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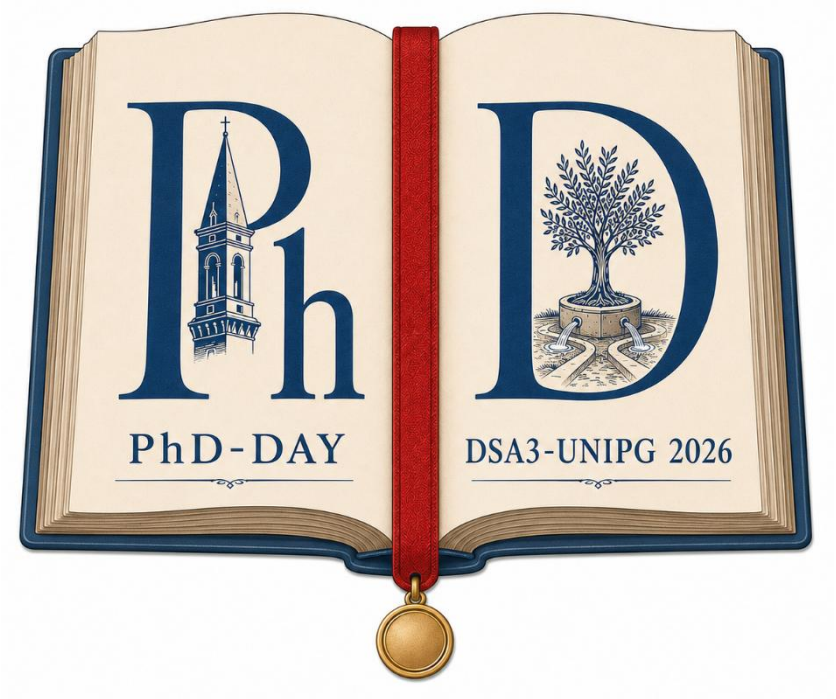

Department of Agriculture, Food and Environmental Sciences at the University of Perugia

September 28th – 29th, 2026
Aula Magna – DSA3 - Borgo XX Giugno 74, Perugia

PROGRAM AND BOOK OF ABSTRACTS

Program

DAY 1	
9:20	**Welcome**
9:30 – 10:00	**Institutional Greetings**
10:00 – 10:30	**Invited speaker – Dr. Silvia Portarena -** Stable isotopes in agricultural research
Session I - Sustainable farming and integrated pest management 10:30 – 11:40 ***Chairpersons*** *Stefano Cimarelli, Flavio Grotto*	**Anna Scian** - Reduction of the use of copper-based products for controlling bacterial diseases **Chiara Traini** - Effect of high density, plant types and biostimulants on yield, canopy structure and water use efficiency on hazelnut **Vittorio Monni -** Sustainable weed management strategies in herbaceous cropping system **Giorgia Carboni Marri** - The ecological role of substrate-borne vibrations in insects and plants *(pages 4-7)*
11:40 – 12:10	*Coffee Break*
Session II - Multi-omics approaches in crops and cattle breeding 12:10 – 13:00 ***Chairpersons*** *Adele Tironi, Claudia Monticelli*	**Lorenzo Salvatore Frisullo** - DNA Methylation as a Driver of Fruit Quality in Tomato: Comparative Insights from Rootstock-Scion Interactions and Parent-Hybrid Systems **Flavio Grotto** - Hairy root-based screening of CRISPR/Cas9-mediated PSY1 knockout efficiency in *Solanum lycopersicum* **Chiara Santomassimo** - Omics-driven approaches to enhance meat quality in Italian beef cattle *(pages 8-10)*
13:00 – 14:30	Lunch break
14:30 – 15:00	**Invited speaker – Assoc. Prof. Fabrizio Alberti** - Harnessing fungi for biological control applications
Session III - Food origin, production, and by-products valorization 15:00 – 16:00 ***Chairpersons*** Muhammad Saqlain Shabbir, Ilenia Dottori	**Arianna Bonucci** - From by-products to functional ingredients: a circular economy approach with producer, consumer, and environmental benefits **Michele Arcangelo Dicorato** - Valorization of Brewing By-Products as an Alternative Protein Source **Akash Kalyanrao Jadhav** - Development and Optimization of Malt Extracts for Beer Production **Andrea Morettini** - A First Step Towards the Authentication of Bulgarian Summer Truffles (*Tuber aestivum* Vittad.) *(pages 11-14)*

Program

Poster session

16:00 – 16:30

Chairpersons
Chiara Traini

P1. Luigia Bosa - Alternative Rearing Strategies for Poultry and Rabbit Production: A One Welfare Approach

P2. Flavia Carbone - Forecasting Processing Pea (*Pisum sativum* L.) Harvest Date: A Climate-Informed Approach for Optimizing Harvest Timing

P3. Ilenia Dottori - Sustainability and Innovation in the Olive-Oil Supply Chain: The Smart Mill for Enhancing the Extraction Process and Oil Quality

P4. Adele Tironi - Conservation and sustainable use of crop wild relatives: Ecogeographic selection uncovers genetic and phenotypic diversity in *Triticum monococcum*

P5. Muhammad Saqlain Shabbir - Valorizing Biomass for Bio-based Inputs for Sustainable Crop Establishment

P6. Claudia Monticelli - Digital DOP: Digital phenotyping and quantitative genetics tools applied to the morphological improvement of maternal lines destined for the Prosciutto di Parma DOP supply chain.

(pages 23-28)

Program

DAY 2	
09:00 – 9:10	**Institutional Greetings**
Session IV - LCA for environmental assessment and ecosystem valorization 9:10 - 10:10 ***Chairpersons*** Luigia Bosa, Flavia Carbone	**Claudia Camplone** - Advancing Life Cycle Assessment for the Integrated Management of Diseases in Soft Wheat **Simone Pelaracci** - Environmental assessment of crop-livestock interactions through agricultural life cycle assessment and modelling **Stefano Cimarelli** - Environmental assessment of legume-based cropping systems and products through agricultural life cycle assessment and ecosystem services modelling **Bilal Zulfiqar** - A Novel Framework Integrating Pest Control Ecosystem Services into Life Cycle Assessment Using Legume-Based Cropping Systems as a Model *(pages 15-18)*
10:10 – 10:40	**Invited speaker – Dr. Renzo Santi** - Industry and PhD Research: Building Value Through Collaboration
10:40 – 11:20	Coffee break and poster viewing
Session V – Social, environmental sustainability and local food policies 11:20 – 12:40 ***Chairpersons*** Simone Pelaracci, Lorenzo Salvatore Frisullo	**Veronica Rossi** - Social Farming, workplace inclusion and integrated tobacco industry: planning processes in co-design for greater equity and safety in working conditions **Arianna Tiralti** - Payments for ecosystem services in the Natura 2000 network: analysis through the value-belief-norm model **Giacomo Giulietti** - Food as a Lever for Territorial Resilience in Inner Areas: The Role of the Umbria Etrusca Green Community in Building a Local Food System **Luana Zamponi** - Territorial governance of agri-food systems as a driver of sustainability transitions *(pages 19-22)*
12:40	Award ceremony for the best poster and final remarks
13:00	**End of the Event**

Session I - Sustainable farming and integrated pest management

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

The increasing difficulty in managing bacterial plant diseases, together with the environmental concerns associated with copper-based products and the emergence of resistant bacterial populations, highlights the urgent need for sustainable crop protection strategies. This PhD project investigated complementary solutions based on nanotechnology, natural mineral resources and microbial biocontrol, with the common objective of identifying environmentally friendly alternatives for the management of bacterial plant diseases.
Among the strategies evaluated, biogenic zinc oxide nanoparticles (ZnONPs), synthesized using a *Lemna minor* aqueous extract, exhibited strong antibacterial activity against *Pseudomonas syringae* pv. tomato (*Pst*), the causal agent of tomato bacterial speck, providing disease protection comparable to the resistance inducer acibenzolar-S-methyl. A complementary mineral-based approach demonstrated that foliar applications of basalt dust (Farina di Basalto® XF; Basalti Orvieto S.r.l.) significantly reduced disease severity through a dual mode of action combining bacteriostatic activity with the induction of structural plant defences, as indicated by enhanced callose deposition independently of canonical salicylic acid- and jasmonic acid-dependent pathways. In parallel, the biocontrol potential of *Pantoea agglomerans* DAPP-PG 734 was investigated, revealing its ability to reduce disease development following co-inoculation with *Pst*. Genome analysis further identified biosynthetic gene clusters potentially involved in the production of antimicrobial secondary metabolites, supporting the role of antibiosis in its protective activity.
Overall, this work demonstrates that integrating innovative chemical, mineral and biological approaches represents a promising strategy to reduce reliance on copper-based products and advance the sustainable management of bacterial plant diseases.

Session I - Sustainable farming and integrated pest management

Chiara Traini - Effect of high density, plant types and biostimulants on yield, canopy structure and water use efficiency on hazelnut

Density of plantation, plant typology and the use of biostimulants to mitigate heat stress are innovative aspects of hazelnut (*Corylus avellana* L.) cultivation. Given the spread of higher planting densities worldwide, two high-density planting systems (1250 p ha-1 and 2500 p ha-1) were compared with the conventional planting density (625 p ha-1) to evaluate the effects on production, vegetative growth and physiological response. For each planting density, two irrigation systems were tested (1.2 L h-1 and 2.4 L h-1) to assess their irrigation use efficiency. Another innovative aspect of this study concerned the type of planting material used, since, traditionally, hazelnut orchards have been established using sucker-propagated plants, whereas grafted and micropropagated plants have only recently been introduced. To evaluate and validate the feasibility of using alternative propagation materials, own-rooted plants were compared with grafted and micropropagated ones across four Italian hazelnut cultivars (Tonda di Giffoni, Tonda Gentile delle Langhe, Tonda Romana e Tonda Francescana). Finally, to understand the possible effects of biostimulants on heat stress, three products (Kaolin, Zeolite, A. nodosum,) were compared with untreated control, in grafted and micropropagated plants, were tested. Data analysis indicated that the combination of planting density 1250 p ha-1 and irrigation system 1.2 L h-1 provided the highest irrigation water use efficiency. Among the propagation methods evaluated, micropropagated plants, although initially smaller at planting, reached the same canopy size as grafted and own-rooted plants by the fifth year after plantation and started the production in the same year, so no juvenile effects were recorded. Regarding the biostimulant treatments, Zeolite produced the best results in grafted plants, whereas A. nodosum was the most effective in micropropagated plants.

Session I - Sustainable farming and integrated pest management

Vittorio Monni - Sustainable weed management strategies in herbaceous cropping system

The European Green Deal and the Farm to Fork Strategy promote the transition towards more sustainable agricultural systems, emphasising the need for effective and environmentally friendly weed management strategies. In this context, this PhD research focuses on developing integrated weed management (IWM) approaches that combine preventive and direct control methods to reduce herbicide reliance while maintaining crop productivity. The research aims to optimise weed control strategies through the integration of agronomic practices, innovative detection technologies, and decision-making approaches. Specific objectives include improving herbicide application efficiency, combining chemical and mechanical control methods, investigating weed–crop competition dynamics, exploring plant-derived substances with herbicidal potential, and assessing the influence of light spectra on weed growth and development. Experiments are conducted in wheat, maize, quinoa, teff, and processing tomato cropping systems, using Erigeron canadensis L. as the main target weed species. Field and laboratory trials evaluate herbicide applications at different crop and weed growth stages, mechanical interventions such as hoeing and finger-weeding, integrated chemical–mechanical strategies, allelopathic effects of plant biomass extracts, and light spectrum treatments. Data collection includes weed density, biomass production, species identification, weed coverage assessment according to the Braun–Blanquet method, phytotoxicity evaluation, and crop yield measurements. Statistical analyses involve ANOVA and non-linear dose–response regression models. The expected outcomes are the identification of sustainable weed management strategies that minimise chemical inputs while supporting crop performance and environmental sustainability. The research contributes to resilient cropping systems by integrating chemical, mechanical, physical, and biological approaches aligned with European sustainability goals.

Session I - Sustainable farming and integrated pest management

Giorgia Carboni Marri - The ecological role of substrate-borne vibrations in insects and plants

Substrate-borne vibrations represent a widespread and effective channel of information transfer in terrestrial ecosystems. Unlike airborne signals, substrate-borne waves propagate through solid media such as soil, plant tissues, and other substrates, providing reliable information over short to medium distances. In recent years, growing evidence has highlighted the ecological importance of these signals across insects and plants. They mediate a variety of intraspecific interactions, including mate finding, alarm signalling, and the coordination of social behaviours, as well as interspecific interactions such as prey and host detection and predator avoidance. In insects, substrate-borne vibrations play a key role in host location, particularly for species whose life cycles depend on finding concealed hosts. Vibrational cues generated by host movement or feeding activity can be exploited by predators and parasitoids to improve host-location efficiency.

Beyond animal communication, plants can also perceive and respond to vibrational stimuli in their environment. Recent studies have demonstrated that vibrations associated with phytophagous insect feeding can induce defensive responses, including the activation of chemical defences in the form of airborne volatile organic compounds (VOCs) and antifeedant compounds. These findings suggest that vibrational cues may function as an early warning system in plant-insect interactions.

Here, we present two case studies on parasitoid insects belonging to *Bethylidae* and *Pteromalidae* (Hymenoptera) which use vibrational cues to locate concealed hosts, and a case study showing how feeding vibrations produced by *Eurydema oleracea* (Hemiptera: Pentatomidae) trigger the emission of defensive VOCs in *Arabidopsis thaliana* (Brassicaceae) plants. Together, these case studies reveal the broad ecological significance of substrate-borne vibrations across different kingdoms of life. Understanding how vibrational signals mediate host location in parasitoids and defence induction in plants provides new insights into the complexity of ecological interactions and may contribute to the development of innovative strategies for sustainable pest management and crop protection.

Session II – Multi-omics approaches in crops and cattle breeding

Lorenzo Salvatore Frisullo - DNA Methylation as a Driver of Fruit Quality in Tomato: Comparative Insights from Rootstock-Scion Interactions and Parent-Hybrid Systems

Current breeding approaches in tomato (*Solanum lycopersicum* L.) aim to improve productivity, firmness, shelf-life, and stress resistance. However, modern cultivars have seen a decrease in fruit flavors and organoleptic features. Major tomato quality traits include the amounts and ratios of sugars, acids, and volatiles, with sugars being the consumers' dominant sensory factor. These morphological and organoleptic features are regulated by an interplay between the genome, epigenome, and agronomic practices, including grafting. Given the comprehensive literature on epigenetic mechanisms in fruit flavour, we investigated the links between DNA methylation and the phenotype of red mature fruits in different tomato types and cultivars.

We employed the MCSeEd (Methylation Content Sensitive Enzyme ddRAD) technique to assess and compare the relative methylation profiles of fruits in different experimental studies. First, we evaluated how grafting with different rootstocks effects scion methylation profiles, then examined whether differentially methylated regions (DMRs) could be maintained from parental lines to F1 progenies. DMRs overlapping with gene-associated regions were defined as differentially methylated genes (DMGs); from these, we selected DMGs involved in fruit traits as candidate genes for quality control. qRT-PCR validation of *bZIP* and *CP12* genes proved the connection between gene expression, DNA methylation profiles, and fruit sugar contents in grafted plants. Moreover, several genes involved in sugar, acids, and firmness traits retained DMRs from parental lines to F1 progenies, and their functional role will be investigated and discussed.

Session II – Multi-omics approaches in crops and cattle breeding

Flavio Grotto - Hairy root-based screening of CRISPR/Cas9-mediated PSY1 knockout efficiency in *Solanum lycopersicum*

PSY genes encode the key enzymes responsible for carotenoid biosynthesis in tomato (*Solanum lycopersicum*). Three paralogue genes have been characterized (*PSY1*, *PSY2*, *PSY3*) showing tissue specific expression. *PSY3* is expressed in roots, where it participates in apocarotenoid and strigolactone biosynthesis. *PSY2* is predominantly expressed in leaves, where it supports photosynthesis-related carotenoid production. *PSY1* is the primary driver of carotenoid accumulation in tomato fruit, and its expression level determines fruit color, which ranges from yellow to red depending on the extent of *PSY1* activity.
Several studies employing gene editing approaches have demonstrated the central role of *PSY1* in carotenoid biosynthesis and, consequently, in tomato fruit pigmentation. In fruit, carotenoid production is orchestrated by a network of genes involved in the cooperative regulation of *PSY1* function, which becomes active at the "breaker" ripening stage. Beyond this orchestrated regulation, it is well established that carotenoid accumulation in fruit is strictly dependent on the presence and integrity of a functional *PSY1*.
Here, we demonstrate the efficacy of CRISPR/Cas9-mediated *PSY1* knockout in *S. lycopersicum*. We designed a gRNA and assembled a CRISPR construct targeting the first exon of *PSY1*. To establish a rapid and robust proof of concept for our construct, plant transformation was performed via *Agrobacterium rhizogenes*, and editing efficiency was evaluated across the total number of regenerated hairy roots obtained.

Session II – Multi-omics approaches in crops and cattle breeding

Chiara Santomassimo - Omics-driven approaches to enhance meat quality in Italian beef cattle

Improving meat quality in Italian beef cattle breeds through the integration of omics technologies and phenotypic evaluations represents a central challenge for the sustainability of the beef sector. This PhD project, co-funded by the "Consorzio Produttori Carne Bovina Pregiata delle Razze Italiane (CCBI)", aims to develop innovative selection tools by combining classical and molecular approaches, with direct implications for breeding programs of Italian autochthonous beef breeds.

The project is structured into four main phases. First, a consumer-oriented market analysis was carried out to understand purchasing preferences and to identify the key attributes that drive the choice of beef products. Subsequently, the focus was placed on two Italian autochthonous beef breeds, Marchigiana and Chianina. For the Marchigiana breed, more than 60 hair samples were collected from young bulls from the same farm in order to determine the genotype at the myostatin locus and to select two groups of animals with normal (n = 5) and heterozygous (n = 5) genotypes, which were then subjected to sampling and chemical analyses of meat quality traits.

For the Chianina breed, a complementary experimental design was adopted: 60 bulls were randomly selected at the same slaughterhouse and processed in the same cutting plant, all certified by CCBI, and subjected to detailed chemical analyses of meat quality traits. Based on these results, 24 animals were identified and classified into four contrasting groups for fatness (fat *vs* lean animals) and protein content (high *vs* low protein), which were used for subsequent omics investigations.

The selected animals from both breeds underwent transcriptomic and proteomic analyses to explore the biological effects of myostatin variants on meat quality in Marchigiana cattle and to identify pathways involved in fat deposition and muscle composition in the Chianina breed. The ultimate goal is to integrate omics data with phenotypic information on carcass traits and meat quality in order to identify biomarkers associated with superior meat quality traits. The expected results will support the development of genomic selection tools and the implementation of genetic indices targeted at improving meat quality in Italian beef cattle breeds, thereby promoting the environmental, social and economic sustainability of the beef supply chain.

Session III – Food origin, production, and by-products valorization

Arianna Bonucci - From by-products to functional ingredients: a circular economy approach with producer, consumer, and environmental benefits

Agri-food by-products pose one of the most pressing challenges for contemporary food production systems, as their disposal entails considerable economic costs and contributes significantly to environmental pollution, underscoring the urgent need for effective and sustainable recovery strategies. Within this framework, the present research addressed the valorization of olive oil industry by-products, namely olive pomace and olive mill wastewater, rich sources of polyphenols with strong antioxidant and health-promoting properties, with the aim of generating co-products possessing valuable technological and health-related functionalities while reducing the ecological footprint of the production chain. Different phenolic-rich extract formulations were incorporated as bioactive ingredients into a wide range of food matrices, including basil pesto sauce, fish-based preparations, snacks, and margarines, to assess their potential as natural alternatives to synthetic preservatives. Peroxide value, free fatty acidity, volatile compounds, antioxidant activity, and phenolic quali-quantitative composition were evaluated across these applications, revealing a consistent trend: phenolic enrichment substantially inhibited lipid oxidation, limiting the accumulation of oxidation markers; it reduced the formation of undesirable oxidation-derived compounds; and it preserved native antioxidant compounds more effectively than conventional additives, regardless of the food matrix under consideration. In margarine formulations, beyond chemical stability, particular attention was devoted to elucidating the effect of phenolic extract addition on structural properties, assessed through nano- and micro-scale analyses, rheological and thermal behaviour, solid fat content, and water droplet size. Collectively, these findings underscore the versatile role of olive oil by-products as sustainable, clean-label ingredients within health-oriented food production strategies.

Session III – Food origin, production, and by-products valorization

Michele Arcangelo Dicorato - Valorization of Brewing By-Products as an Alternative Protein Source

Brewer's spent grain (BSG), the main by-product of the brewing industry, is rich in proteins, dietary fiber, and bioactive compounds, making it a promising raw material for the development of alternative plant-based ingredients. BSG physicochemical characterization showed a moisture content of 81.2%, a protein content of 23.8% dm, a lipid content of 7.3% dm, and a total dietary fiber content of 54.7% dm. Additionally, BSG exhibited a total polyphenol content of 6.58 mg GAE/g dm and antioxidant activities of 37.28, 8.59, and 12.15 µEq/g dm for FRAP, ABTS, and DPPH assays, respectively. Lipid extraction was performed using both conventional solvents and the green solvents 2-methyltetrahydrofuran (2-MeTHF) and cyclopentyl methyl ether (CPME). In wet BSG, conventional solvents achieved lower lipid recoveries, whereas green solvents provided significantly higher yields, reaching 9.41% and 8.83% dm for 2-MeTHF and CPME, respectively. The recovered lipid fractions were mainly composed of linoleic (42–55%), palmitic (18–24%), oleic (9–11%), and γ-linolenic (5–7%) acids. Protein extraction was subsequently carried out through Alcalase®-assisted hydrolysis. The untreated BSG showed a protein recovery yield of 72.15%, while CPME- and 2-MeTHF-defatted samples achieved yields of 69.33% and 73.61%, respectively. The resulting freeze-dried protein-rich extract contained 61.2% protein, 14.9% sugars, 5.5% free amino acids, and 3.2% dietary fiber, exhibited a balanced free amino acid profile with high levels of leucine and lysine, and showed excellent solubility and emulsifying properties. These findings demonstrate that BSG can be valorized as a functional protein ingredient for high-value food and beverage applications.

Session III – Food origin, production, and by-products valorization

Akash Kalyanrao Jadhav - Development and Optimization of Malt Extracts for Beer Production

The brewing industry is increasingly seeking innovative solutions to improve process efficiency, product consistency, and sustainability while meeting the growing demand for both traditional and No-/Low-Alcohol (NOLO) beers. Malt extracts represent a promising brewing ingredient due to their standardized composition, technological versatility, and potential to reduce water and energy consumption compared with conventional all-grain brewing.

This study presents the results of the first two activities of a Ph.D. project focused on the development and optimization of malt extracts for brewing applications. Three commercial liquid malt extracts currently marketed for bakery applications (Diamaltose, Diamaltoro and Diabarley) were characterized through physicochemical analyses including fermentability, sugar composition, free amino nitrogen (FAN), total nitrogen, colour, viscosity, amino acid profile and β-glucan content. In addition, laboratory-scale wort production trials were performed using a formulation containing 60% Pilsner malt and 40% malt extract to evaluate the effect of extract addition before and after wort boiling.

The characterization highlighted clear differences among the extracts. Diamaltose showed low nitrogen content and a sugar profile favourable for NOLO beer production. Diabarley exhibited a balanced composition, low β-glucan content and favourable processability characteristics, making it suitable for conventional brewing applications. Diamaltoro presented the highest concentrations of FAN, total nitrogen, amino acids and colour compounds, suggesting potential use in darker or specialty beer styles. Wort production trials demonstrated that extract addition timing significantly influences wort composition, particularly colour development and nitrogen content. Post-boil addition resulted in lighter-coloured worts, while pre-boil addition promoted greater colour formation and nitrogen retention.

These results demonstrate the importance of malt extract composition and process conditions in determining their suitability for specific brewing applications and provide the basis for the development of tailored malt extract formulations for traditional and NOLO beer production.

Keywords: malt extract, brewing, wort composition, fermentability, NOLO beer, brewing process optimization, sustainability.

Andrea Morettini - A First Step Towards the Authentication of Bulgarian Summer Truffles (*Tuber aestivum* Vittad.)

The summer truffle (*Tuber aestivum* Vittad.) is one of the most commercially relevant truffle species in Europe. The high market value and the growing international demand often make truffles a target for commercial fraud, mislabeling, and poor transparency in traceability. Developing reliable methods to characterize truffles from different geographical origins is therefore essential to improve transparency within the sector.

This study focuses on the morphological and volatile profile characterization of *T. aestivum* collected in Bulgaria, currently one of the world's leading exporters of summer truffles due to its favorable climate and soil conditions. Despite its commercial importance, no comprehensive morphological or aromatic characterization of Bulgarian summer truffles has been reported to date.

The analytical approach integrates morphological evaluation via optical microscopy—focusing on peridium thickness and spore size measurements—with chemical profiling of volatile organic compounds (VOCs) using solid-phase microextraction coupled with gas chromatography-mass spectrometry (SPME-GC-MS) to identify distinctive aroma markers.

Preliminary results provide the first morphological and aromatic characterization of Bulgarian summer truffles and suggest that their geographical origin can be distinguished when morphological and volatile data are integrated.

A second sampling season is currently underway to account for the natural year-to-year variability that may influence truffle morphology and aroma. The integration of multi-season datasets is expected to strengthen the robustness of the proposed characterization and contribute to the development of analytical tools supporting the authentication and traceability of summer truffles.

Session IV – LCA for environmental assessment and ecosystem valorization

Claudia Camplone - Advancing Life Cycle Assessment for the Integrated Management of Diseases in Soft Wheat

The increasing demand for food requires agricultural systems capable of improving productivity while reducing environmental impacts. Life Cycle Assessment (LCA) is widely recognized as an effective tool for evaluating the environmental performance of agricultural products; however, its application to crop production remains challenging due to the complexity of agricultural systems, particularly in the modelling of pesticide emissions and their related toxicity impacts. This PhD research aims to improve the environmental assessment of soft wheat production through the integration of regionalized inventories, primary data and advanced modelling approaches. The research began with a systematic review of pesticide modelling approaches adopted in agricultural LCA, identifying the main methodological limitations and knowledge gaps. Building on these findings, a regionalized Life Cycle Inventory (LCI) of soft wheat production was developed using five years of primary data collected from the main suppliers of the Colussi supply chain in Central Italy. The resulting inventory was then applied to compare the environmental performance of conventional and precision farming systems through a comparative LCA, highlighting the potential of precision agriculture to reduce input consumption and environmental impacts.
The final stage of the research focuses on improving the assessment of pesticide-related toxicity by integrating mechanistic emission models, toxicity characterization models and proxy substances for active ingredients not currently available in existing LCA databases. This approach aims to provide a more realistic representation of pesticide emissions, environmental fate and toxicity within agricultural LCA.
Overall, the research demonstrates how the integration of primary regional data with advanced modelling approaches can improve the robustness and reliability of LCA studies applied to agricultural production systems, while addressing important methodological gaps in pesticide assessment.

Session IV – LCA for environmental assessment and ecosystem valorization

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

Agricultural life cycle assessment often relies on generic emission factors that may not adequately represent site-specific interactions among climate, soil properties and crop management. Process-based models such as DNDC can provide more detailed estimates of crop productivity, soil organic carbon dynamics and greenhouse gas emissions, but their application requires careful calibration and evaluation using long-term experimental data.
This ongoing study applies the DNDC model to the long-term crop rotation experiment at Papiano, central Italy, established in 1971–1972. The experiment includes contrasting crop rotations and residue management treatments, supported by long-term crop yield records and repeated soil organic carbon measurements. The model is being calibrated using observed crop yields, estimated crop residue inputs and soil organic carbon stocks, while accounting for soil characteristics, climatic conditions and agricultural management operations.
Preliminary results indicate good agreement between simulated and observed data, although the calibration and statistical evaluation are still being finalised. Particular attention is being given to the simultaneous representation of crop productivity, residue inputs and soil carbon dynamics, in order to ensure that improvements in one simulated variable do not reduce the accuracy of others.
Once satisfactory model performance has been established, DNDC will be used to develop plausible alternative management scenarios. These simulations will assess how different crop rotations and residue management strategies may affect long-term soil organic carbon dynamics and other relevant soil and greenhouse gas indicators. The study will therefore support the use of process-based modelling to improve the environmental assessment of Mediterranean cropping systems.

Session IV – LCA for environmental assessment and ecosystem valorization

Stefano Cimarelli - Environmental assessment of legume-based cropping systems and products through agricultural life cycle assessment and ecosystem services modelling.

Legumes provide a wide range of ecosystem services (ES), which can contribute to the sustainability of our food- and feed- systems. Agricultural life cycle assessment (LCA) is a useful tool for estimating the environmental burdens of agricultural production, but ES are currently poorly integrated into LCA. The aim of the project is to integrate legumes ES into LCA following different objectives: i) identifying ES assessment methods and knowledge gaps for ES-LCA integration; ii) modelling C and N dynamics in legume-based cropping systems; iii) developing novel LCA methodology for pollination support service by legume crops; iv) performing an improved LCA of agricultural systems, integrating the identified and developed methodologies for legumes ES.

A systematic review on ES assessment methods on legume crops has been carried out to achieve the first objective. The second step consists of the calibration of DNDC model for greenhouse gasses estimation. For the third objective, a “nectariferous value” for the main agricultural crops is being determined through a meta-analysis of published data. All the works will converge in the final step, integrating legumes ES into agricultural LCA. Knowledge gaps and best practices for ES-LCA integration have been already identified during the first year. At the present stage, both the calibration of the model and the pollination support assessment method are being carried out.

The project will advance the methodology for agricultural LCA, bringing to more comprehensive assessments and to a better representation of agroecosystem interactions in the context of agricultural LCA.

Session IV – LCA for environmental assessment and ecosystem valorization

Bilal Zulfiqar - A Novel Framework Integrating Pest Control Ecosystem Services into Life Cycle Assessment Using Legume-Based Cropping Systems as a Model

The Life Cycle Assessment (LCA) accounts for the negative impacts of synthetic pesticides (e.g., emission, ecotoxicity) but does not credit the ecosystem services (ES) related to pest regulation delivered by diversified cropping systems. This asymmetric accounting biases comparative LCA outcomes in favor of conventional, pesticide reliant agriculture. In this research, a new methodology was established to include biological pest regulation in the LCA through legume-based cropping systems as model. We develop the Pest Control Equivalency (PCE) metric, quantifying pest suppression as Treatment Frequency Index (TFI) equivalents. With systematic review according to the PRISMA guidelines, 43 crop-pest regulation combinations were selected from 46 temperate regions studies. PCE efficacy and PCE yield were calculated, and a proxy-based transfer method was developed to address data gaps. PCE efficacy values ranged between -0.67 and 3.19 TFI ha^{-1} yr^{-1} (median value: 0.71), reflecting the capacity of legume-based systems provide pest suppression equivalent to substantial pesticide reductions. Weeds had the highest PCE efficacy values (median: 1.15), whereas diseases were characterized by the greatest variability. Cereal/legumes had the highest efficacy levels (median: 0.90) compared to others. The proxy classification system (11 groups based on botanical family, growth period, photosynthesis pathway, pest guild, and biomass structure) enables PCE estimation for crops with limited available data. This framework enables LCA to positive pest regulation services, supporting assessment of agroecological crop management practice and evidence-based policies for sustainable agriculture. Future work should expand empirical validation across regions and crop-pest combinations.

Session V – Social, environmental sustainability and local food policies

Veronica Rossi - Social Farming, workplace inclusion and integrated tobacco industry: planning processes in co-design for greater equity and safety in working conditions

In recent decades we have witnessed a strong change in the European agricultural system, today characterised by structural dependence on migrant labour. Italy and Spain are among the leading European countries in this trend, and the tobacco sector is no exception. In collaboration with PMIT, two surveys were conducted to identify, on the one hand, the composition of the farm workforce among farmers and their reflections on this topic, and on the other, to understand the level of integration of foreign workers through a self-assessment questionnaire. In both surveys, a focus was made on Social Farming to understand the predisposition and feasibility of undertaking these paths of job placement for disadvantaged people, also from a perspective of Social Conditionality. The results highlight similarities and differences between the two Countries. In particular, cases of job placement attributable to Social Farming programs and a high perception of the level of integration achieved by workers have been detected.
The work described allowed us to transform the results of University research into useful knowledge for farms and stakeholders in the sector. This has created direct collaboration between University and businesses, strengthening the University's role in putting research at the service of society (the so-called "Third Mission"), contributing to the dissemination of more equitable, inclusive, and sustainable agricultural labor management practices through Social Farming.

Session V – Social, environmental sustainability and local food policies

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

Payments for Ecosystem Services (PES) are increasingly used to support ecosystem conservation and sustainable management by mobilizing public and private resources for the provision of multiple ecosystem services. Building on an initial systematic review and a previous application of the Value-Belief-Norm (VBN) model to university students, the current phase of this doctoral research extends the analysis to firms as potential buyers and forest owners and managers as ecosystem-service providers within PES schemes. Survey data were collected from 101 firms in Central Italy and 100 forest owners and managers operating in Italy. The questionnaires adapted the VBN framework to organizational and forest-management contexts and incorporated environmental knowledge, perceived importance of ecosystem services, attitudes toward PES, institutional awareness, and stated participation. Data were analyzed using descriptive statistics, regression analyses, and complementary path-based models. Across both groups, biospheric values and awareness of environmental consequences were high, but normative orientations alone did not consistently translate into action. Among firms, implemented sustainability practices were associated with environmental knowledge, while willingness to participate in PES was mainly linked to favorable attitudes toward the instrument and familiarity with the Natura 2000 network. Among forest owners and managers, knowledge and positive attitudes toward PES were associated with greater engagement, and 74% expressed willingness to sell sustainability credits. Nevertheless, concerns emerged regarding greenwashing, transparency, ethical legitimacy, and the long-term coherence of incentives with sustainable forest management. The findings indicate that effective PES schemes are likely to require more than economic incentives or pro-environmental values: practical knowledge, credible governance, transparent monitoring, and stronger institutional connections between firms, forest managers, and recognized conservation frameworks such as Natura 2000 are also needed.

Session V – Social, environmental sustainability and local food policies

Giacomo Giulietti - Food as a Lever for Territorial Resilience in Inner Areas: The Role of the Umbria Etrusca Green Community in Building a Local Food System

The growing attention paid to territorial food systems has highlighted the role of food not only as a productive component, but also as a potential driver of local development, social cohesion, and the valorization of territorial resources. However, the literature on Alternative Food Networks (AFNs) and food governance remains predominantly focused on urban and peri-urban contexts, while their applicability to inner areas is still relatively underexplored. This study therefore investigates the conditions under which local food systems can contribute to territorial resilience and support the development of place-based policies in inner areas.

The analysis is based on a review of international literature aimed at identifying models, enabling conditions, and recurring challenges across existing experiences. The resulting evidence is examined in relation to the case of the South-West Orvietano Inner Area and the process promoted by the Umbria Etrusca Green Community, which is currently in the initial phase of developing a territorial food system and planning the future involvement of local stakeholders.

The literature shows that AFNs can generate economic, social, and environmental benefits, while also revealing structural and governance limitations that hinder their transition from niche initiatives to models capable of operating on a broader scale. From this perspective, the Green Community takes the "Food Village" model as a reference, based on the development of a food community, co-design processes, and the analysis of stakeholders' needs.

Strengthening the local agri-food system may therefore help counteract marginalization processes, support agricultural enterprises, and reinforce relationships between communities and their territories, positioning food as a territorial infrastructure and a policy instrument for the development of inner areas.

Session V – Social, environmental sustainability and local food policies

Luana Zamponi - Territorial governance of agri-food systems as a driver of sustainability transitions

The transition towards more sustainable agri-food systems requires new forms of governance capable of coordinating actors, knowledge, and resources at the territorial level. In recent years, a wide range of collaborative governance arrangements, including Food Policy Councils, Living Labs, bio-districts, and territorial partnerships, have emerged. However, evidence on the mechanisms through which these governance arrangements foster change and, on the conditions, determining their effectiveness remain fragmented.

This research aims to investigate how and under which conditions territorial governance arrangements contribute to sustainability transitions in local agri-food systems, with particular attention to rural and inner areas. The methodological approach combines a systematic literature review following the PRISMA protocol with an action research process developed within the GAL Media Valle del Tevere territory, aimed at the co-design of participatory governance models.

Preliminary findings from the systematic review highlight the increasing diffusion of multi-actor governance models, characterized by the central role of inter-institutional collaboration, stakeholder participation, and territorial capacity building. In parallel, the case study will explore how these findings can be translated into operational practices through the testing of participatory governance models.

The research seeks to contribute both to advancing knowledge on the governance of agri-food systems and to the development of operational governance arrangements supporting territorial food policies and sustainable rural development.

P1. Luigia Bosa - Alternative Rearing Strategies for Poultry and Rabbit Production: A One Welfare Approach

Livestock production systems are increasingly challenged to balance productivity with animal welfare, environmental sustainability and the production of high-quality animal-derived foods. In line with the European Green Deal and the One Welfare framework, this PhD project aims to develop and evaluate innovative rearing strategies for rabbit and poultry production by integrating animal welfare, nutrition, genetics, health, and environmental sustainability within a multidisciplinary approach.

The project investigates alternative production systems through the combined assessment of animal-based welfare indicators, behavioural observations, productive performance, meat quality, gut health, microbiota composition, metabolic profiling and Life Cycle Assessment (LCA). Particular attention is devoted to the development of sustainable pasture-based systems, the optimization of feeding strategies and the identification of management and genetic factors capable of improving animal resilience while reducing the environmental impact of livestock production.

The first phase of the research is primarily focused on rabbit production, with the objective of evaluating the interactions among genotype, rearing system, pasture characteristics, animal behaviour, health, performance and product quality. These activities are carried out through collaborations with national and international research institutions, including a research period at INRAE (Toulouse, France), enabling the integration of complementary expertise and innovative experimental approaches. During the following stages of the PhD, the same multidisciplinary framework will be extended to poultry production.

Overall, this project aims to generate scientific evidence supporting the transition towards more sustainable, welfare-oriented, and resilient livestock production systems, contributing to future European strategies for responsible animal farming and high-quality food production.

P2. Flavia Carbone - Forecasting Processing Pea (*Pisum sativum* L.*)* Harvest Date: A Climate-Informed Approach for Optimizing Harvest Timing

Harvest timing is one of the main factors affecting the yield and quality of processing pea (*Pisum sativum* L.) destined for the freezing industry. Delayed or premature harvesting can significantly reduce product quality by affecting traits such as seed tenderness, soluble solids content and shelling yield. As climate variability increasingly affects crop development, traditional empirical approaches to harvest scheduling are becoming less reliable, underscoring the need for predictive, data-driven decision tools.

This PhD research aims to develop a climate-informed framework for predicting the optimal harvest timing of processing pea by integrating agronomic, meteorological and quality-related data. The study focuses on the Italian regions of Umbria and Marche and is based on a ten-year dataset including approximately 5,000 georeferenced field records collected from 365 production sites. Agronomic information, such as sowing and harvest dates, cultivar and yield, is integrated with daily weather data to investigate the influence of environmental conditions on crop development.

The research evaluates the role of Growing Degree Days (GDD) and temperature dynamics in relation to industrial maturity, assessed through quality indicators including tenderometer index, soluble solids content (°Brix) and shelling yield. The expected outcome is a decision support framework capable of improving harvest scheduling, reducing quality losses and increasing the resilience of processing pea production under climate change, with potential applications to other vegetable crops requiring precise harvest timing.

P3. Ilenia Dottori - Sustainability and Innovation in the Olive-Oil Supply Chain: The Smart Mill for Enhancing the Extraction Process and Oil Quality

Extra Virgin Olive Oil (EVOO) is one of the most important food products in Mediterranean countries, widely appreciated for its nutritional value, health-promoting properties, and sensory characteristics. In recent years, increasing attention has focused on optimizing both oil quality and extraction yield through technological innovations and improved management of raw materials. In this context, several studies have investigated the relationship between olive drupe characteristics and EVOO quality, with the aim of identifying the optimal harvesting time. These quality parameters are commonly assessed through conventional laboratory analyses, which are reliable but often time-consuming, destructive, and dependent on extensive sample preparation and specialized personnel. To overcome these limitations, growing interest has focused on rapid and non-destructive analytical techniques: near-infrared (NIR) spectroscopy has emerged as a promising tool for the evaluation of intact olives, both under laboratory conditions and in the field. This technique requires no sample preparation, provides rapid analyses, can potentially be automated, and represents a sustainable analytical approach because it does not require chemical reagents. In addition, NIR spectroscopy could also be applied to the rapid assessment of final EVOO quality. For these reasons, this PhD project aims to investigate the application, within an oil mill, of advanced and non-destructive analytical approaches that can be implemented for both online and offline monitoring. The integration of NIR technology into an intelligent processing system, the so-called “smart mill”, could represent a crucial step towards a more efficient and sustainable management of the olive oil supply chain.

P4. Adele Tironi - Conservation and sustainable use of crop wild relatives: Ecogeographic selection uncovers genetic and phenotypic diversity in *Triticum monococcum*

Einkorn wheat (*Triticum monococcum*) is one of the founder crops of agriculture and represents an important but underutilized genetic resource for wheat improvement and biodiversity conservation. However, many einkorn accessions conserved ex situ remain poorly characterized, limiting their effective use.

This study aimed to develop a representative diversity panel capturing the broadest possible einkorn variability. To the purpose, a panel of 96 wild (sp. *boeoticum*) and 96 cultivated (sp. *monococcum*) accessions was selected through an ecogeographic land characterization (ELC) approach, using environmental heterogeneity as a proxy for genetic diversity. The panel was genotyped by ddRADseq and evaluated for 17 morpho-phenological traits. Phenotypic differentiation was assessed through univariate and multivariate analyses, while genetic diversity was investigated using IBS-based kinship, Bayesian clustering, and PCA.

Phenotypic characterization revealed extensive variation, with significant differences between wild and cultivated groups for 12 out of 17 traits ($p<0.001$). Divergence was mainly driven by domestication-related (e.g., shattering and growth habit) and agronomically relevant traits (e.g., flag leaf traits and growth cycle). Genetic analyses based on 5,540 LD-pruned SNPs after QC revealed a hierarchical population structure. Beyond the clear separation between wild and cultivated accessions, subgroups were also identified. The genetic structure of wild accessions was strongly associated with latitude, indicating geographic patterns of diversity.

Overall, these results demonstrate the effectiveness of the ELC approach for assembling a representative collection of diversity. Moreover, the developed collection represents a valuable resource for conservation, association studies, and pre-breeding programs aimed at exploiting local adaptation and improving wheat genetic resources.

P5. Muhammad Saqlain Shabbir - Valorizing Biomass for Bio-based Inputs for Sustainable Crop Establishment.

This research aims to transform low-value plant-based byproducts or waste biomass into bio-based products to enhance crop performance and nutrition, and early seedling growth, thereby also promoting plant resilience to abiotic stress (Ortíz-Hernández *et al.,* 2026). Among the various strategies to reduce the environmental impact of modern agriculture, the valorization of agro-industrial waste using circular model provides innovative and efficient solutions (Buono *et al.,* 2025). To this end, this study will investigate synthetic routes to obtain biogenic nanoparticles, to be used for improving crop nutrition and protection, and targeted release of bioactive compounds. This approach is consistent with circular economy principles, as it aims at reducing the use of chemical fertilizers and promoting the valorization of natural resources and waste (Curcio, 2026). Various strategies will be used to extract and characterize the bioactive fractions from the above matrices, developing scalable frameworks for their use in modern agriculture (Mosca *et al.,* 2025). The current research aims to bridge the gap between waste management and crop productivity, taking advantage of the intrinsic structural and chemical features of such residues. The development of specific bio-based systems is consistent with the principles of sustainable agriculture (Lin & Geelen, 2018). The integration of these bio-derived materials into farming protocols will provide a viable pathway to minimize environmental degradation while enhancing resource-use efficiency (Ali *et al.,* 2024). In conclusion these bio-based strategies represent an important shift toward reducing the ecological footprint of today's agriculture system.

P6. Claudia Monticelli - Digital DOP: Digital phenotyping and quantitative genetics tools applied to the morphological improvement of maternal lines destined for the Prosciutto di Parma DOP supply chain.

This PhD project aims to develop and validate innovative tools for digital phenotyping and quantitative genetics to enhance the morphological evaluation and genetic selection of maternal pig lines destined for the Prosciutto di Parma PDO supply chain. The increasing demand for high-quality products, together with the need for greater sustainability, efficiency, and animal welfare, requires the adoption of advanced Precision Livestock Farming (PLF) technologies capable of generating objective and repeatable information for breeding decisions. The research will integrate digital phenotyping systems, computer vision techniques, image processing, and genetic information to create predictive models for the assessment of morphological traits relevant to reproduction and carcass quality. Automated acquisition and analysis of images will enable the accurate measurement of conformation characteristics, body proportions, structural correctness, and other phenotypic attributes associated with production performance and suitability for Parma ham processing. These phenotypic data will be combined with genomic and pedigree information to estimate improved Estimated Breeding Values (EBVs) and to identify genetic factors influencing key morphological traits.

Over the three-year period, the project will establish a comprehensive database of Italian breeding pigs, develop and validate machine-learning models for automated morphology assessment, and design novel genetic indices tailored to the requirements of the Prosciutto di Parma PDO sector. The final outcome will be an integrated platform supporting more precise and objective selection strategies, reducing the risk of incorrect breeding decisions and accelerating genetic progress.

By combining phenomics, artificial intelligence, and quantitative genetics, the project will contribute to scientific knowledge in animal breeding while supporting the competitiveness, sustainability, and quality standards of one of Italy’s most valuable agri-food supply chains.

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