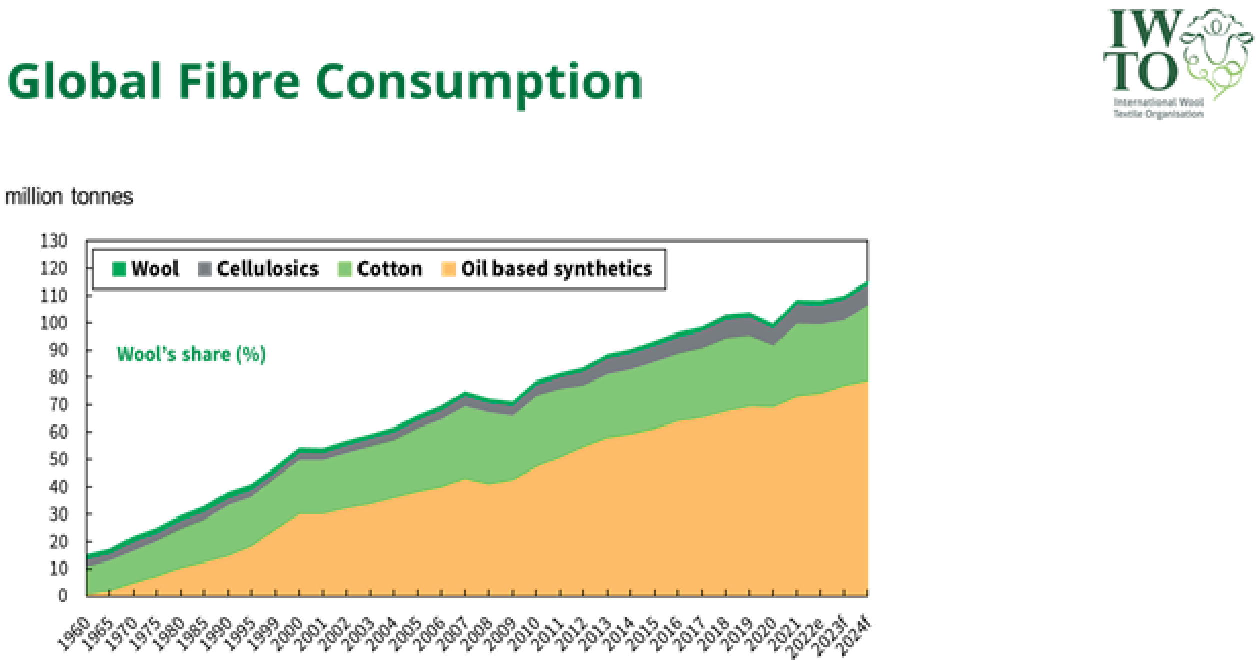
The International Wool Textile Organisation, the IWTO, was created 95 years ago to manage trading standards for wool.

We firmly believe that sheep and their wool can support the aims of the EU and its Green Deal: wool is naturally circular, naturally biodegradable; and does not contribute to microplastic pollution. We are in the process of confirming, through scientific research, the role sheep play in regenerative agriculture and carbon sequestration.

This should present an excellent opportunity for wool, irrespective of breed or micron.

Keywords
Fire protection, sustainability, grazing, agrisilvicultural systems, grazing livestock, silvopasture, sheep, small ruminants, aboveground carbon sequestration, ruminants, agroforestry monitoring

Aditional Attachment II.



Source: IWTO Market Information Edition 18

Study on the acceptability of a goat cheese from an integrated goat rearing hazelnut-orchard system

Professor Carlo Cosentino[1], Dr Anna Maria Rufrano[1], Dr Maria Caramuta[1], Dr Luigi Vergura[1], Dr. Rosanna Paolino[1], Dr. Simone Fedeli[2], Dr. Pietro Viola[2], Professor Pierangelo Freschi[1]

1 University of Basilicata, Potenza, Italy

2 Project partner companies, Potenza, Italy

Introduction

This study is part of a broader study (Cosentino et al., 2020a,b) to evaluate an agroforestry system and specifically addresses the use of a hazelnut orchard ground cover to he grazing of lactating goats of the "Facciuta Lucana" breed. This local breed, recognisable by the two white stripes on its mouth, is mainly found in the Basilicata region. As part of an innovative approach, the perisperm of the hazelnuts served a dual purpose: on the one hand, as a component of supplementary feed for the goats and, on the other, as a refining agent, infused with grappa or Marsala wine, in the production of cheese from the milk of these local goats. The acceptability of these two differently refined cheeses was evaluated in a consumer test.

Case description:

The twelve lactating goats utilised in the experiment were reared in an agroforestry system (pasture in inside the pasture grove - fig.1) and fed supplement for 15 consecutive days with 800 g/head/day of concentrate consisting of the following components: maize 38%, barley 15%, dried pea, oat mixture 15% and hazelnut cuticle 20%. On the hazelnut cuticle the following parameters were determined: Crude protein (Kijeldahl method) 9.0 g/100 g, crude fibre (NIR) 19.0 g/100 g, ether extract (NIR) 15.1 g/100 g. The goat milk samples were collected by mechanical milking, cooled at 4°C and immediately transported to the laboratory for analytical determination of the following parameters: pH (pH metre HI931410, Hanna Instruments, Padua, Italy), protein, fat and lactose (ISO 9622:2013/IDF 141:2013), total viable bacteria count on agar (ISO 2293), somatic cell count (IDF 148-2:2006) and freezing point (IDF 108:2009). Milk had the following characteristics on day 15: (g/100g) dry matter 13.5; ash 0.70; fat 4.50; protein 4.10; lactose 4.65; (cell/ml) somatic cells 410,000; (UFC/ml) bacterial count 546,000; inhibitor search absent; (mC) freezing point -550; pH 6.55. The milk was pasteurised at 65°C for 15,' then cooled to 34°C and subsequently inoculated with lyophilised lactic acid bacteria starter cultures of Lactococcus lactis subsp. lactis and Streptococcus thermophilus (6 g/hL; FL 058, Prodor, Piacenza, Italy) at a temperature of 42°C. After 15', calf rennet (activity 1:10000; chymosin/pepsin 80:20; Santamaria, Burago di Molgora, Italy) was added a rate of 1 ml in 10 L of milk. After 30' of coagulation, the curd was broken and rested under the serum for 10', then the curd was collected and pressed into perforated moulds. The cheeses in the moulds were placed in a steaming vat at 25-27 °C and a pH of 5.20 for 10 h. After the cheese had drained, it was turned over using slight dry salting (2-3% NaCl, pH 5.20). Ten moulds (fig. 2), weighing 500 g, divided into groups A and B, were refined with a blend of hazelnut of perisperm and grappa (A) or marsala wine (B). The cheese was ripened for 30 days in a maturation room at 10 °C and 70% RU. The experimental procedure was carried out in duplicate following the same protocol to avoid environmental influences. The acceptability of cheeses was evaluated by 47 habitual cheese consumers (58% males and 42% females, aged 25-51 years). Cheeses A and B were cut into 20 g samples, coded with a 3-digit series, kept at room temperature for 1 h, and then randomly served to consumers who rated the following sensory parameters: colour, odour, flavour, texture and overall liking, using a 9-point liking scale (1= extremely unpleasant to 9 = extremely pleasant). The consumer test was carried out in individual cabins. The data were analysed using One-WAY ANOVA, and the mean values were compared with Tukey's HSD.The chemical composition of cheeses refined in a mixture of hazelnut perisperm and grappa or marsala showed no significant differences (in A and B respectively: dry matter 54.40 vs 54.59; protein 41.87 vs 41.85; fat 52.19 vs 52.23; ash 13.16 vs 13.13; Polynsatured 0.84 vs 0.89). Acceptance of cheeses aged in a mixture of hazelnut perisperm and grappa (A) or Marsala wine (B) (mean±DS) was, respectively: Color 7.08±1.00 vs 7.06±1.06, Odor 7.25±1.20 vs 7.32±1.24, Flavor 7.00±1.60 vs 7.01±1.33, Texture 7.01±1.33 vs 7.04±1.45; Overall liking 7.51a±1.42 vs 7.09b±1.25.

Conclusion

This study underscores the viability of integrating agroforestry systems in goat husbandry for cheese production, specifically focusing on a local goat breed. The findings highlight the potential of agroforestry systems in enhancing sustainability and product quality within traditional farming practices. Emphasizing the importance of local breeds and agroforestry synergies, this research contributes to the promotion of environmentally resilient and economically viable approaches in Southern Italy's goat farming.

Acknowledgment
PSR Basilicata Region 2014/20 Mis. 16 – Sm. 16.2 Project Corilus 2; Rete di Impresa Basilicata in Guscio.

Keywords
Agropastoral farming systems, hazelnut, milk, cheese, grazing

Aditional Attachment II.

Figure 1. Goats of the 'Facciuta lucana' breed grazing in the interfiles of a hazelnut orchard.

Figure 2. Goat cheese refined with flavoured (grappa or Marsala wine) hazelnut perisperm.

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Influence of hedgerows distance and orientation on grass production and quality under contrasted climatic conditions

Mr. Thiery Tanguy[1], Dr. Dufrasne Isabelle[2,3], Czaplicki Sébastien[2], Hornick Jean-Luc[3], Dr. Géraud de Streel[4]

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Introduction

Agroforestry is encouraged in agroecological systems as it could improve their performances and resilience. However, some breeders are reluctant to plant hedges despite the advantages they provide. These farmers fear a reduction in grass production due to competition effects.

Objectives

The present trial aimed to provide data related to the influence of hedges on grass production and quality. More specifically, we investigated the simultaneous influence of orientation and distance from hedgerows on grass biomass and composition under contrasted climatic conditions.

Materials and methods

For this trial (conducted from 13/06/2022 to 09/08/2022), six fenced plots were placed along two-branched hedges in pastures grazed by cows. Hedgerows were located East, West and North of the plots with two replications per orientation. Biomass production and grass quality were checked twice : 11/07 and 09/08 at four distance on each plot. Measurements were conducted over two periods : 13/06-11/07 and 12/07-09/08. For the first period, the climate conditions were favorable to grass growth (43mm precipitations and average min/max temperatures: 12.4°C and 23.1°C), while they were unfavorable during the second period (15.9mm precipitations, average min/max temperatures: 14.5°C and 26.6°C). For the first period, grass was also sampled to determine chemical composition. Parameters measured were : grass composition in water soluble carbohydrate (WSCH) and crude protein (CP), crude fiber (CF) in the dry matter, and feeding values (digestibility, energy value (VEM, Voeder Eenheid Melk), digestible protein (DVE - darn veerbaar eiwit)) and degraded protein balance (OEB, Onbestendige Eiwit Balans).

Statistical analyses were carried on with R4.2.2. Anova models have been setup for biomass production and grass chemical composition, considering the fixed effects of orientation and distances. Ttests, for data with normal distribution, Wilcoxon tests and Krustal Wallis tests for non-parametric set data, have been used to compare the means.

Results and discussion

Unsurprisingly, grass biomass was significantly higher for the first period compared to the second one (100,8 ± 44,7 vs 27,8 ± 15,8 g m2-1 ; P <0,001). Grass biomasses are given in Figure 1 for each period, orientations and distance. Orientation had a significant effect : East and West orientations allowed higher biomass production than South one, probably due to better solar irradiation (P<0.05). There was no effect of distance alone but significant interaction effects have been observed between distance and orientation (P<0.01). A significant interaction between period and orientation has also been noticed (P<0.01). For period 1, South orientation biomasses increase at further distance and were lower for each distance compared to other orientations. East orientation seems to favor grass growth overall at 20m (P<0.01). Grass biomasses at West were highest than other orientation at 5m and remained constant until 20m and increased at 30m to reach East biomass. For period 2, South orientation biomass was the lowest at every distance, except at 5m where they were higher than other distances (P<0.05) and similar to East orientation biomass at 5m. For East orientation, biomass increased progressively away from the hedgerows. Contrarily, for West orientations, biomass decreased away from the hedgerows to become similar to those of North orientation at the same distances. Although data on hedgerow influence on grass growth for different orientation and distances is scarce, several studies have demonstrated similar patterns of crop performance under hedgerow influence with increasing yields at higher distances from the trees and stronger impacts on crop growth for Est-West tree rows orientation (Dupraz et al. 2018, Heimsch et al. 2023, Van Vooren et al. 2018). The difference on hedgerow effects under contrasted climatic conditions might be caused by shading and microclimatic effects (Quinkenstein et al. 2009) and demonstrate how agroforestry systems can be source of resilience for the production by mitigating extreme climatic effects.

The grass chemical composition shows a good quality and appears to be compatible with the requirements of dairy cows (table 1). CF content was significantly higher at 5m than at 20m and 30m (211 g vs 196 g kg-1: P<0.05). There is a tendency to have lower DVE value at 30m compared to 10m and 20m (P<0.10). CF, WSCH, DVE, VEM and digestibility were lower for grass located at West of the hedgerows (P<0.05). It could be attributed to a lower exposition to solar luminosity.

Conclusion

From these results, it can be concluded that distance to the hedgerow alone is insufficient to predict trees influence on the meadows. Hedgerows influenced grass production with different results depending on the orientation and growing conditions. South orientation had a negative impact when the weather was favorable probably due to the shadow effect but can protect grass in hot and dry condition. Grass quality was generally high whatever the distance and the orientation. However, at West orientation grass quality seems to be lower. These results must be confirmed and explained by other parameters as soil humidity and temperature or solar irradiation measurements.

Keywods

grass quality, grass biomass, Belgium, orientation, hedgerows, quality, agroforestry practices, grassland, distance, climate mitigation, temperate agroforestry

Aditional Attachment I.

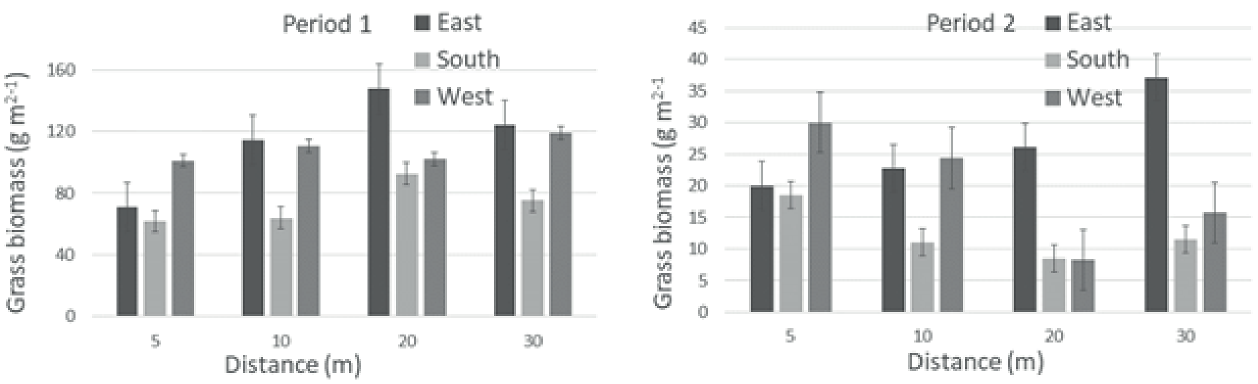

Figure 1. Grass biomass for each orientation and each distance from the hedgerows for cuts 1 and 2.

Table 1. Grass chemical composition and feeding values at different orientation of the hedgerows (cut 1).

	Orientation of the hedgerow			SEM	P value
	East	West	South		
CP (g kg-1)	211.4	202.1	204.8	6.41	0.60
CF (g kg-1)	198.6a	208.0b	195.1a	4.39	0.09
WSCH (g kg-1)	87.0ab	78.6a	97.1b	8.60	0.31
DVE (g kg-1)	98.4ab	96.8a	99.4b	1.10	0.12
OEB (g kg-1)	51.4	43.3	43.0	5.58	0.55
VEM	978.1ab	968.5a	992.9b	6.17	0.06
Digestibility (%)	80.8a	79.1b	81.3a	0.61	0.05

CP: crude protein; CF : crude fiber; WSCH :water soluble carbohydrate expressed in the dry matter, VEM : energy value; DVE : digestible protein; OEB: degraded protein balance

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DairyMix: circularity and sustainability of crop-livestock-forestry systems for dairy production in Europe and Latin America

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Introduction

Dairy production systems (DPS) produce high quality protein and organic fertilisers by converting fibrous resources that cannot be utilized by humans. However, they heavily rely on external inputs, thus meeting a desirable level of circularity only to a limited extent. Dairy production is the agricultural sector where region-specific concepts are most prominently required and where the opportunity to develop circular mixed farming systems is evident, though not sufficiently implemented. DPS can provide valuable ecosystem services through their direct interaction with land, vegetation, soil and habitat, but most are very specialized and based on few crops. Livestock production has become increasingly de-coupled from crop production, and the trend in eastern and western EU countries is not yet changing (Garrett et al. 2017; Animal Task Force, 2021; Ghimire et al. 2021).

There is a clear need for more circularity in agricultural systems and improved economic viability of mixed farming systems. Agriculture needs transformative processes, using systems thinking approaches, to integrate crop and livestock production in the circular economy. It is essential that holistic concepts are developed to ensure sustainability of the sector, and to assist farmers and stakeholders in making knowledge-based decisions (FAO 2018). Agroforestry practices are a key avenue to help the European Union achieve more sustainable agricultural production methods. These practices can contribute to reducing the climate footprint of agricultural production, and achieving other positive effects, such as reduced N leaching, increased ecosystem services, optimized radiation use efficiency and more fertile soil. Fodder trees and shrubs on a dairy farm can provide an additional source of forage, and can also enhance animal welfare by providing shade to livestock during periods of hot weather (Novak 2016; Kraft et al. 2021).

Case description

The "DairyMix" project (www.dairymix.eu) aims to support a more sustainable and circular mixed farming system for dairy production, by defining region-specific concepts for sustainable and circular mixed and integrated crop-forestry-livestock systems in key European areas and in Latin America.

To achieve this goal, dairy farm typologies for integration of crop and livestock production across Europe are assessed, through the collection of data from a wide range of mixed crop-dairy case study farms, which will examine the inflows and outflows of C and N. These case study farms were selected to represent different pedo-climatic operating conditions in Europe, as well as varying levels of crop-livestock integration. The modelling approaches utilized in the DairyMix project are aimed to provide a toolbox of impact mitigation and system diversification options for farming systems for dairy production. Multi-criteria assessment is carried out under a systems thinking approach, evaluating synergies, trade-offs and the linkages of sustainability, circularity and nutrient use efficiency with the economic performance and social sustainability. DairyMix is also developing solutions to enhance the sustainability of mixed systems for dairy production through agroforestry. These include: 1) identification and suitability assessment of tree species for fodder use, 2) identification and assessment of the farm-based agroecosystem services, and 3) scenario analysis on GHG emissions and C sequestration.

Conclusion

The results from this project will be incorporated into the DairyMix online platform, that will build on the information platform created within the EraNet project "MilKey" (www.milkey-project.eu). Results from the multi-criteria assessment will be displayed, allowing the users to evaluate the effect of varying the weights of each factor considered. The platform will also report the modeled effects of mitigation measures and alternative cropping scenarios in representative DPS across Europe and Latin America. In contrast to "one--fit-all" solutions, the DairyMix interactive platform will present a range of options for the sustainability of dairy production, enabling stakeholders, farmers and policy makers to make informed decisions for circular and integrated crop-forestry-livestock systems in their regions.

Acknowledgements

This project is funded by several national funding agencies under the Joint Call 2021 ERA-GAS, ICT-AGRI-FOOD, SusCrop and SusAn on "Circularity in mixed crop and livestock farming systems, with emphasis on greenhouse gas mitigation". Project coordination is funded by the German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE) (DairyMix, grant number 2822ERA15A).

Keywords

crop-livestock-forestry systems, Socioeconomic status, circularity scenarios, livestock, ICT Platform, modelling, decision tool, milk, mixed farming, agroforestry practices, climate change mitigation, multicriteria sustainability assessment, fodder trees

Aditional Attachment I.

Farm	Milk yield per cow (l/cow/year)	Total herd (number of animals)	Total UAA (ha)	Type of production
DE-01	6817	185	231	Organic
DE-02	12323	287	74.0	Conventional
FR-01	8395	240	112	Conventional
FR-02	6224	199	118	Organic
FR-03	9210	292	139	Conventional
FR-04	8830	571	227	Conventional
AR-01	7877	214	85.6	Conventional
AR-02	6733	488	41.0	Conventional
AR-03	10621	176	90.0	Conventional
NO-01	7426	107	92.1	Organic
NO-03	8535	81	80.0	Conventional
NO-05	10107	71	56.9	Conventional
PL-U-01	4305	73	42.2	Conventional
PL-U-02	8032	79	90.9	Conventional
PL-U-04	9231	49	22.3	Organic
PL-P-02	10074	186	88.0	Conventional
PL-P-03	9349	325	331	Conventional
PL-P-04	7000	21	50.0	Conventional
IE-01	5118	48	26.6	Conventional
IE-02	5682	229	148	Organic
IE-03	5687	209	155	Conventional
IE-04	7576	580	160.0	Conventional
IT-01	4825	304	134	Organic

Farm	Milk yield per cow (l/cow/year)	Total herd (number of animals)	Total UAA (ha)	Type of production
IT-02	9104	1174	270	Conventional
IT-03	9588	576	140	Conventional
IT-04	12069	248	30.2	Conventional
IT-05	9094	230	51.4	Conventional
IT-06	10064	307	48.0	Conventional

Table 1: Main characteristics of the case study farms surveyed in the DairyMix project

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Productivity assessment of agroforestry system with livestock in Transylvanian depression

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In Romania, permanent grassland covers 4.9 million hectares, ranking fifth in Europe after France, Great Britain, Spain and Germany. About 14% of these are agroforestry systems of livestock farming on grasslands with sparse trees, randomly distributed. One of the most effective measures to alleviate the negative impact of the aridisation and desertification factors of grasslands, is the rational use and exploitation of agroforestry systems with trees, where all components: soil, vegetation cover, trees, animals, habitat, biodiversity are in an optimal ecological and economic balance. In the Transylvanian Depression, in the Dobolii village, Covasna county, a farm with 80 cattle and 15 horses occupies an 39.0 hectares area, an agroforestry systems with two tree species (Quercus petraea, Mattuschka Liebl and Quercus robur, Mattuschka Liebl), more than 150 years old. At a 7 trees/ha density, with an average diameter of 94 cm and an average height of 21 m, under the protection of their crown, the vegetation cover achieves an 16 t/ha annual Green Biomass Production (GMP), with 18.15 content of crude protein (CP) and 27.45 crude fiber (CF), thus a very good digestibility coefficient and forage quality index as pastoral value. The optimal supply in the soil with nitrogen and the other agrochemical components, also the crown shading of the trees and the interaction of all the agroforestry system components, influence the quality of the forage consumed by animals grazing and favour the production of animal products more than 20-40%. The management of the studied agroforestry system is carried out according to the silvopastoral plan, based on the Guide for the preparation of pastoral plans, approved by the Ministry of Agriculture and Rural Development. The agroforestry system with livestock and trees from Dobolii village, although suffering from the threat of rural decline, we believe that through active conservation and maintenance of traditional uses, the productivity and protective characteristics of the agroforestry system in front of climate change, are unquestionable.

Keywords
protection of space, grazing livestock, production systems, Grassland with trees

Decision Analysis and Impact Pathway for Agroforestry Integration on Dairy Farms in the Eifel Region, Germany

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The integration of agroforestry on dairy farms presents a potential paradigm shift in dairy production in the Eifel Region of Germany. Through consultation and interviews with local farmers, foresters and other experts we have developed a decision analysis model to describe the shift from current production to agroforestry on dairy farms and assess the viability of such a change. Our model involves the deliberate integration of agroforestry systems into dairy farm landscapes. As an exemplary case, we modeled short--rotation plantations with poplar trees.

The model expresses the connections between differences in the microclimate in an agroforestry system compared to grassland influenced by temperature, wind and radiation. It includes the protective function of trees for animal health. Trees can promote the health of diary cows by enhancing resilience against extreme weather and protects from sun radiation.

The model components capture the economic investment required for successful agroforestry implementation. Including agroforestry establishment and managing fields grazed by dairy cows.

Our model addresses the importance of aligning agroforestry practices with established economic models. The long-term value generated by agroforestry practices is also determined by risks associated with trees, milk production and discount rates on the overall capital value. The economic viability of agroforestry on dairy farms hinges on factors such as product prices, milk yield assurance, and the availability of financial support. Our mode evaluates the importance of efficient planning, machinery, and the care of trees.

We generated an impact pathway of the decision problem of integrating agroforestry in dairy farms. Positive connections signify synergies and beneficial relationships between components. Negative connections indicate areas where challenges and drawbacks may arise. The model provides a holistic understanding of how different elements interact within the agroforestry framework. Our model addresses the challenges faced during the implementation of agroforestry on dairy farms. Farmer adoption is a complex process influenced by various factors, including the planning of fences and trees, the selection of tree planting material, and the ongoing care of trees. Our model highlights the need for planning ahead and properly handling dairy animals to ensure successful adoption.

Integrating agroforestry on dairy farms in the Eifel Region, Germany has potential but also possible trade-offs for farmers. Our decision analysis approach offers a robust framework for understanding the dynamics involved in this transformative agricultural practice.

As agroforestry gains momentum as a sustainable solution, our model serves as a valuable tool for policymakers, farmers, and researchers alike, offering insights into the challenges, successes, and potential pathways toward a more resilient and diversified dairy farming future.

Keywords
decision analysis, agriculture, Socioeconomic status, Grassland with trees, grazing livestock, Poplar, Germany, livestock health

Additional attachement

impact pathway for agroforestry on a dairy-farms with grazing

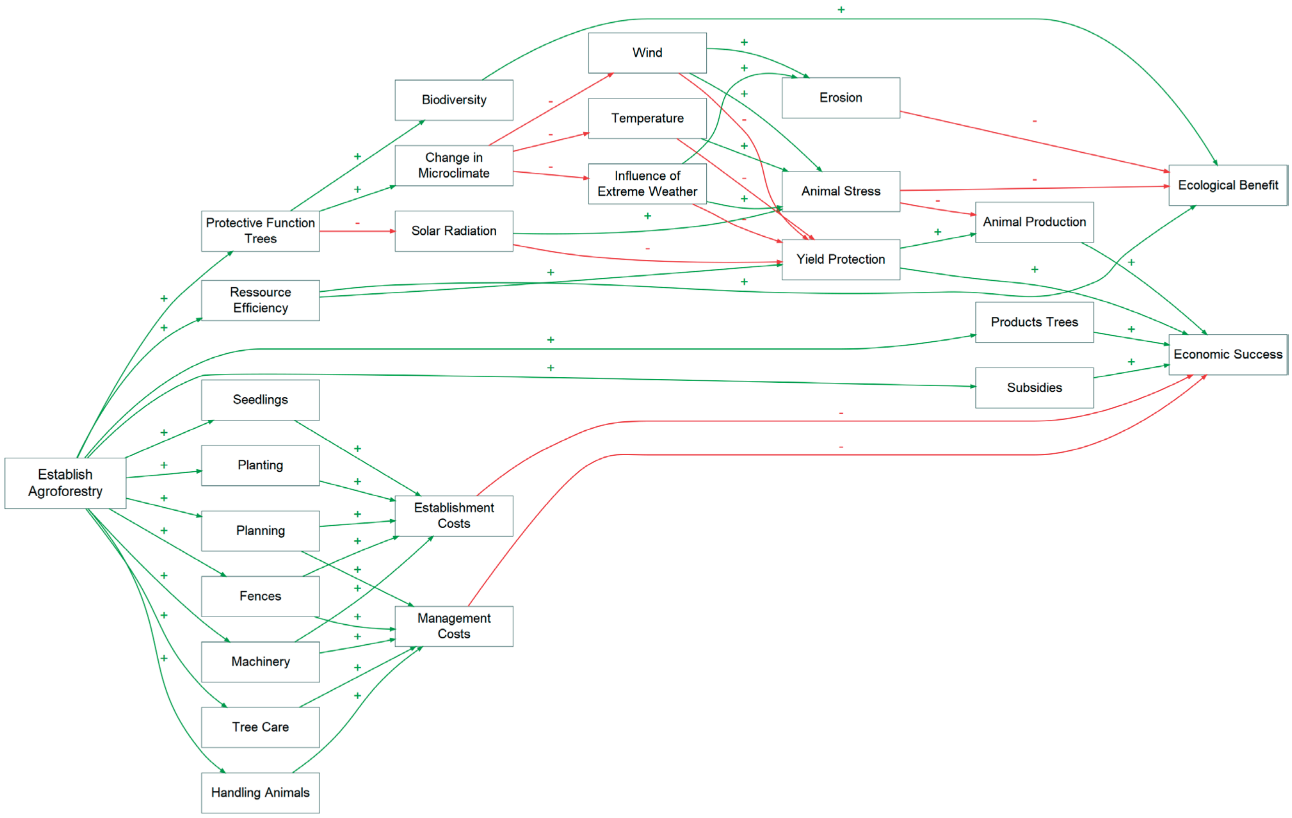

Figure 1: impact pathway for establishing agroforestry on a dairy farm; a node (1st) pointing at another node (2nd) influences the 2nd node; a green arrow marked with a "+" describes a proportional relationship; a red arrow marked with a "-" describes a disproportional relationship

Agroforestry systems for successful bee keeping. The case study from Lubelskie region in Poland

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2 Oxford University, Oxford, United Kingdom

3 Fundacja Korowód, Lublin, Poland

Honey bee is a key element in crop production, especially through pollination. The Lublin region is one of the Polish regions where beekeeping is very well developed. One of the best beekeeping schools in Europe has been operating there since 1945 - the Beekeeping Technical School in Pszczela Wola along with the beekeeping open-air museum. In Lubelskie voivodship the first agroforestry apiary in Poland named Lubelskie Zioła has been established in Sosnówka. The region has 10 190 registered apiaries with over 260,000 hives throughout the voivodeship. The Lublin region produces 14-17% of national honey production, which is approximately 2-3.4 thousand tons.

Currently, the number of apiaries is so large that in some places there is talk of an overabundance of bees - there are too many bee colonies compared to the available nectar and pollen. This is due to monoculture cropping system. Despite honey bee is a key element in crop production, especially through pollination, experts suggest reducing the number of bee colonies in the Lublin region or at least maintaining their number at the current level.

In the past Polish beekeeping has been forest as well as agricultural based. From the beginning of XX c. mostly cultivated areas are used for honey production. Since honeybees are entirely dependent upon flowering plants for their food requirement efficient beekeeping requires supply of both nectar and pollen in adequate quantities. This work examines agroforestry methods of increasing supply of nectar and pollen in agroforestry farm Lubelskie Zioła.

Agroforestry system on this farm has been design with an apiary as a key element of the whole food production model. The following crops are grown on the farm in the alley system: elderberry (Sambucus nigra L.) with lungwort (Pulmonaria obscura Dumort .), elderberry (Sambucus nigra L.) with forest speedwell (Veronica Officinalis L.), variety rugose rose (Rosa rugosa Thunb.) with cloudberry (Rubus chamaemorus L.), elderberry (Sambucus nigra L.) with the cabbage thistle (Cirsium oleraceum (L.) Scop.) as well as phacelia (Phacelia Juss.). Additionally over a hundred melliferous species grow in several forest gardens on aproximately 3 ha across the farm.

The research shows that the proper management of bees, honey production and agroforestry food production benefits the farmer (increased yield of shrubs and fruit trees), the bees and increases the honey production by over 30% as well as its quality and market value. Incorporation of good bee floral trees in Agroforestry system (alley cropping and forest gardens) is beneficial for gaining higher productivity. Specific species cultivated on the farm contribute economically to the honey productions besides their other economic products. Thus agroforestry provides a unique opportunity to enhance nectar and pollen sources for honey bees and honey production, enhances biodiversity and gives a chance for sucessful sustainable bee keeping development.

Keywords

farmers' motivation, climate, agriculture, climate change, climate mitigation, forest ecosystem, carbon farming, agroforestry value chains, active protection, nectar production, carbon neutral, agroforestry systems establishment, Organic Farming, agroforestry system planning, beekeeping, flowering, farm type, Farmland, Adoption, Socioeconomic status, Agroforestry, organic farm, agroforestry landscapes, agroforestry practices, Agroforestry system, ecological zones

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Production of Dalmatian prosciutto from Black Slavonian pig in a silvo-pastoral production system

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The aim of the research was to define production parameters, technological processes and feeding of Black Slavonian pigs in a silvo-pastoral production system for the production of traditional Dalmatian prosciutto. The Black Slavonian pig is an autochthonous Croatian pig breed, created in the second half of the 19th century in Eastern Croatia, in the region of Slavonia. It was created by crossing the Hungarian Swallow Bellied Mangalitsa and the English Berkshire breed. Later, at the beginning of the 20th century, the American Polland China and the English Large Black breed also took part in the breeding of this breed. The black Slavonian pig is distinguished by its high resistance to diseases and conditions of keeping, and throughout history it was bred mainly on drains and pastures, and during the winter it was kept in oak forests where it was fed exclusively on oak acorns. This breed is especially known for its high-quality muscle and fat tissue, which makes it suitable for processing into traditional pork meat and fat products. Dalmatian prosciutto is a traditional dry cured ham produced in the historical region of Dalmatia, along the Adriatic Sea. Dalmatian prosciutto is produced from the thighs of multi-breed crossbred pigs, fattened up to a body weight of 170 kg and aged 12 months. Fresh hams are salted with sea salt, smoked in cold smoke and matured in specific conditions for 1.5 to 3 years. Dalmatian prosciutto is protected by a designation of geographical origin at the level of the European Union. The research was conducted on 120 fattening piglets of the Black Slavonian breed, of both sexes, which were kept in the traditional way on drains and fed with cereals and green alfalfa, and in the last fattening period lasting 3 months, the pigs were kept in an oak forest and fed exclusively with oak acorns. Pigs were slaughtered in a commercial slaughterhouse at the age of 18 months and an average weight of 145 kg. At the same time, 120 commercial farm-raised pigs used in the production of Dalmatian prosciutto were slaughtered, and a comparative analysis was made of the slaughtering properties of the slaughtered pig carcasses and the technological properties of muscle and fat tissue. Among the meat quality parameters, pH values were determined in musculus semimembranosus (MS) and musculus biceps femoris (BF), using a Mettler MP 120-B device (Mettler-Toledo, Schwerzenbach, Switzerland). The final pH values (pH24) were determined 24 h post mortem at the same locations as pH45. Flesh color (CIE L*, a* and b*, CIE, 2007) was determined using a Minolta CR-410 colorimeter (Konica Minolta Sensing Ltd, Singapore, calibrated against a ceramic white plate (Y = 84.9; x = 0, 32 and y = 0.3381), with a D65 light source and a standard two-stage observer. The color was determined on the muscle section. The release of meat juice was measured according to the EZ drip method (Christensen, 2003). Intramuscular fat of of MS and BF was determined using near -IR FoodScan equipment (Foss Analytical, Hillerød, Denmark). Carcasses of Black Slavonian pigs were statistically significantly lighter (145 kg vs.173 kg; $p<0.01$) as well as the corresponding thighs which were significantly lighter (12 kg vs. 16 kg; $p<0.01$). In terms of qualitative indicators of muscle tissue, statistically significant differences were found between the examined groups of pigs in terms of pH value 45 minutes after slaughter in MS and in BF. The pH value 24 hours after slaughter was statistically significantly higher ($p<0.05$) in the muscle of pigs kept in the silvo-pastoral system in relation to the pH value of the muscle of commercial pigs. Muscle color values (CIE L*, CIE a* and CIE b*) were statistically significantly lower ($p<0.01$), that is, the color of MS and MF was darker in pigs from the silvo-pastoral system. The values of meat juice release in MS and BF 24 and 48 hours after slaughter were statistically significantly ($p<0.01$) lower in pigs from the silvo-pastoral system. Intramuscular fat content was statistically significantly higher in MS and BF pigs from the silvo-pastoral system. Then, the fresh pork legs of both groups of pigs were processed according to the specification for Dalmatian prosciutto, salted, smoked and left for ripening. Prosciutto from Black Slavonian pigs reached full maturity at 3 years of age, compared to prosciutto from commercial pigs whose prosciutto was matured after 12 months. Weight loss during ripening (calo) was significantly lower ($p<0.01$) in pigs from the silvo-pastoral system (29%) compared to commercial pigs (39%). We can conclude that the silvo-pastoral system of keeping Black Slavonian pigs is very suitable for the production of high-quality traditional Dalmatian prosciutto.

Keywords
native breeds, acorn, oak, autochtonous pig breed, prosciutto, production systems, quality, silvopastoral systems

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Costs and Benefits of an Centuries-Old Agroforestry Landscape in the Netherlands

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In the Netherlands, awareness for agroforestry is increasing as a way to address the challenges regarding climate change, biodiversity and environmental issues that Dutch farmers are facing. Hundreds of farmers have started creating new agroforestry systems over the past five years. These pioneering farmers are supported in various ways. However, there are also old cultural landscapes in The Netherlands, where trees and shrubs have been part of the agroecosystem for centuries.

This study focuses on the costs and benefits of one of those centuries-old agroforestry landscapes: the typical bocage landscape of the Northern Frisian Woods (NFW) in the north of the Netherlands. This landscape covers an area of 250 square kilometres and is characterized by the presence of linear woody landscape elements. Alder hedgerows (Elzensingels) are by far the most common linear landscape element in the NFW (ca. 3260 km), followed by woodland banks (houtwallen, ca. 607 km) and hawthorn hedges (ca. 49 km). There are 1950 coppice forests covering an area of 390 ha. Families have been farming in this area for centuries. Generations have learned to use natural elements for agricultural purposes: hedge rows as natural fencing and the protection of livestock against extreme sun, rain and wind. The wood of black alder was used for firewood and utilitarian objects such as brooms and oak peel was used for tanning. In addition, different shrubs provided edible fruits. Nowadays, over 600 entrepreneurs in the region are responsible for the management of these woody elements. In the NSW area, many dairy farms combine trees or shrubs and their management with grassland for their livestock.

The farms in this region distinguish themselves from other Dutch by their level of nature-inclusive farming, biodiversity restoration (the occurrence of target species), carbon sequestration, hours of grazing, region-typical side branches and potentially drought resistance, and nitrogen efficiency. The farmers can count on a high level of social appreciation, however, adequate financial appreciation is often lacking. This raised the question: What are the costs and benefits of this form of agriculture and what can we learn from this for the development of new sustainable agroforestry landscapes?

Together with a group of 40 farmers active in the area, a list of 10 main themes has been identified. Monitoring will take place within these ten themes in the coming years. Within brackets, the methods of monitoring are mentioned.

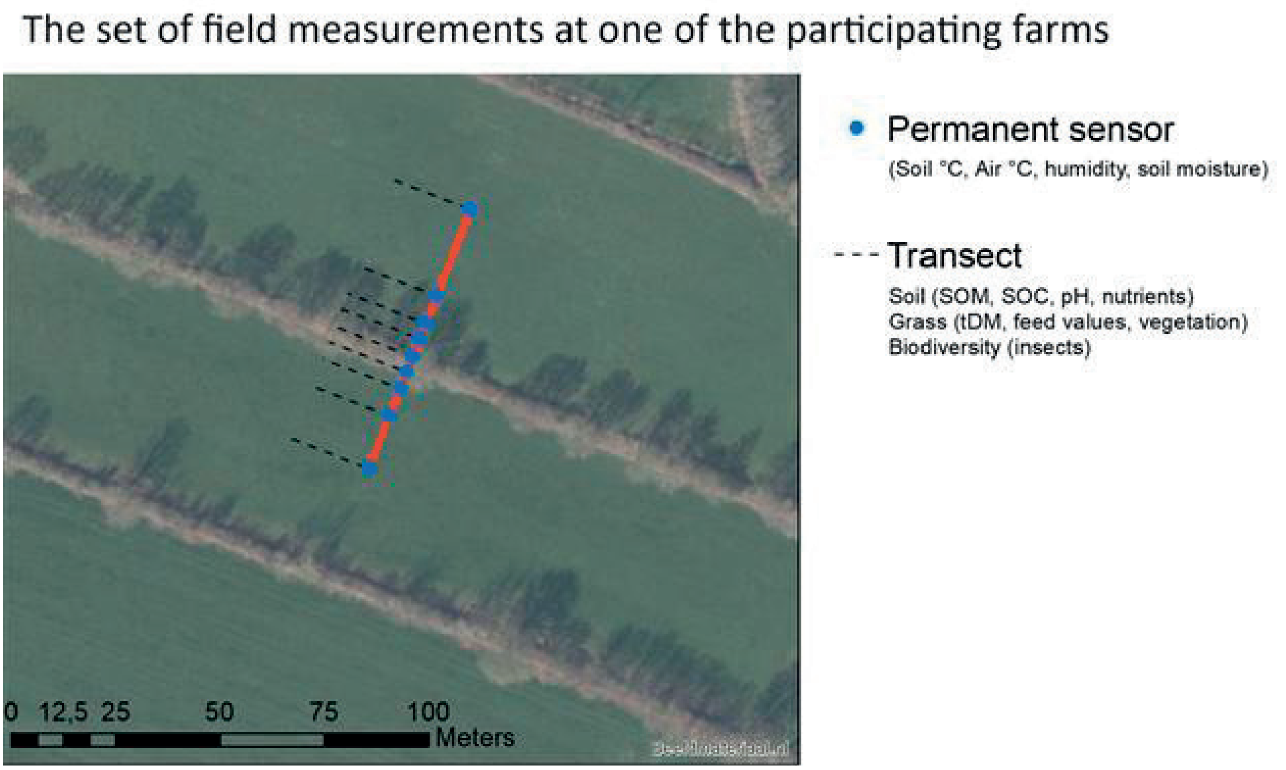
1. Crop yields (grass DM production and feed quality at 4 distances from each side of the trees)
2. Wood production and management of woody elements (cost-benefit analysis based on farm data)
3. Milk production (derived from farm data and literature)
4. Carbon sequestration (aboveground based on earlier measurements and modelling, underground based on soil samples)
5. Animal welfare & health (measuring microclimate aspects, monitoring behaviour, farm data)
6. Biodiversity (hedgerow and grass sword composition and insects in and around the hedgerows at different distances)
7. Nitrogen efficiency (model calculations based on soil and crop measurements)
8. Climate resilience (soil moisture and crop yields)
9. Landscape quality (inventory of tree species)
10. Recreation and education (to be determined)

This approach will provide an overview of the costs and benefits of an agroforestry landscape in the Dutch context. This can be used to develop incentives to maintain productive dairy farming in a small-scale landscape. Moreover, insights will be gained into the effect of woody plants on the dairy farming system, which can be used to develop new sustainable agroforestry systems.

The figure shows a transect of air, soil, grass, and biodiversity measurements taken on both sides of a hedgerow. The centre point of the transect is located in the hedgerow, and subsequent measurements are taken at 1m, 5m, 10m, and the centre of the field (control). For soil sampling, 10 of these transects are realised, totalling 90 measurements. The other measurements will spread out over different locations.

Keywords
silvopastoral, carbon sequestration, agroforestry monitoring, hedgerows, feed value, biodiversity, grazing livestock, agroforestry landscapes, yield, Temperate climate, fodder trees, landscape

Aditional Attachment II.



2.3 Tree Growth and production (I)

Oral presentations

Hall Q3, 29 May 2024, 11:15–12:00

Young Swiss silvo-arable systems: In what shape are they on their 10th birthday?

Dr. Felix Herzog[1], Prof. Mareike Jäger[1], Giotto Roberti[1], Dr. Sonja Kay[1]

1 Agroscope, Zurich, Switzerland

Introduction

Although agroforestry has been on the agenda in Europe for several years and some farmers have started their own agroforestry plots already decades ago, empirical data about the performance of those systems is scarce, due to a lack of systematic monitoring.

Methods

In the 2010s, we started monitoring the tree growth of four silvoarable systems in the Swiss lowlands. They were established by pioneer farmers who engaged in their own agroforestry experiment for various reasons. The systems can be characterized as follows:

- AF1: 5.6 ha planted in 2007 with 545 apple-trees (Malus domestica) in 15 lines, with a distance of 15 meters between lines. The system is managed conventionally with a crop rotation of maize, strawberries, rotational fallow, and winter wheat. The apples are used for juice.
- AF2: 2.5 ha planted in 2009 with 87 fruit trees (36x Prunus cerasus and 51x Malus domestica), intercropped with vegetables. The distance between the four tree-lines ranges from 15 to 50 meters. It is managed organically. We measured the cherry trees only.
- AF3: 1 ha planted in 2011 with 52 poplar (Populus tremula) trees in three lines 52 m apart. Intercropping consists of a rotation of conventional fodder crops and rotational grassland.
- AF4: 2 ha planted in 2013 with 54 fruit trees (Prunus avium, Malus domestica, Pyrus communis) in three tree lines a distance of 24 m. The land is managed conventionally with a crop rotation consisting of winter wheat, ley, and maize.

We measured the tree growth of a sub-sample of the trees in three-years intervals according to a standardized procedure (Kuster et al. 2012). Diameter at breast height (BDH) was measured repeatedly four times during the study period (2014, 2017, 2020, 2023) using a slide gauge. Tree height was measured using triangulation, with a “Vertex 5” tool. The same trees were always measured and mortality was recorded. Tree biomass was calculated assuming that the tree resembles a cylinder in its shape. The wood density values used for poplar, cherry, and apple were 410, 608, and 610 kg/m3, respectively.

Results

Cumulated mortality ranged from 0 to 25 % for the annual mortality and from 8 to 69 % for the cumulative mortality. The highest mortality was found in AF3 (poplars), almost 50% of the measured trees died or were replanted in the 10 years of the study. However, cumulative mortality was up to 70% as some trees died again after replanting. In AF4 (wild cherries) and in AF2 (fruit cherries) only 8 % of the trees died in 10 years. In the apple agroforestry system AF1, 16 % of the trees died and were replanted.

The variability of the tree growth curves is high (Figure 1), with a particularly high variability for the poplar trees (AF3). The tallest poplar trees have entered the exponential growth phase (up to 14 meters in 13 years). The fruit cherries in AF2 and the apples in AF1 grew comparatively slowly. The wild cherries in AF4 showed a linear and constant growth over the 10 monitoring-years and reached higher values than the fruit cherries in AF2 despite the younger age of the system.

Discussion and outlook

The relatively high mortality rate in the poplar plot was unexpected and is not often mentioned in the agroforestry literature. The mortality of the other agroforestry plantings was in the range of 10 – 15% that is expected in forestry projects. Tree mortality has consequences for the establishment costs of agroforestry and should be accounted for when budgeting for the initial phase. The coming monitoring years will reveal whether over the entire life cycle of an agroforestry system, mortality remains a relevant parameter.

Empirical data are required to parametrize and update the models used to predict the performance of agroforestry systems, such as the Yield-SAFE and Hi-sAFe models (Dupraz et al. 2019; Graves et al. 2010a, 2010b). Here, we only provide relatively short time series covering the establishment and early growth phase of the systems monitored. However, monitoring will continue and more data will be collected. Ongoing work in the context of the Horizon 2020 project Agromix uses measured data from mature agroforestry experiments across Europe to calibrate the above mentioned models. This then allows conducting virtual experiments and to examine the behavior of the systems under climate and management scenarios.

Acknowledgements
Part of the monitoring was conducted with support from the following projects: Horizon 2020 Agromix (https://agromixproject.eu/), Horizon Europe DigitAF (https://digitaf.eu/) and Agro4esterie (https://www.agroforesterie.ch/).

Keywords
temperate agroforestry, farmer perception, tree plantations, trees, simulation model, Monitoring, collaborative research, silvoarable agroforestry

Aditional Attachment II.

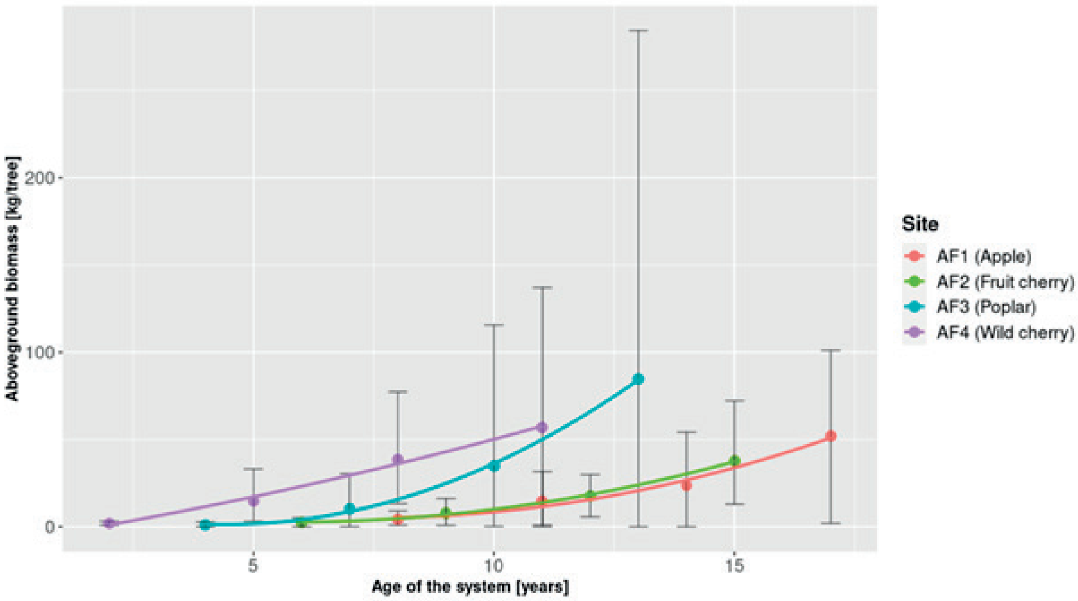


Figure 1: Tree growth (aboveground biomass) in four agroforestry systems. As they were planted in different years, the lines do not overlap. Tree growth monitoring started right after planting in AF4 and only in later years in the other agroforestry systems. The error bars represent the 95% confidence interval of the data.

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Phenology, growth and yield of widely spaced 5-year old poplar trees intercropped with maize in northeastern Italy

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Introduction

The demand for poplar wood for industrial uses has progressively increased in recent years, as well as the need for sustainable and resilient farming systems. Silvoarable agroforestry is gaining increasing interest for improving resource use efficiency, increasing C sequestration and resilience to climate change, and enhancing at the same time the use efficiency of natural resources and the overall productivity per land unit (Lawson et al., 2019; Santiago-Freijanes et al., 2018). The cultivation of poplar together with field crops has gained interest among farmers across Europe because this species grows rapidly, generates a relatively fast economical return, it is easy to manage and highly demanded by wood industries. Poplar also allows to minimize tree-crop competition due to its moderate shading canopy that minimize crop yield impairments (Piotto et al., 2024). However, there is little information available on growth and quality of timber when cultivated at low density, and the impact on crop yield still remain uncertain across the commercial cycle of trees.

Objectives

This study aimed at investigating: i) the diameter at breast height (DBH), tree height, radial growth, and leaf phenology of new HES (High Environmental Sustainability) poplar clones, appreciated for their high Tolerance or resistance to pathogens and insects, in an alley-cropping system in comparison with a poplar monoculture plantation; and ii) the yield of maize intercrop at increasing distance from the tree row.

Methodology

Research was conducted in 2023 in Ceregnano (Rovigo, NE Italy, 45° 05’06” N, 11° 87’ 66” W; 0.5-1m a.s.l.) at the “Sasse Rami” pilot farm of Veneto Agricoltura (VA) in an alley-cropping system (AF) and in a poplar monoculture plantation (C) with the same poplar clones of five years of age. In the alley-cropping system (AF) the tree interow is 40 m, N-S oriented, placed along drainage ditches 150 m long, with 6 m of distance between trees along the row, bringing to 35 trees ha-1. The control specialized poplar plantation (C) had a 6 × 6 m planting scheme, with ~277 trees ha-1. During the season, the following tree parameter were investigated: diameter at breast height (DBH), tree height, radial growth, and foliar phenology of clones Aleramo, Tucano, and Moncalvo in both C and AF (n = 27 and 16-23, in C and AF respectively). DBH and tree height were monitored at the beginning of 2023, leaf phenology from 9 March to 19 April using a national phenological scale (Malossini et al., 1993), and radial growth during the vegetative season through dendrometers (Linear Motion Potentiometer, Bourns-3048). At maturity, maize plants were sampled on a 1-m2 sampling area along three transects orthogonal to the poplar rows with 3 replicates, at distances from trees of +3m, +6m and +12m, both at east and west sides of the tree rows, and in the centre of the alley (C, +20m, assumed as reference controls). For each distance × replicate, plants were threshed to determine grain yield, and quality (by NIRS technology). Statistical analysis was carried out with R studio v. 1.4, using the Tukey’s HSD test for means separation ($P \leq 0.05$) and the two-sample t-test ($p \leq 0.05$).

Results

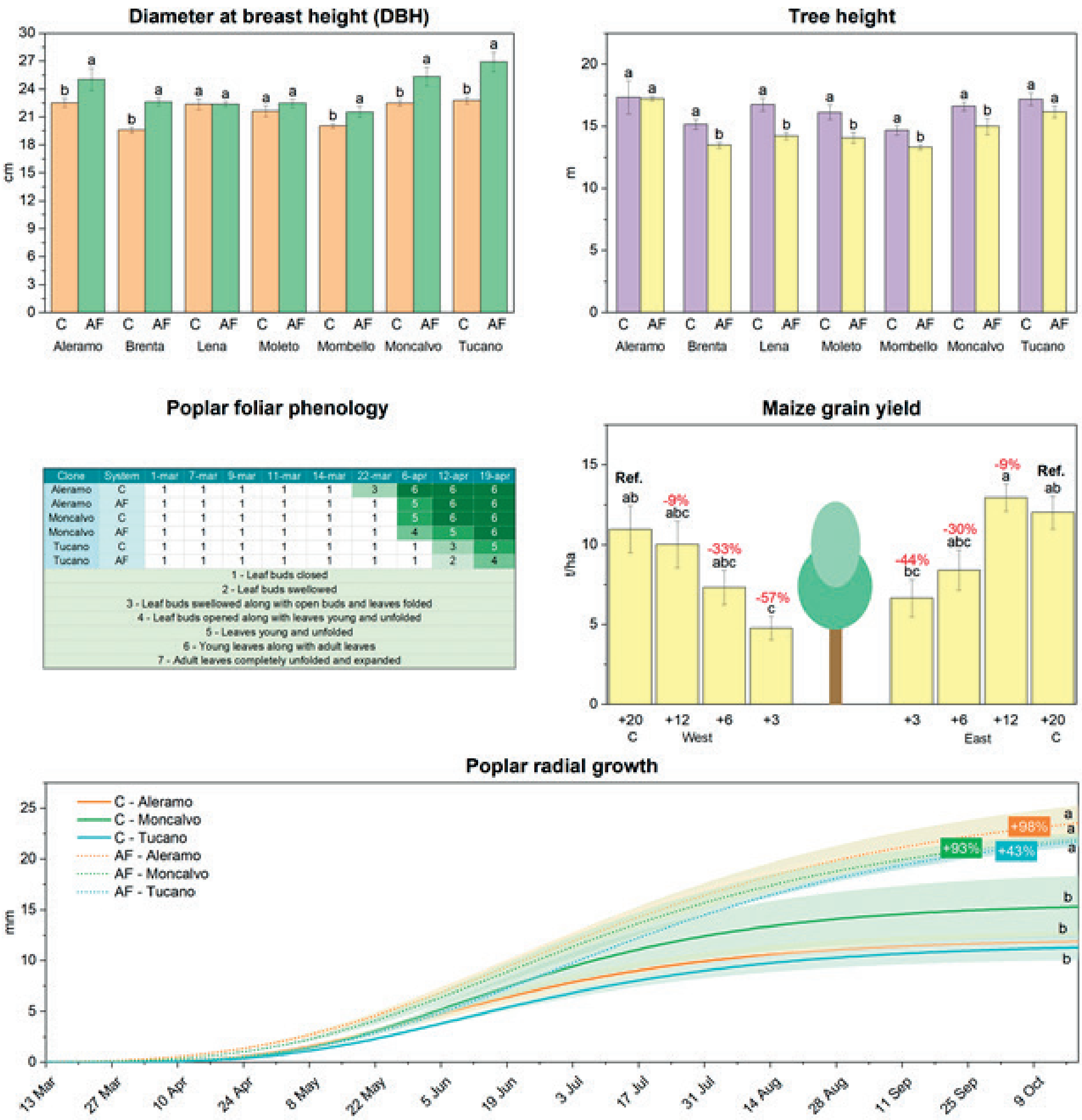
Poplar DBH was significantly higher ($p \leq 0.01$) in AF than in C by 10% on average (24 vs. 22 cm), with the greatest difference in Tucano (27 vs. 23 cm, +15%; $p \leq 0.01$), while no differences were recorded in clones Lena and Moleto. Contrarily, the height of poplars was 9% lower in AF compared to C (14.8 vs. 16.2 m, $p \leq 0.0001$), with the greatest difference observed in Lena (14.2 vs. 16.7 m, -15%), whereas Aleramo and Tucano did not show significant differences (Figure 1). Considering Aleramo, Moncalvo, and Tucano, the fastest growing clones, radial growth in AF were respectively 98%, 93%, and 43% higher ($p \leq 0.001$) as opposed to poplar plantation (Figure 1), while spring foliation was delayed in agroforestry up to one week (Figure 1).

The grain yield of maize decreased significantly ($p \leq 0.05$) in the neighboring of the poplar row, with -32% at +6m and the largest impairment at +3m (-57% vs. C) on the west and -44% on the east sides (Figure 1).

Conclusion
Farmers are currently still reluctant to integrate trees into arable fields because of expected negative impact on intercrop yield and uncertainty on tree growth and timber quality. This study indicates that largely spaced alley-cropping systems with HES poplar clones increase poplar growth DBH, while maize reduces considerably grain yield with 5-year old trees. This suggests including maize as intercrop of arable agroforestry systems in the first years of the poplar cycle only, in order to reduce light competition light competition in this C4 species. Further assessments of poplar HES clones for agroforestry systems in temperate climates should consider the technological properties of wood within a few years at commercial maturity.

Keywords
Specialized poplar plantation, Dendrometers, timber, silvoarable agroforestry, Diameter at breast height (DBH)

Aditional Attachment II.



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Approbation of sweet cherry propagation technologies and selection of the most suitable clones for establishing productive agroforestry alley cropping systems in Baltic region

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Introduction
Due to climate change, the climatic conditions of Latvia have become more suitable for growing sweet cherry (Cerasus avium Moench. syn. Prunus avium L.). Despite its suitability for agroforestry, cherry cultivation has not been widely utilized in the region. Hence, it is particularly important to assess its potential. Fruit can be used in the food and medicine industries, but wood is widely used in interiors, furniture, and musical instruments. In order to determine the most suitable clones, it is necessary to compare both local and foreign clones, because as the climate changes, the best results for survival and productivity may not be shown by native planting material. Although plant material obtained at lower latitudes is often more productive, there is usually a higher risk of frost damage, especially during the autumn and spring periods.

Objectives and research questions
The purpose of this study was to select the most suitable foreign and local clones of sweet cherry, develop methods for in vivo and in vitro propagation of clones, and set up a trial plantation for wood and fruit production. We raised the research questions: (1) Is it possible to propagate local and foreign clones with good wood and fruit characteristics with in vivo and in vitro methods?; (2) Is it possible to successfully establish a sweet cherry plantation in Latvia from selected clones, and how does the risk of frost affect the survival rates of these plantations?

Methodology
The survey and selection of promising clones based on wood (stem length and form) and fruit (size, moisture content) characteristics were carried out at forest resource monitoring sites and existing sweet cherry plantations. We developed a methodology for in vitro (micro-clonal propagation), as well as for in vivo propagation (rooting of leaf cuttings and growing of seedlings from seed). Based on the literature analysis, a recommendation was made for the establishment of sweet cherry plantations. The plantation was established from the planting material propagated in the study, and the frost resistance of selected clones was determined from these sites.

Results
From a total of 64 clones surveyed, 41 suitable clones were selected for the study. Most local clones formed callus well when propagated by leaf cuttings. The addition of lignosilicon and mycorrhizal preparations to the substrate, as well as repeated treatment of cuttings with plant hormones promoted the formation of callus. The clones of 'Muižas 2', 'Šķedes Jānis', 'PU 14498' and 'Karzdabas 4' were the most successful for leaf cuttings propagation. Sweet Cherry propagation from seeds was more suitable for clones '5P', '4P', '3P', '1P' and 'Skriveri-6' with an average germination rate above 80%, while for '6 PS' germination was only 30%. 'Strazdes agrais', '2P', '3P' and 'Skrīveri-6' have higher vitality after germination.

Flat or the south side of the hill are suitable for the establishment of sweet cherry plantations, the north side of the hill or in frost pits are not appropriate. Suitable soil types are sand clay or clay sand with neutral soil reaction and optimal soil moisture. Soil preparation is required before the plantation is established: continuous tillage, or in tillage bands (spacing between bands 2-3 m). The optimum planting distances for sweet cherry are 4x5 m. The growth of planting material requires limiting competition of grassland vegetation by agrotechnical tending. Selective fertilization 2-3 years after planting is required, achieving a mineral content in the soil close to the optimum: P2O – 8-10 mg/100 g soil, K2O – 11-15 mg/100 g soil and NH4 – 5 mg/100 g soil. In sweet cherry plantations 3-5 a year after planting, pruning is required.

At the end of the study, two sweet cherry mother tree plantations were established for the further cultivation of promising sweet cherry clones for berries cultivation (at an early age <10 years) and quality hardwood wood (at the age of 35-40 years). Monitoring of the frost resistance of sweet cherry seedlings shows that during the study, no frost damage was observed in any of the sites.

Conclusion
It is possible to obtain planting material with good wood and fruit characteristics from sweet cherry clones of local and foreign origin with in vivo and in vitro propagation methods. Both local and foreign clones had good frost tolerance, therefore, as long as the plantation is established in suitable abiotic conditions and necessary management practices are carried out, plantations should have a high success rate. The appropriate propagation method is determined by the individual characteristics of the clone. Clones 'Muižas 2', 'Šķēdes Jānis', 'PU 14498' and 'Karzdabas 4' showed the most potential for propagation by leaf cuttings, while 'Strazdes agrais', '2P', '3P' and 'Skrīveri-6' were by sowing.

Keywords
clon, site conditions, Agroforestry, tree plantations, timber, fruit trees

Economic considerations of an agroforestry system with grass and wood production, a case study from north-east foothills site, the Czech Republic

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Introduction

The study deals with an economic evaluation of low-productive agricultural site. It consists in former arable patches bordered by woody-species strips growing spontaneously on balks. This design allowed us to study the woody vegetation -> grass production interaction and to evaluate a potential income from this mixed management. The signs of a former silvo-agricultural approach conducted within the foothills till the end of the WWII were reported by Krčmářová (2019).

Study site

The research plot is situated at 590 m altitude, NE Bohemia (Velký Uhřínov cadastral area; Rychnov n. Kn. county). The meadows are mown twice a year. The 12 m wide woody strips with 15 m wide canopies divide the site into grass-dominated 55 m wide meadows running from NE to SW. Within 1-hectare rectangular study site the 80 m long woody strips covered ca 19% of its area.

Results

Grass crop: The local farmer harvested 1.8 – 1.9 tons of hay bales per 1 ha of the study site in 2019, 2021 and 2022. We estimated, however, more sampled herbal biomass on the transect perpendicular to the woody strips with measured dry matter. Considering maximal 15% hay moisture, our estimates were almost twice higher (3.6 t/ha). It is likely to be attributable to the biomass left on site when using machinery. We sampled manually, which allowed us to take the biomass almost completely. Also the farmer's data (the bale weight) can be biased. As expected, the woody species suppressed the herbal biomass nearby (Fig. 1) and changed its species composition (Bartoš et al. 2022).

The commercialization was estimated on the basis of mean hay biomass totaling 2 t/ha. Based on the 2022 market research, the price of 1 ton of the baled hay was 96 € (24.5 CZK = 1 EUR), which represented an income 192 € /ha. Total annual costs consisted in spring dragging (15 €), both cuts mowing (28 €), hay turning (29 €), pushing the hay off (17 €) and baling (53 €), which equaled to 269 € per hectare and realized a loss of 77 € per hectare. It can be anticipated that meadow without the accompanying woody species will produce more hay, which realizes a different cots/yield balance.

Woody crops: The dominant trees were ash and sycamore; these two shared 85% of a standing volume. Standing volume of understory hazel was negligible. The standing volume of the agroforestry system totaled 75 m3/ha of timber below the saw-log top. A low quality of stems was attributable to a lack of intensive silviculture.

The fuel wood dominated, which means that highly-valuable assortments shared 10%. The mean prices (fuel 61 €/m3, noble hardwoods 122 €/m3) and operation costs 20 €/m3, considering half-volume harvesting in 30-year rotation realized the income of 59 €/m3/year. The woody crops yield, therefore, only partly compensated the hay produce loss in the agroforestry system.

Conclusion

The woody strips shared ca 19% of the agroforestry system. The mean hay production was 2 t/ha/year. Considering 30-year rotation and 50% harvest of woody crops consisting in fuel wood and 10% of the valuable assortments, the mean income from wood sums to 59 € per hectare and year. It can be anticipated that this income would not balance the hay-produce loss realized by the whole agroforestry system compared to a meadow land use. The effectiveness would be increased by silviculture focused on more noble hardwoods and measures increasing of their quality.

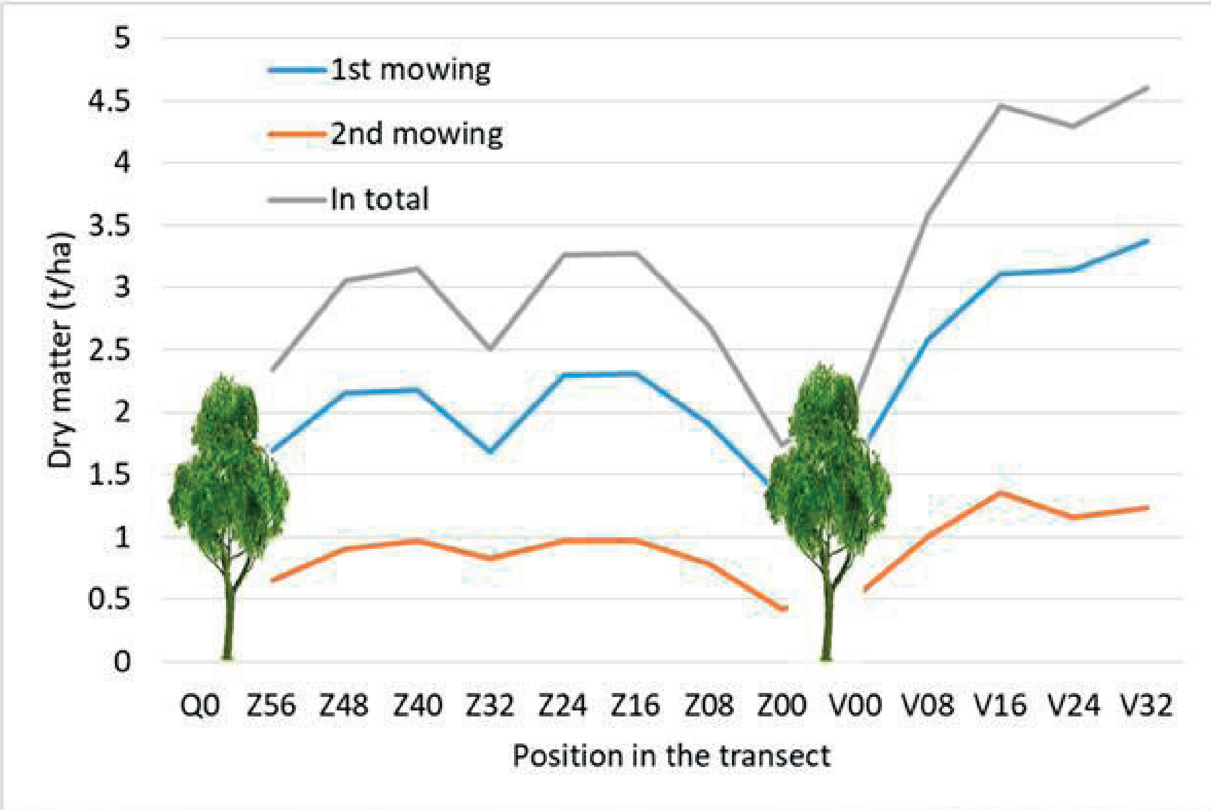
There is, however, an option to get a government subsidy, which makes management on meadows (including the agroforestry) economically profitable because the area of woody patches surrounded by agricultural land can also be subsidized.

Acknowledgement

Supported by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0123.

Keywords
Agroforestry system, Grassland with trees

Aditional Attachment II.



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Tree and crop yield and land equivalent ratio of alley cropping systems with different spatial tree arrangement

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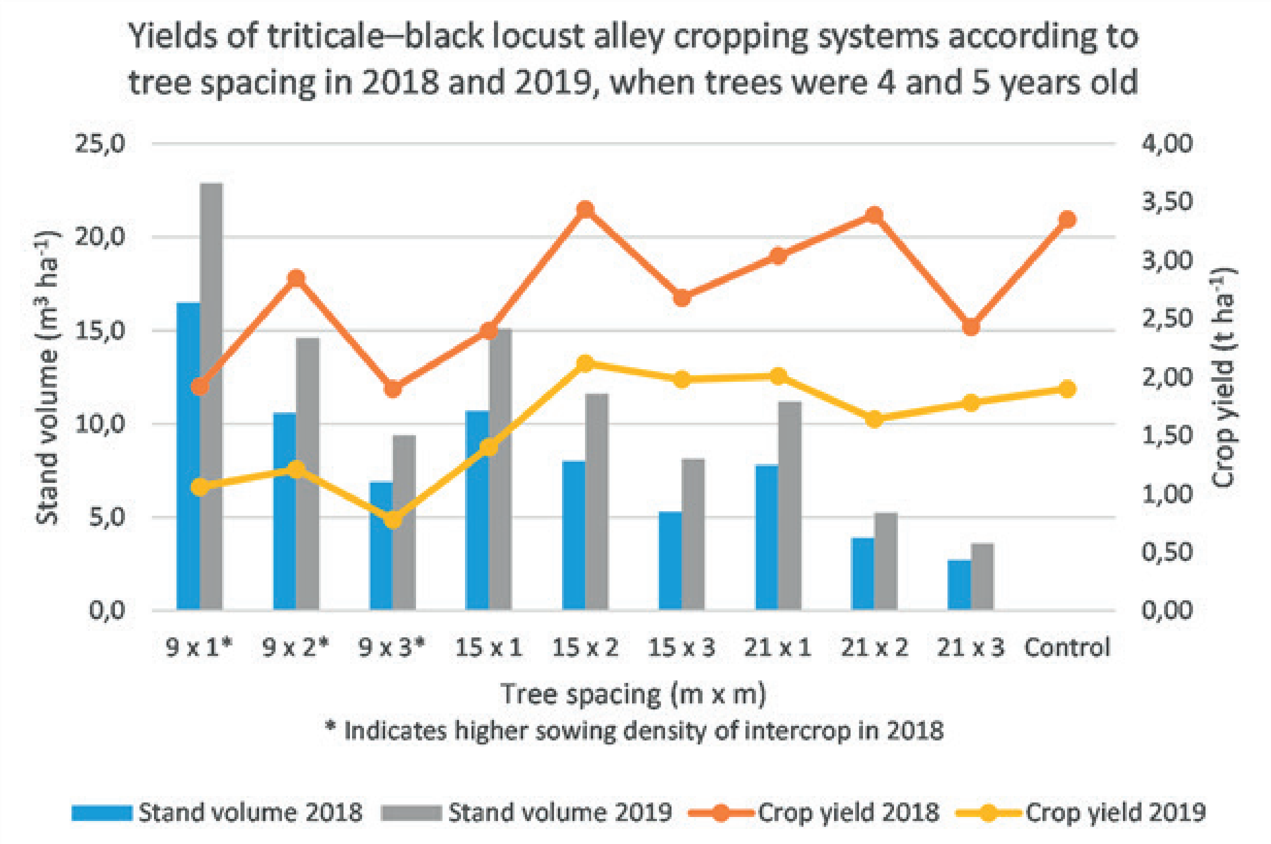
Alley cropping is a specific agroforestry system (AFS), which is regarded as a sustainable land use management, that could play a crucial role in climate change adaptation and mitigation. Previous studies has shown high productivity of AFS, where the land equivalent ratios (LER) of properly designed systems range between 1.2–1.6. The objective of this study is to help to design productive alley cropping systems, by testing different tree planting patterns. Between 2017–2019 we investigated which spatial arrangement of black locust (Robinia pseudoacacia L.) results in the most productive alley cropping system on chernozem brown forest soils, when intercropped with triticale (× Triticosecale Wittm. ex. A. Camus 'GK Maros'). Winter cereals have proved to be a good choise for alley cropping systems, and due to poor site conditions we chose triticale. The black locust energy plantation had previously been established at the experimental station, and it was transformed to alley cropping to produce timber. We analyzed the data of two vegetation periods, when the trees were 4 and 5 years old. The yields of the intercrop (grain yield and above ground biomass) and of the trees were statistically analysed in nine different spatial arrangements (9 × 1 m, 9 × 2 m, 9 × 3 m, 15 × 1 m, 15 × 2 m, 15 × 3m, 21 × 1 m, 21 × 2 m, 21 × 3 m) with 4 replications and land equivalent ratios (LER) were determined. There were significant differences between treatments both in triticale and black locust tree yields (p=0,05). The more trees planted on a hectare, the higher the volume of the stand, and the smaller yield of triticale was observed. Although in 2018 triticale (cereal and biomass production) was more productive between the alleys in treatment 15 × 2 m and 21 × 2 m compared with sole crop control, even only 81 and 86% of the area was sown, respectively. When trees were five years old, in the case of grain yield, treatment 21 × 1 m had higher yield than in the control (Figure 1), and at treatment 21 × 3 m the above ground biomass was higher than the yields in the control plot (conventional crop production), while treatment 15 × 2 and 15 × 3 m were higher regarding both of the parameters. Wood production was the highest in the most dense stand, at treatment 9 × 1 m (1001 trees ha-1; 22,9 m3 ha-1), in all of the investigated years. When trees were five years old, LER values were favourable in six cases (1.35; 1.29; 1.19; 1.07 and 1.07), out of nine when considering the grain yield of triticale. Highest yield was recorded at planting pattern 15 × 2 m (322 trees ha-1; 11,6 m3 ha-1 timber; 2,12 t ha-1 grain yield), where LER was 1.35. Regarding above ground biomass production, the same treatment was the most productive with LER 1.38. Based on the results, black locust and triticale can be a productive tree-crop combination on chernozem brown forest soils, when tree rows are 15 or 21 meters apart from each other, but cereal production radically decreases at 9 meter row--spacing. The crop yields are expected to further decrease over time as trees grow, and tending operations may be justified. We suggest to study further plant combinations with different spatial arrangements and their production under different site conditions and with longer time-span. To explain higher yields in the investigated alley cropping systems compared to the conventional triticale production further ecological research is needed.

Keywords
Black Locust, wood biomass, tree volume, total volume, above ground biomass, agroforestry system planning, design, Trees spatialisation, implementation silvoarable AFS, silvoarable agroforestry, alley cropping, tree spacing

Aditional Attachment II.



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Vitiforestry in Central Europe – A configuration framework for tree and shrub integration in German vineyards

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Introduction

Intensively managed permanent crop systems, such as vineyards, are often cultivated in monoculture that require high resource inputs. This can create adverse effects on biodiversity and ecosystem services (Litskas et al. 2020). The adoption of more ecological management practices, such as cover cropping with flowering mixtures, improved ground cover management and pesticide reduction is spreading due to winemakers' own conviction or public pressure (Mariani & Vastola 2015). Meanwhile, viticulture is heavily affected by climate change and traditional growing practices (e.g. characteristic grape varieties, traditional vine training systems) are increasingly challenged (van Leuuwen et al. 2020).

Vitiforestry applies the concept of agroforestry to vineyards, meaning the intentional integration of trees and shrubs in vineyards and combination with vines. Historically this cultivation system was wide spread in the Mediterranean climate zone, where until today some examples of historic vitiforestry systems remain (e.g. married vine systems "vite maritata" in Italy (Torquati et al. 2015) or hanged vineyard systems "vinha do enforcado" in Portugal (Altieri and Nicholls 2002)). In recent years vitiforesty has (re)gained attention in this region due to its potential positive effects on microclimate and biodiversity (Bourgade et al., 2020). Research on vitiforestry has focused predominantly on Mediterranean climate conditions. The impact of trees on cool-climate vineyard systems to date has been rarely studied, with only little experience on the technical and practical implementation. A study in probably the oldest vitiforestry trial site in Germany shows promising effects of trees on vines, particularly water uptake and nutrients as well as wine quality are (Lang et al. 2018).

Objectives

The aim of this study is to shed light on the functions and services trees and shrubs offer at different levels in viticulture. Further, to provide a classification on how trees and shrubs can be integrated at vineyard and landscape scale. The overall goal is to develop a structured framework for vitiforestry in Central Europe and cool-climate viticulture in general to facilitate the adoption of vitiforestry practices, as well as guiding future research on this topic.

Methods

A first scoping review of existing scientific literature followed by expert interviews and site visits of currently existing or planned scientific and practical vitiforestry projects in Germany provided the basis to create a first structured framework that illustrates functions and services of trees and shrubs in viticulture.

Results

Only limited scientific data on vitiforestry for cool-climate viticulture was found. However, there are few research projects in Germany (University of Hohenheim, Hochschule Geisenheim University), and Switzerland (FiBL) that recently started, with vitiforestry trial sites planted. The effects found in Mediterranean vitiforestry systems most likely can be translated, yet have to be confirmed in upcoming years. Exchanging with practitioners and experts indicated that openness for integrating trees and shrubs is growing among predominantly organic producers in Germany. Their main interest is to increase biodiversity and climate change adaptation as well as promoting marketing. Few pioneering wineries have established actual vitiforestry sites in 2022 and 2023 with field sizes ranging from 0,1 – 2 ha, with one larger site (6 ha) about to be planted. These plantings differ in goals and objectives resulting in different tree and shrub species choices and forms of integration. Other winemakers consider the surrounding vineyard landscape, mostly in historically small-structured areas, as a quasi vitiforestry system and see no benefits in adding additional trees. Integrating existing landscape features and elements with trees and shrubs, such as hedges, vineyard terrace embankments, or remaining single trees, offers the potential to maintain and enhance their functions within the production system.

There are several forms of integrating trees and shrubs at vineyard and landscape level. System design should be guided by goals and objectives of the owners and match with their management capacities (e.g. expected amount and timing of workload, required knowledge) and necessary and available equipment.

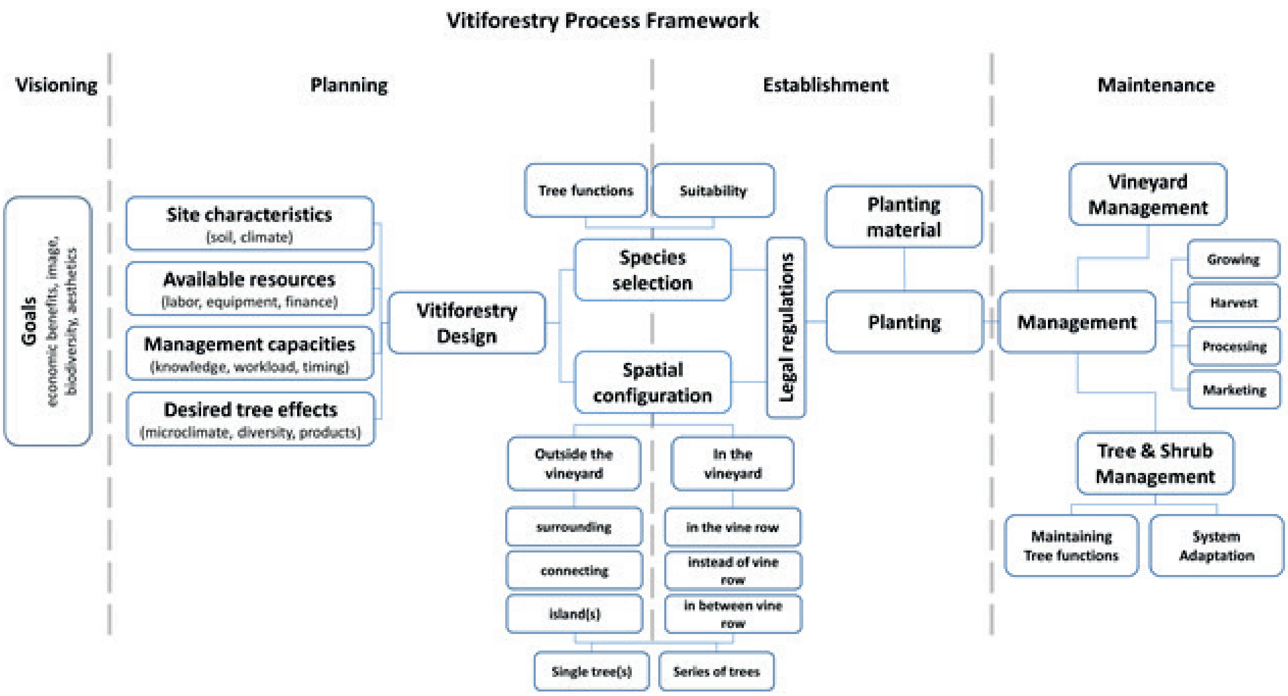
Additionally, growth dynamics over the years need to be considered and management options (e.g. reducing number or canopy size of trees) included. Ultimately, this leads to possible spacing and tree species scenarios.

Trees and shrubs can be placed within the vineyard in the vine row or instead of vine row, but also adjacent to it. At landscape level vitiforestry system can be placed in ecologically most valuable positions (e.g. connecting existing habitats). Harvest, processing and usage or marketing of the vitiforestry component should be considered form the beginning. Vitiforestry can promote product diversification, e.g. through producing additional crops, such as fruits and nuts or funghi (Tuber aestivum). These additional products have shown to accelerate direct marketing of the main product the wine.

Discussion
Vitiforestry in Central Europe is a promising, yet very new field of agroforestry. Working closely with practitioners allowed us to develop applicable knowledge and identify and fill currently existing research gaps.By providing a structured framework for the configuration of vitiforestry systems, we aim to foster its further spread.

Keywords
ecosystem services, temperate agroforestry, agroecology, framework, biodiversity, vineyard, Landscape biodiversity, Socioeconomic status, vitiforestry, climate resilience

Aditional Attachment II.



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The Utilisation of Exceptionally Fast-Growing Varieties with Outstanding Industrial Timber Yield and Quality within the Scope of Agroforestry.

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Introduction

Climate and environmental change in the continental climate of Europe no longer provides adequate circumstances for native species to survive, such as Fagus syilvatica, Picea abies, Fraxinus excelsior, Pinus nigra, Quercus petraea (Illés & Móricz et al. 2022; Fekete et al. 2017; Scherrer et al. 2017; Hanewinkel et al. 2013). Forestry and agriculture around Europe are facing challenges and will need to adapt to the changing circumstances with approaches that can also mitigate the effects of climate change while promoting biodiversity, providing resilient ecosystems services and supplying sustainable forest products.

The traditional Robinia pseudoacacia is the third most planted tree species in the world and 50% of all new afforestations in Hungary are Robinia pseudoacacia. Over the course of the last 30 years, Silvanus Group has successfully completed research and development regarding fast and straight growing Robinia pseudoacacua varieties with the aim of high quality, industrial timber production through plantation forestry. The result of this is the Robinia pseudoacacia 'Turbo Obelisk' variety group, the utilisation of which has already begun in several countries in the last couple years, including the UK as well as the USA. The selectively bred Robinia pseudoacacia 'Turbo' and 'Turbo Obelisk' varieties have a fivefold carbon sequestration capacity and a fourfold yield compared to native tree species used for commercial purposes. These varieties and our plantation technologies can decrease the traditional 30-year rotation period to approximately 15 years, with extremely high industrial wood yield due to the straight growth, resulting in the minimization of waste wood and hence achieving true long term carbon sequestration.

In addition to the potential of these varieties regarding timber production on low quality, marginal soils, it is also vital to emphasize the opportunities these varieties present regarding effectively increasing the yields of agricultural crops as well as efficient pasture management.

Besides the already well-known characteristics of forest belts (wind protection, retention of evaporation, prevention of deflation, improvement of microclimate etc.), if constructed appropriately, agricultural areas could be surrounded and separated by Robinia pseudoacacia 'Turbo Obelisk' plantations of merely 2-3 rows. The intensively growing roots can cover the areas between the plantation strips, underneath the agricultural crops. As the nitrogen fixing bacteria on the roots of Robinia pseudoacacia produce much more nitrogen than is consumed by the tree itself, it is capable of significantly enriching the nutrient level of soils, in turn resulting in higher agricultural yield. This also means that several environmental aspects can also be respected as it can decrease the need for human intervention and for additional fertilizers, whilst it also increases soil health. Its large white flowers support native pollinators and honeybees.

Increasing the yield of pasture management can be another significant approach through our outstanding varieties Robinia pseudoacacia 'Turbo Obelisk' varieties. These varieties bring great yield in terms of fresh green mass, which the grazing animals love. Due to the deep penetrating root system, drought does not decrease their yield significantly and their yield can be several times that of herbaceous crops. They all sprout well, consistently regenerating for the animals to graze.

Goals

The goal is to develop sustainable agroforestry systems that meet the conditions of agriculture and plantation forestry as well as today's environmental protection challenges such as the excessive use of fertilizers and maintaining soil health, whilst also maintaining profits.

Contribution to sustainable practices: Contribute to the development of sustainable agroforestry practices that increase carbon sequestration in arid environments and thereby mitigate the impacts of climate change.

Climate resilience: To research climate adaptation and resilience potential of agroforestry, taking climate change driven aridification into account, as well as climate induced insects and diseases.

Methodology

Outline of the pilot project in the UK, focusing on the large horizontal extent of the Robinia pseudoacacia root system as well as the intensive growth parameters of the plantation strips.

Type of study: experimental design

- Literature review:
  The literature review will be conducted using a systematic and comprehensive approach. The primary goal is to identify, evaluate, and synthesise existing academic literature and research findings related to carbon sequestration of high-quality timber and carbon sequestration in plantation forestry in general, which will be compared with agriculture that don't utilize trees.
- Forestry plantation:
  The study area will be partitioned into two equal-sized segments, the first segment will be designated for exclusive plantation with Robinia pseudoacacia 'Turbo Obelisk', while the second segment will be designated for the cultivation of a mixed assemblage comprising commonly utilized tree species for agroforestry.

- Control soil sampling
- Base soil carbon quantification
- Soil sampling
- Soil and tree carbon quantification

Comparison of the results and synthesis:
Results of samplings will be statistically analysed and compared in order to make a research synthesis.

Discussion
How can farmland owners and operators add a stream of income and create a multitude of ecosystem benefits with Black locust as a multifunctional tree?

Keywords
tree farming, afforestation, case study, field forest cover, carbon farming, carbon neutral, Agroforestry, microclimate, aboveground carbon sequestration, drought adaptation, resilience, adaptation, Land Use, Socioeconomic status, Plant species selection, fast-growing tree, Central Europe, Eastern Europe, climate change, Black Locust, Carbon Balance, sustainable business models, climate smart landscapes, Land degradation, climate change mitigation, silviculture in agroforestry, Agroforestry systems, agrisilvicultural systems, tree volume, pollination, carbon footprint, carbon storage, Tree Crops, climate mitigation, biochar, carbon certification, carbon stabilization, shade, forest ecosystem, honey plants, root system, soil carbon sequestration, climate resilience, tree breeding, agriculture, tree spacing, Agri-Environment-Climate, agroforestry practices, soil organic carbon, wood biomass, timber, circular economy, carbon sequestration, drought, research and development, profitability, forest management, wood, silvopasture, pollinators

Aditional Attachment II.

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How easy was it to establish an alley cropping system in the challenging conditions of the Pannonian region - and when will it bear fruit?

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Introduction

Scientifically tested management options for the woody component of agroforestry in the Pannonian region are scarce. The aspects of different agroforestry systems vary depending on ecological and economic region specificities and need to be assessed accordingly. Thus, the establishment of the oldest experimental alley cropping system in Czechia was evaluated. Studied parameters included above and below-ground growth characteristics, planting survival and germination rates, pruning responses and effects of tree strip integration on soil properties; all compared to agricultural monocrop and forestry control plots.

Research Questions

1. Is it possible to successfully establish woody plants in an agroforestry system (AFS) on a high-aridity site without artificial irrigation?
2. What tree protections and anchors are appropriate for planting trees in open landscapes?
3. Is the seeding of black walnuts a suitable alternative to the planting of trees in open landscapes?
4. What are the benefits and drawbacks of agroforestry tree management compared to forestry tree management in both quantitative and qualitative aspects?
5. Is it possible to observe any tree line integration effects on various components of the agroecosystem in the first years after the establishment?
6. Is there a spatial variability of soil properties and processes within the AFS?

Methodology

The research design comprises both agroforestry and agricultural monocrop plots within one site. The AFS accounts for 3,7 ha out of a total plot area of 9,9 ha. A total of 6 rows have been established. The first three at 18 m intervals and the other three at 18 m intervals 36 m apart. In 2019 a total of 162 poplars (Populus x canadensis Moench.) were planted in the plot and 648 walnut trees (Juglans nigra L.) were seeded in 216 holes. Crop rotation is mainly based on winter crops.

Most of the field observations were performed quarterly between 2019 and 2023. Hydrophysical soil properties were observed daily from March 2022, at 15-minute intervals, with permanent soil sensors. A below-ground assessment was done in February 2023. Soil organic matter (SOM) and Carbon (SOC) assessments were completed in autumn 2023.

Results

Four years after the plot establishment, over 80% of planted poplars survived without any artificial irrigation (though severe drought events were observed only in 2022, whereas 2020 and 2021 were favorable, practically without the occurrence of agricultural drought).

Standard forestry seedling protection methods are not suitable for planting in open landscapes with high pressure of game. Two-point anchorage with welded mesh proved to be the most effective variant.

Seeding 3 black walnuts in one hole resulted in an 81% success rate with one to three walnuts per pit in 2022. After two replantings in 2023, 98% of the holes were occupied. The biomass increment of walnuts in the alley cropping was significantly lower than in the forestry control plot (Fig. 1). Most probably due to competition in the grass strip and drier conditions.

Height increment in the alley cropping poplars was significantly lower than in the forestry control plot. However, the agroforestry management produced higher-quality individuals suitable for growing quality wood assortments. The grass strip was eventually taken over solely by Festuca rubra and remained in good condition without any management, resulting in zero maintenance costs over the full 4 years.

The AFS produced significantly more below-ground root biomass per individual than the forestry plot. Tree roots in the alley cropping occupied substantially larger space laterally and vertically, thus investing in future growth, with the prediction of creating a catchment network for excess nutrients and pesticides. Tree lines and alley crops did not differ in terms of total soil C and N stocks, however, statistical significance was observed in terms of OM quality. The C/N ratio was significantly higher in the control plot. A clear trend towards horizon stratification inducing changes in water regime and porosity was observed in the tree lines.

Conclusion
Establishing alley cropping systems in the problematic conditions of the Pannonian region, characterized by low precipitation totals, changing rain patterns and increased drought probability during the vegetation season, can be very successful. Especially if the establishment is preceded by a thorough analysis of the local conditions followed by a tailor-made design. Favorable rainfall distribution in 2020 and 2021 contributed to a high planting success rate. The correct choice of woody species and the type of their protection, as well as grass strip species composition, appear to be key. Agroforestry management, as opposed to forestry management, has proven to be superior in qualitative wood production, and below-ground biomass per individual, whilst showing promising results regarding carbon sequestration potential. Natural horizon formation can be observed in integrated tree rows, which will result in improving the soil C sequestration potential and water regime. Superior biomass input of the tree lines was not yet reflected in SOC or N stocking, although the treatments did vary in terms of SOM quality.

Keywords
: tree root structure, carbon sequestration, tree-crop-soil interactions, tree volume, alley cropping, soil properties, biomass

Aditional Attachment I.
APPENDIX

	LoI OM (%)	TIC [%]	TC [%]	TOC (%)	TN [%]	TOC/TN
Tree line 0-10 cm	4,86	0,05	1,72	1,68	0,17	10,07
Intercropping 0-10 cm	4,82	0,05	1,75	1,70	0,17	10,02
Control plot 0-10 cm	5,04	0,04	1,78	1,74	0,16	10,72
p-value	0,07	0,63	0,14	0,56	0,64	**0,029**
Tree line 10-30 cm	4,44	0,05	1,50	1,46	0,15	9,71
Intercropping 10-30 cm	4,62	0,04	1,61	1,56	0,16	9,56
Control plot 10-30 cm	4,84	0,04	1,66	1,62	0,15	10,64
p-value	0,22	1,00	0,38	0,35	0,41	**0,0002**

Tab 1. Table of averages and p-values for selected soil properties at the alley cropping system in Žabčice measured among tree lines, intercropped alleys and control plots in September 2023 at depths of 0 – 10 and 10 – 30 cm, where, LoI OM for organic matter gravimetrically measured by Loss on ignition method, TIC for inorganic Carbon content, TC for total C content, TOC for organic C content, TN for total nitrogen content and TOC/N for the organic carbon to total nitrogen ratio.

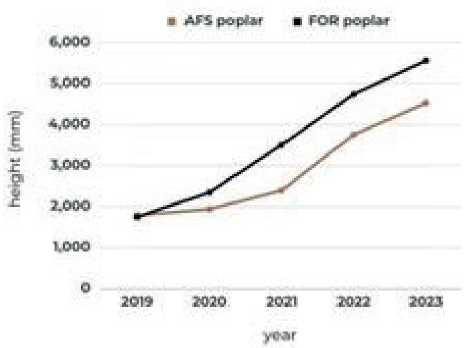
Aditional Attachment II.

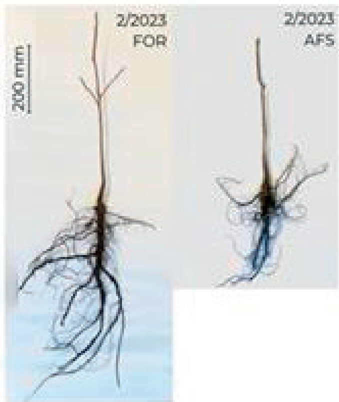
CHARACTERISTICS OF THE SYSTEM

Woody component	*Populus x canadensis, Juglans nigra, Ligustrum vulgare*
Design	6 rows of trees á 18 or 36 m
Total area	3,7 ha
Biogeographical region	Pannonian
Elevation	182-183 m. a. s. l.
Soil type	Chernosem Arenic
Precipitation	500-600 mm
Prevailing wind direction	N->S
Orientation of tree rows	N->S

Dron footage June 2023

GROWTH OF POPLARS AFS VS FOR





An average black walnut individual:
FOR without grass strip vs AFS with grass strip

AFS poplars November 2022

Wood yield in two agroforestry systems including nitrogen-fixing species after nine growing seasons

Abdoulaye Ndiaye[1], Nicolas Marron[1], Erwin Dallé[1], Pierrick Priault[1]

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Introduction

Mixed tree plantations and agroforestry systems including nitrogen-fixing species have potential both in terms of productivity and resource-use efficiencies in comparison to agricultural and forest monoculture systems (Marron and Epron, 2019; Thomas et al., 2021). The woody component in an agroforestry system can produce biomass for lumber or energy purposes. The knowledge of its yield potential, especially under specific pedoclimatic contexts such as the northeastern region of France, is an important information that may help farmers to make decision on whether or not they introduce trees in their fields. The objective of this study was therefore to determine the potential of agroforestry plantations including nitrogen-fixing species in terms of energy wood yield in two agroforestry systems combining poplar and alfalfa then clover, and alder and grassland (graminoids) compared to equivalent monocultures. Aboveground tree biomass was estimated at the end of the tree rotation period of 9 years.

Methodology

This study is based on a 5-hectare experimental site set up in 2014 in la Bouzule near Nancy, in the northeast of France. It is composed of six modalities: alder and poplar monocultures, two agroforestry systems associating alder with grassland, and poplar with a succession of alfalfa and clover, and pure grassland and alfalfa (or clover) plots. The modalities are repeated in three blocks with about 3600 trees in total. The monocultures were planted at a density of 2000 trees per hectare, while the agroforestry systems were planted at a density of 1000 trees per hectare, because every second row of trees was replaced by the crop. The growth of the trees was monitored over 9 years from 2014 to 2022; trees were harvested during winter 2022-2023.

For each of the trees of the plantation, the diameter at 1.30m was measured during winter 2022-2023. In order to determine the dry aerial biomass at the plantation scale, a sample of 240 trees was randomly determined (20 trees per species, treatment (monoculture or agroforestry) and block). For each of these trees, the main stem was cut into 1 m sections which were weighed and summed to determine the total biomass of the main stem. Branches in each 1 m section were also weighed. Water content in stems and branches was determined from wood samples dried at 100°C to estimate dry biomass. Quadratic allometric models linking stem diameter to dry biomass of branches and stems were established per species and per treatment. These models were applied on each tree of the plantation to extrapolate yield of the entire plantation, taking into account tree mortality and planting density.

Results

Individual tree biomass values were higher for poplar compared to alder (Figure 1). For the two species, tree biomass was significantly higher in the agroforestry treatment (23.6 kg ± 1.0 for poplar vs. 4.4 kg ± 0.2 for alder) compared to monocultures (12.0 kg ± 0.4 for poplar vs. 3.4 kg ± 0.1 for alder).

Yields, taking into account planting densities and tree mortality, were higher for poplar than for alder, but not significantly different between the agroforestry systems and the monocultures for the two species: 2.4 Mg ha-1 yr-1 ± 1.1 for the poplar monoculture, 1.9 Mg ha-1 yr-1 ± 1.3 for the poplar in agroforestry, 0.7 Mg ha-1 yr-1 ± 0.2 for the alder monoculture and 0.5 Mg ha-1 yr-1 ± 0.3 for the alder in agroforestry.

Conclusion

Estimated dry aerial biomass were low irrespective of the treatments in comparison with other studies (e.g. Ghorbani et al., 2018). Both species exhibited higher tree biomass in the agroforestry system as compared to the monocultures, with the poplar trees being twice heavier in the agroforestry systems than in the monoculture. This higher tree biomass in the agroforestry systems is probably due to a lower competition between trees caused by a planting density that is twice lower than in the monoculture (as every second line of trees has been replaced by the crop). In addition, a facilitation effect caused by the presence of the nitrogen-fixing crop in the poplar agroforestry system could have played a role as it has been already demonstrated in the past (Thomas et al. 2021). The use of poplar trees in association with nitrogen-fixing crops seems to be a promising option. However, tree yields on an hectare basis were not significantly different between treatments because of the presence of less trees per hectare in the agroforestry systems due to higher mortality and lower planting density than in the monoculture.

Keywords
wood biomass, Agroforestry, mixed plantation, above ground biomass, nitrogen-fixing species

Aditional Attachment II.

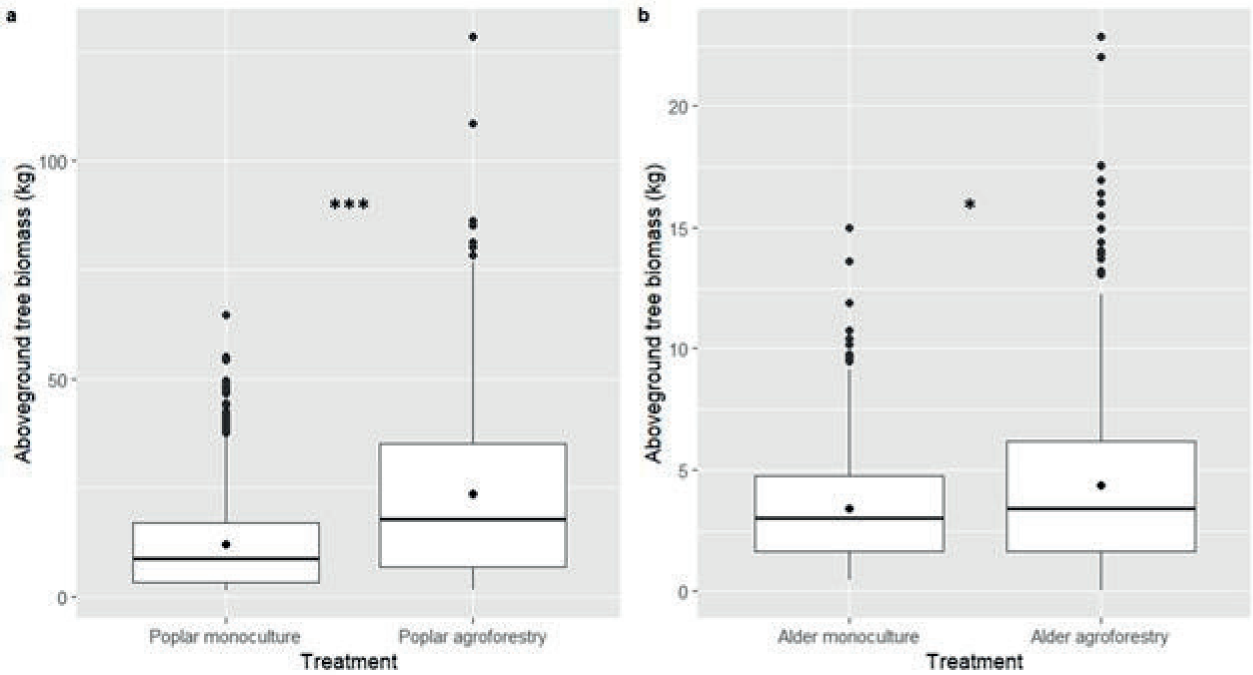

Figure 1: Variation of dry aboveground biomass of the tree expressed in kg as a function of treatments (monoculture, agroforestry) in poplar (a) and alder (b). The data are represented in the form of boxplots and include for each treatment, the estimated biomass of each tree of the plantation. Bold lines represent the median and boxes are delimited by the first and third quartiles. The points outside the boxes represent the extreme values and the points inside represent the mean values of dry aboveground biomass for each treatment. The significant differences between treatments are represented by asterisks for each species: **P*<0.05 and ****P*<0.001.

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2.3 Tree Growth and production

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Chronology of plantation in perennial agroforestry systems: Is it better to plant olive trees in vineyards, or grapevine in olive orchards?

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1 ABSys, Univ Montpellier, CIHEAM-IAMM, CIRAD, INRAE, Institut Agro, Montpellier, France

Agroforestry is of growing interest to winegrowers as a way of coping with climate change, thanks to the buffering effect of trees on the microclimate. Conversely, olive growers in France are interested in diversifying their production, for example by growing vines for wine or table grapes. However, trees and vines compete for light, water and nitrogen resources, and these competitions change across time, as the trees and vines grow and colonize the soil. This raises questions about the dynamics of planting: is it better to plant the trees first, and wait for the tree to be large enough to create a beneficial microclimate to protect the young vines? Or should the two species be planted at the same time, so that their root plasticity enables them to create a spatial complementarity between their root systems? Or can the trees be planted in an existing vineyard (as many winegrowers wish to do, taking advantage of gaps in the vineyard to plant the trees) without the vine exerting too much competition on the young tree?

In order to answer these questions, we ran a virtual experiment using the Hi-sAFe model (Dupraz et al. 2019), which has recently been adapted to simulate olive tree (Barbault, submitted) and includes the STICS model for soil-crop simulation, including grapevine (Valdés-Gómez et al. 2009). We compared three planting chronology modalities: tree first (TF), vine first (VF), or both at the same time (BST), and compared the results with vine-only (VC) and tree-only (TC) controls. The second species (olive tree in VF, grapevine in TF) was planted six years after the start of the simulation, as well as both species in the BST system. Simulations were run for 23 years. The olive trees were planted at a density of 222 trees per hectare (15 m between tree rows, 3 m between trees along the row), and 4 rows of grapevine were simulated between two tree lines. The soil and climate were those of a grapevine plot located in Restinclières Agroforestry Platform. The simulated plants were not fertilized nor irrigated.

The results (e.g. figure 1) were surprising, as some of our hypotheses were not verified: we expected the yield of vines associated with olive trees to be lower than that of vines alone, due to competition for water, nitrogen and light. But the comparison of grapevine yield in VF vs VC showed that the competition by trees had a minimal impact on grapevine yield. On the contrary, and in accordance with our hypotheses, the grapevine benefited from the microclimate created by olive trees: in years with low grapevine yield, yield was higher in systems with olive trees (e.g. years 14 and 17 in VF, compared to VC), and all the more so when trees were old (compare year 3 of BST, with young trees, and of TF, with older trees). The simulated yield of olive trees was very low and showed an unexpected production pattern (early peak of production) even in the tree-only control. Despite these inaccuracies, the simulation results highlighted the fact that tree-crop interactions are indeed complex and make it difficult to get an intuitive grasp of the functioning of the system. The presence of grapevine seems to accentuate the irregularity of production of olive trees, as there are more no-yield years in TF than in TC. Regarding the chronology of planting, the results confirm our hypothesis that olive trees perform better when planted in existing vineyard (the cumulated yield in VF is higher than in BST between years 6 and 14), although this trend seems to reverse as trees get older due to several no-yield years in VF. This seems to be confirmed by the comparison between VF-BST vs TF (delayed peak of production but with a much higher value in VF and BST compared with TF), but these results must be taken with caution because they do not correspond to the same climatic years. Simulations could be remade on a set of generated climate scenarios to mask this climate effect. Further analysis of the simulation results will focus on understanding the mechanisms responsible for the complex tree-vine interactions patterns, in particular in terms of i) dynamics of soil colonization by roots (explaining the presence or absence of root profile complementarity), and ii) reduction in heat and water stress resulting from the modified microclimate.

Even if some aspects of the simulations still require improvements, the model gives us access to variables that would be very difficult (or even impossible) to measure in the field, and enables us to test and compare several systems over the long term. The results of the simulation showed the good potential of olive-grapevine associations, which could help stabilize grapevine yield, under the condition that tree management is adapted to reduce the phenomenon of irregularity of production of olive trees.

Acknowledgement
This work was supported by ANR through PRIMA project Biodiversify and by Département de l'Hérault through project PIRAT.

Keywords
light and water competition, Mediterranean resilient agriculture, fruit orchards, vitiforestry, Hi-sAFe model, multifunctional olive systems, microclimate

Aditional Attachment II.

Figure 1 : Simulated yield of grapevine and olive tree as a function of plant age, in compared three planting chronology modalities: tree first (TF), vine first (VF), or both at the same time (BST), and in vine-only (VC) and tree-only (TC) controls

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Valorisation of conifers (Pinus mugo and Picea abies) through steam distillation and hydroalcoholic maceration for flavouring Italian spirit grappa

Miss Anna Perbellini[1], Mr Fabio Pelloso[1], Prof Stefano Grigolato[1], Prof Tommaso Sitzia[1], Prof Stefano Bona[1], Prof. Lorenzo Guerrini[1]
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The use of conifers as flavouring agent in grappa is a traditional practice in the Italian Alps. Grappa is produced by distillation of fermented grape pomace derived from cultivation and vinification within the Italian territory, while aromatised grappa is obtained by infusion of aromatic plants, giving a peculiar aroma and colour to the spirit (DM 747, 2016). The use of conifers in grappa aromatisation is usually limited to specific plant organs, such as cones and young shoots, subjected to maceration within the spirit. Different studies analysed the chemical composition of cones and sprouts of Pinus mugo and Picea abies, and consequently the compound extracted during the maceration (Lis et al. 2019; Mofikoya et al. 2022; Garzoli et al. 2023; Schoss et al. 2023; Valussi 2023), while a limited number of works focused on the wood and bark composition (Kreps et al. 2017; Lis et al. 2019).

Valorising conifers by-products, such as wood chips, for grappa aromatisation would represent an added value in forestry, agroforestry and silvopastoral systems in terms of both economic and environmental sustainability. Nonetheless, the direct contribution of a multipurpose forest-based value chain relies on a synergistic approach along the production process. Through the development of Non-Wood Forest Products, agroforestry systems could contribute to the socio-economic development of marginal areas (Depommier 2003; Di Cori et al. 2022; Indratna et al. 2023).

Steam distillation and maceration are extraction techniques commonly applied to plant material. In steam distillation, volatile compounds are extracted within the essential oil; differently, traditional hydroalcoholic maceration allows for the simultaneous extraction of both volatile compounds, responsible for the olfactory profile, and non-volatile compounds, related to the tactile characteristics of the final product.

Objectives / research questions

This study delves into the prospect of segregating the extraction of volatile and non-volatile compounds. The extraction fractions resulting from steam distillation and hydroalcoholic maceration are utilised to enhance the flavour profile of the Italian spirit grappa. Our primary hypothesis posits that by decoupling these extraction processes, producers can distinguish and customise their grappas. Specifically, the key sub-objectives of this study encompass: I) implementing steam distillation and maceration techniques for the extraction of wood chips; II) utilising essential oil, aromatic water, and wood chips for grappa flavour enhancement; III) evaluating the sensory profile of the resulting grappa, contingent upon the type of flavouring employed.

Methodology

Pinus mugo and Picea abies wood chips were extracted by steam distillation and hydroalcoholic maceration. Steam distillation was performed through a stainless steel extractor, equipped with a tube-in-tube condenser and a cohobation system. Essential oil and aromatic water were separately collected, and yield was measured. Fresh and post-distillation spent wood chips were subjected to maceration in a hydroalcoholic solution. A 40% alcohol solution was used in the experiment to simulate the alcohol content of grappa. Throughout the maceration process, pH, ORP, and °Brix were monitored. Colour analysis in the Lab colour space was computed, based on colorimetry data. Extractions were performed in three replicates for both plant species. Based on the flavouring material, different types of grappa were produced: grappa flavoured with Pinus mugo essential oil or Picea abies aromatic water, and two grappa flavoured through hydroalcoholic maceration of fresh wood chips and post-distillation spent wood chips, from both plant species. All products were analysed by GC-MS. Finally, the sensory profile of the three types of finished products were tested through discriminant tests and descriptive evaluation.

Results

In terms of essential oil yield, steam distillation revealed significant differences between the two plant species. Pinus mugo wood chips exhibited a quantitatively higher yield (0,4%) as compared to Picea abies (0,01%). Measurements performed over maceration allowed for an early monitoring of the extraction and gave useful insights on quality and process control systems. Analysis of the samples' chemical composition by GC-MS provided a characterisation of the essential oils obtained from Pinus mugo and Picea abies wood chips, and also gave evidence of the aromatic profile of the different flavoured grappa. The sensory analysis further supported the discrimination of the samples based on the olfactory and taste features, but also highlighted consumers' preferences of the different products and fostered a descriptive analysis of conifers flavoured spirits.

Conclusion

This study set the basis for the optimisation of steam distillation and hydroalcoholic maceration process to enhance the value of forest by-products from Pinus mugo and Picea abies and their application in grappa flavouring. Furthermore, it fosters product diversification, enabling a greater customisation of grappa sensory profile and faster development and adjustment of olfactory and tactile characteristics in the final product.

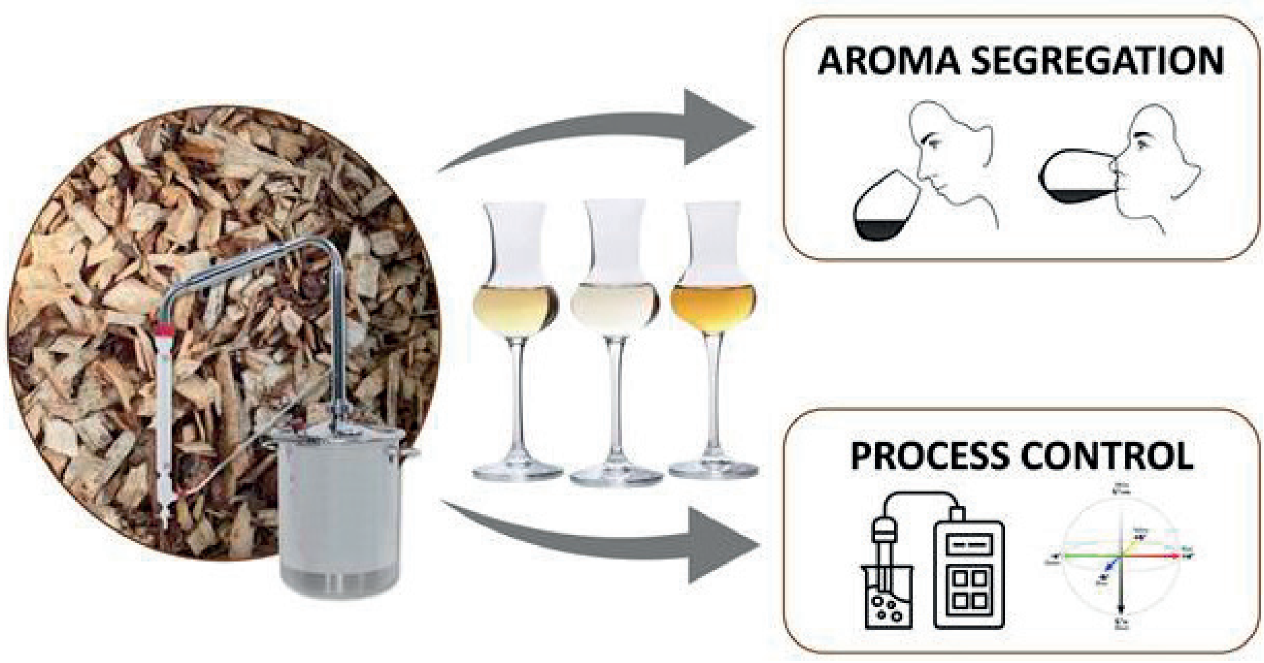
Acknowledgments

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

Keywords

steam distillation, food engineering, innovative food & non-food systems, case study, essential oil, food

Aditional Attachment II.



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Booma Women Cooperative - case of use of NTFP products in Southern Zambia

Ing. Lukáš Karas[1], Mgr. Kamila Hejlíková[2]
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Introduction

Booma Women Cooperative was established in 2022, and officially registered in 2023 thanks to the support of the Czech Embassy in Lusaka. The Cooperative comprises of 12 local women who collect and process Non-Wood Forest Products (NWFP), especially Mongongo nuts. It is in Sichyaa A area of Mukuni village/chiefdom in the Southern Province of Zambia.

One of the NWFP are edible seeds of Schinziophyton rautaneii (Mongongo or Booma in local languages, family Euphorbiaceae). According to Keegan and Van Staden (1982), fruit production is about 1t per hectare in northern Namibia. It is a deciduous tree growing from sub-humid to semi-arid regions of southern Africa. It occurs in open forests as a dominant or co-dominant species with other species such as Afzelia quanzensis and Burkea africana. The average annual temperature of the area is around 20°C (Chidumayo, 2010).

Traditionally, local women collect Mongongo nuts and use them as a daily staple food or in medicine. The tradition of processing Mongongo nuts is transmitted among women for at least 12 thousand years. Edible oil can be made from nuts and used in cuisine or in the cosmetic industry due to its positive effects on skin or hair (Robbins and Campbell; 1990, Chidumayo, 2010).

However, increasing agriculture fields, human-wildlife conflict, and neglect of forest products lead to the cutting of trees and deforestation which leaves local women and children vulnerable. The Cooperative supports women in adding value to NWFP through processing. Increased production of NWFP will generate economic and social benefits, which will lead to the protection and sustainable management of the local forest and environment within the community.

Objectives

The aim of the Cooperative is to provide means to sustainable forest management, regeneration, and protection of trees and natural resources through adding value to NWFP which will lead to economic and social benefits, building capacities in the communities to manage the environment and biodiversity sustainably. With cooperation with experts from Mendel University in Brno, the Cooperative is researching the germination of S. rautanenii.

Methods

The Cooperative bought a new and easy-to-maintain and repair cold press seed oil machine from a Czech company. The oil from collected seeds is sold in local shops or processed further into cosmetic products. Women from the Cooperative receive the money from selling products.

One of the goals of the Cooperative is to find the most suitable way how to regenerate local populations of S. rautanenii by producing seedlings. Firstly, it will be determined if the seed contains any abscisic acid (germination inhibitor). Then two methods of germination were designed. In both methods, one half of the collected seeds will be intact, and the other half of the seeds will be scarificated by removing part of the seed testa.

The first method uses the effects of cold stratification. Seeds will be stored in a climabox at constant temperature of 4°C for 3 months. After that, a germination test will be conducted to determine the germination rate. The second method uses the effects of phytohormone Ethylene. According to Keegan and Van Staden (1981), seeds of S. rautanenii had the highest germination rate using Ethrel. Ethylene is naturally produced in some species when fruits ripen (Alexander and Grieson, 2002), like tomatoes, bananas, or mangoes. Seeds of S. rautanenii will be placed in a plastic bag together with either bananas or mangoes, and when ripening, they should produce ethylene. Thus, in the second method, the germination rate of seeds treated with Ethrel solution and seeds from plastic bags with fruits will be compared.

Results

The Cooperative comprises nowadays of 12 local women from Mukuni village/chiefdom. The main income of the household of married women is generated by their husbands, while widowed and single women rely only on the collection and selling of NWFP within the community. Furthermore, Mongongo nuts are also an important staple food and local women use part of the collected nuts for their own consumption. Within the Cooperative, the income from nut selling is approximately 1000 ZMW per year.

The results from germination trials are not yet known, because the research is still ongoing.

Conclusions

Booma Women Cooperative provides means to local women to process and produce local NWFP, especially Mongongo nuts. The income from the selling of Mongongo oil goes directly to women, helping them generate income for the household.

Keywords

business models, Zambia, agroforestry practices, Agroforestry system, Mongongo, non-wood forest product

Aditional Attachment II.

BOOMA WOMEN COOPERATIVE

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Chestnut as a multifunctional and suitable tree species in agroforestry – growth of trees in silvopasture case study from western Slovakia

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Introduction

In Slovakia, we have several tree species that receive little or no attention. Here belongs, for example chestnut (Castanea sativa Mill.), which is one of the oldest non-native woody plant species in Slovakia. This tree species is not very known and used in Slovakia, despite the fact that it is a very promising and multi-purpose tree species. Chestnut is also suitable tree species for establishment of agroforestry systems, but up to now its potential for agroforestry systems for agricultural land management has not been used. It can be very interesting and perspective both in terms of nut production and high quality and well-durable wood for construction purposes.

The aim of this contribution is to present the potential of chestnut in terms of its use as a useful fruit and valuable forest tree and evaluate the growth parameters (diameter at breast height and total height) of chestnut individuals in such agroforestry system.

Case description

As the pilot research-demonstration plot was selected a chestnut-poultry silvopasture orchard in Suchá nad Parnou (Trnava county) in western part of Slovakia. This chestnut agroforestry farm is managed by private farmer on 1.2 ha and the cultivation is combine with animal farming (about 50 pieces of poultry and geese). There is no specific time management of poultry grazing in orchard. Only part of poultry graze freely, so no problems with soil compaction have been observed. Chestnut trees are planted to produce nuts used for human consumption and direct sale. The main soil type is anthropogenic soil and the soil profile is weakly acidic to acidic, with a very small supply of mineral nitrogen, with a high content of carbon and humus, non-carbonate with a suitable supply of nutrients (N, P, K, Mg, Ca) in the top horizon. The area can be a representative climate-soil-growth conditions in the Danube Lowland concretely hilly land of the Trnava loess hills. The location Suchá nad Parnou was chosen, because of the already established system of agroforestry, where long-term permanent cultures (chestnut, domestic plum) are grown on one area and domestic animals are raised with a specific time and space arrangement. At the same time, there is a mutual ecological interaction between both components.

Conclusion

Based on the measurements it was found that 21 years after planting (2023) average diameter at breast height of chestnut individuals reached 14.5 cm. The lowest recorded diameter at breast height was 5.0 cm and the highest was 25.2 cm. Average last year diameter at breast height increment reached 0.4 cm. Further 21 years after planting (2023) average height of chestnut individuals reached 5.2 m. The lowest recorded height was 3.0 m and the highest was 7.4 m. Average last year height increment reached 0.6 m. The obtained measurements show that chestnut trees have a good soil and climate conditions at mentioned agroforestry farm, since one of the important factor, which is the relief of the hills creates favourable conditions for mitigating the differences between the annual and daily temperature fluctuations. In this way, the chestnut can survive the adverse effects of low temperatures, summer heat or lack of moisture. In Slovakia today, this promising tree face insufficient care from the state bodies, as there are no specific management measures for them yet. It is possible to plant them in the open country focused on agroforestry systems. Creation of agroforestry systems with chestnut on permanent grasslands, which would also be used as hay meadows, or pastures will enable combined and diversified production including farm animals with higher added value. In conclusion it is important to notice that chestnut agroforestry systems can play important role in providing ecosystem's services, as food provision or cultural services, but also biomass provision and climate regulation.

Acknowledgment

The contribution was supported by the Slovak Research and Development Agency APVV (under the contract No. APVV-20-0326) and the project "Models of transformation of non-forest land overgrown with tree species to production agroforestry systems (TRANSAGROLES)".

Keywords
extensive production system, timber, Central Europe, fruit trees, Agroforestry, grazing, silvopasture

Aditional Attachment II.

Identifying strengths and weaknesses of the Italian Gin production for technological innovation, sustainability and socio-economic development of marginal areas

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Introduction

In recent years, gin has experienced a remarkable global success. Its consumption witnessed a higher surge compared to any other alcoholic beverage in 2018, and the trend continues to rise. The significant rebirth of gin, coined as the "ginaissance", began in the early 2000s, triggered by historical and economic events that prompted craft production in numerous countries. In Italy, by 2020, 225 gin brands were active. This growth is evident in the emergence of a distinct gin culture, associated with gin bars, specialized media and books (Pedeliento et al. 2022). Gin is defined as a spirit derived from juniper (Juniperus communis L.) berries (Black 2022; Regulation (EU) 2019/787). However, the potential combinations of botanicals for creating novel recipes are limitless. This flexibility in gin distillation has led to the development of unique products closely linked to their production area. Medicinal and Aromatic Plants (MAPs) offer a wide range of ingredients, but their provisioning still relies on wild collection rather than cultivation. Many MAPs used in gin grow spontaneously in forest environments. Shifting from collecting wild plants to farming, agroforestry could represent a sustainable and conservative strategy (Rao et al. 2004). Therefore, the increasing demand of such MAPs for gin production could be intertwined with the implementation of diversified agroforestry systems in marginal areas, through the development of Non-Wood Forest Products, as a value adding strategy (Depommier 2003; Di Cori et al. 2022; Indratna et al. 2023). Knowledge of current trend of the production chain becomes extremely important to balance environmental and economic considerations, while maintaining or enhancing the quality of the product.

Objectives / research questions

This study aims to provide an overview of the current production and economic framework and to identify the strengths and weaknesses of gin distillation. It seeks to explore the role of technological innovation in optimising the gin production process, as well as the implications for the socio-economic development of the industry, consistent with its traditional roots and local development goals.

Methodology

To identify the economical, production and technological features of gin production chain in Italy, the experimental layout involves two steps: a qualitative analysis, based on a semi-structured interview; and quantitative analysis, based on a questionnaire. As outlined by Kallio et al. (2016), the qualitative analysis comprises a semi-structured interview consisting of five main open-ended questions related to five macro-areas: company description; territory and tradition; raw materials; technologies used and innovation; areas for improvement. The interview is conducted orally via Zoom, recorded and transcribed. The quantitative analysis involves a written questionnaire, with multiple-choice or brief open-ended questions. More detailed information on production, quantities produced, types of machinery, and company sizes, is collected. Sample selection was carried out among Italian gin distillers and the number of participants was outlined based on the saturation criterion. Data collected underwent content analysis, as an objective and systematic examination to classify data into categories.

Results

Results of the content analysis highlighted strengths and weaknesses in gin production chain. Producers perceive a growing demand for this product, underlying a special interest of consumers towards craft gins, with attributes related to sustainability, tradition and the local origin of the recipe and raw materials. Challenges concerning legislation, quality of raw material, sustainability and control of the production process, product quality and standardisation, and consumers' knowledge were recognised. While juniper (Juniperus communis L.) preserves a predominant role in the majority of gin recipes, different plant species are used, to enhance the link of the product to traditional areas. Simultaneously, due to the lack of specific regulations on the product and process characteristics, the market becomes accessible to a wide range of products. The variety of styles and ingredients requires a deep technical knowledge of the raw material and the distillation process. Variations in the availability and quality of the raw material have been highlighted;

and it has been pointed out that changes in the quality of the botanicals and the distillation method might result in perceivable alterations in colour, taste and yield of the final product. In production plants equipped with automatic process control systems, differences among batches can be reduced, thereby obtaining a more standardised product and reducing non-conformity issues. The producers' perspective on the flourishing market gave relevant insight on the need for improving the traceability and sustainability of the product. The quantitative questionnaire allowed for a detailed categorisation of the producers, according to specific features of the company and the supply chain, together with data on the production technology and production flows.

Conclusion

The implementation of a semi-structured interview proved to be a systematic method to obtain gin producers' expertise on the research topic. Drawing together qualitative and quantitative data, this study gave relevant information for evaluating and optimising the sustainability of the process, from the collection of raw materials to the consumption of the final product.

Acknowledgements

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Keywords

distillation, sustainable food production, semi-structured interview, gin, stakeholders, Juniperus communis L.,farmer perception, non-wood forest product, Sustainable management, sustainability, rural economy, consumers, spirits, innovative food & non-food systems, production systems, rural development, business opportunities, sharing of experience, food, sustainable business models

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A beekeeper's contribution to the study of Quercus pyrenaica honeydew honey and acorn production in the Montesinho Natural Park, Portugal

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3 Forest Research Centre (CEF), School of Agriculture, University of Lisbon, Tapada da Ajuda, Portugal

Introduction

The Montesinho Natural Park (MNP) stands out as a protected area with a diverse landscape, encompassing agricultural land, agro-silvopastoral systems, and extensive oak forests, where Quercus pyrenaica holds prominence. These oak forests are historically managed as silvopastoral systems, and offer multifunctional benefits such as wild non-wood forest products (mushrooms, medicinal herbs, game and, in particular, acorns and honey) that contribute significantly to local economies. As inhabitants of this region, we want to harness the potential of these systems. We currently have around 250 hives for honey production, and we are studying the possibility of using acorns for the subsequent production of flour and other derived products.

MNP honey, recognized as a Protected Designation of Origin (PDO) product, underscores the close link between honey quality and the region's floral richness. Despite the prevalence of oak honeydew production in the Iberian Peninsula, uncertainties persist that require research regarding Q. pyrenaica honeydew source and processes, honeydew honey production evaluation, development of production models, and botanical source discrimination through chemical characterization.

Acorns are a product in growing demand for flour and derivative products, with more and more dedicated research, although there is still a lot to be address regarding key areas like estimating acorn production, understanding edaphoclimatic drivers, and addressing acorn abortion, a limiting factor for both forest regeneration and the development of acorn-based products.

Objectives / Research questions

Whilst working in the Montesinho region, we noticed a particular relationship between bees and oak trees. Throughout the summer, we often observed some exudates on the acorns. These exudates are visited by bees, and hence may be associated with the production of honeydew honey, as well as appearing to be the reason or a consequence of extensive acorn abortion.

This led us to contact some research institutions to explore these issues, and out of this collaboration came the national FCT project "ACORNDEW - Boosting the sustainability of the Montesinho Natural Park oak forest through innovation: valorisation of acorn and honeydew". This collaborative effort involves scientific partners (Instituto Superior de Agronomia, Instituto Politécnico de Bragança, Universidade de Vigo) and associative partners (Agrupamento de Produtores de Mel do Parque). The project objectives span from understanding tree and climate variables affecting acorn and honeydew production to developing models, identifying beekeeping guidelines, and characterising the quality profiles of honey and acorns.

Methodology

As a producer and SME partner, we play a key role in establishing four study apiaries in diverse oak forest stands across the natural park. Each apiary, featuring ten hives, is dedicated to the project's goals. Our responsibilities include site selection, regular hive management, pest control, and honey extraction. During the production season, we weigh honey frames fortnightly to track summer honey influx (Fig 1A). Honey samples are also collected between each weighing for palynological assessments (Fig 1B). At the end of the season, each hive honey is extracted, and a 1 kg sample is taken for later physico-chemical analyses. Additionally, we contribute to oak phenology monitoring, observing flowering, acorn development, and abortion rates, and evaluating the presence or absence of sweet saps, on multiple shoots per several oak trees. We also support the data and acorn collection activities on the established monitoring plots, both to assess production and for subsequent processing into flours and oils.

Results

Entering our fourth project year, the initial three years of honey production evaluation unearthed some significant findings. Weighing's carried out during the summer make it possible to verify the variation in the flow of honey into the hives and relate this variation to the observation of honeydew and the presence of insects (aphids), helping to discern whether the honey has a floral or non-floral origin. Acorn availability exhibited substantial inter-annual variation as well as inter-site variability. Acorn abortion rates reached levels as high as 90%, while samples of acorns with exudations showed signs of phytopathogenic bacteria, shedding light on Q. pyrenaica acorn development challenges (Fig 1C).

Conclusion

Moving forward, the project aims to correlate honey and acorn production with various factors, including climatic variables, forest inventory data, and physico-chemical properties. From our point of view as producers, we want to obtain the knowledge and tools that will enable us to efficiently produce a high quality, differentiated honey, and to make an informed assessment of the possibility of exploiting acorns, either for human consumption or for other purposes. This comprehensive approach underscores our commitment to enhancing the sustainability and economic value of the Montesinho Natural Park's oak forest.

Acknowledgments

This work is financed by national funds through FCT - Fundação para a Ciência e a Tecnologia, I.P., under the ACORNDEW project (MTS/SAS/0099/2020).

Keywords

acorn, Quercus pyrenaica, Oak honeydew honey, Pyrenean oak, oak, acorn production, non-wood forest product

Aditional Attachment II.

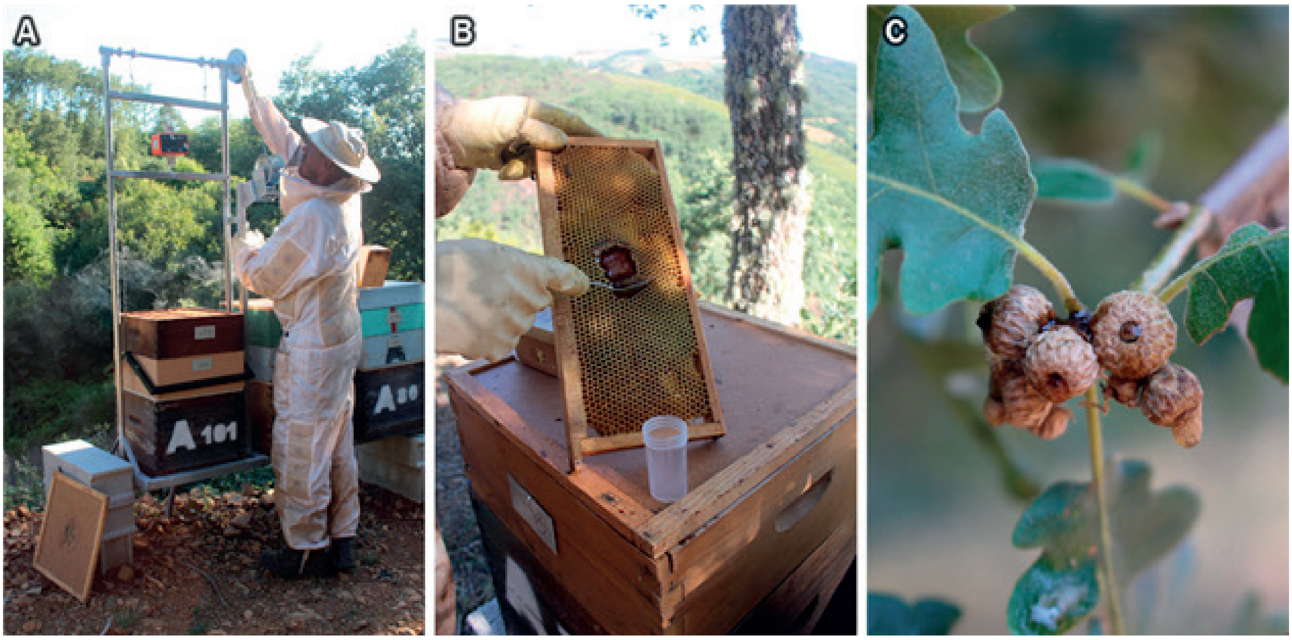

Fig 1 – The work carried out during summer in the project's hives involved (A) weighing and (B) collecting honey samples weekly or fortnightly. (C) Acorns of Q. pyrenaica at the beginning of their development, with visible exudations.

2.5 Models and Tools (I)

Oral presentations

Hall Q3, 28 May 2024, 14:45–16:15

FarmTree for European Agroforestry Decision Support

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This presentation will highlight the efforts of FarmTree BV in making scientific and practical agro-ecological knowledge available to farmers and experts. The work is kindly supported by the project REFOREST (https://agroreforest.eu) financed by the European Union´s Horizon Europe Programme under Grant Agreement Nr. 101060635.

Challenges in Agroforestry Adoption
Agroforestry addresses the challenge to balance nature restoration and agricultural production. However, agroforestry decision-making at farm and regional level is not always informed by the wealth of research and experience gathered over the last decades. Constructing 'Agroforestry business cases' is complex and time-consuming.

FarmTree's Approach
FarmTree BV is a social enterprise based in Wageningen, The Netherlands that aims to process scientific and local knowledge into local decision support services across the globe. Towards this end FarmTree collaborates with scientists and local experts and develops online databases and tools to make their knowledge available to farmers. Practitioners' feedback steers such tools' development.

The FarmTree System & Toolkit
The FarmTree interface combines a farm cover plan (crops + trees + management) with default tree/crop, climate, soil and price data, and simulates up to 50 years' of a plot performance for finance, labour, yields, soil fertility, biodiversity, and other indicators. FarmTree's current functionality includes: comparing monocrop versus agroforestry performance; generate performance estimates for multi-purpose agroforestry planning; landscape performance dashboards for governance actors.

Currently linked system modules include:

1. A database of species modelling variables1
2. A process-based agro-ecological model, that generates a wide array (+50) performance indicators2
3. An online user interface, that enables the user to design an Agroforestry plan and review its future performance
4. Near-future functionality expansion includes: make available agroforestry systems' digital twins, calibrated agroforestry species, APIs for linking to colleagues' tools and models3

FarmTree objective
At the EURAF conference, we want to explore with colleagues how expertise and tools can be linked and made accessible to farmers and experts alike. This includes partnerships with knowledge institutions, farmers' organisations, and private actors, for calibration and validation, and for elaborating a product--market fit. The goal is to develop an information service that allows farmers to both plan and report on Agroforestry performance to inform actors like governments, carbon traders, and consumers.

1 Within the REFOREST project, the CAFS database has been updated with +80 relevant European agroforestry species calibrated with regional and field data from seven European countries (LLs).

2 Additional functionalities have been built within the REFOREST project to further adjust the model to the European agroforestry context (e.g. including seasonality effects on species production)

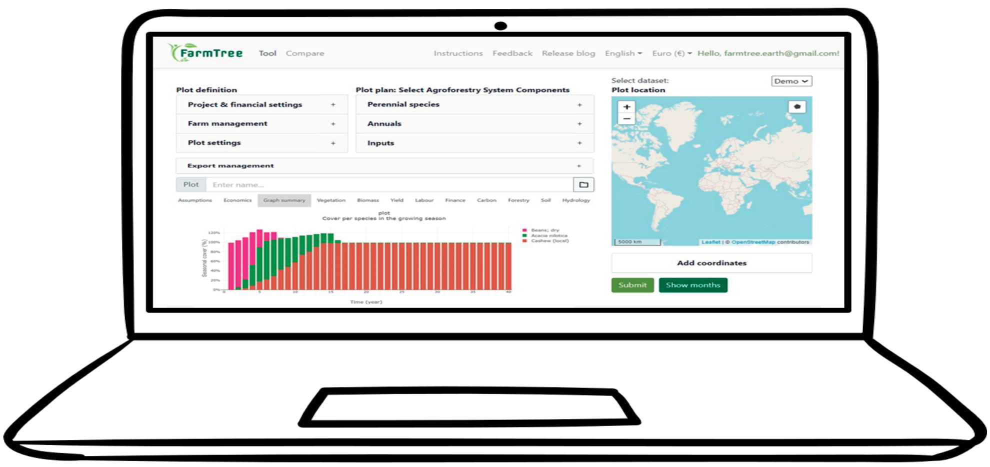
3 Additional functionalities have been built within the REFOREST project to further adjust the interface to the European context (e.g. including additional languages to increase user accessibility)

In conclusion, FarmTree aims to develop partnerships to offer a scalable decision-support solution to realize the full potential of agroforestry for sustainable land-use practices across Europe.

Aditional Attachment I.

	Decision-support (DS) concept	Scientific rigour	Agroforestry Fit & GoTo Market	Paying customers	Scaling as SaaS product
FarmTree	Model conceptualised and working for KPI generation	Incorporating scientific - and calibration on-going	Active market research & incorporating feedback	Paying customers drive innovation	Last mile user-fit on-going
Scientific Dynamic Models	System understanding rather than DS focus	Science at the heart	DS applicability not clear	Rarely paying customers	Usually absent
Remote Sensing	Technology for high-over info-generation	Science at the heart	DS applicability not clear	Customers have M&E focus, not decision-support	Not Agroforestry-oriented
Project Management Tools	Not Agroforestry oriented	NA	Not Agroforestry oriented	Customers pay, but are not AF-oriented	Not Agroforestry oriented
Expert Spreadsheets	Experts' project-specific carbon, bizz spreadsheets	NA	Not market oriented	Not market oriented	Not market oriented
Species selection tools	Selection criteria & framework clear	Tools are incomplete but data capture on-going	AF-oriented, follows requirements research	Tools are open-source but rarely used	Tools usually offline
Plot layout tools	Plot layout principles clear	Underlying data locally verified	Some are expert-market oriented	Expert use common	Online, but poorly linked
Plot location maps	Conept is info provision, not DS	NA		Open source and service rarely paid for	Most are online

Figure 1. The Agroforestry decision-support service model of different tools in the agroforestry domain. FarmTree aims to simultaneously develop a science and market-based decision support service, to be applied at scale, for practitioners all over Europe and beyond, through a social entrepreneurial model.



AgroforesTreeAdvice: an advice aggregator for tree species selection for agroforestry systems

Dr Marie Gosme[1], Kristoffer Ronn-Anderson[2], Birk Skyum[2], Clément Rigal[1,3], Raphael Paut[4], François Warlop[5], Sarah Carton[6], Paul Pardon[6], Jakub Houska[7], Jan Weger[7], Lubos Úradníček[8], Antonín Martiník[8], Michael den Herder[9], Rico Hubner[10], Ana Tomas[11], Sonja Kay[12], Cécile Antin[13], Evert Prins[14], Bert Reubens[6]

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2 Regen Farmer, Aakirkeby, Denmark
3 CIRAD – UMR Absys / ICRAF - Vietnam country office, Hanoi, Vietnam
4 INRAE – UMR Agronomie, Saclay, France
5 Research Group for Organic Farming, Avignon, France
6 Flanders research institute for agriculture, fisheries and food (ILVO), Belgium
7 VUKOZ, Průhonice, Czech Republic
8 Mendel University, Brno, Czech Republic
9 European Forest Institute, Joensuu, Finland
10 German Association for Agroforestry e.V. (DeFAF), Germany
11 MVARC, Beja, Portugal
12 Agroscope, Switzerland
13 CIRAD, AMAP, Montpellier, France
14 Louis Bolk Institute, Bunnik, The Netherlands

Tree species selection is a crucial step in the design of agroforestry systems, for which farmers expressed the need for decision support systems (DSS). A quick search among the partners of the DigitAF Horizon Europe project (https://digitaf.eu) allowed us to identify several such DSS, which had been developed independently, in different countries and for different agroforestry systems. These include DENTRO (tree selection for silvoarable and silvopastoral systems in Flanders), ShadeTreeAdvice (shade tree selection for coffee and cocoa agroforestry systems), SCSM (soil and climate suitability model for a range of trees and shrubs worldwide), Deciduous (fruit tree rootstock selection in France) and a Czech trees characteristics database. In this presentation, we present our joint efforts to develop a common framework in which these tools could all fit, in order to increase their i) findability (all tools are gathered in the same place), ii) accessibility (a common interface allows users to query the tools with interfaces having the same look and feel), and iii) interoperability (API requests can be used to query all tools).

Our hypothesis was that all tree selection tools work by matching tree traits to selection criteria defined by the user in order to provide a suitability score for each tree species, and that the selection criteria, although being different between different tools, could be organised in a structured way to make comparisons between tools possible. We considered that tree suitability depends on i) adaption to local conditions and ii) efficiency at providing the desired benefits (tree products and/or ecosystem services (ES). Based on the trait-function-service framework (Violle et al. 2007), we organized the data according to two types of tree traits: response traits (causing the response of the tree to its environment, and so driving its adaptation to local conditions) and effect traits (allowing the tree to perform functions leading to the production of ES, e.g. fulfilling the farmer's objectives). Criteria linked to the provision of ES (and therefore the matching effect traits) were organized following the CICES 5.1 classification (Haines-Young and Potschin 2018) at the highest levels, and subsequent levels were added when more details were needed (e.g. distinguishing between different uses of wood). In the absence of internationally recognized classification of criteria linked to the adaptation to local conditions, these criteria were organized as adaptation to soil, climate, biotic context, constraints at plot scale, constraints at farm scale and constraints at socio-economic level. As for ES, we classified these criteria in a hierarchical manner, allowing different levels of details according to the focus of each tool. Finally, we developed a shiny app using this common framework to interface with several tree selection tools.

Initial work on the five species/rootstock selection tools mentioned in the introduction proved that the idea is feasible: the criteria used in each tool were categorized according to the common framework. Table 1 shows the number of criteria of each top category in each tool. The shiny app aggregates the advice of these five tools. It allows users to define their site conditions and objectives, compute the adaptation and efficiency scores of each tree species and visualize the results in graph or table form; it also supports URL requests. It is available in six languages and can be tested at https://agroforestreeadvice.sk8.inrae.fr/.

After the proof of concept is done, we aim at enlarging the tool contributors beyond the limits of the DigitAF project. Therefore, we created a repository under EURAF GitHub account (https://github.com/euraf/agroforestreeadvice). The code is open-source and we welcome contributions (adding new languages, adding new tools, improving code). The tool will be tested and further improved within DigitAF Living Labs.

Acknowledgment
This work was funded by the European Union under grant agreement: 101059794. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. The European Union cannot be held responsible for them.

Keywords
ecosystem services, online tool, climate, soil characteristics, Agroforestry system, trees, design, Plant species selection

Aditional Attachment I.

criteria		Tool					
type	category	Dentro	ShadeTreeAdvice	SCSM	DECIDUOUS	Czech	Total
effect	provisioning	6	16	1	7	106	136
	regulation	9	29	4		4	46
	other			2			2
response	climate	10	3	2	2	5	22
	soil	4			3	2	9
	biotic context	2					2
	constraints at plot level		1				1
	constraints at farm level				2		2
	constraints at socio-economic level						0
Total		31	49	9	14	117	220
Tree species		80	215	383	27	59	

Table 1 : Number of criteria of each type in each tool

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Optimal land use share for climate change adaptation of a Mediterranean silvopastoral system: A simulation approach using Hi-sAFe model

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2 INRA (UMR-SYSTEM), University of Montpellier, Montpellier, France
3 Centre for Agroecology, Water and Resilience (CAWR), Coventry University, Coventry, United Kingdom
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5 Environmental Remote Sensing and Spectroscopy Laboratory (SpecLab), Spanish National Research Council, Madrid, Spain

Climate change will pose several challenges to agricultural systems in the coming decades. Expected effects will include not only a reduction on the average productivity but also an increase in temporal variability, due to a higher frequency of extreme events, leading to a reduction in the stability of the production. Agroforestry systems (AF) are argued as a feasible land use to increase the resilience against climate change. However, there is little evidence on the combined effect of AF on the productivity, stability and resilience of agricultural systems and which is the optimal combination of land uses at farm level to improve all of them. The aim of this study was to assess the optimal combination of different land uses to improve the production, stability and resilience of a Mediterranean silvopastoral system in the coming decades.

Tree growth, pasture production, stability and resilience and water yield from 1990 to 2090 was simulated using the Hi-sAFe model (Dupraz et al. 2019). We used downscaled RCP8.5 climate data to simulate the temporal dynamics of open grasslands and agroforestry with low, medium and high tree density (25, 50 and 100 trees ha-1, respectively). Simulations were validated with current AF tree structure, long-term data of tree growth (2011-2023) and pasture production (Mg ha-1, 2014-2021). Tree parameters were calibrated with field measurements. Pasture parameters were calibrated using an optimization algorithm based on values of phenological stages gathered from the MODIS Land Cover Dynamics (MCD12Q2) product. Based on simulated pasture production, we computed one metric of stability, as the mean divided by the standard deviation, and one of resilience that is related to the return period of the largest shock that the production can absorb (Zampieri et al. 2020). Water yield was computed as the difference between precipitation and the sum of soil evaporation and tree and pasture transpiration. Farm optimal land use composition was assessed based on tree growth, pasture production, stability and resilience and water yield for three different periods, 1990-2025, 2025-2065 and 2065-2090.

The results showed that the model successfully simulated tree size, based on stem diameter at breast height, tree height, leaf area index and crown area (RMSE = 4.3, R2 = 0.99 and MAE =2.6), after a spin-up run of 110 years to simulated current tree characteristics. Tree growth (RMSE = 4.3, R2 = 0.99 and MAE = 4.1) and pasture production (RMSE = 0.28, R2 = 0.72 and MAE = 0.24) were also successfully simulated. The model simulated a substantial decrease in pasture production by the end of the century, being significant in open pastures as compared to current conditions (~ 50 % decrease). Pasture stability and resilience were higher in AF regardless of tree density. Tree growth was dependent on tree density, it peaked at the beginning of the century in high tree density, followed by median tree density, while low tree density showed consistently lower values. Water yield was higher in open pastures than in AF particularly in high tree density, and there was a significant reduction by the end of the century. Based on this parameters, optimal farm composition depended on the period considered (Fig. 1). At the beginning of the century, a farm composed by aprox. 45 % of open pastures, 5 % of low tree density and 50 % of high tree density was optimal. However, by the end of the century, the share of high tree density was shifted to intermediate tree density, suggesting a thinning of high tree density.

In conclusion, AF seems a feasible option to optimize farm land use, but careful planning of tree density should be considered. Current Mediterranean silvopastoral systems tree density is much lower than 50 trees ha-1, suggesting that an increase in tree density can improve the production, stability and resilience of the pasture layer, without compromising tree growth and water storage.

Acknowledgement

This research was part of the AGROMIX Project and received funding from the European Union's Horizon 2020 research and innovation program under grant agreement 862993.

Keywords
resilience, dehesa, landscape planning, Hi-sAFe model, stability, adaptation

Aditional Attachment I.

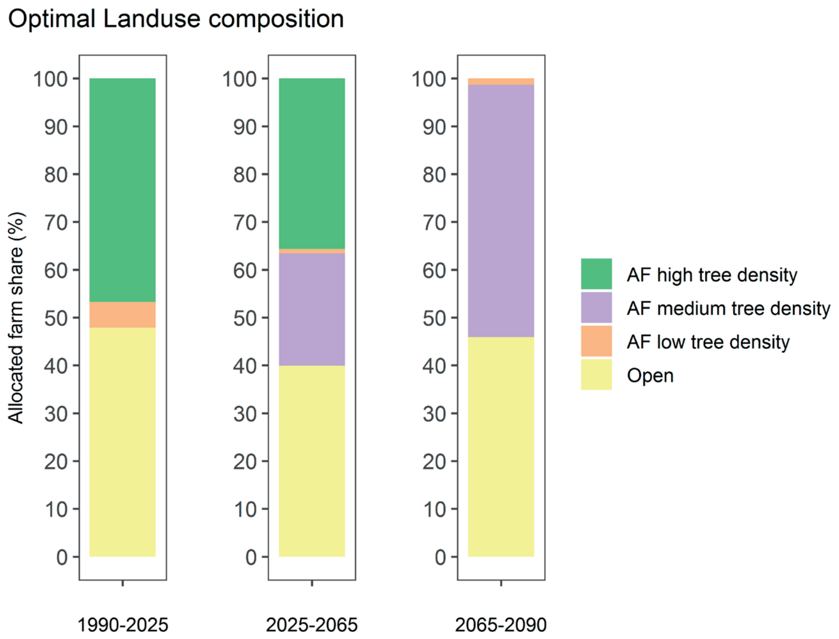
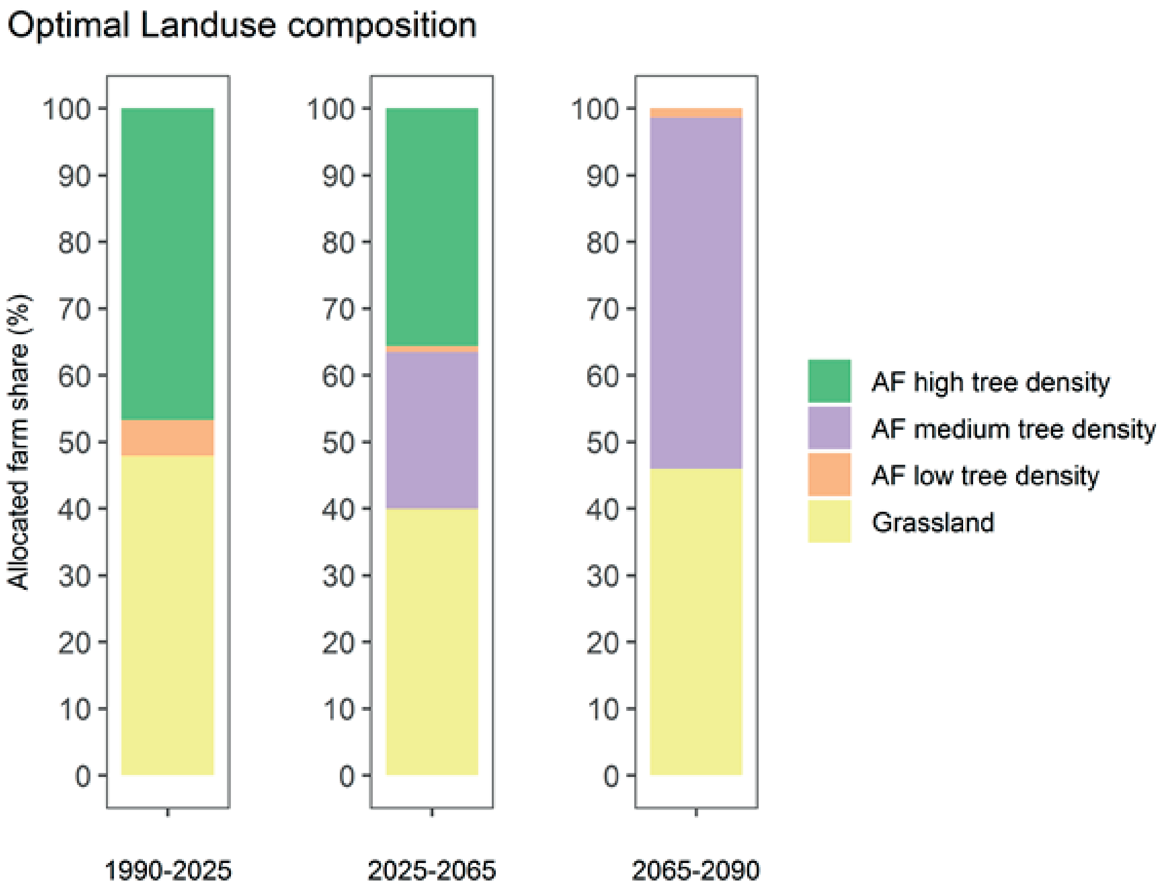


Figure 1. Allocated farm share of land uses based on mean values of simulated pasture production, stability and resilience, tree growth and water yield during current and future scenarios under RCP8.5.

Aditional Attachment II.



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Evaluating the multifunctional sustainability of different agroforestry systems

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Agroforestry systems are recognised as sustainable alternatives to conventional agriculture (e.g. Smith et al. 2022), however this conclusion is complicated by the wide diversity of different types of agroforestry systems and even debate as to what agroforestry actually means (e.g. Nair et al. 2022; Mupepele and Dormann 2022). For example, agroforestry systems include both traditional and modern innovative designs, differing tree densities, and different tree functions and species diversities (Smith et al. 2012). The relative sustainability benefits and trade-offs of these different types of systems is poorly understood, but is critical for the appropriate promotion, design and management of agroforestry systems for sustainable production of food and other products. Therefore, in this study we aim to assess the multifunctional sustainability of different types of agroforestry systems.

We are collecting data using the Public Goods (PG) Tool, originally developed by the Organic Research Centre (Gerrard et al. 2012; Smith et al. 2022). We adapted PG Tool specifically for agroforestry systems. The PG Tool is designed to assess the sustainability and public goods provision of individual farms, using farmer-provided input data relating to crop production and farming practices. To select representative study farms, we first developed a map of agroforestry farms in the UK using internet sources and knowledge of colleagues, and categorised these according to their historic/traditional or modern status, depending on whether they were planted prior to or after 1970 (roughly when the term 'agroforestry' began to be used, and research of innovative systems emerged (Smith 2010)). For modern systems, these were further categorised as having high or low tree density (more or less than 100 trees per hectare). Modern systems were also categorised according to their tree diversity, with diverse systems having at least four tree species within an individual field. This led to five categories in total (historic/traditional, modern high-density diverse, modern low-density diverse, modern high-density simple, modern low-density simple).

Within each of these five categories of agroforestry systems, a representative sample of agroforestry farms was selected. These farms are currently being assessed for their sustainability benefits, including soil management, energy and carbon, social capital, and farm business resilience. This data is collected by a researcher visiting each farm for approximately half a day, using the adapted Public Goods Tool.

Our results will allow a comparison of the sustainability of different types of agroforestry systems according to their historic/modern status, tree density and diversity, in addition to trade-offs between different elements of sustainability (see Smith et al. 2022). This will inform an understanding as to the value of different agroforestry systems in terms of public goods delivery, and how the design and management of agroforestry systems can maximise sustainability benefits.

Acknowledgements

This abstract is based upon work from project 101060635 - REFOREST. Funded by the European Union. We are grateful to the farmers who have participated in the research.

Keywords

public goods, sustainability assessment tools, farm-scale sustainability assessment

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DECIDUOUS: a user-friendly tool to support fruit tree choice for agroforestry

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Introduction

Fruit agroforestry appears to be a relevant option for farmers interested in diversifying their system for various purposes (Castel et al., 2019). Livestock farmers may be interested in shelter and protection against birds of prey for animals, while vegetable farmers, arable or wine growers may be interested in fruit production, and also other services provided by trees in the cropping system. In Europe, there are more and more successful examples of fruit tree planting in arable, market gardening and grassland, but also examples of failure due to inappropriate choice of fruit trees by farmers, for a number of reasons. The first one is that these farmers generally do not have specific knowledge of fruit growing, and don't have fruit advisors in many regions where fruit production is not a main production. Farmers therefore don't know the most determining criteria for selecting fruit trees (species, rootstocks, cultivars). In some cases, farmers depend on the availability of nursery stock, and this available material might not always be adapted to farmer and plot constraints.

From agroforestry advisors' point of view, the needs and expectations coming from interested farmers are redundant.

Material & method

In this context, we have been working since 2021 on a decision-support tool for choosing fruit trees for agroforestry projects. To build this tool, we organized knowledge-sharing workshops to (i) define the important criteria for choosing fruit trees (Cf. figure 1), (ii) weight these criteria and (iii) characterize fruit species according to these criteria. We asked support from 22 fruit tree experts (6 researchers, 10 farmers/advisors, 6 agricultural engineers), some of whom were also consulted individually after the workshops. At the same time, we worked with agronomy students (Montpellier SupAgro) to design the tool's architecture, content, database and ergonomics.

We then developed a calculation algorithm to match farmers' constraints with the characteristics of the different species included in our tool. The algorithm is a computer program for multi-attribute decision making, inspired by DEXi-type tools (Bohanec, 2020).

The final step was to compare the tool's results with the experts' knowledge, with a view to optimization. The tool is currently parameterized for six main fruit species (apple, pear, plum, peach, apricot, cherry).

Results

The criteria considered in the DECIDUOUS decision tool were dealing with:

- Soil characteristics (pH, depth, hydromorphic level, Calcium level),
- Climatic conditions and late frost or drought risk,
- But also specific questions like time availability for farmers for each season, tree height expected for agroforestry system…

Criteria and associated scores have been gathered into a 'expert matrix', and the decision tool has been built under R-Shiny interface for a user-friendly and 'funny' approach.

The algorithm is based on a weighting system that matches the characteristics of the fruit tree species with the criteria entered by the user. The algorithm calculates a total score, which is the weighted sum of the criteria according to (i) the user inputs and (ii) the importance of each criterion ranked by the experts.

Finally, the R-Shiny tool returns a list of possible choices, according to the answers given by the user, with a relative scoring table, and colors depending on the correspondence with entry data (figure 1). A list of low-susceptible cultivars is also proposed for each species, and various regions of France. Most of farmers won't have time/space to spray for tree protection, that's why the most adapted to low-input systems have to be proposed (Malusa & al., 2022).

The final but most decisive part of the work was to ensure that results given by the tool are robust enough for end users in order to avoid wrong recommendations. To do so, experts were asked to run simulations with the tool and observe results with their knowledge. In some cases, the algorithm formula and matrix had to be modified to improve the tool results.

Perspectives

The tool has been finalized for the French context and 6 main fruit species in February 2024.

It will afterwards be implemented :

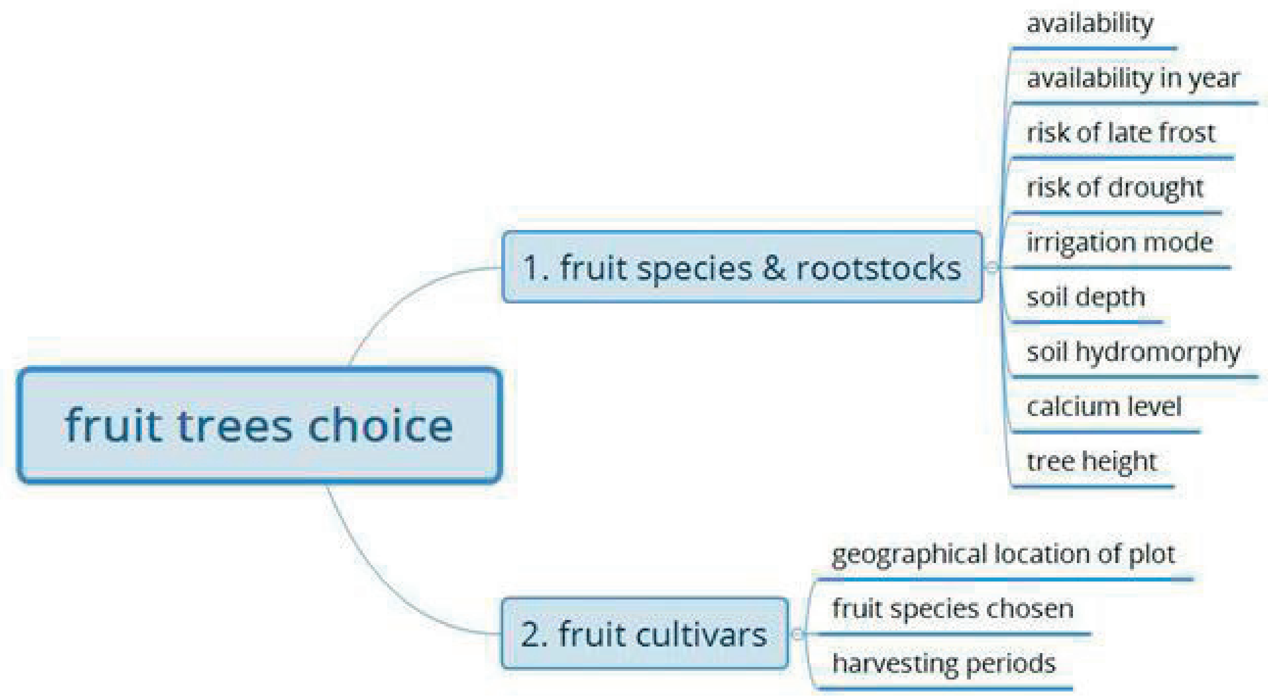
- In other EU countries with specific national data, in the frame of the Horizon Europe DIGITAF project (www.digitaf.eu) ;
- With other minor fruit species for the french situation.

This tool should be used for a first approach of tree choice, but the final decision shall be discussed to some extent with other skilled people such as fruit growers, nurserers, advisors.

Keywords

fruit trees, silvoarable agroforestry, fruit orchards, European project, alley cropping, Organic Farming, crop production, orchards, decision-making, agroecology, temperate agroforestry, orchard, Agroforestry, crop variety, France, decision tool

Aditional Attachment II.



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2.5 Models and Tools (II)

Oral presentations

Hall Q2, 29 May 2024, 10:30–12:00

CarboCatch: assessing tree biomass carbon using remote sensing and machine learning in an interactive platform

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2 Space4Good, Den Haag, Netherlands

Introduction

High costs for monitoring, reporting, and verification (MRV) diminish the profitability of carbon credits in agroforestry carbon sequestration projects. Currently, a high number of tree measurements have to be taken manually in the field requiring many man-hours. Therefore, CarboCatch was developed with the aim to automate and optimize MRV through a combination of remote sensing and artificial intelligence (AI). CarboCatch is an online interactive platform, that farmers, advisors, landowners, and local governments can use to estimate and plan their carbon sequestration. Per area of interest, the platform generates a map displaying estimated biomass and carbon stock, potential carbon storage of the area, and a suitability map that identifies the optimal tree species for the area based on environment variables, like soil type and ground water levels.

How it works

To estimate the biomass and carbon stock, CarboCatch uses AI models trained with accurately labeled remote sensing data based on ground truth information. The initial focus was on standard fruit and nut trees planted in rows on grassland. The central question was if the proposed methodology could have the potential to (partially) replace field measurements. Field data was collected (diameter at breast height (DBH), total tree height, tree species, GPS location), and a generic allometric equation was used to assess tree volume. In parallel, random-forest models were built and tested using 5-band (red, green, blue, NIR, NDVI) hyperspectral Superview satellite data (0.5 meters resolution) in combination with the field data as ground truth information. Data was collected from several parts of the Netherlands from 11 plots in the winter of 2021. The dataset consisted of a total of 314 data points: apple (73), chestnut (60), walnut (115), pear (15), and 51 locations without biomass geotagging to train the model over "bare soil" locations. A total of 34 models were developed using different combinations of tree and bare soil categories by partitioning of the dataset. To validate the models, for each combination, five different subsets of training and testing datasets were utilized and the performance metrics were averaged. The three best performing models were for the combinations: "walnut + bare soil", "chestnut", and "apple + pear + bare soil". The three models had a high R2 value, 0.83 on average, and a low mean absolute percentage error (MAPE), 22.65 on average. Still, to achieve these results, 80% of the dataset was used for training and 20% for testing, meaning that costly field data collection remains vital. Further research and development is needed to reduce the amount of training data required.

Current developments

Current developments for CarboCatch include: the integration of LiDAR data for assessing tree height; gathering more and better quality field data; improving and harmonizing the biomass volume calculation method; improving data input and output workflow on the online platform for better user operability; integrating a tree detection algorithm and survival rate visualizations.

What the future holds

In the future, more developments are foreseen, such as the development of models for a bigger variety of agroforestry species and systems (e.g. fodder hedgerows) and the integration of a tree species recognition algorithm. Moreover, further data collection and literature reviewing will be required to improve the other functionalities of the platform (biomass growth prediction and agroforestry suitability mapping).

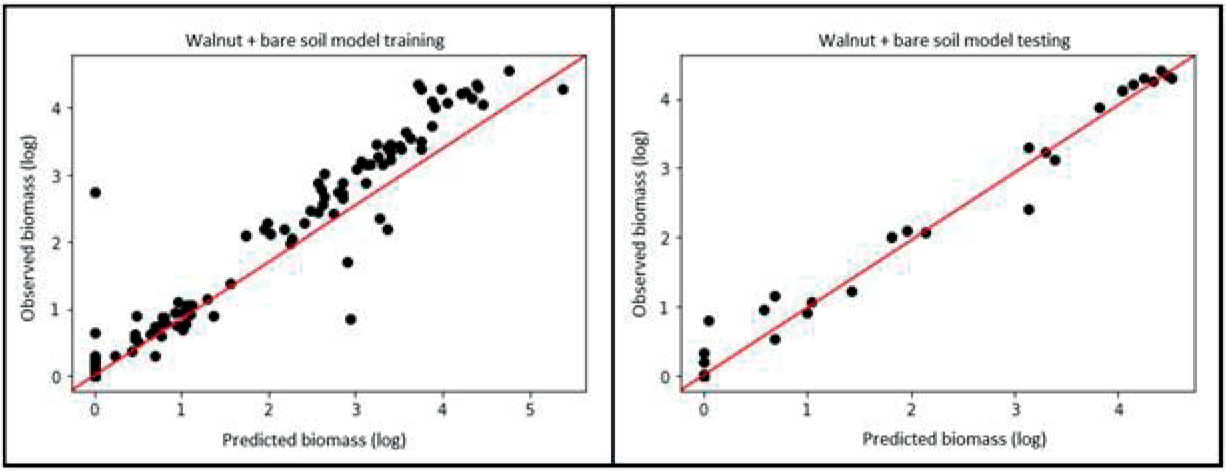
FIGURE CAPTION --> Figure 1 – Results of model performance for "walnut + bare soil" (n=166). Training model average R2: 0.8; Training model average MAPE: 23.57; Testing model average R2: 0.88; Testing model average MAPE: 23.31. Results of 5 runs with different partitioning of training and testing data were averaged to obtain these average statistics.

Keywords
carbon farming, tree volume, suitability maps, payments for ecosystem services, models, carbon sequestration, API, tree detection, walnut, online platform, Satellite monitoring, climate change mitigation, upscaling, Analysis, LIDAR, aboveground carbon sequestration, allometric equation, MRV, above ground biomass, random forests, artifical inteligence, agroforestry monitoring, GIS, Remote Sensing

Aditional Attachment I.

Figure 1 – Results of model performance for "walnut + bare soil" (n=166). Training model average R2: 0.8; Training model average MAPE: 23.57; Testing model average R2: 0.88; Testing model average MAPE: 23.31. Results of 5 runs with different partitioning of training and testing data were averaged to obtain these average statistics.

Aditional Attachment II.



Bibliography

No scientific references, results are not yet published.

The AGROMIX Land Use Change Interactive Map at a European Scale

Ana Tomás[1], Jo Smith[1], A Gabourel[2], JF Lavado Contador[2], S Schnabel[2], JHN Palma[1]

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2 INTERRA, Facultad de Filosofía y Letras, Universidad de Extremadura, 10071 Cáceres, Spain1

In the face of future climate challenges, it is of the utmost importance to drive the transition towards more resilient and efficient land use in Europe. As part of the work developed in the AGROMIX EU HORIZON project (2020-2024), we aimed to provide broader spatial contexts where agroforestry (AF) could be implemented to increase the environmental resilience of agricultural systems and provide effective climate change mitigation and adaptation strategies.

We are implementing a two-fold approach to upscaling; the first part uses a spatial explicit approach to identify target areas in Europe where resilient and climate-smart AF systems should have high priority for introduction, while the second part adopts a non-spatial approach to develop future scenarios of land use/resilience strategies where different models of land use change will be evaluated as pathways towards increased resilience to climate change.

The spatial approach consisted of three steps: (1) selection of suitable potential areas from the total agricultural area in Europe, excluding nature conservation sites and AF areas already identified in the land use/land cover cartography (2) analysis of environmental and climate change risks and socio-economic pressures in the potential areas, and (3) definition of target areas. The outputs from this work are a series of individual maps showing the environmental risks and socio-economic pressures which can be layered together to highlight the target areas.

The non-spatial approach aimed to identify a suite of problem-solution based land use change models for farmers to use. The 'problem' we are addressing is the impact of climate change on agricultural and forestry systems, and the 'solution' is a change in land-use towards a more resilient system. The land-use types we focus on are different types of agroforestry, building on the AGROMIX typology, and demonstrated with real-world examples using case studies captured in the AGROMIX project as well as from other sources including other EU projects, EIP Focus Groups, European agroforestry associations, and from expert knowledge. As there are significant research and evidence gaps in knowledge concerning the resilience of agroforestry land-use types to climate change, an iterative expert knowledge-based Delphi method was used.

A new section of the AGROMIX project website is being developed with a tool organising the data and results in an intuitive way, aimed at farmers and land managers, policy makers and the general public.

In the Target Areas for Agroforestry module, users will be able to choose to map results from the environmental and climate change risks and socio-economic pressures analyses and build up layers to highlight target areas for implementing agroforestry according to their interests.

The Land-Use Change module will display observed and projected climate impact drivers according to IPCC reports, identify the climate drivers and where they will be more likely to occur, and display a matrix of options related to agroforestry and mixed farming systems that could help to improve resilience of the systems. Land use change models and case study examples will be shown for "learning by example" guidance, while these will be linked and contextualised depending on the climate impact drivers and regions previously selected (Fig. 1).

This tool contributes with informed suggestions for farmers and land managers on the resilience path they could take by 1) contextualising their region into climate and environmental risks where an agroforestry approach could be implemented and then 2) identifying a range of AF land use change models that could increase resilience to climate change, illustrated with real-life examples. For policy makers, the outcomes of the spatial modelling and land use change pathway development could be used to inform policy development to support the uptake of AF in priority areas and address any potential social and economic factors that may be barriers to, or conversely, opportunities for implementation (e.g. labour shortages).

Acknowledgements

This work was funded by the European Union under grant agreement: 862993. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. The European Union cannot be held responsible for them.

Keywords
online tool, climate resilience, mixed farming, Agroforestry, climate change mitigation, spatial evaluation

Aditional Attachment II.

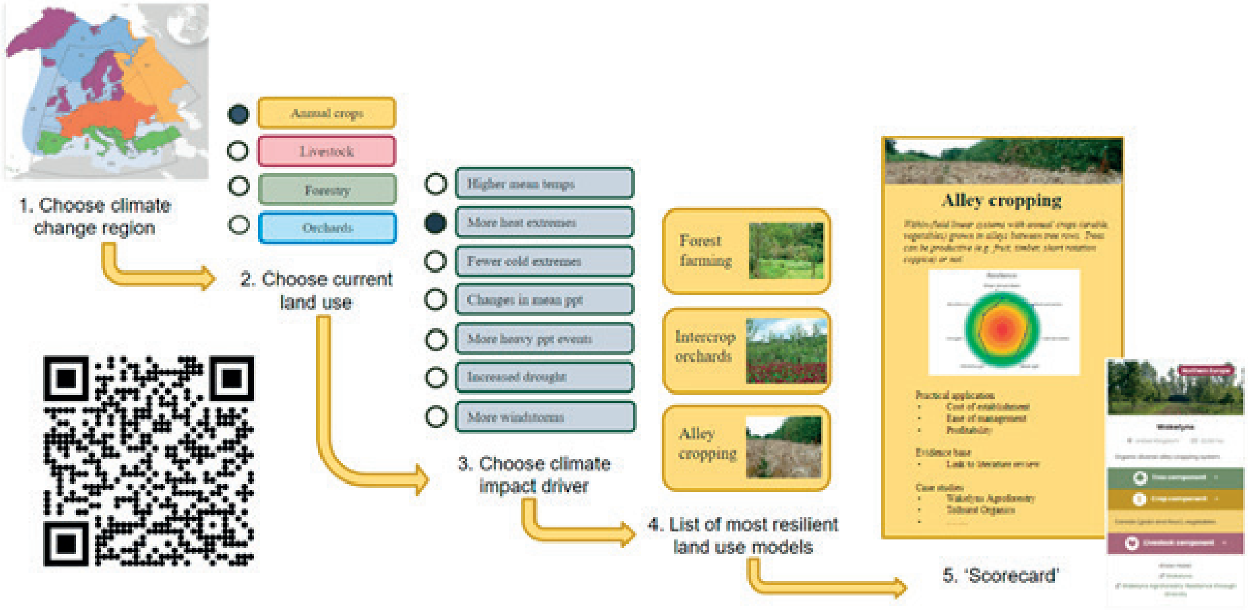

Fig. 1 – AGROMIX Land Use Change Interactive Map available @ https://agromixproject.eu/tools/agromix-land-use-change-interactive-map

2.5 Models and Tools

Poster presentations

Building Q - Foyer, května 29, 2024, 12:00–13:00

Case study catalogue of European initiatives on agroforestry and mixed-farming – An outcome of the HORIZON2020 AGROMIX project

Matthias Baumann[1], **Mareike Jäger**[1]

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Introduction

Climate change and land degradation pose a threat to the agricultural production and agroforestry and mixed-farming practices try to tackle these issues. The HORIZON2020 AGROMIX project brings together farmers, researchers, and policymakers to explore these agroecological solutions for a more resilient land use in Europe. In this framework a consortium of 28 different partner institutions developed several tools, which should facilitate the implementation of these sustainable practices. In order to make information and knowledge from agroforestry and mixed-farming initiatives in Europe accessible for a wider public, a case study catalogue of such initiatives in Europe was created within this project.

Case description

The AGROMIX case study catalogue database includes 77 cases in 12 countries all over Europe and in different climatic regions, thus including various mixed-agricultural and agroforestry practices. A major criterion for inclusion was the availability of data. This online tool acts like a phonebook or an index, it allows to search and filter the entire database and displays the matching cases for different parameters of interest or in a combination of several parameters. The search filter includes categories such as country, partner institutions, scale, and farm size. With the arrows above the title "browse catalogue details", the whole dataset – or the dataset matching the search criteria – can be explored. In the detail view the whole dataset is visible, portraying each case with relevant general information and many different numerical information and parameters such as agroforestry system type (according to Schnabel et al. 2021), field size, plant species, livestock races, etc. Furthermore, a link to publications or websites is often provided, which allows the user to find additional information about a specific case. Finally, an integrated map gives a geographical overview and by clicking with the mouse on a specific case, the whole dataset of the respective case is popping up as a portrait.

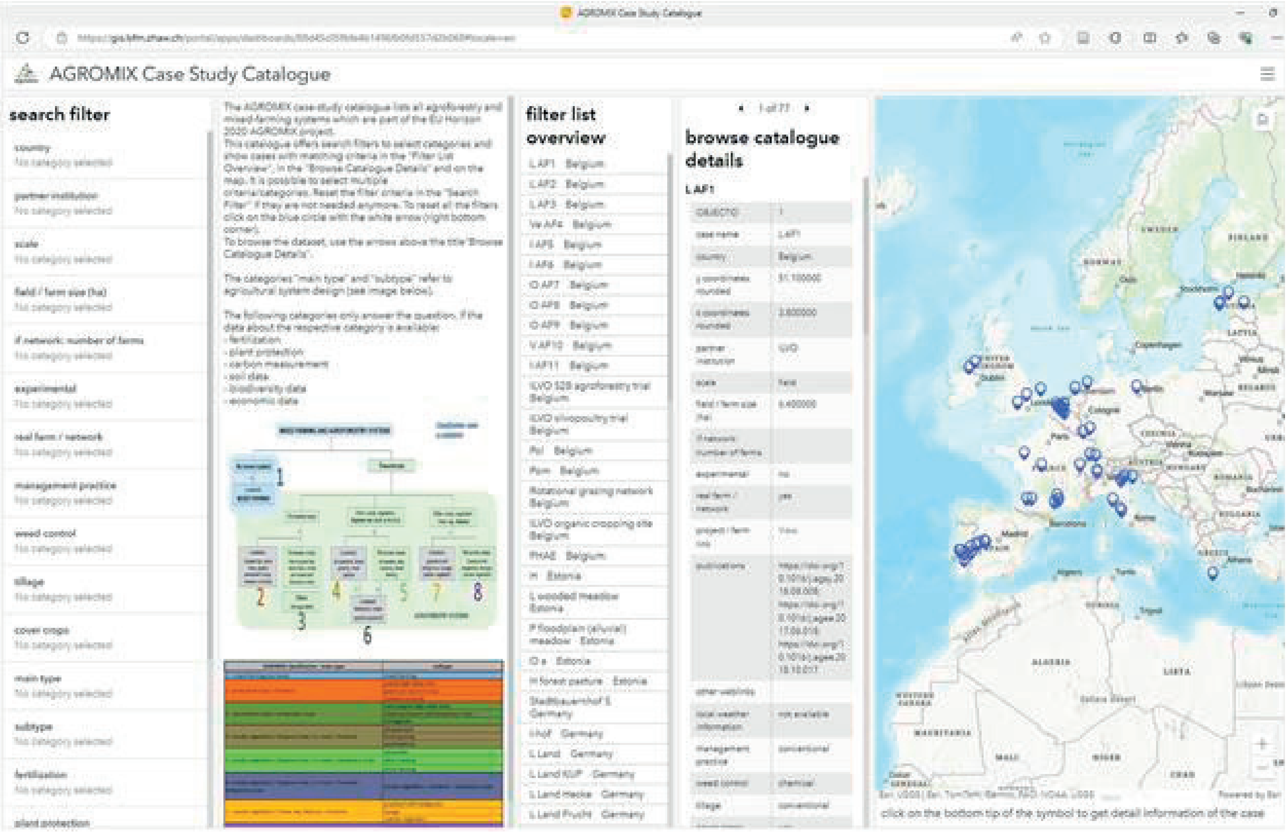
Conclusion

This digital tool can help to increase the visibility of agroforestry and mixed-farming practices outside the AGROMIX project team to a wider research community, but also to farmers, students, policymakers, and other interested stakeholders by giving an overview of successful examples. Hopefully, our case study catalogue will be a puzzle piece in the endeavour to foster the understanding, appreciation and dissemination of agroforestry and mixed-farming agricultural practices and making them more popular.

Keywords

AGROMIX, online tool, Horizon Europe, collaborative research, mixed farming, Europe, Science Outreach, European project, Socioeconomic status, Agroforestry, Dissemination

Aditional Attachment II.



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Modelling temporal and spatial variability in light availability in agroforestry systems

Tom De Swaef[1], Willem Coudron[1,2], Peter Lootens[1], Toon Baeyens[3], Paul Pardon[1], Bert Reubens[1], Sanne Van Den Berge[4], Pieter De Frenne[2], Kris Verheyen[2]

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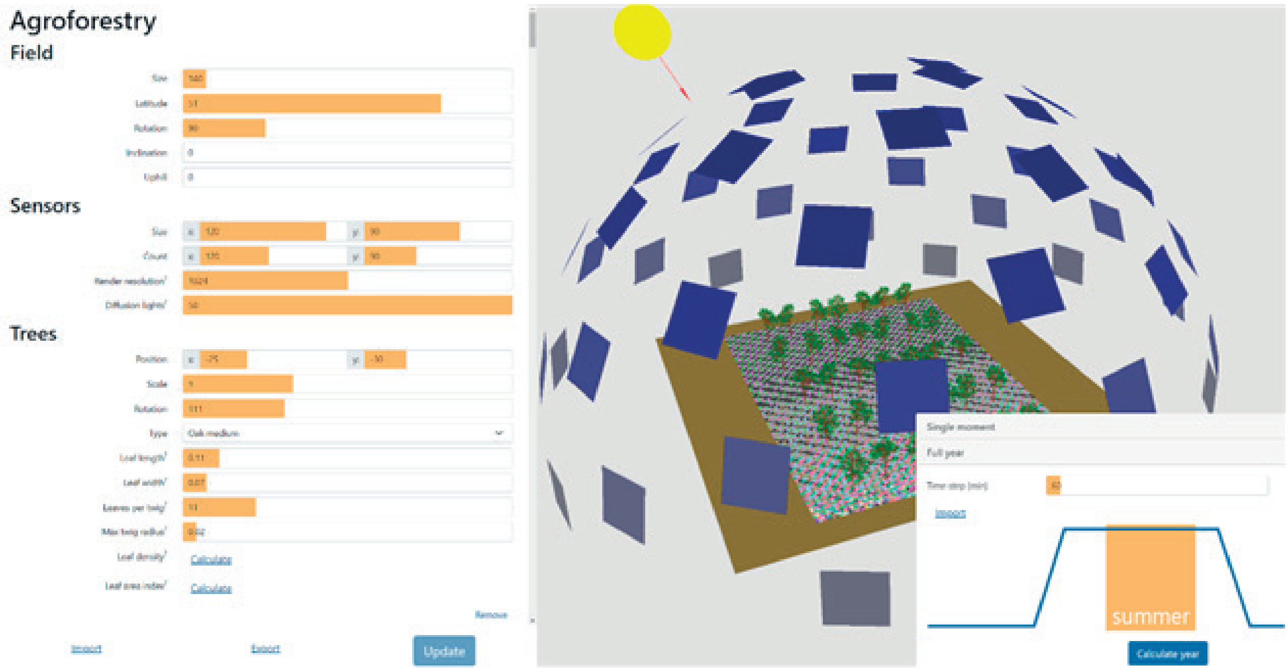
Agroforestry systems bring many biodiversity and functional benefits to agricultural systems and landscapes. For a broader implementation of agroforestry systems, accessible tools need to be developed to facilitate research, design and implementation of agroforestry into our agricultural systems. One of the key aspects of agroforestry systems, at least in alley cropping systems, is the competition for light between tree rows and the crop. This competition for light (in combination with water) typically reduces crop yield closer to the tree rows (Pardon et al. 2018). Because tree rows induce a spatial heterogeneity in the crop, crop management in agroforestry systems would benefit from a precision agriculture approach. This way, fertilizer, varieties or species, sowing densities, etc. could be varied along management zones, and result in a better overall performance of the system. To define such management zones, the spatial heterogeneity needs to be mapped appropriately.

Here we present an intuitive modelling tool to simulate light availability in AF systems based on detailed LiDAR scans of trees. The tool allows the user to generate a 3D mock-up of an agroforestry set-up (Figure 1) using preloaded trees or after uploading customized tree shapes generated from LiDAR scans. From this mock-up, the tool can calculate the spatial distribution of the light transmitted to the crop. These data can then be further processed using functionalities that will become available via an R package. We showcase the potential of this framework by quantifying spatiotemporal light availability in North-South oriented alley cropping systems with trees of different species (Quercus robur, Betula pendula and Alnus glutinosa), ages and phenology. Our tool is freely available on https://agroforestry.ugent.be and can help farmers, advisors and other stakeholders to design agroforestry fields with a minimum of light competition. Furthermore, it allows to delineate zones that can be managed differently in terms of fertilizer application or variety choice.

Keywords
microclimate, online tool, modelling, light availability, Online User Interface, shade, LIDAR

Aditional Attachment II.



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Highlighting the potential of multilevel statistical models for analysis of individual agroforestry systems

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Introduction

Shifting from annual monocultures to perennial polycultures, including agroforestry systems, has been described as the future of modern agriculture. Perennial polycultures can increase resilience of agricultural systems which must remain productive despite increasing environmental and societal pressures. However, such systems provide a unique challenge for experimental research and testing of scientific hypotheses because of their inherent complexity across spatial and temporal scales.

Research gap

We examined current approaches to data analysis and sampling strategies of bio-physico-chemical indicators in European temperate agroforestry systems i.e., farming systems that combine arable and grassland management with tree cultivation. We noted that multilevel models, which offer a practical solution to many field-specific concerns such as pseudo-replication and hierarchical data structures, are currently underused.

Objectives

We aimed to facilitate the use of multilevel models in agroforestry research by introducing key literature and providing a follow-along working R code that illustrated important concepts applicable to agroforestry research e.g., different methods of accounting for spatial autocorrelation and parametrization of the variance-covariance structure. The script was developed based on the crop yield dataset compiled using field data collected in a recently established agroforestry system in central Germany.

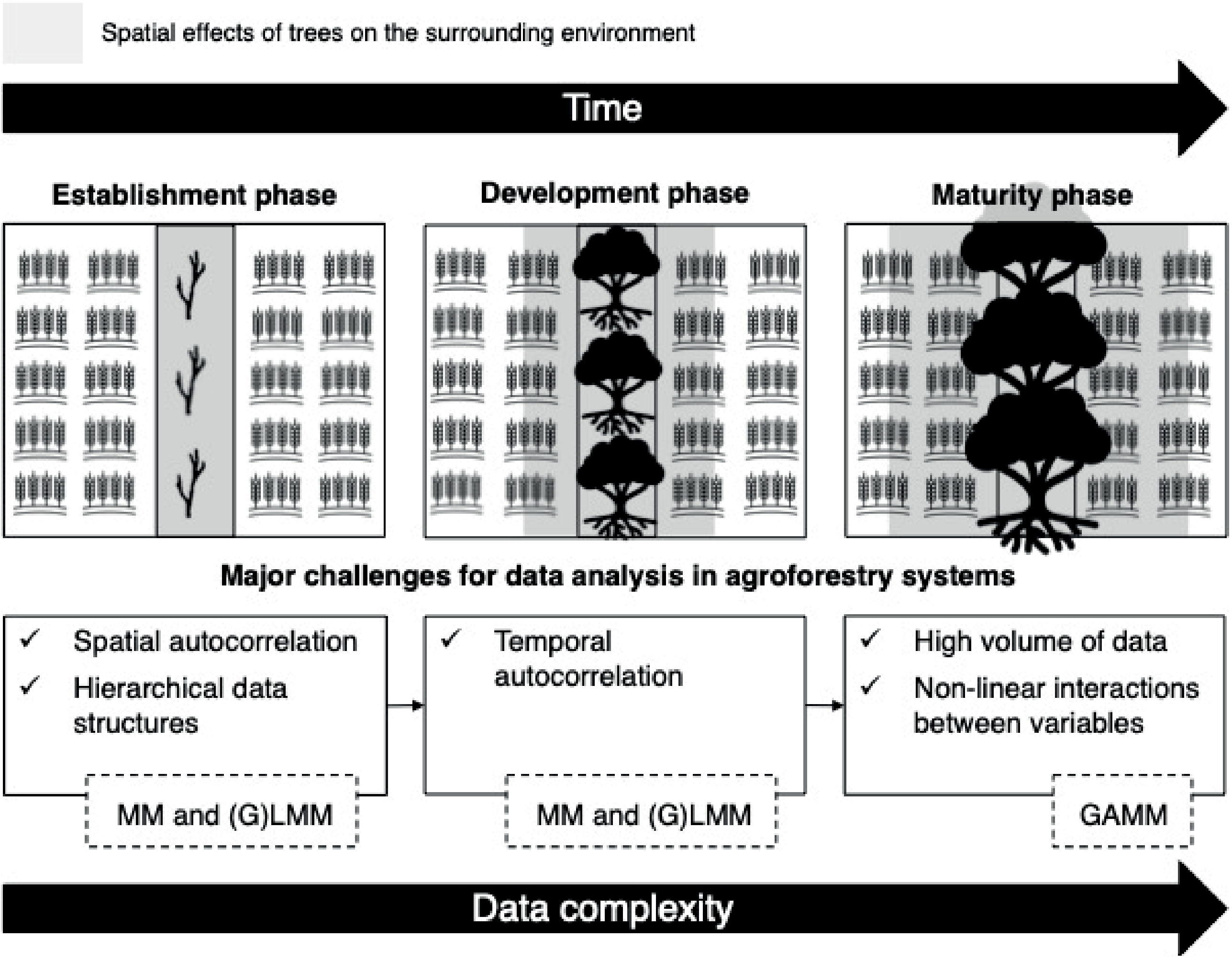
Key messages

In a linked research paper by Golicz et al. (2023), we provided a number of key references for each step of multilevel model fitting i.e., (1) selection and classification of variables at different spatiotemporal scales (e.g., Wiesmeier et al., 2019), (2) important considerations prior to data analysis (e.g., Zuur et al., 2010), (3) accounting for spatially correlated data (e.g., Pekár and Brabec, 2016) and (4) parametrisation of the variance–covariance structure (e.g., Knörzer et al., 2010 and Slaets et al., 2021). Finally, we highlighted the importance of including model diagnostics in future agroforestry research papers as well as thoughtful design of sampling strategies to avoid hasty conclusions regarding the tree row effects, especially in early-stage agroforestry systems.

Keywords

case study, research methods, Literature review, agroforestry monitoring, temperate agroforestry, alley cropping, data paper, modelling

Aditional Attachment II.



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A quick orientation to DigitAF's results presented at EURAF2024 conference in Brno

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The DigitAF project's goals are to develop, improve, and test digital tools to:

- Support policymakers and administrations in devising and implementing efficient agroforestry and carbon farming related policies, and monitor their impact on biodiversity, climate change mitigation and agricultural sustainability.
- Support practitioners of agroforestry to optimise the design and management of agroforestry systems to increase the technical feasibility, productivity, economic performance and sustainability
- Allow actors in agroforestry value chains to verify and market agroforestry benefits, including enhanced biodiversity, carbon sequestration, soil health, and support consumers seeking good value and environmentally beneficial products

DigitAF's approach is based on several principles:

- User-centred approach: DigitAF relies on Living Labs to prioritise tool development according to the needs expressed by end-users and to test and improve tools with end-users.
- Open-source (MIT) licence to allow contributions from a diversity of developers and to allow reuse of the data and code in commercial products.
- FAIR principles: the development of digital tools can only be sustainable if it follows the principles of findability, accessibility, interoperability and reusability.
- The development of a community of developers interested in agroforestry: we aim to gather developers sharing the same objectives and principles, within but also outside and after the project's boundaries to ensure continued maintenance and improvement of digital tools for agroforestry.

During the first 18 months of the project, we have made good progress towards achieving our objectives and following these principles, producing a number of results (Table 1). We have established Living Labs in six countries (CZ, FI, NL, IT, DE, UK), gathering more than 100 persons. Within them, we have conducted a survey to see if the technical, administrative and economic challenges faced by stakeholders in our LL (Tranchina et al. 2024a) are similar or not from those already identified in the literature (Tranchina et al. 2024b), and to identify the social and psychological factors influencing the use of digital technologies in agroforestry (Reissig et al. 2024).

For policy-makers, we synthesised agroforestry-relevant policies both in terms of past expenditures and of strategic plans, which allowed us to find out what the green architecture of the new CAP has done for agroforestry (Lawson et al. 2024a). Computation of the current and potential area under agroforestry, combined with estimation of the carbon storage potential of agroforestry has allowed us to show that agroforestry can help EU achieve net zero in the land sector by 2040 only if agroforestry (including hedges, windbreaks and small coppices) are promoted in the parts of Europe where the tree cover on agricultural land is lowest (Lawson et al. 2024b). But our work was not limited to the EU, and we also analysed if Swiss Agricultural and Climate Strategy represented a missed opportunity for agroforestry (Kay et al. 2024)

For agroforestry practitioners, we have created or improved DSS to:

- analyse the cost-benefit of agroforestry systems (Carton et al. 2024)
- optimise feed production and quality in alley cropping systems by adapting grass-herb composition (Reubens et al. 2024)
- optimize management practices based on tree architectural diagnosis (Antin et al. 2024)

We have also developed more in-depths models to better simulate the temporal and spatial variability in light availability in agroforestry systems (de Swaef et al. 2024), or the hydraulic processes within crops under agroforestry conditions to see if agroforestry can prevent cavitation (Soulard et al. 2024). Those are two important processes to better predict the balance between competition and facilitation in agroforestry systems.

For value chain stakeholders, we have mapped the agroforestry value chains at each Living Lab (Burgess et al. 2024) and improved an agroforestry map of Europe to help value chain development (Hübner et al. 2024).

In parallel, we have worked with tool developers to improve the Findability, Accessibility, Interoperability and Reusability of tools. For example, we have developed a complete, diverse and detailed online database of the current digital agroforestry environment (Tomás et al. 2024) to improve findability of tools. In order to improve interoperability of tree selection tools, we have developed an advice aggregator for tree species selection for agroforestry systems (Gosme et al. 2024). Finally we have established an agroforestry community-driven architecture of interlinked digital resources, to create an Agroforestry Virtual Space were users and code developers can interact to improve agroforestry tools in an open-source, agile and user-centered approach (Palma et al. 2024).

Acknowledgment
This work was funded by the European Union under grant agreement: 101059794. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. The European Union cannot be held responsible for them.

Keywords
farmers, farmers' decision making, policy-makers, digital tools, modelling, FAIR, models, simulation model, online tool, Open -innovation, Value chain analysis, agroforestry value chains, decision tool, value chain, European project, numerical modelling, agricultural policy, sustainability assessment tools, farmer perception, Policy support

Aditional Attachment I.

Session	type	Title	Authors
2.3	P	Contribution of tree architectural diagnosis for optimizing management practices.	Antin, C. et al.
3.1	O	Mapping agroforestry value chains with Living Lab participants across Europe	Burgess, P. et al.
3.1	O	Supporting farmers online with a user-friendly decision support tool: introducing the INTeractive Agroforestry Cost-benefit Analysis Tool (INTACT)	Carton, S. et al.
2.5	O	Modelling temporal and spatial variability in light availability in agroforestry systems	deSwaef, T. et al.
2.5	O	AgroforesTreeAdvice: an advice aggregator for tree species selection for agroforestry systems	Gosme, M. et al.
4.1	O	Agroforestry map of Europe – moving from a basic map to an advanced database	Hübner, R. et al.
3.3	O	Swiss Agricultural and Climate Strategy: a missed opportunity for agroforestry?	Kay, S. et al.
3.2	O	What has the green architecture of the new CAP done for agroforestry?	Lawson, G. et al.
3.3	O	Can agroforestry help the EU achieve net zero in the land sector by 2040?	Lawson, G. et al.
2.5	P	Agroforestry Virtual Space: establishing an agroforestry community-driven architecture	Palma, J.H.N et al.
5.1	O	Social and psychological factors influencing the use of digital technologies in agroforestry: preliminary results from the DigitAF project.	Reissig, L. et al.
2.1	O	Can we optimise feed production and quality in alley cropping systems by adapting grass-herb composition? First results of an artificial shade experiment.	Reubens B. et al.
2.5	P	Can agroforestry protect crops from cavitation? : Proposition to link an AFS model and a plant hydraulic model	Soulard, F. et al.
2.5	P	Online Agroforestry Tools Database: developing a complete, diverse and detailed database of the current digital agroforestry environment	Tomás A. et al.
5.1	O	What technical and administrative challenges impede the adoption of agroforestry practices? A global perspective through a systematic literature review.	Tranchina, M. et al.
5.1	O	Technical, administrative and economic challenges faced by European agoforestry pioneers: preliminary results from the DigitAF project	Tranchina, M. et al.

Table 1: list of results from the DigitAF European project presented at EURAF 2024 conference in Brno, Czech Republic

Estimating the potential productivity of agroforestry in North Rhine-Westphalia based on evidence from other temperate agroforestry systems

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Despite the growing body of evidence regarding the strong potential for agroforestry to provide various environmental, economic and social benefits, many regions have not (yet) seen widespread adoption (den Herder et al., 2017). Hesitation to adopt agroforestry has been particularly prevalent in temperate regions, with most temperate-zone countries featuring very low adoption despite mounting evidence that most benefits also apply in temperate regions (Jose 2009; Kay et al.; 2019; Smith et al.; 2012; Sollen-Norrlin et al., 2020). Low enthusiasm about agroforestry on the part of farmers and policymakers appears to partially stem from concerns about unwanted outcomes, most notably in the form of reduced yields, which could negatively impact farm income and food security (Graves et al., 2009; Jose et al., 2009).

Our study aims to shed light on the potential productivity of agroforestry within the German state of North Rhine-Westphalia (NRW). The state currently only has a handful of agroforestry systems. Since most of these systems have only recently been established, farmers and policymakers lack local showcases of agroforestry that could allow insights into the long-term performance of agroforestry in this region. To address this lack of evidence, we established a suitability matrix to map existing research on agroforestry systems in temperate zones to conditions in NRW, considering data on the local climate, topography, soil, land use, major crop types, and growing periods. Using the suitability matrix, we estimate similarities between agroforestry systems across a broad range of studies and conditions. Based on the similarity between site conditions in NRW and conditions under which available evidence was generated, we draw inferences about the predictive power of the evidence for our study region.

We compiled published evidence on the productivity of temperate agroforestry systems, with a particular focus on studies that compared land equivalent ratios or other measures of productivity between agroforestry systems and treeless agricultural systems. To evaluate the potential of this evidence for gaining insights that are relevant to our region of interest, we also mapped site conditions across the state of NRW. Evidence from places that do not correspond closely to conditions in NRW or studies that fail to report crucial site information were discarded. From the evidence that was considered valid and relevant, we drew inferences for agroforestry productivity in NRW, weighting the evidence according to the similarity between the environmental conditions of the study site and the region of interest. Even in the absence of direct site-specific evidence, this strategy allows us to make informed predictions of anticipated outcomes for agroforestry systems in NRW. Results are expected to address the level of validity or misconception associated with farmers and policy-makers concerns regarding the potential productivity of agroforestry in the region. A further ambition of the study is to present a methodology that can be applied to other regions where concrete evidence regarding outcomes of agroforestry implementation is missing but can be derived from readily available studies.

This abstract is based upon work from project 101060635 - REFOREST. Funded by the European Union.

Keywords
sustainable food production, Adoption, farmers' decision making, production systems, adoption constraints, Policy support, temperate agroforestry, probabilistic simulation, Food security, agroforestry system planning, modelling, crop production, economic performance

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Agroforestry Virtual Space: establishing an agroforestry community-driven architecture

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Introduction

The DigitAF research project (July 2022 - June 2026), funded by the European Commission, aims at a high quality implementation of agroforestry (AF) to foster climate change mitigation and adaptation in agriculture and to ensure sustainable management of natural resources. The project goal is to provide the main actor groups with tools answering their needs, in particular digital tools. In this context, we proposed to build the so-called "Agroforestry Virtual Space" that aims to be relevant to a diverse array of stakeholders involved in agroforestry, climate change mitigation, and sustainable natural resource management. In particular, targeting those seeking more centralised information on available tools and data related to agroforestry, while, at the same time, interested in boosting the cooperation in development of such tools and data availability.

Case description

The Agroforestry Virtual Space (AVS) is building pace and aims at enabling a community of developers focused on AF to engage and share their latest developments. It also provides a centralised resource for cherry-picking by different stakeholders that can align and target the usage of specific tools to their context.

With the aim of creating a legacy beyond the project, the AVS is being designed as a "place" where a lively AF community can keep up, interact, and work together to validate, extend, and design existing and new AF software environments. Such a venture is being embedded within long-lasting international AF entities, e.g. European Agroforestry Federation (EURAF), guaranteeing that the tools and data development community continues under a stable environment while ensuring continued active engagement after the project's end.

The AVS is therefore being designed with an architecture that connects several initiatives, that aims to embrace and fit the FAIR principles (Findability, Accessibility, Interoperability, Reuse), introducing concepts of FAIRness scoring, while being a while being a meeting point for different target audiences in an agroforestry context. The virtual space is not centrally coordinated but gathers and triggers a network of several decentralised initiatives where awareness of existence, collaboration, and long lasting legacy is key, i.e. the AVS can sustain itself after the end of the DigitAF project.

Fig 1 caption: Establishment of an initial agroforestry virtual space with self-sustainable platforms for co-creation and collaboration in agroforestry context aligned with FAIR principles: https://digitaf.eu/tools-database/ ; https://github.com/euraf ; https://www.youtube.com/channel/UC-CqJO8goJC6MnpzClrDlYg ; https://digitaf.eu/questions-answers/ ; https://zenodo.org/communities/euraf ; https://digitaf.eu/projects-database/ ;

Conclusion

A set of digital platforms are being made available with a shared agroforestry context, aiming to boost the collaboration between different agroforestry actors taking advantage of web 2.0 collaborative platforms.

Uptake of agroforestry is needed in European farmland, and collaboration, co-creation and co-development is key to bring actors closer and build up a stronger and consistent swirl of spin-offs delivering improvement of tools, enhancing information and building up knowledge of a multifunctional and complex land use that needs support for uptaking.

The work presented here provides the "substrate", "seeds", some "seedlings" and the nearest future will provide exposure to a wide audience that will test the nurturing of the platforms that are designed to be self-sustainable beyond the DigitAF project. Agroforestry actors should feel welcome to engage in these collaboration platforms so agroforestry can thrive faster in farmland landscapes.

Acknowledgment
This work was funded by the European Union under grant agreement: 101059794 (DigitAF). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. The European Union cannot be held responsible for them.

Keywords
tools, modelling, Analysis, web 2.0, collaborative, co-development, Online User Interface, online, network, Living lab, co-creation, models, databases, co-design

Aditional Attachment II.

Tools database

AF Code GitHub

AF tools demo videos

Questions and Answers

AF OpenPub Zenodo

AF Projects database

Exploring Agroforestry's Complexity: A Data-Driven Perspective on Uncovering Key Interactions using Hi-sAFe and UQLabs

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2 Scotland's Rural College, Scotland

Agroforestry is a multi-functional land use system that can simply be described as agriculture with trees[1]. Agroforestry systems take advantage of the, generally, poorly understood interactions that occur amongst crops, trees, and livestock. Agroforestry has been demonstrated to present numerous benefits which include conservation of biodiversity, regulation of natural pests and diseases, regulation of soil, increased air and water quality, efficient cycling of nutrients, and resilience to climate change (Rao et al. 1997; Smith et al. 2012).

Based on a literature review completed as part of this research, the challenges in modelling agroforestry systems are mostly due to the large number of parameters and interactions which take place. However, the Pareto principle states that 80% of consequences come from 20% of causes (Backhaus 1980), (Sheikholeslami et al. 2019). In other words, only a small number of parameters cause the largest change in output. Based on this principle and using global sensitivity analysis techniques, this research aims to identify and quantify the most important parameters or interactions between parameters which have the highest effect on agroforestry outcomes.

The aim of this research is to inform researchers and practitioners regarding the most important parameters to monitor, understand, and measure to get the desired outcomes of their agroforestry system. To this end, the general purpose uncertainty quantification software UQLabs (Marelli et al.), developed by ETH Zurich, will be used for ranking parameters, computing sensitivity indices, and interaction factors. The UQLabs framework allows for the possibility of linking third-party software through an interface. This research utilizes this feature to perform global sensitivity analysis on experiments simulated with Hi-sAFe (Dupraz et al. 2019), a complex, three-dimensional, dynamic model for simulating temperate agroforestry systems developed by INRAE for over 25 years. Thus, not only allowing for a deeper understanding of the results obtained by this simulation software, but also being able to run large-scale experiments with several uncertain parameters to help uncover the intricacies of agroforestry systems.

Keywords

Socioeconomic status, models, Hi-sAFe model, simulation model

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[1]https://www.worldagroforestry.org/about/agroforestry

Can agroforestry protect crops from cavitation? : Proposition to link an AFS model and a plant hydraulic model

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2 ABSys, Univ Montpellier, CIHEAM-IAMM, CIRAD, INRAE, Institut Agro, Montpellier, France

3 Flanders research institute for agriculture, fisheries and food (ILVO), Belgium

This study addresses the question if agroforestry systems (AFS) can serve as a protective measure against cavitation and embolism in crops. Water deficit is one of the main threats to plants. Prolonged water stress can induce damage to the water transport system (Corso et al., 2020). Indeed, the flow of water within a plant vascular system is propelled by negative tension in the xylem. As the plant experiences increased dryness, this tension intensifies, potentially causing a disturbance in the transport of water through the plant's vascular system with the formation of gas bubbles (cavitation) or the interruption of the water flow (embolism) (Tyree and Sperry, 1989). Cavitation and embolism in plants is a phenomenon that significantly affects plant water status and, consequently, crop health. However, the phenomenon of cavitation can be difficult to observe in the field because of the constraints inherent in studying this process, as well as the constraints due to the study of agroforestry systems (time, financial, logistical) (Cochard, 2006). To study cavitation in AFS, we propose a novel approach through modeling and numerical simulation. This approach integrates two models: (i) the Hi-sAFe model, a mechanistic AFS growth model (Dupraz et al., 2019), and (ii) the SUREAU model, a mechanistic model focused on the hydraulic architecture of plants and the water resistance and water capacitances of their organs (Cochard et al., 2021). This study aims to bridge the gap between AFS modeling, at the plot scale, and plant hydraulic modeling, at the individual scale.

Planned actions involve utilizing the Hi-sAFe model to model the entire agroforestry plot: predict gross yield, and contextual factors, and plot scale processes (water fluxes, nitrogen fluxes, and microclimatic interaction). Then the prediction from the Hi-sAFe model as inputs on identified specific days for the SUREAU model to determine the presence and severity of cavitation in the crop, and its spatial distribution about the tree row. This information should then be introduced in the Hi-sAFe model to adjust crop productivity.

Thus, the correction of the results of the Hi-sAFe model would allow the quantification of the impact of cavitation and embolism on the AF plot. This correction mechanism aims to enhance the accuracy of predictions related to plant water status, ultimately contributing to improved assessments of crop health and resilience within agroforestry systems.

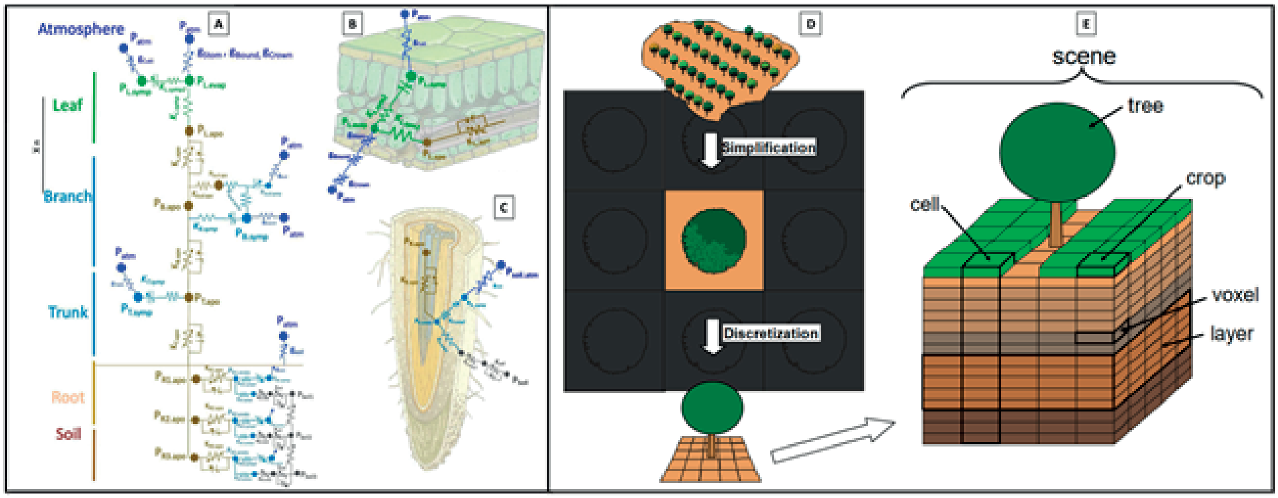
Our study allows us to foresee several perspectives. Firstly, we anticipate the ability to predict the percentage of crop mortality due to drought events within agroforestry systems, providing valuable insights into the vulnerability of crops to water-related stressors. This predictive capability becomes even more crucial in the context of climate change and the rising frequency of extreme weather events, where understanding and mitigating their impacts on agriculture are of paramount importance.

In conclusion, this research not only proposes an innovative integration of AFS and plant hydraulic models but also lays the foundation for more accurate predictions and proactive management strategies to safeguard crops in the face of evolving environmental challenges.

Keywords

yield, SUREAU model, Hi-sAFe model, Agroforestry, climate change mitigation, Mechanistic Model, silvoarable agroforestry, soil water content, cavitation

Aditional Attachment II.



Legend: Left: Idealization of the soil-plant-atmosphere continuum in the modelling framework of SurEau. The plant is described as a network of conductances and capacitances. **(A)** represent the whole architecture of the model. **(B)** and **(C)** show the formalizations for leaves and roots, respectively. From (Cochard et al. 2021)
Right: Simulated Hi-sAFe scene reduces a landscape into its simplest replicable unit **(D)** and is discretized into a 3D, spatially explicit voxel grid **(E)**. From (Dupraz et al. 2019)

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Online Agroforestry Tools Database: developing a complete, diverse and detailed database of the current digital agroforestry environment

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Introduction

Part of the aim of the DigitAF research project (2022-2026) is to «implement a multi-actor approach, directly engaging with and providing digital tools to actors whose decisions impact AF development». Digital technologies offer unprecedented capacities to collect data and synthesise knowledge to support decision-making, as well as to reach out to a targeted audience, improve communication, and boost networking. Amongst initial interactions within the consortium, arose the suggestion of creating a catalogue of agroforestry related tools. Which components of agroforestry systems are least explored in these tools? Which indicators are analysed the most, or conversely, what are the knowledge gaps? Which tools could work together to generate more complete and meaningful outputs? These are all questions that could be addressed with a complete, diverse, and detailed database of the current digital agroforestry environment. Initially started as a spreadsheet database, this format rapidly showed its limits, becoming too large, with some redundant information (repeated entries), limited capacity to find and sort tools, and a limited possibility to reach a larger audience.

Methodology

We chose a fully open-source and collaborative methodology, i.e. any user may contribute new tools to the database and edit any incomplete or outdated information about any of the tools. To achieve this, the interaction with the database and results display should be easy and comprehensible. There will also always be a quality assurance step before entries are published, assuring that the minimum information is correctly provided, guaranteed by the ongoing support of the European Agroforestry Federation (EURAF).

During development of the first implementation, we considered the following questions:

- What information should be collected about each tool? A minimum level of detail about each tool must be considered so that the database becomes useful versus the burden of requesting too much information.
- What ways to use to collect, preserve and edit tool information? It should be as easy as possible to enter new information, but it should also leverage new collaborative technologies and promote a "geek spirit" in the community.
- Which are the better ways of displaying tool information and filtering results? Mostly related to user-interface (card display) and user-experience (useful filters), mainly driven by user needs identified through their feedback.

Results

The Database

The online tools database gathers tools in one place to ease their access. Available filters allow users to search for tools depending on different criteria, depending on the user needs. A quick FAIRness score is available for each tool to enable an assessment preview of the easiness of their findability, accessibility, interoperability and reusability (more details below).

Adding a new tool through a Google Form

A very common way of collecting information is through a questionnaire, and the Google Forms platform is free and easy to use. It is available at https://forms.gle/cKwFUzGuckhfSHum6 and should be used by the least tech-oriented contributors to add a new tool that might be useful. There are seven sections of questions, many of them multiple choice. They are divided into general questions about the tool, some about more technical details, about its use, accessibility, and documentation. It takes about 10-15 minutes to complete. The only personal information collected is the user email to ask any follow-up questions that may arise, particularly if something is very incomplete, or not understandable.

Adding a new tool through GitHub

To foster some "geekiness" in the agroforestry community, contributors may alternatively contribute directly to the agroforestry database repository, set within the GitHub EURAF Community (https://github.com/euraf).

All the information regarding the process of how to contribute to the database is described and continuously updated in the repository's README file, available at https://github.com/euraf/AF-tools-database#readme.

FAIRness score
This concept is based on the FAIR principles (https://www.go-fair.org/), whose guidelines help to improve the Findability, Accessibility, Interoperability and Reusability of digital resources (Jacobsen et al. 2020; Wilkinson et al. 2016). When applied to the online tools database, it helps users to better understand the state of development and openness of each tool. This automatically calculated, but human-verified, scoring system also works as a self-assessment for tool developers to understand their tool's strong points and improve their weaker spots. Its final goal is to help to increase accessibility and interoperability between tools whose developers seek continuous improvement.

Conclusion
The Online Agroforestry Tools Database is already implemented in the DigitAF project website (https://digitaf.eu/tools-database), but can be integrated in other websites with an iframe from https://mvarc.eu/tools/dev/digitaf_tools/. The acceptance and willingness to participate in this endeavour is growing, mostly driven by DigitAF consortium members and developers of tools used within the Living Labs. The next step is to widen the exposure of this database and challenge the agroforestry community to add new tools, contributing to a growing community of digital tool users and developers devoted to the improvement of agricultural sustainability through adoption of thriving and efficient agroforestry systems.

Keywords
agroforestry system planning, Open-source, Tools database, FAIR, Agroforestry

Aditional Attachment II.

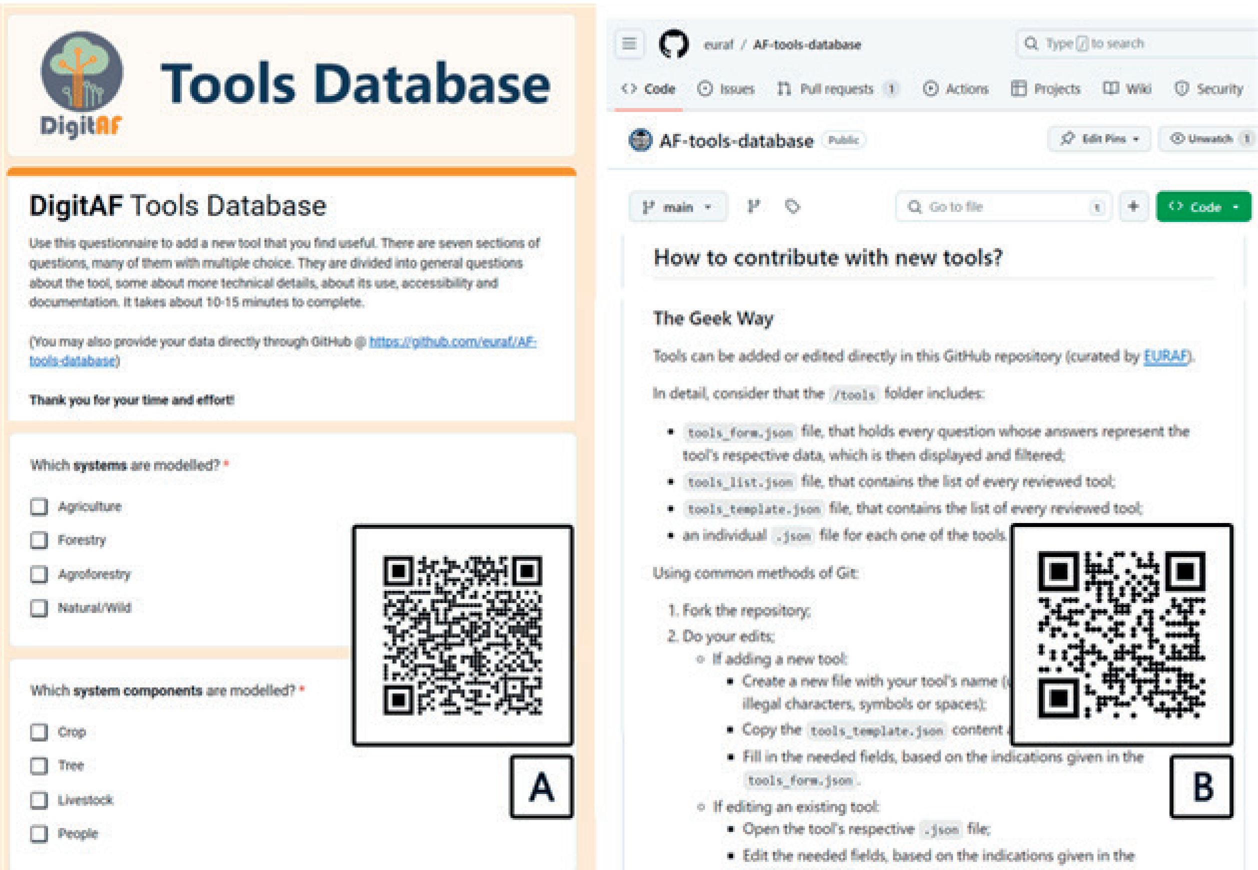

Fig 1: Contributing an agroforestry tool to the database: A) with a Google form, B) via GitHub

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Acknowledgements

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Nurturing agroforestry connections: app for smart tree choices and community collaboration

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The AGROMIX project assessed the evolving needs of farmers as agroforestry practitioners by means of surveys and workshop sessions with project pilot teams and stakeholders. Both peer-to-peer knowledge exchange as well as help with the choice of tree-crop species for agroforestry systems were identified as top priorities. To better meet these evolving needs of farmers, advisors and other users, the project started a collaboration with the existing Landfiles app in order to co-develop a new tool. The need for knowledge exchange was addressed by enhancing the current networking capabilities on Landfiles by onboarding new groups and fostering interaction with existing groups to better connect the agroforestry community in Europe. On the other hand, the need to empower users to make well-informed decisions when selecting tree crops and cultivars was met by building the 'Treefiles' app, a collaboratively built database that is hosted within the Landfiles platform, based on user content. This app allows researchers and advisors to contribute with their datasets, whilst critically, enabling practitioners to share their own data, contextualised with their experiences by means of pictures and comments. Furthermore, 'Treefiles' features functionalities to compare tree species or cultivars on ecological, managerial and economic traits based on bundled user input.

Through a participatory approach, user input and feedback are instrumental in refining the app's features from design to implementation using an iterative development cycle. At the conference the AGROMIX project will present the launch of the app, with the goal of contributing to sustainable agroforestry practices by providing a user-friendly digital tool that is free to use for farmers.

Keywords
agroforestry system planning, decision support tool, Socioeconomic status, TreeFiles, tree species database, collaborative research, landfiles, know-how transfer, online tool, decision-making, decision tool

Bibliography

2.6 Agrivoltaism

Oral presentations

Hall Q3, 29 May 2024, 18:00-19:00

Designing C neutral farms with the combination of agrivoltaic and agroforestry systems

Dr Christian Dupraz[1], Dr Damien Fumey[2], Ms. Amélie Chauveau[4], Dr. Sophie Bellacicco[2], M. Günter Hutter[3]

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4 SunR, Lyon, France

Improving the C budget of European farms is an issue. Farms can improve their budget by many options including sequestering C in soils and trees, reducing fossil fuels use through electrification of tractors and machinery, and producing renewable energy from biomass or with agrivoltaic systems. A new scheme of Agrivoltaic-Agroforestry farms is developed here to achieve this C neutrality without decreasing the farm agricultural production and income. Agroforestry allows C sequestration in the long term, while Agrivoltaics produces renewable energy from the start. Several co-benefits from the combination of agroforestry and agrivoltaism are evidenced. Agrivoltaism can provide ecosystem services to the crops or animals on only a limited part of the farm area, and agroforestry can provide also ecosystem services on the rest of the farm. Agrivoltaics can provide electricity that is used to replace fossil fuels in driving the farm equipments. The high electricity income from agrivoltaics can also subsidize the plantation of new agroforestry systems on the remaining farm area. It is anticipated that for 1 ha of agrivoltaics, the resources to plant and manage 10 ha of agroforestry could be provided by the electricity producer. Current estimates of agrivoltaic development in France amounts to 100 000 hectares for the next 25 years. With such a development rate, large areas of agroforestry installation could be achieved. Combining agrivoltaics and agroforestry has the potential to increase the social acceptability of agrivoltaic systems, as agroforestry systems (including hedges) can help to better integrate agrivoltaic systems in the landscape. There are currently some concerns that agrivoltaics may deter farmers from agroforestry systems, as a consequence of the high revenue from land leasing to electricity companies, and the fast return from agrivoltaics as compared to agroforestry. Linking the two systems would be a win-win option, ensuring that both the energy transition and the agro-ecology transition are achieved simultaneously at the farm scale.

Figure 1 : AI generated images of an “AV+AF” farm (left) or “AF under AV” plot (right). Images generated with Dall-E 3

Keywords

Climate smart agriculture, climate change mitigation, Carbon Balance, shade tolerance, agroforestry systems establishment, carbon sequestration, carbon farming, electricity, shade, Agrophotovoltaics, Agrivoltaics, ecosystem services, farm-scale sustainability assessment, carbon footprint, carbon neutral, landscape transformation, innovative food & non-food systems

Aditional Attachment II.

Assessing the potential for agrivoltaics in Swiss agriculture

Mareike Jäger[1], Dionis Anderegg[1], Sven Strebel[1], Jürg Rohrer[1]
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Introduction
Agrivoltaics refers to the dual utilisation of land for agricultural purposes and energy production with photovoltaics. As agrivoltaic systems are typically located outside of building zones, in Switzerland permits for their construction are only granted if they are site-specific (e.g. located in less sensitive areas) and provide benefits for agricultural production.

This study quantifies the potential for electricity production from agrivoltaics in Switzerland, taking the existing agricultural land and legal rules into account. The methodological basis for the spatial study was developed in Jäger et al. (2022) and further developed in Anderegg et al., (2024) regarding the accuracy of the irradiation rates in the areas under consideration.

Methodology for area selection
In the study, only areas located within a buffer of 1000 m around building zones are considered. Areas that intersect with national conservation interests are excluded. This also applies to alpine grazing areas and biodiversity promotion areas.

The PV yield calculation for suitable areas is based on the irradiation and the area at the respective location as well as the type of agrivoltaic-system suitable for the management status. In the feasibility study by Jäger et al. (2022) a suitable system type was defined for each management status:

- Covered PV systems with bifacial modules and wide row spacing (around three times the module table width) were used for open arable land (e.g. potatoes or wheat).
- In permanent grassland (natural meadows or pastures), two bifacial modules in landscape format, mounted on top of each other are assumed, which run in rows in a north-south direction.
- In the area of permanent crops (e.g. vines or orchards), the yield was calculated using bifacial, semi--transparent modules with a light transmission of 50 %.

The GCR (ground cover ratio) of the system type was not described in more detail in this study, as only the energy yields were determined. However, existing agricultural PV systems from Germany and the Netherlands were used as reference systems. To determine possible crop yield reductions due to shading, the GCR of the reference systems must be included in further considerations.

In the next step, an energy yield simulation was then carried out for each system type at the reference site in Kloten (ZH), where the typical irradiation corresponds to the average irradiation in the Central Plateau. Areas with an annual irradiation < 1000 kWh/m2/y are considered unsuitable and excluded. The remaining areas are then categorised into the three crop groups “open arable land”, “permanent crops” and “permanent grassland” based on the crops grown on them. The Utilized agricultural area (UAA) is based on the model “Cultivated agricultural areas identifier 153” (FOAG, 2023) and was assigned a management status based on the crop grown on them. Analogous to the feasibility study by Jäger et al. (2022), the energy yield of reference systems per system type was then scaled linearly with the horizontal irradiation at the site.

Methodology of irradiation conditions
A raster data set with a spatial resolution of 100 m is used as the data source for irradiation. This contains the irradiation in a typical meteorological year per month or a whole year and was generated with Meteonorm Version 8 (Meteotest, 2022). The far horizon was considered. The far horizon describes for each angle (azimuth) at which solar altitude (elevation) the surrounding mountains/hills cause shading.

The typical irradiation from the grid data set with Meteonorm Version 8 (Meteotest, 2022) shows a very high level of agreement with the Swiss measuring stations, with deviations of 1 to 2 %.

Results
A total potential of 323 TWh/y was calculated for agrivoltaics in Switzerland. The potential is therefore 6 times higher than Switzerland’s electricity production in 2022 (SFOE, 2023). The potential is spread over an area of 583’499 ha and therefore covers 56 % of the agricultural land available in Switzerland in 2022 (excluding alpine grazing areas). In the winter half-year, there is a potential of 95 TWh, the specific winter yield averages 349 kWh/kWp or 29 % of the annual yield. The average specific winter electricity yield of

agrivoltaics is therefore around a third higher than the average specific winter electricity yield of PV systems on roof surfaces.

Most of the potential lies on open arable land at 225 TWh/y. The potential for permanent grassland is 85 TWh/y, and 13 TWh/y for permanent crops. In the case of permanent crops, areas with vineyards account for the largest share of the potential, followed by orchards (apples, stone fruit, pears). The geographical distribution shows a concentration of potential on the Central Plateau.

Keywords
Agrophotovoltaics, spatial analysis

Aditional Attachment I.
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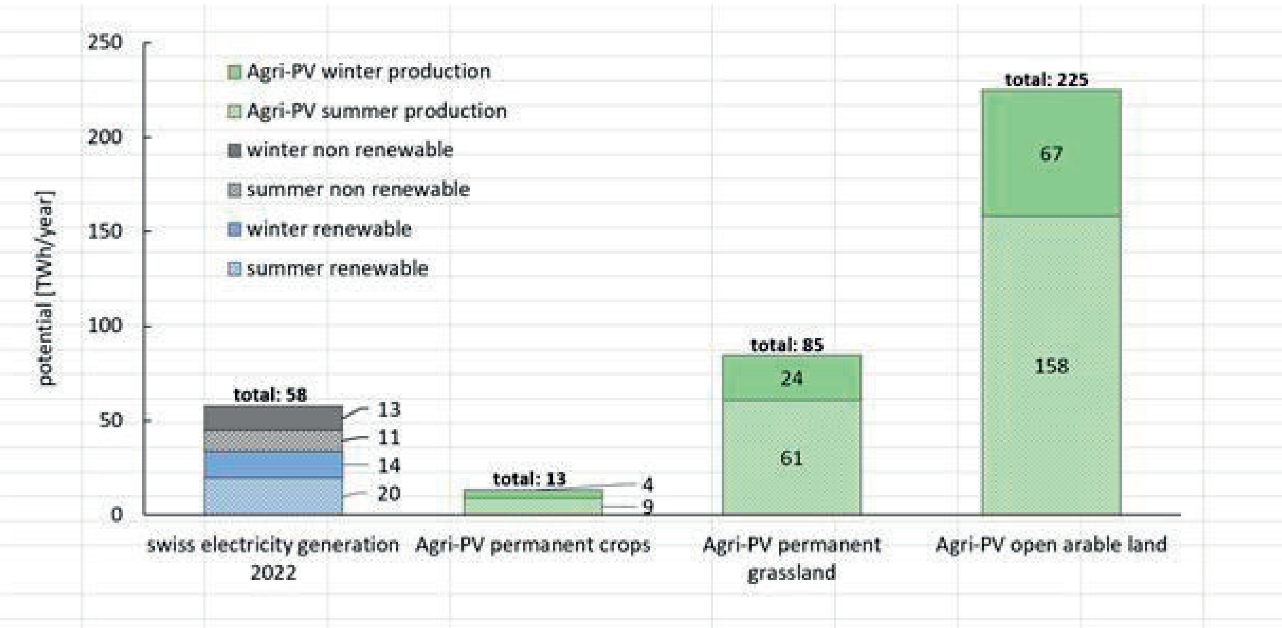
Aditional Attachment II.



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Solar panel effects on dry biomass production: results from a case study in Greece

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The Photovoltaic Parks (PVP) represent a relatively new concept in Greece with their adoption being lately exponentially increasing. They are an environmentally friendly land use as an alternative to fossil fuel use. This article presents the results from a case study in Greece where the effect of solar panels on dry biomass was evaluated.

Several studies report the creation of a microclimate under the panels of a PVP, often dubbed as 'cool island effect'. The panels' shadows reduce the underneath plants' PAR, and affect soil and air temperatures, which are significantly cooler under solar panels rather than between panels or on a control parcel (Armstrong et al., 2016). Evapotranspiration intensity and soil temperature tend to be positively correlated, meaning that a cooler area beneath the panels will reduce the need for plants to evapotranspirate. Furthermore, less wind was recorded under and between the solar panels, leading to air temperatures varying less during the day. The cooler temperatures lead to significantly reduced annual GDDs under the panels (Armstrong et al., 2016), which will impact the plant's growth. These conditions are suited for shade plants. Panels also affect soil moisture (Du Hamel et al. 2023). The shade provided by the panels reduces the evapotranspiration of plants, especially in arid or Mediterranean climates like Greece.

A key issue arising from this double use of the same relates to evaluating the yield of the crops in both agrivoltaic and agroforestry systems with Dupraz (2023) proposing the use of the Ground Cover Ratio (GCR). The present work presents the results from field samplings in five PVPs in Greece, focusing on the effect of solar panels on dry biomass production. The five PVPs are located in Central Greece in former agricultural land with the older one (PVP2) being grazed by sheep. All parks are in characteristic areas with Mediterranean climate, with hot summers and mild winters. None of the parks are in protected zones and are all being mowed 3 times a year, without any use of herbicide. The biomass was collected using a 0.25 m2 metallic square where all plants were collected and cut to the ground. In total five samples were collected under the solar panels, five between rows and five outside of each PVP or at their edge as controls. Sampling and handling of the samples followed standard procedures. Statistical analyses were made by IBM SPSS statistics software, v. 24 (ANOVA and the Least Significant Analysis (LSD) test).

Table 1

There were no statistical differences in the dry biomass under the panels (Table 1). Dry biomass was higher in the control of PVP2, which was expected since it is a natural area mostly composed of shrubs. Additionally, the area inside the PVP is grazed so most of the biomass is removed by the livestock. Dry biomass was higher outside the panels of PVP3 and PVP5 and this can be explained by the geographical location of both PVPs (further south than PVP1 and PVP4).

The results suggest a high potential for biomass production from the PVPs depending on the site. Based on the samples collected and the PVPs visited, it seems that there are several options to take advantage of the shading from the panels for alternative production i.e. with species that withstand or even take advantage of such shading.

Acknowledgment
This project has been funded with support from the National Energy Holdings (project AUA ELKE 06.0147). This communication reflects the views only of the author(s), and the Company cannot be held responsible for any use which may be made of the information contained therein.

Keywords
silvopastoralism, Climate smart agriculture, biodiversity, sheep

Aditional Attachment I.

Table 1: Comparison of the dry matter (DM) results between the different PVPs for the same conditions (under or outside of the PVP panels or control)

DM kg/ha	PVP1	PVP2	PVP3	PVP4	PVP5
Under1	1392 a	1734 a	1780 a	1936 a	4781 a
Out2	2050 i	4033 i	6924 ii	2852 i	5973 ii
Control3	3090 *	12390 **	5108 *	4726 *	4396 *

Different symbols following values within the same row indicate a statistical difference at 0.05 based on ANOVA and LSD test: 1Under indicates under the solar panel. 2: Out indicates outside the solar panel. 3: Control indicates a natural setting (surrounding area) of previous land use

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Agrovoltaics in alley-cropping agroforestry systems - first results of experimental installation

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Introduction

Agrovoltaics (AgPV) or more precisely, modern agrovoltaic systems have potential to diversify opportunities of farmers on land and to expand the range of their products (Dupraz et al., 2011). Further, a significant contribution can be the increase of energy self-sufficiency and the own use of produced electricity in the operation of farms and, on a wider scale, the increase of the resistance of rural and socially weaker regions to fluctuations in energy prices by including AgPV in community energy trends (Janota et al., 2023). A sensitive topic in conditions of the Czech Republic as well as some other CEE countries — as a result of the "first photovoltaic boom" (2009-2011) — is the question of the appropriate use of high-quality agricultural land for the installation of photovoltaic modules. According to latest legislation, it will be possible to install AgPV in the CZ only in so-called permanent crops (hops, vineyards, SRC etc.).

Objectives/research question

The aim of our work is to evaluate technical, productional and environmental aspects of AgPV installed in alley-cropping agroforestry systems.

Methodology

Experimental installation of photovoltaic modules was done in the alley cropping agroforestry system at research station Michovky (AFS-1; 0.6 ha). AFS was established for experimental purposes by transforming an over-aged tree nursery (15 years) in 2018-2019 into a silvoarable system consisting tree lines of maples, linden, ash and rowan in NWW–SEE direction. Tree crowns created connected canopy as stand density has been relatively high (440 trees / ha) as well as tree height (8-10 meters) before AgPV installation. Crops strips between tree lines are 15 meters wide and farmed by an agro-cooperative with same crops and similar agronomy as on their neighboring field.

Three types of PV modules (2 x CIGS 135 W, 2 x mono c-Si 400 W and 2x bifacial mono c-Si 380 W) were installed vertically with possibility of changing inclinations in the row resp. below crowns of semi-mature trees (66 m long, 15 linden) in January 2021. During two years we have measured efficiency of electric production of these types of PV modules, but also climatic and hydric parameters around them to assess their effect on production conditions of agricultural crops. Precipitation, air temperature at 1.5 m, soil surface temperature, soil temperature and moisture at -10 cm – were monitored by sensors (TOMST) 3 meters from photovoltaic modules and trees and on nearby 40 ha field (control) during vegetation periods 2022-2023.

We have also conducted experiment with drying of energy chips using electricity from this experiemental AgPV in island operation mode (V-VIII 2023). Volume of the drying and control boxes were 5.3 m^3 (cca 1 tone of fresh woodchips). A REMCO RAV 30 fan (650 W, output 3300 m^3/hr) created theoretical airflow of 165 m^3/m^2/hour in flor drying grid. The air flow mode was chosen to model the island regime — the fan was switched on when the experiemntal AgPV power plant produced >700 W.

Results

The results of monitoring showed that the AgPV modules installed in tree rows did not change statistically significantly the microclimatic and hydric conditions of the of crop field (spring barley, winter wheat) in the close neighbourhood in comparison with the tree rows without ApPV. Much stronger influence was found with factor of the orientation of trees rows, e.g. temperatures were statistically higher on the southern (SWW) than on the northern (NNE) side. A rather surprising result was the finding that the yield of electricity production from AgPV was relatively high between 63-89% according to specific power output of PV modules and 54-74% according to area for individual types and module settings. Electric efficiency has improved of AgPV when branches of linden were removed, which were the closest to modules and thus creating shade during morning period. In experiment with drying of wood chips, a reduction in the moisture content was achieved from the original 52% to 12% in 45 days, while in the control box it was 32%, which led to improved parameters for energy utilisation (calorific value +5GJ/t, occurrence of decaying fungi 4x lower).

Conclusions

Our results of experimental AgPV in AFS Michovky showed that PV modules can have relatively good electricity production especially if tree crowns are appropriately modelled and declination of modules is changed according to seasons. The removal of several trees from the ALS and the subsequent installation of PV modules did not affect microclimate parameters and therefore probably had no additional effect on production parameters of crops in AFS. The results of experiments with drying of wood chips proved a good potential of AgPV to be combined with biomass energy cycle on farm level. We will continue with evaluation of experimental AgPV including evaluation of economic efficiency of AgPV on farm level or in an energy community scheme.

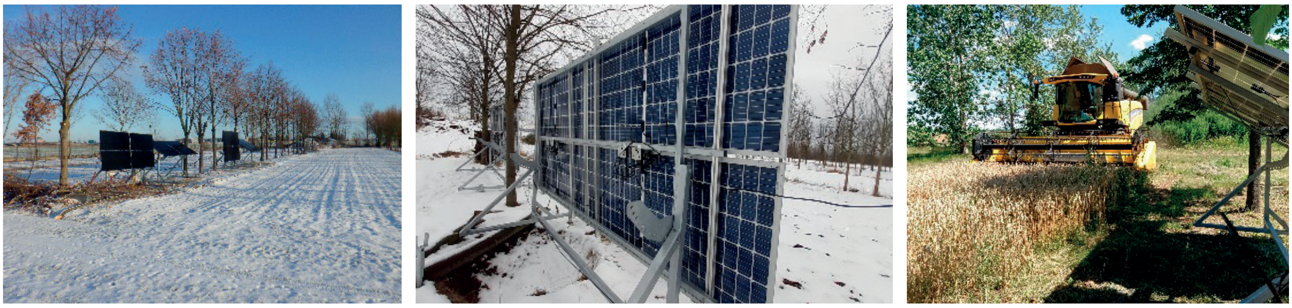
Acknowledgement

Our research was supported by the project TACR Theta (TK 04010166).

Keywords

silvoarable agroforestry, Agrophotovoltaics, microclimate, electricity

Aditional Attachment I.



Picture 1: Experimental AgPV Michovky - photovoltaics panels (CIGS 135 Wp, mono c-S 400Wp and mono c-Si bifacial 380 Wp) installed in the row of mature linden

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2.6 Agrivoltaism

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

The evolution of solar energy in Greece: from ancient singing statues to modern agrivoltaics

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In Greece, the construction of large-scale "photovoltaic parks" (PV) is a relatively new concept as an alternative to fossil fuel use, exhibiting an exponential increase in both their size and installed capacity. This article presents a short history of solar energy use in Greece since ancient times to the modern concept of agrivoltaics.

Solar energy has been used since antiquity for an admirable array of applications such as "the singing statue" powered by solar heat, as well as to its use to burn enemies' wooden ships with huge lens/reflectors (Archimedes invention in ancient Syracuse) or just to dry annual seeds or fruits for storage (Chatzikakidis, 1982).

Since the beginning of the 20th century (Rallis, 1982), Greece has been energy self-sufficient (99%) until the 1920, but in the 1980's the concept of "73.2% of primary energy consumption" was adopted, with various forms of energy contributing to coverage of country.

The triggers to increase research, funding and applications on solar energy were the 10-fold increase of petrol prices of 1973 and the energy crisis of 1979. A burst of research followed (Chatzikakidis, 1982), placing mostly emphasis on the use of solar power for heating water or home heating or in forestry (Tsoumis and Pasialis, 1982). It was foreseen that technology in the upcoming years will develop ways to reduce the existing high cost, stressing the need for higher funding of the relevant research (Rigopoulos, 1982) and expand their applicability. Kikidis and Pattas (1982), foreseen the future increased use of structure to capture solar energy to produce electricity.

Still, back in 1988, the cost of photovoltaic panels is mentioned as a major obstacle for their wider adoption and application, both in Greece and internationally (Institute of Solar Technology, 1985). Environmental and education issues arose in 2002 with reference on the increased use of PV parks (among others). It was foreseen that, environmental issues and commitments such as the Kyoto protocol, will widen their market rending them more financially competitive. As for the relation to agriculture, this is only related to their use for greenhouses' temperature modification, water purification (desalinization) or irrigation (Institute of Solar Technology, 2023). With the EU's target to reach carbon neutrality within the next 30 years (EU, 2019), the challenge of fundamentally reshaping its current electrical energy sector which today still heavily relies on fossil fuels is indispensable.

Nowadays, Greece is evolving and adapting from the simple solar panels for water heating, exclusively power production, or for greenhouses application to a new era that introduces the concept of the combined use of the same land for energy production via solar panels and for agriculture, terms as "agrivoltaics". Agrivoltaics multiple use(s) in the same piece of land, moderating the criticism that PV farms receive regarding how they deprive valuable agricultural land from food production in favor of power generation.

Solar panels could be used as tools to facilitate and improve agricultural practices and production, i.e. by protecting crops development, especially under drought and intense heat conditions. For example, Jung and Salmon (2022) suggest the replacement of plastic crop covers by PV panels, to increase their economic return. Agrivoltaics are further important in locations/countries of arable land scarcity, such as Japan (Tajima and Iida, 2021) and Greece, where they seem like an interesting alternative land-use option for abandoned or degraded farmland.

Grazing represents a viable solution to increase the land's overall productivity while offering an ecosystem-based practice to remove underground vegetation (Heins et al. 2022). In Greece, grazing is officially applied inside seven PV parks (by National Energy Holdings) and latest observations and measurements showed no interference of grazing to the amounts of energy produced. Another possible use for the land occupied by PV parks in Greece is for beekeeping. In this aspect, PVPs can represent a biodiversity hot spot for both the establishment of beehives for honey production or for hiving or pollinators and wild bees that use the protected land of PV parks as refugee from nearby agricultural lands polluted with pesticides.

The interaction between solar electricity production and crop cultivation is complex and depended by the types and position of the panels. A general conclusion is that agrivoltaics represent an interesting new land use that can face challenges such as land scarcity and land abandonment of low productivity sites in Greece, and represent an ecosystem-friendly solution that could meet some ecosystem challenges. More combinations of different land uses needs to be tested, such as grazing among the panels, alternative cultivations, hydroponics and planting of shade tolerant crops under elevated solar panels.

Acknowledgment
This project has been funded with support from the National Energy Holdings (project AUA ELKE 06.0147). This communication reflects the views only of the author(s), and the Company cannot be held responsible for any use which may be made of the information contained therein.

Keywords
Agrivoltaics, Land Use, solar energy, photovoltaic parks

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Solar panel effects on certain soil characteristics: results from a case study in Greece

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This article presents the effects of solar panels on certain soil characteristics in five PV parks (PVP) in Greece one of which is agrivoltaic.

Greece has a Mediterranean climate with hot summers, making it appropriate for solar energy, which is the number one renewable energy source in Greece, making up to 4.1 million m2 of land use -the second largest total capacity in Europe. Several studies report the creation of a microclimate under a PVP. The panels' shadows reduce underneath plants' PAR and affect soil and air temperatures, which are significantly cooler under solar panels rather than between panels or control parcel (Armstrong et al., 2016). Studies report a difference in pH under and outside the panels (Noor and Reeza, 2022), with most cases pH being higher under the panels (Moscatelli et al., 2022). Panels also affect soil moisture (Du Hamel et al. 2023). In an arid environment, PV panels' roof effect increases water availability (Hernandez et al., 2020). These panels-induced properties would reportedly stabilize in time, and the microclimate under panels in a hundred years should be roughly the same as today (Wu et al., 2022).

The purpose of this work was to investigate the effect of solar panels on i. soil organic matter (SOM) content, and ii. pH.

Soil samplings were conducted in five PVPs, one of which (PVP2) is grazed by sheep. All PVPs are in characteristic areas of a Mediterranean climate, with hot summers and mild winters. None of the PVPs are in a protected zone and all are being mowed 3 times a year, without any use of herbicide. In total five composite samples were collected under the panels, five between rows and five outside each PVP or at the edge as controls. Sampling, handling of samples and chemical analyses followed standard procedures. Statistical analyses were made by IBM SPSS statistics software, v. 24.

Table 1

Different symbols following values within the same row indicate a statistical difference at 0.05 based on ANOVA and LSD test: 1Under indicates under the solar panel. 2: Out indicates outside the solar panel. 3: Control indicates a natural setting (surrounding area) not affected by the presence of PVPs

No statistical difference was found for SOM content between the PVPs under or outside the panels (Table 1). Based on the results, the previous land use affected SOM content in the controls of PVP4 and PVP5, having the lower values. However, it should be noted that all values, even if not statistically different, were lower in the last two compared to the other three PVPs. On the opposite, PVP1 had the higher SOM values than the others, even if not statistically higher. This result relates to the lower pH values measured in the same park and the time that sampling was conducted. As for the effect of the solar panels on SOM, there were no differences between the three conditions (presence of panels or control) for any of the parks.

PVP5 had the higher pH values compared to the other four but not the control ones that were not statistically different between the parks. PVP1 had the lower, even if not statistically different, values which is related to the higher SOM found. The presence of the panels affects soil pH in PVP3. Soil pH under the panels was not different to the one outside or the control but the value outside was different to the control one.

All SOM and pH values found are related to the management applied in the PVPs where biomass is cut in small pieces and left on site as well as previous land use. The results suggest a high potential for biomass production from the PVPs depending on the site. Based on the samples collected and the PVPs visited, it seems that there are several options to take advantage of the shading form the panels for alternative production i.e. with species that withstand or even take advantage of such shading.

Acknowledgment
This project has been funded with support from the National Energy Holdings (project AUA ELKE 06.0147). This communication reflects the views only of the author(s), and the Company cannot be held responsible for any use which may be made of the information contained therein.

Keywords
Agrivoltaics, solar energy, soil analysis, Agrophotovoltaics, photovoltaic parks, Soil Organic Matter

Aditional Attachment I.

Table 1: Comparison of SOM results under or outside of the PV panels or control.

	PV1		PV2		PV3		PV4		PV5	
	SOM %	**pH**	**SOM %**	**pH**	**SOM %**	**pH**	**SOM %**	**pH**	**SOM %**	**pH**
Under1	4,22 a	7,18 a	3,77 a	7,46 a	3,38 a	7,6 b	2,91 a	7,90 b	2,80 a	8,05 c
Out2	4,12 α	7,58 α	3,68 α	7,65 α	3,32 α	7,82 α	2,59 α	7,99 β	2,83 α	8,04 β
Control3	4,88 *	7,86 *	4,00 *	7,02 **	4,05 *	7,67 *	2,51 **	7,63 *	2,84 **	7,87 *

Different symbols following values within the same row indicate a statistical difference at 0.05 based on ANOVA and LSD test: 1Under indicates under the solar panel. 2: Out indicates outside the solar panel. 3: Control indicates a natural setting (surrounding area) not affected by the presence of PVs

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Application of AgriSolar concept in agroforestry: case study from Serbia

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Introduction

Plan is to establish the production of short rotation poplars and willow clones combined with production of electrical energy through agrisolar (agrivoltaic) systems in a comparative study design (various solar panel types, mountings of different heights, seedling types and different watering regime) at the same soil conditions. Lower fertility soils will be used, where it is assumed that production of biomass for bioenergy along with electricity can have benefits that exceed trade-offs.

Case description

The pilot development started at experimental estate of Institute of Lowland Forestry and Environement "Kaćka šuma", a rural area located northeast of the city of Novi Sad. Short-rotation coppice is envisage strips between banks of agri-voltaic panels placed at a range of heights is the final vision. Site preparation (soil preparation, irrigation, planting) and installation of photo voltaic systems will be conducted. After the second year, the stems of poplar and willow clones and other shrub species will be harvested and the biomass, energy and economic performance of different layouts evaluated. The results from each scenario will be analysed, compared and evaluated in terms of biomass production and renewable energy potential.

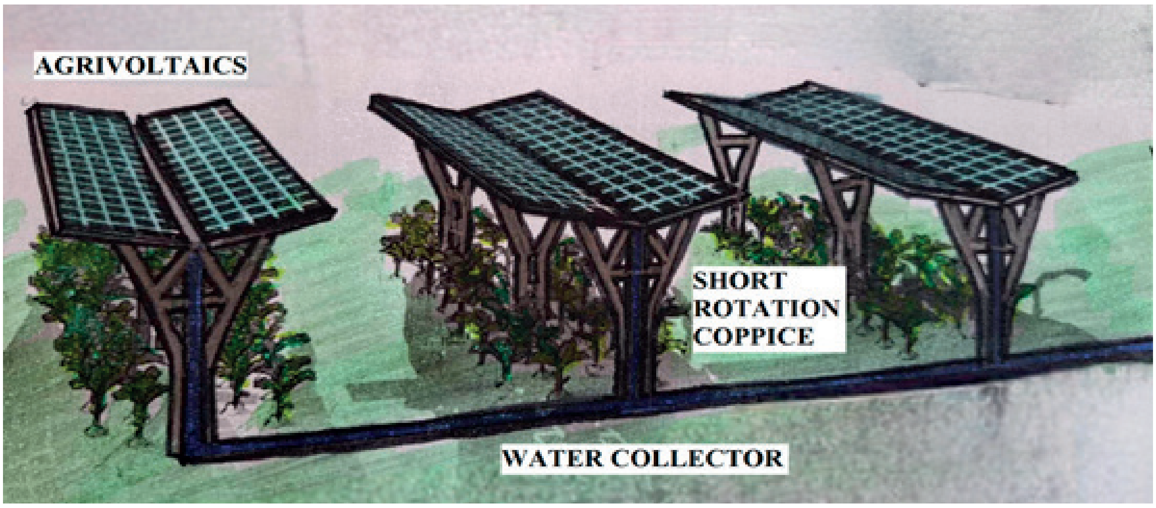
Conclusion

First time that production of wood crop short rotation of poplars and willow clones is planned to be combined with production of electrical energy through agroforestry-photovoltaic system in comparative study of particular designs (various solar panel types, mountings of different heights, seedling types and different watering regime) at the same soil conditions in Serbia. It is expected that our approach will serve as an example of good practice.

Keywords

agriculture, forest management, agroforestry systems establishment, electricity, Agroforestry

Aditional Attachment II.



Theme 3: Economy and Policy of Agroforestry

3.1 Business Models

Oral presentations

Hall Q1, 29 May 2024, 10:30–12:00

Mapping agroforestry value chains with Living Lab participants across Europe

Professor Paul Burgess[1], Laura Cumplido-Marin[1], Margherita Tranchina[2], Alice Ripamonti[3], Fabrizio Giuseppe Cella[3], Alberto Mantino[3], Victor Rolo Romero[4], Lojka Bohdan[5], Michael den Herder[6], Rico Hübner[7], Evert Prins[8], Waas Thissen[8]

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7 Deutscher Fachverband fur Agroforstwirtschaft (DeFAF), Germany
8 Louis Bolk Institute, Bunnik, The Netherlands

Introduction

The European food system faces the triple challenge of how to enhance food security whilst maintaining the livelihoods of food producers and addressing the challenges of climate change and biodiversity loss. Whilst the current food system is able to produce high quantities of high quality food, there is a need to reduce the climate change and loss of biodiversity associated with food production. This seems to imply that additional safeguards and higher standards are needed. By contrast, political leaders are under pressure to ensure that food is supplied at the lowest cost, particularly during a "cost of living crisis", and supermarkets in the pursuit of providing the lowest cost food to consumers cut the margins received by food producers. Is there a way forward to solve the trilemma?

Objective

The DigitAF research project (GA number: 101059794; July 2022 - June 2026), funded by the EU, aims at high-quality implementation of agroforestry to foster climate change mitigation and adaptation in agriculture and to ensure sustainable management of natural resources. Some components of DigitAF focus on policy makers and practitioners, but a third part focuses on how the value of agroforestry can be accounted for and valued in value chains. The objective of this paper is to describe the method and results for some initial work on improving our understanding of agroforestry value chains.

Methodology

The value chains related to six agroforestry systems were examined using facilitated workshops with six "Living Labs" engaging with policy, practitioner, and value chain stakeholders in Czechia, Germany, Finland, Italy, the Netherlands, and the United Kingdom, plus an additional workshop in Spain. In some locations, "ice-breaking" activities, suggested by researchers at the University of Pisa, were used to encourage collaboration. The next stage was to identify a suitable case study. Silvopastoral systems were selected in Czechia, Germany and Spain, and silvoarable systems were chosen in Finland and the UK. The beef and dairy sectors were the focus in Italy and the Netherlands respectively. Next, using a workshop or interviews a schematic map of the flows of products, services, finance and information was developed for the selected case study with a discussion on opportunities and challenges (Tranchina et al. 2023). The next stage was to digitise the resulting maps using MindMaple (https://www.mindmaple.com) and to synthesise the main insights.

Results and discussion

In preparing a synthesis of the results, we found very few reports that map the value chains of food in Europe. This may partly be due to the commercial sensitivity of such information and power dynamics that may constrain information flow. An interesting data source from the United States of America is an nationally funded study of the proportion of the "food at home dollar" that is captured by farm producers and others (Fig 1) (USDA 2023). Between 1993 and 2022, the reported proportion captured by farm producers varied between 10.4 and 15.4%, with some farm income spent on the purchase of upstream inputs and advice (labelled agribusiness). Such figures can be fruitful in opening a discussion on value chains.

A first observation from the workshops was the unexpected benefits of serendipitous outputs from bringing people together. This can range from new insights for government advisors to farmers sharing experiences and concerns. A second observation is that the need to improve our understanding of value chains is only likely to increase. For example many UK supermarkets have targets for net zero supply chains by 2050 and the EU has issued a recent directive 2023/1115 to ensure that selected products are not related to deforestation. A major digital challenge is how to enable the robust calculation and verification of such system properties in a cost-efficient way.

A common theme was how farmers could capture a greater proportion of the final price for the retail product. Across the Living Labs, the following five practices were observed:

1. To maintain a short supply chain from producer to consumer, for example through the use of a farm shop.
2. To enable on-farm processing, be it apple processing or local mobile abattoirs,
3. To increase a farmer's bargaining power through co-operatives, associations, or networks, or to establish equitable longer-term contracts between sellers and buyers.
4. Capturing the value of "agroforestry services" through product certification or publicly funded agri-environment schemes.
5. Improving the quality of products through innovation and sound advice.

Conclusion

The facilitated workshops and interviews on value chains increased connectivity between stakeholders and built relationships. Many farmers feel isolated and methods to strengthen their bargaining power within the value chain are needed. There was particular interest in short value chains, on-farm processing, networks and long-term relationships, certification, and the improvement of product quality.

Acknowledgement

The DigitAF project is supported by the European Union Horizon programme (101059794). We are thankful for those who participated in the workshops.

Keywords

Value chain analysis, participatory research, Agroforestry, food labelling, business opportunities

Aditional Attachment II.

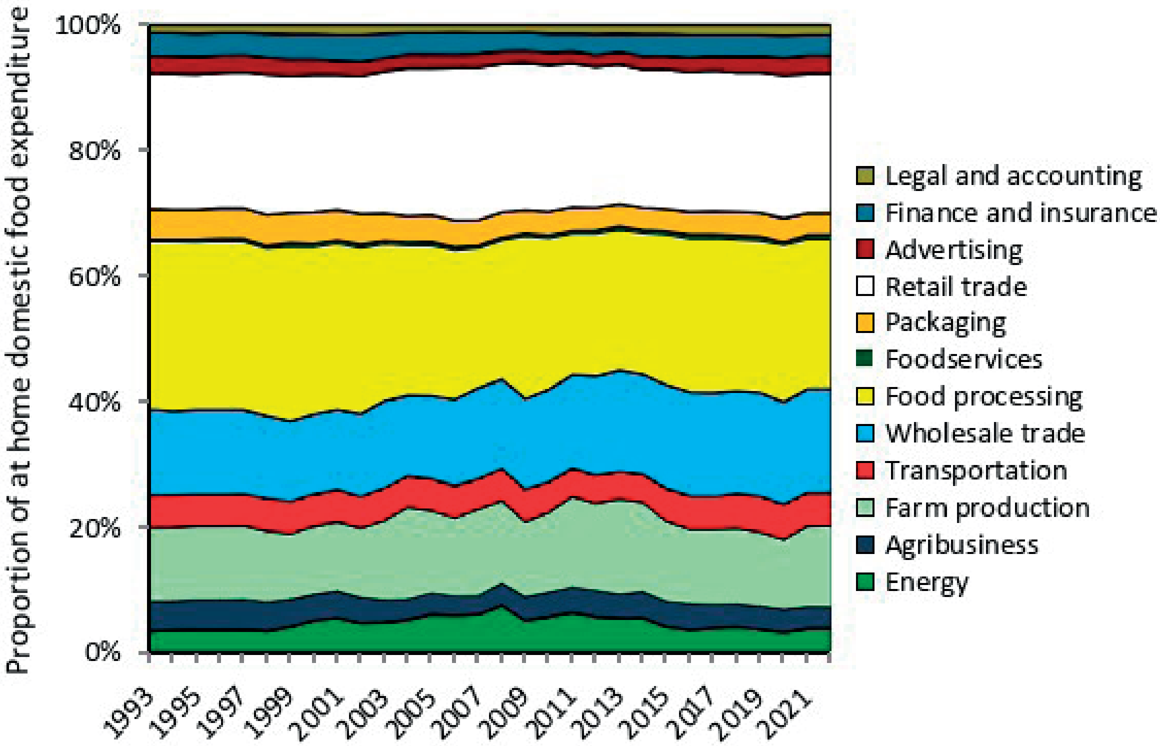

Figure 1. Annual estimates from 1993 to 2022 of the proportion of the "food at home dollar" in the United States of America that is secured by individual stakeholder groups from domestically produced food. Agribusiness includes upstream suppliers of seed, fertilizers, and farm machinery and farm services (USDA, 2023).

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Supporting farmers online with a user-friendly decision support tool: introducing the INTeractive Agroforestry Cost-benefit Analysis Tool (INTACT)

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Introduction

The transition of traditional farming systems toward agroforestry is a long-term project for which the cost-benefit analysis is a laborious task assigned to experts who face complex calculations with multiple components including trees, crops, and animals in one farming system. Ideally, agroforestry farmers should be equipped with user-friendly tools for calculating costs and benefits related to the tree component of their new agroforestry plan. Hence, the INTeractive Agroforestry Cost-benefit Tool (INTACT) has been developed as a strategic solution to guide the users through the relevant tree and shrub-related costs and benefits that can be expected while implementing agroforestry in Belgium and the Netherlands. INTACT is the newest addition to the Agroforestry Planner3, which is an online toolkit consisting of several agroforestry decision support tools, created by partners of the Consortium Agroforestry Flanders.

INTACT is a product that is based on several existing agroforestry models1,2,4,5 and other sources of information with recent key figures7, such as catalogs from tree nurseries. INTACT consists of a separate cost and benefits module of which the structure was furthermore co-developed based on expert advice from stakeholders within the Consortium Agroforestry Flanders' network. For the cost module, five important categories were determined: 1) The purchase of trees and shrubs, 2) Terrain and planting preparation costs, 3) Tree protection costs, 4) Tree management costs, and 5) Harvesting costs. In addition, the benefits module covers 3 categories including the expected freshly harvested fruit and nut yield according to the chosen trees and shrubs. After navigating through both the cost and benefits modules, the final screen will show a cost-benefit analysis over 20 years based on the user's input. In this way, INTACT can specifically offer a partial analysis focusing on the financial impact of the trees (crops and animals are not included in INTACT). However, it is important to stress that INTACT is not intended for an integrated business economic analysis nor for replacing guidance tailored to specific business situations.

Methodology

INTACT was developed using Oracle's web application building technology (APEX) which combines visually appealing interface design with responsive database actions, resulting in real-time processing of user input. APEX is a versatile tool that runs on any modern web browser and can be used on different screen sizes from desktops to laptops or tablet devices.

It is important to stress that user-friendliness was an important determinant for the design of INTACT. INTACT features no max-value constraints on any input field in the web application and, as no fields are mandatory, the users can navigate between the different steps without restrictions regarding the provided input. This gives the users the freedom to experiment and to create a scenario that reflects the project they have in mind. If the users aim for an all-inclusive, detailed, and logical cost-benefit analysis, they should provide as much detailed information as possible about their project.

Preliminary results

The steps in INTACT correspond with the aforementioned cost and benefit categories taken into consideration when constructing a cost-benefit analysis of an agroforestry project. To illustrate, Figure 1 shows the first cost category in INTACT. In this step, the users need to specify which tree species they want to plant to calculate the total cost of trees and shrubs.

Figure 1: Input screen for step 'Purchasing trees'; the users can choose which tree(s) they want to use in their agroforestry system including adjusting tree specifications including the stem circumference.

In the following steps, the users have to make other cost-related choices related to terrain modifications, planting trees, mulching, tree support and protection materials, and maintenance operations. Harvest-related costs for nuts are calculated by the tool MIMOSA which is available at the Agroforestry Planner3. At the end of the cost module, the user receives an overview of the total costs of their agroforestry project (Fig. 2).

Figure 2: Overview of costs related to an agroforestry project.

Next, the benefit module shows an overview of fresh fruit and nut yield. For wood yield, tree growth curves2,6 were used and multiplied by the most current timber prices. Potential income from derived products or processed wood products is not included yet in INTACT 1.0. Finally, INTACT creates a comparison of those costs against the benefits made from the trees.

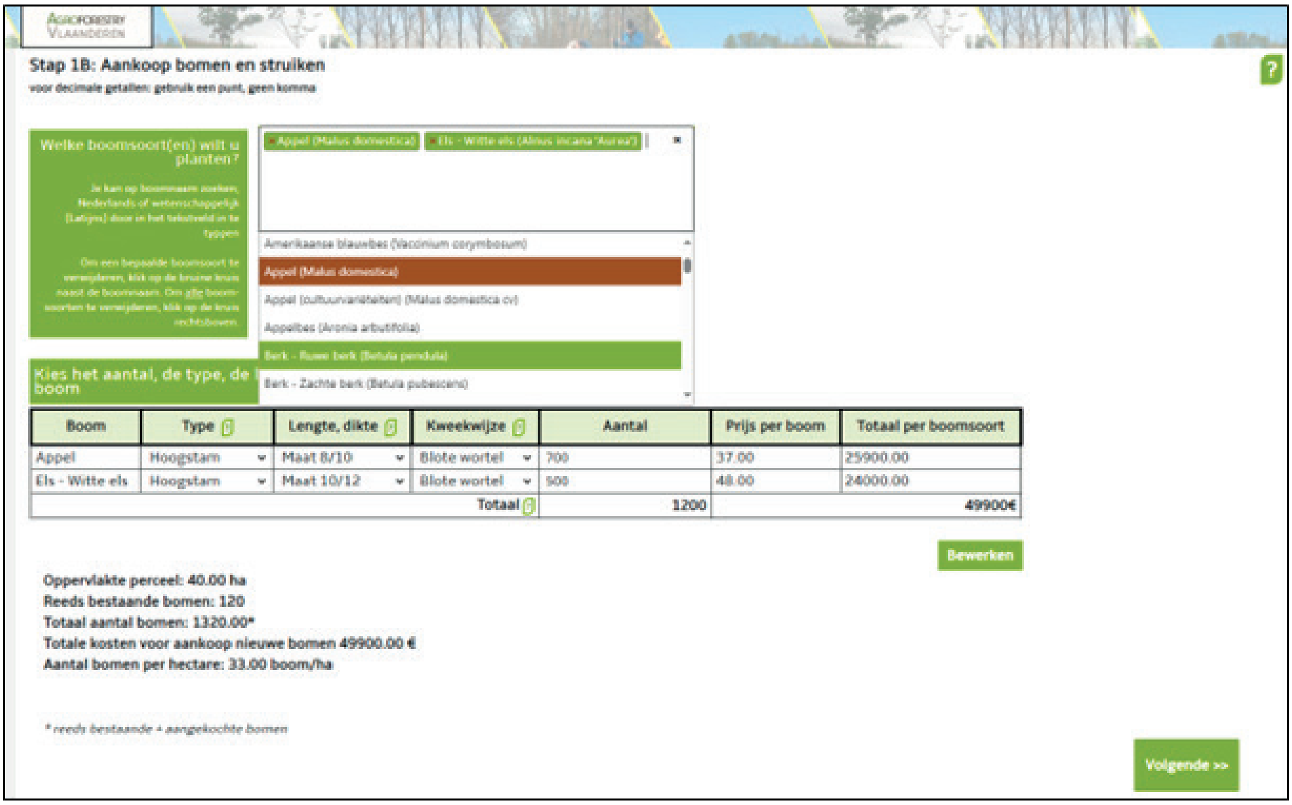
Conclusion

For the development of INTACT, it was important to create an interactive and user-friendly tool that assists in considering the majority of aspects of investment and maintenance costs, as well as expected income from trees and shrubs in an agroforestry system. In this way, INTACT aims to support farmers online by offering a clear framework of costs and benefits that are relevant to trees, i.e. crucial elements in new agroforestry projects. After INTACT 1.0 is launched, more research will be conducted to test INTACT's accuracy with realized agroforestry plans and to further improve user-friendliness.

Keywords

agroforestry system planning, decision-making, farmers' decision making, Agroforestry, decision tool, business models, Cost-benefit analysis

Aditional Attachment II.



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Economic Assessment of Alley-Cropping Agroforestry Systems within a Farm Portfolio in Germany

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Due to climate extremes, pests and high food demand, farmers face increasing challenges to achieve both productivity and sustainability. Agroforestry has been proposed as a means of enhancing sustainable agricultural productivity and resilience (IPCC 2022). As one promising agroforestry practice, alley cropping has been shown to enhance carbon sequestration, habitat for soil biological activity and resistance against wind erosion compared to pure cropland (Veldkamp et al. 2023). However, the lack of adopting agroforestry systems in German agriculture is very apparent (e.g., García de Jalón et al. 2018; Sollen-Norrlin et al. 2020).

In addition to more social science-oriented studies that focus on farmer's perceptions towards agroforestry, there have only been a limited number of studies on the economic assessment of temperate agroforestry systems (e.g., Frey and Cary 2020; Giannitsopoulos et al. 2020). These mostly focus on the comparison of agroforestry and conventional cropping systems or did not consider the farmer's attitude towards risk. Moreover, some economic obstacles might only become apparent at farm level, while the majority of study focuses on the plot level. The need for more studies on economic risk on farm-level was also pointed out by previous studies (Thiesmeier and Zander 2023).

We aim to economically assess temperate alley cropping agroforestry systems in order to identify the economic obstacles and key drivers for the adoption of agroforestry systems on farms. Our aim is to address not only the question of the adoption of agroforestry, but also the question of how much agroforestry is to be adopted at the farm level from a risk averse perspective. We also seek to understand the main factors that determine the proportion of agroforestry in a farm portfolio optimised to balance risk and return.

Based on Markowitz Portfolio Theory (1952), we created a bio-economic farm model and used the Monte Carlo method to simulate economic risk. We used the annuity as an indicator for economic performance and the standard deviation and the Value at Risk to assess the risk. We obtained the yield from an empirical data set of four different study sites across Germany. The agroforestry system consists of parallel tree strips of poplar and a crop rotation of three to four crops, depending on the study site. In the model, uncertainty of yield and price fluctuations from historic time series and extreme weather events were included. The results from the Monte Carlo simulations were used in the portfolio analysis. We analysed the influence of site and climate conditions, the area shares of tree strips and the effect of subsidies on the performance of agroforestry within the portfolio.

Our results show that the relative economic performance of agroforestry compared to conventional cropping systems is highly site specific. On low performing soils, e.g., Gleyic Cambisol with a crop rotation of wheat, maize, barley and oat, agroforestry can outperform conventional cropping systems in terms of economic return under uncertainty. Our bio-economic farm model selected Agroforestry as part of the farm portfolio on two out of the four sites, while the selected area share of agroforestry strongly varied. The key drivers for the performance of agroforestry in the portfolio were the economic performance of the alternative cropping system, the area share of the tree strips (planting layout) and the amount of subsidies.

Our study contributes to the knowledge of agroforestry in farm portfolios and explores the role of market and climate risk in adopting agroforestry. In contrast to earlier findings, we conclude that agroforestry is not necessarily more risky or less profitable than conventional cropping systems. By identifying the key drivers for the economic performance, we can suggest under which conditions agroforestry might be economically attractive to farmers.

Keywords

Risk assessment, Tree Crops, temperate agroforestry, business models, farmers' decision making, economic performance, alley cropping, Poplar

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Holistic modelling of different agroforestry systems within the ReForest project to promote adoption in Europe

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Agroforestry has the potential to produce diverse food and income sources, provide balanced development of the region and aid in sustainable management of agriculture, natural resources and climate action. IPCC recommends agroforestry as the most promising inclusive solution on land for climate change mitigation and adaptation. It is primarily supported and recognized under the Common Agricultural Policy (CAP) in Europe, and farmers adopting it are eligible for incentives under Pillar I & II.

However, as the implementation of CAP is at the discretion of Member States, different regulations at federal state levels, adoption pathways, and lack of awareness, information, and experiences on specific agroforestry methods hinder the extensive adoption of agroforestry systems. Practitioners and legislators need examples and cases to refer to, but these can take a long time. A holistic view of the system with tangible and intangible factors must be considered at the farm and large-scale levels for practitioners and policymakers to favor adopting agroforestry systems.

We generate a comprehensive graphical conceptual model of agroforestry systems developed from a detailed literature review and consultation with experts (agroforestry practitioners, researchers, policymakers and consultants) on agroforestry systems as shown in Figure 1. The model offers a holistic overview of agroforestry systems and their interrelated dynamic components, including tangible and intangible factors. Our model takes into consideration the farming costs, benefits and risks and how these lead to an expected net present value for farmers. Planning, establishing, and maintaining agroforestry systems is often complex and is associated with a high initial investment. Market fluctuations, price variation, changing legislation, and potential crop failures due to pests, diseases, and weather events further complicate the adoption of agroforestry systems. Risk aversion increases with high uncertainty of local landuse policies, regulations and investment for farmers contemplating adopting agroforestry systems. Our model offers a synthetic representation of the current state of knowledge of the agroforestry system, encompassing all system complexities.

Figure 1 Graphical conceptual model of agroforestry systems

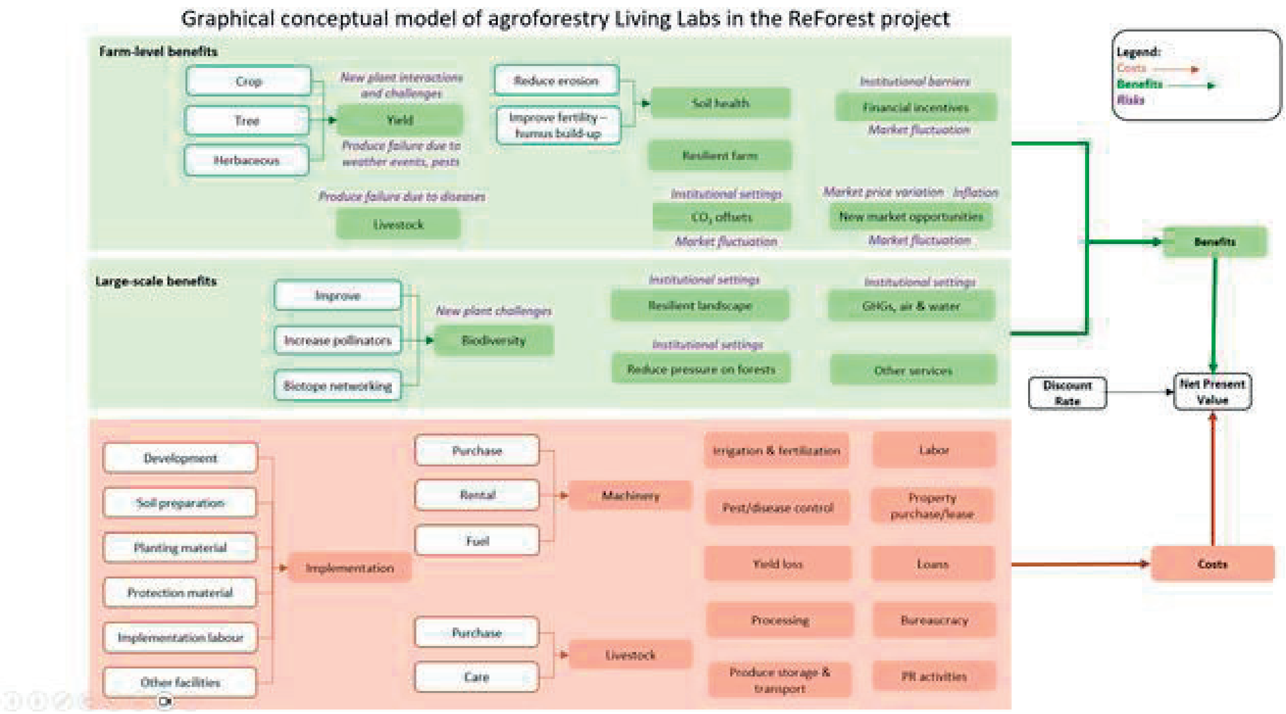
We translate our conceptual understanding of the agroforestry system into mathematical formulations and program simulations of the potential futures for multiple Living Labs agroforestry systems under the ReForest project. We quantify our probability distributions from all information sources, including expert knowledge elicitation methods through stakeholder workshops. We apply a Monte Carlo simulation to generate ranges of plausible outcomes and to provide assessments of economic (farm-level), ecologic and social (large-scale-level) benefits to reveal the parameters that most impact the outcomes of the systems and require further investigation. Gathering further information on these variables can help other farmers and policymakers realize the long-term benefits of agroforestry and thus promote agroforestry adoption. These models provide farmers, policymakers and stakeholders with better-informed decision-making to support the implementation and proliferation of agroforestry across Europe.

This abstract is based upon work from project 101060635 – REFOREST, funded by the European Union.

Keywords

business models, Policy support, Risk assessment, decision analysis, Socioeconomic status, temperate agroforestry

Aditional Attachment II.



An economic evaluation of agroforestry systems with annual crops and poplar plantation in the North of Italy based on FADN data..

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Introduction

Forestry is an integral part of rural development policies: since 2007-2013 programming period, a variety of measures have covered different types of support for forestry investments and management. The EU Regulation 1305/2013 introduced a specific measure for the creation of agroforestry systems where trees are grown in combination with agriculture on the same land. For the next programming period (2023-2027) the Italian CAP Strategic Plan has provided subsidies for the introduction of agroforestry systems as investments for forestry in agricultural lands (SRD05) and their maintaining (SRA28). Both measures comply with the environmental objectives of the Green Deal, the rural development policies, the forest strategy and the EU national and european biodiversity. It is widely recognised that the combination of trees and crops can influence positively the agricultural land management and the production of several ecosystem services (biodiversity and landscape conservation, carbon sequestration in biomass and soil, reduction of soil erosion and nutrient leaching, air and water quality improvement, etc.). (Pantera et al., 2021; Jose, 2019; Fang et al., 2005). In the EU27, about 358,000 ha are used for different forms of arable agroforestry, (Augère-Granier, 2020).

Agroforestry systems based on poplar have been studied and investigated in several countries like United Kingdom (Willis et al., 1993), Germany (Langhof and Schmiedgen, 2023), Baltic Regions (Daugaviete et al, 2022), France (Van Lerberghe, Parizel, 2019), India (Chandra et al., 2011). In Italy the economic and environmental benefits of poplar-based agroforestry systems have been investigated mainly in the northern part of the country and in experimental case-studies. Despite of the high importance of this combined systems, in general farmers do not consider agroforestry as a profitable alternative to standard agricultural practices. Measures providing subsidies for the introduction and maintaining of agroforestry in Italy have been applied in the last programming period only in two regions, in a very limited number of farms and hectares.

Specific analysis on the assessment of the profitability, costs and revenues generated by the combination of wood plantation and annual crops in Italian agroforestry systems are very few. One of the first surveys concerning the yield of wheat and rice combined with poplar (Prevosto, 1971) have been revised with updated prices recently (Rosso et al., 2021). This work is a contribution to this research area: economic data regarding the poplar plantation are treated and compared together with the gross margin per hectare of the agricultural crops (wheat, rice, maize) assessed on the basis of the Italian FADN (Farm Accountancy Data Network) data for the interesting Regions (3-years average, 2020-2022).

Objectives

The aim of the work is the assessment of the economic feasibility of agroforestry systems (combination of poplar and annual crops) in the North of Italy, specifically in the Po valley where poplar cultivation is widespread. The objective is to assess if, under certain conditions, the agroforestry management can influence farm income and in what direction. Several scenarios are compared, considering the most common poplar clone (I-214) and the new MSA clones (“massima sostenibilità ambientale”) characterized by a high productivity and environmental sustainability.

Methodology

The economic analysis is implemented considering data collected in literature and on the field as concern poplar and data coming from the Database of Italian FADN for agricultural crops. The Farm Accountancy Data Network is one of the most important microeconomic surveys in Europe. It collects information suitable to be used for structural and socio-economic analysis of the agricultural sector in all the Member States. The Italian FADN is conducted at regional level and is possible to estimate the costs and revenues of farms and specific crops. The 3-years average of the gross margins per hectare of wheat, maize and rice have been used in the implemented analysis.

Final considerations

The comparison among different scenarios and combinations of poplar with the selected arable crops shows that the profitability of specific agroforestry systems could guarantee a diversified revenues for farmers.

The assessment is made on the basis of average data and simulating given conditions. The yields of poplar and crops depends by several factors that have been not fully considered in the analyzis, but the assessment done on the basis of market price and updated surveys like FADN could give an indication about the different rentability of agroforestry systems compared with monocoltural agricultural management. The evaluation permits to have also an idea about the importance of subsidies for this kind of farm management.

Keywords
economic performance, Socioeconomic status, agricultural revenue diversification

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3.1 Business Models

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Agroforestry value chains in Finland: a case study of three agroforestry farms in Finland

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Agroforestry is a non-mainstream land management practice in Finland and it is little discussed in public and policy discourses as a part of sustainable agricultural production. Whereas in Finland agroforestry receives little attention, at European policy-making level societal need for sustainable land use practices in agriculture and forestry has been increasing due to challenges climate change sets to farming, forestry and local communities. In this context, agroforestry offers new possibilities for environmentally, socially and economically sustainable production and value chains in Finland. In this study value chains in three different Finnish agroforestry farms practicing agroforestry as one of their business activities are presented to describe the current state of agroforestry in Finland. In two of the studied farms alley cropping is used as the main agroforestry farming method and in one farm forest grazing is practiced. The data is collected through semi-structured questionnaires, interviews and documents with case study methodology as the qualitative research strategy for this study. As strengths of agroforestry farming, the results of this study show that agroforestry farmers have in general very good knowledge of agroforestry systems they use and that farmers continuously search for more information and collaborate with their socio-economic networks in developing farming and business activities. Whereas marketing skills and limited further on-farm processing of produced raw materials are weaknesses typically present in agroforestry farms, the studied farms have short value chains benefiting from non-mainstream marketing and distribution methods such as community-supported agriculture and direct on-farm sales. As agroforestry farmers operate in non-mainstream environment of agricultural production in Finland, the results of this study may offer new insights to farming not only to aspiring agroforestry farmers but also to mainstream farmers and decisionmakers. Overall, the results of this study can open new insights into better understanding agroforestry and agroforestry value chains for connecting farmers and consumers in new more sustainable ways in climate-friendlier production and consumption in Finland.

Keywords
agroforestry value chains, Agroforestry, business models, Finland, short value chains, sustainable food production, sustainability, farmers, sustainable business models, case study

Agroforestry Value Chains in Europe: A stakeholder-based approach to understand regional and product-specific value chains in eleven case study regions

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1 Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Deutschland

Agroforestry systems have several agro-ecological advantages but the implementation of agroforestry also depends on their economic performance. To explore economic opportunities for agroforestry farms in Europe, it is important to understand existing agroforestry value chains. This knowledge informs practitioners' decision-making by exploring more profitable activities and marketing channels for agroforestry products. On a regional level, understanding value chains can help to identify deficits and promote the development of agroforestry value chains. Value chains describe the entire sequence of activities necessary to bring a product or service from its initial conception, through various production phases to its delivery to the end consumers and its eventual disposal (Kaplinsky & Morris 2000). This research defines agroforestry value chains as value chains of products produced within agroforestry systems including timber, non-timber tree products as well as various agricultural goods and services directly obtained from agroforestry systems. The literature about agroforestry value chains in Europe is sparse, which is why this research addresses this knowledge gap.

The objective is to assess the current state of agroforestry value chains in selected regions in Europe with a special focus on all activities and actors directly connected to the farms. To better understand regional value chains and where value is created, the four research questions encompass:

1. What are agroforestry products in the respective European regions?
2. Which value chain actors are present in the research areas?
3. What value-adding activities do farms perform?
4. What are restrictions and missing actors in the existing value chains?

The data will be collected using a participative stakeholder-based approach in eleven case study regions in Europe. In each region a workshop with about twenty to thirty participants from a regional multi-stakeholder network is held in January and February 2024. To create a common ground for the transdisciplinary workshop participants, the session starts with a short introductory presentation defining agroforestry value chains and explaining the procedure. A list of regional agroforestry products is discussed and extended by the group.

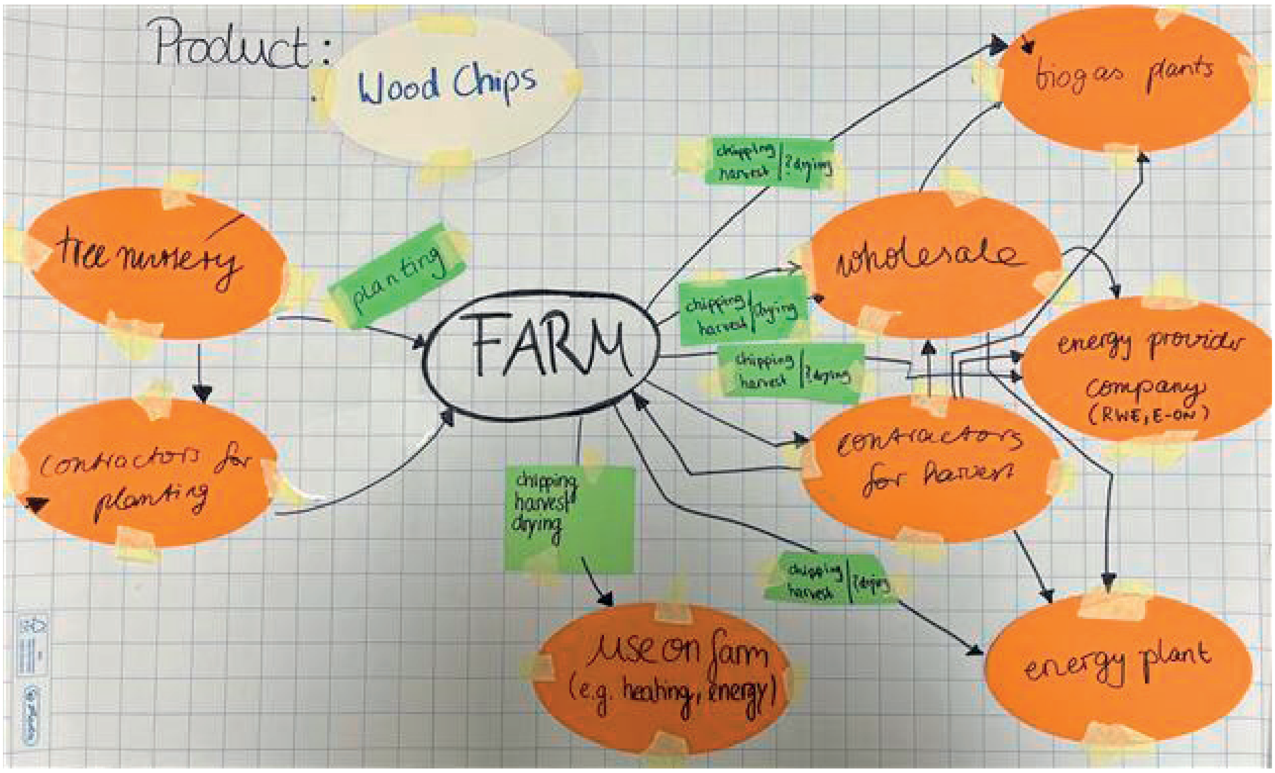
The participants divide into smaller groups of five to seven people. Each group creates one to three product-specific value chain maps. Farms are at the center of each value chain. In a first step, the participants collect value chain actors on cards, position them around the farm and connect all actors with arrows in the direction of product or service flow. These actors should include input sellers as well as output buyers. In a second step, they collect all activities that need to be performed by the farm after buying or before selling the product from the input seller or to the output buyer. The cards are positioned on the arrows directly connected to the farm, either between the input seller and the farm or between the farm and the output buyer. The results from the group work are presented and discussed in the plenary. The group discussion is protocolled in order to assess restrictions of existing value chains and explore desirable value chain actors in the region.

The result of this exercise will consists of minimum 44 regional and product-specific agroforestry value chains. The photo attached to this abstract shows an example of a wood chip value chain in Brandenburg, Germany. The resulting value chain maps will serve as a basis to answer the research questions for the respective research regions. We expect that the value chain maps will highlight the diversity of agroforestry products and value chains in Europe indicating which activities are performed by the farm in order to capture additional value from their agroforestry systems. We also learn about the shortcomings of value chains in the regions and suggest strategies how to further develop regional agroforestry value chains in the future.

In conclusion, this study provides a basis for future research on European agroforestry value chains. The list of value chains will not be exclusive and the results will be context-specific to the research regions. Nevertheless, it can also serve as an orientation for practitioners, consultants and policy stakeholders in the study regions as well as a starting point for research in other regions.

Keywords
Tree Crops, Value chain analysis, Europe, livestock, timber, AF4EU, participatory research, crop production, stakeholders, stakeholder-based approach, agroforestry value chains

Aditional Attachment II.



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A peek into consumer desires for Community Supported Agriculture in Flanders: can agroforestry be an asset to attract CSA participants?

Ir. Helena Tavernier[1,2], Dr. Kaat Van Hoyweghen[2], Dr. Iris Vanermen[2], Kato Van Ruymbeke[2], Dr. Liesbet Vranken[2], Dr. Erwin Wauters[1]

1 Flanders Research Institute For Agriculture, Fisheries And Food (ILVO), Merelbeke, Belgium

2 KU Leuven, Leuven, Belgium

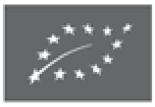
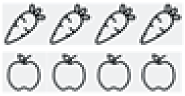
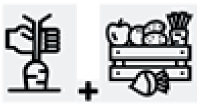
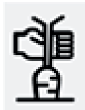
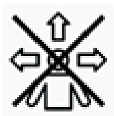
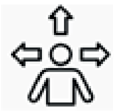
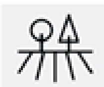
Community Supported Agriculture (CSA) is a form of farming where citizens collaborate with farmers by either paying for the harvest in advance through a subscription, or by co-investing in the farm. Many CSA farms seem to work with agro-ecological and/or organic methods (Barbosa et al., 2022; Hvitsand, 2016; Vicente-Vicente et al., 2023) and agroforestry. Is this agro-ecological working method a requirement for CSA participants? And which factors play a role in consumers' decision-making process to participate in CSA? Can agroforestry be an asset to attract CSA participants? In this study, we focus on the case of Flanders.

To answer these questions, a discrete choice experiment in an online survey will be used. A discrete choice experiment is a stated preference method that attempts to mimic an individual's decision-making process as much as possible. Different hypothetical scenarios are presented to the respondent where each scenario is characterised by certain factors or attributes that differ in levels of these attributes. The respondent has to make a trade-off between different alternatives offered in choice cards. This makes it possible to identify consumer preferences (Lefebvre et al., 2021; Mariel et al., 2021; Vanermen, 2022).The design of the choice experiment (choosing attributes and levels) occurred in three steps. First, a literature review was conducted with search terms like 'consumer interest in CSA' 'non participant interest in CSA' 'success factors of CSA' and 'factors affecting CSA participation'. This was followed by an internet search for examples of existing CSAs to check their formula and characteristics. Based on this, in a second step, in the summer and autumn of 2022, in-depth interviews were conducted with CSA farmers and members of these farms. Why did they join such a farm? What, if anything, made them hesitate to join? And for farmers, what factors do they think convince consumers to join? Have they already implemented changes to recruit members? In a third step, focus groups were organised in the winter of 2022-2023. Both focus groups in which CSA members participated as focus groups with random consumers were organised to get a clear picture of factors in consumers' decision-making process. Besides an open discussion, focus groups also included an individual scoring exercise for which participants had to score attributes discussed earlier according to the importance of that attribute to them (Jeanloz et al., 2016).

The following attributes (see Figure 1 for an example of a choice card) are included in the discrete choice experiment: working method (conventional, agro-ecological without label, organic with label), diversity of fruit and vegetable supply (low, medium, high), logistics (self-pick, self-pick or pick-up at the farm, self-pick or home delivery), freedom of choice, social activities at the farm (yes or no), agroforestry (yes or no) and subscription price. The experiment will be sent out in January 2024 by means of a survey to a desirable sample of about 500 respondents. Accordingly, the results of the survey will show which of these attributes have an important influence in the decision-making process and to what extent. In addition to the choice experiment itself, further questions from the Food-Related Lifestyle Instrument scale (Brunsø et al., 2021) will be used to try to explain heterogeneity in consumer preferences for CSA. With the data collected, we will try evaluate which attributes or characteristics influence whether or not consumers participate in CSA and to what extent agroforestry can attract new consumers to become CSA participants.

Keywords
business opportunities, decision-making, Belgium, business models, economic incentives

Aditional Attachment II.

Attribute	Option A	Option B	
Working method	Organic agriculture, label 	Conventional agriculture 	I will not participate.
Diversity offer	Low diversity 	High diversity 	
Logistics	Self-harvest or pick-in up on farm 	Self-harvest 	
Choice freedom	No choice freedom 	Choice freedom 	
Social activities	No social activities 	Social activities 	
Agroforestry	Agroforestry 	No agroforestry 	
Price	€ 400/year 	€ 600/year 	

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3.2 European Policy

Oral presentations

Hall Q1, 28 May 2024, 14:45–16:15

Regulatory and policy framework for agroforestry systems in Spain

Dr Jaime Coello[1], Dr Gerry Lawson[1], Dr Manuel Bertomeu[1], Dr Andrea Casadesús[1], Dr Laura Armengot[1], Dr Ferran Pauné[1], Ms Diana Pascual[1]

1 CTFC - Forest Science and Technology Centre of Catalonia (Spain), Solsona (Lleida), Spain

Introduction

This study presents the regulatory and policy framework of agroforestry systems (AFS) in Spain. The content has been produced as EURAF Policy Briefing 44 (https://euraf.net/category/policy-briefings).

Results

- AFS in Spanish CAP Strategic Plan 2023-27

The articulation of AFS in the Spanish CAP Strategic Plan 2023-27 (CAPSP-Es) is summarised:

i) Definitions and consideration of AFS: There are several mentions of agroforestry, silvoarable and silvopastoral systems in the CAPSP-Es. A maximum of 100 trees/ha is set for maintaining the status of "arable land" or "permanent grassland", with the possibility of increasing this limit. It is also established that agricultural land classified as 'forest' can receive support for agricultural activity, if there is no double financing. For permanent pasture (land with herbaceous and/or woody fodder species), the payment thresholds are based on a coefficient based on the woody species and on ineligible non-productive elements: inaccessible or base land, steep slopes.

ii) Pillar I: In the context of Good Agricultural and Environmental Conditions for biodiversity and landscape, Spain has adopted the three options proposed by the Commission in GAEC-8 to allocate 4-7% of agricultural areas to non-productive elements, fallow land, intercropping or N-fixing crops without pesticides. Information on the conversion and weighting coefficients and the protection status of the selected landscape elements is relatively complete. However, the maximum size of a wooded area as a landscape feature is 0.3 ha, whereas the minimum area for a wooded area to be legally considered as forest is 1 ha, so that wooded areas between 0.3 and 1 ha would not be protected or registered. The potential of GAECs 1 and 9 to support the conservation and sustainable management of Dehesas is recognised.

Spain has activated nine eco-schemes, six of which can be related to AFS: 809-Agroecology: Biodiversity sites in cropland and permanent crops; 801 / 802 (Carbon farming and agroecology: Extensive Grazing, Mowing and Biodiversity in Humid / Mediterranean Pastures) - particularly relevant to Dehesa, and 806 / 807 / 808 (Carbon farming: Green and inert cover in woody crops on flat / medium slope / steep slope and terraces) - particularly relevant if grazed.

iii) Pillar II: Of the 13 Environmental and Climate measures activated in Spain, there are 7 that can help promote AFS, in particular 6502.2 - Maintenance of afforestation and agroforestry systems (activated in 10 of the 17 regions). Other relevant measures are 6501.1 Integrated plant production (4), 6501.2 Sustainable crop commitments (10), 6501.3 Promoting and sustainably managing pastures (8), 6501.6 Maintaining or improving habitats and traditional farming activities that conserve biodiversity (11), 6501.8 Soil improvement and erosion control practices (4) and 6502.1 Forest management commitments (4). All regions have activated at least one of these measures and twelve regions have activated at least three.

In addition, 7 of the 15 activated Investment measures can help promote AFS, including 6881.1 Non-productive forestry investments in afforestation and agroforestry systems (11 regions). The other 6 measures are 6844 Support for non-productive investments in agricultural holdings linked to climate change mitigation and adaptation, efficient use of natural resources and biodiversity (7); 6864 Support for investments in agricultural diversification (3); 6881.2/3/4 Non-productive forestry investments in forest damage prevention (16) / in forest damage restoration (15) / in forestry measures with environmental objectives (15) and 6883 Productive forestry investments (11). All regions have activated at least one of these measures and 15 regions have activated at least three.

iv) Objectives and targets set for Spain: The most important objectives are R17 (afforestation, restoration and agroforestry on 38,967 ha) and O16 (maintenance payments for afforestation and agroforestry on 87,285 ha), although neither of these objectives distinguishes the target area for each type of intervention.

- Opportunities and threats for AFS deployment in Spain

We have conducted a SWOT analysis of AFS in the regulatory, political, socio-economic and climatic context in Spain, carried out with more than 25 stakeholders and resulting in 31 arguments (strengths, weaknesses, opportunities and threats). Moreover, we include a description of the SIP system in Spain ("SIGPAC"), which includes AFS-relevant land uses such as "wooded pasture" or "pasture with shrubs", although there is no specific category for silvoarable systems.

Conclusions

We conclude that the CAPSP-Es provides the most favourable framework to date for the maintenance and promotion of multiple AFS, with funding opportunities under both pillars. Moreover, our SWOT analysis discusses the context for AFS deployment in Spain in the near future.

Acknowledgements

LIFE Montserrat (LIFE13 BIO/ES/000094), LIFE MIDMACC (LIFE18 CCA/ES/001099) and LIFE AgroForAdapt (LIFE20 CCA/ES/001682), funded by the EU LIFE Programme.

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Keywords

CAP Strategic Plans, Policy support, Policy, Agroforestry, Land Use Policy, landscape policy, agricultural policy

What has the green architecture of the new CAP done for agroforestry?

Mr Gerry Lawson[1], Ms Judit Csikvari[1], Mr Patrick Worms[1], Mr Constantin Muraru[1]
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Introduction

Several policy documents in the European "Green Deal" appeared to promote agroforestry, but it is not certain that the early promise has been delivered. The policies included:

A presidency working paper (20.5.2019), which concluded that "agroforestry is fully eligible for Direct Payments when justified based on the local specificities - e.g. density/species/size of the trees and pedoclimatic conditions - and the value added by the presence of trees, to ensure sustainable agricultural use of the land".

The Green Deal (11.12.19), which instructed Member States (MS) that "CAP strategic plans should lead to the use of sustainable practices, such as precision agriculture, organic farming, agro-ecology, agro-forestry and stricter animal welfare standards."

The Farm to Fork Strategy (20.4.20), which promised that "New 'eco-schemes' will offer a major stream of funding to boost sustainable practices, such as precision agriculture, agroecology, carbon farming and agroforestry. Member States and the Commission will have to ensure that they are appropriately resourced and implemented in the Strategic Plans".

The EU Biodiversity Strategy (20.5.20), which called for "the uptake of agroforestry support measures under rural development should be increased as it has great potential to provide multiple benefits for biodiversity, people and climate", that "10% of agricultural area should be brought back under high-diversity landscape features"

The new Forest Strategy (16.7.21), which called for "planting at least 3 billion additional trees in the EU by 2030" and stated that "this tree planting in rural areas can work well with agroforestry, landscape features and increased carbon sequestration."

The Fit for 55 Package (14.7.21), accompanying Staff Working Document which suggested that many of these 3 billion additional trees could be established in agroforestry systems [1], and committed the EU to a net emission target of -310 Million tonnes CO2 equivalent by 2030, and to emissions neutrality in the land sector by 2035 (although this last commitment was removed by the European Parliament).

Objectives

To review the delivery of strategic commitments for agroforestry in the EU, including the achievement of agroforestry and forestry planting targets in the existing and forthcoming CAPs.

Methodology

We tracked the progress of relevant Regulations and Directives through trilogue discussions between the European Parliament, Council and Commission, and reviewed the agroforestry targets provided by Member States in their various strategic plans (CAP, Adaptation and Energy and Climate).

Results

The results were published and updated in the following EURAF Policy Briefings:

Agroforestry Definitions of EU Member States [2]
EU Permanent Grassland Definitions [3]
Landscape Features in the new CAP [4]
Agroforestry in CAP Strategic Plans of 14 Member States (Briefings 31-44) to be published by March 2024.
Agroforestry and EU Adaptation Plans [5]
Agroforestry and EU Mitigation Targets [6]
Agroforestry and the EU Certification Framework for Carbon Removals [7]
Agroforestry and Parliament's report on Sustainable Carbon Cycles [8]
Agroforestry and the EU Nature Restoration Law [9]
Agroforestry and EU LULUCF and NECP Targets [10]
Agroforestry and the EU Sustainable Finance Initiative [11]

Sadly, agroforestry is only included in 17 of the 945 CAP measures relating to Article 31 (ecoschemes), Article 70 (agri-environment-climate) or Articles 73-74 (investment). But agroforestry may be eligible for funding in almost 250 further measures. This is hard to confirm since these measures have not been mapped against the two indicators most relevant to forestry and agroforestry. Eligibility cannot be confirmed without direct contact with the CAP Management Authorities.

Only a minority of the Climate Adaptation Strategies/Plans and Energy and Climate Plans of Member States mention agroforestry: 11 from 27 in both cases, although three countries have not submitted NECPs. (Table 1).

Conclusions

- Strengths: Agroforestry has been defined by all Member States, and is treated seriously in some Adaptation Plans (esp. CZ, FR, IT, SK) and Energy Climate Plans (esp. CZ, FR, HR, LT, LU).
- Weaknesses: Most Member States neglect agroforestry in their CAP, Adaptation or Energy Climate Plans. According to the Commission, almost no MS has a realistic roadmap to meet its 2030 LULUCF target. A shortfall of 50-70 MTCO2e is predicted, and trees in forestry or agroforestry can make little contribution on this timescale.
- Opportunities: afforestation and agroforestation schemes of 1 million ha/year from 2025 could deliver climate neutrality in the land sector by 2040, but this is 10 times more than in the existing plans of MS [6].
- Threats: A mere 5% of the agroforestation and 25% of the afforestation targets were achieved in the previous CAP, and to date only 13 million of the 3 billion additional trees have been planted. The inability of Member States to meet tree-planting targets is systemic and carries no penalties. Fires, storms, disease and increasing harvests are reducing the ability of forests to deliver the required sequestration. Agroforestry, particularly on mineral soils, will be vital to plug this gap.

Keywords

agricultural policy, agroforestry landscapes, Policy, afforestation, Agri-Environment-Climate, Agroforestry

MS	AD Strategy	AD Plan	Adapt?	NECP?
AT	2017	2017	y	(n)
BE	2010	2016	n	y
BG	2019		y	(n)
CY	2017		n	n
CZ	2015	2021	y	y
DE	2008	2011	n	n
DK	2008	2012	n	n
EE	2017		n	n
EL	2016		y	y
ES		2020	y	y
FI	2005	2022	n	n
FR	2007	2017	y	y
HR	2020		n	y
HU	2018		y	n
IE	2018	2023	n	y
IT	2015	2022	y	n
LT	2012	2013	y	y
LU	2020		y	y
LV		2019	n	n
MT	2012		n	n
NL	2017	2017	n	n
PL		2013	n	(n)
PT	2015	2019	n	n
RO		2018	n	y
SE	2018	2022	n	n
SI	2016		n	n
SK	2018		y	y
TOTAL			11	11

Table 1 Inclusion of agroforestry in the Agroforestry Strategies and National Climate and Energy Plans of Member States (as of 15.1. 2024)

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Lawson G, Muraru C, Maja D, Anna DB, Grassner A. Agroforestry and the Sustainable Finance Initiative. EURAF; 2023. Report No.: Policy Briefing #28. Available: https://zenodo.org/records/10391086

Agroforestry in Czech Republic - A new measure of CAP strategic plan for programming period 2023-2027

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Introduction

Agroforestry has been proposed as a new measure for the CAP programming period 2023-2027. In the Czech Strategic Plan, approved by the European Commission on 24 Nov 2022, contributes to three CAP specific objectives:

(i) to contribute to climate change mitigation and adaptation, including by reducing greenhouse gas emissions and enhancing carbon sequestration, as well as to promote sustainable energy;

(ii) to foster sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency;

(iii) to contribute to halting and reversing biodiversity loss, enhance ecosystem services and preserve habitats and landscapes.

The measure had been prepared since 2019 at meetings of a working group. Members were (in addition to representatives of the Ministry of Agriculture and the Ministry of the Environment): representatives of various research institutions and universities, Nature Conservation Agency, the State Agricultural and Intervention Fund, as well as NGOs (Czech Association for Agroforestry, the Association of Private Agriculture, etc). The aim was to set the conditions of the measure in such a way that it help farmers to allay concerns about planting trees on agricultural land and to support the establishment of functional agroforestry systems. Measure with its conditions was presented to the farmers in January 2021.

Objectives

Expected area of newly established agroforestry systems is 900 hectares for programming period 2023 – 2027. Agroforestry support is currently provided through two interventions of the Czech CAP Strategic plan. 42.73 Establishment of the agroforestry system and 26.70 Maintenance of the established agroforestry system, while detailed conditions are set in the Government Decree No 140/2023 Coll., on the setting conditions for the implementation of the agroforestry measure (Agroforestry regulation).

Methods

After establishment, agroforestry parcels are registered by farmers in the Land Parcel Identification System (LPIS) - as crop type subcategories on arable land or permanent grassland. Two categories are supported: (i) silvoarable AF (100 of forest or fruit trees per ha grown in alley cropping design on arable land); and (ii) and silvopastoral AF (100 trees per ha on permanent grasslands). A list of permitted tree species has been prepared, containing 46 forest and 13 fruit species. The measure includes a condition that one tree species must not account for more than 40% of all tree species (i.e. at least three species must be planted) and at least 50 % of trees must be forest trees. The soil under the trees remains standard arable land, grassland, or permanent grassland (Figure 1).

For the establishment of the agroforestry system the support is amounted to EUR 4,353 per 1 ha. For the management of the agroforestry system established is provided a yearly support of EUR 754 per ha for the following 5 years (5 yrs. commitment). During and after this commitment, at least 75 % of established trees must be alive.

In case of establishing agroforestry in Natura 2000 sites, an approval from nature conservation authority is need as well as in case of planting non-native tree species or hybrids. In the case of specially protected, areas consultation is also recommended.

Results

End of September 2023 was the last date to submit Declaration of Interest for a subsidy for an agroforestry measure. By this date, there has been submitted 151 declarations for a total area of 1,472.3 hectares. The applicants should indicate the maximum area on which they intended to establish the agroforestry system in the declaration, but it needs not to be fulfilled.

Ministry of Agriculture or the State Agricultural and Intervention Fund posted materials to help applicants. They could also ask specific questions related to the establishment of an agroforestry system to meet the conditions stated in agroforestry regulation. Advisers from the Czech Association for Agroforestry were available to help with the design of the agroforestry system project and could answer questions from the agroforestry practice.

Several applicants informed that the area planted would be lower than the area declared. Some of the applicants did not want to plant trees on land they do not own, a number of applicants decided to divide the soil blocks to try agroforestry first on a smaller part with the intention of submitting a declaration for another part in the following year. Some of the applicants did not use the possibility to plant fruit trees and established agroforestry systems only with forest trees.

In the first year of a period 2023 – 27, 87 farmers established agroforestry systems on the total area of 610.3 hectares (Table 1).

Conclusion

Even though the agroforestry regulation is relatively strict, and the version was approved in May 2023, we see a high interest of Czech farmers to establish agroforestry plots, after the first year of the running support.

Keywords

Adoption, CAP Strategic Plans, agroforestry systems establishment, agricultural policy

Aditional Attachment I.

<table>
<tr><th>Agroforestry measure 2023</th><th>Number of applicants</th><th colspan="3">Extension (ha)</th></tr>
<tr><td>Declaration of interest*</td><td>151</td><td colspan="3">1,472.6</td></tr>
<tr><td rowspan="5">Application for support**</td><td rowspan="5">87</td><td colspan="2">Silvoarable</td><td>Silvopastoral</td></tr>
<tr><td>Standard arable land</td><td>Grassland</td><td>Permanent grassland</td></tr>
<tr><td>163.8</td><td>25.5</td><td rowspan="2">420.8</td></tr>
<tr><td colspan="2">189.3</td></tr>
<tr><td colspan="3">610.3</td></tr>
</table>

Table 1. The number of applications for Agroforestry measure and extension of established agroforestry systems in 2023
* by the end of Sept 2023
** by the end of Nov 2023

Aditional Attachment II.

The benefits of integrating agroforestry practices in regenerative/agroecology systems: knowledge gaps in meta-analysis literature

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Although agroforestry has attracted interest in the European Union (EU) in recent decades and has received some support from the Common Agricultural Policy (CAP), it has only been marginally implemented by farmers in EU member states to date. In the current CAP 2022-2027 and in view of the challenges to meet the goals of the EU Green Deal and Farm to Fork strategy, the EU Commission is collecting the available scientific evidence to support decisions about funding schemes for agricultural practices, including agroforestry. Recently, different evidence maps based on published meta-analyses (MAs) have been synthesizing the available evidence regarding the environmental benefits of agroforestry 1–5.

Different types of agroforestry practices are described in such meta-literature, with different degrees of integration within regenerative/agroecology farming systems. With this term, we intend farming systems which aim at agroecosystems regeneration by simultaneously integrating different management options (such as crop diversification, soil management, reduced input, crop-livestock integration, management of landscape elements etc.) with more holistic view (agroecology approach). According to agroecology principles, the combination of diversified agroforestry practices (especially multi-species/ multistrata/ successional vegetation designs and crop-livestock integration) with other practices promises to be key to enhancing agri-food system sustainability, resilience and environmental health.

Objectives

This study, through a comprehensive systematic review of published MAs, has two main objectives:

1. to map different agroforestry practices, according to their degrees of integration into the agroecology framework;
2. to synthesize existing scientific evidence on the environmental, climate, and production impacts of agroforestry practices;
3. to identify critical knowledge gaps in the literature to indicate the possible paths for further research.

Results

We screened over 100 records retrieved from Web of Science and Scopus databases from which 31 MAs were selected. Each MA synthetizes through statistical analysis the results of several individual studies conducted around the world (ranging from 3 to 140), reporting the comparison of agroforestry practices versus conventional agriculture, on a large set of environmental and agricultural production outcomes.

We mapped existing results, grouping agroforestry practices into 10 different types, plus a general category for results obtained from unspecified types of agroforestry practices (Fig.1). From the definitions provided by the MAs, we also classified how these practices fall simultaneously into different management categories existing in the CAP framework. Based on this, we ranked the different agroforestry types using an ''agroecology score'' (i.e. the number of management categories simultaneously involved by each type of agroforestry). The type "Diversified agroforestry systems" (including multi-species/ multistrata/ successional vegetation designs which often integrate livestock in mixed farming) covers the highest number of management categories (8), followed by ''agroforestry with leguminous trees'' and "silvopasture systems" (Fig. 1).

The different MAs show strong consensus across different types of agroforestry practices, compared to conventional agriculture, reporting significant positive effects on a wide range of environmental, climatic and production objectives of the CAP, with few or no trade-offs among them (4% of all results reporting significant negative effect). Evidence is however available mostly for agroforestry systems as general category (54 results over a total of 213). The most studied types are "agroforestry systems (all types unspecified)", "silvoarable systems" and "hedgerows, windbreaks, shelterbelts" (Fig.2).

The highest agroecology-scoring types (i.e. diversified agroforestry systems) received little attention (9 results). Results however look promising, with the highest share of significantly positive effects (78%), on carbon sequestration and biodiversity metrics, and no trade-off. However, only 1 of these MAs include experiments carried out under European pedo-climates.

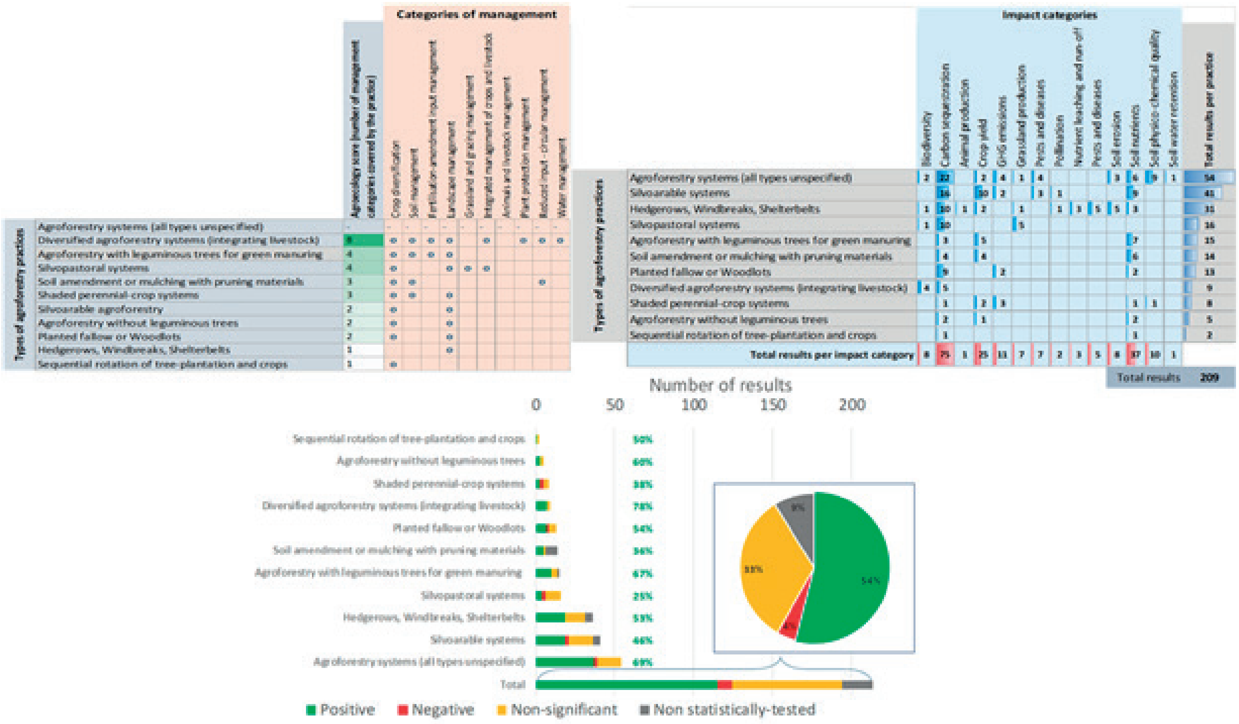
Conclusions

We conclude that there is evidence for regenerative-agroecology agroforestry to show positive effects on climate mitigation, soil fertility and biodiversity enhancement. However, we also highlight a strong need for further scientific evidence, especially in the European context.

Keywords

agroecology, assisted natural regeneration, systematic review, agricultural policy, meta-analysis, agri-environmental system

Aditional Attachment II.



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Discussing an EU agroforestry policy agenda for the next Commission - an AGROMIX and MIXED joint policy session

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Introduction

This is a joined 10-minute presentation of MIXED and AGROMIX policy research findings. The policy session is open to all EURAF participants and especially other projects with policy research on agroforestry and mixed farming. This session is co-hosted by the Horizon-2020 RIAs (Research and Innovation Actions) MIXED and AGROMIX. We draw on selected results of these two 7-million, 4-year sister projects in their final years.

Objectives

To start the session on agroforestry and mixed farming policies, insights from both projects and stakeholders will be shared and presented to the EURAF 2024 audience. This is with the view to continue the policy co-development and lead to a 'transforming landscapes' action agenda for agroforestry with mixed farming by the new European Union (EU) Commission voted in by the EU parliament in November 2024.

Content and Results

The joined presentation has three parts, presented together by the three authors: (1) CAP overview (MIXED), (2) contrast with England example of policy co-development and (3) analysis of other workshops, policy modelling and recommendations (AGROMIX).

(1) The EU's Common Agricultural Policy (CAP) is an essential element on the path towards more agroforestry. In addition to several policy workshops, the MIXED project analysed an EU-wide database to draw an overview picture of current agroforestry support instruments under the CAP. Selected results will be presented to support the joint discussion. AGROMIX has done a global and EU inventory of agroforestry and mixed farming policy contexts and this is reported already (Figure 1). This was followed by 14 multi-stakeholder workshops (Figure 2), policy modelling and a Brussels AGROMIX-summit 17th April 2024 (https://agromixproject.eu/events/agromix-policy-summit)

For this session following on the CAP overview analysis from MIXED we add: (2) a deeper insight into the two policy workshops in England. This is a devolved nation of the United Kingdom (UK) and after EU-exit the agricultural policy has been further devolved (UK-exit) to the four nations (England, Northern Ireland, Scotland and Wales) hence this case is a highly interesting study as an emerging alternative to common--EU and common-UK wide agricultural policy making for agroforestry with mixed farming. (3) We also present headline insights from further 12 workshops in France, Hungary, Germany (Brandenburg and Rhineland-Palatinate), Switzerland and EU and discuss how this could be complemented by agent-based policy modelling and lead to further refine policy recommendations.

Conclusions

It is hoped the combined, but contrasting, presentations will provide a good starting point for a discussion which can form a wider alliance for 'transforming landscapes' in the next Green Deal of the EU. Further policy research needs and recommendations from the Brussels summit in April 2024 will be feed into the discussion. Input from all EURAF participants is highly welcome, as this is an interactive discussion-based session. We conclude the current Green Deal is not sufficient and needs an update and further improvements also with more grassroots farmers involved into policy co-design. Our work is an attempt to do this for the specific section of agroforestry policies as part of a wider food and farming transformational policy landscape.

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Further information is found at the project websites MIXED: https://projects.au.dk/mixed/networks-national-teams/germany STARGATE: https://www.stargate-h2020.eu/scientific-publications AGROMIX: https://agromixproject.eu/policy-corner

Keywords
Agroforestry certification, Landscape biodiversity, Agroforestry, mixed farming, Land Use Policy, tree physiology, England, agroforestry value chains, agroforestry landscapes, EU Green Deal, Policy, agroforestry monitoring, policy contexts, Organic Farming, AGROMIX, Central Europe, Europe, agroecology, EURAF 2022, Landscape ecology, organic cattle farms, Cork; Montado, orchards, modelling, Agroforestry system, policy co-development, governance, vineyard, Policy support, biodiversity, European project, Science Outreach, organic production

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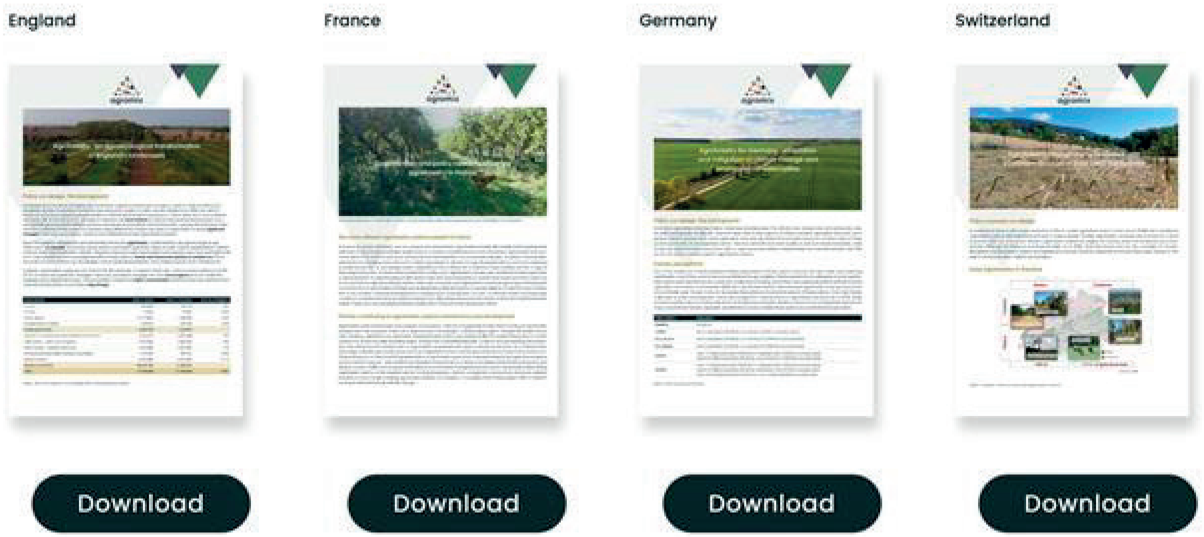

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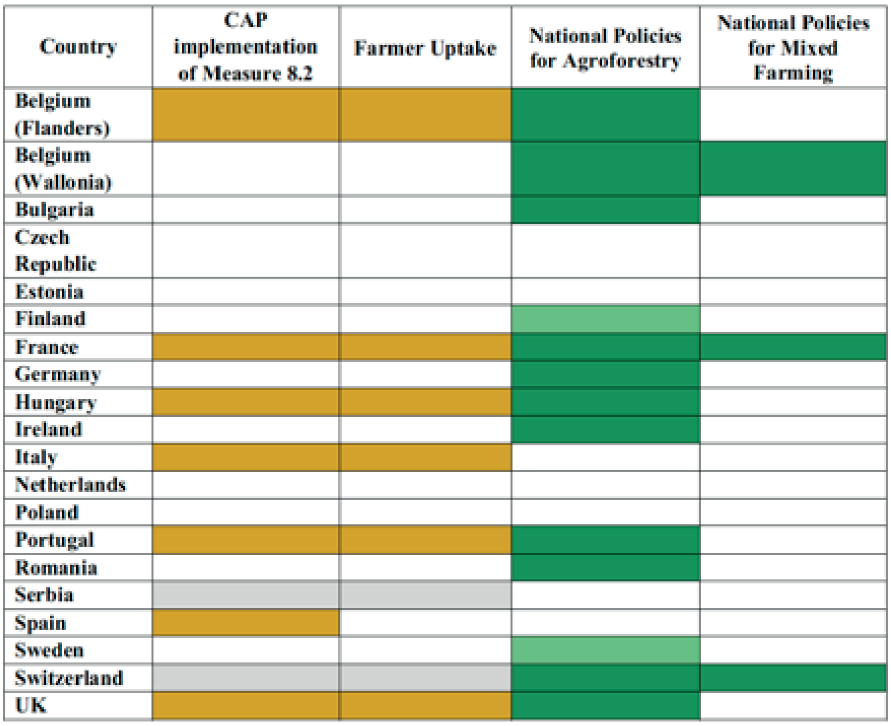

Figure 1: Results showing the European Policy Landscape for AF and MF. The yellow represents 2014–2020 CAP support through Measure 8.2; "Farmer Uptake" represents countries where the schemes were used by farmers; while grey is for countries where the CAP doesn't apply. The dark green represents national support, while the lighter green found within "National Policies for AF" represents places that only have AF support when it comes to reindeer husbandry (Finland and Sweden). Source: Buratti-Donham, J., Venn, R., Schmutz, U., & Migliorini, P. (2023). Transforming food systems towards agroecology–a critical analysis of agroforestry and mixed farming policy in 19 European countries. Agroecology and Sustainable Food Systems, 47(7), 1023-1051. https://doi.org/10.1080/21683565.2023.2215175

Policy Corner

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See project websites for publications and academic and non-academic references.

3.2 European Policy

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Agroforestry policy in Poland after 2023

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2 Polish Agroforestry Association, Puławy, Poland

Introduction
Agroforestry (AF) policy in Poland, including Trees outside Forest (ToF) is, as a rule, a part of afforestation policy, although is not mentioned in key environmental regulations. Since 2023 has only been supported by Intervention 10.13 - Establishment of AF systems, where is defined as a land use form.

Objectives
Overview of CAP SP (Strategic Plan) documents was made to present support for AF in Poland.

Results
Apart from GAEC 8 rules, AF policy applies only to intervention 10.13 (Establishment of AF systems), 10.12 (Establishment of in-field afforestation) and corrresponding measures, funding maintenance of those systems (sub-measure 8.8).

In line with 10.13 intervention, AF should be established in row(s) where trees and shrubs planted on arable land are combined with cultivation, and in any arrangement, where the wooded area is part of permanent grassland (TUZ). Plantings should be carried out with at least 3 native tree or shrub species, including, but not limited to, biocenotic or melliferous species. The plantings should be dominated by deciduous species, planted at a rate 150-250 trees/ha and protected from damage alternatively by 3 stakes, repellent use, sheep wool or tubes.

A complementary to AF instrument (since 2022) is establishment of in-field trees outside the forest (windbreaks.hedges), planted at not more than 0.5 ha, with width 4-20 m and density 1.500-2.500 trees/ha.

Conclusions
Agroforestry in Poland is defined and supported only within SP interventions.

A significant limitation of AF support is the exclusion of farms implementing agro-environmental-climate measures, organic farming measure and ecoschemes. The second restriction is removal from the AF species list of fruit and short rotation trees (willows, poplars) breeds. A major problem for AF farmers is the lack of suitable planting material in private nurseries and State Forest nurseries. AF is a new concept in Polish CAP policy, implemented under conditions of low investment in dissemination of AF knowledge by decision makers, advisors and agri-business. On the other hand, interest in AF is growing among farmers and encourages knowledge exchange.

Figure. Agroforestry (top half) and in-field trees (windbreaks/hedges) (bottom half) establishment instruments are complementary CAP measures to support Trees outside Forest on agricultural areas of Poland.

This abstract is based upon work from project AGROMIX, which has received funding from the European Union´s Horizon 2020 Programme under Grant Agreement Nr. 862993.

Keywords
Agroforestry, CAP Strategic Plans, AGROMIX, agricultural policy

Aditional Attachment I.

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CAP Strategic Plan for Poland
https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans/poland_en

Exploring the problems in the application of agroforestry measures in Italy

Researcher Rosa Rivieccio[1], Researcher Sonia Marongiu[1], Freelance Erica Mazza[1], Researcher Raoul Romano[1]
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Introduction

Agroforestry systems are integrated systems of crops and/or livestock activities that made possible to satisfy the need for self-sustainability of the farmers. In the last decades, the importance of agroforestry has been understood, and scientific evidence and policy institutions recognise that agroforestry is a strategic topic for several environmental and social aspects. In EU agroforestry is mainly supported by the Common Agricultural Policy (CAP), i.e. Rural Development Programmes (RDPs). Few countries have applied for the measures specifically designed to the enhancement of agroforestry systems in Europe. Italy is one of these, but few Regions have included this measure in their RDPs, and with a scarce success.

The aim of the study is to provide an overview of the reasons that have led to a very scarce adoption of agroforestry measures in Italy, to offer some recommendations aiming to improve the future policies for agroforestry in the next programming periods.

Methodology

The work started from the results of a financial analysis of the agroforestry measures in two last CAP programming periods in Italy to know level of CAP support of agroforestry practices. The first measure specifically devoted to agroforestry practices was the Measure 222 (2007-13) named "First establishment of agroforestry systems on agricultural land". In the CAP 2014-20 agroforestry was promoted in the sub-measure 8.2 "Support for establishment and maintenance of agroforestry systems" devoted to the establishment and maintenance of agroforestry systems. In the new programming period 2023-27 agroforestry support is divided in two interventions:

- SRD05: Establishment of agroforestry systems, Action 5.3: Establishment of agroforestry systems on agricultural surfaces,
- SRA28: Maintenance support for afforestation and agroforestry systems, Action SRA28.3: Maintenance of agroforestry systems on agricultural surfaces.

In the two last programming periods only 5 up 20 Italian Regions have activated the measures supporting agroforestry, and even in these cases the level of funding was respectively 0.3% and 14.1%. The analysis highlights the limited amount of resources destined to agroforestry and the high gap between the financial resources allocated and spent for the measure. Considering also the last programming period, 11 Regions never activated agroforestry measures.

After exploratory interviews, a survey has been conducted by two questionnaires addressed: the first one called "QR" has been addressed to all the 21 Regional managing authorities (19 Regional authorities and 2 Autonomous Provinces) and the second one "QE" was referred to the farmers or technicians which work in agricultural and forestry enterprises.

The QR has 41 questions and the QE has 58 questions and the scheme of the two questionnaires is very similar in the first part on 'general information' and the second on 'agroforestry knowledge". Instead of the central part, that is specific for the interviewers and their specific work as well as the final part on 'general remarks and future perspective'.

The questionnaires were launched on 20th of July 2023 on the online page on the Italian website of the RDP (https://www.reterurale.it/agroforestry), it.

Findings

The answers obtained by the compilation of the two surveys are 27 for QR and 87 for QE, that are respectively responses rate of 100% and 95% by all Regions. They are summarized in 3 different districts described in Table 1.

The point of view of the regional administrations (QR) pointed out that there is low interest in agroforestry and a failure to adhere to the open calls. The resources initially allocated to support agroforestry have not been spent and rescheduled for other interventions.

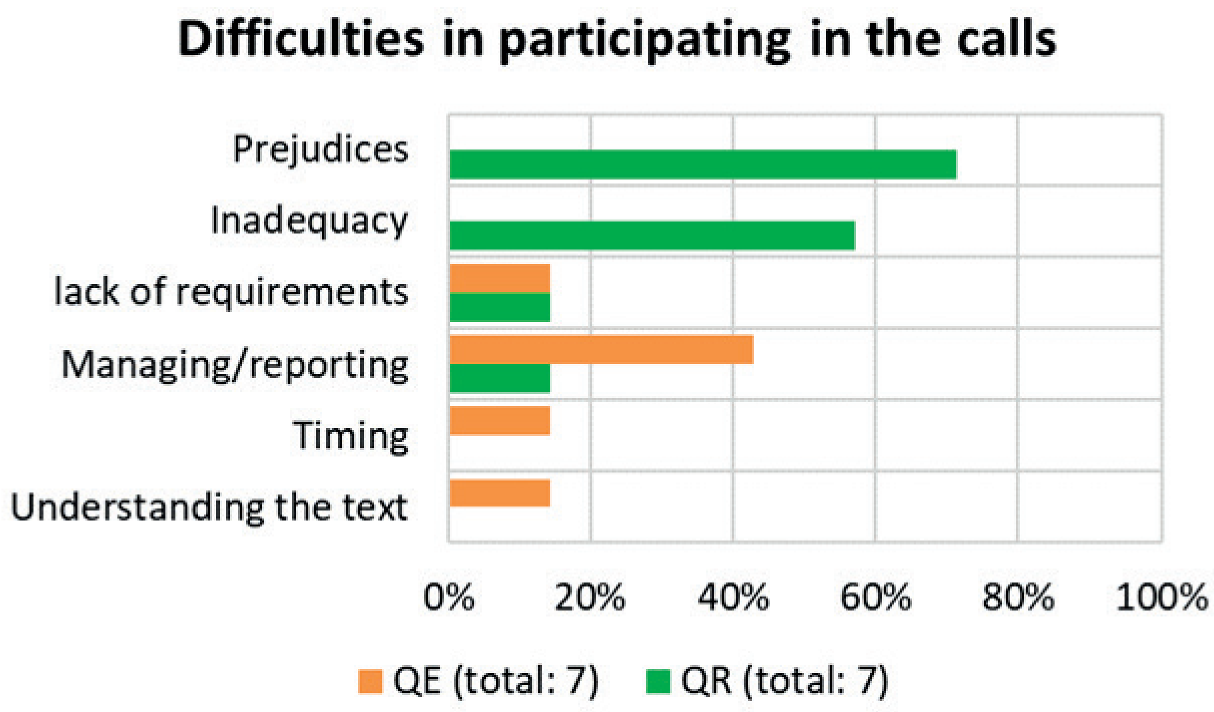
For QE, the Regions with the highest response rate has been Tuscany (17) while the only one which no answer is Valle d'Aosta. The answers came by 68% from the enterprise's owners. 57% of the interwiees have agroforestry systems and the 82% of financed with them with own resources. 30% of the agroforestry systems are silvopastoral system, 28% are linear, and 17% are riparian strips.

The difficulties in participating in the calls are explained in Figure 1 that compares the answers by the regional administrations and by the farmers.

Final remarks and implications
The analysis presented in the work offers an overview of the application of agroforestry measures in Italy and an evaluation of the reasons why the farm adoption of agroforestry practices can be considered not satisfactory. There are several reasons explaining this failure, as highlighted in the analysis of the responses to a questionnaire addressed to the Regional administrations and the agricultural holdings and enterprises. The overall policy framework of the CAP seems to be one of the most relevant reasons that have prevented the full implementation of the measure. On the farm side, although farmers are aware of the economic (in terms of diversification of incomes) and environmental benefits deriving from agroforestry, a lack in the information regarding farming practices and communication has been pointed out.

Keywords
CAP Strategic Plans, decision-making, landscape policy, rural development, agroforestry system planning, Agroforestry system, Agroforestry, farmers' decision making, agricultural policy

Aditional Attachment II.



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Windbreak hedges and multi-functional hedges in agricultural landscapes in Lower Austrian

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Introduction
The Lower Austrian Authority of Land Reform has been planting soil protection plants (windbreak hedges) on agricultural land with its soil protection stations for more than 60 years. On behalf of farming communities, municipalities and agricultural businesses, more than 3,000 hectares of soil protection plants have been planned, planted and maintained until their existence is secured. The legal basis for this funding campaign of the Province of Lower Austria is the guideline for the funding of soil protection systems in Lower Austria.

Case description
Soil protection hedges are strip-shaped plantings of native trees and/or shrubs with an average separation width of no more than 20 meters. Due to their structure and species composition, these plants have a positive effect on the environment, for example by protecting agricultural land from wind erosion, water erosion or other natural hazards, improving the microclimate, reducing the negative effects of climate change, increasing biodiversity, revitalizing the landscape, etc.

Funding from the province of Lower Austria consists of the provision of the necessary personnel and materials for the planning, construction and maintenance of soil protection facilities and the necessary advice.

According to the CAP Strategic Plan 2023 to 2027, the creation of so-called multi-functional hedges can be funded. From 2023, multi- functional hedges are newly planted hedges with mainly shrubs and trees. They must be directly adjacent to arable land, created as part of the agri-environmental programme ÖPUL and a concept approved by a competent regional authority and recorded and confirmed in the AMA's INVEKOS GIS for each field.

Conclusion
The amendment to the Forest Act, which came into force on November 16, 2023, explicitly addresses agroforestry areas - which also include multi-functional hedges. In contrast to windbreak hedges, agroforestry areas do not become forest if they are reported to the responsible forestry authority within 10 years. This regulation is intended to give applicants greater flexibility and overcome the barriers that sometimes exist against planting hedges in the cultivated landscape.

Keywords
tree plantations, climate, Agroforestry, Austria, multifunctional landscape, hedgerows, erosion phenomena, fruit trees, landscape, shelterbelts, windbreaks, rural development, biodiversity

Aditional Attachment I.

Aditional Attachment II.

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Interreg AT-CZ234 SYM:BIO “Hecken in der Landschaft“ (Folder, Guideline)

Other Media:

Interreg AT-CZ234 SYM:BIO “Maintaining hedges in the landscape” (Project films)

Agroforestry adoption in Germany: Using decision analysis to highlight the effects of institutional barriers and funding options on system profitability

Simon Swatek[1], Dr.-Ing. Prajna Kasargodu Anebagilu[1], Dr. agr. Marcos Jiménez Martínez[1], Prof., Dr. agr. Eike Luedeling[1]

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Since the 2023 reform of Europe's Common Agricultural Policy (CAP), Germany has implemented a legal definition of Agroforestry (AF) in its national legislation. AF is now recognised as an agricultural system eligible for direct payments, and the maintenance of such systems can be funded under the eco-scheme (ES) program if certain requirements are met. Despite providing farmers with the legal security of harvesting trees from their AF systems, the number of newly registered AF plots and the demand for the ES have been low. BMEL estimated that in 2023, 25,000 ha of AF systems will be registered under ES; in reality, only 51 ha have been registered under ES (BMEL, 2023). This implies that Germany may fail to meet its goal of implementing 200,000 ha of AF by 2026. The increase in annual funding in 2024 from 60 to 200 € per ha of wooded area is considered insufficient. This is particularly because payments for all ES not just AF are set to increase. Other ESs that demand less management effort and provide less environmental benefit may maintain a comparatively higher demand (Böhm, 2023). Consequently, these adjustments do little to encourage the adoption of AF in Germany. Although, several federal states have introduced investment support measures for establishing AF systems in 2023, subsidising 40 to 80 % of eligible investment cost, their impact is yet to be observed.

This contribution offers an overview of the post-CAP-reform institutional barriers, which are presumed responsible for the low adoption rate of AF in Germany. It catalogues available funding options, highlighting differences across Germany's 16 federal states. Additionally, we simulate currently available and hypothetical funding scenarios based on suggestions from the German AF association (Deutscher Fachverband für Agroforstwirtschaft, DeFAF) (see: Böhm et al., 2023) to depict the impact on the overall AF systems' long-term profitability (i.e., the net present value (NPV) and 30-year cash flow). The goal is to provide suggestions for developing adequate funding schemes to raise the attractiveness of AF for farmers.

A Decision Analysis (DA, see Luedeling & Shepherd, 2016) approach is used to model an existing AF system in North Rhine-Westphalia (NRW), Germany. The system comprises 10 ha of arable land with 15 rows containing a total of 473 apple trees. The crop rotation in the arable component consists of wheat, maize, barley and rapeseed. Integrating permanent structures into agricultural systems always requires a thorough decision-making process. DA can support intricate decisions, particularly when observational data is limited. This is because DA models integrate local, expert, and stakeholder knowledge and data from literature reviews. After identifying the decision, which in this case is the binary choice on whether to implement an AF system, a conceptual model encompassing all decision-relevant aspects is formulated. This model includes expected revenue, expenses and risks. Subsequently, probability distributions are assigned to the input variables through expert knowledge elicitation, transforming the conceptual model into a probabilistic one. Using Monte Carlo simulations, input values are randomly drawn from the distributions assigned to each variable, resulting in outcome distributions. These can then be compared across different decision scenarios (i.e., funding schemes). This allows for drawing conclusions about which policy scenario leads to the highest probability of positive outcomes. To account for the variety of options for determining the discount rate, which influences the cash flow and NPV, a value range is employed for this variable. Thereby, the probabilistic nature of the model is utilized to address the inherent uncertainty associated with the discount rate.

The preliminary findings indicate no significant impact of the annual subsidy on the NPV of the AF system. Scenarios on investment support measures introduced by 5 federal states and funding scheme suggested by DeFAF are evaluated. Only the hypothetical funding scenario (AF_Hypothetical_fund), demonstrates a significant positive effect on NPV, exhibiting both a higher arithmetic mean and median NPV compared to the treeless baseline system (Fig. 1).

Figure 1: Probabilistic analysis of Net Present Value of the treeless system (baseline), the AF system without funding and with the various funding options.

The preliminary results support the remarks by German agroforestry stakeholders, emphasizing the inadequacy of the annual funding payment. In alignment with DeFAF's demands, a significant increase in the ES payment combined with a nationwide implementation of full investment support is recommended to enhance the appeal of AF systems and reach national targets. It is highly suggested that policymakers consider this, when formulating AF funding schemes in the future. In summary, this study provides insight into possible future outcomes of the modelled AF system and the adequacy of existing funding measures while providing policymakers with a crucial overview of how to create an enabling environment that promotes the adoption of AF and contributes to meeting the national targets.

This abstract is based upon work from project 101060635 – REFOREST. Funded by the European Union.

Keywords
Policy support, fruit trees, decision analysis, Analysis, models, adoption constraints, modelling, profitability, agricultural policy, CAP Strategic Plans, decision tool, implementation silvoarable AFS, Germany, alley cropping, economic incentives, agroforestry systems establishment, probabilistic simulation, decision-making, economic performance, risk factors, Policy, silvoarable agroforestry

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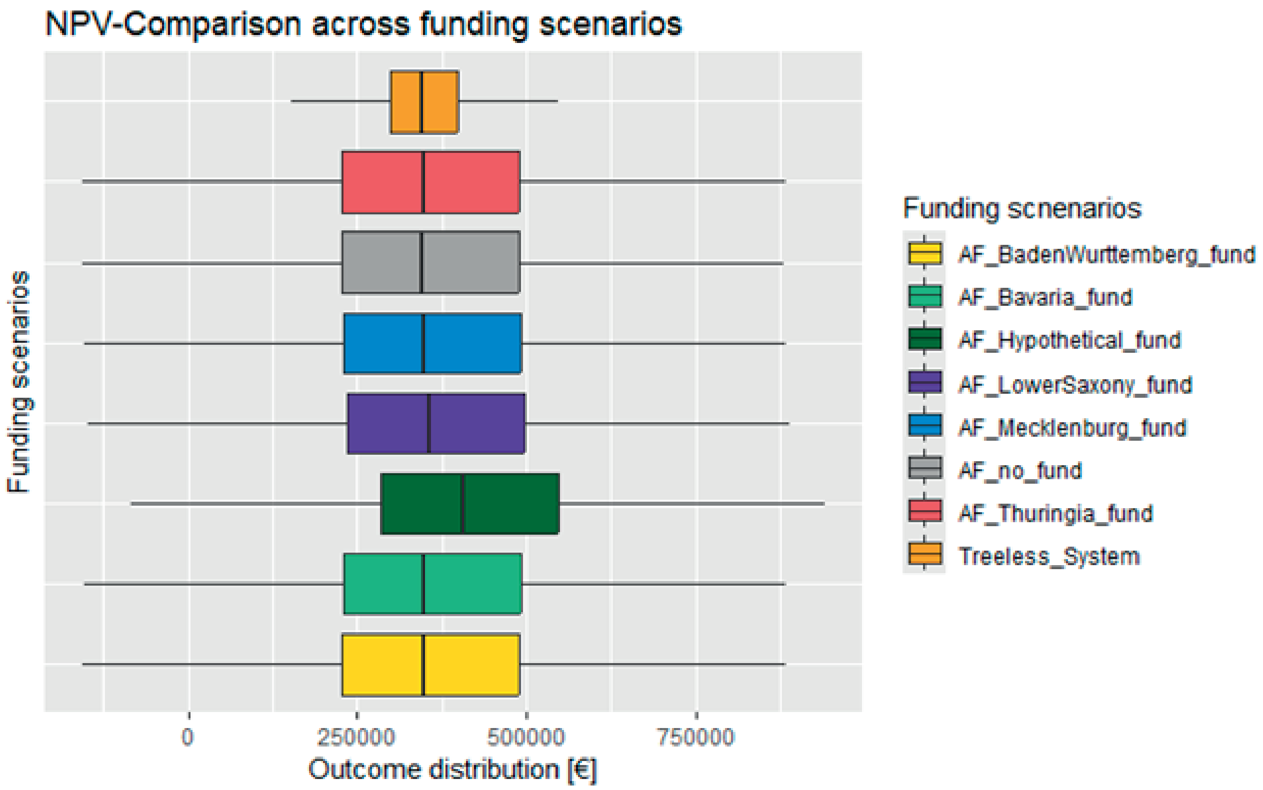

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Transitioning to Agroforestry: A Comparative Analysis of the Profitability of Agroforestry vs. Arable Farming in Brandenburg under Varying Policy Scenarios

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Introduction

Agroforestry can address multiple environmental challenges around biodiversity, soil conservation, carbon sequestration, and climate adaptation simultaneously. However, few such systems exist in Germany apart from traditional orchard meadows. Especially landscapes with little green infrastructure and marginal soil conditions like Brandenburg, a federal state in north-eastern Germany, would greatly benefit from the switch towards more agroforestry.

As one of the driving forces for farmer uptake, the economic performance of agroforestry is therefore crucial to understand. Therefore, two research questions were posed:

1. How does the economic performance of poplar alley cropping under different site conditions in Brandenburg compare to arable production?
2. Which policy measures can compensate for potential economic losses when switching from an arable to an agroforestry system?

Material and Methods

To answer these questions a modelling approach was chosen using the Agroforstrechner (Böhm and Werwoll 2020). This tool allows the comparison of net present value (NPV) of the arable and agroforestry area and was originally published as an Excel based spreadsheet model. For the purposes of this research it was transferred to a Python based script and relational databases to improve runtime and stability. A discount rate of 4% was chosen, similar to other NPV based studies (Graves et al. 2007; Giannitsopoulos et al. 2020; Kaske et al. 2021). Five agricultural zones, characterised by their yield potential, were taken into account to approximate economic performance under varying site conditions. For each agricultural zone, crop shares consisting of the economically most relevant crops were created (winter what, winter rye, winter barley, and winter oilseed rape). Silage corn was excluded due to its higher susceptibility to light competition. In terms of agroforestry design, 20 ha model plots with poplar tree strips of 6m width were used. The tree strips are cultivated in medium and short rotation at alley widths of 24m, 48m and 96m. Both short- and medium rotation poplar have a total rotation of 24 years with harvest intervals of four and eight years, respectively. The only considered tree output is wood chips for sale. Additionally, three prices for wood chips were considered as a sensitivity analysis (CARMEN e.V. 2023). The prices levels are the average net producer price over the last five years (2017-2022), as well as the lowest and highest prices that occurred in that time. Lastly, to assess the impact of agroforestry policy support on competitiveness, six scenarios were created:

a) no policy payments arable or agroforestry;
b) Eco-scheme payments of 200€/ha wooded area;
c) Eco-scheme payments of 850€/ha wooded area;
d) Investment aid covering 40% of total establishment costs in year one with (b) from year two;
e) Investment aid covering 100% of total establishment costs in year one with (b) from year two

Results

Results showed short rotation alley cropping (Figure 1) had higher NPVs than medium rotation alley copping, mainly due to lower establishment costs. Short rotation alley cropping can be competitive at high wood chip prices without policy support, while needing subsidies at low or average prices. Medium rotation systems were not competitive without policy, at all price levels. Current policy payments as described in scenarios (b) and (c) were unable to make agroforestry systems competitive except at high wood chip prices. The coverage of 40% of establishment costs would only marginally increase the range of wood chip prices and site conditions under which agroforestry could become competitive. By covering full establishment costs this would drastically improve. The policy scenario under which most agroforestry systems, site conditions and wood chip prices would become competitive was scenario (d). Besides policy support, economic performance was strongly influenced by wood chip prices, relative yield potential of poplar and arable crops, and site conditions. Alley width had smaller impacts, mostly changing the magnitude of impact instead of its direction.

Figure 1: Change in NPV (%) from switching to short rotation poplar agroforestry under different policy scenarios for the five agricultural zones in Brandenburg under average wood chip prices.

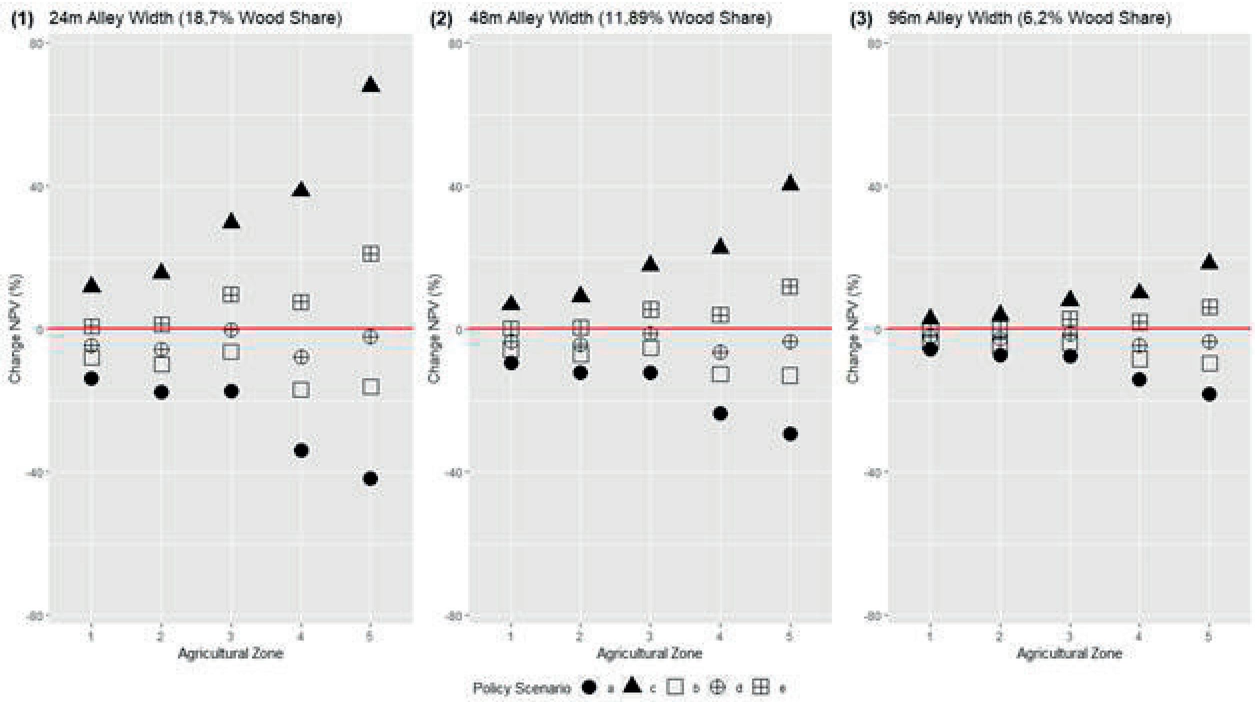
Figure 2: Change in NPV (%) from switching to medium rotation poplar agroforestry under different policy scenarios for the five agricultural zones in Brandenburg under average wood chip prices.

Conclusion

The provision of substantial policy support is needed for the establishment and/or retention of agroforestry systems in Brandenburg. Otherwise, they will remain an underrepresented land use system. The German Strategic Plan set a goal of 200'000 ha wooded area within agroforestry systems as a crucial component to meeting the sectors carbon reductions. However, as of 2023 only 51 ha were registered under the agroforestry eco-scheme. This analysis has shown that even with the increase to 200€/ha wooded area for the year 2024 agroforestry is not competitive. A renegotiation of policy payments and framework conditions therefore seems appropriate for the current as well as the next CAP programming period for effective farmer incentives.

Keywords
economic performance, agricultural policy, temperate agroforestry, alley cropping, economic incentives, profitability, Policy, silvoarable agroforestry, Poplar, AGROMIX, Germany, modelling

Aditional Attachment II.



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Policies for agroforestry, a narrative review of four 'continental' regions: EU, India, Brazil and the U.S.A

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Agroforestry as a multifunctional land use is a viable transition pathway to sustainable agriculture offering a 'win-win' for biodiversity, carbon sequestration, on-farm profitability, resilience, and social wellbeing. However, the re-integration of trees on farms goes against the previous decades' push for de-mixing, intensifying, and simplifying production methods, and farmer uptake remains low. As understanding and support for more integrated farming systems builds, an enabling policy landscape is needed to support this transition. This narrative review therefore compares both direct and indirect policies for agroforestry across four 'continental' regions: the EU, India, Brazil and the U.S.A, exploring the content, development, objectives and policy integration to provide insight into: how policies for agroforestry are currently framed; the governance process of their development; and whether over-lapping and inter-connected policy objectives are included. Policies were reviewed using a narrative approach, interpreting content with discourse and thematic analysis and a set of developed attributes as a transformation framework. We find that policies for agroforestry are increasing gradually, but are typically confined to an agronomic understanding, with limited inclusion of the socio-political aspects of food and farming. Except for Brazil, policies appear to be narrow in scope with few stakeholders included in their development. Policies do not challenge the status quo of the dominant corporate agri-food system and appear to miss the transformative potential of agroforestry.

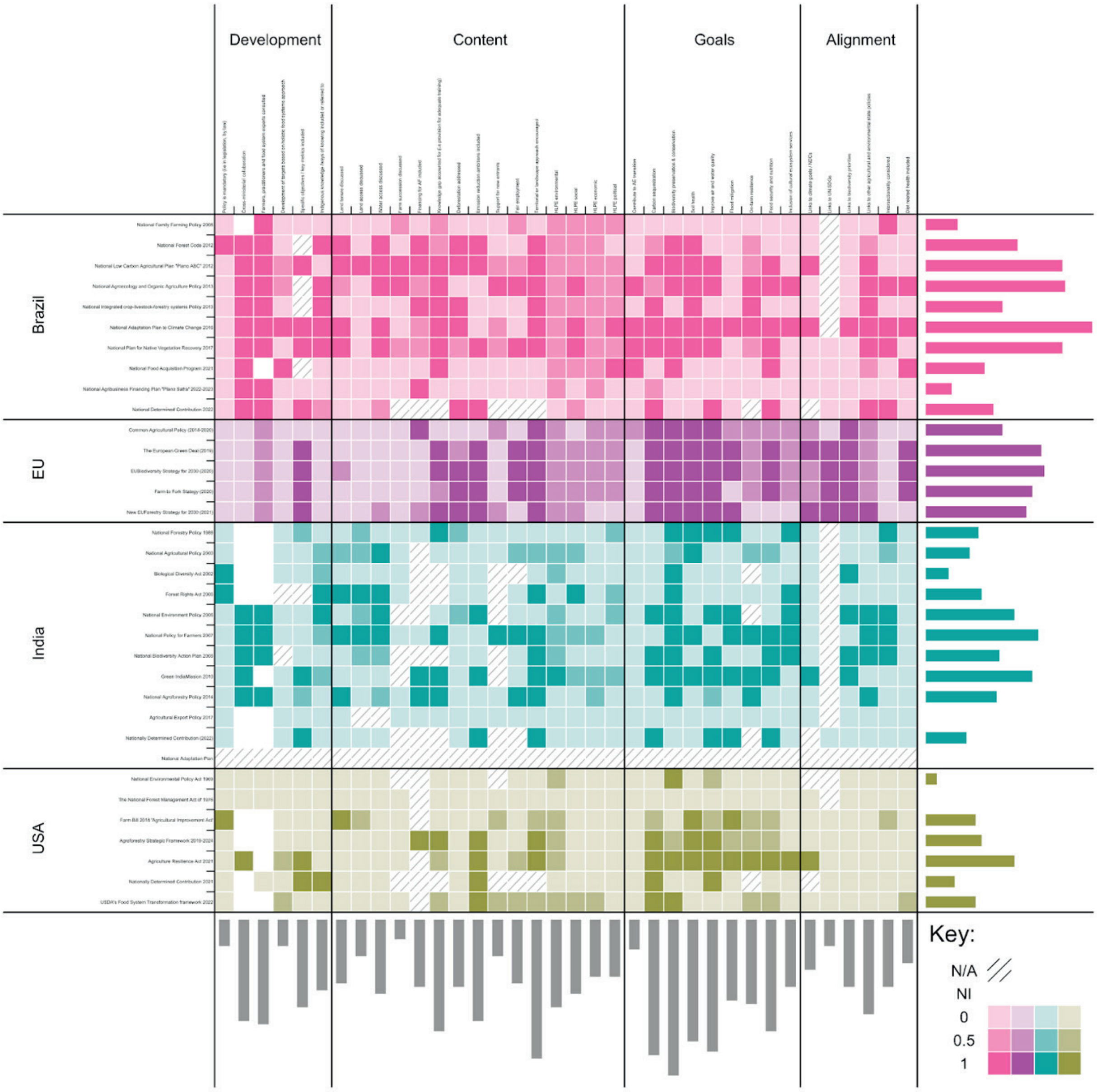
Methods:
Four 'continental' regions, which together represent a significant proportion of total global cropland were chosen for this analysis: the European Union (EU), India, Brazil and the United States of America (U.S.A). These four regions are highly relevant given their collective contribution to global agricultural production and export and therefore their subsequent contributions to global greenhouse gas emissions (USDA 2019). The EU, India, Brazil and the U.S.A have comparable policy models in that they all have a combination of overarching policies at the federal level (or supranational level in the case of the EU) as well as at the individual state or member state level, which can work against or in tandem with the broader policies.

Policies, both direct and indirect were identified for each region following a 'snowball sampling' approach (Parker et al., 2019). The legislative and policy database, FAOLEX, was employed to source policies. Relevant government websites, academic and grey literature and expert knowledge were also used to complement the list of policies. The authors define 'direct policies' to be those that specifically mention agroforestry such as India's 'National Agroforestry Policy' (2014) or the USA's 'Agroforestry Strategic Framework 2019-2024' (2019). Given the small number of direct policies for agroforestry, 'indirect policies', such as Brazil's 'National Low Carbon Agricultural Plan' (2012) or the EU's 'National Environment Policy' (2006) were also included. The inclusion (or exclusion) of the indirect policies was decided based on an initial assessment of the policies' perceived relevance to either agroforestry, trees on farms, agricultural production, or, where the authors considered the policy goals to overlap, such as the USA's 'Agriculture Resilience Act' (2021) or India's 'Biological Diversity Act' (2002). Policies up to and including the year 2022 were considered for the review.

The policies were then reviewed using a narrative approach, interpreting the content using discourse and thematic analysis. 'Attributes' that the authors understand to be critical tenets to food system transformation, in line with environmental and societal sustainability were identified and discussed. The High Level Panel of Experts, '13 Principles of Agroecology' (2019) were thematically grouped and are included as distinct attributes in the analysis, given their relevance to the discourse on transition pathways to sustainable food systems that includes the socio-political. To analyse the degree to which policies with overlapping objectives and aims are complimentary, an additional set of attributes related to policy alignment was included. As a result of this exercise, thirty-six attributes were developed and grouped into four categories: policy development, policy content, policy goals and policy alignment (Table 1). Each policy was then scored against each attribute, either scoring 1 for yes, 0.5 for partially or 0 for no. 'Not Applicable' and 'Not Enough Information' were also included to allow for specific instances.

Both direct and indirect policies for AF were identified across the regions. The USA and Brazil do not have direct national policies for AF but provide direct policies at the state level. India has a National Policy for Agroforestry (2014) but no regional or state policies and the EU has direct policies both at the regional and individual member state (MS) level. However, the support for AF uptake (both in terms of financing, knowledge exchange and the policy environment) is minimal. As for AF policies being developed in line with other national and international targets such as Nationally Determined Contributions or the Sustainable Development Goals, some of the more recent policies are aligned, but on the whole this link is not evident from the data. In addition, this review could not find enough evidence to suggest that current policies have been developed with a holistic food systems framework and therefore miss the transformative potential of AFS. Brazil being the exception, which took a food systems approach in the development of The National Food Acquisition Program, which addresses affordability, supply chain and health. However, no target has been developed to apply this policy, arguably making it ineffectual. Further, Brazil carried out consultation with relevant actors in all the policies assessed, an important component of an agroecological approach.

Policies relating to AFS are increasing gradually over time. The more recent policies appear to include a greater diversity of policy goals, such as carbon sequestration, improving air and water quality and biodiversity preservation and conservation. This could be due to increased public awareness and the increasing pressure on governments to act in response to our environmental crises. However, the socio-political aspects of food governance and AFS are not being included to the same extent, with policies omitting to address land tenure, financing, employment, food security and nutrition or diet related health.



Key points:
The findings of this review add to the limited body of policy related research for AFS and how they are currently framed within a diverse set of both direct and indirect policies. Some practical implications of this work are as follows.

- Collaboration may lead to greater policy integration

There is a slight trend towards greater policy integration the more recent the policy (Figure 1). It is not possible to say from the data whether increased cross-ministerial collaboration and the inclusion of farmers, practitioners and food-system experts directly leads to greater policy integration, however for the USA, low scores within policy development match with low scores for integration. Whereas the results for Brazil could highlight how increased cross-ministerial collaboration results in greater integration, particularly when looking at links to other agricultural and environmental state policies (Figure 1). This would be in line with thinking that inclusion of a greater diversity of stakeholders within the policy process results in more effective policies (Parsons & Barling 2022). There is some 'joined-up' thinking when it comes to AFS and other agricultural and environmental state policies particularly within Brazil and the EU. A surprisingly small amount of policies link directly to climate goals or NDCs. As for diet-related health, most regions do not make the link between AFS and the potential for improved nutrition or health.

- Policy inconsistencies may hinder AFS uptake and limit potential for co-benefits

Despite regions scoring higher for alignment, inconsistencies and contradictions exist both within and across policies reviewed. For example, while CAP direct payments (under Pillar 1) follow a per-hectare income support, CAP Rural Development funding (under Pillar 2), is based on the provision of public goods, a direct contradiction. Specifically for AFS, up until the most recent CAP, there were official guidelines for how many trees could be planted per hectare, which have remained in MS RDP's when defining AF. Therefore, although AF is in theory supported, it is within an environment that creates challenges for entry and experimentation, which makes it harder for the expansion of AFS championed within the Biodiversity and Forestry Strategies, for example. In Brazil, the integrated crop-livestock-forestry systems (ILPF) and agroforestry have been addressed as if they were interchangeable, however, in practice, the integration of trees and agriculture within ILPF systems are mostly separated spatially and temporally, not configuring an agroforestry system (AFS), leading to overestimations.

- Policies for AFS lean towards agronomic reading of NbS concept, limiting its transformative potential

The majority of policies included in this review lean towards an agronomic understanding of AFS as a NbS, favouring policy goals and content linked to environmental objectives such as carbon sequestration, biodiversity preservation and conservation, air and water quality and flood mitigation. Objectives linked to diet, health, access to land and water are generally left out, thereby limiting the transformative potential of AFS as a NbS.

- Lack of legal obligations inhibits tangible action

Notably, only three of the 34 policies included in this study are legally binding, meaning there is no legal obligation for the mandates in the policies to be met. This could give reason to doubt the 'committedness' of governments in relation to making real change. It may also highlight one of the critical gaps in the policymaking process, whereby policymakers do not take the time, or are not given the time or due process, to progress ideas from merely ambitions and targets, to tangible actions and pathways.

- People and practitioners are absent within policy

For the most part, the EU, and the USA, the two 'higher income' regions included in this review do not include the framework of intersectionality in their policies (The USA Farm Bill scores 0.5, all others 0). Taking an intersectional approach to policymaking and policy analysis requires identifying, understanding and addressing the structural inequalities in a given context that account for these different lived experiences and inequalities (Munro et al., 2014, Mitra and Roa 2019). This omission of intersectionality within the policy arena is unsurprising but noteworthy. Brazil and India, which both score higher on in terms of wealth inequalities, both have four policies that include intersectionality. This could be perhaps due to a greater recognition of the diverse countries' demographics, including a stronger recognition of indigenous and traditional peoples and cultures. Other lowest scoring attributes include farm succession, support for new entrants and, surprisingly, links to the UN SDGs.

Keywords
land-use, sustainable food production, policy contexts, multifunctional landscape

3.3 Carbon farming and Neutrality Certifications

Oral presentations

Hall Q1, 31 May 2024, 8:30–9:15

Swiss Agricultural and Climate Strategy: a missed opportunity for agroforestry?

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Introduction

The overarching goal of the international community is to achieve climate neutrality by 2050. Many countries, including the European Union and Switzerland, have committed to this as part of the Paris Agreement. To achieve this ambitious goal, the European Union has implemented the European Green Deal, the new Common Agricultural Policy (CAP) and the European Climate Law, which places a strong focus on active carbon sinks through land use / land use change. The agricultural sector is explicitly included with new approaches such as carbon farming. Alongside others, agroforestry in particular is named as one solution.

In Switzerland, a slightly different approach was chosen. Joint efforts have been made between agriculture and the food sector so that Swiss agricultural production has to reduce greenhouse gas emissions by at least 40% compared to 1990. The Swiss Climate Strategy for Agriculture and Food 2050 was presented in 2023 (BLW, BLV, BAFU, 2023). It reports that the Swiss agricultural sector emitted 8.1 million tons of CO2eq (Mt CO2eq) in 1990 and still 7.1 Mt CO2eq in 2020. The climate strategy sets out several measures in two areas in order to achieve the zero emissions target by 2050. Firstly, 1.6 Mt CO2eq are to be avoided by adapting consumption and production patterns (food sector). Secondly, 1.4 Mt CO2eq are to be mitigated by improving the efficiency of herd management and feeding, optimal fertilizer management, substitution of fossil fuels with renewable energies and curbing the loss of soil carbon stocks (agricultural sector). Agroforestry is not listed as a measure, but only in the annex it is proposed to support modern agroforestry starting earliest in 2030 (BLW, BLV, BAFU, 2023).

Against this background, we posed two research questions: i.) How great is the potential of agroforestry as a climate mitigation measure in Switzerland? And ii) what is the impact of a 5-year delay in the implementation of a support scheme in relation to the overall 2050 net zero target?

Method

To address the first research question, we evaluated the potential of agroforestry for climate mitigation on Swiss agricultural areas. We assumed that agroforestry could potentially be implemented on both arable land and grassland. An average Swiss agroforestry system consists of 50 trees per hectare. According to monitoring and modelling, these systems store between 2.5 and 5 t CO2eq per hectare per year (Kay et al. 2020).

Addressing the second research question, we focus on two different components over time – the social behaviour of the agroforesters (=implementation rate) and the biological development of agroforestry systems (=growing rate) and calculated their effects over time. Based on the theory of the diffusion of innovations (Rogers 2003), the rate of implementation follows a fixed pattern und will increase over time. This is in line with observations from Swiss agroforestry projects, where farmers and landowners needed up to two years to design their individual agroforestry system. Moreover, the growth of agroforestry systems also follows a fixed pattern. While we often assume an average growth rate per year, young trees actually have a significantly lower biomass growth rate than older trees, the development is not linear.

Results and Discussion

Implementing agroforestry on additional 1% of Swiss agricultural land would results in 0.025 – 0.05 Mt CO2eq per year, increasing it to all grasslands (60% of Swiss agricultural land) would even mitigate 1.5 – 3 Mt CO2eq per year. This exceeds all other measures mentioned in the climate strategy. Traditional agroforestry systems already exist on around 8% of Switzerland's agricultural land (Herzog et al. 2018), while around 500 hectares are managed as modern agroforestry systems.

For running up against the 2050 deadline, it makes a difference when large scale agroforestry implementation starts. An average hectare of agroforestry planted in 2025 will already be 25 years old and will have captured around 27 t CO2eq, while a system established in 2030 will only have captured around 10 t CO2eq (Figure 1). The climate protection effects are further delayed by the implementation rate, which more or less resembles a Gaussian distribution curve. In the case of agroforestry, farmers and landowners will wait until there is a legislation in place and will afterwards adapt their systems to the legal framework. Consequently, the climate effect will be slowed down significantly. A similar time lag effect between introducing a legal measure and their effects was seen by Watts et al. (2020) establishing biodiversity action.

Conclusion

Agroforestry could make a significant contribution to climate protection in Switzerland. It also has a climate adaptation effect by promoting resilient food and feed production and fostering biodiversity and natural resources. However, time is running and delaying support programs for the introduction of agroforestry will be costly because people need time to think and implement and nature needs time to grow.

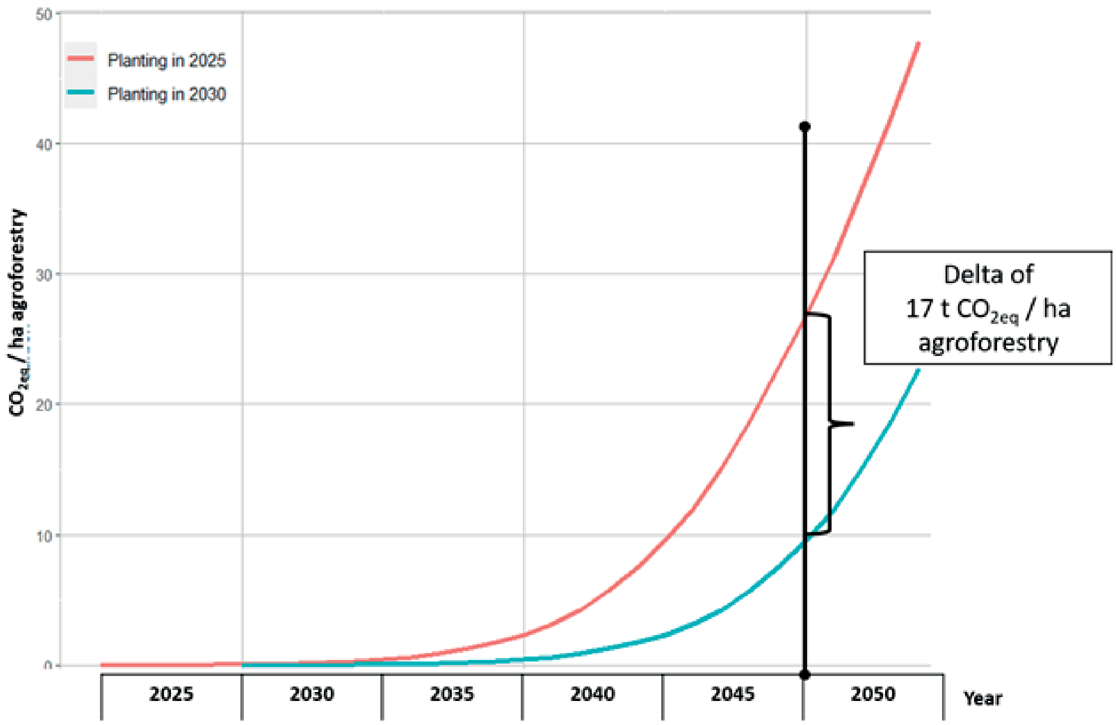
Acknowledgment

This work was funded by the European Union under grant agreement: 101059794. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. The European Union cannot be held responsible for them.

Keywords

Policy, Agroforestry, climate mitigation, carbon sequestration

Aditional Attachment II.



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Can agroforestry help the EU achieve net zero in the land sector by 2040?

Mr Gerry Lawson[1], Dr Sonja Kay[2], Dr Michel den Herder[3], Ms Anna de Boeck[4], Dr Manuel Bertumeu[5], Professor Paul Burgess[6], Mr Davor Deranja[7]

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Introduction

Agroforestry systems cover around 15.1 million ha in the EU in 2012 or about 8.8% of the Utilised Agricultural Area (UAA). Recent flexibility given to Member States in their definitions of "permanent grassland", allows inclusion of grazable-shrubs, and the area of trees and shrubs in agricultural use may be greater [1]. Agroforestry and sustainable management of soils are prime candidates for certification under the draft EU Carbon Removal Certification Framework (CRCF) [2] and the Sustainable Finance Initiative [3], and it seems to meet all the "sustainability" co-benefits of the CRCF: viz, climate mitigation [4], carbon adaptation [5], sustainable use of water resources, transition to a circular economy, pollution prevention and control, protection and restoration of biodiversity and ecosystems. But what is its potential contribution to EU emission reduction targets? And is there sufficient available land for a large programme of afforestation and agroforestation?

Objectives / research questions

The revised EU Land Use, Land Use Change and Forestry Regulation (LULUCF - 2023/839) entered into force In May 2023. It set a collective GHG reduction target for LULUCF for Member States of -310 Mt CO2e/yr by 2030, and almost all Member States will find the targets extremely difficult to achieve - because of increasing pressures on forests through, disease, fire ageing-structures and increased exploitation. Sequestration is estimated to have been around 212 MtCO2e in 2022, and the most recent evaluation by the Commission of Member States' commitments to increase this [6] concludes that the EU is on track to miss the LULUCF target of 310 Mt CO2e by around 40-50 Mt/yr in 2030. Given the time that trees take to grow, we asked the question: how much contribution to the 2030 targets could an emergency programme of afforestation and agroforestation make to closing the LULUCF shortfall by 2030. In addition, we ask whether it will be possible to achieve overall GHG neutrality in the Agriculture, Forestry and Other Land Use sector (AFOLU) by 2040, given that the current annual emission of non-CO2 gases from agriculture is around 380 MtCO2e?

Methodology

As part of an update of EURAF Policy Briefing #8 on Carbon Farming [7] we reviewed the literature on sequestration of agroforestry systems in temperate regions and used 2018 Copernicus data on tree crown density superimposed on Coring estimates of agricultural land cover to evaluate the scope for very-large scale afforestation and agroforestation: focusing on those areas in Member States which have fewest trees. These are usually the areas of greatest environmental pressure [8], where the mineral soils stand to benefit most from the introduction of small forest-blocks, agroforestry and landscape features.

Results

Around 27 studies reported reliably on temperate agroforestry sequestration data (6 Atlantic, 7 Continental, 12 Mediterranean, 4 Canada/USA). Some of them recorded whole system biomass and carbon stocks, others evaluated the annual prunings and residues. Several combined measured and modelled data, to account for the whole lifespan of an agroforestry system – from planting to harvesting. The average agroforestry system captured around 1.44 t C/ha/yr or 5.27 t CO2/ha/yr aboveground. Systems ranged from 0.15-0.90 t C/ha/year in Mediterranean oak in Dehesa or Montado systems to 5 t C/ha/year in dense poplar agroforestry systems in the UK.

Excluding Natura 2000 areas, we concluded that more than 77% of EU agricultural land (~130 Mha) has less than 10% tree crown cover and almost 60% has zero tree cover (~100 Mha) . Therefore, there seems to be an excellent opportunity to increase tree-cover on all agricultural land to 10%, by introducing an emergency programme of small-scale afforestation and agroforestation (Figure 1). The latter has the advantage of keeping land in “official” agricultural use and retaining eligibility for agricultural basic payments. If an average total (above- and below-ground) sequestration of 5 tCO2e/ha/yr is assumed for the EU, an emergency tree-planting programme of 1 million hectares per year, starting in 2025, would generate around 80 Mt CO2e/yr by 2040. This will go a long way to filling the estimated annual net-emissions gap in the land sector (AFOLU) in 2040 of 110-120 Mt CO2e. It assumes, however, a scale of tree-planting completely without precedent in Member States. The currently proposed planting area in CAP Strategic Plans over the seven-year period from 2023-2029 is only 0.619 million hectares.

Conclusion

An additional 80 MtCO2e/yr of LULUCF sequestration in the EU could be captured by 2040 through an emergency afforestation and agroforestation programme of 1 million ha/yr from 2025 onwards. This would greatly contribute to achieving net-zero in the land sector (AFOLU) by 2040, but this scale of planting is approximately ten times bigger than that currently included in the CAP Strategic Plans and Forest Plans of Member States.

Acknowledgment

This work was funded by the European Union as part of the DigitAF project under grant agreement: 101059794.

Keywords

agricultural policy, carbon sequestration, Agroforestry, Agroforestry certification, climate mitigation

Aditional Attachment I.

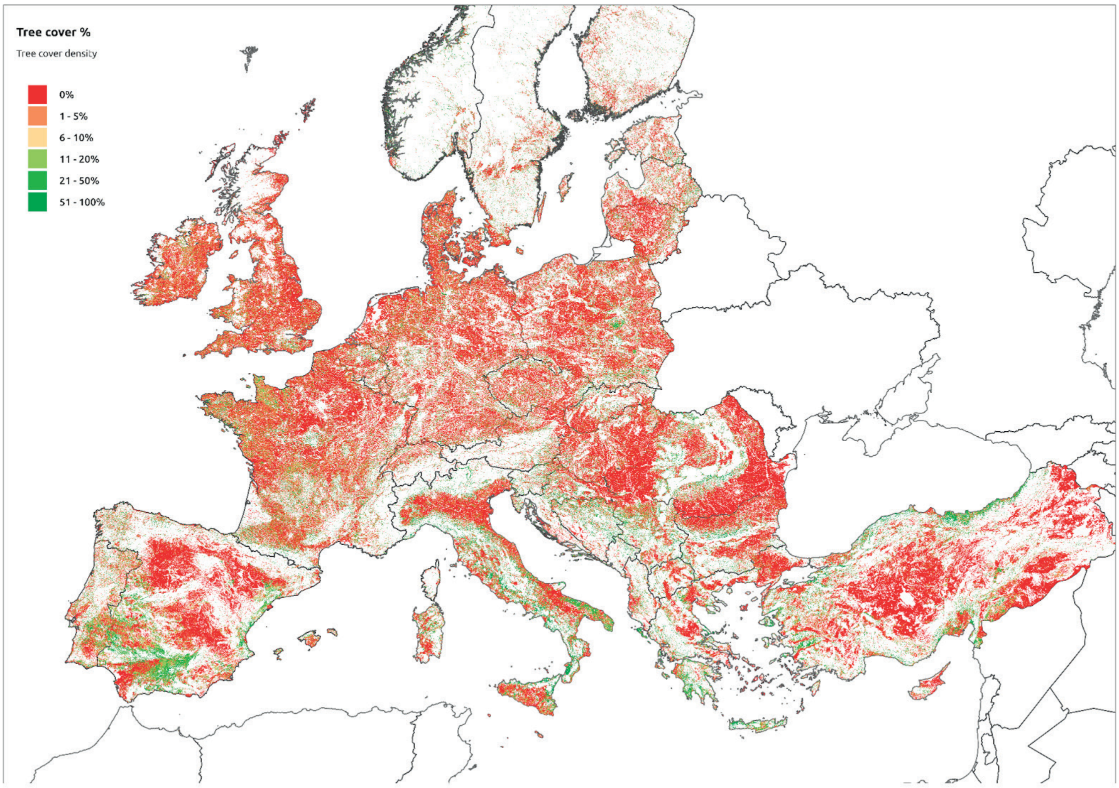

Figure 1. Tree cover density (% tree cover in 100 m pixels) in agricultural land in the 39 EEA countries. The red areas are priority planting areas where tree cover density is particularly low. Source: Copernicus tree cover density 2018 superimposed on CORINE agricultural land 2018. Each pixel in this map covers 1ha.

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Unlocking carbon negative farming products with agroforestry systems

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Introduction

Curralões, a farm where Moinhos de Vento Agroecology Research Centre (MVARC) is established, covers 240 ha near Mértola in Baixo Alentejo, in south-east Portugal. In the last 15 years, the average rainfall has dropped to 273mm, and as elsewhere, climate change impacts are a concern with drought a frequent issue in recent years. Farming in the area is heavily reliant on subsidies and in chasing such subventions, land management practices in the region are often antagonistic to the need to increase resilience to climate change.

In 1994 over 130,000 Pinus pinea trees were planted on 160 ha farm under an afforestation measure in the CAP Pillar 2, with the aims of increasing carbon storage and improving forestry resources. The pines have followed a thinning and pruning model and have very slow growth and have low productivity. The understorey is dominated by a shrub layer composed primarily of 'rockrose' (Cistus ladanifer L.) which, to comply with the CAP conditionality of "good agricultural and ecological conditions" (GAEC), have to be less than 20% cover and under 50cm in height. It is common practice in the region to use an offset disc harrow every four to five years to control the shrub.

Objectives / research questions

As part of a resiliency strategy, MVARC is proposing to manage rockrose as an agricultural crop (see Palma et al 2024). Rockrose is an aromatic plant, producing a highly valuable, although low yielding (~0.01-0.05%) essential oil (EO) and hydrolate with interesting properties for cosmetics and pharmaceutical industries. At the same time such industries are seeking raw ingredients with sustainable labels. To complement this,we aimed to quantify the carbon balance of the agroforestry system that is producing the essential oil and hydrolate.

Methodology

We used the carbon balance method from Crous-Duran (2019) to estimate the source of greenhouse gas emissions from the field operations. The shrub germinates spontaneously and is coppiced every two years. There is no ground preparation, seeding, or fertilisation involved.

The emissions from field operations are included for travel to and from the farmyard to the field and for harvesting the shrub with the shrub mulcher. Emissions from the steam distillation process are due to the wood burning the boiler (25 kg wood h-1) consumption are included. We considered distillation of 600 kg of leaves in a day, harvested in the morning, distilling in the afternoon. Each distillation was considered for three hours each, totaling six hours of distillation in one day. Because oil is present in higher yield in summer (average of 0.04%), we only considered 60 days of seasonal work.

For estimating the carbon sequestration rate in the trees of the agroforestry system we used a drone flight to provide 1) the geolocation of all trees, 2) a surface model and 3) a terrain model with 25 cm resolution. For each tree location, the terrain model was subtracted to the surface model to provide tree heights. Heights were divided in 14 cohorts with 50 cm increments, i.e. [1-1.5m[,[1.5-2[, …,[7.5-8], and tree diameter at breast height (dbh) sampled for each cohort. Equations from Correia et al (2010) were used to estimate aboveground biomass and a root-to-shoot ratio of 0.2 to estimate the belowground biomass. The tree biomass estimated for each cohort was then multiplied by the number of trees in that cohort. To estimate the annual storage of carbon we assumed a conservative yearly growth of the stand of 1 %, corresponding to an average stand increase of 4.8 cm in height and 0.15cm in dbh.

Results

The total daily emissions of the field operations and distillation process is 321 kg CO2 eq, while the yearly emissions (60 working days) emit 19.4 Mg CO2 eq.

The drone recorded 50,485 trees. Heights [1-8m] and diameters [3-40cm] fit within the range of other sampled stands of stone pine (e.g. Tomé 2010). The standing agroforestry trees are storing a total of 5683 Mg Co2eq and the conservative growth estimation indicates a yearly increment of 142 Mg CO2 eq.

The balance between emissions and sequestration is -122.8 Mg CO2eq, evidencing a carbon negative production of this new crop under an agroforestry system (Fig 1).

Conclusion

The agroforestry system provides a carbon sink, as well as a growth rate of trees that not only offsets the emissions from the production of essential oil and hydrolate from rockrose, but enables these products to be carbon negative. Many products are now being labelled "carbon neutral" but agroforestry systems, in this case, provide "carbon negative" products.

Further research will use biophysical models to estimate forest growth and thinning options, consider the standing biomass in the rockrose coppiced system, compare to other business as usual land management systems using off-set disc harrowing, and assess the introduction of post-distilled organic material for soil improvement that will also increase soil carbon.

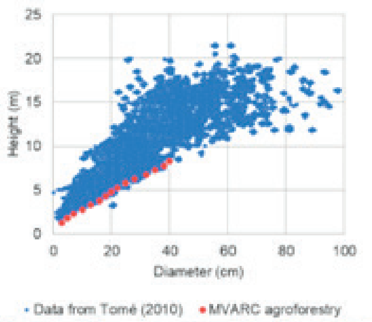
Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

Keywords

Agroforestry systems, climate change, silvoarable, GIS, Climate smart agriculture, modelling, coppice ,climate change mitigation, mixed plantation, cistus ladanifer, Case studies, carbon farming, arable weeds, shrub control, GHG emissions, carbon neutral, carbon storage, carbon footprint, Growth models, crop variety, Agroforestry, carbon certification, Land Use, Carbon Balance, dryland agroforestry, rockrose, soil improvement, carbon sequestration, dryland, Adoption

Aditional Attachment II.



		Kg CO_{2eq} day^{-1}	Mg CO_{2eq} year^{-1}
Emissions	Diesel runing tractor for harvesting	31.2	1.9
	Travel from farmyard to field	7.8	0.5
	Travel to farmyard from field (loaded)	9.1	0.5
	Circulating pump for water cooling (solar powered)	0	0
	Wood for heating boiler for distillation	275	16.5
	Total	323.1	**19.4**
Sequestration	Total Stand Biomass (Mg)	3100	
	Annual biomass increment (Mg year^{-1})	78	
	Total Stand Carbon (Mg)	1550	
	Annual carbon increment (Mg year^{-1})	39	
	Total Stand (Mg CO_{2eq})	5683	
	Annual increment (Mg CO_{2eq} year^{-1})	**142**	
	CO_{2eq} Balance (Emissions - Sequestration), Mg CO_{2eq} year^{-1}	-122.8	

Fig1: Top-left: Inventory of the agroforestry trees compared to other stone pine stands from literature (Tomé 2010). Top-right: Carbon balance calculations. Emissions from the production of essential oil and hydrolate of rockrose, sequestration from the growth of the agroforestry trees. Bottom-left: drone flight identifying about 50,000 trees in the agroforestry. Bottom-middle: A general overview of the agroforestry alleys. Bottom-right: The management of the alley to stimulate rockrose growth to harvest/coppice every two years

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3.3 Carbon farming and Neutrality Certifications

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Carbon farming: an emerging opportunity to promote agroforestry

Dr Ivan Hajdukovic[1], Dr Jaime Coello[1], Dr Laura Armengot[1], Dr Camilla Dibari[1], Dr Diana Jimenez-de-Santiago[1], Dr Marcos Jiménez Martínez[1], Dr Prajna Kasargodu Anebagilu[1], Sebastian Mayr[1], Dr Wiebke Niether[1]

1 CTFC - Forest Science and Technology Centre of Catalonia (Spain), Solsona (Lleida), Spain

With the growing ambition of the European Green Deal to address current challenges related to climate change, environmental degradation and food security, policy initiatives and sustainable practices are needed to transform the European Union into a more resilient, integrated and resource-efficient economy. Agroforestry systems, as a multifunctional land use, could be at the centre of this transition due to their environmental, economic and social benefits. Recent studies show the need for a policy framework that links food systems, agriculture, forestry and rural development into a holistic approach for environmental, economic and social sustainability (e.g. Donham et al., 2022; Hajdukovic, 2023). However, in order to achieve this transformation, it is essential that the socio-economic value of the ecosystem services provided by agroforestry systems is identified and incorporated into the financial focus. In this regard, the policy and regulatory framework for agroforestry in Europe is growing, as agroforestry systems are supported within the two pillars of the new Common Agricultural Policy (CAP) and are explicitly mentioned to be promoted in the European Green Deal and in key related policy roadmaps such as the Biodiversity, Forest, Bioeconomy, Soil and Farm to Fork strategies, among others.

The growing interest in agroforestry is also leading to an increasing number of national and EU-funded projects dealing with this discipline. Some of these projects are working together to examine and propose improvements to the policy and regulatory framework affecting these systems. This study is part of this joint initiative and examines the role and potential of agroforestry as a carbon farming practice in Europe. We provide an overview of the scientific literature and recent policy developments, focusing on several key aspects of carbon farming in Europe:

First, the study provides a definition of carbon farming and identifies the benefits and challenges of adopting agroforestry as a carbon farming practice. The study also explores the potential of new approaches such as outcome-based and hybrid carbon farming schemes for agroforestry systems, with a view to the future development of sustainable financing schemes for agroforestry based on payments for ecosystem services.

Secondly, it examines how agroforestry can contribute to climate change mitigation and biodiversity co-benefits.

Thirdly, the study presents a framework for the development of a carbon farming scheme for agroforestry, focusing on the types of funding mechanisms and sources for carbon farming.

Finally, it discusses the prospects for carbon farming and agroforestry in Europe from a policy perspective.

This study shows that carbon farming schemes based on payments for ecosystem services need to be further promoted to overcome the main barriers to agroforestry adoption. In this context, a hybrid scheme may be able to overcome the limitations of both actions-based and results-based mechanisms to effectively achieve climate change mitigation goals. A hybrid carbon scheme for agroforestry needs to consider the combination of different sources of finance to cover the costs of establishing and managing agroforestry systems and to reward farmers for environmental outcomes. Agroforestry can be funded through different carbon farming mechanisms and sources, such as the CAP (e.g. eco schemes, Agri-Environment and Climate Measures), private initiatives linked to voluntary carbon markets, the corporate supply chain, or a combination of these funding options. However, only voluntary carbon markets are generally results-based. CAP policy instruments can potentially cover farmers' initial and ongoing costs by providing activity-based payments for the expected environmental benefits of their land management practices. In the coming years, carbon farming should be the first step towards a real change in the contribution of agriculture and (agro) forestry to the EU's environmental and climate objectives. The way in which carbon farming schemes are designed and implemented will be crucial for the upscaling of agroforestry to contribute to the EU's environmental and climate objectives.

Acknowledgements

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- Transition project (PCI2021-121959) is financed by the PRIMA Call 2020, Work program Topic 2.2.1
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- CDR PoEt is supported by the German Ministry for Research and Education (BMBF) (Grant Number: 01LS2108A)

Keywords

Land Use Policy, Policy, Europe, carbon farming, climate change, climate change mitigation, soil organic carbon, soil carbon sequestration, silvoarable agroforestry, carbon sequestration, agricultural policy, Agroforestry, European project, CAP Strategic Plans

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Comparison of sequestered carbon amount in coffee agroforestry plantations, silvopastoral systems, and tropical highland forests in the central part of the Peruvian Amazon.

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1 Mendel University in Brno, Brno, Czech Republic

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3 EL Colegio de Puebla, Puebla, Mexico

Agroforestry systems are an important land use type in Central and South America. We focused on the ability of these systems to sequestrate carbon from the atmosphere. The study aimed to evaluate and compare the amount of sequestered carbon in different types of land use in the vicinity of Oxapampa town in the central part of the Peruvian Amazon. The research was conducted in the autumn of 2022 with a focus on three main types of land use: coffee agroforestry plantations, montane tropical forests, and silvopastoral systems. Agroforestry plantations of Coffea arabica shaded by Pinus spp. and Inga spp. species were compared with degraded secondary forests and silvopastoral systems shaded by Inga spp. Data collection was carried out with Field-Map technology and 47 study plots on 6 transects were measured. Non-destructive methods with different allometric equations were used (Segura 2006; Chave 2014) to estimate biomass. The evaluation of soil carbon stock was determined based on soil analysis using a Soli-TOC device.

The results showed that there was no statistical difference between the amount of carbon sequestered in the tree biomass of agroforestry coffee plantations and forest ecosystems using allometric equations. The total carbon fixed in the shade tree biomass on agroforestry coffee plantations was estimated to be 19.7 Mg C ha-1 using Chave's allometric equation (CAE) and 14.7 C ha-1 using Segura's allometric equation (SAE). The amount of sequestrated carbon in shaded trees in the silvopastoral system was 9.9 Mg C ha-1 (CAE) and 8.8 Mg C ha-1 (SAE), and in secondary degraded forests, it was 7.9 Mg ha-1 (CAE) and 6,9 Mg C ha-1 (SAE). The stated results do not consider the amount of carbon in the grass biomass in silvopastoral systems (now under data collection and will be defined soon). Soil carbon stock was highest in forest stands in the upper soil layers. At lower depths (20-30 cm) the difference between the studied ecosystems was no longer registered (Figure 1).

Acknowledgements

The project/research was supported by the Specific University Research Fund MENDELU

Keywords

soil carbon sequestration, carbon sequestration, shade-grown coffee, Agroforestry system

Aditional Attachment II.

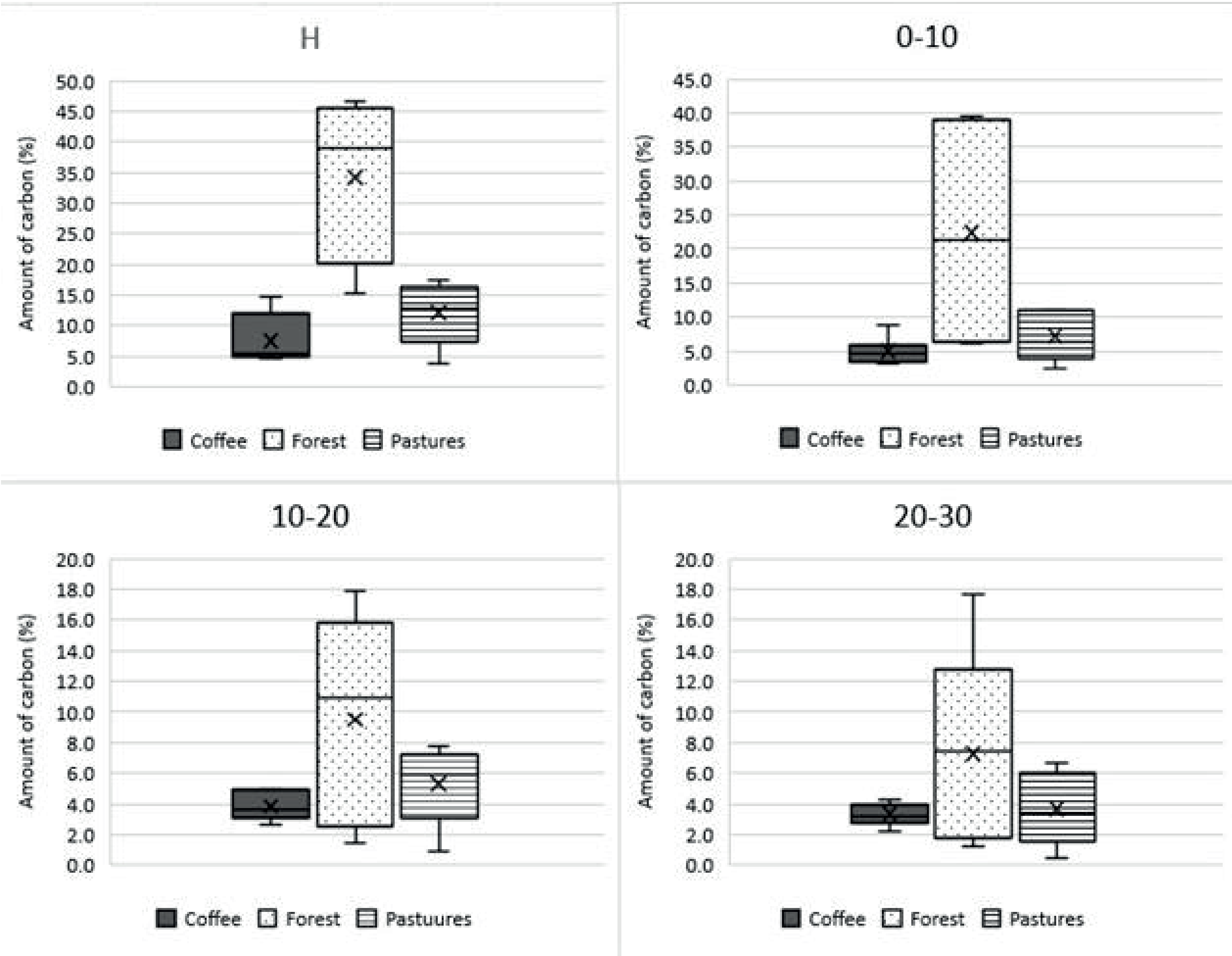

Figure 1: The amount of carbon in the soil at different sampling depths in different types of land use.

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Effectiveness of Payments for Ecosystem Services in support of Agroforestry in the trinational Upper Rhine

Sebastian Mayr[1]
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Agroforestry is a Carbon Dioxide Removal (CDR) method with technological readiness and notable removal potential and strong co-benefits. Payments for Ecosystem Services (PES) have been discussed as a policy instrument to overcome barriers to agroforestry adoption and/or maintenance and already enjoy wide application. However, the knowledge about the effectiveness of PES in support of agroforestry is limited. This study evaluates the effectiveness of incentives provided under the European Union's Common Agricultural Policy (CAP) for scattered fruit tree meadows in the German Upper Rhine region and reasons for their effectiveness. It does so by identifying national and regional CAP incentive schemes through literature review and assessing their acceptance by farmers through enrolment data. The results are contrasted with long-term time-series of agroforestry stocks and are expected to show an ineffectiveness of the CAP incentives in maintaining scattered fruit tree meadows and resulting ecosystem services. The analysis of drivers and barriers of PES effectiveness is based on a literature review and interviews with farmers and experts applying a theory of change. The results are expected to point rather to barriers related to structural agroforestry "complements" of PES schemes such as support of the labor market or mechanization of agroforestry systems rather than inputs and factors related to PES scheme design. Lessons and policy recommendations resulting from this study should benefit policy-makers and scholars alike.

Keywords
Policy, incentives, Payment for Environmental Services, payments for ecosystem services, economic incentives

3.4 Scaling Up of Agroforestry Innovations

Oral presentations

Hall Q1, 31 May 2024, 9:15–10:00

Actor perspectives on agroforestry law in Germany

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Introduction
Agroforestry systems (AFS) can contribute to climate change mitigation and adaptation, enhance biodiversity and prevent soil erosion (Tsonkova et al. 2012; Torralba et al. 2016). As such, they enhance multifunctionality (Veldkamp et al. 2023) and may foster multiple nature's contributions to people (NCP) (Elbakidze et al. 2021). Nonetheless, modern AFS are seldomly adopted across Europe (Den Herder et al. 2017). To this end, subsidies under the Common Agricultural Policy and the protection of trees and shrubs in nature conservation law have been criticized as a barrier to the adoption of agroforestry (Tsonkova et al. 2018). On the other hand, AFS have been shown to be critically assessed out of nature conservation concerns (Pe'er et al. 2017). However, while these different perspectives on agroforestry might imply different views on the revision of the legal framework, little is known about the view of actors from NGOs and administration on agroforestry and agroforestry-related law.

Research questions
In targeting these research gaps, and by taking Germany as a case study region, it is the aim of this contribution to analyse the view of farmers, representatives from administration and NGOs on agroforestry and agroforestry-related law. We address the following research questions:

1. How do actors define agroforestry and which nature's contributions to people do they associate with it?
2. Which possibilities and barriers are associated with subsidy law and command-and-control law?
3. 3Are there preferred options to revise the legal framework and if so, which ones?

Methodology
We conducted semi-structured interviews with farmers and representatives from NGOs and administration in Germany and Europe. To account for the multilevel governance structure and the strong influence of the Common Agricultural Policy on agroforestry, we interviewed actors from the local German level (districts) to the European level. The interviews were coded with MAXQDA applying methods of deductive-inductive coding (Kuckartz 2018). The interview results were complemented with a content analysis of press releases and position papers published by various actors on agroforestry-related law.

Results
At the local level, actors were often unfamiliar with the concept of agroforestry or associated it with the plantation of fast growing tree species for the purpose of biomass production. Contrary, traditional agroforestry systems such as orchard meadows were less often defined as agroforestry. While actors politically engaging for agroforestry stressed the multifunctional purposes of agroforestry and mentioned multiple nature's contributions to people, representatives from nature conservation or farming associations highlighted the negative effect agroforestry systems might have on open grasslands or agricultural production respectively. While there was agreement that low funding for agroforestry under the CAP in Germany was a barrier, the role of nature conservation law was perceived differently. With regard to the revision of the legal framework, the introduction of a subsidy for the establishment of agroforestry systems received strong support, while other measures such as promoting advisory services and fostering value chains for agroforestry products were additionally named by the interviewees.

Conclusions
Our results highlight that views on the legal framework for agroforestry are closely intertwined with understandings of agroforestry and associated nature's contributions to people. These divergent views need to

be addressed in law, if the law is supposed to steer agroforestry development in Germany and Europe. Next to addressing subsidies for agroforestry, especially the relationship between newly established and existing traditional agroforestry systems and other woody landscape features might need to be addressed to avoid conflicts and overcome legal insecurities.

Keywords
governance, adoption constraints, Agroforestry system, nature conservation law, agricultural policy, orchard meadows, CAP Strategic Plans

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Scaling agroforestry through Payments for Ecosystem Services: A scoping review

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Agroforestry is a Carbon Dioxide Removal (CDR) method with technological readiness and notable removal potential. Payments for Ecosystem Services (PES) have been discussed as a policy instrument to overcome barriers to agroforestry adoption and already enjoy wide application. This study reviews the literature concerning PES and agroforestry to elucidate the position of the subfield within the broader PES literature and identify its thematic foci. It further assesses its empirical evidence regarding PES effectiveness and its determining factors. Effects are ecosystem services, economic and social effects such as income changes and equal participation in the PES scheme, respectively. The results suggest that the subfield is rather small compared to PES and forests or agriculture with a focus on the Global South, especially Latin America. The subfield emphasizes carbon sequestration as an ecosystem service but not its financial remuneration. The empirical evidence suggests that PES can in fact serve as an effective policy instrument to enhance agroforestry systems with respective ecosystem services and co-benefits for farmers. Cash payments and technical assistance are highlighted as most important drivers for the provision of ecosystem services, among multiple other factors and conditions. Farm-level characteristics, like small farm size, high entry requirements or low cash payments are the key barriers to PES scheme enrolment. Apart from establishing appropriate conditions for PES effectiveness, more targeted PES can increase their cost-effectiveness and make agroforestry ecosystem services more competitive to impact investors. A supportive political-legal framework and additional public funding for PES in support of agroforestry can further contribute to scaling agroforestry.

Keywords
review, incentives, carbon sequestration, Agroforestry, Payment for Environmental Services, Policy, Literature review, payments for ecosystem services

Dealing with the complexity and variety of agroforestry systems: a proposition to categorise scalable agroforestry systems in the Netherlands

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2 Wageningen University & Research, Wageningen, The Netherlands

Agroforestry is characterised by a wide variation of types of systems, applications, and configurations. This intrinsic diversity offers many opportunities to design agroforestry systems that meet the specific needs and goals of farmers, as well as the challenges and opportunities of different local contexts.

However, the diversity of agroforestry systems can often lead to confusion and misunderstandings. It is well-known that farmers and other stakeholders may have different understandings of the term "agroforestry", which leads to a lack of efficient communication and understanding and can hinder the development of agroforestry. In addition, the diversity of agroforestry systems makes it difficult to make concrete statements about the financial feasibility of agroforestry, and its contribution to ecosystem services, such as biodiversity, water quality, and carbon sequestration. To put it simply: agroforestry systems are too different to make generic statements about them.

The public – private partnership research project Verdienmodellen Agroforestry (Development of Agroforestry-business models) focusses on business models of agroforestry and has proposed a categorisation of agroforestry systems in the Netherlands. The eight proposed systems are:

a) Functional hedgerows in arable systems (windbreaks, buffer strips and shelterbelts to support arable production with minimal direct production from the trees)
b) Alley cropping in large-scale arable systems(silvoarable system as above, but with productive tree rows that provide direct financial value, with wide spacing to give room for arable production)
c) Alley cropping in small-scale arable systems (silvoarable system with focus on the production from productive trees and with a smaller role for arable production over time)
d) Grazed orchards (silvopasture with standard trees or trees for wood production in a square planting pattern combined with livestock)
e) Alley cropping with pasture (silvopasture with productive trees in rows combined with pasture)
f) Fodder trees and hedges(silvopasture with fodder trees on pasture with grazing livestock)
g) Tree-planted free-range areas for poultry (free-range areas planted with productive trees and shrubs to provide shelter)
h) Productive food forests in rows (Food forest systems with perennials planted in rows to facilitate mechanisation and harvesting and a minor role for arable production)

These systems were selected because they are currently most common in the Netherlands, likely to be scalable for Dutch agriculture, fundamentally different from each other and together cover the majority of current agroforestry initiatives in the Netherlands. These eight systems cover the agricultural sectors in which agroforestry is currently most adopted. Between the different systems the economic role of the woody crops in the system differ, making these 8 suitable for different intensities of production. In practice, there will be many intermediate types of the mentioned systems, and within each system there are countless subcategories. For example, within each system there can be variation in levels of complexity (e.g. diversity of tree species).

Agroforestry systems for pig farms or small-scale agroforestry systems for market gardens also may have great potential, but have not yet been taken up in this categorisation, because these are not yet very much known and researched and are therefore not (yet) considered scalable. In the future, other interesting types may develop that are not yet clearly in sight. The categorisation is therefore explicitly intended as guidance for the understanding and quantification of common agroforestry systems and is not intended as a blueprint for farmers.

This categorisation helps to overcome a number of barriers:

a) Firstly, it provides a comprehensive overview of the variation and possibilities of agroforestry in the Netherlands. This will break down the 'single image view' that different stakeholders may have on agroforestry.
b) In addition, agroforestry farmers might identify more with the specific type of systems than the term agroforestry in general, as it is such a broad term.

c) This categorisation provides guidance for policymaking by showcasing the different types of agroforestry, making it easier to see which type of system might be desirable in a specific landscape. For example, in open landscapes, where high tree-density agroforestry systems are not desirable, but low tree-density systems may contribute to the realisation of area-specific goals.
d) Additionally, it provides perspective for research, as it can provide a certain structure in agroforestry research and enables streamlining discussions about the effects of different systems on e.g. business models and ecosystem services.

In the coming period, it will be considered how these categories can be linked to crop registration and the Dutch CAP.

Keywords
Policy, agroforestry monitoring, design, Agroforestry, Socioeconomic status, agroforestry practices, temperate agroforestry, land-use classification, agricultural policy

3.4 Scaling Up of Agroforestry Innovations

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Orchard meadows: recommendations for maintaining a valuable land use system by stakeholders in Brandenburg, Germany

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2 Äpfel und Konsorten - Streuobstwiesen und -äcker e.V., Storckow, Deutschland
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4 University of Göttingen, Department of Agricultural Economics and Rural Development, Göttingen, Deutschland

Orchard meadows represent a traditional agricultural system in Central Europe that is a product of multifunctional land-use practices. For a complex set of reasons, orchard meadows face economic and agricultural challenges, which is more evident in the study area of Brandenburg, compared to Southern Germany. The current extent of orchard meadows in Brandenburg can only be estimated, as no official statistics exist. Only a fraction –around 16,000 trees located on 56 farms – received funding within the 2nd Pillar of the CAP's agri-environmental schemes. The overall estimate for traditional orchard meadows in Brandenburg is 600 ha. Inadequate support measures and the regulatory framework are seen as the main factors in a continuous decline in orchard stands making it a threatened land-use system. Climate change and its consequences, droughts, weakened trees, pests, and diseases are taking their toll. The necessity for maintenance and preservation of this land use system, especially in view of the biodiversity crisis, highlights the need to find adequate solutions to preserve the ecological and cultural services provided by remaining orchards, emphasizing their potential as a climate mitigation possibility. There is a chance that new types of orchard meadows can evolve in the context of panning, establishing, and funding modern agroforestry systems.

In close collaboration with the ongoing research project "New perspectives for orchard cultivation", funded by the Ministry of Agriculture, Environment and Climate Protection Brandenburg, expert knowledge was evaluated and classified, to create a deeper understanding of what is needed for the preservation and development of orchards as a traditional agroforestry system. The DPSIR model (Driver, Pressure, State, Impact, and Response) is applied to analyze the governance structure of orchard meadows. In a multi-stakeholder approach, the evaluation of 13 guided expert interviews in Brandenburg explores the socio-economic factors that cause orchard meadow decline and derives solution approaches. The qualitative content analysis is processed in MAXQDA.

The results of the study give valuable insights and answers to the questions of how orchard meadows can be managed and maintained under current ecological and economic conditions with a distinct focus on the climate crisis and its effects. New management practices, innovative approaches in marketing, adapted funding and regulatory framework conditions, and the promotion of biodiversity are essential to preserve orchards as valuable biotopes. An adaptation of the regulations regarding management aspects such as fertilization, plant protection, and irrigation could be necessary under the changing conditions of climate change. Better acquisition and more supportive maintenance are necessary to give farmers incentives to remain existing and create new orchard meadows. A combination of orchard meadow funding with other eco-schemes could have a supportive effect. The integration of new species and the production of valuable timber in the orchard system is recommended to spread the ecological and economic risk. New types of orchard meadows in terms of cultivation, regulation, and funding are discussed (Figure 1).

The increasing interest and support for agroforestry systems provide new opportunities to revitalize and establish new types of orchard meadows. Hence, "extensive fruit orchards as permanent crop" and "fruit-based agroforestry systems" are pointed out to further develop orchard meadows. The collaborative development and publication of recommendations for action involving all stakeholders through targeted training and further education measures in the context of orchard cultivation, orchard maintenance, and modern agroforestry concepts are a core element to coincidently achieve food production, climate adaptation, and nature conservation.

Keywords
agricultural policy, orchard meadows, Land Use Policy, Germany, DPSIR model

Aditional Attachment II.

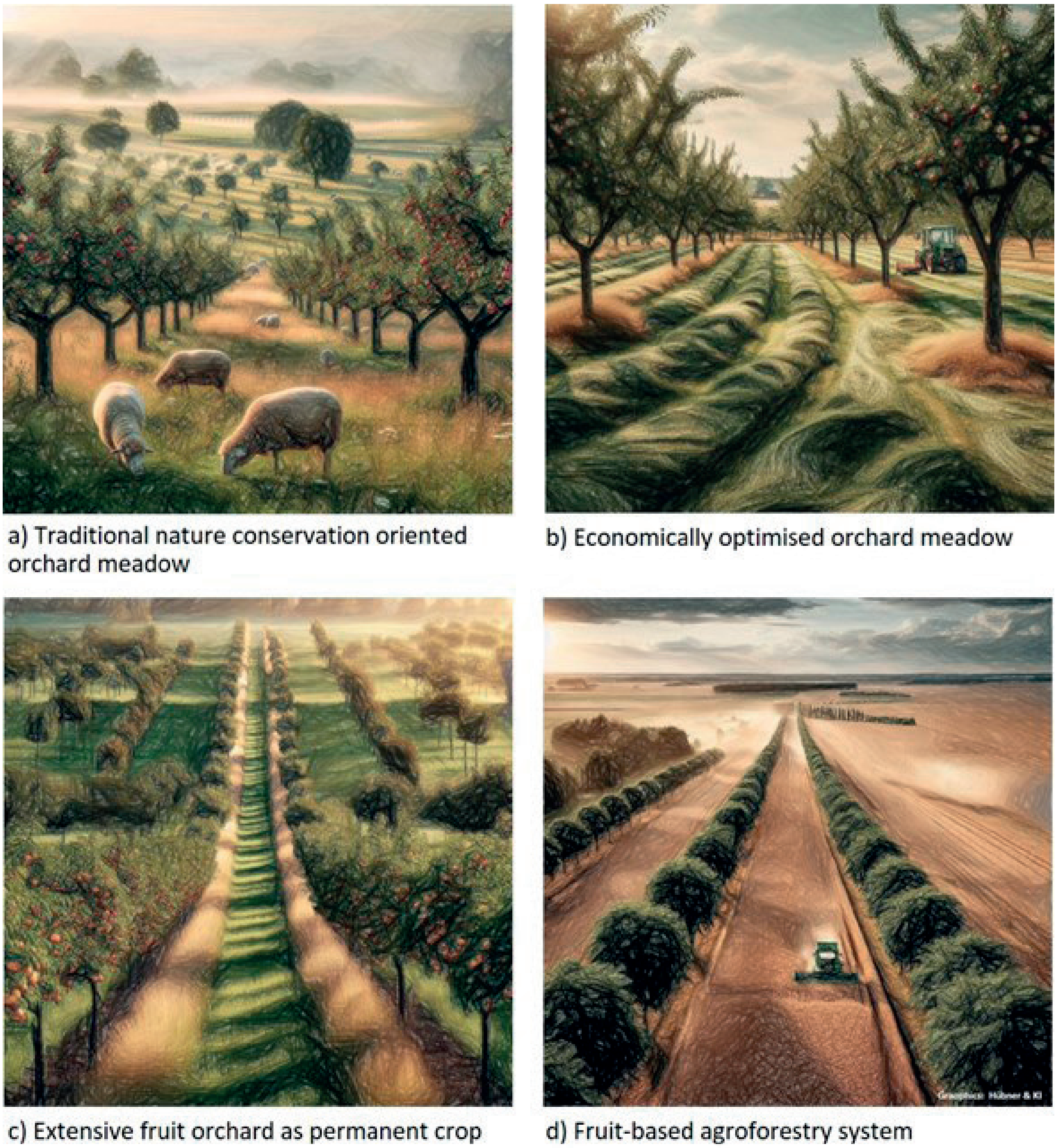

Figure 1: Systematics of orchard-related land-use systems in Germany

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Fostering agroforestry farmers' connections in the Iberian Peninsula with a Thematic Social Network

Diana Jiménez-de-Santiago[1], Dr Jaime Coello[2], Mr Nicolas Minary[3], Jacob Threadgould[4], Manuel Bertomeu[5], Jessica Pinto[3], Dr Andrea Casadesús[1], Dr Josep Crous-Duran[4]

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All over the world, farmers are increasingly adopting agroecological methods to protect their soil, promote biodiversity, and strengthen resilience in adaptation to climate and market challenges. However, these farmers (who are open to) adopt new practices are still a scattered minority, which hinders their possibilities for communicating, exchanging experiences, and knowledge-sharing with their pairs. Taking advantage of the current technologies, thematic social networks can play a relevant role in connecting farmers with shared interests. These tools are particularly effective when facilitating connections across diverse actors within specific value chain sectors, a niche sub-sector (i.e., a given crop or agroecology approach), and when acting as a bridge for individuals who may not otherwise interact face-to-face. Landfiles (https://landfiles.com/) is a French application that aims to "support and accelerate the development of new agroecological techniques." It is a free collaborative platform based on tailored groups and categorised in multiple different ways, including by geography, crop type, and farm type.

Landfiles allows its users to share information, observations, and knowledge about their land and operations, including research, studies, pictures, reports, and experiments. As other social networks, the app lets the members post, react, comment, and share information. The aim is to connect farmers who are active (or interested in) agroforestry and mixed farming, both between them and with the emerging consulting and research community on this topic. It is therefore intended to facilitate interactions within the platform and beyond, including periodical web-based meetings to discuss specific issues between the group members, and other activities that the members find interesting to organise.

In April 2023, a group called "Comunidad de sistemas agroforestales y cultivos mixtos" (Community of agroforestry and mixed farming systems, by its name in Spanish) was launched in the framework of Transition (https://www.transition-med.org) and LIFE AgroForAdapt (https://agroforadapt.eu) projects, who were joined in November 2023 by two additional EU-funded projects: Agromix (https://agromixproject.eu) and DigitAF (https://digitaf.eu) and is open to further members, projects, and entities to join. The group is devoted to agroforestry and mixed farming systems in the Iberian Peninsula. Currently (January 2024), it has contributions in Spanish, Catalan, and Portuguese hosting 100 members. From them, 74% are classified as farms (n=74) and the remaining 26% (n=26) are researchers or practitioners. Farms members are distributed in 9 out of 17 Autonomous Communities of Spain (95%), with Catalonia at the top of the list, followed by Castile-Leon, hosting 62% and 15% of them, respectively.

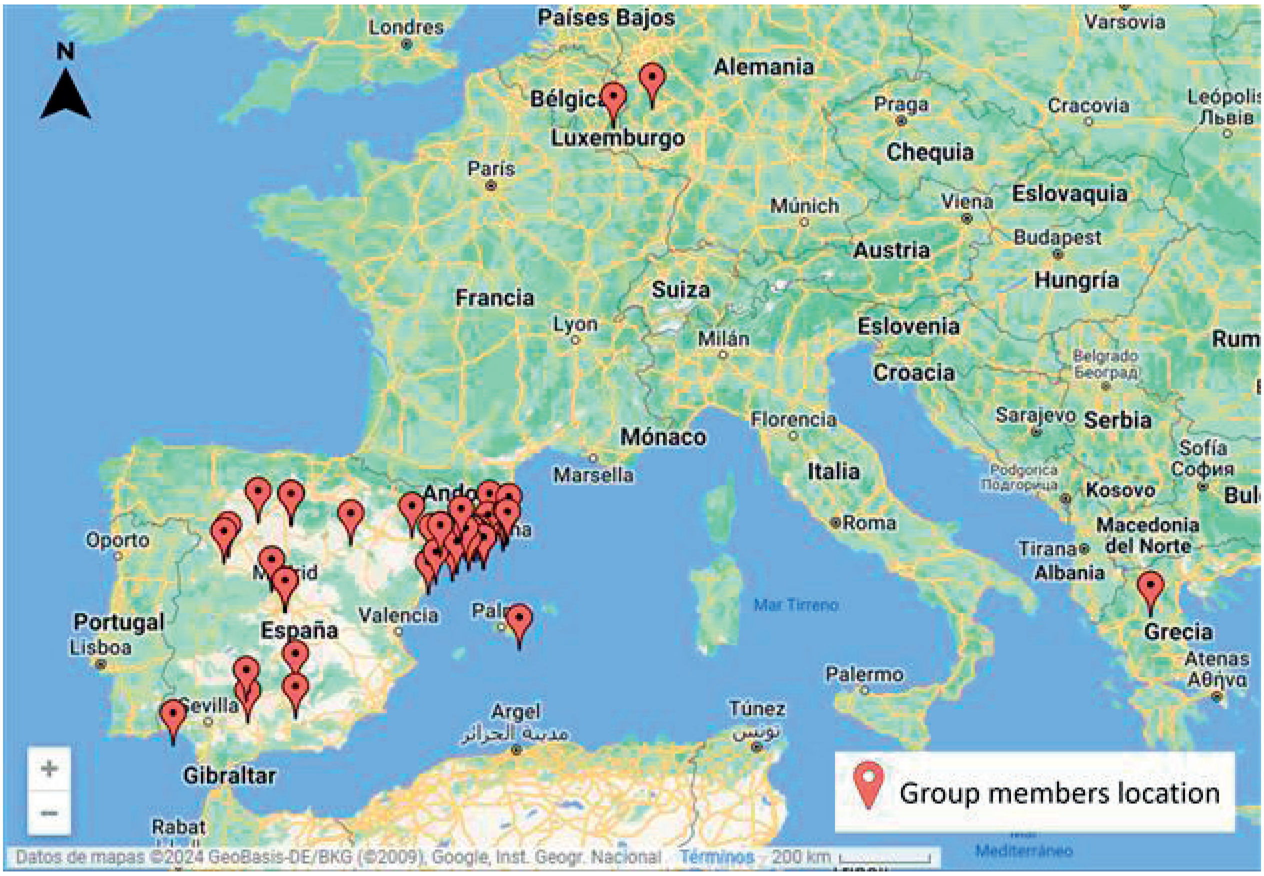
Up to now, the group "Comunidad de sistemas agroforestales y cultivos mixtos" has shown the diversity of activities and crop combinations in the Iberian Peninsula. It is being useful not only for farmer interaction but also for connecting different projects with similar interests in agroforestry and mixed farming systems. Currently, these projects are fostering the group, creating content (posting, commenting, etc.), and facilitating new farmers to register and make their first posts. In the near future, the aim is to leave the floor to the farmers to enhance peer-to-peer interaction and empower them taking the lead of this group, so that it will be autonomously managed at the service of the agroforestry sector.

Acknowledgments

- LIFE AgroForAdapt Project (LIFE20 CCA/ES/001682) is financed by the LIFE Programme of the European Union
- Transition Project (PCI2021-121959) is financed by the PRIMA Call 2020, Work program Topic 2.2.1
- DIGITAF Project 101059794 is financed through the HORIZON-CL6-2021-CLIMATE-01 Action of the European Union.
- AGROMIX Project.

Keywords
know-how transfer, farmers' motivation, Mediterranean resilient agriculture, Iberian Peninsula, Agroforestry systems, mixed farming, producers' group, online tool

Aditional Attachment II.



Theme 4: Agroforestry in Society and Culture

4.1 Education, Training, Dissemination and Promotion (I)

Oral presentations

Hall Q3, 29 May 2024, 15:45–17:15

E-Academy Agroforestry: Design and development of an agroforestry e-learning tool for Flanders and the Netherlands

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Introduction

Knowledge dissemination is key to introducing agroecological approaches such as agroforestry to farmers who wish to transform their conventional agricultural system into a climate-resilient one. At the moment, a handful of universities in the Netherlands and Flanders (i.e. the University of Amsterdam2, Ugent3, and Wageningen University4) offer agroforestry courses to their students. Outside universities, course materials relating to agroforestry exist but these are often scattered, paid, time-limited, and/or English services offered by consultants and small companies. This could create a barrier, causing individuals to be less inclined to learn more about agroforestry. However, teaching and learning resources about agroforestry should also be accessible to farmers and e.g. horticultural schools. This is why the EU-Project FarmLIFE created the 'E-Academy Agroforestry' which is a free accessible online learning platform about agroforestry.

Objectives

The E-Academy Agroforestry aims to make teaching and learning resources about agroforestry accessible to and suitable for farmers, consultants, agriculture students and teachers, policymakers, agrotechnicians, tree nursers, volunteers who work in the sustainable agriculture segment, and other agroforestry enthusiasts. Secondly, we want to guarantee flexible tools without (financial) barriers. The E-Academy Agroforestry remains a free and open-access tool that is available on the Agroforestry Planner website1. To guarantee flexibility, the E-Academy has no compulsory order and the student is free to explore an e-module to learn more about one topic or to follow the entire series of e-modules chronologically. The latter option should guide people who start from traditional agriculture to become aware of the possible agroforestry options for their farming system. Lastly, we opted to get insight into how people experienced the content and user-friendliness of the e-modules for which we added evaluation forms in the testing phase of the E-Academy.

Methodology of developing the E-academy

The set-up of the E-Academy follows the path of the participating farmers from the FarmLIFE project5, in which the participants were encouraged to understand how different components within agroforestry systems interact to create a design that meets their farm's needs. However, adaptions had to be made for the online environment. We secured the constructive alignment6 to design a learning experience with e-modules that follow logical steps, offering both knowledge and advice5. Because of the self-paced and asynchronous learning, there is no learner-instructor interaction in this E-academy. Nevertheless, it was shown that learner-learner and learner-content interaction are more predictive for online learner engagement, with an emphasis on learner-content interaction8. To get insight into how people experienced the content and user-friendliness of the e-modules, approximately 300 farmers, policymakers, and other interested were invited to review the first version of the e-modules.

Results of using the E-academy

For those who wish to learn more about agroforestry at their own pace and in their free time, the E-Academy Agroforestry offers six e-learning modules about the following relevant topics:

- e-module 1: What is agroforestry?
- e-module 2: Ecological interactions between trees, crops, and animals
- e-module 3: Tree species selection
- e-module 4: Planting techniques and tree management
- e-module 5: Agroforestry Vision: set strategic goals and dreams
- e-module 6: Agroforestry design

These six topics should equip the E-Academy student with theoretical and technical knowledge that can be implemented in starting new agroforestry practices, guiding people who want to implement agroforestry on their farms, and/or understanding all the steps involved in implementing agroforestry systems in general. Overall, the E-Academy Agroforestry offers easily accessible and bundled knowledge on agroforestry in Flanders and the Netherlands. This could contribute to the awareness of the possibilities of the transition of conventional agriculture towards climate-resilient agroforestry farms in these countries.

Regarding the evaluation of the e-modules, 96 out of approximately 300 people responded positively and received the link for evaluation. Surprisingly, the number of views was higher than

expected: e-Module: 1 (172 views); 2 (97 views); 3 (57 views); 4 (26 views); 5 (51 views); 6 (28 views)). This can be explained by the fact that the e-modules were accessible to anyone visiting the Agroforestry Planner during the review period. In the evaluation form, the respondents were asked to rate (1-5) the e-module that they finished. Even though only 42 respondents filled out the evaluation forms, there were still people inquiring about participating in the review after closing the review opportunity. In the end, the e-modules resulted to be sufficient each (Fig. 1), indicating that the E-Academy is right on track.

Conclusions

This E-Academy Agroforestry stimulates interaction with the course content by offering text, images, interactive exercises, instructional videos, and videos with farmers. The number of views shows that there is a great interest in such a tool. Interaction with other e-learners is not directly possible through the course itself but is promoted by stimulating the learners to actively participate in agroforestry-related events and to link to local agroforestry networks.

Keywords

education, e-learning, agroforestry system planning, online tool, Dissemination, online course, training, higher level education, Agroforestry

Aditional Attachment I.

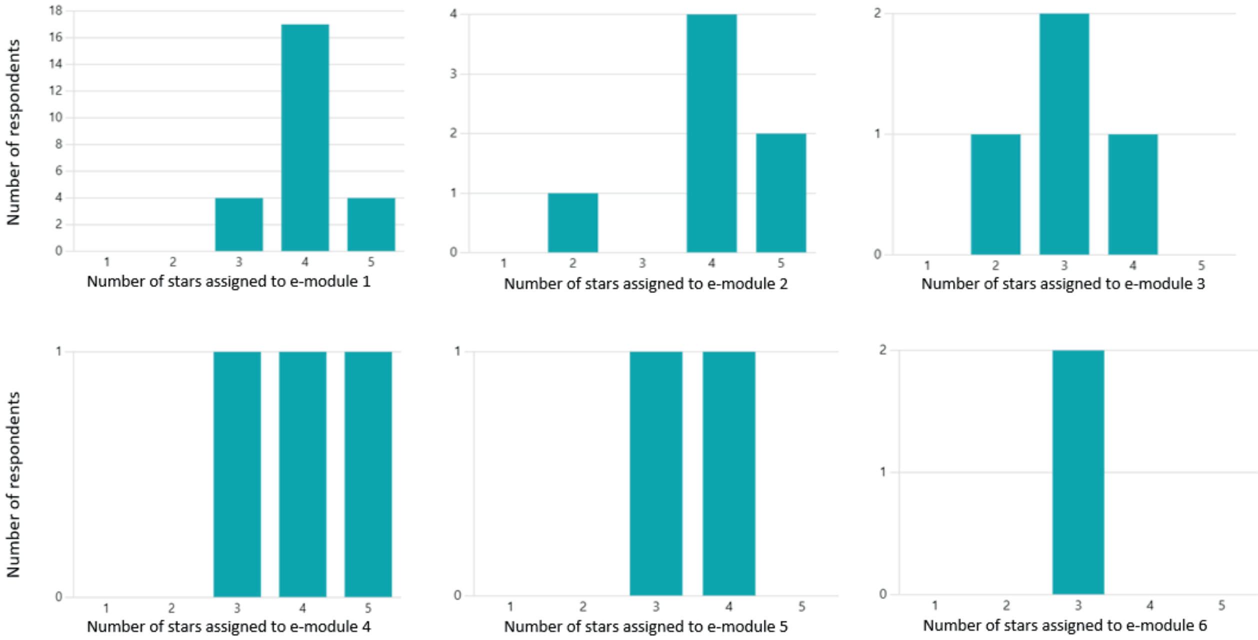

Figure 1. In the evaluation form, the E-Academy student was asked to assign stars (between 1 and 5) to rate the e-module that they finished. The six graphs represent how many respondents gave a certain number of stars to each e-module. The following average scores were obtained: 4 (e-module 1); 4 (e-module 2); 3 (e-module 3); 4 (e-module 4); 3.5 (e-module 5); and 3 stars for e-module 6.

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Yanqing Wang, Yang Cao, Shaoying Gong, Zhen Wang, Na Li, Li Ai (2022) Interaction and learning engagement in online learning: The mediating roles of online learning self-efficacy and academic emotions, Learning and Individual Differences vol. 94

Mobilizing local stakeholders to develop more resilient farming systems – the example of the agroforestry living lab in the lower Rhine area, Germany

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Introduction

Intensive agricultural production causes significant challenges across Europe. Unsustainable farming practices cause erosion, contribute to the loss of nutrients and soil organic matter, and lead to sedimentation and pollution of river systems in many parts of Europe (Karamesouti et al. 2015; Van Oost et al. 2009). While consumers are attaching increasing importance to the compliance of the food they consume with social, ecological, hygienic, and ethical production standards (Grunert 2017), the diversification of farming systems can also increase the economic resilience of agricultural producers (de Roest et al. 2018).

Against this backdrop, the purposive integration of trees with arable crops and/or livestock on the same land unit has great potential to reduce the environmental impact, and to strengthen the ecological and economic resilience of farm enterprises. What could provide business opportunities through the generation of a set of new products, such as high-value fruits and nuts, is still for the Lower Rhine producer surrounded by uncertainty due to the lack of technical information on the efficiency of local agroforestry practices. Seeking to fill this gap, the regional living laboratory promotes agroforest systems through multidisciplinary research work.

Objectives / research questions

The paper aims to present the concept of an agroforestry living lab, designed to co-create, jointly investigate with land users, and to promote locally adapted agroforestry systems in the lower Rhine area, Germany, using case study examples. Starting from an analysis of the stakeholder landscape, the paper presents the transdisciplinary research methodology employed by the living lab and the project objectives and activities pursued over its lifetime, and initial results. The presentation thus aims to encourage the exchange of best practices, obstacles and lessons learned, and inspire the work of similar initiatives elsewhere in Europe.

Methodology

The project is based on a participatory living lab methodology for agroforestry systems, which consists of a transdisciplinary cycle of five components, i.e. (1) planning the implementation and/or maintenance of the systems, using the six core principles, relevance, restoration, respect, reciprocity, responsibility, and relationship (The Living Lab Project 2024), (2) concept design with advice on the best arrangements and the most appropriate trees, (3) experimentation, (4) validation by monitoring and evaluate results of sustainability indicators and finally (5) commercialization or market analysis of the products produced in the implemented systems (Ståhlbröst and Holst 2013). The planning phase was established by the team as the first step, because the university already had contact with a group of farmers and public institutions interested in implementing agroforestry systems. In addition, the indicators were based on the Sustainable Development Goals for data collection and consultation of secondary sources.

Results

Since its inception in January 2023, stakeholder interactions have taken place that involved more than 30 agricultural producers, municipalities, agricultural advisors and extension organizations, interest groups, and further value chain stakeholders in order to gain as much information as possible about the underlying circumstances of farming in the Lower Rhine region. The interactions were individual and collective, stimulating a continuous and communicative approach to build trust and confidence between the stakeholders.

Once the partners had been defined, we organized a workshop on the planning and design of agroforestry systems, thus beginning the first and the second stages of the living lab's participatory methodology. Every agricultural producer made an individual decision on the type of agroforestry system to be implemented on their land based on own ideas and resources. At the moment we have two partners who have already implemented agroforestry, two in the planning phase and one in the design phase.

Further, the municipality of Kleve and the Chamber of Agriculture also came on board as partners, providing an area to establish a pilot project as a prototype for flexible field experimentation testing combinations of annual plants and trees for the farmers of the Lower Rhine. Soil preparation is planned for September and tree planting for autumn of this year. All agroforestry areas are documented as of 2024. In parallel, we have been working since January on the definition of monitoring indicators and data collection for each system in collaboration with our partners.

Conclusions

After approximately one year of existence, the first two components of the agroforestry living lab methodology at the lower Rhine region are in the process of being finalized. Planning is understood as choosing the area and the main crops of the agroforestry system to be produced and marketed in the future. Design is the configuration of the system itself and the arrangement of the different species that will make up the system.

Although the project has only just begun, the living lab has already attracted considerable attention among farmers and the civil society, demonstrating the general openness and interest towards agroforestry systems. With the first few farmers having established agroforestry systems on their land, a strong basis for further research and dissemination of this land use type in the region is available.

Keywords

know-how transfer, collaborative research, agroforestry value chains, participatory research, Living Laboratories, Living lab

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Agroforestry map of Europe – moving from a basic map to an advanced database

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Mapping of agroforestry examples revealing information on trees and shrub species and their combination with animal husbandry and crops, including planting layout, business strategies, and respective photographic impressions is of great interest to the public, experts, and farmers.

To further spread the concept of agroforestry as a promising land-use system and convince farmers by learning from the experience of their peers, the European Agroforestry Map was initially developed in the AGFORWARD project (2014-2017) (Palma, Crous-Duran et al. 2015, Burgess and Rosati 2018) and continued by EURAF (2024). In the meanwhile, organizations in several EU countries and regions developed databases and maps within their activities, such as in France, Flanders, and the Netherlands, or by partners in the LIFE AgroForAdapt (2024) project for parts of the Mediterranean. The attempt of the new agroforestry map of Europe is to bring these activities together in a uniform layout to summarize, visualize, and explore the online map across Europe and in English language.

There are different types of stakeholders characterized on the map: interested parties (the ones currently thinking or planning agroforestry systems), farms, and educational/information organizations. Specific information is requested from the user for each user type. There is the option of uploading photographs. Depending on the information provided in the online form, the interested parties are assigned to different categories. The categories are displayed as colored symbols on the map.

While the regional approach using the native language as GUI is continued, standardized categorizations and a uniform database structure together with the use of botanic names and English translations allow for a uniform display of an EU map and evaluation. Funded through the REFOREST project and with the support of the project collaborates in the DIGITAF project is collected, verified, and processed in one database (Figure 1). Based on the experience of the German agroforestry map since 2019 (DeFAF e.V. 2023, DeFAF e.V. 2024), with 142 registered agroforestry sites by the end of 2022, and by using the latest programming technique, an updated online map will be created and its use promoted among national agroforestry associations. To capture the experience of various mappings, an interactive online document to develop the map categories was set up and commented on by the participants. Furthermore, the resulting map features several improvements, both for the user as well as for the administrators. To mention a few: any newly uploaded photo will automatically resized and watermarked to mark its source from the map. Entries can be added from persons interested in setting up an agroforestry system. Such entries can later be changed into an established system on the map. Any alterations by the user will be screened through an administrator needing confirmation. This greatly shifts the responsibility from the organization to the users and makes the map more interactive with the users. The update also involves further improvements to prevent fraud through an email verification procedure and all measures necessary to fulfill data protection legislation. The users decide which personal information should be displayed on the map.

To conclude, the new agroforestry map of Europe will distribute the burden of entries towards individual users, however, will be managed through national or regional responsible persons. The resulting map data is better protected and its management is structured and transparent. The user experience should be increased through a straightforward GUI and various possibilities for searching, filtering, and viewing.

This abstract is based upon work from project REFOREST and DIGITAF, which received funding from the European Union´s Horizon Europe Programme under Grant Agreements No. 101060635 and No.101059794.

Keywords
Europe, agricultural policy, Land Use Policy, Adoption, European project, Agroforestry Map of Europe, Agroforestry

Aditional Attachment I.

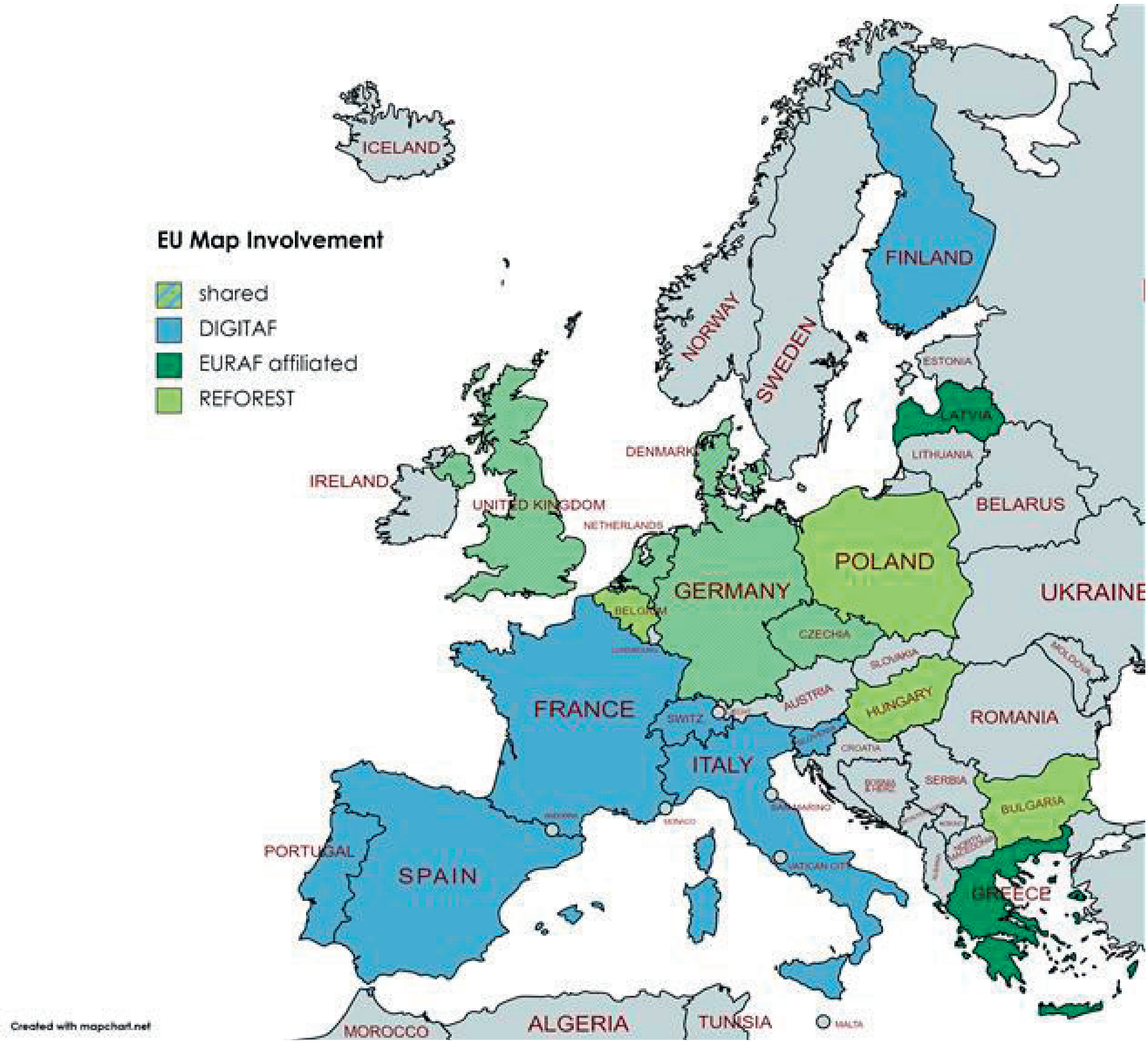

Figure 1: Country map of Europe highlighting the involvement of EU-project partners in DIGITAF and REFOREST in developing and collecting information for agroforestry map of Europe.

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An Agroforestry Network in Evrytania region: Farmers Experiences and Adoption

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Evrytania is one of the most mountainous regions in Greece with forests, rangelands, geological formations, and natural water reservoirs forming a landscape of unique beauty and natural value. A major part of the agroforestry systems in the region are silvopastoral, integrating woody vegetation with crop and/or animal systems to benefit from the resulting ecological and economic interactions (Mosquera Losada at el. 2020), with local farmers representing an important component. However, as most remote areas in the country, Evrytania's depopulation have lately reached alarming rates since most young people move to bigger cities and lowland regions. This and the preservation of its traditional agroforestry systems were the major reasons that Evrytania was selected to be included in the three-years European project AF4EU activities in Greece, promoting agroforestry through the development of an interactive, innovation-driven, and multi--actor agroforestry network. The AF4EU Consortium is composed by 12 partners from 10 different countries and counts with the contribution of 5 associations. The aim of this article is the present the results obtained by the 1st RAIN workshop of the project.

Under the framework of the project a Regional Agroforestry Innovation Network (RAIN) in Evrytania was established, composed of livestock breeders and beekeepers, focusing on building awareness among a broad range of stakeholders working in rural environment and the positive impacts of different types of agroforestry systems on their production and environmental services. Special focus was placed on promoting the systems and training farmers, landowners or people working on farms to further establish and implement agroforestry systems on their landholding.

The 1st RAIN Workshop was organized in summer 2023. A total of 28 actors attended this RAIN meeting while two more will be organized in the future. A survey distributed during the workshop identified the main characteristics of the participants who were classified into different groups: 1) Farmers, 2) Policy makers, 3) Advisors, 4) Researchers and 5) Other categories (meat traders - butchers, cheese makers, restaurateurs, and consumers) (Figure 1), with 29% being practitioners (farmers/beekeepers) and 30% advisors. The farmers were classified in 2 groups: sheep and goat breeders and beekeepers. The largest proportion of the participating farmers were older than 30 years old, with 57% of the total belonging to the age group of 35-44 while 36% where 55-60 years old. Only the 7% of the participants belonged in the age group of 18-24 years old. This element highlights the need to address the younger age groups of farmers and strengthen their choices to work in the agroforestry sector by choosing to reside permanently in the mountains of Evrytania.

Figure 1. Representation of stakeholders who attended the 1st Evrytania RAIN in 3rd July 2023

Most farmers who participated in the first workshop were technical education graduates while 78% had compulsory education. Their common educational basis allows them to feel safe to express their concerns or weaknesses in approaching scientific issues and strengthens them as a team. All were local as reflected by the percentage (67%) of those who live permanently in the mountain villages and by the percentage (33%) of those who live in the small town of Karpenisi.

Only 22% of the participants had a previous knowledge of Agroforestry. The 78% had not heard this term before, despite being aware of the use of woodlands as pasture. Farmers as a whole expressed an interest in learning more about agroforestry and the silvopastoral systems linked to the land use they already practice. The farmers' choices are summarized in two options: the option "more face-to face" meetings garnered the percentage 56% of preferences and the option "more field trips" garnered the percentage 44% of the preferences. 50% of the farmers prefer short videos as a material for learning about practical agroforestry applications. 17% of them prefer long videos – documentaries and the same percentage choose scientific articles. Practice abstracts and technical articles gather 8% of their selections.

Picture 1. Group working in 1st Evrytania RAIN Workshop in Karpenisi

From an educational innovation perspective stakeholders highlighted the need of a "Booklet and Online Map of AF farms" and the "Lesson modules at all education levels". They, also highlighting the "Learning by doing… and by sharing: networking, and open days at farms". Finally, from a policy innovation perspective, the stakeholders prioritized the silvopasture as a land use management system for grasslands and the production of "Factsheets: current policy an AF at regional level".

The results of this meeting highlighted the need to further elaborate approaches to reach out farmers in more remote areas such as in Evritania and pinpoint the importance of projects such as the AF4EU.

Acknowledgment
This work was conducted as part of the Agroforestry Business Model Innovation Network - AF4EU - project, which has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101086563.

Keywords
silvopastoral systems, SustainFarms, education, sustainable food production, decision-making, wildfire risk, land use change, Environmental Services, silvopastoral, CAP Strategic Plans, Living Laboratories, Mediterranean socio-ecological systems, livestock production, Trees Outside Forest, extensive production system, pollinators, grazed woodlands, business opportunities

Aditional Attachment II.

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Enhancing Agroforestry Practices: The Landfiles Application's Journey in Knowledge Sharing and Collaborative Innovation

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Introduction

In the field of agroforestry, where expertise and innovation are paramount, Landfiles application (https://landfiles.com) aims to amplify the dissemination and knowledge of agroforestry practices. Aware of the importance of mutual inspiration among farmers, Landfiles is a digital tool that facilitates this exchange by allowing users to draw inspiration from the lessons learned and experiences of other farmers. Through this platform, we aspire to strengthen the links between sector actors and encourage adopting more effective and sustainable agroforestry practices.

Case description

Coming from a farming background, Nicolas MINARY identified the importance of sharing practices to break farmers' isolation and accelerate regional practice changes. Landfiles was set up in 2017 and began developing a mobile app designed to facilitate the exchange of knowledge between farmers. This interactive platform allows interactions between farmers and technicians, consultants, and researchers on this topic to develop and disseminate participatory surveys and experiments. The knowledge derived from these experiences is shared with all members, which is essential for technicians and farmers eager to deepen their understanding of agroforestry.

The platform growth/impact can be illustrated with several examples of groups in France, Spain, the Netherlands, and Italy, animated by various partners. We will provide detailed feedback on the method developed, which has enabled us to collect over 60,000 observations to date, including 20,000 photos on over 10,000 plots within private or public groups. This method has enabled the maximization of exchanges and the rapid dissemination of information. We will point out the key success factors and provide advice to replicate the experience in other geographical contexts, in any European country.

The platform unites nearly a hundred groups focused on agroforestry and agroecology. Most of these groups are private, and some have decided to open their access to the public.

Creating a private Landfiles group or joining a public one, farmers record plot information, privately or shared, exchanging knowledge and learning from peers.

In the attachment, you will find an example of a shared experience on setting up a fruit hedge, including valuable details on the techniques used and the results obtained. This interaction enriches the whole group and stimulates the adoption of new methods and approaches.

The app's customizable features, like data form creation, enable users to share structured practice information. This flexibility in data collection is essential to adapt the tool to the specific needs of each sector and working group. The ability to locate plots and follow the history of observations also allows collaborators within the same agricultural operation to share information with colleagues and partners.

The richness of the application also relies on its ability to generate data syntheses. With various tools such as maps, histograms, and personalized reports, users can not only visualize but also deeply analyze the information collected. These analyses help in making evidence-based decisions and continuously improving agroforestry practices.

In early 2024, the Landfiles app has nearly 9,500 registered users, with three-quarters being farmers and 90% located in France. These users are integrated into public or private working groups (90% of which are private). The public groups focus on agroforestry and agroecology, primarily within livestock farms, large crop farms, and vineyards, as well as to a lesser extent within market gardens. These publics groups have over 2000 observations and 3000 photos.

With technical institutes, associations, and businesses, we have developed data dictionaries specifically for experimentation in agroecology, compiling over 2000 references that will be made available to group facilitators who wish to use them.We have tested, improved, and deployed this method of group facilitation in France, and recently in Spain through a PRIMA project. With the Agromix project, we will be rolling out the app across Europe, launching on May 28th at the EURAF 2024 event. During this event, participants will be able to explore existing public groups through an automated translation system, and it will be possible to create and manage one's own network of farmers via the platform.

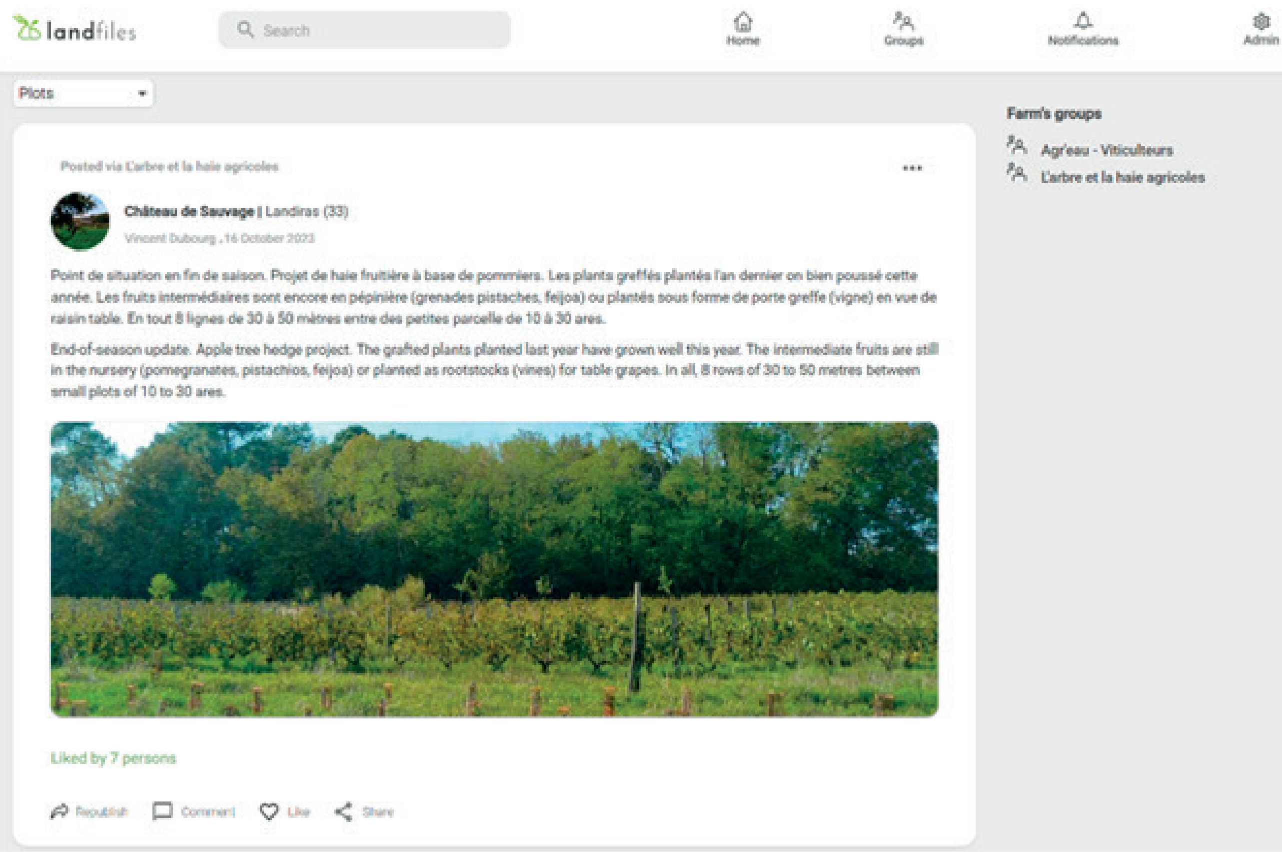
Conclusion

Landfiles is an innovative thematic tool designed to share experiences and methods with a wider audience and to organize participatory experiments easily. The intuitive interface enables the mobilization of communities of farmers and technicians around a specific issue. As developers of the platform, we would like to provide feedback on the developed methods and offer advice to replicate these successes in different contexts to foster the levers of success in farm management practices and promote agroforestry as an essential pillar of sustainable and resilient agriculture.

Keywords

agroecology, SustainFarms, knowledge synthesis, AGROMIX, Agroforestry, sustainable soil & water management, Agroforestry system, Open -innovation, participatory research, Analysis, collaborative research, ICT Platform, agriculture

Aditional Attachment II.



Paradigm shift of agroforestry in Slovakia: from an unknown concept to a concrete policy support scheme in less than 5 years

AnnaMaria Mitrova[1,3], Milada Šťastná[1], Ladislav Bakay[2,3]

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2 Slovak University of Agriculture, Faculty of Horticulture and Landscape Engineering, Nitra, Slovakia

3 Slovak Agroforestry Association, Slovakia

Introduction

Slovakia, once "a black hole of agroforestry", is one of the countries that managed to implement support for agroforestry in the National Plan of Common Agricultural Policy 2023-2027 (NP of CAP). Apart from this intervention, there has been a boom in local and regional projects, activities, and financial support from the private sector in the form of various grants. Nonetheless, the baseline situation was not favourable at all. In 2020, Ministry of Agriculture and Rural Development proclaimed, that it does not register any farmers practising agroforestry. In cooperation with various stakeholders, we have documented the gradual transformation of agroforestry in Slovakia. The shift in awareness, perceptions, barriers, and opportunities, and the genesis of concrete legislative measures, some of which are yet to be implemented.

Research Questions

(1) What is the state of knowledge of agroforestry in Slovakia?
(2) How is agroforestry perceived in Slovakia?
(3) What types of agroforestry systems are of interest in Slovakia and what should be supported?
(4) How to orient the educational activities of the Slovak agroforestry association?
(5) What are the barriers and opportunities for agroforestry in Slovakia?
(6) What legislative measures should be introduced in Slovakia?

Methodology

To develop appropriate strategies to systematically implement agroforestry practices and policies in Slovakia, an overarching study design was selected. The design adhered to a case study approach involving face-to-face surveys, online surveys, and focus groups over a 12-month period, between October 2022 and October 2023. Stakeholders' attitudes and perceptions towards agroforestry were collected in relation to three landmark events organised by the Slovak agroforestry association (SAA) (Fig. 1). This approach enabled recording the baseline before the first agroforestry conference held in Slovakia and the shift between events. The partial results also served as a basis for the preparation of further events, as part of the systematic promotion of agroforestry. Such an approach is valuable for generating context-dependent knowledge that facilitates future hypothesis and theory formulation (Starman 2013; Denzin 2023).

Results

Prior to the first conference, participants had low awareness of the term agroforestry. The answers in subsequent surveys, focus groups, and face-to-face interviews gradually gained in detail and expertise. Respondents identified the potentially most suitable systems for different areas of Slovakia and also connected them to various natural and socioeconomic conditions of the country. For example, overgrown agricultural land reverting to forest or so-called "white areas" and their use for silvopastoral systems were associated with rural regions, with uplands, and with the management of privately owned land by the respective farmer. State financial assistance for grazing restoration in these areas has been identified as one of the options to support implementation of agroforestry systems (AFS) and therefore to enable the transfer of the areas altogether, as this is a costly bureaucratic process, unprofitable for the farmer. Silvopastoral systems were also linked to protection and restoration of certain biotopes. Participants also stressed the need to not only allow but also actively support: the cultivation of fast-growing and non-native tree species, multilevel cultivation in combination with shrubs, and the overall management of trees in AFS – which remains to be prohibited. Among other barriers and challenges, respondents addressed the problem of the understanding of agroforestry itself, especially in decision-making positions and among the professional and general public. It was pointed out that the state authorities do not communicate sufficiently neither the upcoming changes nor the changes that have already entered into force. They perceive a reluctance to meet their demands, they do not feel listened to, and often feel literally bullied by the controls and restrictions. The participants considered the bureaucracy, to be the biggest obstacle to the adoption of agroforestry in

Slovakia. Among other systematic obstacles, they outlined the land regulations, and thus the overall ownership structure in the country, the lack of access to land ownership and long-term lease. Suggested legislative changes derived from the focus group, survey, and face-to-face interviews are displayed in Fig. 1.

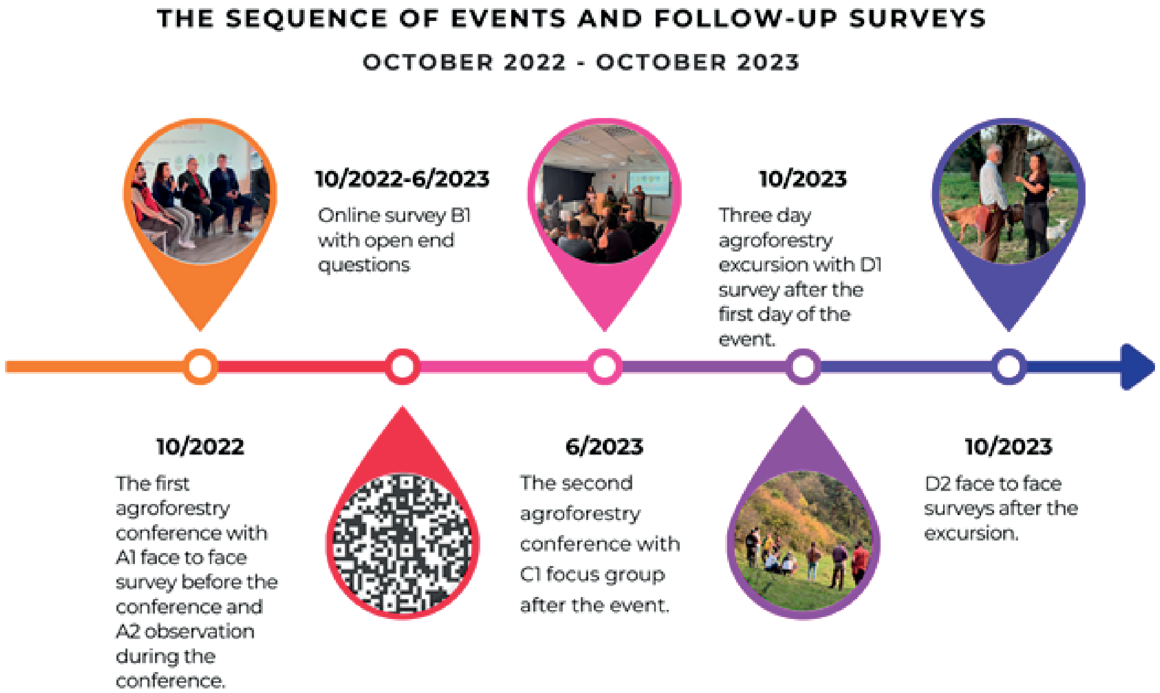
Conclusion

Slovakia has experienced a remarkable improvement in awareness of agroforestry during past years. The systematic approach to educational and lobbying activities, seems to have had a substantial impact on the recent development. This research outlined the state of knowledge, perceptions, barriers and opportunities, and the genesis of concrete solutions for agroforestry in the country. Nevertheless, there are still many obstacles to be tackled with, including the basic understanding of agroforestry as such. Integrating all stakeholders in the decision-making process, support of living labs and thus support of knowledge-based decision making is a crucial step for future advancement of agroforestry in Slovakia. Our research results can further endorse policy design and creation of more effective support systems.

Keywords

farmer perception, Dissemination, Policy support, decision-making, adoption constraints

Aditional Attachment II.



SUGGESTED CHANGES AND LEGISLATIVE MEASURES TO IMPROVE THE ADOPTION OF AGROFORESTRY IN SLOVAKIA

- Anchorage of the concept of agroforestry in the national legislation;
- Setting up supports based on knowledge-based interprofessional discussion, with positive motivation of farmers;
- Allowing the cultivation of economically interesting tree species, specifically fast-growing and non-native tree species such as autochtonous fast-growing tree species, hybrid poplars and black walnut;
- Financial support for the transformation of white areas into productive agroforestry systems;
- Introduction of a separate culture for agroforestry systems in the Land Parcel Identification System (LPIS);
- Clear and timely publication of guidelines by ministries and the Payment Agency on the measures to be taken, combined with the organisation of face-to-face and online workshops to improve accessibility for all;
- Establishment of accessible advisory services;
- Support for agroforestry initiatives at national level in the form of grants for both research and civil society organisations, focusing on support for Living Labs;
- Inclusion of agroforestry in the land consolidation process;
- Regulation of overpopulated game animals – deer;
- Introduction of management plans for agroforestry systems similar to those for forests;
- European Union's clear support of agroforestry over industrial agriculture.

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4.1 Education, Training, Dissemination and Promotion (II)

Oral presentations

Hall Q3, května 29, 2024, 17:30–18:00

Workshop: How can digital data and information tools increase the visibility of agroforestry and mixed farming to promote such systems among different stakeholders?

Matthias Baumann[1], Sara Burbi[3], Rosemary Venn[2], Martina Re[3], Paola Cassiano[3], Alberto Mantino[3], Dennis Touliatos[2]

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2 Centre for Agroecology, Water and Resilience, Coventry University, Ryton-on-Dunsmore, UK

3 Sant'Anna School of Advanced Studies, Pisa, Italy

Introduction

Agroforestry and mixed-farming systems are seen as promising agricultural practices that offer both adaptation and mitigation strategies in the face of climate change. Despite their potential for productivity and carbon sequestration, widespread adoption by farmers remains hindered by a combination of factors, such as inadequate policies, lack of financial support, technical expertise, and visibility. In order to address these shortcomings, stakeholder exchange and information sharing lays the groundwork to promote such systems.

The AGROMIX case study catalogue will be the starting point of the workshop and serves as an example of a digital data and information dissemination tool for farmers, scientists, policymakers, and others. This will provide an avenue to promote further collaboration with other European Commission funded projects, such as AGROMIX case study catalogue or Treefiles app or DigitAF.

Objectives / Research Questions

The objective of this workshop is to explore ways to increase the visibility of agroforestry and mixed farming in order to promote such systems among different stakeholders. Participants of the workshop will be assigned different stakeholder roles and will identify key information needs and use-cases of digital information tools for different stakeholder groups as well as discuss the feasibility of long-term operation and maintenance and possible synergies of such tools and initiatives.

The following questions will be investigated during this workshop:

- How is the catalogue used by different stakeholders? How can the user experience be improved?
- How can the catalogue be adapted to better satisfy the needs of the different stakeholders (purpose of the catalogue, missing content/data, or functions)?
- How can the long-term operation and maintenance of the catalogue be secured (motivation and solutions for data updating/mutation, IT infrastructure, process/workflow definition)?
- How can the catalogue and other digital data and information tools increase the visibility of agroforestry and mixed-farming and foster the promotion of such systems?
- How can different digital data and information initiatives/projects join forces or be linked to make use of synergies (AGROMIX case study catalogue or Treefiles app or DigitAF)?

Methodology

The 1 duration of the workshop is designed for at least 1.5 hours.

15' Explaining the AGROMIX case study catalogue to the workshop participants.

10' Open discussion on the needs of each of these 5 stakeholders. Then all participants will be split into different stakeholder groups, assigning each the best fitting role:

- farmer/practitioner/landowner
- extensionist/advisor
- scientist
- policymaker
- NGO

45’ Depending on the total number of participants, each group will contribute to two or three questions mentioned above. The participants will be asked to reflect on the questions given and brainstorm ideas and solutions and visualize them for example by drawing mind maps. Each group will be supported by a facilitator of the organisation team to keep progress and the time management on track.

20’ Afterwards, each group is asked to present their results and conclusions to all participants.

10’ A facilitator will summarize the outcomes from all groups and will draw general conclusions. At the end, possible next steps will be discussed before the facilitator wraps up the entire workshop.

The number of participants is unrestricted and is limited only by the size of the available room at the conference venue. Depending on the number of participants or the available time, the methodological approach will be adapted.

Materials

- Pens
- Markers
- Cards/post-its
- 5 flipcharts/(whiteboards)

Results

To make best use of the outcomes of the workshop for the participants, pictures of all the posters and produces will be taken, the results and conclusions will be summarized in a concise report and sent to all participants who have assigned on a list.

The results and conclusions of the workshop can be taken up at a speech during the EURAF 2024 conference to present them to a wider audience.

Conclusion

The participants will get an insight of the different needs of each stakeholder group regarding digital data and information tools. This should translate to improved future solutions adapted to each stakeholder. Thereby the workshop participants will be able to better promote agroforestry and mixed-farming systems by increasing their visibility. In the best case, this workshop will be an initiation to new initiatives or projects and forces are joined to create comprehensive digital data and information tools, adapted to the needs of different stakeholders and with durable maintenance and operation concepts. The groundwork laid in the workshop should be a stimulus to make strategies for long-term management and dissemination of data, information, and knowledge an integral part of future projects by creating ideas and providing guidance.

Keywords

European project, mixed farming, Agroforestry, Horizon Europe, Science Outreach, collaborative research, AGROMIX, Dissemination

Let's talk about trees: development of strategies for vocational training and communication about agroforestry in Germany

Julia Guenzel[1]
1 Defaf E.v., Cottbus, Deutschland

Introduction

The transformation of food systems is a major challenge when it comes to achieving a sustainable land use. With its multifunctional character and many advantages for society and nature, agroforestry has gained increasing attention as one solution for this. In Germany, several initiatives and research projects have targeted this sustainable land-use method in recent years, its effects and the options for incorporating agroforestry in the agricultural sector. However, despite its potential, the progress of adoption is yet slow.

In order to achieve changes in the food system a multi-dimensional perspective on how land-use methods can be transformed is essential (Leeuwis, Bookaard & Atta-Krah, 2021). Since agroforestry affects the interests of various stakeholders like farmers, political decision-makers, communities and the nature conservation sector (Huebner & Schulze, 2020; Kopplin & Sänn, 2020), it is essential to involve these actors directly when targeting the further promotion of agroforestry. In the frame of the project AgroBaLa, the German Agroforestry Association (DeFAF) aimed at an approach connecting the technical implementation of agroforestry with the continuous sensitization and training of relevant actors, so that new multipliers could be identified for further communication and training on agroforestry throughout the agricultural sector.

Case description

In the project region Lusatia, south-Brandenburg in Germany, farmers are increasingly struggling with agricultural productivity due to the mainly sandy and light soils low in nutrients as well as the progressive negative effects of climate change. Agroforestry, highlighted by the IPCC as one of the most important measures in the fight against climate change (IPCC 2023), has been introduced to the region several years ago, also because of its potential for restoring post-mining landscapes, which are widespread in Lusatia (Grünewald et al., 2007). Although several farmers have started to cultivate agroforestry systems, the broad adoption of this land-use system is dragging and also the acknowledgment of its potential seems to be limited on behalf of decision-makers and administrative bodies.

In order to consolidate the use of agroforestry in Lusatia as a model for other regions in Germany, the project AgroBaLa ("Agroforstry-based circular economy as a basis for a structural diverse and climate-resilient agricultural land-use with high added-value potential") aimed at elaborating new potentials for added value through agroforestry systems and at the same time developing new forms of training formats for various target groups relevant for promoting agroforestry. The goal was to create a knowledge base on the most effective ways for vocational training as a basis for enhancing the educational sector on agroforestry in the long term.

The project partners Brandenburg Technical University Cottbus-Senftenberg (BTU) as well as the farms of Thomas Domin and the ZGJ Landwirtschafts GmbH worked on the enhancement of their already existing agroforestry systems. Part of this was the experimentation with amongst others the production and application of biochar. As fourth project partner the DeFAF targeted the knowledge transfer and development of target-group-specific education and communication formats. The goal was to identify multipliers, who in the long term take on agroforestry as a core topic for sustainable transformation in agriculture.

To achieve this, several steps were taken. Based on an initial target-group analysis and an online survey on needs and preferences for educational offers, a number of different communication materials (e.g. factsheets), training formats with varying intensity as well as general events for informing about agroforestry were implemented. As a second step, the acceptation of the formats was analyzed through evaluations with the attendees at the end of each event as well as through an online survey on the effectiveness of the communication materials. Furthermore, two workshops were implemented with potential multipliers, most of whom had already taken part in earlier events and are professionally working in the context of agriculture or nature protection.

The knowledge from AgroBaLa was also used for developing the agroforestry academy, which had been initiated in 2022, offering two intensive courses including several in-person and online seminars. Main target groups were farmers and agricultural advisors as they are directly connected to the practical implementation of agroforestry and thus important multipliers for the topic. The effectiveness of the courses, attended by altogether 16 farmers and 16 advisors, was evaluated together with the attendees at the course end.

Conclusion:
W1ith the development of new training offers on agroforestry a so far niche topic has been advanced to a subject increasingly integrated into the educational efforts. The direct targeting of multipliers and collaboration with recognized partners in the agricultural education sector like regional farmers' associations and the agricultural academy of Brandenburg proved to be successful in the sense that agroforestry was increasingly taken up as a topic. It was also realized that next to general information events on agroforestry, specific technical trainings on topics like economic aspects or planting and management techniques are needed in order to further support farmers in the practical implementation of agroforestry.

Keywords
requalification, Promotion, Adoption, training, know-how transfer, Dissemination, network

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4.1 Education, Training, Dissemination and Promotion

Poster presentations

Building Q - Foyer, 29 May, 2024, 12:00–13:00

Harvesting Insight with the 'Agroforst Podcast'

Christa Hirschvogel[1], Mareike Jäger[1]

1 Zurich University of Applied Sciences, Wädenswil, Switzerland

Introduction

Agroforestry, a sustainable land management system that integrates trees and shrubs into agricultural fields, holds immense promise for enhancing biodiversity, soil health, and overall farm resilience. Recognizing the need for a dynamic platform to share insights, bridge gaps in knowledge, and inspire a wide audience, our 'Agroforst Podcast' was born. This is a comprehensive exploration of our podcast series, offering a captivating journey into the dynamic and intricate realm of agroforestry systems in Switzerland and neighboring regions.

Podcast Overview

Our podcast series is designed to be accessible to a diverse audience, including practitioners, researchers, policymakers, and enthusiasts. Each episode delves into different facets of agroforestry, featuring expert interviews, case studies, and practical tips. By adopting a conversational and engaging format, we strive to demystify complex concepts and render agroforestry practices more accessible.

Key Themes

(1) Case Studies and Success Stories: Highlighting real-world examples of successful agroforestry implementations, we showcase how this approach has positively impacted farmers' livelihoods, biodiversity conservation, and environmental sustainability.

(2) Expert Interviews: Engaging with leading experts in agroforestry, we explore cutting-edge research, innovative practices, and emerging trends. By providing a platform for dialogue, our podcast facilitates the exchange of knowledge among researchers, practitioners, and policymakers.

(3) Practical Tips and How-Tos: We offer actionable insights for farmers interested in incorporating agroforestry on their lands. From choosing suitable tree species to pruning techniques, our podcast equips listeners with practical tools to implement agroforestry practices effectively.

Impact and Outreach

Our podcast series has garnered a wide and engaged audience, reaching listeners across continents in a total of 20 countries. As of today, March 4, 2024, episodes of the 'Agroforst Podcast' were downloaded more than 7300 times. The continuous upward trajectory of download numbers over time is noteworthy, with early episodes experiencing the highest download rates. The inaugural episode, listened to over 690 times, peaked at 90 downloads in April 2023 and sustained a robust engagement, with over 40 downloads even in February 2024. Notably, 79% of our listeners opt for mobile devices, with 54% using Spotify, 11% tuning in via Apple Podcasts, and another 10% utilizing the Buzzsprout Embedded Player on our dedicated platform (agroforest.ch/podcast). Farmers in particular appreciate the podcast format and accessibility, as it enables them to work simultaneously.

On Spotify, the favored platform among our listeners, 257 dedicated followers have joined the 'Agroforst Podcast' community, extending across 16 countries. Sharing dynamics reveal that 51% prefer WhatsApp, 26% utilize direct links, and an additional 19% leverage other methods. Notably, Episode 7 (Hazelburger) emerges as the most shared, a testament to its resonance with our audience. Moreover, our listener demographics reveal a composition of approximately 60% male and 30% female, with a significant proportion of nearly 40% falling within the age range of 28 and 34.

The 'Agroforst Podcast' has been advertised on multiple platforms, from LinkedIn posts of the ZHAW, Agridea, AGROMIX and private parties, to Newsletters (DeFAF, IG Agroforst), to Website entries (AGROMIX, Biovision) to Instagram posts. Further engagement of our listeners happened via our podcast mail address where we received questions and enquiries to collaborate.

Future Directions
Our goal is to expand the podcast's reach and the agroforestry community in Switzerland and surrounding countries. Preferably, we would like to achieve that by producing a second series and further emerge into the opportunities and challenges of agroforestry in an audible way.

Conclusion
In an era where sustainable agriculture is paramount, our agroforestry podcast helps to shine the light on innovative agroforestry systems, inspire people and show trends. This poster presentation at EURAF 2024 provides an opportunity to share our journey and exchange insights with fellow agroforestry enthusiasts.

Keywords
AGROMIX, Socioeconomic status

Aditional Attachment II.

AGFORWEB a project for bridging agroforestry education and practice in Western Balkans

Dr. Sara Lukić[1], Dr. Vladimir Ivezić[2], Dr. Krasimira Petkova[3], Dr. Dijana Vuletić[4], Dr. Milić Čurović[5], MSc Aleksandar Baumgertel[1]

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3 University of Forestry, Sofia, Bulgaria
4 Croatian Forestry Research Institute, Jastrebarsko, Croatia
5 University of Montenegro Biotechnical Faculty, Podgorica, Montenegro

Agroforestry practices on West Balkan: weaknesses and strengths – AGFORWEB is a two-year project co-funded by EU through Erasmus+ program Key Action 2 Partnership for cooperation.

Agroforestry offers nature-based solutions in many aspects, starting from improving the environment and combating climate change to improving the socio-economic status of the local community. In this regard, there is a need to raise people's awareness of the potentials, benefits, and advantages of agroforestry both for environmental protection and human well-being, and for education of the agroforestry professionals who are able to support stakeholders in planning, design and practicing agroforestry.

The aim of the AGFORWEB project is to provide a solid foundation for the education of new professionals in the field of agroforestry who should master the knowledge of state-of-the-art agroforestry systems and practices and digital skills and competences. Their support in implementation of agroforestry should be valuable starting from farm to landscape level. Also, the intention of AGFORWEB is to strengthen the cooperation between higher education and the local community and strengthen the connection between science and practice (Fig. 1).

The education of professionals who are able to effectively plan and design agroforestry practices to accomplish potentials of agroforestry requires well-tailored curricula of Agroforestry modules. To achieve this, seven curricula in the field of Agroforestry have been revised and adapted to meet the needs of country-specific environmental and socio-economic conditions. New learning materials will be created for students in the form of textbook, manual, and multimedia material for mastering digital skills.

The building a digital database on the most commonly used agroforestry practices in consortium countries is the core output of the project. This database is intended to enable the improvement of education and raising of digital literacy, in terms of the development and improvement of digital skills and research. Maintaining the database should be a continuous process that includes further improvement and addition of data on newly implemented agroforestry practices. In this process are involved students, researchers, farmers, local self-government, and enterprises interested in agroforestry implementation. Together, they should contribute to the growth and improvement of the database through data collection in the monitoring process. These activities strengthen cross-sectorial cooperation.

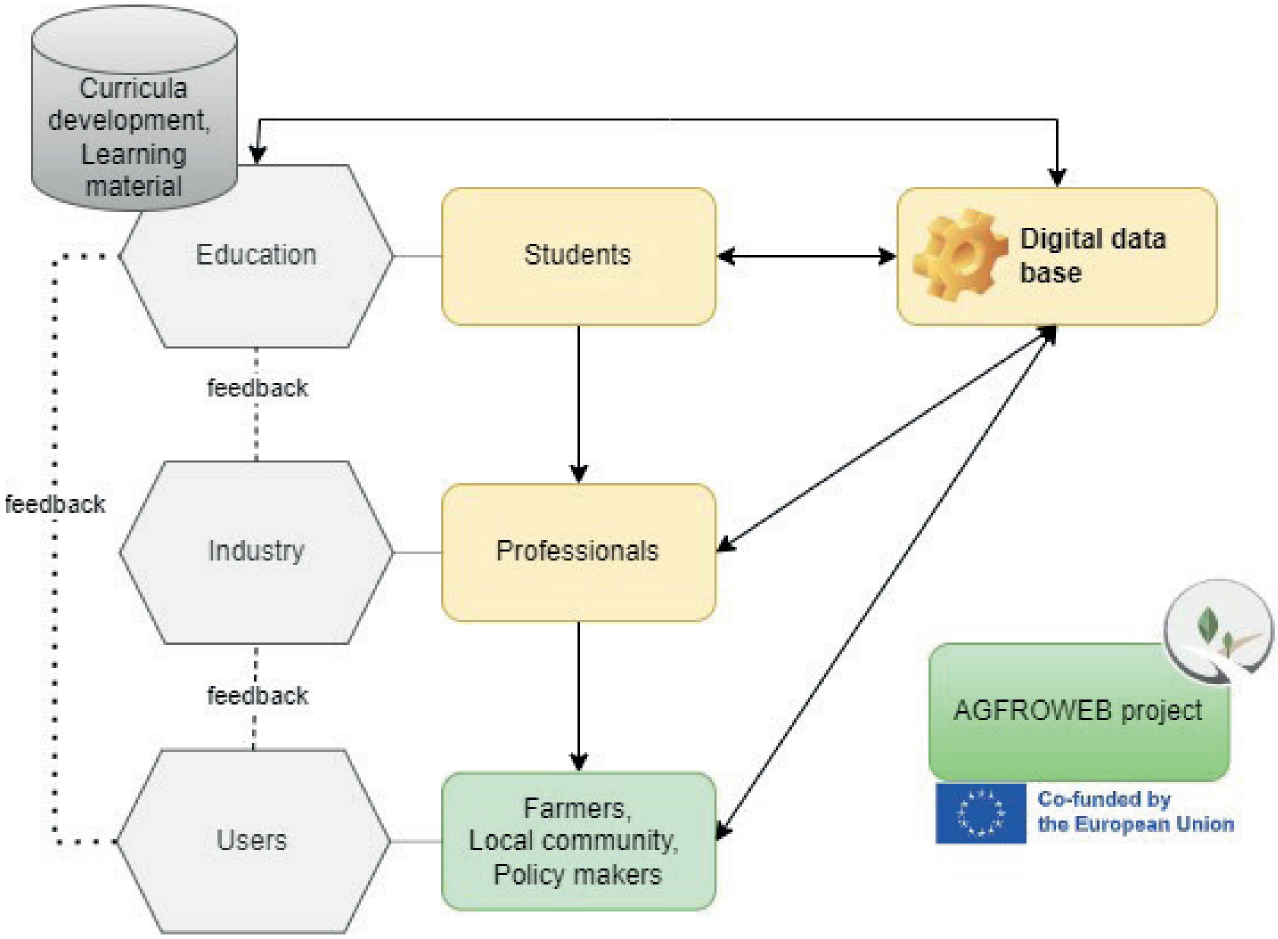
Lifelong learning publications are prepared for agroforestry practitioners - local farmers, enterprises, self-government, and other stakeholders. The methodology applied for preparation of lifelong learning publication involved combining academic knowledge and real-life experience in establishment of most common agroforestry practices with participatory approach focused on conducting workshops that enable various participant groups (farmers, decision makers) to achieve tangible outcomes. These workshops are designed to explore and apply subsidy mechanisms offered by various donors, with the aim of encouraging greater adoption of agroforestry systems.

AGFORWEB gathered five institutions from four countries: the countries of the European Union - Croatia and Bulgaria and the countries of the Western Balkans - Serbia and Montenegro. The aim of this cooperation is the exchange of experiences in education and practice of agroforestry between partners and co-creation of knowledge.

The outputs of this project can be the base for further networking and knowledge exchange in the development of policy for agroforestry in Western Balkans.

Keywords
knowledge gaps, higher level education, knowledge synthesis, ERASMUS+, Eastern Europe, Agroforestry

Aditional Attachment II.



Contribution of Hellenic Agroforestry Network to public awareness

Dr Konstantinos Mantzanas[1], Professor Anastasia Pantera[2], Emeritus Professor Vasilios Papanastasis[3]

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2 School of Forestry and Environmental Management, Agricultural University, Athens, Greece

3 School of Forestry and Natural Environment, Aristotle University, Thessaloniki, Greece

Introduction

The Hellenic Agroforestry Network (HAN) was founded in 2012 and is one of the constitutional members of European Agroforestry Federation (EURAF). It is a network of people who care about nature and the rural landscapes, which, in Greece, are natural and multi-diverse. These landscapes support a large variety of plant species, herbaceous and woody, and they include important cultural elements created by humans in their long-term coexistence with nature. The main components of these landscapes are the trees, which may be indigenous or cultivated, used to produce timber or fruits, and characterize the environment where humans live and thrive (Papanastasis et al 2009).

Agroforestry is defined as the deliberate combination of trees and crops and/or pasture at the same piece of land. The systems managed in this way are also named agroforestry systems. They are mixed systems with the main characteristic being the presence of trees. These trees serve many functions such as productive, environmental, and cultural. They provide many products such as timber, firewood, cork, fruits, acorns and foliage for animal feeding, pollen, and nectar for bees, etc.; and services such as soil improvement, reduction of surface runoff, conservation of biodiversity and landscape improvement. In Greece, there are three types of agroforestry systems: silvoarable, silvopastoral and agrosilvopastoral.

Agroforestry systems constitute a traditional land use in Greece, especially in mountainous areas. However, they are not well known to the agencies responsible for land management and the scientific community has not paid the appropriate attention so far. The agricultural model applied after the Second World War had as a target the maximization of agricultural production. In order to achieve this goal, a large number of mixed systems were converted to monocultures. The trees were removed to facilitate the circulation of agricultural machines. On the other hand, the European Union's subsidies applied till 1990' contributed to tree cutting, because trees had to be excluded from the productive area of farms to become eligible for subsidization.

During the last few years, the conservation of traditional agroforestry systems is considered urgent for maintenance of good soil condition, high biodiversity, functional agricultural landscapes and for economically supporting the rural population who live in the mountainous areas. Also, the development of new economically viable agroforestry systems is considered necessary.

This Network will help provide and exchange information on the management practices of traditional and new systems in order to become economically sustainable. It is also expected that it will promote the knowledge for the conservation of agricultural and forestry landscapes in Greece, which are in danger of being phased out by the irrational practices applied in the name of neo-technological development.

Public awareness in agroforestry

During the period from its foundation HAN had a difficult role in order to highlight the importance of agroforestry for the country, identify and highlight traditional agroforestry systems, inform the services of the Ministries, especially the Ministry of Rural Development and Food, convince farmers of the importance of trees in the fields, to prevent the cutting of trees from traditional systems, to convince the state to implement the favorable agri-environmental measures of the CAP for agroforestry in Greece, to promote the research and study of traditional systems, to create and promote the technology for the installation of new systems in the fields and much more. Several day conferences were organized by HAN with the collaboration of Hellenic Agricultural Chaber for scientists, Technicians and Farmers (Thessaloniki and Larissa-central Greece in 2013, Lamia and Athens in 2014, Kavala and Serres-northern Greece 2015, Athens 2018, Thessaloniki 2020) in order to disseminate and promote success agroforestry practices from Greece and other European countries. During the coronovarius period, HAN co-organized web conferences with the Green Institute and contributed to publications in Greek and English language (Tsiakiris et al. 2021). In addition, HAN collaborated with Green Institute and EnoP (European Network of Political Foundations) and published a new book in Greek and English language (Tsiakiris et al. 2023) related to agroforestry landscapes in the era of climate change. Recently in December of 2023, HAN organized a day conference in collaboration with the Greek team of IFSA (International Forest Student Association) entitled "Employment prospects in agroforestry systems", aiming to the introduction of agroforestry practices to young forestry students since the lack of agroforestry courses in most Forestry and Agronomy Schools.

Regarding research interests, HAN involved in several projects as an end user body and the last 2 years contributed to DigitAF project as Affiliated Member of EURAF. HAN will contribute to the role of agroforestry in CAP strategic plans and on the implementation of agroforestry measures in the EU countries and in the UK and Switzerland.

Acknowledgements: This contribution was realized within the DigitAF project 'DIGItal Tools to help AgroForestry meet climate, biodiversity and farming sustainability goals: linking field and cloud', (Grant Agreement number 101059794) A Horizon Europe Research and Innovation action project funded by the European Union.

Keywords
agroforestry systems establishment, Agroforestry, agroforestry practices, agroforestry landscapes, agroforestry system planning

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Illustrations of agroforestry systems as a method of science communication

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2 ARGE Agroforst - Association for the promotion of agroforestry, Vienna, Austria

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Introduction

Agroforestry systems (AFS), in the sense of tree strips on arable land or grassland (alley cropping), are very diverse: tree species, tree lifespan, tree densities per hectare, management of tree strips and undergrowth, etc... This can lead to confusion, different mental images and sometimes even contradictory assessments. The StartClim project "Agroforestry - how trees on the field can help solve the biodiversity and climate crisis" presented here therefore aims to sort the very different designs of silvoarable AFS in practice in Austria in order to provide a clear basis for discussion.

Objectives

The aim of the project is to provide an initial well-founded orientation for farmers, decision-makers and the interested public (consumers) by systematically analysing the possible benefits of various agroforestry systems in Austria in terms of CO2 sequestration potential in the woody biomass, biodiversity potential in the agricultural landscape and suitability as climate change adaptation. The results of the analyses are to be prepared together with the AFS themselves as illustrations for the interested public and farmers. Furthermore, the illustrations and visualizations of the results of the investigated agroforestry systems can be used beyond the project duration and can be used in a variety of ways and that the interested population (consumers) can be informed about agroforestry as a possible, resilient land use system.

Methodology

Five different silvoarable agroforestry systems (AFS) commonly occurred in Austria are under survey in this project:

(1) Value wood only (ex.g. Sorbus sp., Juglans sp.),
(2) value wood with fruit (ex. g. Juglans regia),
(3) short rotation system (Poplar sp.),
(4) fruit intensive (es.g. Malus domestica, Pyrus communis, Prunus sp.),
(5) mixed system (fruit, value wood, nurse trees).

All five AFS types are designed as alley-cropping systems, with 2m tree strips, 30m distance between the tree strips, north-south orientation, usual arable farming, flat area, mature AFS, 600-800mm precipitation and good soil conditions. These AFS types are illustrated by a graphic artist to get all important information at a glance (ex. g. Venâncio, 2022). The illustrations serve as a template for a panel of experts to classify them in terms of biodiversity potential (species biodiversity). In addition, 4 variants per AFS type are also discussed with the experts: 1) effect of age of AFS (<15a vs. >25a), 2) effect of management of the tree strips (flower mixture sown and mowed once a year vs. no seeding and intensive use e.g. mowing 3 times a year); 3) effect of harvest strategy (clear-cutting vs. staggered tree clearing); 4) effect of region (Pannonian influenced east (e.g. Weinviertel Lower Austria) vs. Continental influenced regions (e.g. valleys in Upper Austria)).

In addition to the opinion of experts on biodiversity potential, two other environmental services are examined within the project: climate change adaptation and CO2 sequestration potential. For this purpose, a comprehensive literature review is undertaken and the five defined AFS are examined with regard to their effectiveness as climate change adaptation measures. With regard to CO2 sequestration potential, calculations are made on the storage of the above-ground and underground tree biomass of the five different defined AFS (Markut & Siegl 2022). The magnitudes of the results of the three environmental services (biodiversity potential, climate change adaptation potential and CO2 sequestration potential) are presented graphically and printed together with the illustrations of the AFS types on free cards and shared online as well.

Results

Draft versions of AFS illustrations are now available (Figure 1) and will be completed mid-March. The expert surveys will take place at 20th march of 2024. The calculations of CO2 binding potential will be completed by April at the latest and the literature research on the climate change adaptation will be finished in May at the latest. The free cards are scheduled to be printed in June 2024. The results from the entire project will also be disseminated and published on communication channels of the StartClim funding programme.

Partial results can therefore be presented directly at the conference.

Conclusion

The distribution of the free cards, the downloads on the homepage and further spreading of the AFS concept in practice will show whether a certain reach is achieved. It would be interesting to do scientific work on whether illustrations combined with scientific findings are a suitable means of creating and strengthening awareness in agriculture and society of the diversity of AFS and the diverse environmental services of AFS.

Keywords

biodiversity, Austria, climate change mitigation, silvoarable agroforestry, adaptation

Aditional Attachment II.

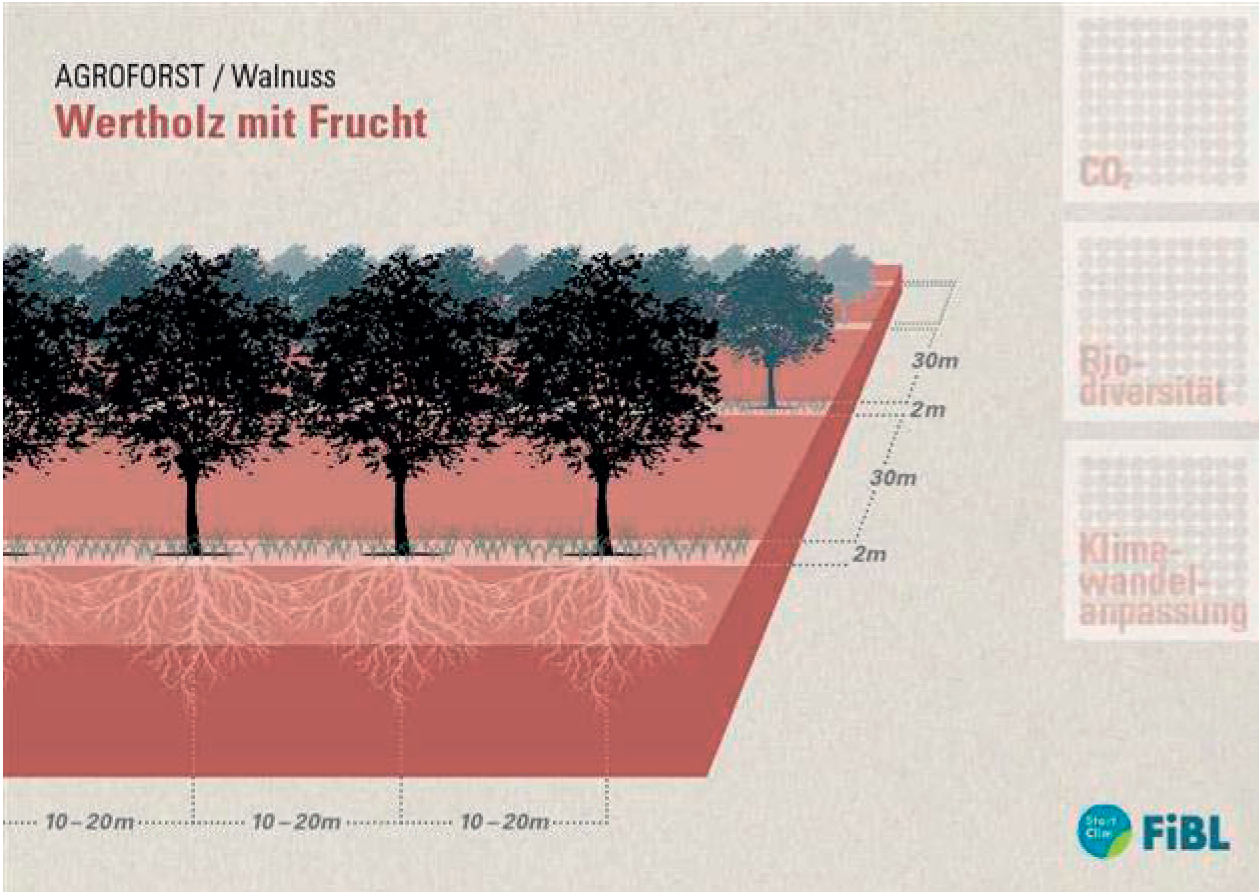

Figure 1 Illustration of one agroforest system (#2: value wood with fruit, e.g. Walnut). © K. Gyimesi

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Integrating an agroforestry experimental site into education and research on carbon sequestration for more climate-friendly universities

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Introduction

In view of climate change, universities, as public institutions and actors in knowledge production and dissemination, bear a special responsibility for actively shaping sustainability processes. The research network REKLINEU (regional pathways to climate-neutral universities) investigates current carbon dioxide emissions and their future avoidance, reduction and compensation in the university environment. Regarding this compensation, an agroforestry experimental site was recently established at the University of Applied Sciences Weihenstephan-Triesdorf (HSWT). The implementation process and research was and is characterised by cooperation between faculties and integration into students´ education.

Case description

The agroforestry experimental site measures 5.5 ha, is split in two parts (one with agroforestry, the other as an internal control) and has been under conventional crop rotation until 2023 (now organic). The agroforestry comprises five rows with silvoarable plantings in short and long rotations. Silvoarable systems in temperate Europe show carbon sequestration potentials in the soil and tree biomass above- and belowground, varying with the type of agroforestry system (Cardinael et al., 2017; Mayer et al., 2022; Palma et al., 2006). The agroforestry site counts in total 56 timber trees (Prunus avium, Juglans regia, Acer pseudoplatanus, Sorbus torminalis), 120 grey alders and fluttering elms and 480 poplars planted in four planting variations with four repetitions each. The experimental site was planned within one year jointly by the agricultural and the forestry faculties as well as the technical service team of the university. In spring and autumn 2023, the agroforestry system was implemented with staff members and students of the agricultural, forestry and horticulture faculties and participants of the REKLINEU network.

As part of the university modules on agroforestry systems (winter semester, interdisciplinary module) and energy crop cultivation (summer semester), practical planning and implementation processes on the experimental site enriched the student's education. Students in the energy crop cultivation module actively contributed to the planning process as part of a project work. Teams of students for example completed the planning of the poplar strips with suitable spacing and planting methods, calibrated the rows and carried out the planting. Other students planned, calibrated and planted a supplementary planting of flowering perennials to increase the biodiversity of wood strips. Challenges that arose during the planning and implementation process were discussed at regular meetings and reflected in the project report. Future project works will focus on the monitoring of the established wood strips and replanting of trees and perennials if necessary. During a planting day, students of the agroforestry module were able to apply and consolidate knowledge learned in lecture, such as the planting process, tree protection, planting material quality and design of agroforestry systems. The experience gained during the planting day was reflected in the students planning reports for agroforestry planning scenarios. The intensive practical collaboration also promoted the group work and - partly interdisciplinary - exchange between students, as well as between students and lecturers.

In the scope of the REKLINEU research project, the carbon sequestration potential in the soil and tree biomass is investigated on-site. The soil organic carbon content is measured in 0-50 cm depth at 79 sample points in two transects at each planting variation, added by humus sampling in 0-15 cm. The initial sampling campaign in 2023 was carried out in cooperation with the Bavarian State Research Center for Agriculture (LfL). Soil structure mapping and soil erosion tests were conducted in the scope of a bachelor's thesis. Further research projects on the experimental site include the investigation of key economic figures and the monitoring of effects on arable crops, microclimate, biodiversity, and establishment of trees.

Conclusion

The implementation of an agroforestry system on a university campus promoted participatory processes and the applied education and research at the university throughout the entire process, thereby promoting the dissemination of agroforestry into applied sciences and supporting transformation paths at universities towards more sustainability.

Acknowledgment
The REKLINEU project is funded by the Federal Ministry of Education and Research in Germany (BMBF; FKZ 01UN2208B).

Keywords
climate mitigation, education, agroforestry systems establishment, silvoarable agroforestry, Temperate, Agroforestry, soil carbon sequestration, carbon sequestration, Agroforestry system

Aditional Attachment II.

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4.3 Historical Landscapes: heritage identity and a driver for sustainable tourism

Oral presentations

Hall Q3, 31 May 2024, 8:30–9:00

Traditional agricultural landscapes as a form of agroforestry systems and their disappearance from the Czech landscape

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Introduction

Traditional agricultural landscapes are characterized by a distinct and recognisable structure which reflects clear relations between the composing elements evolving during several centuries (Antrop 1997). They represent preserved pre-industrial landscapes that have been managed by traditional means in contrast to intensive, usually large-scale, management. Nowadays they face abandonment and disappearance despite the fact that they provide cultural and social values (Špulerová et al. 2017) and can be considered as hotspots of biodiversity, especially in the context of agricultural landscape (Špulerová et al. 2015). Due to the variety of different land uses (arable fields, vineyards, orchards, grasslands) they can be considered as a historical form of agroforestry systems.

Objectives

The aim of the contribution is to find out to what extent the traditional agricultural landscapes (TAL) from the past have been preserved nowadays and what were the driving forces behind their disappearance.

Methods

We have chosen Kyjovsko region (470 km2) as our case study area. It is situated in South Moravia, Czech Republic, and is characterized by predominant agricultural land with long history of viticulture as well as rich folklore and occurrence of TAL. TAL were defined as a mosaic of small vineyards, arable fields, orchards, meadows, gardens and scattered trees. They were researched in two periods – 1826 and 2017. The period of 1826 was represented by maps of stable cadastre at the scale of 1:2880, which were geroreferenced and vectorized to create a vector layer. The present period was represented by combination of available vector and raster data. These included agricultural land from the Land Parcel Information system (from 2017), digital cadastre data (from 2018), biotope mapping (from 2013), settlements, roads, railroads and water courses from Fundamental Base of Geographic Data on the Czech Republic (from 2017), forest types from Forest Management Institute (from 2017) and orthophoto from 2017, which served both as a control and source for unidentified patches. Besides the mosaic of Tal, other land cover classes were captured, like large arable fields, large vineyards and orchards, forests, grassland, water bodies, settlement (including garden), etc. Created land cover maps enabled calculated extent of TAL in each time period and their overlay provided data about preservation of TAL and their change into other land cover categories.

Results

Traditional agricultural landscape in the middle of 19th century covered 3,748 ha (i.e. almost 8 % of the studied region). In 2017, its size was reduced to 2242 ha, i.e. 3 % of the studied region. The area of preserved TAL was only 920 ha (1 %). The main reasons for the disappearance were urbanization, i.e. spread of settlements into their surrounding, collectivisation of agriculture during the socialist period of 1950s-1990s, leading to creation of large arable fields, vineyards or orchards, and also and abandonment, i.e. overgrowth by woody vegetation. The fact that only 920 ha of the orginal TAL were preserved is not only due to the previously mentioned reasons but also due the different position of TAL in the landscape. Nowadays, TAL can be usually found in the immediate surrounding of the settlements. On the other hand, in the 19th century, TAL were situated farer from the settlement, often at the borders of respective cadastre.

Keywords
Central Europe, traditional landscape, heritage, Land cover change, urbanization, Analysis, Field abandonment, agriculture intensification, Landscape ecology

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Historical agroforestry on forested land: drivers of its distribution in the 19th century

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4 CREAF (Ecological and Forestry Applications Research Centre), Autonomous University of Barcelona, Barcelona, Spain

Introduction
Traditional agroforestry on agricultural land was common in the past in Central Europe. However, much less is known about agroforestry on forested land, mainly because it was often banned by forestry authorities during the 20th century.

Objectives
To map the distribution of agroforestry uses on forested land (forest grazing, hay cutting, litter raking) in the 19th century in Moravia (eastern Czech Republic, ca. 27,000 sq.km) and to understand the driving factors behind this distribution.

Methodology
We use archival research to map the distribution of agroforestry uses in forests for each of the 3567 townships. We then combine supervised learning classification and logistic models to comprehend the relationship between this distribution and environmental, land use and forest management predictor variables.

Results and conclusion
Agroforestry in forests occurred in almost every township in the 19th century. Its distribution reflected environmental, land use and forest management factors. For hay cutting and forest grazing the pattern is remarkably clear. The former typically occurred in townships with large forests where the proportion of grasslands was low. The latter was common at higher elevations under high forest management and on soils of lower fertility, which confirmed the traditional image of forest grazing as a highland activity in the Czech Lands. In contrast, the ubiquitous presence of litter raking made it more difficult to decipher the relationship between predictors and this agroforestry use.

Keywords
forest management, historical ecology, leaf, silvopastoral, History, grazed woodlands, trees

4.4 Urban Agroforestry

Oral presentations

Hall Q3, 31 May 2024, 9:00–9:45

The role of agroforestry for the ecological transition and socio-territorial regeneration in periurban areas. A case study in the city of Milan

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4 Department of Veterinary Medicine and Animal Sciences, University of Milan, Milan, Italy

Agroforestry practices can play a key role in ecological transition and socio-territorial regeneration in peri-urban areas, particularly when designed and implemented according to agroecological principles and through participatory tools that encourage citizens' involvement and long-term engagement towards one's living environment such as: public plantings, self-building workshops, shared agroforestry system management activities, field training initiatives, community mapping activities, talks and cultural events. Thanks to all these initiatives, the regenerative agroforestry system becomes a new community hub where people can experiment with ecological and transformative practices, where to learn new skills and develop abilities, and where to spend time putting themselves at the service of the common good. Thus, our presentation aims to illustrate some first results of our interdisciplinary analysis dedicated to assessing ecosystem services generated by agroecological practices in the periurban area in the Milan metropolitan city South-Eastern edges, next to the last city buildings. The area belongs to the Rural Park South Milan and the Vettabbia Valley system, an historical ditch flowing out of the city into its rural surroundings. A "unique" suburbs for Milan: a large and central area, nestled between a compact city and the countryside; a neighborhood composed of different parts that are proposed or undergoing various processes of transformation; an environment animated by endogenous projects that represent grafts of change and bring attention back to "shadowed" spaces and inhabitants. In the area under analysis there are territorial criticalities related to the degradation and abandonment of buildings (farmsteads) and artifacts (traditional irrigation systems, embankments, washhouses) belonging to the historical heritage.

Here non-profit organisations have activated in 2018 an applied agroecology project: two experimental plots with multi-strata productive agroforestry systems were designed and implemented (1 ha each, 12,000 productive and non-productive trees and shrubs, more than 40 species and 32 fruit cultivars) through participative approaches, directing involving citizens in didactical activities, plantings and other agroecological activities, aiming at developing a bottom-up local, regenerative supply chain. Agroecological principles are adopted (no pesticides, no chemical fertilizers, no irrigation, minimum tillage, cover crops, mulching), including phytoremediation strategies. Productive and production-supporting elements are managed through intensive pruning and biomass inputs to the soil in such a way as to facilitate greater complexity, dynamism and productivity. During 2023, within the project "Adopt a hen!", a hundred of egg-laying hens breeding on mobile coops was introduced in the agroforestry system according to the principles of rational grazing, with the aim of making the ecological-productive processes within the system itself more complex and creating Milan's first peri-urban agrosilvopastoral initiative supported by an active community of citizens.

Through qualitative-quantitative analytical tools and a transdisciplinary research approach, we want to understand how, and to what extent, experimental agroforestry practices, guided by the observation of the natural environment and through a culturally acquired pattern, enable the creation of a new regenerative peri-urban landscape, an expression of ecological and cultural values that bind the community to its living area restoring in people a deep sense of place and genuine sentiments of usefulness to the ecological transition of the city.

Our contribution will focus on:

- floristic-vegetation analysis results, also through the use of ecological indicators, and pasture control, with reference to the implementation of its agroecological management and related ecosystem services;
- analysis results on fecal biomarkers (search for sterols and stanols as possible indicators of fertilization and manuring). Pollen analysis results of sediment samples for carbonized plant macroresidues with the aim of understanding past soil uses;
- socio-territorial analysis results: mapping, monitoring and implementation of cultural ecosystem services generated by the presence of the agroforestry system and its implementation to an agro-sylvopastoral system with the inclusion of egg-laying hens on mobile coops and rational grazing. Socio-territorial analyses will be carried out through structured questionnaires, semi-structured in-depth interviews, community mapping activities.

Keywords
agroecology, research-action approach, grazing, biodiversity, Socioeconomic status, Landscape ecology, succession, urban green infrastructure, syntropic agriculture, Regenerative communities, mobile chicken coops, ecosystem services, Cultural Ecosystem Services, Agroforestry systems, stratification

Aditional Attachment II.

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How does urban planning include agroforestry systems? The case-study of italian cities

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Introduction

Urban and peri-urban agroforestry (UPAF) is an emerging urban practice that can contribute to promoting the resilience of cities to climate change effects while improving the set of ecosystem services provided by urban agriculture and urban forestry (Borelli 2018).

Most studies focus on the ability of UPAF to provide ecosystem services and their connection with GI (Russo 2018, McKlain, 2014) or on any negative aspects associated with the specific of urban contexts such as the presence of contaminants in fruit and vegetables (Romanova, 2021, Izquierdo 2015) or allergies due to pollen (Lorenzoni-Chiesura, 2000). Another important source of information consists of studies on urban food forests (Allen, 2021, Riolo, 2018), which however can be considered as a subgroup within the broader topic of UPAF. To date, very few is known about the role of urban planning in promoting agroforestry both in specific case studies and research at country level (Kowalski 2018).

Research questions

To fill this gap, this paper aims at 1) evaluating the presence of UPAF in Italian urban plans 2) exploring the relationships between local urban planning tools and overarching national strategies and legislation 3) evaluating the appropriateness, and relevance of urban planning for the adoption of agroforestry systems in urban and peri-urban areas.

Methodology

We examined 140 urban plans of all the Italian cities having a residential population equal to or higher than 50.000 inhabitants. In parallel, the national framework laws, and the regional legislation concerning agroforestry issues was analysed. Semi structured interviews were conducted to officials and local politicians of those cities where UPAF elements where retrieved. The questionnaires aimed at understanding the motivations and the process that led to include agroforestry into urban planning documents. Open-ended questions were processed with the thematic analysis method. Quantitative data were collected on a series of Likert scales ranging from 1 to 10 or 1 to 3 and analysed with descriptive statistics that included means and percentages. The non-parametric Mann-Whitney test was used to detect statistically significant differences.

Results

The study highlighted that UPAF is poorly developed in urban planning, being only intentionally included in 3 voluntary planning tools such as green plans. Nonetheless, non-intentional UPAF elements such as preservation of tree rows in peri-urban areas, can be retrieved also in principal urban planning of additional 12 cities, thereby demonstrating a fertile environment to promote agroforestry systems in urban contexts. At national and regional level, agroforestry is gaining attention in national strategies and policies for rural areas, while it is lacking for urban areas. The poor presence of UPAF in Italian urban plans shows that it is necessary to make a qualitative leap to ensure the spread of edible green infrastructure where agroforestry can play a significant role. Questionnaires to decision makers and officials of the cities where agroforestry was intentionally introduced highlighted that grass-root organizations and knowledge hubs are crucial to promote UPAF. They create an enabling environment that make possible the introduction of agroforestry in the green infrastructure. Participative processes, co-design and funding of specific interventions were the most common actions carried out. In those cities where agroforestry was not intentionally included in urban planning, motivations such as conservation of traditional landscape features or a generic attention towards green policies paved the way to elements of UPAF. In these contexts, urban forestry and urban agroforestry were indifferently treated. These cities used similar actions (e.g. participative processes) as well as direct funding to realize their interventions.

Discussion and conclusion

The level of detail provided by urban plans appears as the most appropriate tool to introduce agroforestry in urban and peri-urban contexts. By working on a detailed scale, it can flexibly and functionally define the strategies of social, economic, and environmental urban components (Miljković, 2019). At the same time, it is necessary, at national level, to update the regional regulations in the agricultural and forestry sectors, especially for peri-urban contexts. A further output of the study refers to the appropriateness of activating community engagement processes and facilitating bottom-up initiatives as well as encouraging the contribution of knowledge hubs to better shaping urban policies UPAF-friendly. The study showed that thanks to grass-root initiatives such as the “Picasso food forest” in the municipality of Parma (Riolo, 2019), city planners modified the regulations on common goods and the green plan. In other countries were UPAF has been already integrated into urban planning such as Canada (Kowalsky, 2023) and Sweden (author’s research in progress), the relevance of both grass-root organizations and knowledge hubs to influence city policies and municipal by-laws was confirmed. Especially in the Canadian context, co-governance models can successfully support UPAF. Further research on this topic is required at international level to understand the main drivers that can favour the introduction of agroforestry in urban planning and to find the most appropriate planning tools according to different national contexts.

Keywords
urban planning, Peri-urban belts, Policy, rural-urban interface, urban green infrastructure

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Exploration of the functions and potentials of urban forest gardens in Sweden

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According to UN estimates, in 2007, for the first time the urban population exceeded the rural population and a further growth of 66% of the world population is expected by 2050 (United Nations, 2014). The uncontrolled growth of cities has caused social and environmental challenges such as the emergence of slums and/or degraded suburbs, inequalities, unemployment, food insecurity, pollution, loss of green spaces and biodiversity (Salbitano, 2016), (Camhis 2006, Godfray, 2010). Such sustainability challenges are often addressed in policies of cities/municipalities (Stoltz and Schaffer 2018).

Recently scholars have highlighted that agroforestry systems, often in the form of urban forest gardens/food forest (UFG /UFF) can contribute to mitigate some of such negative effects of urbanization in the Global North (Clark and Nicholas 2013, Albrecht and Wiek 2020, Zanzi 2021, Romanova 2021). UFG's can be considered the most important entry points for agroforestry in urban areas since they can be located, in a flexible manner, in densely populated areas as well as in the outskirts of the cities.

In Sweden, several urban forest gardens have been initiated during the last decade. Such initiatives have come from various grassroot movements or been initiated by municipalities or emerged as a part of various educational programs. Despite the growing interest for urban forest gardening, there is a lack of knowledge on the overall features of UFG's, their main characteristics and their functions and potential fulfillment of urban policies. To fill the gap, this paper has the following objectives: i) to make an inventory of all Swedish UFGs and to characterize them according to origin, management, and ecosystem services provided ii) to identify the main drivers that led to the establishment of UFG's iii) understand the potentials of these UFG's in relation to urban sustainability policies.

UFG's were inventoried using snowballing methods from key stakeholders involved in forest gardens, an online based interactive map of forest gardens in Sweden, newspaper articles, specialized gardening journals and by local forest garden and permaculture groups on facebook. 13 Swedish urban forest gardens located in 8 municipalities were visited between August to September 2023. A total of 18 face to face semi structured interviews were conducted with grass-root members of the forest gardens, schoolteachers and officials in the municipalities where forest gardens had been adopted. Qualitative data were elaborated with the thematic analysis method by identifying patterns to derive the main themes. Close-ended questions were processed using descriptive statistics such as means and percentages.

Swedish UFG's can be classified into three main categories according to their origin: bottom-up (initiated and managed by grassroot movements), top-down (initiated and managed by municipalities), and educational (initiated and managed by schools/educational programs). Bottom-up UFG's first appeared in the last 10-15 years, then followed by school UFG's. Top-down UFG's were initiated the last 1-2 years. The main factor for the establishment of an UFG is the presence of any kind of educational centers (public school, folk high school, adult education etc) or groups of practitioners interested in permaculture and/or agroforestry. The knowledge generated from grassroots were important for top-down initiated UFG's where officials were supported throughout the entire process and in issues such as the choice of suitable site, species, design and of management practices. All stakeholders underlined the importance of the social function of UFG's in providing cultural ecosystem services (e.g., recreation, aesthetic qualities and psycho-physical well-being) for the neighborhood whilst provisioning services (e.g., food production) were considered as least important. According to all respondents UFG's have a key role in introducing agroforestry into city policies and the process behind its adaptation could act as a model for decision makers. UFG's have a multifunctional role in urban planning since their presence could reinforce communities, connect people to nature and healthy food and enable connections between different professionals and stakeholders. Conversely, they require continuity of funds and skilled labor for maintenance that may not always be available. Additionally, officials indicated that agroforestry could be introduced in public parks and peri-urban agricultural lands and woodlands.

The numbers of UFG's in Sweden have increased over the last decade. Grassroot initiatives have contributed to the adoption of agroforestry in public urban green spaces and in various educational contexts and have functioned as a bridge and practical implementation of issues on the agenda for municipalities. The growing number of UFG's in urban areas could serve as a model to include agroforestry into urban policies. Lack of suitable technique and management skills and continuity of funds may hamper this process.

A possible guideline for UFG's sites should include i) the presence of knowledge hubs and grassroot movements to provide technical guidance for initiating and managing UFG's ii) long term investments iii) close collaboration and shared goals among all actors involved (municipalities, active gardeners and schools) iv) appropriate planning tools.

Keywords
stakeholders, food forest, urban forest garden, policy contexts, Food security, sustainability, landscape planning, urban green infrastructure, social well-being, multifunctional landscape, temperate agroforestry, urban planning

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Theme 5: Agroforestry in Practice

5.1 Farmers Experiences and Adoption (I)

Oral presentations

Hall Q1, 29 May 2024, 14:00–15:30

Establishment of silvopasture agroforestry system in combination with regenerative grazing - ReFarma Lidmaň

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2 Landscape architect, Vyškov, Czech Republic

3 Agroforestry entrepreneur, Lukavec, Czech Republic

The objective of the conference paper is to present the project of Refarma, a regenerative and agroforestry farm in Lidmaň, owned by farmer Tadeas Michalik. The farm is located in Bohemian-Moravian Highlands (600 m above sea level) and it spreads on 57 ha of forests, grassland, fast growing plantations and wetlands.

The transformation of the farm consists of the following features:

building new ponds for habitat and water storage functions

keyline design agroforestry on pastureland

transformation of fast growing plantation to silvopastoral system

new fencing, water pipelines and access infrastructure

The overall land plan is based on concepts presented in Darren Doherty's "Regrarians" system, and especially on the concept of "scales of permanence" by P. A. Yeomans.

The first phase of planting was done in 2023 on 12 ha of keyline silvopastoral system. 1245 trees of the following species were planted: oaks, linden trees, European wild apple trees, willows, common alder, ashes, mulberries, walnuts, cherry trees and grafted hazels.

The paper reflects the challenges of design and implementation of a silvopastoral agroforestry system in the Czech legal and natural conditions.

Keywords

regenerative grazing, water management, landscape planning, livestock health, Agroforestry, fodder trees, silvopastoral

Agroforestry in the legal framework of Slovakia

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Introduction

Since Slovakia joined the EU in 2004, the legal framework has been influenced by EU policies, including the Common Agricultural Policy (CAP). Until 2022, there was no legislation for agroforestry land management in Slovakia. The latest CAP Strategic Plan (SP) 2023-2027 includes for the first time specific interventions in the field of agroforestry. Following this SP, there are several national legal provisions at the level of government regulations on agroforestry. The aim of this paper is to provide an overall view of the legal options and barriers to the establishment and maintenance of agroforestry systems in Slovakia. This paper focuses on the whole legal framework related to agroforestry and its implications for the systematic implementation of this practice in the country.

Case description

Agroforestry is mentioned several times in the CAP SP, especially in the SWOT analysis. Agroforestry is recognised as an adaptation and mitigation measure that contributes to erosion prevention, biodiversity enhancement, carbon sequestration, and microclimate improvement. Slovakia lists agroforestry as part of BISS payments (Government Regulation No. 435/2022 Coll. and 436/2022 Coll.) in Pillar I and as non-project support in Pillar II (Government Regulation No. 3/2023 Coll.). Under this Regulation, the first intervention will be granted for the establishment of an agroforestry system on an agricultural area, and the second for the protection and maintenance of the established agroforestry system.

The initiative to support agroforestry under Pillar II originated in the Rural Development and Direct Payments Section of the Ministry of Agriculture and Rural Development (MoARD), without which this intervention would not have made it into the CAP SP. The preparation took 2 years. Officials had the difficult task of grasping such a broad issue for the first time and mapping directly onto it the support for setting up agroforestry systems that should work instantly in practice. The proposal of the drafting working group was therefore limited and simple. Despite the great simplification, a number of misunderstandings arose when it was put into practice. The methodological guidelines did not sufficiently explain Government Regulation No. 3/2023 Coll. on non-project support for the establishment, protection, and maintenance of agroforestry systems in terms of what was planned and what farmers could afford in the light of the existing legal standards.

Government Regulation No. 3/2023 was implemented in January 2023 and the methodological guidance was issued in March of the same year. Farmers had only 2 months to fully understand the implications and apply for support. In cooperation with the Slovak Agroforestry Association, we obtained feedback from them, and it turned out that this period was very short. Already in the first year, the intervention was exhausted, there was a lot of interest, and it was used mainly for green fallow land, so it did not fulfil its overall purpose. The main shortcomings are considered by the farming community to be the impossibility of managing the trees in the first five years (harvesting, pruning) and the impossibility of growing high-yielding introduced tree species such as black walnut, acacia, fir and Douglas fir in agroforestry systems, and even a number of indigenous fast-growing species such as willow, poplar, alder, hornbeam, birch, ash, cherry and sweet chestnut.

Conclusion

Agroforestry in Slovakia has to deal with the existing barriers of the current legislation applied before the new CAP strategy. Nature Conservation representatives do not support tree planting in some general land use types or do not give consent for many high-yielding non-native tree species. The dogma of no grazing in forests survives in forestry authorities, even though our ancestors have done so for hundreds of years. The statutory duration of land leases is not very conducive to agriculture in general and agroforestry in particular. Inconsistent legislation applies to so-called 'white areas'. "Abandoned agricultural land overgrown with successional growth of trees, the felling of which is very difficult for the nature conservation authorities to approve. These areas are not eligible for direct payments (subsidy support), although grazing is possible with agroforestry management.

Keywords
decision-making, Adoption, CAP Strategic Plans, Policy

State of the art in the Netherlands: a crucial role for provincial agroforestry networks

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Agroforestry has seen a rapid increase in the Netherlands in recent years, both in terms of the mentioning of agroforestry in policy-related documents as in actual hectares of agroforestry.

To guide this development in the right direction, the ministry and its executive body RVO were advised in 2020 to initiate a number of developments (Luske et al. 2020). In 2021, a specific look was taken at how agroforestry is organised in the Netherlands and how information about agroforestry can be shared better (Prins et al. 2021). It was concluded that agroforestry in the Netherlands is characterised as a typical bottom-up movement that started in 2017, in which (provincial) learning networks play a major role and an overarching national agroforestry network would be beneficial.

A national agroforestry network

As a result the Agroforestry Network the Netherlands (Agroforestry Netwerk Nederland/ANN) was launched in 2021 to connect governments, researchers, and farmers and to facilitate this bottom-up movement on a national scale. Among other activities, this network is working on the development of a national research agenda for agroforestry.

Provincial agroforestry networks

Agroforestry farmers connect to the national network through provincial agroforestry networks. The first provincial network started in the province of North-Brabant in the year 2017, by bringing together an initial group of 25 (mostly) cattle farmers, farming on sandy soils. This group now consists of 200 farmers, also including arable farmers from the western part of the province. In 2022, the network in the province of Gelderland was launched, where mainly cattle farmers and poultry farmers are affiliated. In 2023, networks were also established in provinces where mainly arable farming is practiced, such as in the provinces of Zeeland and Flevoland. The Netherlands has twelve provinces, of which currently seven have an established provincial agroforestry network and three provinces are currently starting up networks (table).

Why it works

Each provincial network consists of an inner ring of farmers and an outer ring of other actors. By structuring it in this way, farmers in the inner ring can jointly take a step further in agroforestry with complete openness and trust toward each other. They often need the outer ring to take the next steps, but the core is a strong bond between the participating farmers. We see in long-existing networks that this connection between farmers leads to cooperation in the longer term, such as the collective purchase of materials, exchange of knowledge, and joint processing and marketing of products.

Each provincial network consists of farmers who voluntarily join to gain knowledge and skills. The networks provide farmers with a platform to share ideas, experiences, and challenges, and to learn from each other. The networks also help farmers to make their voices heard by policy makers. Many restrictive legislation and opportunities for subsidies are indeed at the provincial level. Existing provincial networks have in many cases already ensured that barriers in the area of legislation are reduced and useful subsidies for agroforestry are awarded. Provinces are pleased with the existence of the networks because they have a central point of contact to talk to agroforestry farmers. This is crucial, since the greater part of agroforestry-related policies are decided on a provincial level.

Strengthening the national movement

All provincial networks are represented at the national level in the National Agroforestry Network. In this way, policymakers can also learn from each other and solutions can cross-pollinate. It is of utmost importance that it can be made clear at the national level that hundreds, or even thousands of farmers are considering agroforestry, so that national legislation can be facilitated and sufficient funds can be released for planting, conducting research and sharing knowledge. The National Agroforestry Network also includes a network for food forests. This network focuses on supporting and professionalising food forests in the Netherlands. In the development of food forests, farmers often encounter the same legislation and knowledge gaps.

Future developments
In 2023, the Agroforestry Network Netherlands has committed itself to start provincial network in all remaining provinces. It is expected that the map will be fully filled in 2024 and that for all farmers it will be clear who their first point of contact is for agroforestry developments. In 2024 efforts are made to explore how the farmers that are part of these network can connect with EURAF through EURAF Netherlands.

Keywords
network, Policy, bottom-up, EURAF, Adoption, Agroforestry

Aditional Attachment I.

Table: Status of the agroforestry agroforestry networks per province with estimations on the number of farmers involved and area of agroforestry

Province	Status of agroforestry network*	Number of farmers involved	Area of agroforestry realised (ha)	Area of agroforestry in planning (ha)	Dominant type of agroforestry
Drenthe	2	25	50	100	Silvopastoral
Flevoland	3	25	100	200	Alley cropping
Friesland	1	50	75	250	Silvopastoral, alley cropping
Gelderland	3	125	250	1000	Silvopastoral
Groningen	2	25	50	100	Alley cropping
Limburg	3	75	150	300	Silvopastoral, alley cropping
Noord-Brabant	3	200	500	1250	Silvopastoral, alley cropping
Noord-Holland	1	25	25	100	Silvopastoral, alley cropping
Overijssel	3	75	100	300	Silvopastoral, alley cropping
Utrecht	3	50	100	200	Silvopastoral
Zeeland	3	50	50	100	Alley cropping
Zuid-Holland	2	25	50	100	Silvopastoral
Total		**750**	**1500**	**4000**	

* 1. Preparatory phase, 2. Starting-up, 3. Operational

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Social and psychological factors influencing the use of digital technologies in agroforestry: preliminary results from the DigitAF project.

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Introduction

Agroforestry is a nature-based solution that offers a significant potential for potential for increasing sustainability in the agricultural landscape (Stewart et al. 2022).

Objectives / research questions

Despite its proven potential, the adoption of agroforestry faces context-specific challenges, including a lack of decision-making tools and barriers that hinder the assessment of economic, environmental and social benefits. Digitalization has changed and continues to change agricultural production (e.g. Bronson 2019; Klerkx et al. 2019) in different types of farms and also holds great potential for agroforestry (Stewart et al. 2022). Digital farming technologies are a more recent phenomenon. There are several studies on how they have been introduced on farms (e.g. Barnes et al. 2019; Heitkämper et al. 2022; Nowak 2021; Tamirat et al. 2023). In Agroforestry digital decision aids, tools or applications can help planners and managers with design and management – but they are often not easy to use or understand. Seen the innovative nature of both digital farm technologies and agroforestry with its diversity in structure and products, there is very little known about the choice of digital agroforestry technologies by farmers, in particular in Europe (Kalanzi et al. 2021; Van Cauwenberghe et al. 2023).

The DigitAF Horizon Europe project aims to promote digital tools for agroforestry. One of its tasks, presented in this paper, was to identify the state of use of digital agroforestry tools by farmers and to provide in-depth insights into the decision-making process of agroforestry farmers in different countries from a social and psychological research perspective.

Methodology

As part of a multi-stakeholder survey within the DigitAF project, a section was designed to specifically understand (1) farmers' level of adoption of digital agroforestry tools and (2) farmers' social and psychological factors influencing the use of digital technologies in agroforestry. In addition, variables describing the farm structure (farm type, farm size, mobile and internet infrastructure) and sociodemographic situation (age, gender, education, financial situation) were used as control variables in the analysis. The survey was conducted using Google Forms.

The survey asked the following closed-ended questions using Likert scales to understand the side of the farmer as decision-maker: knowledge about digital farming technologies and also about digital agroforestry, attitude towards the phenomenon of digitalization in agriculture in general and in agroforestry, workload, personality, technology affinity, self-efficacy, motivations behind the usage of digital agroforestry tools and social influencing factors like the recommendation of their usage by consultants. In addition to attitudes towards digital agroforestry technologies, we also surveyed specific attitudes, such as the attitudes to data sharing, knowledge of data protection and farmers' willingness to share data were also part of the survey.

The sample consisted of 37 responding farmers. They were recruited from six Living Labs in seven European countries (IT, DE, NL, UK, FI, CZ, BE). All farmers were part of Agroforestry Communities. Agroforestry was chosen by 30 farmers when asked, "What is your farm type?".

Results

The survey shows that about one third of farmers already using digital technologies in agroforestry. The largest share of farmers in our sample is in the information phase of this technology adoption.

As seen in Figure 1, we find a predominantly positive attitude towards digital technologies in agriculture in general, and this applies to these technologies in agroforestry.

Figure 1 Attitude of farmers towards digitalization in farming and digitalization in agroforestry (N37).

Farmers in the Living Labs also have a high affinity for technology interaction. They also have in common a mostly medium financial situation, a self-declared workload that is too high and an intermediate knowledge of agroforestry.

Discussion and Conclusion

Despite the different contexts in which all members of the Living Labs operate the social and psychological influences on the use of digital agroforestry technologies seem to be similar. Farmers have positive attitudes towards digital technologies in agriculture in general and agroforestry in particular. The following analyses will show the factors on the farmers' side and shed light on their decision-making process to apply digital agroforestry technologies. As our sample has a high proportion of users and farmers interested in these technologies, we can show the facilitating factors for the use of digital agroforestry technologies on farms. At the end of the analyses, we will make recommendations on the features and capabilities that enable the technologies to be used, thereby facilitating the practice of agroforestry and strengthening its diffusion.

Acknowledgment

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Keywords

Agroforestry, Decision, knowledge, perception, decision-making, farmers' motivation, risk factors, decision analysis, facilitation, case study, adoption constraints, Case studies, farmer perception, personality, Adoption, farmers' decision making

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What technical and administrative challenges impede the adoption of agroforestry practices? A global perspective through a systematic literature review

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Introduction

Climate change caused by the emission of greenhouse-gases from human activities, represents a challenge to human and planet health and affects vulnerable communities in a disproportionate manner (IPCC 2023). The IPCC mentions agroforestry as an effective adaptation measure to reduce climate risk and improve the sustainability of food systems (IPCC 2022a) as well as a mitigation option in the AFOLU (Agriculture, Forestry, and Other Land Use) sector, which together with improved and sustainable crop and livestock management, and C sequestration in agriculture, could contribute to a reduction between 1.8 and 4.1 GtCO2-eq per year (IPCC 2022b). Other estimates indicate that by implementing agroforestry in the 10% of the area with the most relevant number of accumulated environmental pressures (related to soil health, water quality, biodiversity and climate change impacts), could lead to a C sequestration of 2.1 to 63.9 million t C per year (7.78 and 234.85 million t CO2 per year) varying by type of agroforestry (Kay et al. 2019).

Objectives / research questions

Despite the growing amount of literature regarding the multiple benefits of agroforestry such as C sequestration (Albrecht and Kandji 2003; Terasaki Hart et al. 2023), reduction of soil erosion (Palma et al. 2007), resilience to climate change from smallholder farmers (Verchot et al. 2007), conservation of biodiversity (Edo et al. 2024) and generation of ecosystem services (Torralba et al. 2016), the adoption of agroforestry systems also presents a number of challenges and barriers that require comprehensive examination and attention from the academic community, the policy actors and beyond. The novelty of this work stands in its systematic approach and its focus on stakeholder perception rather than investigating factors affecting adoption or non-adoption with an external perspective. The goal of this work is to provide a comprehensive and systematic overview of what is present in the literature regarding the obstacles stakeholder perceive with regards to agroforestry adoption, gathered through participatory research methods.

Methodology

We chose to perform a systematic literature review following the methodology described in the PRISMA framework (Page et al. 2021). The first step of the review protocol development process was to define the research question, which can be summarized as follows: "According to the literature, what do agroforestry stakeholders perceive to be the main challenges hindering the adoption of agroforestry practices, globally?"

The query was constructed in an iterative manner by extracting the two primary concepts central to our research question, which represents the research objectives and the key themes under investigation. The key concepts were identified as I) "Agroforestry", and II) "Challenge".

TITLE-ABS-KEY (agroforest* OR agro-forest* OR silvopastur* OR silvo-pastur* OR silvopastor* OR silvo--pastor* OR silvoarabl* OR silvo-arabl* OR hedgerow* OR shelterbelt* OR "riparian buffer strip*") AND TITLE-ABS-KEY (obstacle* OR challeng* OR hinder* OR barrier* OR difficult* OR struggl* OR troubl*)

A detailed breakdown of the title, abstract and full text screening is available in Figure 1.

Results

After the selection of the 90 studies to be included in the review, the relevant data was extracted and categorized in a datasheet. The following data was extracted from each relevant paper and subsequently organized in homogeneous categories: 1) Region of interest; 2) Investigated agroforestry system (when multiple systems were investigated, it was categorized as "agroforestry"); 3) Methodologies utilized in the papers; 4) Number, gender ratio and type of stakeholders (when multiple stakeholders were present, it was categorized as multistakeholder) 5) Relevant obstacles found in the paper (which were then later initially categorized into i) technical and agronomic ii) socio-economic and iii) policy and legislative).

Across the analyzed papers (n=90), we encountered issues pertaining to the category of technical issues in 86% of cases (n=78), followed by the category of socio-economic issues in 76% of cases (n=69) and the category of policy-related issues in 62% of cases (n=56). We then proceeded into further categorizing the issues, resulting in 31 obstacles that stakeholders around the globe perceive according to the examined literature with regards to agroforestry adoption, pertaining to i) technical-agronomic (T.01-T.15), ii) socio-economic (E.01-E.10) and iii) policy-legislative (P.01-P.06) aspects.

Figure 1 PRISMA 2020-consistent flow diagram showing the identification screening and inclusion process of the systematic literature review (Haddaway et al. 2022)

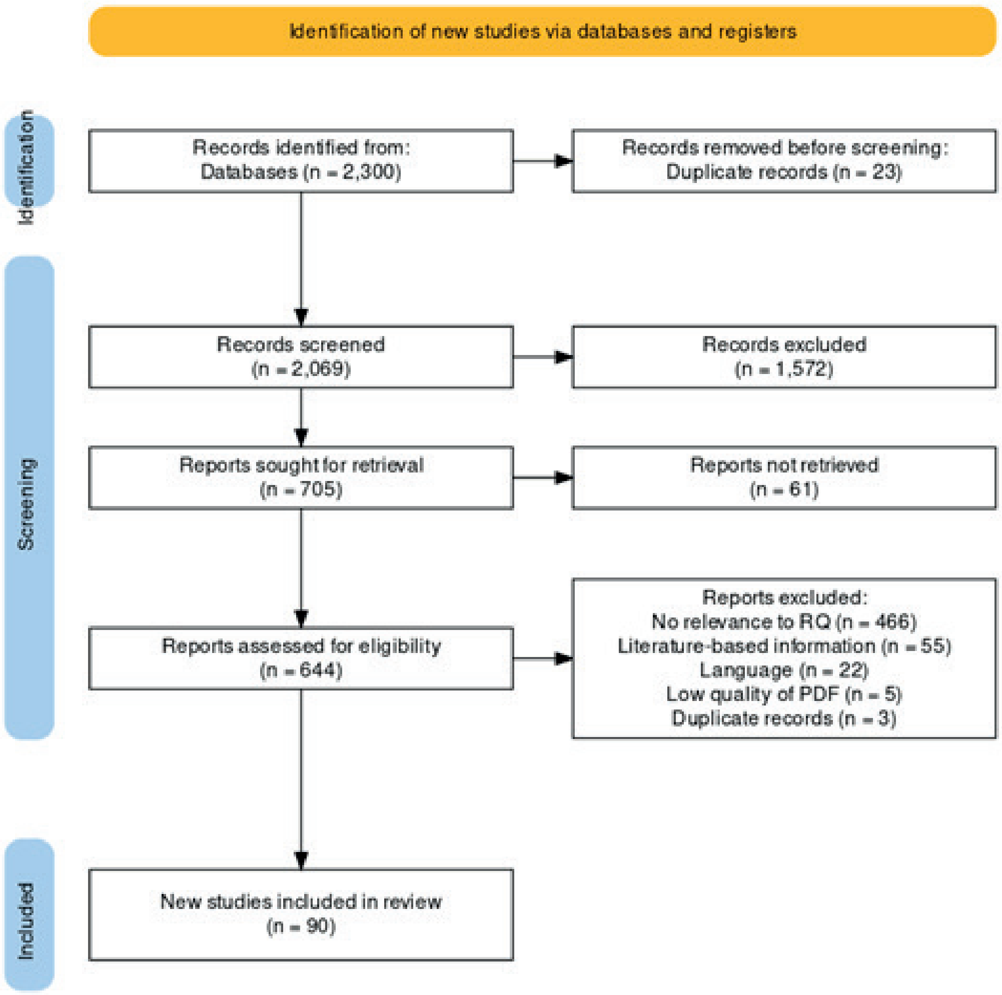
Conclusion

In light of the complexity and intricacy of the challenges that actors in the value chain are faced with in relation to agroforestry adoption, we highlight i) the need for an integrated multidisciplinary approach to problem solving and collaboration among actors; ii) the importance of the involvement of farmers in policy design through participatory processes to enable the sustainability transition; iii) the need to take into account regional peculiarities and local context to effectively promote the adoption and maintain the use of agroforestry systems globally.

Keywords

Agroforestry, economic incentives, policy co-development, Adoption, Policy, adoption constraints, agricultural policy

Aditional Attachment II.



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Technical, administrative and economic challenges faced by European agroforestry pioneers: preliminary results from the DigitAF project

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6 European Forest Institute, Joensuu
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9 Faculty of Tropical AgriSciences, Czech University of Life Sciences, Prague, Czech Republic
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13 Louis Bolk Institute, Bunnik,

Introduction

Climate change is extremely urgent, and there is a need to shift towards more sustainable and resilient economies and food systems (IPCC 2023).

Agroforestry, the practice of deliberately integrating woody vegetation (trees or shrubs) with crop or animal systems (Burgess & Rosati, 2018), has been gaining attention as a sustainable land-use practice. Agroforestry is a promising climate mitigation practice: it is estimated that implementing agroforestry in the 10% of the area with the highest number of accumulated environmental pressures, could lead to a carbon sequestration of 2.1 to 63.9 million Mg C a–1 (7.78 and 234.85 million Mg CO2eq a–1) (Kay et al. 2019).

Objectives

Despite its proven potential, the adoption of agroforestry faces context-dependent challenges, including the lack of decision-making tools and barriers hindering the assessment of economic, environmental, and social benefits. The DigitAF Horizon Europe project (2022 to 2026) aims to co-develop digital tools tailored to address the unique needs and concerns of diverse stakeholders in the agroforestry landscape. By adopting an end-user-centered, multi-actor approach, the project aims to involve policy actors, practitioners (farmers, advisors etc.), and beneficiaries of AF goods and services in project activities. Thus six Living Labs (LL) in six European countries (IT, DE, NL, UK, FI, CZ) have been created. The work presented here focuses on the stakeholder perceptions on technical and administrative challenges

Methodology

A multi-stakeholder survey was designed within the project to understand the perception, use, needs and wants of the various actors regarding agroforestry and digital tools, examining in depth past research and similar projects (Camilli et al. 2018; García de Jalón et al. 2018; Graves et al. 2017; Liagre F 2005; Rois-Díaz et al. 2018; Rolo et al. 2020; Tsonkova et al. 2018).

The initial distribution of the survey focused on participants of the DigitAF LLs and selected stakeholders Belgium, and achieved a total of 92 responses. In one section of the survey, respondents were asked to rank a series of technical, economic and administrative issues through a Likert scale.

Results

The survey shows limited use of digital tools across all stakeholders. Members of the LL agreed upon a high demand for digital tools for the management of an agroforestry system. These include tools for system design, tree selection, crop, tree and animal performance and management of agroforestry systems. Also, tools on economic aspects of agroforestry systems and environmental aspects (biodiversity, carbon neutrality, soil health) are valued. They indicated that a tool related to agroforestry-related CAP matters could be of great relevance. From an environmental point of view, users would appreciate a tool or model aiding them in evaluating the carbon neutrality of agroforestry systems.

As seen in Figure 1. the survey participants see the main technical problems in implementation of agroforestry mainly in knowledge gap among practitioners about tree planting and management and necessity of substantial change of farming practices. The participants see the main economic obstacle in the large initial investment connected with establishment, but also high management cost in following years. The stakeholders also share the fear that and increased number of tress/ha would result in loosing CAP support and further administrative burden when implementing agroforestry.

Discussion and Conclusion

Despite the different contexts all the members of the Living Labs operate in, a large part of the needs and wants overlap. For example, the actors have a positive attitude towards the development of a (European) map of agroforestry practitioners and other actors. Also in most LL, the center of gravity of needs and wants are tools for agroforestry practitioners and advisors. There is a high demand for tools for the design and management of agroforestry systems, as well as decision support tools on the topic of financial aspects and tree and crop performance. The prediction as well as the monitoring of ecosystem services (with emphasis on carbon sequestration and biodiversity) is also an important topic for tool development. Furthermore, all LL made suggestions to increase user-friendliness by making tools available on mobile phones in the field, taking into account that tools must be accessed quick and easy, often without an internet connection.

This work provides great insight into the challenges faced by agroforestry stakeholders. but the initial sample may exhibit bias. Participants in this survey represent a highly educated subset of farmers who are exceptionally interested and knowledgeable about agroforestry. This bias is inherent to the nature of the survey, which was intentionally designed as a first attempt to gather insights from pioneers of agroforestry. Therefore, the outcomes of this survey should be interpreted accordingly. The next steps of the project are to analyze the survey results and, based on these results, to shorten and simplify the survey and distribute to a wider audience of stakeholders at European level.

Acknowledgment

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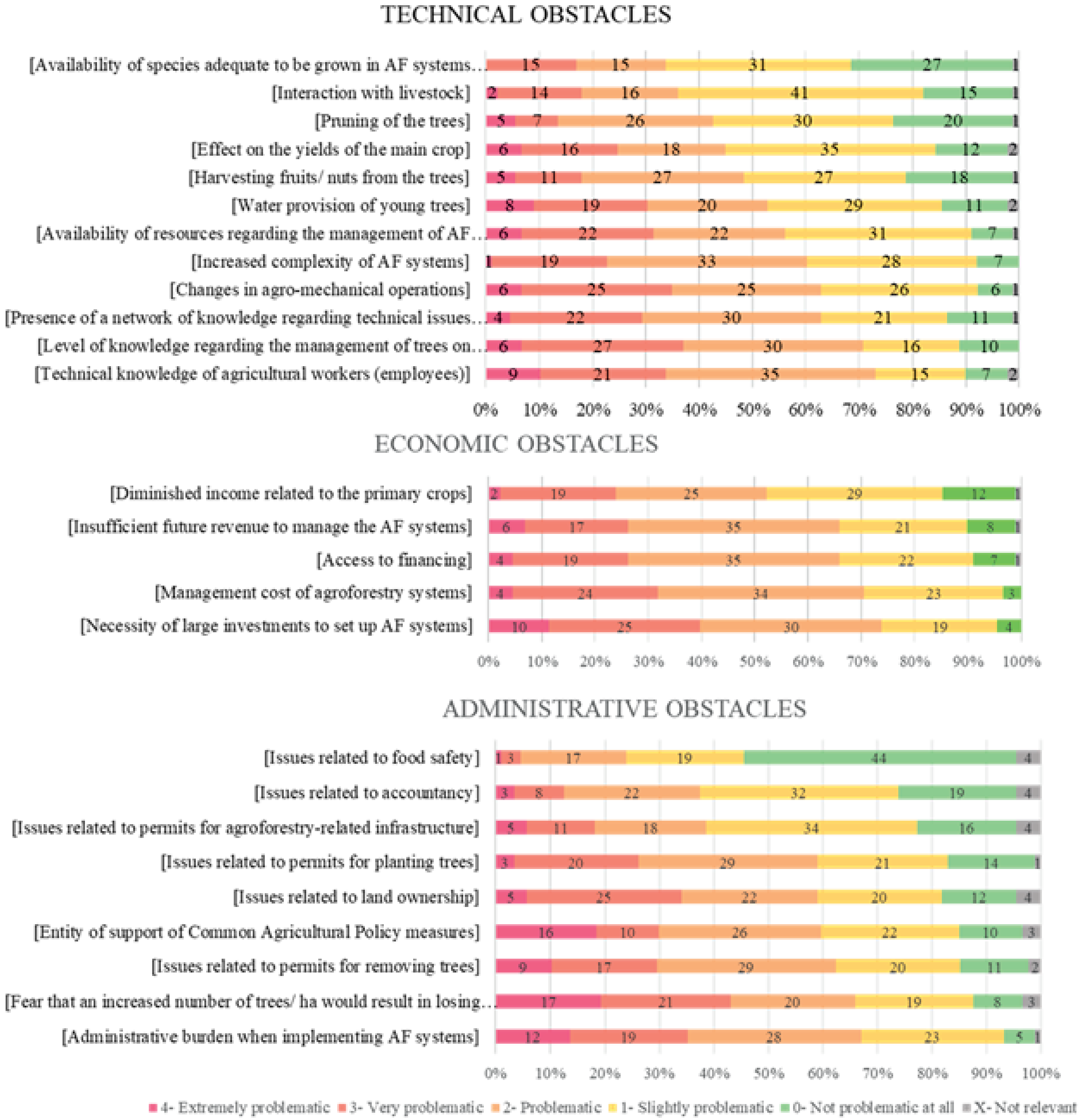
Keywords

Adoption, Agroforestry, agroforestry practices, participatory research, adoption constraints, case study, collaborative research, agricultural policy

Aditional Attachment II.



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5.1 Farmers Experiences and Adoption (II)

Oral presentations

Hall Q1, 29 May 2024, 15:45–17:15

Implementing Syntropic Agroforestry Systems in Germany

Renke de Vries[1]
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Since 2019 several syntropic agroforestry sites haven been planted in Brandenburg (East Germany). These systems are characterized by a successional development, stratified tree lines and ideally timed pruning of trees, herbs and grassland for biomass production. They are designed to regenerate the ecosystem instead of degrading it. Every part of the ecosystem is seen as a part of the puzzle with a specific function to optimize life and is not to be categorized as good or bad.

I (Renke de Vries) was responsible for the establishment and management of these tree lines in Alt Madlitz from 2019 till 2023. I have learned from the Suisse founder of syntropic agriculture Ernst Götsch in Brazil. In 2019, I began to build up a system which applies the syntropic principles to middle European conditions. This meant identifying the right species and their place in succession and adapting the system to European working conditions and the European state of mechanization.

Till 2023 about 18 km of syntropic tree lines have been established on arable fields. These tree lines differ highly in their species composition. They are combined with grazing animals, field crops and/or poultry. Furthermore about 0,6 hectare of syntropic forest transformation has been done. The challenge of establishing tree lines on an open field without irrigation and without noteworthy losses was achieved in one of the driest regions of Germany (average of 450 mm precipitation).

A high quality of the sapling and to work with seeds as much as possible were therefore of particular importance. The difference in drought resistance and general health between middle/high stem fruit trees in comparison to fruit trees grown in pots with the air pruning system or direct seeded fruit trees was enormous. Apart from that the establishment of a dense herb layer and productive grass, clover and herb mixes on the side of the tree rows have proven to be of crucial importance. In order to create such a system precise planning is necessary. Preparations should start at least one year before planting. However, with proper planning and preparation these syntropic systems are highly resistant to drought and pest issues. They are made to last more than 100 years continuously improving the ecosystem.

The main focus crops in Brandenburg have been sea buckhorn, apple, pear, plum, walnut and hazelnut. In addition numerous trials with cultures like grape vine, chestnut, silverberries and many more were carried out. The results show that almost every tree crop or vine can be grown in a syntropic system.

Besides the chances that syntropic systems offer on arable land these have an enormous potential for forest transformations. Right now, big parts of European forest are dying or suffering severely from climate change and mismanagement. If we just replace certain species but reforestation is done in the same ways future problems are inevitable. A first trial to transform pine monocultures in Brandenburg shows that working with syntropic principles brings a healthier and faster rejuvenation than conventional or ecological forest transformations. In this approach a part of the monoculture was cut down and the forest succession started again from zero. Especially the late successional trees should be established by seed. By growing from seed they can form their root system undisturbed and their microbiome is not damaged by the practices of conventional nurseries.

The first fields of syntropic agriculture in East Germany have been a huge success. The syntropic approach works very close to nature and gives humans a meaningful role in the ecosystem. Scaling these systems and adapting machinery could be one of the main tools to minimize and solve the ecological disaster we are witnessing these days.

To adapt to the changing climate, we need to use the tools of syntropic agroforestry. This means we need diverse, stratified systems and a well-designed ground layer. We need to accelerate natural processes by regularly pruning the non woody species and the timber trees integrated into our production fields. The trees need to be established in a way that the natural succession and selection processes are to take place. This means to bring out the long living trees by seed as much as possible. If not possible by seed the trees should be raised and transplanted in young age with as little damage to the root system as possible. We also need to realize that our nature is constantly changing and that we cannot be static in our choice of species. This means that we must overcome the banishment of certain species. Instead of arguing about "native" or "invasive" we should try to discover the function of the species. If those steps are followed, we will be able to establish productive agroforestry systems even under a changing climate and without further depleting our water resources for irrigation.

More information about the author can be found here https://urlsand.esvalabs.com/?u=https%3A%2F%2Fwww.syntropickezemedelstvi.cz%2Fkonzultanti%2Frenke-de-vries%2F&e=7da38bd4&h=4ff1baac&f=y&p=n

Keywords
agroforestry system planning, syntropic agriculture, Corylus species, hazelnut, Agroforestry, ecological restoration, succession, silvopastoral, agroforestry systems establishment, Socioeconomic status, resilience, drought, land use change, drought adaptation, agroforestry practices, Corylus colurna, Europe, ecosystem services, biodiversity, Germany, stratification

Resilience of French Mediterranean mixed fruit tree-vegetable systems: from theory to practice

Léa Garreau[1], Dr Rodolphe Sabatier[1], Dr Marc Tchamitchian[1]
1 INRAE Ecodéveloppement, Avignon, France

Agricultural systems undergo a broad spectrum of changes in their environments. In these circumstances, being resilient is a key property of agro-ecosystems that makes it possible to continuously change and adapt (Darnhofer 2021). For socio-ecological systems, resilience is defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks." (Walker et al. 2004). Diversification of farming systems is a strategy that is repeatedly put forward to increase the resilience of farms (Perrin, Milestad, Martin 2020). In Europe, an emblematic diversified farming system is fruit and vegetable agroforestry in its diverse forms (forest garden, syntropic agriculture, permaculture etc.). These forms can be grouped together under the term of mixed fruit tree-vegetable systems (MFVS). An MFVS is a system where diversified fruit trees and vegetables are intercropped (Paut 2020). This type of system is often perceived by farmers as being intrinsically resilient thanks to diversification. However, no study has yet investigated the resilience of such systems. A crucial issue that needs to be considered when addressing this question is that there is no typical profile for MFVS and the goals and issues of each MFVS is highly farmer dependent.

As part of the PRIMA-TRANSITION project, we established a method to document the resilience of MFVS centred on farmers objectives and issues. We based our work on the definition of resilience proposed by Walkers et al. (2004). The first part of our work consisted in revealing what made the system resilient for the farmers. Based on semi-structured interviews with 18 farmers different Mediterranean MFVS, we identified (i) the disturbances that most impacted them, (ii) the properties of their system that they wanted to maintain and (iii) the levers that they used to do so. These interviews allowed us to have a global understanding of the functioning of the farm and of the drivers of their resilience. The interview outline aimed at making farmers talk about a satisfactory state of their farm. The farmers described these states according to five dimensions: (i) global organization of the farm; (ii) agroecological driving of the plot; (iii) economic performance; (iv) provision of ecosystem services; and (v) access to knowledge in agroforestry. During the interviews, the farmers also explained the resilience levers that they mobilize when they go through a disturbance. We could distinguish two types of levers: piloting (daily farm management is at the basis of the system's resilience) or structuring the system (biological interactions between the components of the system are at the basis of the system's resilience), and two ranges of resilience levers: they either rely on ecological levers mainly or follow a multidimensional view in which case they combine ecological, social and economic levers. Farmers could be grouped in categories according to the type and range of levers that they mobilized.

Secondly, and based on these perceptions of resilience by the different farmers, we measured a set of indicators. We therefore measured the resilience indicators in these farms to evaluate how close is the current state of the farm from the satisfactory state. These indicators relate to ecological services, work organisation and economic balance. We measured the same set of indicators for every farm but the analyse of the value of each indicator was done regarding the specific farm's profile. It shows to what extend the farmers build systems that correspond to their point of view on resilience.

Finally, these results were a basis for workshops aimed at empowering the farmers on the resilience subject. Thanks to a situation play, the aim is to generate a reflexivity on the degree of reorganisation to implement in the farming system depending on the nature and the frequency of the disturbance. During both an individual and a collective phase, farmers are invited to explain their reaction in front of different disturbance scenarios. The aim is to describe the different levels of reaction depending on the type of disturbance, evaluate the added value of resorting to a collective reflexion to build resilient response to disturbances and to determine the best conditions for maximizing the benefits of group reflection while minimizing its drawbacks.

To conclude, our work addressed the question of the resilience of MFVS and showed that farmers act in different ways to be resilient. This diversity of behaviours reflects the heterogeneous farmers' objectives. We combined three tools: interviews, indicators measurement and workshops, obtaining qualitive and quantitative data to document the resilience of MFVS and to empower the farmers on these questions. We believe that this work can serve as an example to extend the notion of resilience to other farming systems and to constitute a case study for future studies aimed at comparing the choices made by the farmers to be resilient for different farming systems in France and worldwide.

Keywords
European project, mixed fruit tree-vegetable systems, intercropping, resilience, agroforestry practices, Socioeconomic status, agroecology, horticulture, farmer perception, Interaction orchard/intercropping, climate resilience, agricultural revenue diversification, Mediterranean resilient agriculture, mixed horticultural system, farmers' motivation

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The beauty of agroforestry orchard

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2 Statek u Macháčků, Huntířov 179, 468 22, Skuhrov, Czech Republic

Description of the farm

At our farm, located in Huntířov village in the foothills of the Jizera Mountains, N Bohemia, we take care of 18 ha of land in organic way. We grow vegetables and fruit and thanks to the so-called community-supported agriculture (CPA), we form a community of people who care about their health, as well as a healthy landscape. Our fields are located on southeast slope at an altitude of 430 m.

I started farming in 2006, together with my father, and in 2010 I founded Statek u Macháčků on family land, with the main intention of growing fruits and vegetables in organic quality. I started on about 1 ha of the original intercropped orchard with mature fruit trees (tall varieties of apples, pears, plums, cherries, together with currant shrubs within the tree rows), planted at the distance of 12-14 m among alleys of trees. In between those tree alleys, we started growing vegetables such as carrots, parsley, parsnips, potatoes, garlic, onions, first only for the needs of the family and then from 2010 also for customers. From the beginning, the effort was to operate within CSA (community supported agriculture), producing organic boxes, which we imported to nearby towns. At the beginning, it was about 15 organic boxes per week. Gradually, we began to expand our holdings and establish other intercropped orchards on our own or newly purchased land. At the beginning, we used the land among the tree rows to produce grass and hay for dairy cows but gradually, with the increase in interest in organic vegetables, the land was cultivated for growing vegetables (carrots, onions, pumpkins, beets, etc.), garlic and potatoes. At present, together with my wife we farm on our own land and we mainly produce vegetables, fruit and tie bouquets. In 2023, we have achieved the production of around 70 organic boxes per week and deliver them to five towns nearby.

Agroforestry experience

In 2023, as part of a new agroforestry support, we established additional agroforestry plots with a total area of 4 ha (0.6 ha on arable land and 3.4 ha on permanent grassland). We planted permitted forest trees (oak, maple, hornbeams, linden, ash, wild apple, cherry, plum and pear.) in rows with a distance of 7 x 14 m and the north-south row orientation. Currently, we have also started raising hens for eggs, and we would like to use a mobile chicken coop for grazing them in the new silvopastoral system.

I have been practicing agroforestry since the beginning of my farming and I consider it natural to grow fruit trees with vegetables, as our ancestors did. Over time, however, we gain a lot of valuable experience. In the plantings, the orientation of the tree rows is predominantly east-west, due to the slope of the terrain, thus planting the trees along the contour. The older and large mature trees cause shade on the north side that has a positive effect on the soil moisture. There, the soil dries out much less in the summer heat. However, on the south side, the soil is becoming very dry, often with less rain, not much moisture falls there. Since we use a drip irrigation system for growing vegetables, it doesn't bother us that much.

Our experience also tells us that planting and growing woody plants requires considerable care and labour, especially in the early years. From the beginning, it is mainly a matter of choosing high-quality saplings, with suitable rootstocks, ensuring their thorough protection and support with poles and fencing, as well as sufficient watering and weeding, to minimize the competition with grasses. It depends on the type of tree, e.g. an apple tree needs significantly more care than a plum tree, regards the competition of grass sod. Mice and rats cause considerable damage to our fruit tree plantations.

Our intercropped orchard is matter of our heart, when everything blooms in spring, then the trees turn green and rows of vegetables and flowers can already be seen in the rows, it is simply beautiful. We harvest from the trees, from the bushes that are between the trees and then also the vegetables and flowers from the rows in between, it's a very pleasant feeling.

Plans for the future

I've always wanted to do more of agroforestry, but it's a struggle with bureaucracy. Until now, it was a big problem to grow trees on agricultural land so that I could receive classic agricultural subsidies, like other farmers. I am glad that in 2023 a new agroforestry subsidy title was created. I just hope it will be a bit modified to be less restrictive and allow establish excellent and beautiful agroforestry systems. If I had more land of my own, I would also plant them with agroforestry and give them a higher value, economically, ecologically and aesthetically.

Keywords
alley cropping, agroecology, organic farm, intercropping, fruit orchards

Aditional Attachment II.

A first-hand account of establishing productive nut agroforestry over 200 hectares of farmland in East Anglia, UK

Mr Archie Ruggles-Brise[1]
1 Spains Hall Estate, Braintree, United Kingdom

Agroforestry in the UK is a niche concept, productive agroforestry even more so. Despite gaining increasing traction amongst practitioners, eNGOs and policy makers it remains rare, and is commonly only implemented at very small scale (sub 20 hectares). This case study looks at one of the largest productive silvo-arable systems established in the UK, from business planning, design to procurement and establishment. A farmer-led scheme, covering around 200 hectares of productive farmland in East Anglia incorporating biodiversity gain, woodland creation and water stewardship alongside nut agroforestry resulting in a completely new land-use model for the UK. The case study looks at the challenges faced by the land manager in building the business case for agroforestry, including market insights (or lack of) and returns modelling, capital funding, plant sourcing and skills development in order to reveal the considerable barriers to large-scale uptake amongst the UK agricultural community.

Spains Hall Estate is a pioneering family-owned farming business close to Cambridge, UK. Led by a multi-generational family partnership the estate is pioneering an integrated approach to sustainable land management, balancing perennial and wild food production with quantified ecosystem services outcomes, including flood risk reduction, drought mitigation, carbon sequestration, nature recovery and social impact.

Case Study description

With over 6000 trees planted in a silvo-arable row arrangement across 180 hectares the hazel, truffle and walnut system established in 2022-2023 makes Spains Hall Estate one of the largest productive silvo-arable systems in the UK. In addition the Estate has over 25 hectares of timber silvo-pasture timber agroforestry (some of which has been in place since the 1940s). The layout and intercropping systems developed alongside the silvo-arable rows, designed to rebalance the land use across a range of ecosystem services outcomes, makes the system as a whole unique.

This case study will focus on the practical and financial challenges of establishing the new nut AF enterprise, but will also refer to policy conditions, and wider landscape-scale considerations that helped form part of the over landscape-scale scheme design.

Part 1 – Why do something different?

Covering climatic challenges, financial and environmental risk, a Natural Capital approach to land use outcomes appraisal was used to inform risk/reward land-use modelling. The role of climate change scenario potential impacts on existing farming systems in East Anglia will be touched on, in the context being a trigger for system change. Experience gained from visiting nut growing systems in the US and Europe will be referred to in the context of system design for greater sustainability.

Part 2 - Building the business case

There were many challenges sourcing sufficient information to build a comprehensive enterprise-level business case. Including securing information and insights on varieties, yields under AF type conditions, markets, and sourcing appropriate expertise to support the enterprise modelling and management in the UK.

Part 3 – The Money, where did it come from?

Finance to establish a new farming system is essential, but for silvo-arable systems in the UK it is vanishingly rare, and often tied up with overly restrictive grant conditions. The challenges, and ultimately the source of, funds to deliver the novel nut agroforestry system are set out, though many challenges remain.

Part 4 – The trees are the easy bit, surely?

Sourcing suitable nut tree varieties in the UK is extremely challenging. The main barriers include the lack of detailed knowledge and experience of their performance in a UK context, and the volume of available stock. Brexit has led to additional import administration, and the current small scale of the UK nut industry means existing supply lines are not well established and domestic production is limited to a few heritage and ornamental varieties.

Part 5 – Planting, protection and management – practical challenges in the UK

As a valuable, and long-lived, crop the nut trees in the Silvo-arable system require careful establishment and protection from a range of pests and diseases. Weather conditions in the UK mean that some of the approaches to nut harvesting commonly used elsewhere aren't suitable for the UK, these are explored in the context of a mechanise-by-default approach to system design.

Conclusion
Having been through the process first hand, and at a rare scale for the UK, this case study explores the challenges experienced around industry knowledge, financing, public policy, sector acceptance and practical delivery of large-scale agroforestry. Suggestions for areas of additional research, both academic and applied, include yield modelling for commercial nut varieties in a UK context, within and outside AF systems of various designs, market insights and forecasting, climatic and pest challenges, development of an industry-centric advisory and research programme to mirror those in other geographies. There remain significant challenges for improving financing, policy context, industry organisation and support for others wishing to develop similar systems in the UK and Europe.

Keywords
floristic complex, agroforestry system planning, silvoarable, soil improvement, walnut, crop production, walnut varieties, spatial planning, alley cropping, water scarcity, climate mitigation, England, natural resources, ecosystem services, Landscape ecology, outdoor system, agricultural revenue diversification, tree farming, business models, restoration, sharing of experience, farmers' motivation, climate resilience, pay-back time, feasibility, landscape planning, multifunctional landscape, agrisilvicultural systems, agricultural policy, carbon sequestration, grazing, water infiltration, silviculture in agroforestry, nature-based solutions, succession, sustainable business models, Policy, Payment for Environmental Services, agroforestry systems establishment, wood, Corylus species, resilience, oak, rural renewal, understorey growth, trade-off, payments for ecosystem services, carbon storage, land use change, pollination, agroforestry value chains, landscape transformation, grassland, soil biodiversity, Land cover change, soil characteristics, environmental impact, temperate agroforestry, biodiversity conservation, crop-livestock-forestry systems, Landscape biodiversity, fungi, consumers, green economy, Temperate climate, biomass, buffering climatic extremes, case study, climate change, soil properties, Adoption, hydraulic facilities, agri-environmental system, soil depth, green infrastructure, wild food, Agroforestry, flowering, land-use classification, afforestation, silvoarable agroforestry, willow, know-how transfer, decision-making, grazing livestock, agroforestry monitoring, tree spacing, hazelnut, Remote Sensing, Tree Crops, climate smart landscapes, farmer perception, harvest index, landscape policy, hedgerows, Landscape approach, crop-livestock integration, landscape, soil water availability, crop variety, alleys, land-use, rural development, rural economy, intercropping agroecosystems, truffle production, GPS livestock tracking, innovative food & non-food systems, sustainable food production, agroecology, carbon farming, soil analysis, GHG measurements, farmland bird, organic mulching, Socioeconomic status, environmental sensors, agroforestry practices, GHG emissions, biological corridors, production systems, land cover, water resources, policy co-development, farmers' decision making, farm-scale sustainability assessment, climate, research-action approach, adoption constraints, soil organic carbon, Floristic diversity, Land Use Policy, intercropping, mixed farming, silvopasture, e-learning, horticulture, ecosystem valuation, Agri-Environment-Climate, Land Use, Dissemination, profitability, water food energy nexus, implementation silvoarable AFS, incentives, soil fauna, extensive production system, food, Farmland, Soil Organic Matter, soil water content, climate change mitigation, soil moisture, intercropping system, soil carbon sequestration, Land owners, Climate smart agriculture, herbivores, Agroforest structure, biodiversity, farm type, Case studies, Water quality, design, agriculture, heritage, organic matter, soil conservation measures, soil biogenesity, temperate region, GIS, Juglans regia x nigra, sustainable soil & water management, shade, water management, policy contexts, Temperate, ecological restoration, stakeholders, Grassland with trees, business opportunities, Risk assessment, silvopastoral

Aditional Attachment II.

5.1 Farmers Experiences and Adoption

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Chicken-pastured orchards – a silvopastoral agroforesty system for community supported agriculture. A German pilot study in the peri-urban area of Saarbrücken

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Introduction

Community supported Agriculture (CSA) and microfarming are niches within German agriculture, however, they are growing noticeably in the last decade. The number of CSA farms in Germany has increased from 8 farms in 2008 (Kraiß & van Elsen 2008) to almost 500 farms (and many more initiatives) in 2023 (Netzwerk Solidarische Landwirtschaft, 2024). Many of these farms are newly founded by young people who focus on agroecological approaches that offer a comparatively high number of jobs per unit of land. Therefore, they are potentially of high importance for both peri-urban and rural development. At the same time the access to land for these farms is often limited. Thus, methods for sustainable intensification such as agroforestry can be of key interest for CSA farms and support their success.

The basis of CSA as a marketing scheme is in the vast majority of cases vegetable cultivation. Most CSA farms are specialized in this, many do not offer any other products. Nevertheless, the integration of other, additional products is desirable, both from the consumer's perspective and from the farmer's perspective with regard to the diversification of production (Bestman 2015, Zandbergen 2016). But diversification in such small, already complex farms is a challenge. The joint research project AGROMIX investigates, based on 12 pilot sites in various European countries, if and how agroforestry and mixed farming can be implemented to increase sustainability and resilience of the respective farming systems.

Case description

Stadtbauernhof Saarbrücken, one of pilot sites, is a CSA microfarm in the peri-urban area of Saarbrücken, that was founded in 2015. Since then, Stadtbauernhof (literally translated "city farm") has established itself as market garden vegetable farm and now supplies around 120 households and three restaurants with vegetables. As the farm's members and customers showed interest in other, additional products, a consumer survey was initially carried out as a first step of the case study. The survey revealed that customers are primarily interested in fruit, processed fruit products, eggs and honey. An obvious idea is the integration of fruit and poultry products in an agroforestry system – a system with many potential synergies and a potential higher production per hectare (Zandbergen 2016; Bestman 2015). The synergies encompass agroecological, economic and social aspects (Bosshardt et al. 2022, Burgess et al. 2017), e.g. animal and tree health as well as product and income diversification (Zandbergen 2016). Additional products expand the marketing spectrum of the farms (Bestman 2015). The challenges for further diversification of such farms lie in the increasing complexity. With a comparably small farm size, economies of scale in production can hardly be exploited.

Therefore, within AGROMIX a case study was carried out to assess the feasibility and economic advantage of a chicken-pastured orchard for CSA. The aim of the study was to not only assess the feasibility at single farm level but also identify the general prerequisites and success factors for integrated fruit and chicken farming in an agroforestry system as an additional branch for CSA farms, including the value of synergies, and providing key figures.

The work follows the AGROMIX co-design methodology "reflexive interactive design" (Bos 2010), including a context analysis and a co-design workshop. In addition, existing knowledge and experiences were compiled through literature research, interviews and field visits.

Conclusion

There is not much scientific literature considering the agroecological benefits of chicken-orchards available, apparently further studies of this system are needed (Bosshardt et al. 2022; Zandbergen 2016). Some interim results were achieved as part of the project work.

Microfarms specialized in vegetable production often lack time for highly intensive fruit cultivation and chicken management. In this regard, two approaches seem to be suitable:

a) The production is outsourced to third parties and linked through cooperative marketing. In this case either an AF (micro)farm with fruit and chicken production or two separate cooperating enterprises must reach a critical minimum size. Experience from other farms obtained from the interviews shows that fruit production must be sized for about 300-600 households (e.g. by supplying several CSA farms) and the keeping of laying hens with at least 100 (cost-covering) or 400 laying hens (small profits possible) to secure the income of one or more workers.

b) The existing vegetable production is labor-intensive with corresponding work peaks. Accordingly, new branches of the business must be harmonized with vegetable cultivation. This means that only very extensive fruit growing and less labor-intensive chicken farming are possible.

In general, the framework of a CSA makes it possible to use specific and high value production methods like the use of old fruit varieties and dual-purpose chicken breeds, provided that the community supports this and finances it through its contributions. A second, future workshop, which will also deal with the overall economic viability of the AF system, will focus on possible approaches for the combined extensive production of fruit and poultry products.

Keywords

case study, silvopastoral systems, horticulture, Agropastoral farming systems, Agroforestry, AGROMIX, natural pest control, fruit orchards, agroecology

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First experiences of AF intervention implementation in Poland

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Introduction and obcjectives
Financial support of agroforestry (AF) in Poland is provided by Intervention 10.13 - Establishment of AF systems since 2023. The intervention objective is to establish 3900 hectares of agroforestry until 2027. The measure is not well recognised by farmers and its promotion by decision makers and advisors is very poor. The aim of the paper is to characterize spatial distribution of AF interest among Polish farmers.

Methods
Analysis was performed using the data of The Agency for Restructuring and Modernisation of Agriculture (ARMA), in charge of CAP subsidies payment in the country.

Results
The total area reported under the intervention in 2023 covered 187,69 hectares, an average of only 0.0013% in relation to Poland's agricultural lands (AL). One can observe a very strong variation between 16 provinces in terms of the declared size of AF area (figure). Farmers from northern parts and south-western parts of the country are more interested in the measure than producers from eastern Poland. This is due to differences in land use structure, with larger fields most suitable for AF trees planting. The second reason is increased awareness of some pilot farmers, already familiar with the technology and keen to spread the knowledge to their neighbours. The largest share of intervention (39% of the area) was observed for farmers with an area of 10-50 hectares. More than 1/3 of the farms belonged to the 1-10 ha area group. A full analysis was hampered by the unavailability of data on declared area. 56% of the AF instrument beneficiaries were in the 41-64 age range. Farmers younger than 40 years were interested to a lesser extent (32%). Older farmers (>64 years) were less interested in the intervention (10%). In relation to the total number of farms in the country (41) - registered entities in the ARMA in 2018 - 0.003% of beneficiaries applied under the AF intervention.

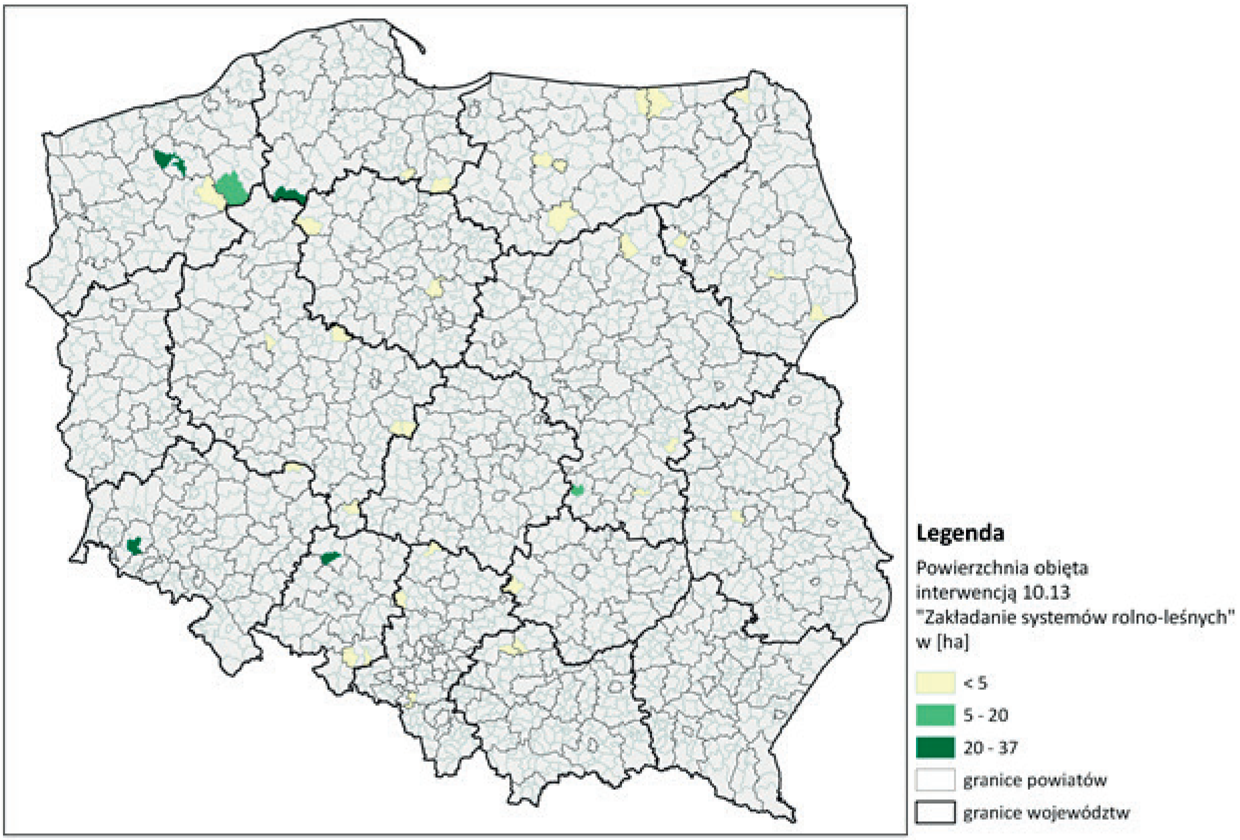
Conclusions
The interest of farmers in the first year of recruitment to receive support to agroforestry establishent was extremely small and strongly spatially differentiated. No correlations and trends that would indicate special features of interest were detected. Further analysis of the data in the following years is needed to observe potential trends.

Figure. Spatial structure of AF establishment intervention in Poland in 2023.

This abstract is based upon work funded by the Ministry of Agriculture and Rural Development within the targeted subsidy of IUNG - the task DC 2.2.12 "Evaluation of the implementation of the selected CAP SP instruments for the period 2023-2027".

Keywords
farm type, CAP Strategic Plans, agroforestry systems establishment, Poland, adoption constraints

Aditional Attachment I.



Biochar for agroforestry in Poland

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Introduction and objectives

How to increase the positive impact of agroforestry on the environment and soil productivity? How to manage excess woody biomass? The solution is low input production of biochar. For this purpose, the KON-TIKI flame curtain method was tested on three different farms.

Methodology

Biomass was obtained from various sources: pruning of forest plantations, dead wood from agroforestry systems, and wood harvested from removing invasive tree species. The labour input in man-hours needed to produce one unit of product [m3] of biochar was estimated. Processes such as transportation, harvesting and preparation of biomass, carbonization process, quenching and unloading were taken into account.

Results

It was found that it takes 16-20 man-hours to produce one m3 of biochar (8-10 hours of work by two people taking into account breaks). The amount of substrate available depends on the size of the farm and its specialisation. Small farms with forest and agroforestry systems (5-10 ha) could provide a few tonnes of wood at a time, resulting in only 2 m3 (400-500 kg) of biochar. A large farm (300 ha) with silvopastoralism could provide 20 t of dry wood sufficient for 4-5 t of product. The process of registration for the national market and certification for the European market is not cost-effective in both cases, so local use of the product is preferred.

Conclusions

The biomass gathering process can be greatly accelerated by increasing the number of people or by using agricultural equipment such as tractors and trailers. The biomass burning process can be accelerated by using a small fraction of wood up to 5 cm thick. Transportation and unloading contribute little to the total production time. Selling the product on a small scale is not viable due to the need to obtain registration and certification, but its use on the same farm is allowed. An additional source of income could be the biomass processing service with a mobile burner and the increase in yield obtained after using the product. Biochar can be used to improve soil quality, as an additive to manure and compost, or burned as a renewable fuel.

Figure. Biochar prepared from a finer fraction of wood using the flame curtain method

This abstract is based upon work from project REFOREST, which has received funding from the European Union´s Horizon Europe Programme under Grant Agreement Nr. 101060635.

Keywords

agroecology, REFOREST, economic performance, biochar

Aditional Attachment I.

Two original agroforestry living labs in service of regenerative agriculture promotion in Slovakia

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Introduction

Modern agroforestry systems and regenerative agriculture are still relatively unknown and little-spread technologies in Slovak agricultural practice. In order to more broadly introduce them in the farmer community two unique models – living labs were established.

Case description

Living labs were established in the western part of Slovakia, a region of intensive conventional agricultural production. This part of country is dominated primarily by large agricultural enterprises that grow field crops in large field blocks with areas of up to 150 ha. Therefore, it is desirable to improve biodiversity, fertility and sustainability of the agricultural land by means of woody plants and regenerative approach employment.

One of the living labs (A) is focused primarily on the combination of woody plants and field crops - silvoarable, but there is also an experiment with pasture. The trees in this alley cropping system are mainly represented by fruit trees, with emphasis on old varieties. They are grafted on very vigorous rootstocks (Malus domestica Borkh., Pyrus communis L.) forming 1,8 m tall trunks. In addition to the ecological and production function, these plantings also have added value in conservation of the endangered gene pool of landraces and old varieties of fruit trees. Field crops grown in interrows of woody plants are grown in a system of regenerative agriculture (no till), so it is possible to monitor not only the benefit of agroforestry, but also to compare the benefit of regenerative agriculture with conventional agricultural production. It is a prospective system for future research, as it is the unique system in the conditions of Slovakia.

The second living lab (B) is represented by a low-input alley cropping model based on black locust (Robinia pseudoacacia L.) and lavender (Lavandula angustifolia Mill.). This recently established woody plant skeleton should ensure natural nitrogen fertilisation (through N-rich leaf litter and root exudates) and crop pest/disease regulation. In this season we plan to sow the first crop (winter wheat, Triticum aestivum L.) and follow a standard rotation as applied by partner farmer with the conventional farming system.

Conclusion

We intend not only to describe eco-physiological background of the production process in all plant components of both experimental models but also evaluate level of soil carbon sequestration (climate change mitigation measure), biological diversity changes as well as economic benefits. Moreover, our experimental fields will be available to farmers as a demonstration site, for excursions of university students studying regenerative agronomy and other visitors interested in sustainable exploitation of natural resources.

Keywords

Agroforestry, fruit trees, Living lab, agroforestry systems establishment, agriculture, alley cropping, Black Locust

Aditional Attachment II.

The evolution of agroforestry landscape features: an historical perspective of Tenuta di Paganico farm, Italy

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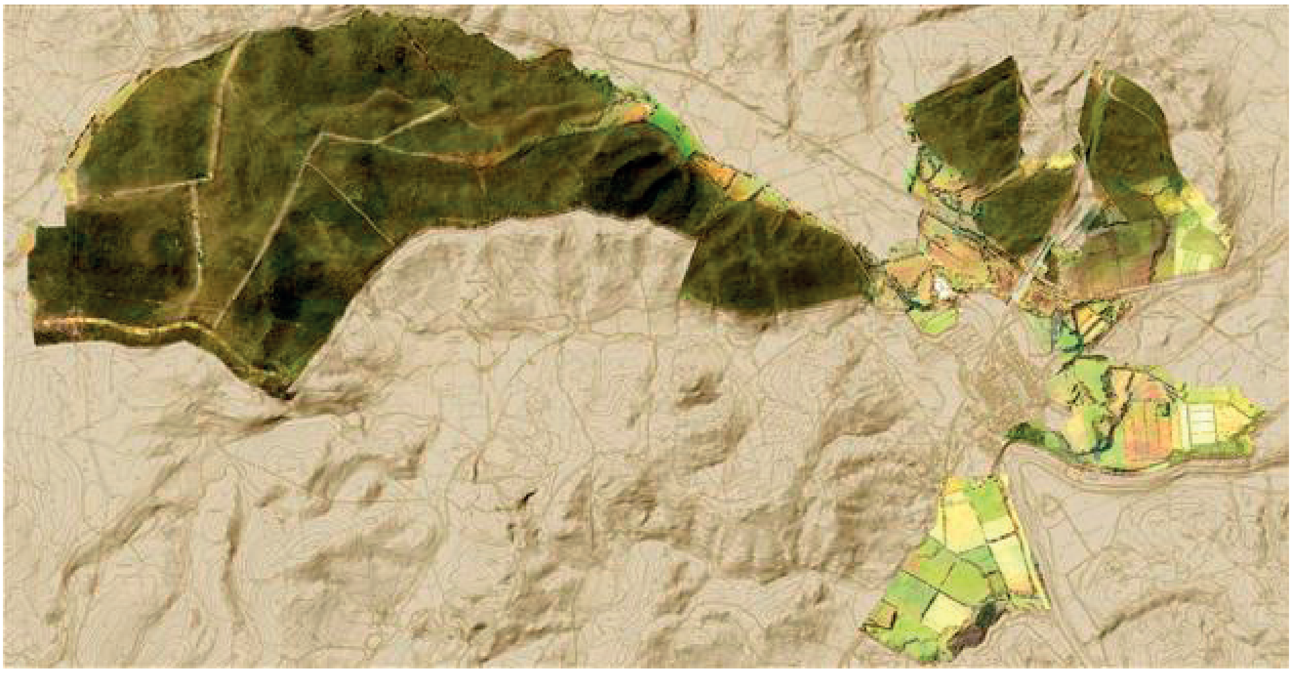
The territory around the town of Paganico (Civitella Paganico, Grosseto, Italy - https://maps.app.goo.gl/Gh9raAFDrkrsceLV8) had a complex history over the past centuries: in thirteenth century it belonged to the State of Siena, then in 1553 it passed among the properties of the Municipality of Montalcino, in 1580 was held by the Tuscan Grand Duchy, and finally, from 1630 is was part of the Marquisate of the Patrizi Family. The Tenuta di Paganico farm was created in 1924 by the Florentine forestry agronomist Alberto Uzielli supporting the view that "there's really no contrast between agriculture, even intensive, and silviculture" (1). For this purpose, since 1929 an agricultural reclamation project has been drawn up on the 3975 ha of the farm, in order to: a) create 267 ha of firebreaks grassland areas with oak or turkey oak scattered trees; b) gradually convert all of the Turkey oak coppice forest to tall tree system aimed at silvopasture; c) split woodlands into 19 sections of 35÷300 ha/each, through permanent fencing for raising mainly Maremmana cattle breed; d) extending the duration between two thinning in turkey oak coppice; e) allocate the lands in fair proportion among the peasants. The aim of this paper is to underline all the landscape modifications over the past 190 years of farm history, highlighting how agroforestry management has always been a constant goal in setting the scene. Already in 1832 the area was mainly devoted to agroforestry, with a strong integration of silviculture and livestock, as 6% of the surface was occupied by grazed forests and another 14% by pastures, while most of the surface was covered by oak forests managed as coppices. In 1954 pastures were partly replaced by arable land and by mixed cultivations, but 6% of the surface was anyhow devoted to pastures and wooded pastures. Today, the Tenuta di Paganico farm covers about 1400 ha, of which 74% is forest (mainly tall tree system of Turkey oak), 18% of arable land, 6% of pastures and wooded pastures, and 2% of uncultivated land, testifying the importance of a traditional management aimed at integrating forest and livestock management for the preservation of the local landscape features, of high historical, cultural, and aesthetic relevance.

Keywords

silviculture in agroforestry, landscape transformation, case study, organic cattle farms, Socioeconomic status, Land cover change, biodiversity, spatial planning, trees, livestock, agroforestry landscapes, silvopastoral systems, silvopasture, grazed woodlands, wildfires, agrisilvicultural systems, Agropastoral farming systems, crop-livestock-forestry systems, silvoarable agroforestry, beef, forest management, traditional landscape, grazing livestock

Aditional Attachment II.



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Conversion of abandoned tree-covered permanent grassland into productive agroforestry pastures in Slovakia

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According to the Statistical Yearbook of the Land Fund of the Slovak Republic of 1 January 2022 and the Land Cadastre, the area of agricultural land is 2,373,563 ha, of which 849,273 ha are permanent grassland. Approximately one third (more than 30 %) of the area of permanent grassland is unused, abandoned and overgrown with shrubs and trees in various stages of succession, and such areas are mostly allocated from the agricultural land area for the subsidy system.

In recent years, we have seen a significant increase in the interest of owners and farmers in using such areas for pasture production, which is also related to their efforts to include these areas in the subsidy system. Currently, the common practice in Slovakia is so-called revitalisation - restoration to the original state by reclamation measures, in which all woody vegetation is removed from such areas. Another option, which is currently strongly preferred due to climate change but not yet officially used in Slovakia, is the conversion of these areas into productive agroforestry silvopastoral systems - pastures with the retention of part of the existing trees or shrubs.

In order to obtain new domestic knowledge on such conversion, the National Forestry Centre is working on the project "Models of transformation of tree-covered non-forest land into productive agroforestry systems" for the Ministry of Agriculture and Rural Development of the Slovak Republic within the framework of its research plan. In the first two years of the project, 3 series of research plots were established in different natural conditions in Slovakia. Each series consists of the following 3 sub-plots with an area of 0.25 ha: "A" control plot without intervention, "B" plot converted to agroforestry pasture and plot "C" converted to pasture without trees. These series of research plots will be used as living laboratories for long-term research on all aspects of such conversion and will also serve as examples of good practice. In the poster, we will provide more information about the established research plots, the methodology and the first findings of the research.

The conversion of abandoned permanent grasslands overgrown with trees into managed agroforestry pastures is also important for several EU protected habitats and species in NATURA 2000 network. In the next part of the poster, we will therefore present the first practical knowledge we gained at the NFC during management measures to save juniper stands as part of the solution of the IP LIFE NATURA 2000 SVK project (https://www.prirodaprevsetkych.sk/en/about/).

Keywords
Grassland with trees, silvopastoral systems, agroforestry systems establishment, Field abandonment, Case studies, field forest cover, experimental site, Forest cover changes, Living Laboratories, research and development, restoration

Resilience through diversity: 30 years of agroforestry at Wakelyns (UK)

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The year 2024 marks 30 years since the first trees were planted at Wakelyns in Suffolk in the east of England and over the following years a diversity of different silvo-arable systems were established on the 22 ha site. Led by the late Professor Martin Wolfe and his wife Ann, the pioneering work of Wakelyns Agroforestry has been an inspiration to a generation of farmers. With firm policy targets for the increase in woodland cover and trees outside woodlands as part of the UK government's net zero strategy, Wakelyns also has a significant role as a demonstration site for encouraging the uptake of agroforestry under a new payments offer being rolled out in 2024. This demonstration potential is realised through an active programme of activities and events for visitors on site, not least an annual Agroforestry Open Weekend spearheaded by Wakelyns since 2021 and now involving tens of agroforestry sites throughout the UK and beyond.

Based on a new update of the 2020 report "Wakelyns Agroforestry: Resilience through diversity" (Jo Smith and Sally Westaway 2020), this paper reviews research that has taken place at the site over the last 30 years. This poster presentation highlights both the economic and ecological impacts of integrating trees into a farming system, and assesses the sustainability and resilience of agroforestry in comparison with monoculture production. The knowledge exchange function of Wakelyns and similar sites is discussed in the context of increasing policy support for options that respond to the climate and nature crises.

Keywords

demonstration AFS, climate resilience, silvoarable, agroforestry practices

Aditional Attachment II.

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Initiatives of Agroforestry - Forest garden developments in the farms of members of Hungarian Permaculture Association

Mrs, Dr Zita Szalai[1], Mr Balázs Kulcsár[1], Miss Dóra Szlatényi[1]

1 Hungarian Permaculture Association, Hungary

Introduction

The Hungarian Permaculture Association's (HPA) primary goal is to popularize sustainable agriculture practices/systems like permaculture, agroforestry, forest gardening and agroecology, among practitioners, farmers and the wider society. Our main goal is to develop a network of people, organisations, farms and other projects who seek to participate in creating a more sustainable culture. https://permakultura.hu/en/

The Association introduced education programs in different levels: Permaculture Design Course (PDC) nationally, Introduction to Permaculture courses, practical workshops, Permaculture Club. Our work teams cover a wide spectrum of activities, including research, design, and education. We are in network with permaculture organizations on international level, and are connection with Hungarian Civil Association of Agroforestry and the Fruit Farming Network of Carpathian Basin. HPA has strong relationship with agroforestry developments some of members are national representative in EURAF. MAPER had supported the implementation and dissemination of results of AFINET project in Hungary. Currently, the HPA is participating in the DigitAF project as affiliated partner of EURAF.

Case description: Agroforestry is a practicing way of land use at permaculture farmers: different type of agroforestry like silvoarable, silvopastoral, and forest gardens are in practice at permaculture farms. At the moment we have 47 registered farms dealing with different types of agroforestry. It can be followed by our mapping system. https://permakultura.hu/terkep/ According to their development they are sorted as: bud, shoot, and grove from the beginners to the most developed systems. Description of the farms can be reached from clicking the map symbols.

Some of the permaculture farms has long history is establishing agroforestry type of land use: like Valaha tanya, since 2006 www.valahatanya.hu, https://www.facebook.com/valahatanya. Previous land use of the farm was conventional arable field cultivation. The farmer established alle cropping system consisting of fruits trees and bushes intercropped with fodder cultivation coming from a composition of natural like diverse pasture. Protective hedgerow and block compartmentation of the farm was established with purpose and management implications. The installation of the protective hedgerow around the area was one of the first steps in the development of the farm. Among the timber species, black locust is the main stand-forming species in the hedgerow; oak, beech, elm and flowering ash are the associate tree species. Due to this, within 4 years there has been a significant decrease in wind pressure, and most probably in chemical pollution as well. Hedgerow serves the energy need of the farm coming from rotational pollarding of every second tree is carried out by the farmer, to maintain the multipurpose functions of the hedge. Wood pasture establishment and fodder production in the orchard for grazing (ship, poultry) and cutting in the orchard area is good combination. (Figure 1) Grazing is limited because of some damage to the trees (mainly debarking by goats). According to the farmer's experience, the use of tree protectors is required. The farm is serving for purposes of living lab in REFOREST project in Hungary.

Manna forest garden https://mannaerdokert.hu/ is a typical small scale forest garden serving the need of a family. Structure and species were selected according to Hungarian circumstances', following the instruction of Crawford (2022) for food forest development. Steppe-garden on the South part of Hungary providing forest pasture for animals of the farm. https://www.facebook.com/sztyeppekert . The oldest (33 years) permaculture project is called "Noé bárkája" (Noah's Ark) permaculture experiment site, in the North -East part of Hungary in Tápiószele, where agroforestry, forest gardening is the main type of land use.

Conclusion: One of the main of HPA is collaboration with other agroforestry practitioners, organizations on national and international level. With networking at home and abroad, we can exchange ideas and can get experience from other similar organizations from Europe to make environmentally friendly agriculture like agroforestry known among farmers. Further aim was popularizing forest gardening and agroforestry - through good examples of permaculture farms - in order to make it more attractive for farmers on national level. Additional aim is to make agroforestry as land use systems be officially acknowledged in the national legislative and administration system.

Keywords

multifunctional landscape, horticulture, education, training, natural resources, Agroforestry systems, food forest, Policy support, participatory research, agroforestry practices

Aditional Attachment II.

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5.2 European Initiatives and Projects

Oral presentations

Hall Q1, 29 May 2024, 8:30–10:00

Agroforestry and Innovations in Europe: Results from EIP-AGRI OG analysis in the context the of FOREST4EU project

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Introduction

New Global challenges, including the sustainability crisis, climate change and the interdependencies of growing global social and economic systems, require new forms of land governance to adapt technologies, economies, and societies (TWI2050 - The World in 2050, 2018).

In this context, agroforestry (AF) is recognised at the EU level as a land-use practice and system that can address the above-mentioned multiple challenges and offer opportunities to integrate interdisciplinary perspectives, leading to significant innovations and increasing sustainability. In Europe, the Common Agriculture Policy (CAP) supports establishing and enhancing agroforestry systems on agricultural or forest land with specific funding provided under the Rural Development Policy (RDP). However, farmers and policymakers have not yet sufficiently acknowledged the relevance of agroforestry systems - that's why engaging these actors is mandatory to understand the importance of enlarging the area covered by agroforestry systems and acknowledging the ecosystem services provided. The muti-actors approach is crucial to overcoming technical, economic, educational, and policy challenges in developing AF systems and filling the gap between knowledge and implementation (Mosquera-Losada, 2023). In recent years, this approach has been successfully implemented at the national/local level within the Forestry and Agroforestry Operational Groups (OG) of the European Innovation Partnerships (EIP-AGRI) financed by RDP. These OGs have encouraged collaboration among different actors, promoting the development of concrete innovations. However, the results of OGs struggle to cross national borders: innovations and best practices tend to remain in the local environment and do not reach the European level. In this context, the present work developed in the framework of the Horizon Europe project FOREST4EU (https://www.forest4eu.eu/) aimed to analyse, from different perspectives, the innovations proposed by AF OGs at local levels to obtain an overview of the AF innovations that can support farmers and EU policy.

Methods

To do that, firstly, five multi-actor inter-regional topic HUBs (ITHUBS) have been created, dealing with 1- wood mobilisation, 2- climate change mitigation, 3- sustainable forest management and ecosystem services, -4 non-wood forest products and 5- agroforestry. The data presented in this work are related to innovations coming from two of the five ITHUBs, specifically ITHUBs 4- non-wood forest products, and 5- agroforestry, as both of these approaches represent multifunctional and integrated strategies that can significantly contribute to enhancing the sustainability of the agroforestry environment and the related communities.

The different innovations developed by OGs were collected in the form of Extended Summaries and classified according to the type of innovation (technological, process, product, service, organisational, social) following the understanding of innovation in EIP-AGRI OGs as defined in the "Guidelines on Programming for Innovation and the Implementation of the EIP for Agricultural Productivity and Sustainability" (2013).

Successively, innovations have been prioritised by stakeholders (forestry and agroforestry practitioners, including individuals, professionals, or organisations involved in the management, conservation, and sustainable utilisation of forest resources, reforestation or management of mixed systems) in each of the nine countries during 'prioritisation workshops' (i.e. collaborative sessions that allowed mapping the different needs of innovation for the ITHUBs and highlighted differences and similarities between countries).

Results

A total of 174 Extended Summaries have been collected, encompassing innovations from 85 OGs in nine EU countries. Specifically, for the two ITHUBs focusing on non-wood forest products and agroforestry, 69 innovations (36 non-wood and 33 agroforestry) were generated by 32 OGs across six partner countries. The non-wood and agroforestry ITHUBs innovations were classified as 18 technological, 10 of product, 22 of process, 14 of service, 1 organisational and 4 social (Figure 1). Subsequently, these innovations went through a prioritisation process within each country, enabling us to map, rank and exchange the innovations within each of the nine countries, employing a multi-actor approach. This work resulted in a comprehensive map of innovations and an assessment of the consistency and discrepancies across nine EU countries.

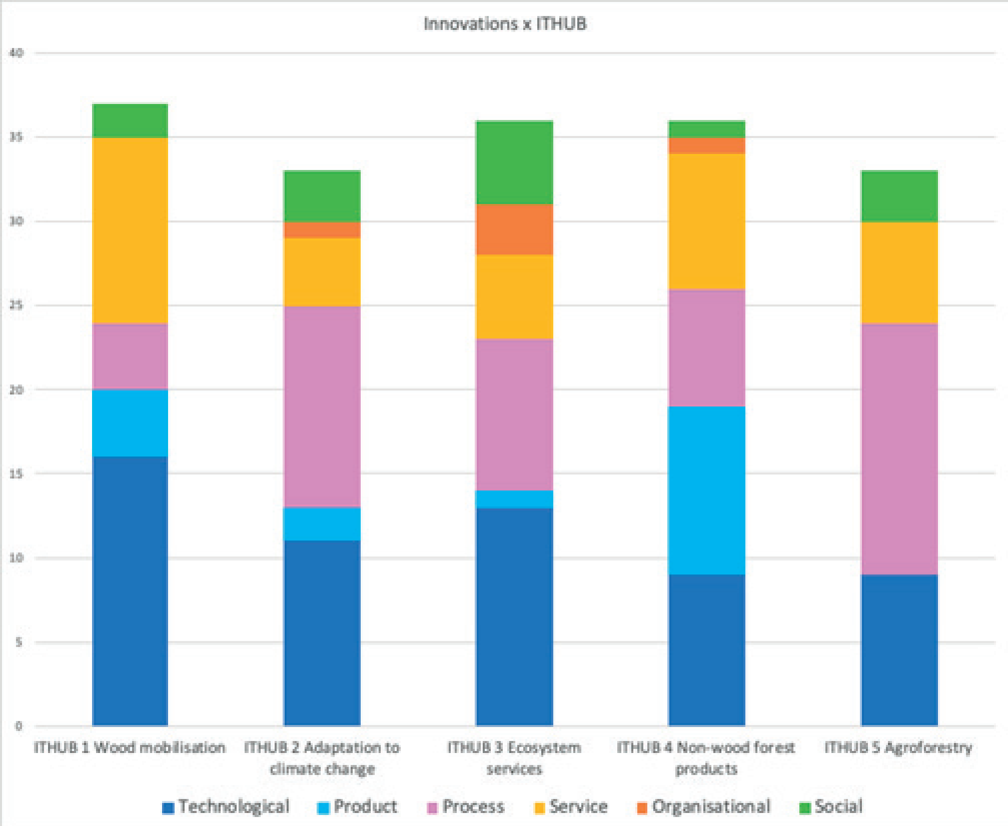
Conclusions

This work provides an opportunity to gain a European overview of the innovations proposed by OGs in the Agroforestry sector, enabling a collection of the innovations, challenges and needs with a special focus on the countries that currently have no OGs. Furthermore, the prioritisation process is useful for linking practice with a policy perspective, facilitating an understanding of the common needs and differences between countries and helping to overview the needs of the AF sector at both local and community levels to improve the uptake and implementation of innovations and best practices.

Keywords

participatory research, EIP-AGRI OGs, Agroforestry, non-wood forest product

Aditional Attachment II.



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Implementing dynamic agroforestry: a case study of the ot4d/ppp project in Serbia

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In recent years, nature and food production enthusiasts, led by a Swiss farmer and researcher, have conceptualized and implemented the principles of syntropic agriculture i.e. dynamic agroforestry (DAF). Originating predominantly in Brazil, this form of agriculture integrates agroforestry and polyculture methodologies. Syntropic agriculture, in essence, diverges from conventional agricultural paradigms by emphasizing the principles of agroecosystem regeneration through long-term processes, as opposed to input-driven approaches prevalent in industrial systems. The term "syntropy" symbolizes a system capable of accumulating matter and energy, evolving towards increased complexity over time, with the overarching objective of fostering abundance. This sustainable agricultural model is grounded in a profound understanding and reverence for the complex dynamics of natural systems. Syntropic agriculture mimics the ecological processes of ecosystem regeneration and harmoniously integrates with existing food production systems. What sets this form of sustainable agriculture apart from others are the principles of Permanent Soil Cover, Enhanced Photosynthetic Intensity, Stratification, Natural Succession and In-Situ Synchronized System Management (Götsch E 1995; Andrade et al. 2020; Babec et al. 2022).

In European regions, syntropic agriculture is in its early stages, with principles adopted to existing agroecological conditions and desired production goals. Ongoing research within Organic Trade for Development/Public Private Partnerships (OT4D/PPP) project named "Sustainable & climate resilient sunflower value chain and corresponding innovative climate resilient production systems" involves multiple DAF sites, established during 2022/2023, serving as demo plots for research and practical dissemination of knowledge to scientific, governmental, and farmer communities. Within these sites, previously established hazelnut and apple orchards are enriched with fast, medium, and slow-growing, and medium and long-life cycle shrubby and wood species. These species will serve as shade, timber, material for soil cover production, and berry production, while between the rows, field crops are grown. Around 450 m of the hazel (Corylus avellana) plantation was diversified with Paulownia (Paulownia elongate), American sweetgum (Liquidambar styraciflua), Scotch laburnum (Laburnum alpinum), Birch (Betula pendula), English oak (Quercus robur), Sugar maple (Acer saccharum), Lime (Tilia grandifolia), Hybrid poplar (Populus x euramericana), White poplar (Populus alba) and Red currant (Ribes rubrum) seedlings (Figure 1a). Diversification of the apple (Malus domestica) orchard was achieved with White and Hybrid poplar, Sugar maple, and Paulownia seedlings. The other two DAF sites were installed from the beginning on bare soil with the primary goal to act as buffer zones between organic and conventional production, but also to provide all additional services that are achieved during production according to syntropic agriculture principles. The first buffer zone was established with hazel as the main crop. A total of 450 m long tree rows were installed. The second buffer zone consisting of 675 m of tree rows has two lines of apple and one line established with hazel as the main crop. Paulownia, White poplar, Lombardy poplar (Populus nigra var. italica), Willow (Salix alba), Catalpa (Catalpa bignonioides), China tree (Koelreuteria paniculata), Narrow-leaved ash (Fraxinus angustifolia), Birch, Plum (Prunus domestica), Red, Black and White currant, Goosberry (Ribes grossularia), Maple, and Lime were additional species at both buffer zones. Herbaceous species such as Spearmint (Mentha spicata), Peppermint (Mentha × piperita), Comfrey (Symphytum officinale), Smooth coneflower (Echinacea laevigata), Horseradish (Armoracia rusticana), and Sage (Salvia officinalis) were also planted at all sites, to fill the niches instead of the weeds and to be the first for income production. Research within the project focuses on the effects of such systems on soil characteristics, as well as the biological and productive properties of species in the system. Thus, the continuous turnover of woody organic material, sourced from pruning measures (Figure 1b) is a crucial strategy for enhancing and sustaining soil fertility. Considering that these are young systems, wooden mulch obtained from poplar was introduced during the establishment (Figure 1c). Experiences from the southern hemisphere indicate multifaceted benefits, encompassing improvements in soil structure, alterations in C/N ratios, pH modifications, microbial activity and modified interactions with weeds, insects, and diseases (Lemieux 1997). Despite these promising indicators, further research of these phenomena is deemed essential for comprehensive understanding and application in varied regional contexts.

Figure 1a,b,c (left to right). Research and demo sites according to DAF principles in Serbia

Keywords
biodiversity, agroforestry practices, soil improvement, stratification, European project, dynamic agroforestry, syntropic agriculture, succession

Aditional Attachment II.

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Successional agroforestry versus monoculture in citrus cultivation – a pilot study in the Argolic Plain, Greece

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In the Argolic Plain in Greece, citrus is cultivated in intensive monoculture. Yet this has led to the overexploitation of groundwater aquifers due to water scarcity. Other production externalities include soil compaction and depletion of soil organic matter. In contrast, successional agroforestry systems (SAFS) with higher tree densities and more litterfall shading the soil surface may potentially reduce evapotranspiration and water use. Further effects of SAF may be increased soil organic matter levels and increased populations of soil fauna contributing to improved soil physical properties. Higher tree densities might also protect citrus trees against frost damage and the overall increase in plant diversity may also deter pests. However, SAF is new to Greece. To gain more practical knowledge, a pilot study comparing citrus grown as a SAF with traditional monoculture was established near the village of Argoliko in spring 2022. We hypothesised that in the successional agroforestry plots, after one year, soil bulk density would be lower, macro- and meso-faunal diversity and abundance higher and that citrus tree damage from both frost and insect pests would be reduced. We also aimed to estimate costs as well as the yield and value of harvests in the first year.

Plot size was 2100 m2 and comprised citrus planted at 5 m x 5 m in both monoculture and agroforestry. In the agroforestry, three types of rows were developed. All rows contained tagasaste (Cytisus proliferus), eucalyptus and poplar with: 1) no additional tree species; 2) olive trees (Olea europaea); or, 3) peach, fig, walnut, willow and a forestry tree species (oak, elm, laurel or European nettle tree). In the agroforestry, all the tree rows were covered over a width of 2 metres with a 10 cm layer of straw mulch. For each row of trees, an herbaceous-low stratum was developed, consisting of different vegetables and other crops to yield in the first year. Two crop cycles were planned, one with annual crops and one with perennial crops. The annual cycle consisted of sweet corn, beans, cabbage, garlic, and potato. The perennial cycle consisted of rosemary, sage, artichoke, and faba beans. The spaces between the rows in the agroforestry were sown with a green manure, consisting of Vicia sativa, Vicia faba, Avena sativa, Lolium multiflorum, Medicago sativa, and Trifolium repens, which was periodically mown and used as mulch for the tree rows, while in the monoculture the natural emerging vegetation was mowed three times that year.

The average soil bulk density in the monoculture was 1.08 g/cm3 and was significantly (p = 0.0018) higher than in the SAF (0.93 g/cm3). The macro- and mesofauna in both systems was clearly dominated by the Malacostraca class. A total of three different earthworm species were found in the agroforestry system. These were Aporrectodea rosea (endogeic), Octodrilus complanatus (anecic) and Bimastos parvus (epigeic). In the citrus monoculture only A. rosea was found. Earthworm abundance was also greater in the SAFS (n = 22) than the monoculture (n = 1).

Overall, 50% of trees planted in the SAFS did not establish in the first year; more than half of these losses were of tagasaste. The grasshopper species Eyprepocnemis plorans caused a 77% loss of citrus trees in the SAFS, while the monoculture had no losses. In the monoculture, however, frost damage caused 6% mortality rate.

The SAFS had a significantly higher resource and labour input than the citrus monoculture in the first year, mainly due to the planting of the trees. Yields from vegetable crops in the first year were 2364 kg/ha of potatoes, 859 kg/ha of cabbage, 364 kg/ha of garlic and 132 kg/ha of artichokes.

In summary, soil bulk density as well as biodiversity and abundance of earthworms in the SAFS improved significantly in the first year compared to the monoculture. On the other hand, pest damage was greater in the SAFS. The results confirm that SAF causes significantly higher input costs in the first year than the monoculture and show in this case that the vegetables grown did not yield enough in the first year to counter the expense. Tagasaste was not to be recommended due to high mortality rates. However, more longer-term, replicated studies are needed to establish cost benefits over the life cycle of the system and to optimise tree and crop combinations.

Keywords
silvoarable agroforestry, soil biodiversity, case study, buffering climatic extremes, Olea Europea, legumes, fruit orchards, agroecology, ecosystem services, Mediterranean resilient agriculture, plant species richness, research and development, Poplar, syntropic agriculture, Juglans regia x nigra, temperate agroforestry, oak, earthworm, soil improvement, organic mulching, potato, Agroforestry, agrisilvicultural systems

Mediterranean Agroforestry and Mixed Farming systems: practical innovation and knowledge exchange (Transition project)

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Agroforestry and mixed farming systems play a key role in resilient agriculture within the challenging context of global change in the Mediterranean region. They have positive environmental impacts and enhance the resilience of agroecosystems and rural societies while improving the returns on assets for farmers. The rich heritage and heterogeneity nature of agroforestry systems in the Mediterranean, shaped by local climatic and socioeconomic factors, underlines the need for a comprehensive understanding of diverse systems.

TRANSITION is the acronym for "Innovative Resilient Farming Systems In Mediterranean Environments", a 36-month PRIMA-funded project (from 2021 to 2024). It involves 10 partners among universities (UNICT, UVIC-UCC), research institutes (CTFC, INRAE, NOA, SRTA-City), private companies (EDGE, Landfiles), and a farmers' association (AFAF) from 6 Mediterranean countries (Spain, Italy, Greece, France, Egypt, and Algeria). The Transition project (https://www.transition-med.org) aims to promote the potential knowledge expansion of agroforestry and mixed farming systems in the Mediterranean basin. Figure 1 summarises the bottom-up methodological approach and the main activities carried out.

The presentation will focus on the diversity of the selected systems and how they evolved through the different activities of the project activities.

Agroforestry and mixed farming systems in the five study regions were identified and prioritised. A participatory approach was used to select the pilot farms and to identify socio-economic barriers and resilience indicators (socio-economic and ecosystem services). Four different systems in 32 plant/tree/livestock combinations were selected (three in the north and two in the south of the Mediterranean). Spain (n=4), Italy (n=2), and Algeria (n=8) selected 14 agroforestry field sites. France and Egypt selected 16, and 1 mixed-farming field sites, respectively. Furthermore, Spain evaluated one innovative crop.

The selected systems were field-monitored over two cropping seasons according to previously selected resilience indicators. Part of the data collected fed crop productivity and soil carbon storage models coupled with earth observation data, were used to develop maps and calculations of the projected climate scenario's impact on the extension of the selected systems. Soil and productivity models were calibrated and validated for the olive trees and winter cereals using data from Italy and Spain.

A literature review and a subsequent meta-analysis were conducted to assess the vulnerability and resilience of agroforestry and mixed farming systems in terms of productivity in the Mediterranean basin (Scordia et al., 2023). The results indicate a negative effect of trees on crop yield, highlighting the need for further scientific data and studies on these systems. However, during extreme climate events, effective management of agricultural practices can optimize the synergies between tree cover, tree species, and crop species.

A policy study was performed through bibliographical research coupled with interviews with policy actors, to provide tools, evidence, and knowledge on policy affecting the dissemination, promotion, and adequate implementation of agroforestry and mixed farming systems in the Mediterranean.

By empowering the expansion of agroforestry and mixed farming systems through practical innovation and knowledge exchange, the Transition project implemented different actions: i)on-farm demonstration of the resilient strategies in each region; ii)deployment of an interactive digital platform for knowledge-sharing; iii)business model catalogue; iv)thematic webinars; and v)artistic illustrations.

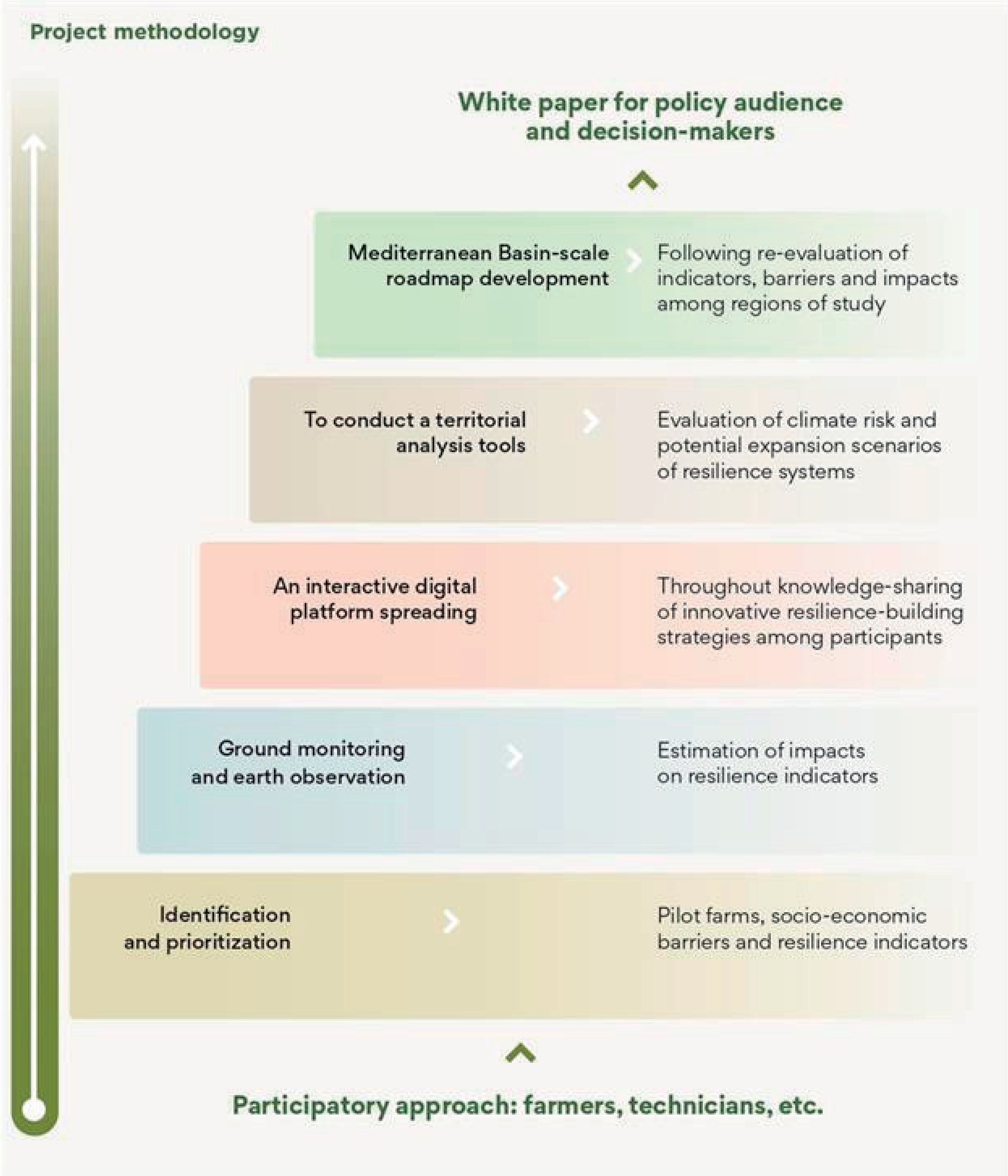
Demonstration activities let the farmers interact and share experiences in the implementation/ management of the different systems. The Landfiles (https://landfiles.com) is a platform that allows users to share information, observations, and knowledge about their land and farm operations, through pictures, reports, and messages. Originally in French, it was translated into English, Spanish, and Italian as part of the project. Then, a group of Spanish farmers was created: “Comunidad de sistemas agroforestales y cultivos mixtos” (Community of agroforestry and mixed farming systems, by its name in Spanish). In collaboration with the LIFE AgroForAdapt project, the group was promoted to other projects and initiatives throughout the country, and by January 2024 it had 100 members. The farmers’ group strategy is being replicated in Italy, Algeria, and Egypt. In addition, a business model catalogue for the most promising systems is being developed to better assess their potential at a multi-scale level. Thematic webinars for technical audiences will provide information and tools on the management of the studied systems. Finally, the project already produced a set of artistic illustrations to: i)show the variety of combinations that agroforestry systems can take in the Mediterranean region, and ii)help raise awareness of the presence of these systems, thus helping to make them better known to the general public.

In summary, at the end of the project, the integration of participatory approaches, evidence-based information from field sites, modelling results, and policy studies will be used to generate a roadmap for the Mediterranean region. It will provide policymakers with robust information that empowers the expansion of agroforestry and mixed farming systems ensuring their holistic understanding in the Mediterranean region.

Acknowledgment
TRANSITION project (PCI2021-121959) is financed by the PRIMA Call 2020, Work program Topic 2.2.1

Keywords
Socioeconomic status, modelling, mixed farming, Mediterranean resilient agriculture, sustainability, Agroforestry, resilience, participatory research

Aditional Attachment II.



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Using participatory methods to promote agroforestry in the Netherlands and the United Kingdom

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Introduction

The climate emergency and the need to decarbonise is driving a major change in European economies including agriculture and land use. This transition requires farmers, advisors, researchers, and others in the food system to work together in new ways, and there is likely to be a significant role for agroforestry, i.e. the integration of trees with farming.

Between 2020 and 2024, the European project AGROMIX has used a participatory design approach to work with farmers in 12 locations across Europe to drive the transition to resilient and efficient land use in Europe.

Method

The participatory design approach was based on the Reflexive Interactive Design approach (RIO in Dutch) (Bos etal., 2009). RIO is an approach to push significant structural change, i.e. system innovation. It is a systematic approach used to interactively design system innovations in complex and controversial contexts, reforming existing 'mainstream' agricultural systems. In AGROMIX a simplified version of this approach was implemented what will be described in a future publication. The presentation will compare the experience of a pilot group in Winthagen in the Netherlands with that of a pilot group in Bedfordshire in the United Kingdom.

Results and discussion

In Winthagen (NL), the participatory approach took place at a regional scale. In an early meeting, the group identified their objective as to support adaption to climate change, strengthen biodiversity, improve water management, landscape aesthetics, and living quality, and at the same time ensure economically viability in the region. In Winthagen, the participatory design approach resulted in four design proposals that could, if implemented on a regional scale, support these objectives. They include: 1) a joint crop plan that guarantees the spatial distribution of different crops in the area, and 2) diverting water to verges and overflow plots via the construction of small attenuators in the road to increase water infiltration from and along roads. A third practice was 3) developing multifunctional swales that can be diversely planted for flowering, fruit, nuts, or biomass for energy and building materials, which can both support biodiversity and provide local self-harvesting opportunities. A fourth practice 4) was creating mini stone quarries through the landscape for temporary water storage during flood events. As a co-design process pilot, Winthagen has been effective in involving various stakeholders and designing novel solutions for the area. The majority of stakeholders identified the first practice to be most easily achievable, and they are now exploring how to further develop the ideas.

In Bedfordshire (UK), two initial meetings brought together farmers, researchers, land agents, and advisors from the Marston Vale area, which covers about 160 km2, in November and December 2021. At these meetings, the primary challenge identified by the group was an awareness of the need to understand the net level of greenhouse gas (GHG) emissions from each farm, but confusion as to which GHG tool to use and a lack of expertise and time to collate the necessary data. Hence in the next stage of process, Cranfield University staff and students worked with five farmers and two GHG modelling organisations to estimate the net level of GHG emissions from five farms. Estimates were also made of the level of additional tree cover needed to enable each farm to achieve net zero GHG emissions. Although arable farms can reduce GHG emissions by improved fertilizer management, increasing tree cover is also an option to reduce emissions over the next 40 years. Although the UK study did not initially or directly focus on agroforestry, working with the immediate challenges identified by farmers has led to conversations about the increased integration of trees on farms. Hence working with the local Forest of Marston Vale Trust, at least one of the farmers has established substantial new areas of trees on their farm.

Conclusion
Based on the experiences in the pilots we see participatory design as a valuable and engaging approach to support the development of mixed farming systems such as agroforestry systems, based on the needs of the participants. When implemented on a regional level, farmers and other regional stakeholders such as land agents, farm advisors and civil servants learn and understand the potential role of agroforestry for tackling important regional challenges such as flood risk and carbon sequestration. Because the co-designed solutions address the challenges raised by the participants, they are likely to be implemented in practice.

Keywords
carbon sequestration, participatory research, European project, Case studies, participative design method, design

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The new life of the experimental plot of Vézénobres in France

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The site of Roumassouze, in the town of Vézénobres (Gard), is an experimental and historical site in France. It has been the subject of numerous publications on the functioning of agroforestry systems and has also served as a starting point for major regulatory reforms around the CAP.

But this site has known a history by stages: a first stage where a cereal farmer planted the 11 ha in 1996 (with different species - poplars, hybrid walnuts and various hardwoods species), in partnership with the administration and INRAE, until the harvest of poplars in 2010. Following the takeover of the farm by a farmer in organic farming on this date, the research projects evolved, giving rise to the participatory research project Arbratatouille led by Agroof and new research partners. But the farmer who retired in 2023 asked Agroof to take over the farm in order to continue the experimental and educational vocation of Roumassouze. A new stage is initiated around this project approaching its 30th anniversary.

A Participatory Steering Committee

Like the participatory research approach developed by Agroof, the use and redesign of the site and tree management, as well as the experimental orientations of the site, will be discussed in the steering committee. The latter will be voluntarily multidisciplinary and will bring together, once a year, scientific, technical and financial partners wishing to get involved in the project.

A charter of operation of the site will be drafted collectively, stipulating the main principles allowing the proper functioning and sustainability of the agroforestry agricultural system and its use as an experimental site, in accordance with the objectives and ethics of the stakeholder structures.

Toward innovative actions in 2024/2030

1/ Evaluating the tree potentialities

In 2023, all trees were evaluated and measured: classical dendrometric measurements (total height, log height, diameter at 1m30, canopy circumference) and health and wood quality. Some modalities were scanned with Lidar terrestrial, with or without leaf, and according to different modalities of tree maintenance.

The repetition of these measurements will constitute a priceless reference in adult agroforestry conditions and will feed various existing models such as ECOAF (developed by CIRAD AMAP, INRAE d'Orléans and AGROOF) or ECoYieldSafe.

2/ Soil characterization and monitoring of carbon stocks

Some parts of the land were subject to soil analyses carried out at the plantation (1996) then in 2007 (DAR project 2006/08), in 2015 (AGRIPSOL project) and 2018 (ARBRATATOUILLE project). In 2023, we mapped the soil and the impact of the trees, making 8 soil pits with sampling within the different agroforestry pure crop control plots. Analyses of organic carbon content and apparent densities were carried out.

3/ A characterization of part of the land biodiversity

Biodiversity monitoring was carried out at several periods, notably between 2006 and 2011 (cereals), then from 2014 to 2018 (market gardening). The beetle and arachnid communities were mainly studied, showing a significant richness of species. From 2023, these studies have been amplified and will be repeated at regular intervals, calling on specialists from the different biological groups (birds, pollinators, flora, etc.).

4/ Follow the evolution of the microclimate and the water balance

Starting in 2024, the research team will measure microclimatic parameters, evaporative demand and water use efficiency in different levels of agroforestry shading at different distances from trees compared to control areas without trees. The different experimental modalities will be equipped with rain gauges and irrigation meters in order to assess water inputs. In addition, tensiometers, radiation, air temperature, relative humidity and wind speed sensors will make it possible to calculate evapotranspiration and thus approach the quantities of water mobilized by plants.

5/ Develop technical and economic references

The objective will be to continue monitoring the technical and economic performance of crops (working time, yield, quality) depending on the different experimental modalities. From planting to today, and in the future according to different evolution scenarios.

A territorial project under study

The experimental site project is also part of a participatory research approach on a territorial scale. If Roumassouze will be a flagship site for certain research actions such as varietal selection, we must multiply the adjacent sites, in cereal, forage or wine systems. Eventually, it is a question of developing experimental agroforestry on more than 500 ha on the plains of Gardon. A reflection is undertaken with the Water Agency and local authorities to go in this direction. The objective is to create the first agroforestry experimental basin in France, in order to constitute the base of regional research.

Keywords
experimental site, participatory research, adaptation, Agroforestry

Aditional Attachment II.

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5.2 European Initiatives and Projects

Poster presentations

Building Q - Foyer, 29 May 2024, 12:00–13:00

Integrating annual crops and short rotation coppice for on-farm production of ramial wood chips - a description of a new agroforestry trial at agroscope (Switzerland)

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1 Agroscope, Field crop systems and plant nutrition group, Nyon, Switzerland

Row cropping is an agronomic system that has ensured, since the green revolution, high yields so as to keep pace with a growing world population. However, such intensive production systems have increased the environmental footprints due to high consumption of fertilizers, pesticides, water and soil. In order to reconcile the growing food needs with environmental sustainability, different agronomic solutions (= management practices) have been proposed (Foley et al. 2011). Alley cropping (AC), as part of agroforestry, represents one of these transformative agronomic solutions where trees and/or shrubs are integrated with annual crops (Wilson and Lovell 2016; Wolz and DeLucia 2018). An innovative, but still understudied alley-cropping system integrates short-rotation coppices for on-farm production of “ramial wood chips” (RWC) that will be then used as soil organic amendment. This option is particularly helpful in regions where farming systems do not host livestock and animal-derived manure cannot be easily available. Ramial wood chips is made from branches and twigs with a diameter less than 7-8cm and originally was used to recycle wood residues as fertilizer for forestry (Barthès et al. 2010). The addition of RWC seems to positively affect a set of physical and chemical soil properties promoting the formation and maintenance of a fertile soil as recently reported by Fontana et al. (2023). However, one the major issues related to the RWC is the availability of the product, currently obtained mainly from gardening residues. By considering the reported positive effects of soil addition of RWC (Fontana et al. 2023), here we describe the set-up of a new alley-cropping system for in-situ production and use of RWC at Agroscope – Nyon (Switzerland). The Swiss alley cropping is located in Nyon (46°23′55.7″ N, 06°14′24.72″ E, altitude: 442m) within the research domain of Agroscope - Changins. The climate is characterized by mean annual precipitation and air temperature of, respectively, 994mm and 10.2 °C. The soil of the field site can be classified as calcaric cambisol (FAO) with a content in soil organic matter < 2%. The alley cropping system covers a surface of c. 1.5 ha. It is delimited by five hedgerows (6 m-wide x 120 m-long) that have been planted in March 2023. Each hedgerow is formed by four rows of Salix viminalis hybrids (Discovery and Endeavour) with inter-row spacing of 2m, and intra-row spacing between the cuttings of 50cm. Willow hedgerows have been selected because of their productivity and the RWC quality (Westaway 2020). These hedgerows of fast-growing Salix plants will be used for the in-situ production of RWC with a coppice rotation depending on the growth rate (we expect the hedge to be coppiced every 4-6 years). The four crop alleys between the five hedgerows have a width of 24m. In addition, a 1.5 m-wide grassland strip of alfalfa (Medicago sativa L.) between the border of each hedgerow and the crop is also present so to facilitate the machinery trafficking. The following 4-year long rotation, in accordance with local agricultural practices, has been established: winter wheat / rapeseed / winter wheat / pea and cover crops before winter wheat and pea. Concerning the RWC treatments, each crop alley has been divided into 5 sampling plots (20m x 21m) corresponding to the RWC treatments of 0, 25, 50, 75 and 100 m3/ha. For each RWC treatment, four replicates are available for a total of 20 experimental plots. The RWC amendment has been incorporated in autumn 2022 using a rototiller at a depth of about 10 cm. In addition, control plots (12 x 6 m) adjacent to the alley-cropping system, but without any influence of the hedgerows, have been be set up with four replicates of 0, 50 and 100 m3/ha of RWC addition. The first yield of winter wheat has been already collected in summer 2023 in strips at different distance from the borders of the hedges so as to monitor the effect of competition between the crops and the willows. Currently, rapeseed is growing on this alley-cropping trial.

Keywords
alley cropping, hedgerows, Socioeconomic status, ramial wood chips

Aditional Attachment II.

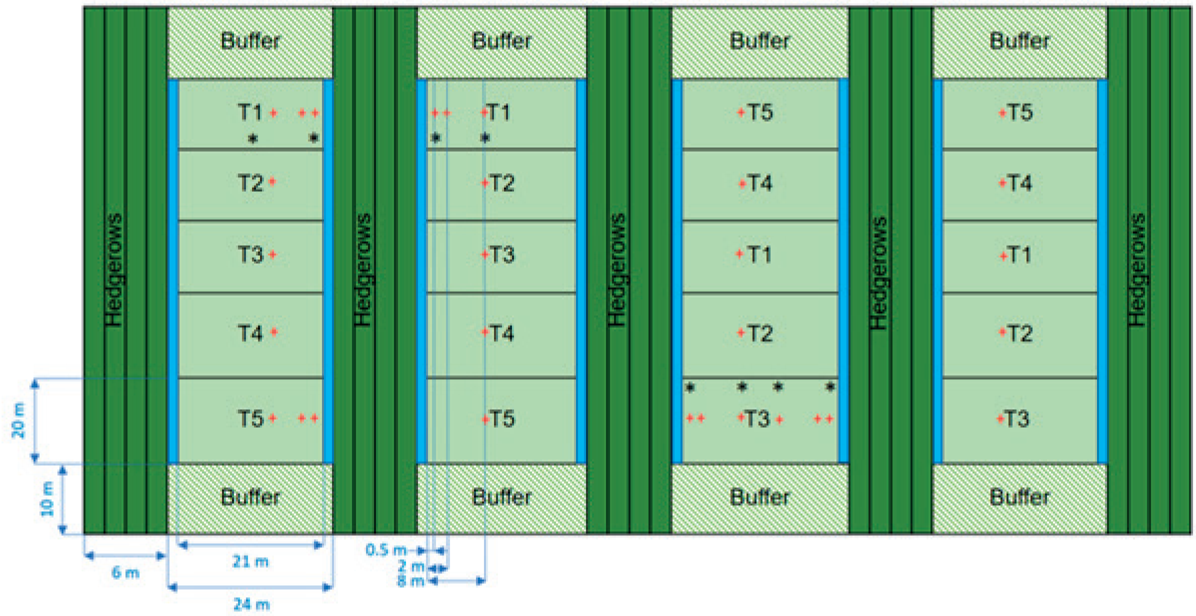

Fig. 1: Experimental design of the alley cropping system at Agroscope - Nyon (Switzerland). T1, T2, T3, T4, T5 indicate the different ramial wood chips treatments of, respectively, 0, 25, 50, 75 and 100 m^3 ha^{-1}.

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Giving voice to the past, present and future of agroforestry in Italy: the first AIAF national agroforestry Forum

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Introduction

AIAF is the Italian National Agroforestry Association established in 2014 following the foundation of the European Agroforestry Federation, EURAF, in 2012.

In ten years AIAF, affiliated to EURAF and connected with its history, has created a group of people coming from Italian universities, national and local institutions, local advisors and public and private farms, who have consolidated a network committed to study and practice several agroforestry themes.

This process resulted from the operose activities of the first president and members of the association, but also, in more recent years, from the activities of the organization (2018-2022) of two European Agroforestry Conferences: EURAF2020 online (May 2021) and EURAF2022 in Sardinia (May 2022).

Such an extended, troubled and unusual experience, due to the period of the Covid 19 pandemic, has been a testing ground for AIAF and its network.

Besides a strong engagement in agroforestry research and on-farm transfer of innovations, AIAF involvement in EURAF conferences has also brought out the potential of neglected and/or unexplored agroforestry terroirs within the different Italian regions and landscapes. Thus, the need to create an opportunity for meeting and confronting at national level, arose. In order to meet such goals, the most suitable event format was a forum. The geographical and political proper place for AIAF's first national Forum was the Capital: the headquarters of the National Research Council in Rome. This contribution reports the main lessons learned from this first Italian Forum on agroforestry.

The first Italian Forum on agroforestry

The Forum was entitled "Farming through trees" (Coltivare e allevare con gli alberi) and was held on 6-7 December 2023. The Forum programme included six plenary sessions (round tables), dedicated to the following topics: Primary production; Carbon sequestration and climate emergency; Biodiversity and other ecosystemic services; Policy and certification; Landscape and territory culture; Economy and rural development.

Main points emerged from the Forum

- There is the need to explain the term agroforestry to everyone, at different levels, making it widespread knowledge.
- A homogeneous mapping of agroforestry systems is needed at the national level.
- The shift from individual entrepreneurial actions to systematization of current innovations is needed.
- Projects and policy actions to bridge the gap between research and applicability of results in the field need to be promoted. In fact, result-based indicators (and not action-based measures) have to be considered as the best tool for assessing the effectiveness of agroforestry systems.
- The quantity and value of carbon credits generated by agroforestry systems to indicate their sustainability need to be defined.

- The animal component in an agroforestry farm, if well managed, can contribute to increasing biodiversity.
- The problems of mechanization in managing agroforestry systems is still one of the major issues.
- Agroforestry systems are “living heritage”: biocultural elements of agrobiodiversity.
- Agroforestry landscapes should not be considered only as static systems to be preserved. Rather, they need to be thought of as dynamic, being inspirational for modern rural development strategies.

Conclusions

“Farming with trees” was not only the title of the Forum, but it also represented the vision of the association. Through the event, the large variety of agroforestry case studies, observations, field experiences and research was the protagonist of the two-day event. The Forum was a showcase of the rich set of silvoarable and silvopastoral systems, sometimes detected as vegetal ruins that, while leaving traces of a past to be preserved, nevertheless, represent as sustainable forms of dynamic and modern productive landscapes providing important aesthetical and cultural functions which are increasingly appreciated by farmers and the general public.

Despite being hosted in one of the most prestigious places for Italian science and research, the event climate was very informal, fostering new contacts and consolidating old acquaintances and friends, through a lively confrontation on new and traditional agroforestry practices. The Forum in Rome gave rise to a set of relationships AIAF intends to put at the heart of its activities to promote interactions between trees and crops, animals and human activities. The event was also an opportunity to introduce the recently established AIAF Scientific Technical Committee which supports the association, sharing its mission and goals. The collaboration and commitment of the whole AIAF team and the interactions with the Forum public were so stimulating that it was decided that the Forum will be held annually.

Keywords
network, silvoarable, Agroforestry, Agroforestry farming, agroforestry landscapes, silvopastoral

Aditional Attachment II.

Agroforestry in Italy: the new HandBook on agroforestry practices for farmers

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In 2023, the Italian National Rural Network funded the publication of the handbook entitled “Agroforestry in Italy: an opportunity for farms” (Agroforestazione in italia: una opportunità per le aziende agrarie). The initiative, promoted also by the Italian Agroforestry Association (AIAF), compiled contributions from numerous authors. It was mainly targeted to farmers, technicians, extensionists and aimed at providing comprehensive information on the current state of agroforestry systems in Italy.

Following a brief analysis of the current agroforestry terminology and a short illustration of agroforestry landscapes at both national and European level, the handbook gives a detailed overview of silvoarable and silvopastoral systems with a special focus on both historical and innovative practices focusing on the interactions among trees, crops, and animals.

The handbook addresses the following issues: the effects of trees on microclimate, edaphic environment and biodiversity, the tree-crop interactions in silvoarable systems, the tree-animal interactions in silvopastoral and agrosilvopastoral systems, adaptability and growth of tree species in silvoarable systems, the multifunctionality and ecosystem services in agrosilvopastoral systems. Emphasis is placed on market dynamics, economic considerations, and environmental sustainability, along with a thorough examination of current and future policies within national and regional Rural Development Programs. A comprehensive overview of the novel certification scheme developed in Italy for agroforestry wood products highlights the key role of certification in the market. The final section offers detailed descriptions of some of the most representative agroforestry case studies. In this paper, just three out of seven case studies are reported.

Case description

Sasse Rami pilot Farm - Veneto Agricoltura Agency (Ceregnano RO)

The «Sasse Rami» pilot and demonstrative farm of Veneto Agricoltura, Ceregnano (RO), hosts experimental agroforestry trials focused on poplar (Populus × canadensis Moench) and paulownia (Paulownia tomentosa Steud), two of the most interesting tree species for high-productive alley-cropping systems in the Padana Plain. 14 poplar clones and 6 paulownia clones are cultivated both in a specialised plantation (6 x 6 m for poplar and 5 x 4 m for paulownia) and in a nearby alley-cropping system (one clone per row), with N-S oriented tree rows planted along drainage ditches and spaced 40 m apart. Veneto Agricoltura, together with Universities and Research Centers, is studying the multiple interaction between trees and arable crops, with a focus on the identification of the poplar and paulownia clones more suitable to agroforestry.

Alberata d’Asprinio system

The “Alberata d’Asprinio”, also called Alberata Aversana or vite maritata (“married vine”), is a vine cultivation system dating back to the Etruscan times and featuring the rural landscape of Aversa (Campania region). The “married vine’ grows high up to 15 metres, held up by live supports (poplars or elms). The impressive vine barriers have given rise to a peculiar wine-growing culture, closely linked to the type of farming. The harvesting of the Asprinio grapes is defined as “The heroic grape harvest” as it is managed by very skilled grape-pickers climbers. This practice declined after the 1970s. In recent years, young farmers are engaged again in Asprinio production, lately nominated as intangible UNESCO heritage.

Centro di Ricerche Agro-Ambientali Enrico Avanzi Pisa

The “Enrico Avanzi” Agro-environmental Research Center, Pisa, is leading a long-term experiment (LTE) to understand the potential contribution of perennial crops within arable or mixed systems (agro-pastoral). The initiative named ARNINO LTE is led by the University of Pisa and Scuola Superiore Sant’Anna, with the support of CREA - Foresta e Legno. Through a multidisciplinary approach, it focuses on studying ecosystem services generated by agroforestry systems comparing two crop rotations (three-year arable and seven-year mixed) within a agroforestry system and a conventional (without trees).

Conclusions
Even though this publication cannot be classified as an exhaustive technical compendium, it can be considered as a guideline offering useful inputs to farmers who wish to start or implement agroforestry systems.

In this respect, the description of the case studies, mainly related to on-farm transfer of innovations at real farms, can represent for farmers and technicians a set of different agroforestry models to take into account when applying agroforestry practices. Moreover, it can serve as a pilot set for developing a possible agroforestry mapping.

However, the handbook can also be an easy source of information for beginners to get acquainted with agroforestry as well as a reference tool highlighting points of strength and criticalities of agroforestry for policy and decision makers when developing policy measures and land planning.

Keywords
ecosystem services, silvoarable, Agroforestry farming, certification, Pilot farm, silvopastoral

Aditional Attachment II.

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LIFE AgroForAdapt project (2021-26): Promoting Mediterranean agroforestry as a tool for climate change adaptation

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The main objective of the LIFE AgroForAdapt project (2021-2026 - www.agroforadapt.eu) is to promote agroforestry systems as a measure of adaptation to climate change in the Mediterranean agriculture and forestry sectors. The agroforestry systems we are working with are silvoarable (with a wide range of crop and tree species) and silvopastoral (in both grasslands and forests). The specific objectives of the project are:

i) To increase the agroforestry demonstration area by installing and/or managing 76 demonstration systems (totalling more than 850 ha) and inducing replication in a further 1,400 ha.

ii) Evaluate the impact of these agroforestry demonstration systems on multiple ecosystem services and indicators related to profitability (yield, economic balance, LER), adaptation to climate change (air and soil moisture and temperature, vulnerability to forest fires), biodiversity (flora, birds, insects), etc.

iii) Develop and apply innovative design, planning and commercial tools to facilitate the adoption of agroforestry.

iv) Promote agroforestry systems in policies and regulations and in climate change adaptation plans.

v) Raise awareness of the interest and multifunctionality of these systems to the society in general and to the agri-livestock and forestry sectors in particular.

The work area covers almost the whole of two Spanish regions (Catalonia and Castilla y León) and two French regions (Occitanie and Provence-Alpes-Côte d'Azur). The project has eight partners with complementary profiles: a research and transfer centre (Forest Science and Technology Centre of Catalonia - CTFC, coordinator), four public administrations (Provincial Councils of Barcelona and Girona, Metropolitan Barcelona Council, Catalan Department of Climate Action, Food and Rural Agenda), two private forestry and agroforestry consulting companies (Agresta S. Coop and Agroof SCOP) and a land stewardship NGO (Fundació Emys). In addition, the project has the Tarragona Provincial Council and the French Water Agency (AE-RMC) as co-financiers and the company Sorbus Bosques Multifuncionales and the Baix Llobregat County Council as collaborators.

In March 2024, the project reaches its halfway point, with all the demonstration systems installed and undergoing regular monitoring in accordance with the experimental protocols. The main actions we are currently developing include:

- Develop two tools to prioritise areas for silvoarable systems (based on landscape connectivity, tree cover, topography, nitrate leaching risk, soil features) and silvopastoral systems (combining critical areas for wildfire management and feasibility of silvopastoralism).
- Promoting agroforestry networking. Of particular note is the Comunidad de Sistemas Agroforestales y Cultivos Mixtos (https://landfiles.com/es/comunidad-de-sistemas-agroforestales-y-cultivos-mixtos), an initiative promoted in collaboration with other European projects, which aims to bring together the agroforestry community in Spain and Portugal, with a predominant role for agroforestry farmers.
- Analysis of the legal and political framework for agroforestry systems and initiation of measures to promote them in the working area. To this end, we collaborate with other European projects and institutions to join forces and achieve greater impact.
- Development of innovative tools for joint agro-forest-livestock planning at the level of farms or groups of farms (25-500 ha) and at the level of municipalities and supra-municipalities (25-250 km2).
- Pilot experience in the commercial promotion of products from agroforestry systems.
- Training and dissemination activities: organisation of conferences, specialised courses and technical visits, and production of articles and technical manuals.

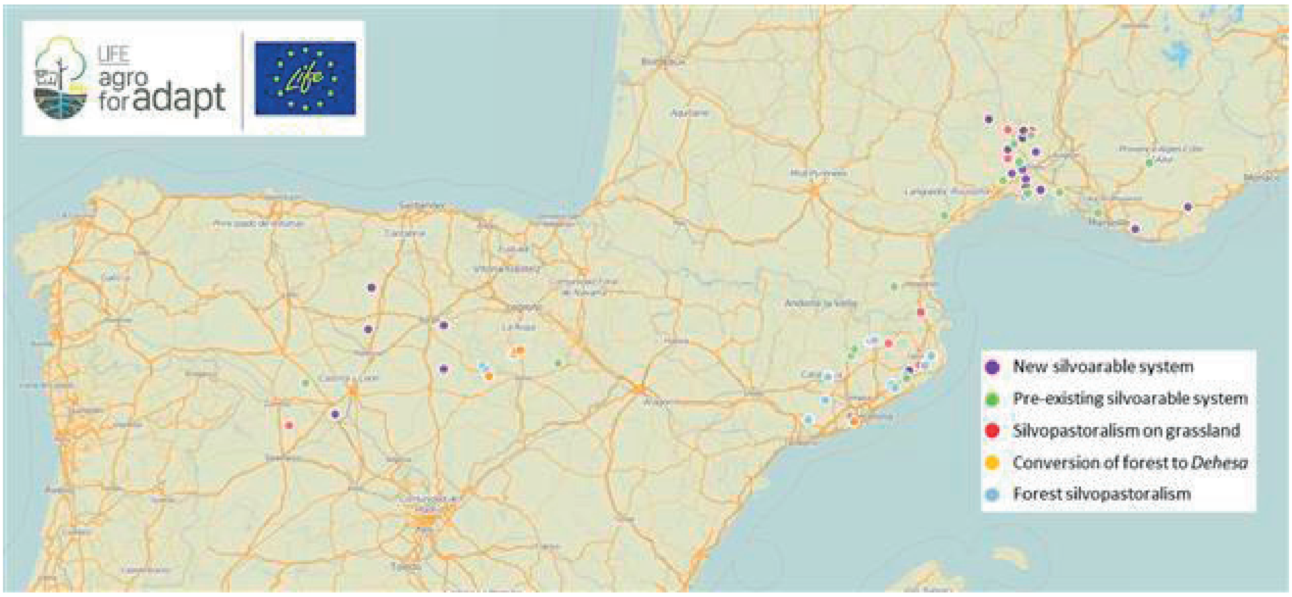
The LIFE AgroForAdapt project (LIFE20 CCA/ES/001682) is funded by the LIFE programme of the European Union. We are grateful to the private and public landowners where the demonstration agroforestry systems are installed.

Keywords

silvopastoral, rural-urban interface, wood, hedgerows, climate change mitigation, online tool, livestock, fruit trees, landscape mosaic, temperate agroforestry, Sustainable management, shade, burn probability, soil organic carbon, silviculture in agroforestry, grazing livestock, crop production, adaptation, Mediterranean resilient agriculture, agroecology, agrisilvicultural systems, alley cropping, agroforestry practices, ecosystem

services, Carbon Balance, soil improvement, fodder trees, agroforestry monitoring, forest management, carbon sequestration, resilience, grazed woodlands, walnut, Socioeconomic status, restoration, wildfire risk, agroforestry system planning, production systems, Agropastoral farming systems, wildfires, training, landscape planning, Climate smart agriculture, silvoarable agroforestry, agricultural policy, agroforestry systems establishment, Agroforestry, Juglans regia x nigra, Fire protection, agroforestry value chains, biodiversity, drought adaptation, soil carbon sequestration, climate change, Regenerative communities, silvopastoral systems, Policy, GIS, European project, Wildfire, France, intercropping, Soil Organic Matter, soil biodiversity, soil moisture, Grassland with trees

Aditional Attachment II.



Agro-ecological strategies for resilient farming in West Africa

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Agriculture is one of the key focus areas of the partnership between the European Union (EU) and the African Union (AU), with the EU's focus being on facilitating a green transition according to its Green Deal (GD) objectives. The GD is a set of long-term policy initiatives that define the EU's climate strategy to reach net zero emissions by 2050. Its implications for Africa are multifaceted, such as the implementation of new agricultural standards, deployment of the EU-Africa biodiversity strategy, or creating a circular economy. Climate change is projected to compromise agricultural production, especially in smallholder systems with little adaptive capacity, as currently prevalent in many parts of Africa. In particular, West Africa (WA) is known to be particularly vulnerable to climate change due to high climate variability or high reliance on rain-fed agriculture, especially due to the urgent drive to meeting food, healthy diet, and economic needs. To support a transition to sustainable food systems, agro-ecological farming is emerging as a compelling response to the challenges West Africa faces, aiming to reduce the environmental impacts of agriculture while meeting the growing demand for food, contributing to landscape quality and biodiversity, and enhancing resilience.

The CIRAWA project is an EU-funded project under the call "Agro-ecological approaches in African agricultural systems" (HORIZON-CL6-2022-FARM2FORK-01-12) with project ID: 101084398. The project is working with smallholder farmers in West Africa to improve food nutrition, livelihoods, and ecosystem health. Bringing together 14 partners from 9 countries, it is coordinated by CARTIF (Spain) and aims to develop new agroecological-based practices that build on existing local and scientific knowledge to help create more resilient food supply chains in 8 regions across Cape Verde, Ghana, Senegal, and The Gambia. The project has a total budget of 6.9 million euros and a duration of 54 months, starting in January 2024 and ending in June 2027.

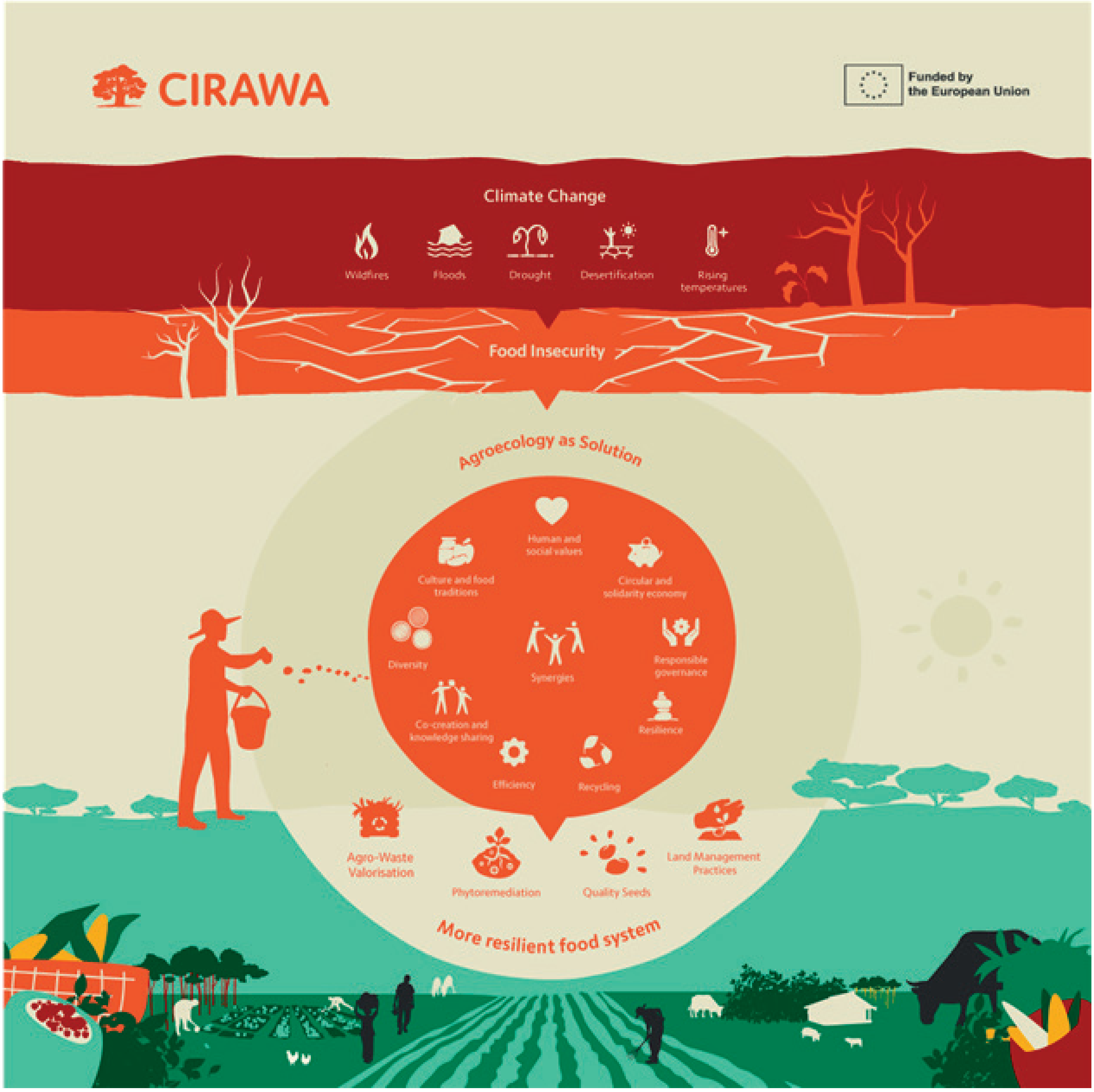
CIRAWA unlocks the potential of agro-ecology in West Africa by building on existing indigenous and scientific knowledge to improve food and nutrition security, livelihoods, and planetary health while tackling climate change and the environmental impact of agricultural practices. The project works on innovative agro-ecological approaches through the following strategies: (i) valorization of agro-wastes and bio-based fertilizer production; (ii) production of high-quality seeds; (iii) saline soil reclamation through phytoremediation; and (iv) soil fertility, water, and crop management practices.

Within this approach, the project aims to test the contribution of agroforestry systems according to the principles of agroecology to strengthen food and nutrition security. It also aims to adapt and implement best agro-ecological practices that promote the conservation and restoration of agricultural diversity and boost organic production, generating opportunities for increased agricultural productivity and facing uncertain scenarios generated by climate change. The starting point is the DELTA project (ISRA) in Senegal and the Agro-floresta project in Cape Verde (ADPM). The implementation of living labs in the Senegal River Valley is underway, targeting agro-ecological transition in the region, and two experimental fields were created in 2021 in Santo Antão Island (Cape Verde), which will be continued and even enlarged within the project, where agroforestry systems were installed together with suitable agro-ecological techniques.

The present poster aims to present the project in general and specifically the work done related to the agroforestry trial sites being developed and the different practices being studied.

Keywords
agroecology, European project, Food security, resilience

Aditional Attachment II.



Trees for the climate - experiences from a new agroforestry climate protection programme for German-speaking countries

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Introduction

The regional climate protection programme for agroforestry supports farms in Germany, Austria, Liechtenstein and Switzerland in the planning and implementation of agroforestry systems and is run by SilvoCultura GmbH in cooperation with the myclimate foundation. This programme aims to provide funding per tree for the planting and management of agroforestry and its input for climate protection. In addition, a free advisory service is offered.

Case description

The funding programme is for farms that want to establish new silvopastoral or silvoarable agroforestry systems. The farms receive investment support in the form of a planting contribution per tree and free advice on issues relating to optimal planting design, tree species selection, planting and care. The funding is provided in two tranches: the farms receive the first tranche directly after planting and a second tranche three years after planting following a second consultation on the farm.

The regional climate protection programme for agroforestry was developed by the myclimate foundation together with its partner SilvoCultura. The customers of myclimate finance the programme through voluntary contributions to climate protection. No CO2 compensation payments are generated or traded. This means that the farms benefit from the financial support for new plantings by customers from industry and the private sector but are not part of the CO2 certificate market. The donors from industry cannot count this contribution towards the voluntary reduction of their own CO2 footprint. They can only use their contribution for communication purposes, for example in their sustainability reports. In this way, farms can utilize the climate savings achieved through tree planting for their own company balance sheet.

Conclusion

Initial experiences have been very positive. In the first nine months of the programme, contracts for around 10,000 trees have already been signed with farmers. By the end of this support programme, a total of 20,000 trees will have been planted. In terms of trees, the focus is on walnut and chestnut trees, standard fruit trees, timber trees and wild fruit trees. In general, the economic viability of agroforestry projects is characterised by the question of when the financial compensation for the original service - be it in the form of fruit or wood or for ecosystem services - begins. Agroforestry systems are in a poor position here: high initial expenditure and late returns on capital require a great deal of patience when it comes to financing and increasing investment risk. Contributions from the voluntary carbon market to ecosystem services of agroforestry systems can help to reduce the high investment costs of the first few years and thus increase the attractiveness of converting to agroforestry.

Keywords

carbon farming, voluntary carbon market, climate resilience, Agroforestry

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https://www.silvocultura.ch/programm

Agroforestry Research in Germany – Past, Present & Future

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Agroforestry as a promising land-use practice is gaining momentum in Germany. The intensive farming practices coupled with an increase of extreme weather events (e.g. droughts and flooding) in recent years, pose enormous challenges for agriculture (e.g. biodiversity loss, soil depletion). The positive aspect is that both in politics and among the general public agroforestry is considered to be an important part of the answer to these challenges. This has led to an increase in media coverage on the topic and general public awareness (Sollen-Norrlin et al 2020). Also, farmers are becoming more willing to consider these long-term components as solutions to be integrated into their land management (Tsonkova et al. 2018). There is an increasing number of educational offers (such as courses or academies) as well as consulting services (Hübner-Rosenau et al. 2018). However, in total the area of newly established agroforestry systems remains well below the officially declared goal of the German government aiming to reach 200.000 ha of agroforestry systems by 2026 (DeFAF e.V. 2023). Meanwhile, remaining traditional agroforestry systems, such as traditional orchard meadows, are continuously declining (Plieninger et al. 2015). Thus, there is a large gap of the currently perceived agroforestry development and an actual increase in the area of planted agroforestry systems. Predominantly, it is barriers on the political and regulatory side that remain. In order to overcome these, research can help to provide the necessary data and background for the development of reasonable policy and subsidies for practitioners.

How can agroforestry research contribute to facilitate the emergence of agroforestry as a sustainable land-use practice and help to overcome existing barriers and hinderances most effectively? The objective of this study was to (1) generate an overview on the evolution of agroforestry systems research in Germany and (2) shed light on the current perception of agroforestry stakeholder groups and their expectation on agroforestry related research. We assess the characteristics of past research project in order to learn from the past and guide future agroforestry systems research by synchronizing research efforts with actual perceptions and current needs of practitioners to promote agroforestry adoption.

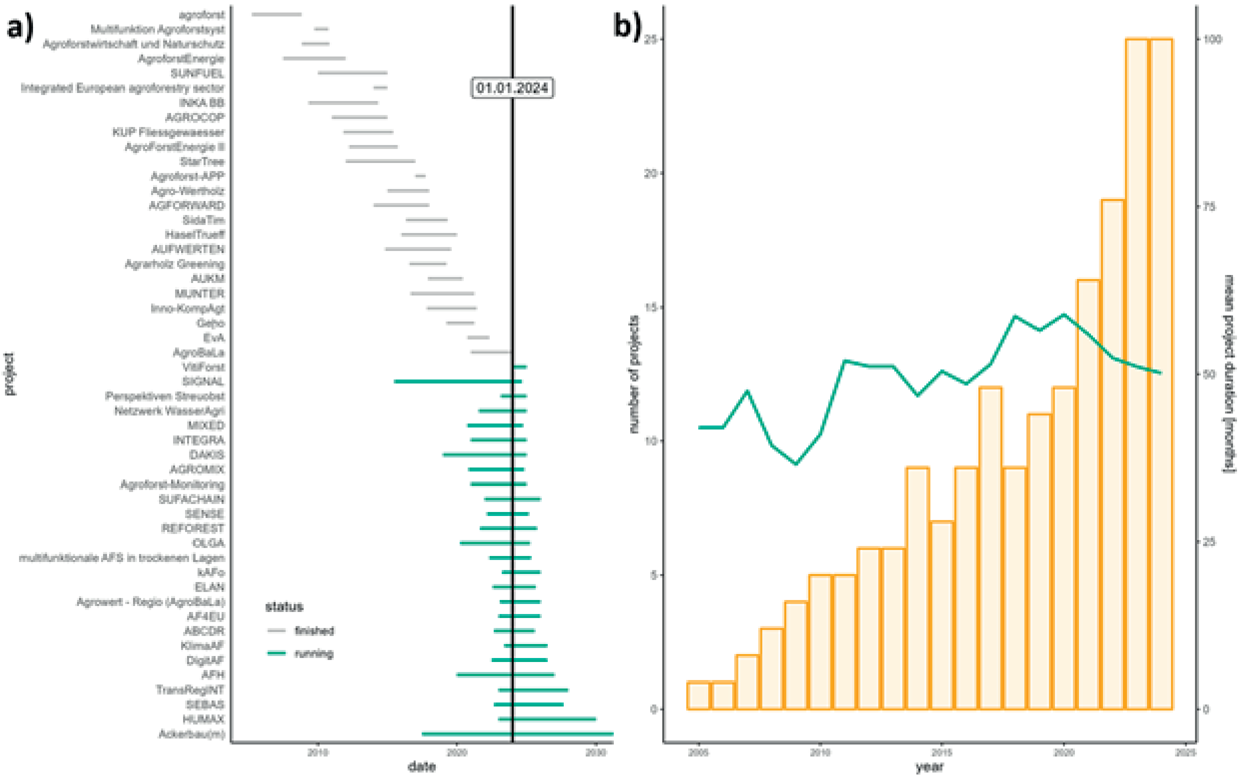
We created a database of agroforestry research projects in Germany over the past 20 years and looked at their research questions and goals. We categorized them according to their scope, topic, location, partners and stakeholders involved among others. Furthermore, a survey among four different agroforestry stakeholder groups, namely farmers with and without agroforestry systems, researchers and consultants on the 9. German Forum for Agroforestry Systems 2023 was conducted, asking for their motivation and interest as well as limitations and hinderances for the adoption of agroforestry systems in Germany. In total 102 stakeholders took part in the survey. We juxtaposed survey results with the analysis of research projects, which allowed to bridge the gap between existing research and practical needs.

Research on temperate agroforestry systems in Germany started only in the early 2000s with several extensive research projects that followed and first long-term research sites of modern agroforestry systems being established. We show diverse emerging patterns in the German agroforestry research landscape. Since the 2000s when agroforestry research took off in Germany the number of research projects has increased considerably, featuring a growing number of institutions, stakeholders and research foci. We identified 50 agroforestry research projects since 2005, the majority of which are currently running (27), highlighting a strong increase in research activities on agroforestry in Germany, further accelerating since 2021. While provisioning services through agroforestry receive most attention in research, improving site conditions as well as ecological considerations are the main priorities to engage with agroforestry among all stakeholder groups. This corresponds with findings of García de Jalón et al. (2018) who found the environmental contributions of agroforestry to be perceived as the most important benefits of agroforestry among different agroforestry stakeholders across Europa. Inadequate policy and funding for agroforestry is considered the main barrier for a wider implementation of modern agroforestry, followed by knowledge gaps especially highlighted by farmers which haven't adopted agroforestry yet and researchers. Economic risks were more prominently named among farmers with established agroforestry systems and consultants.

Our analysis sheds light on the future direction of agroforestry research and is intended to support the conduct of impactful research that addresses outstanding research questions and provides meaningful answers to promote the wider adoption of agroforestry.

Keywords
stakeholders, Dissemination, agricultural policy, Agroforestry, adoption constraints, research and development

Aditional Attachment I.



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Empowering EU Rural Regions to scale-Up and adopt small-scale Bio-based solutions: the transition towards a sustainable, regenerative, inclusive and just circular bioeconomy - Latvia HUB

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Project RuralBioUp main objective is to support innovators to scale-up inclusive and small-scale biobased solutions in rural areas, through the creation of a favourable ecosystem to be maintained within the empowered regions and transferred to other ones, in order to contribute to regional, urban and consumer--based transitions towards a sustainable, regenerative, inclusive and just circular economy and bioeconomy across all regions of Europe. Project expected results are - 9 Regional Hubs in 6 EU countries implementing 9 Action Plans on 18 value chains, in which at least 1.000 innovators are supported (e.g. participation in networking events and other activities foreseen by Action Plans), a.l. 50 new inter- and intra-value chains collaborations (activated by RuralBioUp, e.g. partnership agreements between companies and/or farmers, solutions funded, etc.) established to adopt small-scale bio-based solutions in rural areas.

In Latvia HUB region are enough biomass and resources from agriculture and forestry that could be used in small-scale biobased solutions in rural areas by creating new products or solutions. Region strategies and policy documents support bioeconomy development in the region and see it as future economy for regional growth and transition to low carbon economy. The region has infrastructure for small-scale biobased solution development through universities, research institutes and regional platforms. Funding is available for small-scale biobased solution development, but information is not collected in one place and it is hard to navigate in all funding possibilities. That will be eliminated within framework of this project. Most off the networks are within specific stakeholder groups, what leads to slower information exchange between different stakeholder groups. This will be improved by with Latvia HUB, where different stakeholder will be informed on regular bases about news in bioeconomy and funding opportunities.

Within our project, we've established a novel value chain related to agroforestry. Our primary goal is to produce soil fertilizer as the end product of this chain. In Latvia, agroforestry predominantly involves cultivating trees on former agricultural lands that are no longer actively used due to challenges such as low soil fertility, stoniness, heaviness, sandiness, or a high-water table.

To promote optimal tree growth in these challenging soils, fertilization is essential. However, conventional mineral fertilizers can be prohibitively expensive for farmers and foresters, leading to reluctance in their use on agroforestry tree plantations. Unlike traditional agriculture, where annual harvests yield immediate returns, income from agroforestry tree plantations accumulates gradually over a longer period—typically 15 years—until the trees are ready for harvest.

In our region, various waste products are generated, presenting an opportunity for sustainable resource utilization. These waste materials include: Wood Ash: Produced by boiler houses; Low-Quality Peat: Extracted from peat mines; Low-Fraction Biochar: Derived from charcoal production plants.

Our project aims to create a value chain that collects and processes these by-products. We'll pelletize them in varying proportions to create effective soil fertilizers specifically tailored for agroforestry systems. These pellets will be strategically applied to the field—either in lines or individually around each tree—during plantation establishment.

Already, some field demonstrations have been conducted in other projects, yielding promising results. By harnessing these waste materials and integrating them into agroforestry practices, we can enhance soil health, support sustainable land management, and contribute to long-term ecosystem resilience.

Project funded by European Commission, Horizon Europa Framework Programme (HORIZON), Circular economy and bioeconomy sectors (HORION-CL6-2021-CIRCBIO-01), agreement No. 101060618.

Keywords
Horizon Europe, agroforestry value chains, RuralBioUp, Value chain analysis

Mixed Farming and Agroforestry Systems in Practice: The Cheese Valley, a Multi-Actor Co-Design and Co-Research Initiative Focused on the Pecorino Toscano DOP Value Chain

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The "Cheese Valley" multi-actor co-design pilot, part of the AGROMIX (H2020 project Grant N.862993) participatory activities, is centered around the Pecorino Toscano PDO value chain in southern Tuscany. This pilot brings together diverse stakeholders, including local farmers, advisors, the cheese factory board, regional policymakers, scientists, and retailers. The study area confronts environmental challenges such as soil erosion, extreme rainfall events, and summer droughts. To tackle these issues, farmers have received support to expand their knowledge about climate-smart practices, including reduced soil tillage, intercropping, grazing management, precision feeding and tree planting.

The co-design pilot underscores the importance of disseminating knowledge about agroecological practices and strengthening farmers' networks to enhance the sustainability and resilience of the Pecorino value chain. The first meeting in 2021 involved 16 participants representing various roles in the supply chain, aiming to foster better relations and communication among stakeholders. This effort resulted in a diagram highlighting the interactions within the value chain. The second meeting in 2022 incorporated activities such as speed-dating, SWOT analysis, and identification of common scenarios for transitioning to sustainable mixed-farming and agroforestry systems.

The SWOT analysis pinpointed strengths, such as history and tradition, weaknesses like a lack of innovation, opportunities in research and collaboration, and threats related to production costs. The meeting delved into how strengths could offset weaknesses and how opportunities could mitigate threats. Within pilot activities, a participatory mapping exercise was conducted to identify agroforestry knowledge gaps among farmers. The community map integrated scientific data and stakeholder perceptions, emphasizing the necessity of participatory approaches for land management.

On-farm experimental trials were conducted to gather scientific data to enhance understanding of the actual implementation of agrosilvopastoral systems. Poplar trees were planted in 2021 to increase fodder availability for lactating sheep in early summer. The feeding trial, involving providing poplar stems and leaves to lactating ewes, yielded promising results in 2022-2023. No significant difference in daily milk production was observed between the groups of sheep fed with and without poplar in their diet, across both years of the study. Additionally, to bolster the identity of Pecorino Toscano DOP from the Manciano dairy, a study focused on rebranding the product was undertaken. This involved an approach rooted in brand management and corporate identity, in collaboration with a design institute.

Challenges in the pilot included the need to rebuild trust among stakeholders. Future steps encompass extending successful field trials to other farms and addressing the aging farmer population through the training of new farmers. In summary, the Cheese Valley pilot actively involves multiple stakeholders and tackles challenges throughout the value chain. The success of the LL depends on ongoing collaboration, knowledge dissemination, and sustained support for small farms in the region.

Keywords

crop-livestock-forestry systems, farmers' decision making, farmer perception, tree plantations, participatory research

The eco2adapt project in Greece: from ancient fairies to modern rhizotrons

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Valonia oak forms traditional agroforestry systems, mainly silvopastoral, that are distinctive for their high natural value (Der Herder et al. 2015) but also for their important economic, social and cultural value (Pantera et al. 2018). In Greece, great forests with old valonia oak trees reportedly existed during the past in Peloponnese, Attica, and Aegean islands. The species at that era provided wood and acorns, tannins for tannery and dye production extracted from the acorn cups and were famous since antiquity for religion reasons. Greek mythology expresses the intense interest ancient Greeks took in natural phenomena (Baumann, 1984). The history of oaks is interrelated with Greek history and mythology as it is one of the most frequently mentioned species. In Greek mythology, the oak or drys in Greek (druids is most probably a derivation of the name dryads), was a sacred tree dedicated to the mighty Zeus (Baumann, 1984). On his sacred oak grove in Dodoni, the priests used to listen to the sough of the leaves of a huge oak tree for their divinations (Baumann, 1984, Tsitsas, 1978; Grispos, 1936). Goddess Athina advised the Argonauts to take a piece of this tree for their protection (Nikolaidis - Asilanis, 1995). According to the mythology a nymph, an Amadryas, was born with each oak seedling and she was living and dying with the tree: by protecting an oak tree, people were protecting the nymph gaining her benediction. However, when a tree was cut or destroyed, the Nymph would punish the person who caused the destruction for rending her homeless, forced to find another tree to inhabit. When the Nymph preferred to wander in the forest without inhabiting any tree she was named “Dryas”. When a desecrater named Érysichthon cut a sacred oak that belonged to the goddess’s Demetra (Demeter), the goddess punished him by an insatiable eternal hunger (History of the Hellenic Nation, 1971). At another occasion, the semi-human god Panas (Pan) was chasing Syriga, an amadryas, so her sisters transformed her to stubble in order to save her (Baumann, 1984). In the popular saying ‘once an oak tree falls everyone tries to chop a piece from it’ the oak tree is used as metaphor to describe any powerful person that once she/he loses her/his power, everyone tries to take advantage of it.

Through time these systems’ value switched to other uses with more economic value but nowadays it is confined to firewood production and for grazing livestock. Natural regeneration in these systems is affected, besides grazing which is a major factor in limiting valonia oak natural regeneration, by a number of factors that influence these systems with climate change being an important one (Papadopoulos et al. 2017).

Based on climate change scenarios, it is estimated that valonia oak is the third species that may face significant decrease to its populations area, scaling up to a loss of 56%. and in the study area in particular, the expected temperature increase and precipitation decrease represents a crucial factor affecting the establishment of saplings and young seedlings or even the survival or young and older valonia oak trees. Under the framework of the present study, we attempted an initial investigation of the effect of drought on valonia oak seedlings and young saplings.

For this, permanent experimental plots have been established inside the forest to evaluate several parameters including soil. The experimental area is located in the Xeromero valonia oak silvopastoral system in W. Greece composed of open to relatively open stands with 25-50 trees/ha-1. Seven rectangular plots covering an area of 40 m2 are presently established and fenced again grazing from livestock and wild animals. In each plot we measured the number of seedlings and young sapling, dry biomass production and several soil parameters. In 2023 12 rhizotrons were established to monitor root growth under different management. The rhizotrons were constructed by opening small pits of 70x50x50 cm size and consisted of four small glasses secured over the pit wall and one big (50x50 cm) against another pit wall. Two months after establishment, root growth is evident in the glasses (Figure 1).

In the forest, wildlife cameras were established to monitor biodiversity. Up to today several vertebrates have been recorded with wild boars being the most abundant.

On a next level, we will establish real life soil moisture detectors in the rhizotrons to evaluate and relate root growth to soil moisture as well as soil microbial community.

Research work such as the one conducted under the framework of the eco2adapt project, is valuable since it has already provided proof for the necessity to take measures to protect this forest that can be characterized as a biodiversity hot spot. It will also provide input for upcoming policy regulations.

Acknowledgment
This work was funded from the European Union under the eco2adapt project (grant agreement N 101059498)

Keywords
grazing livestock, silvopastoral systems, rhizotrons, historical ecology

Aditional Attachment II.

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Promoting SMART associations and innovative financing for responsible forest management and carbon sink enhancement.

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Agroforestry systems play a crucial role in climate change mitigation and adaptation, in the provision of ecosystem services and the development of the circular bio-economy. They also provide significant employment, which at the European level amounts to about 2.6 million people, especially in rural areas.

In Italy, however, the problems affecting the forest and agroforestry sector are manifold. Depopulation, abandonment and high land fragmentation of public and private properties have made the implementation of efficient, responsible and economically sustainable management difficult due to high costs, lack of technical staff and limited organisational capacity.

Moreover, in the current climate crisis context, the lack of active forest management contributes to increasing the impacts of extreme weather events such as forest fires, landslides, floods,, with consequences for the health of habitats, the resilience of agroforestry systems and the profitability of the services they can provide.

Within this framework, the project EU LIFE Climate Positive aims to contribute to an increase in natural areas managed according to quality principles to improve ecosystem services, with particular reference to carbon sequestration and the maintenance of biodiversity. This general objective will be achieved through (i) the promotion of SMART and digital associations in the agroforestry sector as the primary social management tool able to overcome fragmentation and enhance responsible management and carbon removals in the agroforestry systems in Italy; (ii) the development and implementation of a nationally valid carbon sequestration monitoring system that allows for effective certification of positive impacts that can be used in relevant markets; (iii) the development of business models to remunerate agroforestry owners for activities aimed at increasing carbon sequestration and maintaining biodiversity, through the private market in connection with future carbon farming initiatives.

In the context of the project, innovative agroforestry interventions will be carried out in several pilot forest associations, aiming to present various activities that can enhance climate change mitigation through carbon sequestration and reduce the vulnerability of forest ecosystems. All these realities are representative of the national picture in terms of problems, context and baseline. In fact, the forest areas where the project activities will be conducted are characterised by high fragmentation; some have recently been subject to extreme events (fires, landslides); many have been abandoned in silviculture; and several have a vital function in preventing hydrogeological instability. Through key replication and exploitation activities, together with the scale-up of robust business models based on ecosystem services remuneration, the project aims to have a positive climate and biodiversity impact on a large portion of forest lands by 5 years after the project ends, in line with the objectives of the European Green Deal, the Forest and Biodiversity Strategy for 2030 and the European Framework for Carbon Removals Certification.

Keywords

forest management, landscape planning, sustainability, resilience, business models, Agroforestry systems, payments for ecosystem services, climate change mitigation, climate resilience, carbon certification, aboveground carbon sequestration, governance, Land fragmentation, partnership, Case studies, rural development, sustainable business models, Agroforestry, carbon farming, responsible forest management, Dissemination, forest ecosystem, nature-based solutions, biodiversity conservation, carbon storage, Land owners, adaptation, carbon sequestration

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Promoting landscape resilience in the Mediterranean basin trough knowledge and alliance of agriculture and forestry: the ResAlliance project

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In Europe, the Mediterranean region is considered one of the regions more prone to the effects of climate change and related hazards, and is a region whose lands are predominantly under agriculture and forestry management practices. The impacts are seen in temperatures warming 20% faster than the global average resulting in reductions of 10 to 30% of summer rainfall, increasing water shortages, desertification, reduction of crop yield and increased risk of wildfires. These factors result in increased stress, pressure and vulnerability on agricultural land and forests, and indirectly expose them to other types of hazards like crop pests and pathogens. This also increases the complexity of management, as there is more uncertainty about the specific impacts on activities and land. Overall, this is leading to a decline in agricultural and forestry economic and productive capacities. Two of the most impactful social, environmental and economic hazards for the Mediterranean basin are wildfires and droughts.

The present abstract aims to share the first results collected in ResAlliance, complete name "Landscape resilience knowledge alliance for agriculture and forestry in the Mediterranean basin". It is a 3-year thematic network project funded by the Horizon Europe Programme of the European Union. The project's aim is to increase the awareness, understanding, skills and engagement of farmers and foresters

providing them with the knowledge and tools necessary to implement innovative landscape resilience solutions, in four thematic areas: governance, finance, technology and good management practices.

Practical solutions exist in knowledge and practice across the Mediterranean, however up to now, sharing and transferring these solutions to landowners, foresters and farmers is always a challenge due to lack of appropriate knowledge transfer channels, understanding the specific needs of the practitioners in order to know what to share and transfer, and helping build their capacity on methods and solutions that may be new to them. Not least, the language barrier often generates difficulties in transferring knowledge and connecting good practices that exist in different regions of the Mediterranean.

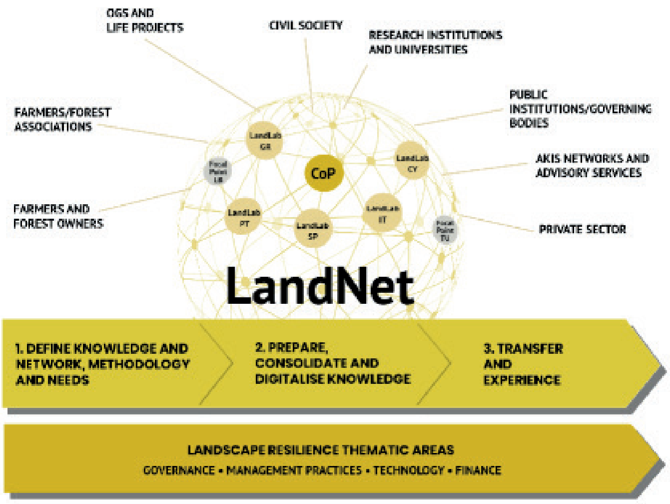
The LandNet, the Mediterranean-wide network created by the project, gave the opportunity to collect the first results, through the dissemination of a survey aimed at evaluating and comprehending the principal needs, barriers, gaps, and potential solutions that stakeholders from the agricultural and/or forestry sectors in the Mediterranean basin may have in conducting their activities amidst current and future changes in land use, socioeconomic factors, and the environment. Based on the responses assessment, ResAlliance will provide conclusions about how to reinforce resilience in Mediterranean agricultural and forestry activities. This presentation aims to show the main climate change impacts and land use change scenarios emerged, in particular: i) Frequency and intensity of the changes in climate and weather (Rainfall variations; Sea level rise; Extreme events); ii) Negative impacts on the activity (f.i the presence of alien and invasive plant or animal species); iii) Socioeconomic factors affecting activity, in particular lack of political stability & long-term policies, urban/industrial development & water competition, increased poverty & rural depopulation, as well as unsuitable infrastructures. The main gaps participants reveled are mainly related to: i) Management practices feasibility and challenges (f.i the absence of facilitation for loans and investments, inadequate support for the activity, limited access to national and international markets, insufficient access to exchange programs, and the absence of affiliation to trade unions, insurance systems, and cooperatives or associations); ii) Adaptation of management practices to environmental/socioeconomic changes (44% of the respondents have indicated that they felt compelled to change practices due to socio-environmental changes, with 23% acknowledging the availability of territorial management practices that could be used); iii) Other tools and capacities to support activity in coping with environmental and socioeconomic changes (f.i the absence or insufficient implementation of R&D programs supporting their activity in their territory; the absence of a regional strategy or local/ sectoral plan to adapt good practices to the changing environmental conditions)

Considering the 4 thematic topics promoted by ResAlliance, the project is producing practice factsheets from the collection of the best case studies in farming and forestry. These best practices will be shared through a massive open online course "MOOC", a multilanguage 3-month course on strategies to enhance Landscape Resilience in the agricultural and forest sector in the Mediterranean region and similar. The course will target farmers and foresters, AKISs, farmer and foresters' associations and representatives, and consultants, but also MSc students of Agriculture and Forestry schools, public institutions and advisors. It aims to transfer knowledge regarding landscape resilience solutions, considering the 4 thematic areas of the project. To facilitate the transfer of knowledge the core of the MOOC will be the description of real practical cases.

The aim of the abstract is to share preliminary results of the survey on landscape resilience needs and to promote the MOOC as a means to transfer and respond to these needs.

Keywords
stakeholders, climate change, forest management, participatory research, Stakeholder engagement, agricultural policy, agroforestry practices, Mediterranean socio-ecological systems, governance, farmers' decision making, agrisilvicultural systems, know-how transfer, online course, agricultural revenue diversification, Fire protection, Landscape approach, European project, agroforestry landscapes, agricultural associativism, drought

Aditional Attachment II.



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Turning the externality provided by agroforestry into a valued asset

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Introduction

The growing demand for wood and food has put increasing pressure on agricultural and forestry sectors. Agroforestry (AF) can relieve this pressure, since AF practices applied in agricultural areas contribute to improving the yield of agricultural and wood products while increasing the ecosystem services of cultivation systems. To meet growing expectations, agricultural sector must strive to realize sustainable food and wood production by internalising the value of ecosystem services – especially of carbon and biodiversity - in business models. One of the key challenges currently limiting the expansion of such practices is the lack of knowledge on the (valorisation of) ecosystem services within stakeholder groups.

Research objectives

Horizon Europe project "REFOREST" aims to create the conditions under which the agricultural application of agroforestry can become attractive for farmers. Therefore, the research objective is to set up a decision support model tailored to the local conditions, which can be easily used in practice and can provide significant help in the economic decisions of farmers interested in the topic in the future.

The Hungarian Living Labs and the planned collaborative work

As part of REFOREST, the University of Sopron (Hungary) works in cooperation with three Agroforestry Living Labs to ensure that the social and economic values of ecosystem services are realized.

The mixed agroforestry Living Lab „Valaha-tanya" is a 16 years old organic agroforestry farm, located on 9.45 ha in Central Hungary. The success of the farm is based on the combined application of agroforestry, permaculture and organic farming. The farm is located in a hilly and windy area and surrounded by intensively cultivated agricultural lands, which conditions presents challenges to the farmer (wind pressure, drought sensibility and chemical pollution). The area consist of 5 smaller fields: silvoarable fruit cultivation, shelterbelt system, mowed wild fruit plantation, multipurpose afforestation and a wood pasture. REFOREST research activities on the farm tries to find solutions to the challenges above, thus includes biodiversity assessment (abundance of soil indicator species, Soil Biological Quality assessment (QBS) and plant biodiversity survey), yield and environmental footprint analysis and remote sensing surveys.

The silopastural Living Lab „Zöld Ág Lovasudvar" is a 8-year-old wood pasture of 20 ha, renovated from an abandoned land in the Bakony mountains. It preserves significant cultural and natural values and provides inspirational location for educational, cultural and professional events. In this area plant biodiversity survey and value chain analysis will be elaborated. Specific focus will be put on the assessment of the wild medicinal plants appearing in the area, due to the management of the wood pasture and the possibility of incorporating them into the agroforestry value chain.

The silvoarable Living Lab is a 3-year-old alley cropping experimental and demonstration site, located in at Bajti Breeding Yard of Forest Research Institute of University of Sopron (NW Hungary). In the 0,5 ha area three types of crop - narrowleaf plantain (Plantago lanceolata), periwinkle (Vinca minor) and sorrel (Rumex rugosus) - are sown and three types of soil cover – geotextile, mulch and beepasture-mix - are applied between Poplar (Populus x euramericana 'I-214') tree rows, in randomized block design with 6 m (between tree rows) x 5 m (within tree rows) network. The main research objective is testing different soil covering methods to improve microclimate and soil humidity due to the main challenges faced locally such as water retention, keeping water in the soil and lifting water from the deepest soil layers to facilitate plant cultivation without irrigation. The planned research activities are soil and air microclimate measurements, indicator species assessment, QBS, yield and environmental footprint analysis.

Results to be achieved

In REFOREST, more than ten European agroforestry Living Labs (in the Czech Republic, Bulgaria, Belgium, Hungary, Germany, Denmark and the United Kingdom) provide input for the quantification of ecosystem services (ES) modelled in agroforestry systems, which contributes to the internalization of social and economic value of ESs in business models. This is complemented by the application of the life cycle assessment (LCA) of farming in order to achieve internal (comparative) and external (efficiency-increasing) benefits. The results of the collaborative work in the REFOREST Living Labs will contribute to the development of decision-making, control and financial support tools covering the entire value chain, and thus to the achievement of future green-economy goals.

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Keywords
Life Cycle Assessment, Agroforestry, agroforestry value chains

Effective and sustainable weed management in agroforestry systems

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Introduction

Effective and sustainable weed management under stricter regulation on the use of herbicides is one of the main challenges for the European farmers, which significantly complicates the cultivation of intensive cultures. Besides, there is few coherent and proof-based information available on the effectiveness and best practices of alternative, holistic solutions. The Horizon Europe project „AGROSUS" will co-create and introduce improved holistic agroecological strategies (AS), for the transformation of weed management in conventional, organic and mixed farming, at eleven European biogeographic regions, in order to reduce the reliance of synthetic herbicides to the environment and increasing biodiversity of agroecosystems. AGROSUS integrates a multi-actor approach and relies on circular knowledge thanks to the synergies with sister projects like CONSERWA, GOOD, and AGRITRANSECT. The ultimate goal of the project is to promote the widespread use of the most suitable solutions from a technological and regulatory point of view with the help of stakeholders and decision-makers, as well as to train and prepare stakeholders (technology transfer). In the frame of AGROSUS University of Sopron will test agroecological weed management practices in close collaboration with three Living Labs: a berry-poplar agroforestry, a conventional arable, and a poplar-aromatic alley cropping system.

Case description

Based on consultation with farmers and agricultural advisors, research and innovation activity will focus on the control of the most problematic weeds in European crops with selected agro-ecological strategies adapted to local conditions and optimising the combination of agronomic levers. In the Hungarian Regional Stakeholder Community University of Sopron will test the effectiveness of different soil covers, weed repellent plant cultivation and use of bioherbicides in agroforestry weed management. Effect of the proposed strategies on crop yield and quality will be assessed in two experimental agroforestry systems:

- Experimental site at the Nursery of the Forest Research Institute of University of Sopron, located near to Sárvár, is dedicated to agroforestry experimentation and demonstration. The system is located in a plain, riparian zone. The 0.5 ha silvoarable system was established in 2021 with poplar (Populus x euramericana 'I-214') and different intercrops such as narrow-leaf plantain (Plantago lanceolata), periwinkle (Vinca minor), sorrel (Rumex rugosus) and beepasture-mixture, sown in randomised blocks.
- The experimental site at the Fertőd Research Station of the Hungarian University of Agriculture and Life Sciences, Institute of Horticultural Sciences, Fruit Growing Research Center was created in 2017 in Fertőd (Hungary). In this area of 0,2 ha poplar tree alleys (Populus x euramericana 'sv-890') are combined with blackberry (Rubus), raspberry (Rubus idaeus) and currant (Ribes) intercrops.

The aims of the research are a) to test different ground cover methods - mulch, geotextile, wood chips, and bee pasture - to determine their efficacy in suppressing weeds and effect on the quality and quantity across three crop categories and b) to assess the effects of bioherbicide use on yields and chemical composition of berries.

In order to get a comprehensive picture of the effects of the examined methods, feasibility and ecological footprint analysis will be done through multi-criteria evaluation of the environmental impact of proposed strategies (soil biodiversity, flora surveys, carbon footprint, GHG emissions, cost, working time etc.).

Among the agroecological methods validated based on the results, the procedures that can be effectively used in practice and widely transferable will be selected. Constraints expressed by the farmers (regulations, high infestation, equipment, feasibility, economic and environmental objectives) will also be taken into account in the validation process.

Expected results

Comparative studies are being conducted in the organic, mixed and conventional farming systems of a total of 24 Crop-Linked-Groups of 14 European Regional Stakeholder Communities, in order to select the appropriate ecological weed management strategies for the most problematic weeds for the key European crops.

Through this collaborative work AGROSUS will provide evidence of optimal and innovative combinations of holistic agroecological weeding techniques for a wide range of crops and farming systems, as well as factors influencing farmers' decision-making, including the social, economic and environmental performance, and trade-offs of different alternative weeding strategies. Co-creation of knowledge and open access data will improve end-user acceptance and increase implementation of alternative weed management strategies.

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Keywords
agriculture, agroecology

Walnut (Juglans regia) in silvoarable alley cropping system: startup and first results of a long-term practice-oriented agroforestry research field in Flanders, Belgium

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In 2023, Inagro, an agricultural research institute located in Flanders (Belgium), initiated a practice-oriented long-term agroforestry research and demonstration field located on its own research facilities. On this plot of 1.4 ha, characterized by a fertile sandy loam soil, arable crops and vegetables are cultivated between rows of walnut trees in a 6 year rotation. It is part of the European network of agroforestry living labs established within the Horizon-Europe project Reforest.

The strategic aim is to tilt agroforestry as an innovative practice beyond the pioneering phase in Flanders. On the one hand by studying the agricultural and ecological potential, practical feasibility and economic profitability of agroforestry. On the other hand, through on-field demonstration and dissemination to a wide range of stakeholders, including farmers (main target group), researchers, advisors, policy makers, agricultural schools, consumers,…

The design of the agroforestry plot was based on state-of-the-art knowledge and experiences on agroforestry in Flemish context. It was kept as simple as possible to ensure reproducibility for Flemish farmers. Walnut trees (Juglans regia broadview) were planted in spaced rows allowing for conventional farming of arable crops (potatoes, winter wheat, maize, winter field beans) and vegetables (leek/cabbage, celeriac/carrots) in between the rows. Underneath the tree rows we installed perennial flower strips to attract beneficial insects (natural pest control and pollination). And at the borders mixed hedges were planted as wind-break and for their biodiversity function.

The main research focus is to study and quantify the direct and indirect impact of trees on crop production and management on the long term and assess the economic profitability based on this site-specific data. We intensively monitor crop health and yield, as well as tree growth and production, micro-climate, soil quality and fertility, water management, biodiversity (insects, bird, bats) and work load for the farmer. Besides manually sampling and measuring these parameters on a regular basis, we installed or used several sensors (Veriscan, pyranometers, weather stations, soil moisture sensors, digital dendrometers, audiomoth, edapholog,…) on the plot.

In 2023, the first year of this long-term trial, leek was cultivated in between the tree rows by a local farmer. As the trees and flower strips were still young and developing, it was not surprising that they did not yet impact the yield and quality of the crop. Loss in productivity was mainly due to the 16% loss of cultivation area inflicted by the trees and hedges. The impact on other parameters was still limited as well. We did however gain a lot of practical experience on the sampling methods and sensor techniques, gathered our baseline data and managed to demonstrate our agroforestry systems to hundreds of farmers and other stakeholders.

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Keywords
legumes, ecosystem services, alley cropping, silvoarable agroforestry, soil characteristics, microclimate, walnut, agroecology, Dissemination, temperate region, tree-crop competition, crop production, Living lab

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