MULTIDISCIPLINARY STUDIES
SUSTAINABLE AGRICULTURE

INTERNATIONAL WORKSHOP

Nourishing the Planet
The future of food in a climate-changing world

BOOK OF ABSTRACTS

20th November 2024
Department of Agriculture, Food and Environment, Aula Magna

Dipartimento di Scienze Agrarie Alimentari e Agro-ambientali
Università di Pisa
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In Supremæ Dignitatis 1343

University of Pisa
PhD Programme in Agriculture, Food and Environment

Preface

As Director of the Department of Agriculture, Food, and Environment at the University of Pisa, I am deeply committed to advancing sustainability, particularly in the context of combating hunger and mitigating climate change, while simultaneously fostering the professional development of our students. Therefore, I enthusiastically supported the PhD student-led initiative to organize the international workshop “Nourishing the Planet: The Future of Food in a Climate-Changing World” on November 20, 2024. This student-driven endeavor demonstrated remarkable initiative, combining intellectual curiosity with strong organizational skills. The students meticulously planned and executed the workshop, from identifying esteemed international speakers and securing funding to managing all logistical aspects. This hands-on experience provided invaluable training for their academic and professional careers. The workshop addressed critical issues related to food systems and sustainability, encompassing diverse topics such as agroecology, climate change mitigation, and the role of technology in agriculture. The program featured a rich array of presentations, including keynote speeches, student presentations, and “elevator pitch” sessions, fostering lively and engaging discussions among over 100 attendees. To ensure that the valuable insights and innovative ideas generated during the workshop are preserved, we have compiled this volume of extended summaries. We extend our sincere gratitude to all speakers and the dedicated organizing committee for their contributions. We hope that the ideas, suggestions, and dreams that emerged from this event will translate into concrete actions by our students and will continue to fuel the research and endeavors of these promising young talents as they shape the future of sustainable food systems. The future needs their inspiration and ideas!

Cristina Nali
Director
Department of Agriculture, Food and Environment at the University of Pisa

Program

8:30-9:00 Registration

9:00-9:10 Welcome address

Prof. Cristina Nali, Director of the Department of Agriculture Food and Environment, University of Pisa

SESSION I: **Food systems and current challenges**

Chair session: *Gianluca Brunori*

9:10-9:15 Introduction - *Gianluca Brunori (University of Pisa)*

9:15-9:30 Talk 1: *Giampiero Mazzocchi (CREA, Rome)* - The elephant in the room: revaluing the role of agriculture in food system approaches

9:30-9:45 Talk 2: *Roberta Sonnino (University of Surrey, UK)* - What's in a Name? Food Policy Networks and the Everyday Governance of Food System Transformation

9:45-10:00 Talk 3: *Martin Caraher (University City of London)* - The Financialisation of Food Systems: Barriers to attaining sustainable diets

10:00-10:15 Talk 4: *Karl Benjamin Kraehmer (University of Torino)* - A multiscalar degrowth perspective on food system transformations and their socio-ecological transformation

10:15-10:40 Discussion and Questions

10:40-11:00 Coffee Break

SESSION II: Agroecology as a sustainable climate solution: the role of ecological actors

Chair session: *Daniele Antichi*

11:00-11:05 Introduction: *Daniele Antichi (University of Pisa)*

11:05-11:20 Talk 5: *Giacomo Bazzani (University of Florence)* - Climate solidarity: low carbon behaviour

11:20-11:35 Talk 6: *Alberto Mantino (University of Pisa)* - Livestock as an essential part of agroecosystem

11:35-11:50 Talk 7: *Guido Lingua (University of Eastern Piedmont)* - Microbial biostimulants for the sustainability of agroecosystems

11:50-12:05 Talk 8: *Giacomo Lorenzini (University of Pisa)* – Climate change and food production

12:05-12:30 Discussion and Questions

12:30-14:00 Lunch

ELEVATOR PITCH SESSION Chair session: *Andrea Serra*

14:00 – 15:00 PhD Projects presentations

Fabrizio Giuseppe Cella

Pierina Díaz Guerrero

Leonardo Ercolini

Giulia Gallo

Simone Nesi

Luciano Pagano

Irene Pagliarani

Lorenzo Pippi

Irene Ventura

Andrea Marianelli

15:00 – 15:10 Questions and Answers Session

SESSION III: The application of technology in cropping systems

Chair session: *Nicola Silvestri, Giovanni Caruso, Alberto Pardossi*

15:10-15:15 Introduction: Nicola Silvestri and Giovanni Caruso *(University of Pisa)*

15:15-15:35 Talk 9: *Stefano Giordano (University of Pisa)* - The role of telecommunications in agricultural systems

15:35-15:55 Talk 10: *Manlio Bacco (JRC)* - The data market: significance for agriculture in the EU. Where is it going, challenges, and limitations

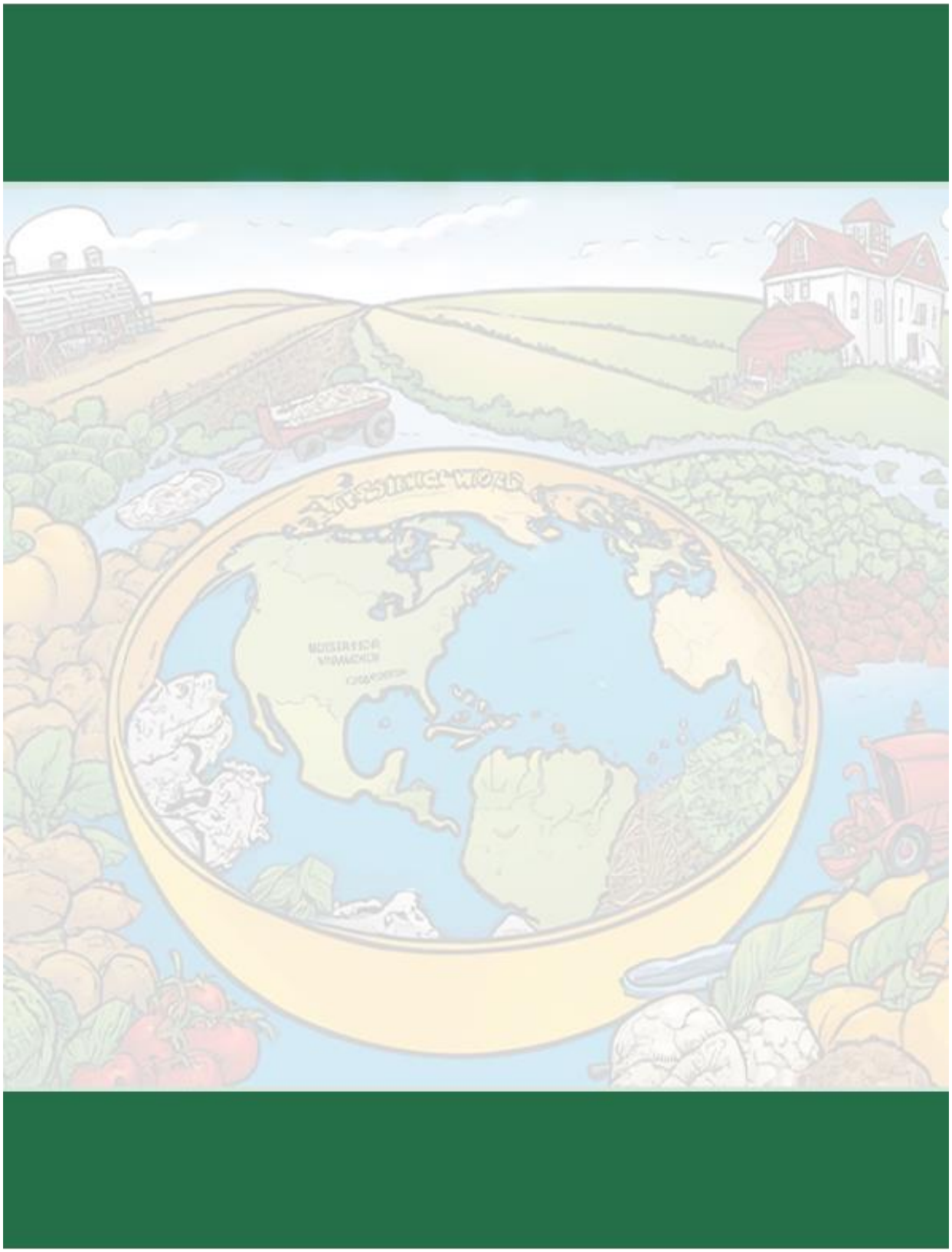
15:55-16:10 Case Study 1 *Gianmarco Bortolotti (University of Bologna)* - A computer vision approach for estimating fruit growth rates in orchards

16:10-16:15 Topic Launch: *Alberto Pardossi (University of Pisa)*

16:15-16:30 Case Study 2: *Carlo Nicoletto (University of Padova)* - Aquaponic systems for the future

16:30-16:45 Case Study 3: *Giuseppina Pennisi (University of Bologna)* - Vertical Farms: an innovative and sustainable technology

16:45-17:15 Discussion and Conclusions



Organizing committee

CARLI Marco (marco.carli1@phd.unipi.it)

Marco is a PhD Student of the Tuscany Region PhD Programme "Pegaso 2023" in Precision Agriculture and Sustainability of Agri-Environment Systems, with a Master's degree in plant and Microbial Biotechnologies at the University of Pisa. He has experience in the investigation of physiochemical and morphological responses of seeds germinating under xenobiotic conditions, the analysis and quantification of primary and secondary metabolites, the molecular identification of different species of phytopathological interest (e.g., Viruses, Viroids, Bacteria, Phytoplasmas, Fungi, Insects, Nematodes), and the use of hyperspectral and metabolomic phenotyping approaches for the early detection and monitoring of plant diseases and abiotic stress. His PhD research project aims to develop novel strategies for the early diagnosis of *flavescence dorée* (FD) in grapevine. Specifically, at the diagnostic level the project is focused on the use of vegetation spectroscopy for a rapid, non-destructive, and inexpensive detection and monitoring of FD, and its molecular characterization, as well as of a metabolomic approach for the identification of metabolites involved in early stages of FD infection.

CELLA Giuseppe Fabrizio (fabrizio.cella@phd.unipi.it)

Passion for science and a curiosity for quality food led Fabrizio to enroll in the Bachelor's degree program in Agricultural Sciences at the University of Turin, where he explored the connections between soil and raw materials. He continued his academic journey by enrolling in the Master's degree program in Animal Sciences, earning his degree with a thesis on improving the quality of beef and the metagenomic analysis of rumen microbiota. Meanwhile, for several years, he engaged in scientific outreach activities, participating in events like the Mantova Food and Science Festival, with the aim of disseminating scientific knowledge within society and combating the spread of fake news. In November 2023, he began his Ph.D. research on "Digitalization of agroforestry systems for sustainable animal production." His research project focuses on how poplar leaves in lamb feeding can impact meat quality. Moreover, he is envolved in a European project to develop a model for beef meat production to enhance the economic and environmental sustainability of farms. The interaction between sustainability and food quality becomes a fundamental theme

expressed within his research project through comparing the quality of beef meat coming from indoor, on pasture, and in silvopastoral rearing systems. Sustainable meat consumption begins with consumer choices, and awareness of what we purchase can only exist if the differences in value are highlighted and communicated. Brillat-Savarin wrote, “Tell me what you eat, and I will tell you what you are”: if this is true, knowing what we eats becomes essential for pursuing a healthy, balanced, and above all, conscious diet.

D’ASARO Lorenzo (lorenzo.dasaro@phd.unipi.it)

Lorenzo is a PhD student at the Department of Agriculture, Food and Environment at the University of Pisa. He began his PhD program in November 2023 by focusing on agricultural chemistry with a research project titled “Study and tuning of an assisted phytoremediation process for the treatment of a site contaminated by heavy metals and hydrocarbons.” The primary objective of his PhD project is to study and develop a feasibility plan for decontaminating a specific polluted site by using the phytoremediation approach and investigating potential plant adaptation strategies from a physiochemical perspective. In July 2021, Lorenzo graduated in “Agricultural Sciences” at the University of Pisa. During his studies, he had the opportunity to work on plant pathology (e.g., mycotoxins). Subsequently, he earned a degree in “Agri-food Production and Agro-ecosystems Management” at the University of Pisa, presenting a thesis titled: “Resistance inducers for the defense of *Vitis vinifera* against *Plasmopara viticola*”, in which he focused on the possible use of *Saccharomyces cerevisiae* extracts as an eco-friendly approach against downy mildew. Lorenzo possesses skills in ecophysiology (utilizing gas exchange and chlorophyll a fluorescence approaches) and biochemical analyses.

DÍAZ GUERRERO Pierina (pierina.guerrero@phd.unipi.it)

Pierina Díaz Guerrero is a Mexican Food biotechnologist. She holds a BSc in Nutrition from the Universidad Popular Autónoma del Estado de Puebla (UPAEP) in Mexico and a Doble Master's degree in Biotechnology. First at UPAEP where she developed a symbiotic fermented beverage based on a discarded pulp from an amazonian fruit named pataxte (*Theobroma bicolor*) and aguamiel (*Agave salmiana*) by acid lactic bacteria inoculation. Her second MSc in Biotechnology with Specialization in Biomedicine from the University of Jaén (UJA) in Spain, where she won a grant to perform her thesis title "Biotechnology for the revalorization of agrifood industry wastes. Extraction of compounds of interest through the application of enzymes" at DOMCA-DMC Research (Granada, Spain). In November 2023, she started her PhD course in Agriculture, Food and Environment Sciences with a project entitled "Sensory analysis and emotional profile as a tool for the valorisation of sustainable and innovative food chain" at University of Pisa and CNR-ISE, Pisa. The objective of her project is to assess the combination of sensory analysis and emotional profile as a methodological approach to enhance a specific food supply chain. This study involves the characterization of the organoleptic profile of specific food types and their potential to evoke emotional responses in consumers. For this purpose, a new method, called Sensory Critical Control Point (SCCP), will be developed and validated to identify in each selected supply chain the main points of the production process that may have an impact on the organoleptic properties of the final product and on consumer acceptance.
She is committed to improving human health, agriculture and the environment through the application of science, technology and bioethics.

ERCOLINI Leonardo (leonardo.ercolini@phd.unipi.it)

Leonardo obtained his master's degree in Agrifood Production and Agroecosystem Management at the Department of Agriculture, Food and Environment of the University of Pisa, with a thesis on the use of drones for monitoring weeds on a maize crop. Afterwards, he began his research activity as fellowship holder at the "E. Avanzi" Agro-Environmental Research Centre. The focus of the study was the analysis of

radiometric properties of crops and weeds in the context of smart agriculture. During this period, he took part in other research projects (PRA_2022_iAgroforestry, Colline Digitali) that allowed him to explore other aspects of precision farming techniques. Leonardo's PhD project devoted to the evaluation of technical solution for the Site-Specific Weed Management (SSWM) is entitled "Application of precision farming techniques in weed controlling". During the 3-year research period, the effects of different levels of weed infestation on the final crop yield (maize) will be evaluated in order to establish appropriate intervention thresholds. In addition, thanks to the collaboration with the CNR-ISTI, the contribution of computer vision applied to high-resolution RGB image for the weed detection will be explored. Leonardo's PhD project is funded by the NRRP (The National Recovery and Resilience Plan) , within the Spoke 5 (Sustainable productivity and mitigation of environmental impacts in livestock systems).

GALLO Giulia (giulia.gallo@phd.unipi.it)

Giulia is an environmental scientist, holding a Double Master's Degree in Environmental Science from the University of Copenhagen and the Swedish University of Agriculture (SLU), obtained in 2021, and a Bachelor's Degree in Food Science at the University of RomaTre. During her Bachelor's she also had the chance to contribute to the research and development of the Food Policy in Rome, where she deepened her skills interdisciplinarity on food security, food policies, and short-food supply chains. Throughout her years in Sweden (2019-2022), she focused her studies on sustainable food systems and food loss and waste. She also worked as project manager in a private company, where she helped researching and developing an insect protein feed, based on recovered food waste. In 2023 she moved to Brussels, Belgium, where she worked at a European Federation as environmental consultant for one year, having background in life cycle assessment, where she explored the EU policies on food and agriculture. In November 2023, she joined PAGE (Pisa Agricultural Economics) as a PhD student, where her research concentrates on food waste prevention, food policies and multi-stakeholder engagement.

MARIANELLI Andrea (andrea.marianelli@phd.unipi.it)

With a background in Animal Production Sciences and a master's degree in Biosafety and Food Quality from the University of Pisa, together with 5 years of experience in the field, he undertook a doctoral path. His passion for research revolves around extending the shelf life of baked goods to reduce food waste. It delves into the use of sourdough from the DOP Tuscan bread consortium, innovative ingredients extracted from fruit and vegetable by-products and explores compostable packaging solutions to combat global warming and get to the consumers clean and short food label. In three words: tradition, innovation, and sustainability. These are the values that guide him along the way.

NESI Simone (simone.nesi@phd.unipi.it)

Simone Nesi is a Ph.D. student in the Department of Agriculture, Food and Environment (DAFE) at the University of Pisa with a research project on "using remote and proximal sensing techniques to assess the response of Mediterranean tree crops to climate change-induced stresses". In 2018 he gained a bachelor's degree in Viticulture and Enology with a thesis on "grapevine water relation and irrigation management in viticulture" and in 2020 he achieved a master's degree in agri-food production and management of agro-ecosystems with a thesis focusing on "the effect of irrigation and rootstock on the vegetative-productive parameters and grape quality of the Sangiovese cultivar". After a work experience as a production manager in a winery, he came back to the University to follow one of his greatest passions: the study and management of abiotic stresses, with a focus on water and salt stresses. The general purpose of his Ph.D. project is to test the effectiveness and transferability of new monitoring technologies in Mediterrenean tree crops. Two specific objectives are: (i) to evaluate the combined use of remote and proximal sensing techniques to detect and monitor two important abiotic stresses induced by climate changes, such as those from drought and salinity, and (ii) to use the information derived from remote and proximal sensing to develop irrigation, canopy and soil management protocols aimed at mitigating water and salinity stresses in vineyards and orchards.

PAGANO Luciano (luciano.pagano@phd.unipi.it)

Luciano's academic background includes a BA and an MA in Agricultural Sciences. Throughout his studies, he delved into the economic and political aspects of agriculture, gaining practical experience through an internship at an agro-technical office and obtaining a scholarship at the University of Pisa. During the internship, the focus of his studies was mainly on the study of Tuscany's Rural Development Program, while the scholarship allowed him to learn more about European and national soil health regulations. In November 2023, Luciano started his PhD studies at the Department of Agriculture, Food, and Environment at the University of Pisa, with the goal of learning more about policies and incentives related to soil health, with a focus on agroecological practices and the costs and benefits associated with their implementation. His research intends to produce several results over the three years, such as: a review of existing policies and incentives that have an impact on soil health and a cost-benefit analysis of practices promoting soil health in agriculture. Environmental and social benefits will be explored in particular in relation to crop management practices complying with the agroecological principles.

PAGLIARANI Irene (irene.pagliarani@phd.unipi.it)

She received her Master's Degree in Plant and Microbial Biotechnology in 2022 at the Department of Agriculture, Food and Environment (DAFE), University of Pisa, with a thesis on the influence of different urban pavements on arbuscular mycorrhizal fungal communities associated with ornamental trees. In 2022 she won a research grant in the field of agricultural microbiology, and she worked for one year in the same Department (DAFE). The activity was mainly focused on the study of beneficial microbial communities characterizing agro-environmental matrices. From April 2023 to November 2023, she continued working on this topic with a research grant on the molecular and functional characterization of beneficial microorganisms in food and environmental matrices. Her research interests are focused on agricultural microbiology particularly on beneficial soil microorganisms such as arbuscular mycorrhizal fungi (AMF) and plant growth promoting bacteria (PGPB) for their application in sustainable agriculture. Throughout her professional journey she has acquired expertise in molecular and culture-dependent techniques to analyse

the complex microbial diversity in different types of matrices. Author of 5 papers in international journals and 10 contributions in international conferences. Currently, she is a PhD student in Agriculture, Food and Environment. Her PhD research is related to the utilization of native AMF as inoculants for alternative and sustainable weed management in agricultural soils aiming at reducing the use of herbicides.

PIPPI Lorenzo (lorenzo.pippi@phd.unipi.it)

Lorenzo is a PhD student of the national PhD program in Sustainable Development and Climate Change, working in the Plant Pathology Lab of the Department of Agriculture, Food and Environment of the University of Pisa. He has a Master's degree in "Urban Green Areas and Landscape Planning and Management" at the University of Pisa. Dr. Pippi has developed an interesting skill set since he is capable of analyzing both standard (e.g., ecophysiological and biochemical results) and high-dimensional data (e.g. hyperspectral and multivariate data sets). His PhD project aims to develop an accurate and high-throughput framework for the diagnosis of plant diseases, and the monitoring of vegetation responses to plant pathogens, as well as of the efficacy of their control methods, based on the use of hyperspectral data collected at multiple scales (from the leaf to the ecosystem). Specifically, it aims to develop spectral indices sensitive to plant diseases and hyperspectral models to estimate commonly investigated plant traits (e.g., photosynthetic, water status and antioxidant traits), and hyperspectral classifications of plant diseases. Dr. Pippi is also interested in the development of a decision support system for the assessment of plant diseases infection risk in the nursey, also including spectral data. The experimental activities include primary agricultural crops, typical tree species in the Mediterranean area, and ornamental plants widely used in nursery and urban environments.

RICCI Gian Piero (gianpiero.ricci@phd.unipi.it)

Gian Piero Ricci is a PhD candidate at the Department of Agriculture, Food, and Environment (DAFE) of the University of Pisa. He obtained his bachelor's degree from DAFE and subsequently earned a master's degree in "Agrifood Production and Agroecosystem Management" defending a thesis focused on plant pathology titled "Indirect methods for the diagnosis of pathogens in basil: from microscopy to molecular biology". After a research fellowship focused on the application of air quality biomonitoring techniques, he currently leads a research project titled "Integrated approaches for the selection of resistant plant material to *Xylella fastidiosa*" at the Plant Pathology laboratory of DAFE, University of Pisa. His project specifically focuses on evaluating the physiochemical parameters of resistant or tolerant fruit tree species (almond tree and pistachio) and characterizing defence responses in some species with varying susceptibility to *X. fastidiosa*.

VENTURA Irene (irene.ventura@phd.unipi.it)

Irene Ventura holds a bachelor's degree in Herbal Sciences and a master's degree in Agricultural, Food, and Agro-environmental Sciences, completing her studies in 2022 in Pisa University, with a thesis on Tuscan wild halophytes and their ethnobotanical uses. Following graduation, she pursued a 6-month traineeship during which she conducted research on various spontaneous accessions of Salicornia perennans, investigating both morphological and qualitative aspects. Subsequently, Irene won a grant to investigate ethnobotanical plant species in Tirli, a little town situated in the municipality of Grosseto. Now, she is providing educational support in two courses of the bachelor's degree in agricultural sciences in Pisa University. Throughout her academic journey, Irene consistently sought to understand the uses of various wild plant species, initially focusing on pharmaceutical applications and then on edible uses. Aligned with her interest on wild plants, Irene's doctoral research will be centered on the botanical characterization of some halophytic species present in Tuscany that not only have ecological significance but also hold potential as crop species. Her research aims to explore the feasibility of cultivating halophytes in hydroponic and aquaponic systems.

By delving into the study of Tuscan halophytic species, Irene aims to contribute valuable insights into their ecology, nutritional content, and overall exploitation for greenhouse production. The study's multidisciplinary approach, incorporating both botanical and horticultural aspects, underscores her dedication to finding solutions that bridge the gap between botanical science and practical agricultural applications, advancing sustainable and innovative agricultural practices. Through her doctoral project, Irene Ventura aspires to not only expand the understanding of halophytic species in Tuscany but also to contribute to the development of sustainable agricultural practices, with a particular emphasis on integrated hydroponic and aquaponic systems.

Abstracts

SESSION I: Food systems and current challenges

The elephant in the room: revaluing the role of agriculture in food system approaches

Mazzocchi Giampiero[1,*]

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Abstract

The talk highlights the role of agriculture in shaping and steering food systems. In a context characterized by the growing diffusion of food policies at a local and regional level, when speaking of “food”, the downstream stages of the supply chain are emphasized, with agriculture being neglected. Recent studies focusing on narratives surrounding Italian local food policies highlight a strong interest in governance tools and interpretive frameworks, yet there remains a lack of understanding about the room for manoeuvre and the levers needed to integrate local agricultural systems into regional food strategies. This gap is partly due to the multi-level nature of agricultural policies and the challenge of using push or pull mechanisms to influence farmers' business decisions. Additionally, the market orientations of agricultural enterprises, often geared toward export rather than local distribution, complicate integration efforts. Despite this, scientific evidence calls for a re-consideration of agriculture and rural development for a thorough and systemic approach to transforming food systems. Indeed, several economic, ecological, climatic, political, and social conditions orient agricultural systems, which represent the essential component underlying the functioning of local food policies based on systemic and circular approaches. These reflections open new research perspectives, from identifying political and administrative spaces for incorporating agriculture into local food policies to exploring policy coherence. The latter can be analysed, measured, and improved through vertical and horizontal integration, thus promoting a more effective transformation of food systems, beginning with the primary sector.

Keywords: agriculture; food policy; food system; policy coherence.

What's in a name? Food policy networks and the everyday governance of food system transformation

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Abstract

Research on food system transformation tends to prioritise global analyses of abstract forces, neglecting the ways in which these shape (and are shaped by) micro-politics and ordinary practices. Using an "everyday governance" framework, this presentation focuses on the seemingly mundane activity of naming a "food policy network" (FPN) to elucidate how practices come together to actualize, resist or confront dynamics of power and authority. The analysis of data collected through 70 semi-structured interviews with the coordinators of different compositional types of FPNs highlights that names are not just identifiers; they are also indicators of strategic orientations towards food system transformation and how these might change over time. As the presentation concludes, a focus on how ordinary practices such as (re-)naming form, change or dissolve offers unique insights into the relationship between abstract and social space and, more broadly, about the diversity of transformative agendas that are emerging on the ground.

Keywords: food system transformation, food policy networks, everyday governance, micro-politics.

The financialisation of food systems: barriers to attaining sustainable diets

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Abstract

The global food system is dominated by financial and corporate interests, hindering sustainable food practices. Food prices rose on average by 20% between January 2020 and January 2022 but the benefits from these price increases went to big business not to food producers and growers. Food has become a speculative commodity, traded for profit rather than sustenance, leading to increased food insecurity. Major food corporations and retailers promote profit-driven models like sustainable intensification, resulting in monocropping, reduced food diversity, ghost acres and a new form of corporate colonialization dominated by the global north and sovereign wealth funds from the Middle East, China and SE Asia. The concentration of power among these entities prevents substantial food policy changes. The COVID-19 pandemic and the war in Ukraine exacerbated and made more visible food insecurity and poverty, while corporate profits soared. During the pandemic lockdown when food became a more valuable commodity a new billionaire was created every 30 hours while a million people "*fall into extreme poverty'.* Key to this accumulation of profits is the takeover of parts of the food system by private equity funds (referred to as vulture capitalists as opposed to venture capitalists), who by splitting-up companies and organising lease and buy-back schemes on both land and capital raise dividends for shareholders while impoverishing food businesses. Addressing these issues requires challenging the power dynamics, promoting sustainable practices, ensuring independent monitoring, and advocating for global accountability to create a more equitable and sustainable food system.

Keywords: Financialization; Food system; Refinancing; Leaseback; Corporate control.

A multiscalar degrowth perspective on food system transformations

Karl Krähmer[1,*]

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Abstract

It is widely accepted that the transformation of food systems - globally responsible for about one fourth to one third of GHG emissions - is a crucial challenge in the current socio-ecological poly crisis. In the wider political and academic debate about socio-ecological change, a central disagreement has emerged over the question if ecological sustainability (and related questions of social justice) is compatible with continued economic growth. Degrowth advocates disagree, arguing, based on increasing empirical evidence, that there is no possibility of achieving sufficiently large and rapid absolute decoupling between economic growth and ecological impacts and that instead an equitable and selective reduction of production and consumption is necessary. Surprisingly though, the implications of degrowth for food systems only very recently have become the object of critical scrutiny and many proposals have focused on small-scale best practice cases and the argument of relocalization, rapidly dismissing the complex global interconnections of the existing food system(s) and their role for food security. This intervention drafts a framework for a differentiated and multiscalar perspective on food system transformation in a degrowth scenario.

Keywords: Degrowth; Ecological Sustainability; Food Systems; Food Security.

SESSION II: Agroecology as a sustainable climate solution: the role of ecological actors

The agroecological way to tackle climate change and agri-food system sustainability

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Abstract

Agroecology is one of the globally outstanding approaches to the transformation towards more sustainable and resilient agricultural and food systems. Funded on the basements established by agricultural ecology, agroecology emerged as a practical application of it since its first definitions provided in the 1990s by Steve Gliesman and Miguel Altieri. Nevertheless, at that time agroecology was mostly conceived only as an ecological way to make agroecosystems less reliant on external inputs through the enhancement of natural resources and ecological factor interactions (e.g., through diversified crop rotations, including cover crops, intercropping and polycultures). Soon it appeared as only approaching also the downstream of food production might result in an effective and impactful shift towards more sustainable food systems. Thus, since early 2000s, agroecology evolved into a holistic and global approach to the transformation of entire agri-food systems. This implied the rethinking, not only of the way the food is produced at the farm level, but also of human relationships along the value chains and of political and economic lock-ins limiting the development of sustainable agri-food systems. Nowadays, agroecology is conceived as a complex approach to the design and transformation of agri-food systems entailing: i) scientific principles for the ecological redesign of agricultural systems; ii) practical approaches collected from practitioners to embed local cultures, knowledges, and adaptations, useful to tackle global challenges; iii) social movements and initiatives to empower people and interpersonal relations in agri-food systems. As such, it is characterized by a strong transdisciplinary and participatory approach enabling all actors to be engaged in the co-design of agri-food systems, aiming at reaching high levels of sustainability and resilience. As more as a result-driven approach than a set of rules, agroecology goes beyond certification standards and binds producers and consumers in a renewed food alliance that acts locally to reach global goals. Pinpointing diversification and agroecosystem health as milestone principles, the agroecological approach empower as ecological actors, not only the human stakeholders involved in value chains, but also all the natural components of agroecosystems, such as plants, animals and microbes. Thanks to the capacity of these latter to buffer, regenerate and transform agroecosystems subjected to external stressors, the agroecological approach is trusted as one of the most effective ways

to increase agri-food systems capacity to adapt to and mitigate climate change.

Keywords: Resilience, Agroecosystems, Biodiversity, Diversification, Health.

Climate Solidarity: low carbon behaviour

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Abstract

Climate-change mitigation is a matter of solidarity. Behaviors that primarily benefit other people are prosocial behaviors that can be considered solidarity at the collective level. For climate-change mitigation, greenhouse gas emissions have to be reduced primarily in wealthy countries, while the major beneficiaries of such a reduction are the populations of developing countries and future generations, who (will) suffer the significant negative consequences of climate change. Climate change has created a new global interdependence that requires a new form of solidarity as a global and intergenerational prosocial behavior. Low-carbon behavior has so far mainly been studied as a form of pro-environmental behavior but not as a form of prosocial behavior. The presentation identifies four approaches to explaining the origin of prosocial behavior that can be applied to the emergence of low-carbon behavior: rationalist, institutionalist, interactionist, and situational approaches. The scope conditions and limitations of each approach in the case of low-carbon behavior are discussed, together with relevant empirical evidence, future research directions, and policy implications. The presentation lays the foundations for the study of climate solidarity as a new interdisciplinary field of research that can make a key contribution to the transition toward low-carbon societies.

Keywords: climate change, global warming, solidarity, sustainability

Innovative methods in breadmaking, packaging and distribution able to increase nutraceutical value, extend shelf-life and reduce waste of bakery products

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Abstract

Bread is a key symbol of local communities due to its reliance on locally sourced ingredients. While consumers prefer artisanal bread, its shorter shelf life compared to industrial products poses a challenge. To improve both shelf life and nutraceutical value, innovative solutions are required. For instance, using pomace powder in bread enhances fiber, polyphenols, and antioxidants. Seaweed (*U. lactuca*) has also shown promise in improving bread's nutritional profile. Additionally, modified atmosphere packaging (MAP) and natural additives like lactic acid bacteria (LAB) in selected PDO Tuscan bread sourdough can effectively extend shelf life while maintaining quality. This research aims to extend bakery products' shelf life and improve their nutritional value using PDO sourdough, fortification with food by-products, and compostable Modified Atmosphere Packaging (MAP). Sourdough fermentation enhances shelf life by reducing pH, slowing staleness, and increasing nutrient bioavailability. Antioxidant-rich ingredients and hydrocolloids help control moisture and preserve product quality. Compostable MAP will be tested to further prolong shelf life.
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Keywords: Bakery products, Shelf-life, bread, Packaging, Sourdough

Microbial biostimulants for the sustainability of agroecosystems

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Abstract

Microbial biostimulants are soil microorganisms associated with plant roots and able to improve plant growth. Such an effect is obtained increasing nutrient availability and abiotic stress tolerance or enhancing some plant quality trait. Microbial biostimulants are naturally occurring in soil.

Modern agriculture has been able to feed billions of people, and it mainly relies on a number of factors to support plant productivity, including mechanization, genetic selection and breeding, fertilizers, phytosanitary products, and the use of monocultures, but it typically neglects the introduction, use or management of biostimulants. However, several agronomic practices linked to conventional modern agriculture are not sustainable in the long term and significantly contribute to global pollution or environmental problems. Biostimulants could help in increasing the sustainability of agroecosystems.

In this lecture, we shall describe microbial biostimulants and their role in agroecosystems and plant productivity, considering the main categories of microorganisms belonging to this group of soil inhabitants. We shall shortly examine the development of agriculture in human history and describe the environmental drawbacks of modern agriculture techniques. In addition, we shall see how microbial biostimulants can contribute to improving the sustainability of agroecosystem through improved soil fertility, plant mineral nutrition and health, better water use, stress tolerance. Finally, biostimulants can positively affect the quality of plant products, resulting in higher nutritional traits and even better income for growers.

Keywords: Microbial biostimulants; Sustainable agroecosystems; Soil fertility.

Climate change and food production

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Abstract

Climate change refers to long-term shifts in temperatures and consequently in weather patterns. Since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas, which is responsible for the increase in atmospheric CO_2 concentration. Environmental temperature has strong and systematic effects on biological processes at all levels of organization, from reaction rates of enzymes to ecosystems. Environmental consequences of high temperatures include increased drought; river/pluvial flooding; increased frequency and intensity of hail episodes; increased length and severity of the wildfire season; changes in phenology, species distribution and relationships, and ecosystem processes; increased activity of parasites. All this entails reduction in suitable areas for crop cultivation and substantial losses in agricultural production, with inevitable impact on our daily lives. Taking inspiration from a hypothetical vegetarian diet based on three main meals (breakfast, lunch and dinner), the possible effects of climate change on availability, prices and organoleptic qualities of cappuccino (milk and coffee), croissant, Caprese salad (tomato), wine, pizza and beer are discussed. The take-home message is simple: If we want more citizens to raise their voices about (or, better, *against*) climate change, we need to talk about something very tangible, immediate, and universal to all: food. Tomorrow's food will be more expensive, will have different organoleptic characteristics, such as taste, will contain more toxic substances, and will force us to change our eating/drinking habits.

Keywords: Temperature, Daily meals, Quality, Prices.

PhD Projects presentations

Agroforestry for ruminants: characterization of nutritional components of leaves and stems from different poplar clones to improve the cncps feed library

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Abstract

Recent years have witnessed increasing awareness of the impact of climate change (CC) on agriculture, particularly in the Mediterranean region. This area, with its rich tradition of adapting to harsh environments and variable climates, faces significant threats from rising temperatures and extreme weather events such as droughts. These challenges can affect crop yields, soil health, and water availability. Alongside these challenges, CC poses substantial risks to livestock production, which contributes 14.5% of global greenhouse gas (GHG) emissions. The livestock sector's environmental footprint includes land degradation, air and water pollution, and biodiversity loss. Moreover, CC exacerbates competition for natural resources, affects feed quality, increases livestock diseases, and induces heat stress, all of which threaten the stability of the livestock industry. Agroecology has emerged as a holistic alternative to conventional agriculture. This approach integrates ecological principles to improve biodiversity, soil health, and resource efficiency while reducing reliance on external inputs. By emphasizing local knowledge and socio-economic context, agroecology fosters sustainable practices that enhance agricultural resilience, mitigate climate change, and support food security. A specific branch of agroecology, agroforestry, offers significant potential by integrating trees and shrubs into farming systems. Agroforestry enhances biodiversity, improves soil fertility and structure, and increases water retention. It also contributes to carbon sequestration, mitigating GHG emissions, and promotes sustainable land management. For this study, Poplars (*Popolus* spp), were chosen as an alternative forage for animal nutrition. They can sequester carbon, enhance ecosystem services such as erosion control and pest regulation and improve the sustainable use of water. The current study explores the nutritive potential of poplar leaves and stems as a feed source for small ruminants during the Mediterranean summer when traditional pasture resources are scarce. This research was conducted in the Maremma region of southern Tuscany, characterized by a typical Mediterranean climate. The region faces severe feed shortages during dry periods,

compelling livestock farmers to rely on expensive and environmentally taxing supplemental feeds. The study systematically collected and analyzed poplar biomass from selected sites to determine its chemical composition and suitability as a feed resource. This analysis focused on key nutritional factors, including crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF), which influence forage digestibility and intake. The research aimed to complement existing feed resources by integrating poplar leaves and stems into ruminant diets, thereby improving the resilience and sustainability of livestock systems in the Mediterranean. Results from the study are expected to expand the Cornell Net Carbohydrate and Protein System (CNCPS) feed library, a dynamic nutritional model for optimizing ruminant diets. By incorporating poplar biomass, this research seeks to provide empirical evidence supporting its role in sustainable livestock systems. Poplar leaves and stems are hypothesized to offer a balanced profile of carbohydrates, proteins, and minerals, making them a viable alternative during the critical dry season. In conclusion, this research underscores the dual benefits of agroforestry in addressing climate challenges and enhancing livestock sustainability. By integrating poplar biomass into animal diets, the study provides a pathway to reduce feed shortages, promote environmental stewardship, and sustain agricultural productivity in the Mediterranean region.ax 3000 characters space included.

Keywords: Agroforestry, Mediterranean region, Browse, Tree, Forage, Livestock, Climate change.

Sensory analysis and emotional profile as a tool for the valorisation of sustainable and innovative food chains

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Abstract

The main problem identified in New Product Development (NPD) area within the Food Industry is the repeated failure of new products often due to a limited understanding of consumer motivation and choice. Indeed, consumer decision-making through sensory evaluation of food is a critical point for gathering high-quality data in sensory analysis. To overcome the gap between the quality perception and the moment of the decision-making and to understand consumer choices, both analytical analyses and affective analyses can be employed. The former is used to measure in detail the sensory evaluation through descriptive, discrimination or grading test, while the latter assesses product preference or acceptability among consumers. Combining affective analysis with novel techniques allows to measure the sensory, emotional, and physiological responses of consumers. One example is the use of wearable biometric sensors, that can capture the subconscious reactions of consumers during sensory tests through electroencephalography, galvanic skin response and electrocardiogram. Therefore, the aim of this PhD project is to evaluate the combination of sensory analysis (panel test,) and emotional profile (wearable sensors methods) as a tool for enhancing a specific food supply chain. A multidisciplinary approach, including panel test, HS-GC/MS and wearable biometric sensors will be applied to define the organoleptic profile of foods such as wine, herbs and spices and extra virgin olive oil, and to evaluate their emotional impact on consumers. For this purpose, a new method, called Sensory Critical Control Point (SCCP), will be developed and validated to identify, within each selected supply chain, the key steps of the production process that may influence the organoleptic properties of the final product and consumer acceptance.

Keywords: Chemosensory analysis, Emotional profile, Volatile Aroma Compounds, Wearables sensors, Quality perception.

Weed green cover as a decision-making tool for site-specific weed management

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Abstract

The reduction of herbicide usage in agricultural practices represents a pivotal objective in the advancement of sustainable farming methodologies, in alignment with the objective of the EU's Farm to Fork strategy. Nevertheless, recent statistics indicate that over 355,000 tons of pesticides were sold in the EU in 2021, representing a 2.7% increase from the previous year. The excessive use of herbicides not only has an adverse impact on the environment but also contributes to the emergence of herbicide-resistant weed populations, thereby reducing the effectiveness of chemical control measures. In response, site-specific weed management (SSWM) has emerged as a targeted approach, which involves the application of herbicides considering the real distribution of the weeds in the field and their potential impact on the crop yield. The application of techniques such as patch spraying and the development of predictive models based on weed coverage enables the optimisation of chemical control and the reduction of unnecessary inputs, providing economic, environmental and health benefits.

This study proposes a methodology for estimating weed green cover (WGC) in order to provide evidence-based guidance on the economic intervention threshold for herbicide application. The experiment, conducted on a maize field at the Agro-Environmental Research Centre “E. Avanzi” of the University of Pisa, located in Central Italy, involved measuring the WGC of 30 plots by drone imaging, in conjunction with yield assessments across plots exhibiting varying levels of weed infestation. WGC was derived by subtracting the average maize green cover from the total green cover in each plot. This method demonstrated good accuracy when compared to manually annotated images. The results indicated a good correlation between WGC and Relative Yield Loss (RYL), thereby supporting the use of WGC as a viable proxy for yield loss estimation. These findings confirm that the application of herbicides can be reduced without compromising crop yield. However, it is essential to conduct site-specific calibration to account for variables such as crop type, local pedoclimatic factors, and the composition of weed’s community. This research underscores digitalization's role in enhancing precision farming, especially for small-to-medium farms that face challenges in adopting advanced SSWM tools. The use of remote sensing technologies, such as UAVs and multispectral

sensors, enables the creation of detailed field maps and precise data for targeted herbicide applications. The study's methodology is adaptable, supporting non-digital farms with threshold assessments and digital farms with ISOBUS-equipped machinery to create precise prescription maps. This adaptable approach supports sustainable weed management and contributes to agriculture's ecological transition.

Keywords: Precision Agriculture, Site Specific Weed Management, Herbicide Reduction, Image processing.

Tackling food loss and waste in food systems

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Abstract

Food waste and loss (FLW) represent a critical global issue, contributing to environmental degradation, economic inefficiencies, and social inequities. Approximately 20% of global food production is wasted, generating 10% of greenhouse gas emissions and intensifying the paradox of "scarcity within abundance," where food insecurity coexists with waste. The issue has gained increasing attention from researchers and policymakers in recent years. Despite this focus, the problem remains insufficiently addressed by current policies. This PhD project provides a critical review of recent academic and policy literature, examining key aspects such as definitions, quantification methods, underlying drivers, and EU policies related to food loss and waste. It highlights significant gaps in existing research and policy, offering insights to guide future efforts. A performed literature review emphasizes the overlooked potential of addressing food losses as a means to effectively implement the waste hierarchy framework, particularly through preventive measures. Additionally, it critiques the predominant tendency to analyse food waste and loss in isolation, rather than as interconnected components of a broader food system. This research aims to analyse FLW in Tuscany's agri-food sector, focusing on the early stages of the supply chain, including production, transformation, and distribution. Employing an action-research methodology, the study combines literature reviews, qualitative fieldwork, and a case study conducted in collaboration with a regional food bank (Banco Alimentare Toscana) and the Agriculture and Rural Development Directorate of the Tuscany Region. Semi-structured interviews with stakeholders will deepen the understanding of FLW drivers and evaluate the effectiveness of current prevention and management strategies. The project seeks to provide actionable recommendations for FLW reduction, promote sustainable policy interventions, and enhance surplus food recovery systems to mitigate food insecurity. By integrating scientific insights with practical solutions, this study aspires to contribute to sustainable agri-food systems and equitable food distribution.

Keywords: Food loss, Food policies, Food systems, Food waste prevention, Overproduction.

Assessments of spatial and temporal variability in a super-high-density olive orchard

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Abstract

New technologies make it possible to monitor the spatial and temporal variability of olive orchards with an increasing level of accuracy. Spatial variability significantly influences olive production, oil yield, and, consequently, the profitability of olive farms. Therefore, understanding and managing the different variability present within the olive grove constitute the two pillars of precision olive growing. A preliminary evaluation of spatial variability in a 4-year-old super-high-density olive orchard (4 m x 1.5 m) of the cultivar *Arbequina* (*Olea europaea* L.) was carried out using the Normalized Difference Vegetation Index (NDVI), derived from Sentinel-2A satellite imagery, and apparent electrical conductivity (ECa) measured using the Mini-Explorer electromagnetic induction sensor (GF-Instruments, Czech Republic). Three irrigation sectors (approximately 2 hectares each) located in different areas of the orchard were identified. Within each irrigation sector, two zones with distinct NDVI values (0.34 ± 0.03 and 0.24 ± 0.04 in zones A and B, respectively) were delineated. Fruit production per tree was measured on October 20, 2023. Vegetative parameters were measured on June 13, 2024, in each zone (six trees per zone) by evaluating trunk cross-sectional area (TCSA) and canopy volume of individual trees. The water status of the trees was monitored during the summer of 2024 by measuring stomatal conductance using a porometer (L600, LI-COR, Nebraska, USA), relative water content (RWC) of leaves using a precision analytical balance (XSbalance, Bormac, Italy), and stem water potential (SWP) using a pressure chamber (PMS 1000, Albany, USA). Fruit production per tree was higher in zone A (1.82 ± 0.58 kg) compared to zone B (0.83 ± 0.41 kg). The TCSA and canopy volume of trees in zone A were 14.5 cm^2 and 1.20 m^3, respectively, while the corresponding values in zone B were 13.0 cm^2 and 0.95 m^3. TCSA was positively correlated with NDVI (R^2 = 0.44) and negatively correlated with ECa (R^2 = 0.57). Moreover, apparent electrical conductivity showed a significant inverse linear relationship with NDVI derived from satellite images (R^2 = 0.47), highlighting the impact of soil ECa on tree vigor and ground cover. Differences in water status between the two zones were observed, particularly in stomatal conductance, with average values of 205 and 169 mmol m^2 s^{-1} for zones A and B, respectively (average of measurements acquired between June and August 2024). Although preliminary, these findings demonstrate

that remotely sensed data and proximity sensor measurements can effectively delineate homogeneous zones within olive orchards. Further investigations are planned to integrate spatial maps with point-specific data collected by plant-installed sensors to better understand the physiological and agronomic implications of spatial variability within the olive grove.

Keywords: NDVI; *Olea europaea* L.; Super-high-density olive management; Soil apparent electrical conductivity.

Promoting soil health through agroecological practices: a cost-benefit analysis

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Abstract

European soils are in a critical state, facing degradation and loss of fertility, which threatens agricultural productivity and environmental health. The fragmentation of soil policies across the EU further complicates efforts to address these issues effectively. The European Union's Soil Strategy for 2030 and the proposed Soil Monitoring Law aim to restore 60-70% of European soils currently considered unhealthy, integrating soil health into national and regional strategies. However, the actual integration of this concept into existing policies remains limited. EU soil policies encompass regulatory and incentive-based instruments, such as the Common Agricultural Policy (CAP), environmental impact assessment directives, and biodiversity conservation strategies. While these policies operate at a strategic level, agroecology represents a practical approach that integrates ecological, economic, and social dimensions to enhance agricultural sustainability. Evaluating the opportunities offered by agroecology, as well as understanding its limitations and potential, could provide immediate recommendations for farmers and for policymakers. In fact by minimizing chemical inputs and favoring ecological processes, agroecological practices promise to improve also soil health. However, several questions remain: what are the main economic and social barriers to large-scale adoption of agroecological practices across Europe? How can these practices be tailored to diverse local conditions to ensure their effectiveness? And what adaptations are needed to scale these practices while maintaining food security and economic competitiveness? In our study we examine the potential of a selected agroecological practice, focusing on weed management in organic viticulture. Conducted in a Sangiovese vineyard in Tuscany, the experiment uses subterranean clover (Trifolium subterraneum L., var. brachycalycinum) as an under-row cover crop, chosen for its self-reseeding ability, reducing labor needs and minimizing soil erosion. A comprehensive cost-benefit analysis (CBA) will evaluate the economic viability, environmental impact, and social implications of this practice. Data collected through structured surveys and expert consultations will capture both quantitative and qualitative dimensions. This practice aims to align with the EU's "Farm to Fork" strategy, targeting a 50% reduction in chemical usage by 2030. Moreover by providing empirical data on the costs and benefits of agroecological practices, particularly non-chemical

weed management, this research could fill a significant gap in the literature. The findings are expected to inform farmers and policymakers, highlighting the potential economic and ecological benefits of agroecological practices and supporting sustainable agriculture policies in Europe. Among the main outcomes we expect data on the scalability of the practice and the impacts inside and outside the farm size.

Keywords: Soil Health, Agroecology, Sustainable Agriculture, Cost-Benefit Analysis.

Acknowledgments: This research work was carried out within the framework of two European projects: OPER8 - European Thematic Network for unlocking the full potential of Operational Groups on alternative weed control and NOVASOIL - INNOVATIVE BUSINESS MODELS FOR SOIL HEALTH.

Arbuscular mycorrhizal fungi: good actors for agroecological transition

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Abstract

Weeds pose a major threat to the sustainability of EU farming systems, with weed management largely relying on herbicides use. With the aim of accelerating the transition to sustainable, safe, and healthy food systems, the Horizon Europe-funded project GOOD (AGrOecOlogy for weeDs) is adopting a multidisciplinary approach based on innovative agroecological weed management (AWM) strategies to enhance the sustainability and resilience of cropping systems. The use of cover crops in combination with seed inoculation with beneficial microorganisms, such as arbuscular mycorrhizal fungi (AMF) represent one of the possible key novel AWM practices to reduce herbicides use and risk. In this study we analysed the AMF communities naturally present in the soil of 14 experimental Living Labs (LLs) from 7 European countries (the Netherlands, Serbia, Italy, Greece, Portugal, Spain and Cyprus) characterized by different cropping systems and edaphoclimatic conditions. Such native AMF communities were massively reproduced in pot cultures, given their status of obligate biotrophic symbionts. Moreover, in order to use seed inoculation as a delivery system of AMF to cover crops, a protocol was developed and tested on seeds from eleven plant species provided by different LLs and characterized by different shape, size, weight and coat. Morphotypes richness differed among EU LLs: the highest one (17 AMF species) was found in Spanish LLs, while the lowest one was detected in Italy and Cyprus (4-5 AMF species). Some morphotypes, identified as *Entrophospora etunicata*, *Pacispora* sp. and *Glomus badium*, were retrieved in five, three and four LLs, respectively. Morphotypes resembling species belonging to *Rhizoglomus* genus occurred in at least five LLs. Additionally, spores belonging to *Ambisporaceae, Archaeosporaceae, Acaulosporacea*e and *Scutellosporacerae* were found at very low density, in many LLs. Seed inoculation protocol was set up using different quantities of AMF inoculum, a commercial liquid adhesive material (LAM) and water, in order to ensure a uniform coverage of seeds. The protocol was then scaled up for on-farm application. Future studies will be carried out in order to analyse the increase of the mycorrhizal inoculum potential of LLs soils and the changes in the native AMF communities after cover crop inoculation. The use of AMF inoculum and cover crops will promote long-term and large-scale agroecological transition towards innovative low-input, safe and resilient agroecosystems.

This work has received funding from the Horizon Europe project GOOD- AGrOecOlogy for weeDs, Grant Agreement n° 101083589.

Keywords: Beneficial microorganisms, Cover crops, Agroecology, Seed inoculation, Weed management.

Use of hyperspectral data to assess the quality and safety of baby leaf lettuce grown in a floating system under different nitrogen and salt conditions

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Abstract

This study examined the capability of full-range (350-2500 nm) reflectance spectroscopy to evaluate the quality and safety of baby leaf lettuce subjected to different nutrient and salt conditions. *Lactuca sativa* L. plants were grown in a floating system under three nitrogen concentrations (1, 7 and 14 mM). Seven days before harvesting, plants were exposed to salinity, by applying Na_2SO_4 or NaCl added in the nutrient solution (EC > 3.00 dS/m). Leaf spectral measurements were paired with standard measurements of photosynthetic pigments, phenolic compounds and ions, for a total of 120 samples (480 spectra) distributed across treatments. Analyzing leaf spectral signatures (400-2400 nm) by partial least squares discriminant analysis, we accurately discriminated plants exposed to the different combinations of nitrogen concentrations and salt treatments, reporting a 97% of overall accuracy for validation. Furthermore, using a partial least squares regression (PLSR) approach, we developed predictive spectral models to estimate from spectra the content of an array of leaf traits commonly investigated to elucidate crop quality and safety, i.e., chlorophylls (Chl) and carotenoids (Car), total phenols, anions and cations. Most of these traits (Chl *b*, Na^+, Cl^-, NO_3^-, SO_4^{2-}, PO_4^{3-}) were accurately predicted by spectral models (model goodness-of-fit for validation, R^2: 0.65-0.86), and good predictions were also reported for Chl *a*, Chl *a* + Chl *b*, Car, Mg^{2+}, F^- (R^2: 0.46-0.58). Finally, variations of vegetation spectral indices and leaf traits derived from spectra by developed PLSR-models confirmed the capability of hyperspectral data to monitor the responses of lettuce to nutrient and salt stress. Overall, the present study highlights the potential of using hyperspectral data for managing protected agrosystems.

Keywords: Crop management, Hyperspectral signatures, Intelligent and automated greenhouses, *Lactuca sativa*, Trait prediction.

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). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Learning from halophytes: evaluating the response of two local ecotypes *Salicornia perennans* Willd. subsp. *perennans* to hydroponic cultivation with saline aquaculture effluents

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Abstract

Climate change has a severe impact on agriculture and food security. One of the main challenges of agriculture is to reduce its impact on land, water and fertilizer. To achieve this goal new sustainable and innovative methods should be developed. Aquaponics is a sustainable farming method combining land-based animal aquaculture (e.g., Recirculating Aquaculture Systems, RAS) and soilless cultivation of plants involving microbiological processes (biofiltration). Aquaponic systems can use fresh, brackish or sea water, with fish and plant species selection depending on salinity. Euryhaline fish like seabream and seabass thrive in varying salinities, but few plants tolerate high salinity. Halophytes are naturally salt tolerant plants adapted to live in high-salinity conditions, up to 12 ppt or more. A few of these plants, such as *Salicornia* spp., are cultivated for their nutraceutical properties and/or as gourmet vegetables with a high retail price. Notwithstanding the growing interest of the scientific community and agriculture sector for these species, halophytes are still minor crops in the world. The aim of this study is to characterize two local ecotypes of *Salicornia perennans* Willd. *subsp. perennans* to optimize their cultivation in a hydroponic raft system using saline aquaculture wastewater and to observe potential morphological differences, as well as differences in yield. Young *S. perennans* plants were collected in late spring from the main saltmarshes in Pisa province, knowns with the names of “Lame” and “Galanchio”, both located within the Migliarino, San Rossore, and Massaciuccoli Regional Park. The two saltmarsh areas differ not only in their distance from the sea and latitude, but also in soil type and salinity. The soil in “Galanchio” is much sandier compared to that of “Lame,” which has a more clay-rich composition and a lower salinity level. Moreover, “Lame” is located in a preserved area of the Regional Park, where only wild animals can impact the ecosystem, whereas “Galanchio” lies on cultivated land that is periodically subjected to agronomic activities. The plants were grown in a hydroponic floating raft system for three months, from May to August 2024, in a greenhouse of Pisa University (Pisa, Italy), with a crop density of 96 plants per square meters, and three successive cuts were made. The treatments were a standard nutrient solution, non-

salinized or with the addition of 25 g/l NaCl, and the effluent from a Sea bream RAS, which was used as such or replenished to the mineral content of the standard nutrient solution. In RAS effluents the salinity was obtained by dissolving 25g/L of synthetic sea salt (Instant Ocean) in tap water. Biomass production, succulence and qualitative parameters were measured at each cut. Both total biomass and succulence increased significantly when a salinized nutrient solution was used. Similarly, these increases are also observed when the effluent is adjusted to the optimal mineral content. The succulence was consistently higher in the “Galanchio” ecotype. Antioxidant concentration and capacity increased under salt-free conditions, suggesting a potential stress response in the plant when salt is absent. In conclusion, local ecotypes of *S. perennans* can be successfully cultivated using RAS salt effluents. However, the unbalanced mineral content in these effluents negatively impacts on key commercial traits of the fresh product, such as succulence and yield. To achieve higher yield and quality product, it is necessary to adjust the mineral composition in the effluent to optimal concentrations.

Keywords: Aquaponics, RAS Effluents, Hidroponyc, Salicornia, Local ecotypes.

SESSION III: The application of technology in cropping systems

The Single Market for Data in the EU: Data Sharing in Agriculture reface

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Abstract

The presentation discusses the European Strategy for Data launched in 2020 and the recently announced Data Union Strategy at EU level. In such a context, the attention is focused on the Common European Data Spaces as enablers of the single market for data. The concept of data spaces is presented, stressing their potential to support interoperable data sharing, access, and use, also when it comes to sensitive data thanks to the use of privacy-enhancing technologies. Then, the attention is focused on the Common European Agricultural Data Space (CEADS), presenting the main results of the AgriDataSpace project recently concluded. Potential future scenarios are briefly discussed to highlight potential impacts of a data space in the sector.

Keywords: Data space, Agriculture, Single market for data.

A computer vision approach for estimating fruit growth rate in orchards

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Abstract

Tracking fruit development throughout the growing season is crucial for efficient orchard management. Regular measurements of fruit size help monitor its absolute growth rate (AGR), an important physiological metric for predicting yield and identifying stress conditions. Traditional caliper-based AGR measurements can be labor-intensive, while existing sensor-based solutions are often costly and provide limited orchard-wide coverage. A new computer vision system (CVS) that uses a depth camera and AI algorithm to estimate AGR directly in the field is introduced. Images of the fruits were captured from distances of 1.0m and 1.5m from the tree row at multiple time points throughout the season. The CVS calculated the AGR for each fruit detected in the images. Preliminary results from the ongoing analysis show a fruit detection rate consistently above 92% and a sizing accuracy of over 97%. While current performance does not yet meet field application expectations, ongoing improvements to the system's algorithm are underway. Notably, the results reported here are based on only 30% of the total dataset, indicating the potential for further improvements in future analyses. This approach aims to leverage the large sample size (potentially encompassing the entire fruit population) to minimize errors from individual measurements and produce robust orchard-level estimates of fruit size and AGR.

Keywords: Fruit size, Apple, Computer vision system, Precision orchard management, Absolute growth rate**.**

Vertical farms: an innovative and sustainable technology

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Abstract

Vertical farms are claimed to be resources' efficient growing systems thanks to the capability to use the vertical dimension for plants' cultivation, to recover water drained by the substrate and transpired by plants, and to reuse nutrients in closed loop cycles. In the absence of solar light and in an airtight environment, such as the one characterizing a vertical farm, lighting devices and climate control units become fundamental for running the system. Both need electricity, making intensive energy use the most significant drawback of the technology. The aim of this presentation is to critically analyze the sustainability claims of vertical farming, figure out a comparison with other high-tech growing solutions, and highlight strategies that may be adopted to transform this "niche growing solution" into a key component of our future food systems.

Keywords: Resource use efficiency, Indoor agriculture, Artificial light, Climate control, Water management.

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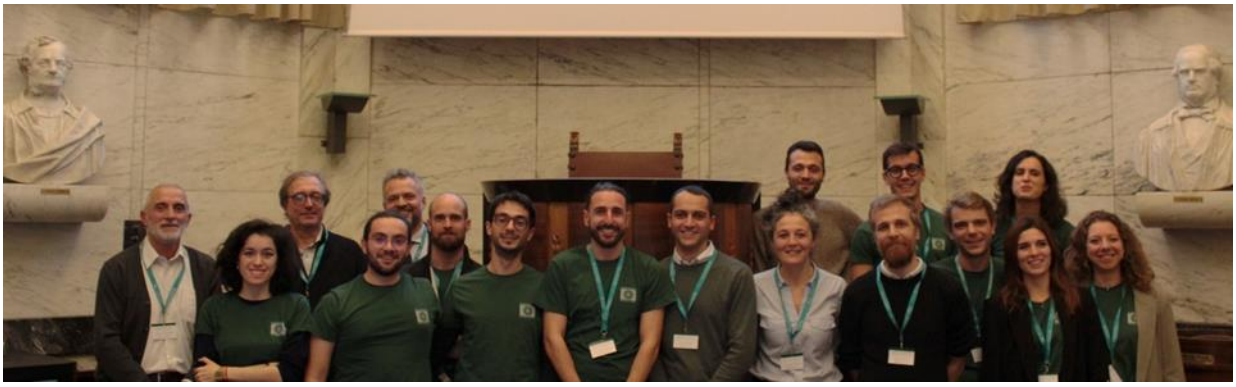

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