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«PhD ANNUAL REPORT
PRESENTATIONS»

PhD DAY
FIRST EDITION, 2024

**Department of Agriculture, Food and Environmental
Sciences and Biotechnologies**

September 24th, 2024

Aula Magna - Borgo XX Giugno 74, Perugia

PROGRAM AND BOOK OF ABSTRACTS

Program

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| 08:15-08:30 | Welcome | |
| 08:30-09:00 | Welcome speech with Institutional Greetings | |
| Session I Biodiversity | <ul style="list-style-type: none">• Eliane Sayde, Towards the establishment of genetic reserves for key crop wild relatives in Lebanon: analysis of strategies across diverse ecogeographical landscapes | |
| 09:00-10:00 | <ul style="list-style-type: none">• Mara Rondolini, Truffle cultivation in natural and agrarian systems to support riparian biodiversity | |
| Chairpersons: <i>Eliane Sayde, Viviana Bolletta</i> | <ul style="list-style-type: none">• Federica Bonini, From biodiversity analysis to the use of resources: the Apennine semi- natural arid grasslands as sustainability paradigm | (pages 4-6) |
| Session II Ecosystem conservation | <ul style="list-style-type: none">• Francesca Napoli, Evaluation of ground-based photovoltaic systems for beekeeping integration and wild pollinator protection• Adriana Poccia, Development of multifunction vegetated strips for agro - ecosystems protection | |
| 10:00-11:00 | <ul style="list-style-type: none">• Chiara Poesio, Effects of agricultural management on soil dynamics and ecosystem functions: Insights from a mid-term trial | |
| Chairpersons: <i>Eliane Sayde, Paolo Masini</i> | <ul style="list-style-type: none">• Jennifer Bertuzzi, Technologies for a sustainable management of water resources in agriculture• Alessandro Bernetti, Assessing the impact of PVC and Bio-Based Biodegradable on Soil Chemical and Microbial Parameters | (pages 7-11) |
| 11.00-11:30 | Coffee break | |
| Session III Biological control | <ul style="list-style-type: none">• Elena Chierici, Invasive alien species: impact on local ecosystems and development of sustainable and effective control strategies• Paolo Masini, Olfactory cues in the host-location of the European ectoparasitoids <i>Sclerodermus cereicollis</i> and <i>Sclerodermus domesticus</i> (Hymenoptera: Bethyridae) | |
| 11:30-12:10 | <ul style="list-style-type: none">• Vito Antonio Giannuzzi, Development of digital decision support systems for application of biological control methods in integrated pest management | |
| Chairpersons: <i>Ilary Belardi, Daniele Andreani</i> | | (pages 12-14) |

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|-----------------------------------|--|
| Poster Session | <ol style="list-style-type: none"> I. Giorgia Mallia, Sustainable and eco-friendly strategies for the development of whisky production in Italy II. Anna Scian, Reduction of the use of copper-based products for controlling bacterial diseases III. Claudia Camplone, Use of a Life- Cycle Assessment (LCA) approach in the integrated management of fungal diseases of bread wheat IV. Simone Pelaracci, Environmental assessment of crop-livestock interactions through agricultural life cycle assessment and modelling V. Veronica Rossi, Social Farming, work inclusion and integrated tobacco supply chain: planning processes in co-planning for greater equity and safety in working conditions VI. Giacomo Giulietti, Measuring the impact of social innovations with the SIMRA method. Evaluation of a project carried out in the south-west Orvieto internal area, financed by the VATO territorial pact VII. Arianna Tiralti, Payments for ecosystem services in the Natura 2000 network: analysis through the value-belief-norm model VIII. Chiara Traini, Effects of High density on yield, canopy structure and water use efficiency on hazelnut (<i>Corylus avellana</i> L.) orchard IX. Lorenzo Salvatore Frisullo, Dear resistance gene, where are you? Developing a genetic and epigenetic map for resistance to <i>Xylella fastidiosa</i> in olive tree X. Arianna Bonucci, From waste to value: valorisation of olive oil mill by-product |
| 12:10-13:10 | |
| <i>Voting for the Best Poster</i> | |

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| 13:10-14:10 | Lunch break |
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| Session IV Climate change | <ul style="list-style-type: none"> • Mona Mazeh, Use of biostimulants in olive to improve tree growth and biotic stress control • Ciro Tolisano, Evaluation of the biostimulatory effects of nanoparticles and plant extracts in plants • Lucia Giordano, Novel bio-protector to mitigate extreme climatic events in vineyards • Eleonore Cinti, Stomatal apparatus, mesophyll architecture and gas-exchange: how plants adapted to climate change |
| 14:10-15:10 | |
| <i>Chairpersons: Chiara Poesio, Mara Rondolini</i> | |

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|--|---|
| Session V Food quality and security | <ul style="list-style-type: none"> • Ilary Belardi, Development of sustainable and innovative strategies for the valorisation of by-products of the brewing industry • Alessandro Mariani, Win the challenge against Tomato Brown Rugose Fruit Virus (ToBRFV) • Viviana Bolletta, Innovative strategies in ruminant feeding to improve product quality and mitigate the environmental impact of animal farming • Stefano Bettini, Does <i>Saccharomyces cerevisiae</i> postbiotic affect hay <i>in vitro</i> digestibility? A comparison between inclusion in the rumen fluid inoculum and dietary supplementation in the donor Chianina bullocks under controlled feeding system |
| 15:10-16:10 | |
| <i>Chairpersons: Ciro Tolisano, Lucia Giordano</i> | |

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16.10-16:40

Brain Break

**Session VI
Genetic
application**

16:40-17:40

Chairpersons:
Vito Antonio
Giannuzzi,
Lorenzo
Salvatore
Frisullo

- **Giacomo Bongiorno**, Breeding Low-Impact Durum Wheat Varieties for Environmental Sustainability
- **Daniele Colombi**, Sustainable beef cattle breeding: the contribution of genomic selection
- **Daniele Andreani**, Unravelling Cold Adaptation and Fermentative Potential: A Genomic Exploration of the *Mrakia* Genus
- **Flavio Gabrieli**, Unravelling the Role of TT8 in Post-Zygotic Hybridization Barriers
- **Aaron Anderson**, Structural Genomics of Neotetraploid Alfalfa to Explore the Process of Polyploidization

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17:40-18:00

Announcement of Best Poster 2024 and Closing remarks

Organizing committee:

Viviana Bolletta

Chiara Poesio

Giacomo Bongiorno

Ciro Tolisano

Eleonore Cinti

Chiara Traini

Collaborator of the organizing committee:

Prof. Emidio Albertini

Daniele Colombi

Mara Rondolini

Session I

Biodiversity

Eliane Sayde, Towards the establishment of genetic reserves for key crop wild relatives in Lebanon: analysis of strategies across diverse ecogeographical landscapes

The conservation of global biodiversity, threatened by climate change and human activities, is crucial. Conserving Crop Wild Relatives (CWR), wild plants related to crops, can contribute to sustainable food production. Lebanon is rich in CWR diversity, especially from the Poaceae and Fabaceae families. To initiate CWR conservation planning in Lebanon, this study prioritized and inventoried CWR taxa belonging to key genera. Population data was collected from databases and mapped. High CWR richness sites were surveyed to assess their presence, conservation status, and ecogeographic characteristics. The CAPFITOGEN3 toolbox was used to analyze the collected data. An Ecogeographical Land Characterization (ELC) map was created to identify the main ecogeographic conditions of Lebanon, and the combination of CWR taxa populations with each ELC category (CWR-Eco unit) was considered as the primary conservation target. Complementarity analyses were conducted to determine the minimum number of sites required to conserve the maximum number of CWR-Eco units within and outside protected areas. The gap in ex situ conservation was estimated by comparing the unique CWR-Eco units documented in genebanks with those existing in situ. The analysis identified 24 ELC categories for Lebanon and 253 different CWR-Eco units from 1460 CWR populations. Complementarity analysis results showed that 22.2% of protected areas harbor populations of 18 target CWR taxa, representing 51.4% of the total. Outside protected areas, a network of 79 cells (5x5 km each) is needed to conserve the predicted diversity of target CWR taxa. The gap analysis revealed that 215 CWR-Eco units (85.0% of the total) are covered by ex situ conserved material, while 38 still require collection efforts. This study identified optimal areas for establishing genetic reserves in Lebanon and highlighted gaps in ex situ collections, guiding future collection missions.

Mara Rondolini, Truffle cultivation in natural and agrarian systems to support riparian biodiversity

Over the last hundred years in Italy, important changes have taken place in the rural landscape. This is due not only to climate change that has altered environmental conditions affecting the ecology of many habitats but also to a change in society that has led to the abandonment of the countryside. All those practices that indirectly helped to maintain stability in certain forest environments were lost. Water-related places are the most sensitive to all these changes, and consequently, the entire biological community belonging to them, as the white truffle. The white truffle (*Tuber magnatum* Picco) is an edible hypogeous mushroom that is highly valued in the culinary world and has become an important economic resource for the rural areas where it grows. In this work, we carried out a survey of potential truffle environments in the Umbria region to identify changes over the years. We then focused on some riparian areas to understand the needs of white truffles in certain environments and to highlight some problems that limit ascocarp production. In order to study the dynamics of such environments, we then focused on the description of ecotones, the areas on the edge of forests, to understand how the biological life of the soil of an expanding truffle bed change. Finally, we explored the floodplains in the Balkan regions, a different type of riparian environment. Here, we conducted a study of the microbiome in the Motovun forest, known for its production of white truffles, and compared it with productive sites in Serbia. To wrap up our project, we went back to Umbria, along the banks of the Tiber River. There, we applied the knowledge we had gained about the connection between truffles and riparian strips to restore a river terrace and establish a new truffle plantation.

Federica Bonini, From biodiversity analysis to the use of resources: the Apennine semi-natural arid grasslands as sustainability paradigm

Semi-natural grasslands are herbaceous formations of secondary origin, maintained by traditional extensive agro-pastoral practices. They are an invaluable treasure trove of biodiversity, among the most species-rich plant communities in the world, recognized at the European level as habitats of conservation interest and protected under the Habitats Directive (92/43/EEC). Nowadays, the existence and the inherent biodiversity of these habitats are under severe threat, and changes in grassland management, including both abandonment and land-use intensification, have been identified as the most negative threat factors. In this context, a better understanding of patterns of floristic composition and biodiversity of these habitats is a crucial prerequisite for applied purposes such as monitoring and assessing their conservation status, as well as for their present and future correct management.

The research activities of my PhD project focus on the semi-natural arid grasslands of the central Apennines, particularly the Umbria region.

In-field campaigns of vegetation surveys have been conducted and previously existing data have been collected in order to create an exhaustive dataset of their vegetational diversity.

An ecological and syntaxonomic characterization of the various types of semi-natural arid grasslands occurring in Umbria region has been performed. A set of typical plant species, i.e. a necessary requirement for the assessment of the conservation status of habitats and their monitoring, has been identified for H6210 and H6230 Annex I grassland habitats. Additionally, an expert system for the automatic classification of semi-natural grasslands of Umbria within the Annex I habitats to Directive 92/43/EEC is being implemented. Moreover, within the collaboration in the H2020 Project "Natural Intelligence - robotic monitoring of habitats", a first attempt to use typical and early warning plant species in the robotic monitoring of grasslands has been made.

Finally, integrating phytosociological with phyto-pastoral data provided useful methodological indications for a sustainable grassland management aimed at the conservation of biodiversity.

Session II

Ecosystem conservation

Francesca Napoli, Evaluation of ground-based photovoltaic systems for beekeeping integration and wild pollinator protection

The habitat of insect pollinators is declining globally, endangering the biodiversity of both natural and cultivated ecosystems. The need for renewable energy has led to increased installations of ground-mounted photovoltaic systems, resulting in the non-agricultural use of land. However, the opportunity to exploit spontaneous vegetation that naturally develops within these installations, or the seeding and planting of plant species (herbaceous, shrubby, and arboreal) of apicultural interest, offers the opportunity to make the presence of such installations less impactful. The PhD project carried out in collaboration with the company Acea Solar s.r.l. deals with this theme and is being carried out in two different photovoltaic installations:

1.A 6.4 MW photovoltaic installation located in the municipality of Canino (VT). Here, perimeter mitigation has been carried out with arboreal and shrubby species selected for their adaptability to the environment, importance for bees, and flowering scalability. To evaluate the effect of mitigation on wild bee populations, trap nests have been installed in 4 different areas at varying distances from the mitigations themselves. The goal is to assess the possibility of managing this site to increase wild pollinator populations.

2.A 3 MW photovoltaic installation in the Valle Galeria area (RM) is also subject to mitigation. Within this site, an apiary consisting of 10 hives was installed at the end of the summer of 2023. The aim is to evaluate possible interactions with *Apis mellifera* of the photovoltaic panels, using techniques capable of assessing sensitivity to olfactory stimuli at the antennal level (EAG, electroantennography) and learning abilities (evaluation of PER, proboscis extension reflex).

Adriana Poccia, Development of multifunction vegetated strips for agro - ecosystems protection

Among the various low-impact tools for safeguarding and improving the environment, buffer strips stand out as one of the most utilized mitigation measures in agriculture. Buffer strips are areas covered with permanent herbaceous, shrub, or tree vegetation, strategically positioned upstream of sensitive areas to shield them from different conditions. Their functions are manifold: they mitigate soil erosion by dissipating watercourse energy and their vegetation acts as a filter, enhancing water and soil quality. This research project aims to establish guidelines for creating buffer strips that effectively enhance agricultural ecosystems by fulfilling various functions based on their composition, characteristics, and placement. The core concept is to design buffer strips with multifunctional action, improving the environment and water quality through diverse phytoremediation processes and preventing pollutant passage from sediments. An additional key objective of multifunctional strips is to bolster the environment by serving as biodiversity reservoirs, employing species capable of emitting volatile substances to attract beneficial organisms, such as predators (to promote biological control) or pollinators. The selected plant species for defining the development of multifunctional strips include *Festuca arundinacea* (Gramineae) for phytoremediation processes, and *Malva sylvestris* (Malvaceae), *Achillea millefolium* (Asteraceae), *Trifolium repens* (Fabaceae), and *Calendula officinalis* (Asteraceae) for enhancing entomological biodiversity.

Chiara Poesio, Effects of agricultural management on soil dynamics and ecosystem functions: Insights from a mid-term trial

The study aimed to evaluate the influence of agricultural management on soil functions crucial for supporting ecosystem services, including biomass production. Specifically, it focused on soil carbon dynamics in both the topsoil and subsoil, with attention to the latter, which has been less investigated until now.

An 11-year trial at the FieldLab (Papiano, PG) was investigated, where a wheat-maize rotation was managed using three agricultural systems: CONV (integrated management, no cover crop, and conventional tillage), ORG (organic management, cover crop, and conventional tillage), and STRIP (integrated management, cover crop, and strip tillage). Soil samples were collected from each plot and fractionated to assess soil aggregation and organic matter (OM) distribution. The OM fractions obtained were analysed for organic carbon (OC) content and categorized into labile (water-extractable and particulate OM), stable (OM associated with aggregates of size 2-0.05 mm [SSA] and < 0.05 mm [SCA]), and resistant (OM resistant to NaClO oxidation) pools. Further, stable isotopes content ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$), microbial biomass (C_{mic}), and potential respiration ($\Sigma\text{C-CO}_2$) were analysed to investigate OM decomposition processes.

ORG and STRIP promoted macroaggregates development compared to CONV, and they showed a higher amount of OC associated with SSA. However, the total OC content throughout the soil depths was similar among the agricultural systems, except for STRIP topsoil which had a higher value. The high $\delta^{15}\text{N}$ in ORG and STRIP suggested the occurrence of intense mineralization, likely promoted by the green manuring with legume cover crops. This hypothesis is further supported by the larger metabolic ($\Sigma\text{C-CO}_2/C_{\text{mic}}$) and mineralization ($\Sigma\text{C-CO}_2/\text{labile pool}$) quotients in the subsoil of ORG and STRIP compared to that of CONV. Overall, the OC stock of the whole soil did not change among the studied systems, suggesting that the introduction of fresh OM into the soil does not promote the stabilization and accumulation of OC.

Jennifer Bertuzzi, Technologies for a sustainable management of water resources in agriculture

The increase in frequency and severity of drought events is a clear consequence of worldwide climate change. Substantial declines in crop yields are occurring in most agricultural regions of the world, with major implications for livelihoods and food security. Globally, 70% of all freshwater withdrawals and 4% of all energy consumption are attributed to the agricultural sector. The unsustainable global demand for fresh water in agriculture requires the integration of monitoring data and models application for optimal irrigation management. SPAC models quantify hydraulic states and water flows in the Soil-Plant-Atmosphere Continuum. The overall objective of my PhD project is to efficiently apply some SPAC models at farm and district scales for smart and sustainable management of irrigation practices. To this end, three crops of interest were selected, i.e olive (*Olea europaea* 'Maurino'), maize (*Zea mays*) and tomato (*Lycopersicon esculentum* Mill.), located in Umbria, Italy. Several variables related to local climatic conditions and soil and plant water status were monitored with ground-based and remote sensors during the summers 2023-2024. In addition, both soils and crops hydraulic traits were characterised. These measurements were used as input data in the parametrization, validation and first application of Sureau (physical-based hydraulic model), SWAP (physical-based water and energy balance model), Feddes (empirical model) and data-driven (Artificial Intelligence) models. We report here an analysis of the data collected during the monitoring campaigns and the preliminary results of SPAC models, e.g. the plant water status dynamic for Sureau, the soil water content dynamic for SWAP, the threshold value of soil water volume based on leaf water potential for Feddes and the plant transpiration dynamic for data-driven models. In order to determine the irrigation schedule and water volumes to be supplied to the crops, these will be implemented and validated during the summer 2025, also for deficit irrigation strategy.

Alessandro Bernetti, Assessing the impact of PVC and Bio-Based Biodegradable on Soil Chemical and Microbial Parameters

Microplastics (MPs), particularly polyvinyl chloride (PVC), pose a significant environmental concern globally due to their resistance to degradation. A microcosm experiment was conducted to assess the impact of PVC (0.021% w/w) on soil chemical and microbial parameters over varying incubation times (3 to 360 days). The experiment revealed significant fluctuations in parameters such as soil CO₂ emission, FDA activity, total organic C (TOC), total N, and water extractable organic C (WEOC) in PVC-treated soils. Moreover, the structure of soil microbial communities, analysed at different taxonomic levels (phylum and genus), was significantly affected by PVC. Specific bacterial and fungal taxa, including *Candidatus_Saccharibacteria*, *Proteobacteria*, and *Basidiomycota*, exhibited notable variations in abundance. Interestingly, after one year, a reduction in the number and size of PVC was observed, indicating potential microbial involvement in PVC degradation.

In contrast, bio-based biodegradable mulch films offer a promising solution to reduce plastic waste in agriculture. Microcosm experiments investigated the effects of Mater-Bi® at two application doses (0.021% and 1% w/w) on soil parameters over one year. Results showed that 1% Mater-Bi® significantly increased CO₂ emissions, water extractable organic C (WEOC), and hydrolytic activity (FDA). However, microbial alpha- and beta-diversity remained largely unaffected, with only taxon-related responses observed. Mater-Bi® influenced the abundance of specific bacterial and fungal genera, such as *Aquicella* and *Malassezia*, suggest a taxon-dependent impact. Additionally, a higher concentration of tightly bound exopolysaccharides (TB-EPSs) at the beginning of incubation with 1% Mater-Bi® implied their potential role in stimulating microbial bioplastic degradation through biofilm formation. Overall, these findings underscore the complex interactions between biodegradable polymers and soil ecosystems, highlighting the need for further research to understand their long-term effects.

Session III

Biological control

Elena Chierici, Invasive alien species: impact on local ecosystems and development of sustainable and effective control strategies

An alien species is defined as a species, subspecies, or lower taxon, introduced outside its natural past or present distribution, and includes any part of such species that might survive and subsequently reproduce. Indeed, these exotic species can undergo different fates, for example, they may not survive transport or may not be able to adapt to the conditions of the area of introduction or they may remain confined to the environment in which they were introduced. However, if they find suitable conditions and increase in population, they will likely become invasive alien species (IAS). Invasive species are a significant threat to global agriculture; in fact, they are a major cause of crop loss and can adversely affect food security and biodiversity. Investigating the behaviour, chemical ecology, molecular ecology, and trophic interactions of the invasive species would be necessary for developing sustainable control strategies in agroecosystems. For instance, classical biological control is historically considered the most promising tool for the control of alien species, however, there is no universal and valid solution for all scenarios, but a case-by-case assessment is essential. In this research, we focused on well-known invasive species of agricultural concern, the brown marmorated stink bug, *Halyomorpha halys* (Stål) and the predator harlequin ladybird *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae). Additionally, we began bibliography research on the Japanese beetle *Popillia japonica* Newman a recently introduced and established alien species in Northern Italy. Some research goals were to improve *H. halys* monitoring strategies developing a novel trap, to test host specificity of a candidate biocontrol agent of the stink bug, and to evaluate pesticide effect on predator and parasitoid behaviour.

Paolo Masini, Olfactory cues in the host-location of the European ecto-parasitoids *Sclerodermus cereicollis* and *Sclerodermus domesticus* (Hymenoptera: Bethyidae)

Sclerodermus domesticus is a cosmopolitan ectoparasitoid of longhorn beetle larvae, but it can also naturally develop on other woodboring species belonging to the family Ptinidae. *Sclerodermus cereicollis* is a species described for the first time by Kieffer on the base of specimens from Annobón island (Equatorial Guinea) and Giglio island (Italy) and then poorly investigated until now regard its taxonomy and biology. Chemical ecology regarding the species *S. cereicollis* and *S. domesticus* is a central issue that should be deeply investigated in order to improve the efficacy of these bethylid species as biological control agents and, moreover, to understand the mechanisms underlying their role as sting dermatitis agents in humans. In order to better understand the host location in *S. cereicollis* and *S. domesticus* species, we have evaluated their behavioural responses in a Y tube olfactometer and in a still air olfactometer towards volatile stimuli deriving from the host microhabitat, the sawdust of the host woody plant, and those indirectly associated with the presence of the host, frass, silk and kairomones deriving from larvae and adults. We divided these chemical stimuli into three major groups, those coming from *Trichoferus holosericeus*, from *Hylotrupes bajulus*, and from the factitious host *Corcyra cephalonica*. A total of 454 insects were tested in olfactometer. Naïve micropterous females of *S. cereicollis* and *S. domesticus* responded to volatile stimuli from sawdust from the host woody plant in the two natural host groups (*T. holosericeus* and *H. bajulus*). A further statistically significant response was recorded towards semivolatile stimuli derived from the host's frass in all major groups. Mainly in still air olfactometer *S. cereicollis* partially responds to stimuli from singular and grouped larvae of HBG and *S. domesticus* towards stimuli from *T. holosericeus* larvae. No significant responses were recorded towards stimuli coming from the *H. bajulus* adult.

Vito Antonio Giannuzzi, Development of digital decision support systems for application of biological control methods in integrated pest management

The impact of climate change on insect population dynamics may have a crucial influence on future pest management strategies. In this context, crop losses due to insect outbreaks are likely to increase substantially. Integrated pest management (IPM) strategies, which tend to obtain a high-quality product while protecting the environment, are progressively supplanting the traditional approaches. Monitoring is a key element of IPM that allows the sustainable use of pesticides. In addition to monitoring, digital agriculture and mathematical models find application in IPM strategies. The brown marmorated stink bug *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae) is an invasive pest, native to East Asia, that has spread to many countries in Europe and America. This herbivore has a wide host range, about 300 cultivated plant species, and causes significant economic loss to agriculture worldwide. The control of this species is overall complicated and must rely on different measures. The adoption of an appropriate monitoring system combined with reliable digital tools, can effectively improve the sustainability of insecticide applications. Phenological and predictive models can find application in DSS (Decision Support System), a set of computer programs, mathematical models and heuristic information that operate synergistically to improve decision making. In order to carry out the implementation of a DSS focused on the control of *Halyomorpha halys*, the monitoring of pest populations has been conducted in a natural reserve located in Emilia-Romagna region. To attract and capture *Halyomorpha halys* specimens, the two-component aggregation pheromone (10,11-epoxy-1-bisabolene-3-ol, also called murgantiol) in combination with the synergist methyl (2E,4E,6Z)-2,4,6-decatrienoate (MDT), the aggregation pheromone of the Asian stink bug *Plautia stali* Scott (Hemiptera; Pentatomidae), has been used as lure in sticky traps. These preliminary data will be integrated with another monitoring campaign that will take place this year in order to test a phenological model developed in the Python environment.

Session IV

Climate change

Mona Mazeh, Use of biostimulants in olive to improve tree growth and biotic stress control

Recently, the use of biostimulants, which are substances that have positive effects on crops, is spreading. These products are capable of inducing physiological, morphological and biochemical adaptations which positively influence nutrient absorption, vegetative growth, and yield quantity and quality. Furthermore, they can also have a positive effect in inducing plant resistance against abiotic and biotic stresses. However, despite the growing use of biostimulants, their mechanism of action and effect on different crops remain largely unknown, making it difficult to fully exploit their potential.

In the period 2022-2024 experiments were conducted with the aim of improving knowledge on the potential use of biostimulants in olive.

An initial experiment was carried out to evaluate the effects on the growth of young olive trees of the following two biostimulants: a micro-organism based (microbial biostimulant) one, believed to promote mycorrhizal formation, and one based on humic and fulvic acids; untreated trees were used as control. The aim was to reduce the time required to obtain transplant-ready trees or to have larger and higher-quality trees within the same timeframe. Potted trees (35-40 cm high) of the cultivar Leccino were used. At the beginning of the trial, in spring, trees were transplanted into larger pots and treated with the biostimulants applied to the substrate. In addition, they were fertilized with either 100% or 50% of the recommended dose of N. The microbial biostimulant resulted in greater stem diameter and tree height. Moreover, it led to increased development of lateral branches and tertiary branching occurred late in 2023. The biostimulant based on humic and fulvic acids gave positive effects on growth only when combined with 100% N fertilization. Elaborations are in progress to determine the effects on leaf activity and nutritional status, biomass production (determined through plant dissection), mycorrhizal formation, and the potential interaction among the factors considered (microbial biostimulant, biostimulant based on humic and fulvic acids, and fertilization rate).

A second experiment was carried out, using the same biostimulants to evaluate the effect on the growth of rooted olive cuttings in order to determine if these biostimulants could be used throughout the whole production process in olive nurseries. At the beginning of the trial in spring, plant cuttings were transplanted and treated with the biostimulants applied to the substrate. In

addition, they were fertilized with 0%, 50% and 100% of the recommended dose of N. The effects of the treatments were determined by evaluating plant growth and leaf activity and composition. Acquisition and elaboration of data are in progress.

A third experiment dealt with olive knot disease. The aim was to verify the effectiveness of a mixture of a low copper compound (Blok 5[®], Cifo srl, Bologna) and an inducer resistance biostimulant (Ionifoss[®], Cifo srl, Bologna) on the control of olive knot disease. For this purpose, the foliage of one-year-old olive trees of the cv. Frantoio, which is very sensitive to olive knot, was treated five times with Blok 5[®] (3 g l⁻¹) and Ionifoss[®] (2 g l⁻¹), according the following scheme: three treatments were carried out 21, 14 and 7 days before inoculation with the pathogen, while the other two treatments were carried out 7 and 14 days after inoculation. Untreated trees were used as control. Olive plants subjected to the five foliar treatments showed a statistically significant reduction in the severity of symptoms, expressed as knots volume. Further studies are being carried out to determine the population dynamics of *Pseudomonas savastanoi* pv. *savastanoi* (*Psav*) *in planta*.

Collectively, these experiments contribute to a better understanding of the potential use of biostimulants in olive, providing a comprehensive evaluation of biostimulants, disease management, and nutrient treatments to support olive plant health and productivity. The findings will aid in establishing best practices for sustainable olive cultivation.

Ciro Tolisano, Evaluation of the biostimulatory effects of nanoparticles and plant extracts in plants

Agriculture significantly affects the environment by consuming non-renewable resources and generating large amounts of waste. Consequently, the need to develop more sustainable and productive agricultural systems is leading to the reuse of agro-industrial waste and other biomass, as they are rich in bioactive compounds, or plant extracts that are not harmful to the environment. In this context, biobased nanomaterials obtained from these biomasses and biostimulants are an emerging and eco-friendly way to reduce the impact of waste, according to the principle of the circular economy, and to minimize the release of chemicals into the environment. In fact, they have the potential to counteract several agricultural challenges by improving crop performance, plant nutrition, and resilience to both biotic and abiotic stresses. In light of the above, the research project aimed, on the one hand, to obtain lignin nanoparticles (LN) to be used as nano-biostimulant on plants under normal and stress conditions, evaluating its effects in promoting an increase in tolerance to abiotic stress in maize, olive trees and tomato plants. Therefore, the extraction and conversion of lignin into nanoparticles were provided starting from pomace, a waste product of the olive oil chain, using an innovative method based on the use of Ionic Liquid. On the other hand, a plant extract from *Lemna minor* L. (duckweed), a free-floating aquatic invasive species, was applied as biostimulant to promote the growth and some traits of crops, being rich in valuable compounds. Finally, the main physiological and biochemical parameters were evaluated to verify the responses of plants treated with biostimulants or nanoparticles. In conclusion, this research aimed to demonstrate that the use of biomass from agro-industrial waste to obtain the above nanomaterial, as well as the use of fresh invasive species to obtain plant extracts, represents a sustainable way to reduce the impact of waste on the environment, promotes the circular economy and provides bio-materials to improve crop performance.

Lucia Giordano, Novel bio-protector to mitigate extreme climatic events in vineyards

Thermal and radiative stresses during grape ripening can adversely affect basic physiological processes, resulting in significant reductions in daily assimilation and instances of photo-damage characterized by leaf chlorosis and necrosis. Moreover, these stressors can lead to an overabundance of flavonols in grape skins as a defense mechanism against elevated levels of UV radiation. In 2023, a study was conducted on grapevines in both field and pot environments in Umbria and Sicily to evaluate the efficacy of a novel bioprotector comprising a blend of β -carotene and α -pinene. The study focused on black and white grape varieties, aiming to assess the bioprotector's ability to safeguard the phenolic and aromatic components of grapes while also examining its potential impacts on yield and basic physiological functions.

Preliminary findings from the study indicate that the bioprotector formulation induced a delay in grape technological ripeness and enhanced the availability of nitrogen readily assimilable by yeast (APA). Further analyses will delve into the phenolic fraction, encompassing the flavonol class, as well as the aromatic fraction, with particular attention to norisoprenoids associated with β -carotene metabolism and the carotenoid cycle.

The results of this research hold significance for viticulture practices, offering insights into potential strategies to mitigate the adverse effects of environmental stressors on grapevine health and grape quality. By understanding how the bioprotector influences grape physiology and chemistry, growers may be better equipped to optimize grape production while minimizing the impacts of stress-induced phenomena such as reduced assimilation and photo-damage. Ultimately, this study contributes to the broader goal of sustainable grape cultivation by exploring innovative approaches to enhance vine resilience and grape quality in the face of environmental challenges.

Eleonore Cinti, Stomatal apparatus, mesophyll architecture and gas-exchange: how plants adapted to climate change

This project aims to analyze the behaviour of the mesophyll, stomatal apparatus, and the resulting changes in plant-atmosphere gas exchange in response to climate change. Through the study of evolutionary models and the direct effect of environmental stresses on different plant species (high CO₂, high temperature, and drought), the ambition is to promote the development of climate-resilient plants. Preliminary data show the evolutionary adaptation of the stomata apparatus of 20 plant species from angiosperm to lycophyte grown in different concentrations of ambient CO₂ during the evolution. Plants developed in periods characterized by low CO₂ levels generally possessed higher densities of smaller stomata than plants developed in periods of high CO₂ levels. In my thesis project, the relationship between genome size, stomatal size, stomatal function, mesophyll architecture, and gas exchange was studied in four *Triticum turgidum* subsp. *durum* varieties with different ploidy levels, in ambient CO₂; among these, we also selected two tetraploids varieties and grew them in different CO₂ concentrations to assess the effect of the stress. Data about tetraploids show that stomata distribution and dimension are affected by different concentrations of CO₂, and the inverse relationship between stomatal size and density is not always true. However, gas-exchange analyses showed no differences in photosynthetic rates, but there is an effect of CO₂ on stomatal kinetic and conductance. Furthermore, analysis of the stomatal apparatus, mesophyll architecture, mesophyll conductance, photosynthesis rate and stomata, and the role of nitric oxide and abscisic acid on stomata kinetic are being carried out in other angiosperms as, *Cyperus esculentus*, *Platanus acerifolia* and six *Quercus* species.

Session V

Food quality and security

Ilary Belardi, Development of sustainable and innovative strategies for the valorisation of by-products of the brewing industry

Brewers' spent grain (BSG), a major brewing by-product (85% of total), generally consists of high moisture (83%), fiber (57%) proteins (23%), lipids (7%), ash (4%), starch (7%), and β -glucans (1%). The packaging industry must adopt sustainable strategies to address plastic issues, and one promising approach could be the use of edible coatings (transparent, scentless, and flavourless barrier), consisting of polysaccharides, proteins, or their combination to extend the shelf life of food¹⁻³.

The study investigated wet BSG extraction methods of functional ingredients (proteins, phenolic compounds, and oligosaccharides) to formulate edible coatings for strawberries.

BSG provided from Carlsberg were processed at the laboratories of DTU Bioengineering (Technical University of Denmark) in collaboration with Prof. Mussatto. Proteins, phenolics, and oligosaccharides were extracted using enzymatic (pH 8.5, 100 μ L/g Alcalase) and hydrothermal (150°C, 60 min) treatments of wet BSG. These compounds were mixed with a starch solution for edible coating formulation to preserve strawberries, which were tested for decay, weight loss, pH, and antioxidant activity.

Sequential extraction yielded high proteins (65%) and oligosaccharides (91%), with a phenolic concentration of 1.13 g GAE/100 g dm. Coated strawberries showed less mold (11-30%) and stable pH (3.5) at day 3 contrary to control (44-54% mold, pH 2.7). The coating produced with both compounds reduced weight loss (12.1%) at day 5 contrary to control (25.5%). It also retained antioxidant activity better over time (35.2% at day 1 to 25.8% at day 12) than the control (45.8% at day 1 to 26.4% at day 5). Using BSG-derived compounds in edible coating formulations significantly improved strawberries' shelf-life.

¹ Belardi I, Marrocchi A, ..., & Marconi O (2023). *Molecules*, 28(24), 7992.

² Qin F, ..., Mussatto SI (2018). *Ind Crops Prod*, 125, 443-453.

³ Gautam A, Gill PPS, ..., Ajay (2024). *Food Hydrocoll*, 155, 110208.

Alessandro Mariani, Win the challenge against Tomato Brown Rugose Fruit Virus (ToBRFV)

Tomato (*Solanum lycopersicum* L.) is one of the most extensively cultivated horticultural species globally with about five million hectares of cultivation in 2022. However, the relentless emergence of new viral pathogens poses significant challenges for this crop. Over recent decades, novel viruses have surfaced worldwide, with "Tomato Brown Rugose Fruit Virus – ToBRFV" being a recent addition to the list. First isolated in Jordan in 2015 from a tomato crop (cv. Candela) in greenhouse conditions, ToBRFV manifests through mild foliar symptoms and distinctive brown-colored, wrinkled fruits. Despite its ability to potentially infect 40 different species across four plant families, tomato and pepper remain its primary agricultural targets.

ToBRFV poses a threat to tomato varieties equipped with the R genes Tm-1, Tm-2, and Tm-2², known for conferring resistance against other Tobamoviruses like "Tobacco Moais Virus – TMV" and "Tomato Mosaic Virus – ToMV". Although genetic resistance represents the most efficient, cost-effective, and sustainable method for controlling viral diseases in plants, the availability of ToBRFV-resistant or tolerant varieties remains limited. Exploring the tomato germplasm and that of its wild relatives emerges as a promising way to discover virus resistances for the development of resistant commercial varieties. Several studies have already carried out screening of tomato germplasm to identify resistance genes against ToBRFV, uncovering sources of tolerance or resistance within various species of the *Solanum* genus.

The primary aim of this research is to identify and characterize potential sources of resistance/tolerance to ToBRFV by developing molecular markers associated with the resistance/tolerance genes in order to introgress these genes into elite populations for the development of commercial varieties. Specifically, the research aims to pinpoint polymorphic SNPs and conduct an association study to identify markers closely linked to the resistance/tolerance genes. Additionally, efforts are underway to devise an efficient method for detecting SNP markers strictly associated with ToBRFV resistance.

Viviana Bolletta, Innovative strategies in ruminant feeding to improve product quality and mitigate the environmental impact of animal farming

The overall goal of the project was to integrate unconventional feed resources (UFR) into ruminants diet, aiming to achieve the following impacts: i) increased product quality using UFR rich in bioactive compounds; ii) decreased reliance on conventional resources and reduced feed-to-food competition; iii) mitigated environmental impact of the supply chain.

In the first year, research focused on selecting unconventional feed resources (UFR) based on their chemical composition and evaluating their potential as ruminant feed. The most feasible strategies identified were using pasture with proper grazing management and incorporating locally available agro-industrial by-products into feed.

During the second year, *in vitro* and *in vivo* trials assessed the effects of selected UFRs on ruminal fermentation parameters, animal performance, and product quality. *In vitro* tests using sheep as rumen fluid donors indicated that feeding sheep 1%, 2%, or 3% dry matter (DM) biochar or olive-phenol-loaded biochar had minimal impact on ruminal fermentation and biohydrogenation.

A first *in vivo* study showed that feeding lactating grazing ewes 11% DM dried olive leaves improved the nutritional quality and health traits of the produced experimental cheese. Also, a consumer test demonstrated higher appreciation for the experimental cheese compared to a control cheese.

Another study showed that a concentrate composed entirely of agro-industrial by-products (distillers, rice husk, olive pomace, molasses, bran, and tomato peels) did not impair the performance of grazing dairy sheep. Rather, the experimental diet improved some milk and cheese quality parameters.

A separate trial indicated that the quality of meat from Black Angus cattle raised exclusively on pasture is affected by the feeding season. Nevertheless, the overall quality of grass-fed beef was excellent throughout the year.

These findings demonstrate the feasibility of integrating UFRs into ruminant feeding to produce sustainable and high-quality animal products without compromising animal performance.

Stefano Bettini, Does *Saccharomyces cerevisiae* postbiotic affect hay *in vitro* digestibility? A comparison between inclusion in the rumen fluid inoculum and dietary supplementation in the donor Chianina bullocks under controlled feeding system

Postbiotics are emerging to improve health, performance and sustainability in animal production. Thanks to their ability to promote favourable ecosystem for host microbiota these additives could potentially increase the digestibility of nutrients. To evaluate the effect of a postbiotic based on *Saccharomyces cerevisiae* (Doxal Italia S.p.A.) on rumen microbiota ability to degrade *Medicago sativa* hay, *in vitro* 48 h fermentations were performed in the Ankom–Daisy II incubator. pH was recorded after 0, 24 and 48 hours of fermentation. In experiment 1, fermentations were performed with non-treated rumen fluids collected at the slaughterhouse from 6 Chianina bullocks. The two-way ANOVA indicates that the direct inclusion of two postbiotic doses (5 and 10 mL) did not affect dry matter (DM), neutral detergent fibre, and crude protein digestibility. The pH value at 48 h was increased ($P < 0.05$) by the postbiotic inclusion at the higher dose (6.8 vs. 6.6). In experiment 2, the rumen fluid used for the *in vitro* fermentation was obtained from Chianina bullocks fed either a control diet or the same diet supplemented (2% DM) with the postbiotic. Rumen fluid was collected through a rumen probe at 0, 30 and 60 days of postbiotic dietary administration and incubated as in experiment 1. Furthermore, in order to evaluate the effect of the postbiotic treatment on DM intake, feed consumption from each animal was recorded every 15 days. Statistical analyses showed no differences in digestibility, pH values and DM intake. Further *in vitro* and *in vivo* studies with genomic approaches are warranted to better elucidate the postbiotic effect on the rumen ecosystem and microbiota.

Session VI

Genetic application

Giacomo Bongiorno, Breeding Low-Impact Durum Wheat Varieties for Environmental Sustainability

This PhD project, aligned with the National Operational Program (PON) “Research and Innovation” 2014-2020, aimed to promote sustainable durum wheat cultivation by developing new varieties and enhancing plant resistance to fungal diseases, particularly yellow (stripe), brown (leaf), and black (stem) rusts. To achieve this, three methodological approaches were adopted. The first approach consisted of conducting agronomic field trials and registration tests with advanced durum wheat lines. The objective was to identify high-quality varieties and register them in Italy’s National Register of Agricultural Varieties. These trials, conducted in collaboration with CGS Sementi (the partner company of the project), evaluated the lines for stability, uniformity, productivity, quality, and pathogen resistance. The second approach focused on Marker-Assisted Selection (MAS). It was observed that molecular markers for bread wheat (*T. aestivum* L.) were more abundant than those for durum wheat (*T. turgidum* var. *durum* Def.). Therefore, markers from both species were tested for their ability to detect rust resistance genes. This approach expanded the range of available markers and helped identify the most effective ones for selecting rust-resistant durum wheat lines. The third approach involved crossbreeding, aiming to introduce resistance genes identified in bread wheat into durum wheat. Currently, promising lines of both durum and bread wheat have been selected and will be used in future crosses to enhance fungal disease resistance in durum wheat through the incorporation of diverse genetic backgrounds.

Daniele Colombi, Sustainable beef cattle breeding: the contribution of genomic selection

Italy has a long history in beef production, with local breeds such as Marchigiana, Chianina, Romagnola, Maremmana, and Podolica which produce high-quality meat. Selection has improved beef production, precocity, growth ability and muscle development, but the genetic determinism of such traits is mostly unknown, being also genomic selection newly implemented in beef cattle industry. The aim of this project is to apply the knowledge of genomics for faster, more efficient, and accurate animal selection in a view of environmental, social, and economic sustainability by considering traditional and innovative traits. The first results, using 33K SNPs-data from young bulls (N=4,064) belonging to these five Italian breeds, revealed their genomic diversity and structure (PCA, pairwise F_{st} , structure), demonstrating that the Maremmana and Podolica rustic breeds are closely related, while the specialised Marchigiana, Chianina, and Romagnola breeds are more differentiated. A genome-wide association study for growth and muscle development traits (average daily gain during performance test, weight at one year old, muscularity) was conducted in the five Italian breeds, indicating a region on chromosome 2, containing the myostatin gene (*MSTN*), which displayed significant genome-wide associations with muscularity in Marchigiana cattle, a breed in which the double muscling phenotype is segregating. Moreover, a significant SNP on chromosome 14 was associated, in the Chianina breed, to muscularity. We then conducted a GWAS analysis for the innovative temperament trait in a 228 animals multi-breed pool (Marchigiana, Chianina, and Romagnola) genotyped with an HD 150K SNPs-chip. The results highlighted a significant SNP on chromosome 23 which mapped inside a cluster of olfactory receptor genes. The identification of diverse genomic regions associated with conformation traits might increase our knowledge about the genomic basis of such traits in Italian beef cattle and, eventually, such information could be used to implement marker-assisted selection of young bulls tested in performance test.

Daniele Andreani, Unravelling Cold Adaptation and Fermentative Potential: A Genomic Exploration of the *Mrakia* Genus

The study of the *Mrakia* genus has attracted the attention of the scientific community due to its psychrophilic aptitude and significant role in revealing microbial adaptation to cold, and its unusual fermentation ability within Basidiomycota. Understanding these traits is also remarkable for various biotechnological applications, such as developing cold-resistant strains for beverage production and environmental bioremediation. This study aims to produce high quality genomic sequences of *Mrakia* type strains for a better characterization and identification of the genetic basis of their phenotypic traits and reliable and highly informative knowledge concerning evolution of metabolic and ecological functions, as well as possible pathogenicity traits, in order to achieve a stable and objective taxonomical classification too. To date, seven strains have been investigated; five of those are type strains (*M. fibulata* DBVPG 8059, *M. stelvica* DBVPG 10734, *M. montana* DBVPG 10736, *M. frigida* DSM 4634, and *M. gelida* DSM 70882), and two are strains belonging to two putative new species (*Mrakia* sp. DBVPG 7820 and *Mrakia* sp. DBVPG 5220). The strains were cultured on YPD medium until the exponential growth phase. Genomic DNA was extracted using Qiagen PowerSoil. Sequencing was performed using ONT technologies in conjunction with short reads from Illumina Sequencing. The bioinformatics analyses were conducted using the assembly tool Flye, followed by correction with Medaka and Pilon. Quality assessment was performed using Busco and Quast. The preliminary results of this study indicate that among the examined strains the largest genome (34169013 bp) was observed in *M. gelida*, while *M. fibulata* showed the smallest (21549664 bp). A correlation between genome size and phylogenetic distribution of the species was also noticed. All microorganisms showed homozygous status, which is consistent with the literature that does not report sexual reproduction of the genus *Mrakia*. Additionally, preliminary tests showed the haploidy of all the tested strains.

Flavio Gabrieli, Unravelling the Role of TT8 in Post-Zygotic Hybridization Barriers

Ploidy variation within plant species introduces significant phenotypic diversity, potentially amplifying the effectiveness of plant breeding efforts. However, production of new polyploids is often hindered by hybridization barriers. Overcoming these barriers selectively could unlock a method to produce novel accessions crucial for addressing food security in a changing climate. In angiosperms, seeds comprise maternal seed coat, triploid endosperm, and diploid embryo, necessitating coordinated development among these tissues for optimal survival and germination. Seed viability is intricately linked to parental genome dosage balance, with deviations often leading to lethality.

In *Arabidopsis thaliana*, imbalances such as maternal excess (4x X 2x) result in defective yet viable seeds, while paternal excess (2x X 4x) leads to severely reduced viability due to a post-zygotic hybridization barrier, the triploid block. Our research focuses on *TRANSPARENT TESTA 8 (TT8)*, an evolutionary conserved bHLH transcription factor encoding gene crucial for seed development. Null mutations in *TT8* enable viable seeds from paternal excess crosses. We examined seeds resulting from intraploid and interploid crosses in *tt8* mutant, as well as in the wild-type background, by morphological and transcriptomic characterization. Morphological analyses of *tt8* mutant seeds reveal smaller size, accelerated endosperm cellularization and delayed embryo development, mirroring maternal excess traits. On the other hand, bulk RNA-seq performed on developing seeds indicate that transcription of protein encoding genes is similarly affected in wild-type interploidy crosses (maternal and paternal excess), while *tt8* maternal mutation similarly affects transcription regulation in paternal excess and balanced crosses, suggesting that transcription in *tt8* maternal mutant is not strongly affected by increased paternal genomic contribution. Hence the relevance of exploring the role of maternal genes in seed development and to clarify the mechanisms of action of TT8, an important regulator of post-zygotic hybridization barriers, and an interesting target for expanding hybridization breeding possibilities for sustainable agriculture.

Aaron Anderson, Structural Genomics of Neotetraploid Alfalfa to Explore the Process of Polyploidization

Autotetraploid species, such as alfalfa (*Medicago sativa* L.), contain four homologous copies of each chromosome, with the potential of four unique alleles at any given locus. This complexity hinders genomic analyses because identifying alleles across loci that reside on each individual chromosome, that is, identifying the sequence of each individual haplotype has been difficult. However, assembling allele-aware chromosome level genomes with current, third generation sequencing technologies, which produce long, highly accurate reads, is now feasible.

We are using PacBio HiFi (Revio) sequencing to identify the immediate structural changes occurring in the alfalfa genome due to polyploidization. We are assembling the genomes of two meiotic mutant diploid parental genotypes and six of their offspring, three neotetraploids arising from bilateral sexual polyploidization and three diploids. These genotypes have been previously evaluated for differences in their phenotypes, gene transcription levels, and genomic methylation patterns (Rosellini et al. 2016). Using the parental genotypes as references for the progeny, we will be able to identify haplotypes and immediate structural changes that occurred as a result of polyploidization. Mapping differences within and between ploidy levels will provide further insight into the genomic effects of hybridization vs polyploidization. These data can then be compared to established tetraploid alfalfa genotypes to explore long term genome response to polyploidization. This information will be useful to breeders looking to incorporate genes or traits from diploid alfalfa germplasm into breeding programs. Preliminary sequencing results for the parents have shown high accuracy with Q values greater than 30 and reads averaging over 10,000 bp in length, which will be assembled both *de novo* and against current diploid reference genomes to determine best assembly methods as we progress with this project.

P1. Giorgia Mallia, Sustainable and eco-friendly strategies for the development of whisky production in Italy

Whisky is one of the oldest and most widely distilled beverages in the world. According to European Union regulations¹, whisky is defined as a spirit distilled from a mash of cereals and aged in wooden casks for at least three years. Whiskies are classified according to the type of grain used, the blending method and the country of origin. Major producing countries include Scotland, the USA, Ireland, Canada and Japan, while the largest markets by volume are India, the USA, France, Japan, the UK, Spain, Canada, Brazil, South Africa and Germany². In Europe, whisky production is mainly based on malted barley, water and other cereals such as wheat or rye, with 150 million litres of pure alcohol sold in 2022³. The aroma and flavour profile of whisky is influenced by several factors, including raw materials, production processes and maturation conditions, all of which contribute to the quality of the final product^{4,5}. Recently, the whisky industry has become increasingly conscious of its environmental impact and has adopted practices to reduce it. The aims of this research project are to develop sustainable and eco-friendly methods for whisky production in Italy, focusing on various aspects such as the use of local raw materials and the optimisation of production processes. Another key issue for sustainable whisky production is the management and valorisation of by-products, as for every 1 L of alcohol produced, approximately 2.5 kg of spent grain, 8 L of pot ale and 10 L of spent lees are generated⁶. The aim of the project is to establish a circular economy within the industry, reducing environmental impact while maintaining production efficiency.

¹ Regulation (EU) 2019/787 of the European Parliament and of the Council of 17 April 2019.

² Chetrariu A, Dabija A, (2021). *Molecules*, 26(11), 3236.

³ Statista (2024) <https://www.statista.com/statistics/1430245/production-volume-spirits-eu-by-segment/>

⁴ Bathgate G N (2019). *Journal of the Institute of Brewing*, 125(2), 200-213.

⁵ Stewart G, Kellershohn J, Russell I (2021) Academic Press.

⁶ White J S, Stewart K L, Maskell D L, Diallo A, Traub-Modinger J E, Willoughby N A (2020). *ACS omega*, 5(12), 6429-6440.

P2. Anna Scian, Reduction of the use of copper-based products for controlling bacterial diseases

As a consequence of the constant increase in the world's population, the demand for agricultural products is growing every year. However, along with this increase comes a rise in production losses due to the effects of climate change and phytopathogens. Copper-based phytosanitary products are extensively used to combat fungal and bacterial infections and are sometimes the only solution. The toxicity of copper, leading to its accumulation in soil and water, has become an environmental and health concern for humans and non-target organisms. Moreover, many bacterial phytopathogens have developed resistance to major treatments, including copper, making the development of new control strategies urgent. While the use of nanoparticles in the fight against phytopathogens raises concerns about their potential toxicity, it represents an innovative and sustainable alternative to traditional pathogen control strategies and merits further investigation. Some nanoparticles act as pesticides, causing pathogen death, others indirectly enhance plant defences, acting as biostimulants and some can have both properties. This research project aims to evaluate the effectiveness and potential application in agriculture of various nanoparticles, both organic and inorganic, as well as low-copper compounds, and compare their performance with conventional copper-based treatments to identify more sustainable alternatives and reduce the usage of copper compounds.

P3. Claudia Camplone, Use of a Life- Cycle Assessment (LCA) approach in the integrated management of fungal diseases of bread wheat

Due to population growth and increased demand for food, in the last decades agriculture has evolved towards a direction that involves the use of several inputs to optimize production in order to meet current demand. Among these, pesticides are extensively used to manage various pests including plant diseases, weeds and insects, to improve crop yield. However, their impact on the ecosystems might be significant and should be therefore estimated. Life Cycle Assessment (LCA) is a method that considers all phases of the production process to assess the overall environmental impact of a product or service. However, in some cases, it can be challenging to estimate the burden of a specific stage, such as pesticide use in agriculture, due to the high variability present that is difficult to account for. This project aims to delve into this topic by considering the practical and applicative implications of the life cycle assessment (LCA) within the supply chain of Umbrian wheat. The first step will involve a bibliographic study of existing literature, enabling us to evaluate the models available for estimating the impact of pesticides and identify the most prevalent ones, along with their strengths and weaknesses in different circumstances. Subsequently, a study is proposed that, drawing upon data from the local supply chain of Colussi s.p.a., will construct a life cycle inventory (LCI) to facilitate potential future studies in the central Italy region. Finally, the project will undertake an LCA study using data collected from three of Colussi s.p.a.'s primary suppliers in the local area, focusing on the environmental impact of pesticides. Data acquisition will be facilitated through collaboration with a DSS, requesting sufficiently specific data to enable predominantly primary data studies.

P4. Simone Pelaracci, Environmental assessment of crop-livestock interactions through agricultural life cycle assessment and modelling

Global greenhouse gas (GHG) emissions reached 59 Gt of CO₂-eq in 2019 with a growing demand for reducing greenhouse gas emissions from the livestock sector. Life Cycle Assessment (LCA) has been successful in assessing greenhouse gases from livestock systems. However, LCA methodologies need to be improved to evaluate greenhouse gases in the LCA of livestock systems to better incorporate crop-livestock interactions.

The aim of this research is firstly to analyze existing models used for emission estimation. A review of existing models was then undertaken to develop a consistent harmonization approach. In this case study, the review focused on carbon sequestration accounting models in soil. The method involved conducting two anonymous expert surveys and a series of expert workshops (n=19) to establish general and specific criteria for evaluating LCA methods for greenhouse gas emissions in livestock systems. Once the various accounting models have been analyzed and evaluated, one of the best-evaluated models will be selected for calibration and validation. Field experimental data will be used for estimating C and N emissions.

Following this trial, a LCA of the crop-livestock system will be integrated with the selected model. This analysis will reveal how accounting for greenhouse gas exchanges in the cultivation phase for livestock feed preparation influences the final LCA result.

Lastly, a complete LCA of the crop-livestock system will be conducted, considering the contribution of biodiversity during the cropping cycle and how this aspect affects the final result. For this analysis, one of the available biodiversity models, which has already undergone a previous evaluation, will be selected.

P5. Veronica Rossi, Social Farming, work inclusion and integrated tobacco supply chain: planning processes in co-planning for greater equity and safety in working conditions

Recently the new Community Agricultural Policy (CAP) introduced the principle of Social Conditionality, that could be an opportunity for agricultural companies, such as tobacco companies, to develop virtuous practices such as those of Social Farming (SF), which involve the inclusion of disadvantaged people in agricultural activities. For the agrarian world, SF has always been a possibility for contamination with the non-profit world and the public sector, allowing it to produce public goods, create job opportunities for disadvantaged people and offer services to the community. The contamination between SF and integrated tobacco supply chain (profit) instead, it is an absolute innovation, a small experimental laboratory that Philip Morris Italia (PMI) and the Department of Agricultural, Food and Environmental Sciences of the University of Perugia intend to attend to measure the benefits that can be obtained for communities and territories. Infact SF is able to respond to the growing needs of the territories, so it is not only a “virtuous practice”, but also a significant component of a new model of sustainable rural development and of a new participatory local welfare. Therefore, the PhD program aims to insert disadvantaged people into the tobacco supply chain of PMI. The first step undertaken, was to analyze the literature focused on: work in agriculture, inclusion and working cohesion of disadvantaged subjects and ethical-social innovations (especially in tobacco companies). Then, having placed these theoretical foundations, the second step will be to conduct a sample survey on the organization of tobacco supply chain units, with a focus on needs in terms of skills and human resources. For this reason, a questionnaire was created, in collaboration with PMI, which will be submitted directly to the PMI’s tobacco companies, that are present in Umbria, Campania and Veneto regions. From this investigation, a clear picture of company characteristics and respective needs (also specific to the regional context) will be defined. Based on these results, a work placement paths for disadvantaged individuals will be planned, which will create added value throughout the integrated tobacco supply chain of PMI.

P6. Giacomo Giulietti, Measuring the impact of social innovations with the SIMRA method. Evaluation of a project carried out in the south-west Orvieto internal area, financed by the VATO territorial pact

Rural communities in internal areas have always experienced a situation of suffering and hardship compared to other areas of the country, mainly due to: isolation, lack of work, low education and lack of services. This unease, widespread within the population, leads to the birth of social innovation initiatives through groups of subjects who organize themselves to counter it. The impacts that are obtained from the initiatives undertaken are long-term changes that affect different dimensions of the territory (environment, economy, society, relationships). In rural territories included in internal areas, there are many initiatives undertaken by the population and administrations over the years. The South-West Orvieto Internal Area, the first pilot area in Umbria, is a reference in the area for the number of projects carried out. In the last decade, the municipal administrations and other institutions present have been protagonists of the implementation of various social innovation projects, financed by various regional, national and European funds including those of the VATO Territorial Pact (Valdichiana, Amiata-Val d'Orcia, Trasimeno, Orvietano). The evaluation concerns the project called Clanis, born in 2013 in the municipalities of Fabro, Ficulle, Montegabbione, Monteleone d'Orvieto and Parrano included in the Southwest Orvieto Internal Area. The idea foresees the creation of a network of services dedicated to agricultural producers in the Orvieto and lower Siena areas, to lead to the increase and enhancement of local agricultural production. The project, funded by the VATO Territorial Pact, has been partially implemented and many structures are not yet up and running. To assess the impacts produced by this social innovation, the evaluation framework developed within the Social Innovation in Marginalized Rural Areas (SIMRA) Horizon 2020 project will be used. The results obtained will allow to assess whether the initiative has produced cross-sectoral (Social, economic, environmental and government) and multilevel (on individuals, community and society) impacts.

P7. Arianna Tiralti, Payments for ecosystem services in the Natura 2000 network: analysis through the value-belief-norm model

Negative anthropogenic environmental changes have been widely documented in recent decades pointing out the urgency of a drastic socio-ecological transformation in response. The critical state of the ecosystems worldwide requires environmental policy instruments capable of promoting the sustainability of natural resources by including environmental, economic and social aspects. The ecosystem services approach and related policy tools, such as payments for ecosystem services (PES), are mentioned as a promising solution to halt ecosystem degradation. Stakeholder and community participation in the design process of a PES leads to more effective, inclusive, and lasting results. The Natura 2000 European ecological network is a multi-faceted context rich in relationships between ecosystem services, providers, beneficiaries, public and private, appearing to be particularly interesting for the definition of PES. Although little known among EU citizens, Natura 2000 is an innovative approach for the coordinated conservation of biodiversity that aims to harmonise the maintenance of habitats and species with human needs through the creation of a large-scale network of protected areas. The main aim of this study is to analyse the factors that influence participation in a PES scheme in the context of Natura 2000 network sites. To do this, the value-belief-norm (VBN) model is applied in order to better understand how values, beliefs and norms, in addition to selected knowledge and socio-demographic variables predict the willingness of individuals to pay for ecosystem services on their territory. Questionnaires target three main stakeholder groups: businesses, landowners and students in the Umbria region. The analysis of the results will outline stakeholders' awareness and attitudes toward ecosystem services and PES concepts, as well as the influence of their values, beliefs, and personal norms on the possibility of implementing a PES program in Natura 2000 network areas.

P8. Chiara Traini, Effects of High density on yield, canopy structure and water use efficiency on hazelnut (*Corylus avellana* L.) orchard

In hazelnut orchards (*Corylus avellana* L.), the density of plantation directly affects the vegetative growth of the plant, the amount of light that penetrates the canopy and productivity. Since the management of the orchard has the purpose of maximizing the yield and quality of the fruits, the objective of this study is to verify the influence of light and water regimes on plants with different planting densities. The theses considered are three and provide densities such as high (2500 plants/ha), average (1250 plants/ha) and low density (625 plants/ha) (control). The study will be carried out on hazelnut plants grafted on non-polloniferous rootstock (*C. colurna* L.), belonging to the variety Tonda Franciscana, implanted in 2017. The analysed parameters are: volume and height of the plant, with technology UAV (Unmanned Aerial Vehicle), amount of light that penetrates inside the canopy, using the luximeter and qualitative and quantitative evaluations of its fruits. In order to maximize production, the purpose of the work is to define the minimum volume of water to be administered to plants, to assess which part of the plant the plants use the least amount of water producing more. To do this, sensors were inserted into the soil, two depths from the surface (30 cm and 50 cm) connected to the irrigation system so it is possible to constantly monitor the soil moisture. There are two irrigation systems that provide 100% and 75% of the water for each system density.

Samples are taken monthly between May and October.

P9. Lorenzo Salvatore Frisullo, Dear resistance gene, where are you? Developing a genetic and epigenetic map for resistance to *Xylella fastidiosa* in olive tree

The aim of this project, lasting a total of three years, is to develop a genetic and epigenetic map in olive trees for the identification of markers associated with genes for resistance or tolerance against *Xylella fastidiosa* subsp *pauca*. To this end, a segregating F1 population already characterized for resistance and susceptibility toward the pathogen will be used. For genomic and epigenetic characterization, the ddRAD-like protocol, MCSed, will be applied, which allows the identification of thousands of single nucleotide polymorphisms (SNPs). Bioinformatic tools will then be used to identify if one or more SNPs are associated with the genes for resistance to *Xylella* spp. Furthermore, a method based on the data obtained by MCSed will be developed to identify the possible presence of epigenetic markers (epimarkers) associated with resistance. The genetic and epigenetic maps, obtained at the end of the research project, can be combined into an integrated map that will enable, in future breeding programs, the selection of new, more resistant, and productive olive cultivars.

P10. Arianna Bonucci, From waste to value: valorisation of olive oil mill by-product

The olive oil production chain has a significant impact on the environment. Pruning alone produces 25 kg of twigs and leaves per tree per year, to which are added every 100 kg of processed olives, other leaves representing 5% of the weight of the olives, 35 kg of solid waste and 440 litres of olive mill wastewater. They are all rich in phenolic substances, which are phytotoxic but at the same time have important technological and health properties. Consequently, in accordance with the principles of circular economy, green and mild technologies such as ultrasound and tangential filtration on membranes, will be applied on an industrial scale for the pre-treatment, extraction, purification and/or stabilisation of olive oil by-products. Valorisation will take place through the development of feed and food prototypes, either by using the wastes directly or by obtaining phenolic extracts from them. The latter, due to their antioxidant and antimicrobial properties, will replace conventional synthetic preservatives and, being anti-allergic, anti-inflammatory, antiviral and anticarcinogenic, will give benefit on the consumer. This responds to the growing demand for functional foods, clean labels, sustainable processes, and reduced waste production.

These different applications will be characterised by physical and chemical analysis. Then, they will be subjected to a quali-quantitative analysis of the phenolic molecules and tocopherol, by means of RP-HPLC-DAD/FLD. In addition, their stability under different storage conditions will be tested, including a real-time shelf-life evaluation. In addition, sensory analyses will be conducted by a panel of tasters, using both analytical methods (discriminative and descriptive) and affective ones (blind expected and informed acceptability tests). A market analysis will be carried out to estimate the consumer interest and propensity to buy such foods derived from the application of the circular economy. Finally, during the activity, events will be organised to promote and disseminate the research results to bring consumers closer to a sustainable approach to the food system.