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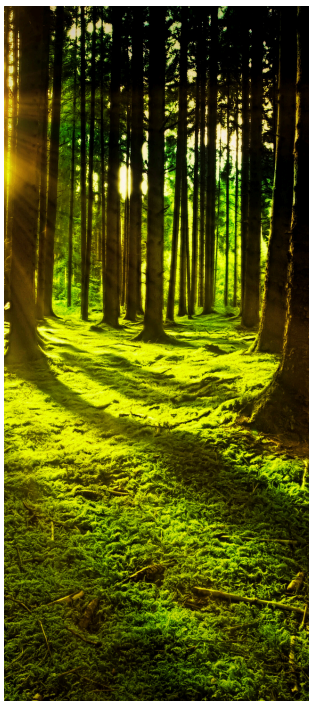
BOOK OF ABSTRACTS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Session P1: From Field Variability to Packaging Innovation: Multidisciplinary Approaches to Modern Enology.

Thursday 5th June. Chair: Elisa Giampietri.

Auxin treatment delays the onset of ripening of grape varieties cultivated in the Valpolicella area.

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The overall temperature increase related to the ongoing climate change is leading to a progressive advance in the fruit ripening period, with negative effects on the quality of the final product.

Grapevine (Vitis vinifera L.) is one of the most extensively cultivated fruit crops globally, primarily due to the significant economic impact of the wine industry. The stages of the grapevine vegetative and reproductive cycle are largely controlled by atmospheric conditions, and climate change is creating significant issues with achieving the optimal balance between acidity and sugar levels of the ripened fruits. Several strategies have been proposed to mitigate these effects.

In this study, we collected data from multi-year trials involving auxin treatments aimed at delaying the ripening of some of the most important grape varieties grown in Valpolicella (Verona, Italy). The trials were conducted in a guyot-trained vineyard located in the eastern part of the Valpolicella area. Grapes of cvs. Corvina, Corvinone, and Spigamonti were treated with 1-naphthalene acetic acid (NAA) before veraison. By monitoring the dynamics of the main technological parameters, it was found that auxin application resulted in a delay of about 10-15 days in the entire ripening process, with significant variations due to the different sensitivity of the grape varieties to treatment.

Additionally, the expression pattern of well-known regulators of the onset of ripening was monitored from the treatment until harvest in Corvina grapes suggesting that the entire ripening program was delayed. Ongoing transcriptomic and metabolomic analyses will improve current knowledge of the molecular mechanisms regulating the initiation of ripening in the grapes that can be of use in adapting the grapevines to the changes imposed by global warming.

Keywords: Grapevine, Ripening onset regulation, Hormone treatments, Gene expression, Climate change

Exploring within vineyard variability to model 'Aglianico' fruit yield and grape composition.

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Vineyard variability poses a persistent challenge to viticulturists due to inhomogeneous fruit yield, grape composition, and required production inputs, often leading to suboptimal vineyard management. Traditionally, growers aim to meet the average vineyard requirements, but nowadays the advances in precision viticulture (PV) allow the identification of within vineyard variability through the mapping of physiological, vegetative, and productive traits. Within vineyard zoning may represent a possibility for wineries to further differentiate harvested grapes. In southern Italy, the 'Aglianico' cultivar is highly valued, yet its response to vineyard variability in hilly environments remains underexplored. The aim of this work was to explore within vineyard variability and exploit this variability to model fruit yield and grape composition. The study was carried out for two years (2023-2024) in a 4-ha commercial vineyard located in Montemarano (Avellino). During the vegetative season, the following measures were carried out on 136 geolocated vines: predawn leaf water potential (Ψ_{pd}), stem water potential (Ψ_{stem}), stomatal conductance (gs), and SPAD index. On the same days, UAV flights with a multispectral camera were conducted. Fruit yield per vine and total soluble solids (TSS) were measured at harvest. Multiple linear regression (MLR) was used to predict fruit yield and TSS using vine physiological data. A random forest (RF) algorithm was used to predict vine physiological parameters using raw multispectral bands. MLR analysis highlighted that late season Ψ_{pd} (veraison and ripening) was the best predictor to estimate TSS. Fruit yield was best estimated using SPAD index measured at veraison. The RF model based on multispectral data to estimate Ψ_{pd} and SPAD highlighted how the model was improved by including the standard deviation of the spectral response. This research demonstrates how PV can optimize vineyard management by guiding surveys to collect only selected data. This approach can help growers in seeking efficient, data-driven decision-making for vineyard management.

Keywords: *precision viticulture, UAV, grape quality, multispectral, variability*

Consumer Acceptance and Preferences for No- and Low-Alcohol Wines: A Systematic Review.

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No and Low alcohol (NoLo) wines represent an emerging trend for the global wine industry, gaining an increasingly wide audience thanks to advances in dealcoholization techniques and an increased focus on consumer preferences (Meillon et al., 2010; Bucher et al., 2018). These wines offer an innovative option for those looking to reduce their alcohol consumption – due to medical reasons or ethical/religious considerations - without sacrificing the wine experience.

The study presents a systematic literature review using academic databases like Scopus and Web of Science (WoS), examining the key factors influencing consumer perception and acceptance of NoLo wines, conducted within the DEWINE project. The PRISMA methodology was applied to ensure a rigorous selection of relevant studies, and the SPICE framework was used to define the research objectives. Bibliometric analyses and network visualizations generated with software like VOSviewer and Bibliometrix were also employed to map emerging trends and keywords.

Our findings reveal a growing interest in NoLo wines, driven by health concerns and a shift towards healthier lifestyles (Saliba et al., 2013; Deroover et al., 2021). However, significant challenges persist, such as the perception of inferior quality compared to traditional wines (Bucher et al., 2018), sustainability issues (Schulz et al., 2024) and overcompensation aspects (Vasiljevic et al., 2018). Consumer preferences for NoLo wines are influenced by factors like taste (Bucher et al., 2019; Naspetti et al., 2019), price (Bruwer et al., 2014; Bucher et al., 2020), personal motivations, and cultural and religious differences (Chan et al., 2012). The study also highlighted the importance of effective marketing strategies and transparent labeling to enhance consumer awareness and acceptance (Pickering, 2000).

This review identifies significant knowledge gaps, particularly in understanding long-term consumer preferences and the market potential of NoLo wines. These insights are vital for the wine industry to overcome current challenges and align with evolving consumer trends. To conclude, our research contributes to the growing body of literature on innovative wine products and provides a foundation for future studies in this rapidly evolving field.

Keywords: *Totally and partially dealcoholized wines, consumer acceptance and preferences, PRISMA, VOSviewer, Bibliometrix*

Upcycled White Grape Pomace for Chitosan-Based Active Food Packaging

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The present study investigates the valorization of white grape pomace to recover bioactive extracts for incorporation into chitosan-based films obtained through a novel acid-free procedure. Initially, the white grape pomace was subjected to conventional extraction using a 60% ethanol solution at 60 °C for 1 hour, then purified using Amberlite XAD16N resin. The extract presented a total polyphenol content of 111 ± 2 mg GAE/g. Additionally, the DPPH assay revealed an antioxidant capacity of 976 ± 37 μmol TE/g extract, while the ABTS assay showed a value of 570.5 ± 0.2 mg TE/g extract. Additionally, the FRAP assay indicated a notable increase in reducing power, with the purified extract reaching 5642 ± 161 μmol Fe(II)/g extract. Chitosan solutions were prepared by means of an initial dissolution of chitosan in aqueous organic acid, subsequent neutralization, and a resulting gel dissolution in water by introducing carbon dioxide. The carbonation process is reversible, thus facilitating the removal of acidic residues from films and coatings. Acid-free chitosan films were then prepared by incorporating the extract at concentrations from 0 to 10% $w/w_{Chitosan}$. Chitosan solutions' rheological and films' properties (water stability, barrier, and optical properties) were characterized. The shear thinning behavior of the chitosan solution showed a suitable viscosity for the coating process (viscosity in the range 10^4-10^3 cP for shear rate 10-100 s^{-1}). Acid-free chitosan films presented a Water Vapor Permeability of 0.013 ± 0.001 g mm m^{-2} d^{-1} Pa^{-1} and an Oxygen Permeability of 4.1 ± 0.4 cm^3 μm m^{-2} d^{-1} Pa^{-1}. The materials were tested on model food matrices to assess their effectiveness as active edible packaging.

Acknowledgment: "ON Foods –Research and innovation network on food and nutrition Sustainability, Safety and Security – Working ON Foods", funded under the PNRR Mission 4 Component 2 Investment 1.3 - Call for proposals No. 341 of 15 March 2022 of Italian Ministry of University and Research funded by the European Union – NextGenerationEU; Project code PE00000003, Concession Decree No. 1550 of 11 October 2022.

Keywords: *packaging, grape pomace, active packaging, chitosan film*

Dealcoholized wines in the face of climate change: how to enhance sustainability and quality while meeting consumer demands.

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The wine industry is facing two major challenges today: global warming impact on grape composition together with a decreasing demand due to consumers' concerns based on their health perception. In fact, global warming accelerates grape ripeness, leading to higher alcohol levels and organoleptic composition modifications. In parallel, to decrease the quantity of CO_2 allowing good yeast performance, it would be valuable to use selected/modified yeasts capable of working at lower temperatures in transformation cellar processes. At the light of this, our aim is to compare the use of modern methods of dealcoholization, in single or multiprocess cycles, where each cycle determines the duration of achieving a target ethanol content. Indeed, there are different procedures and relative efficiencies leading to heterogenous alcohol levels expressed as Alcohol By Volume (ABV) which determines the following categories: (i) partially dealcoholized (0.5% < ABV < 8.5-9%) and (ii) dealcoholized (ABV < 0.5%). From the available literature, such technologies can be categorized into three main phases, based on pre-fermentative, fermentative, and post-fermentative processes. This study analyses technique performance that reduces alcohol content without influencing aroma, composition or the wine structure. A specific focus will deal with ecological footprint of such processes with the use of Life Cycle Assessment (LCA) approach to compare the ecological performance of different alternative processes of dealcoholization and may favor a reduced ecological footprint contributing towards an increased process sustainability. Dealcoholization also supports the current and emerging European policies promoting sustainability and innovation for the agri-food industry. By producing No-Low (NoLo) alcohol wines, wineries can also enlarge their market target to include health-oriented consumers and cultures with alcohol consumption restrictions, impacting economic and social sustainability. In conclusion, we think dealcoholization as a genuine solution for today's markets and environment, leading in the next future to a more resilient and sustainable winery industry.

Keywords: Dealcoholization, Sustainability, Winemaking Innovation, Life Cycle Assessment, No-Low (NoLo) Alcohol Wines.

Non-destructive predictions of quality parameters in table grape and tomato

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The study presented focuses on the development of predictive models based on quantitative data from fruit and vegetable crops collected using non-destructive techniques, specifically referring to the table grape variety *Allison* and the processing tomato variety *Taylor*, grown in the Puglia region. Using the Scio™ spectroscopic sensor, the concentration of soluble solids (°Brix) in *Allison* grape berries was measured, with a sampling of 120 samples in 2023 and 120 samples in 2024. For Taylor tomatoes, the dry matter content was calculated from a total of 100 samples in 2024.

The predictive models were developed using the R programming language on the RStudio Integrated Development Environment. For each model, four combinations of data preprocessing were applied, followed by the construction of a PLSR regression model optimized through 10-fold cross-validation. The *Allison* 2023 model showed a standard deviation (STD) of 1.89, a coefficient of determination (R^2) of 0.77, a root mean square error (RMSE) of 0.90, and a ratio of performance to deviation (RPD) of 2.10. For the *Allison* 2024 model, the results showed STD 2.11, R^2 0.80, RMSE 0.93, and RPD 2.26. For the *Taylor* tomato, the results for dry matter content model showed the following values: STD 1.89, R^2 0.73, RMSE 0.98, and RPD 1.94.

The models obtained demonstrated a good predictive capability, highlighting an increasing reliability from 2023 to 2024 for *Allison* grape. The values of R^2 and RPD indicated that the developed models show significant potential for future non-destructive uses. Regarding the *Taylor* dry matter content model, the parameters suggested a satisfactory predictive capability, though there remains room for further refinement. The non-destructive approach based on spectroscopic measurement systems represents a solid opportunity to improve the efficiency and sustainability of crop management, optimized by forecasts of crop quality/yield obtained without collecting/destroying the samples.

Keywords: *NIR Sensor, Predictive Models, R Programming Language*

Totally and Partially Dealcoholized Wines in a Traditional Wine Culture: Consumer Acceptance and Market Potential in Italy.

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Totally and partially dealcoholized (NoLo) wines are an emerging category that cater to consumers seeking to moderate their alcohol intake while still enjoying the taste and experience of wine. These wines undergo specialized processes to remove a portion or all of their alcohol content (Regulation (EU) 2021/2117). As health consciousness and responsible drinking habits gain prominence (Silva, 2024), NoLo wines present an appealing alternative for wine enthusiasts and occasional drinkers. In order to understand consumer perceptions and potential acceptance of these innovative products, a comprehensive questionnaire has been developed as part of the DEWINE project. The questionnaire will administered in Italy which was selected due to its rich wine culture and consumption patterns, along with the fact that the approval for producing NoLo wines on a national level has only been granted recently (MASAF, 2024). The survey employs a methodical approach to gather insights into consumer attitudes, preferences, and purchasing intentions towards NoLo wines. It begins by assessing participants' wine consumption patterns, preferences, and involvement in wine-related activities. Utilizing rating scales and choice-based conjoint analysis techniques, the questionnaire elicits participants' intentions to try NoLo wines, their willingness to choose these products over conventional wines, and their willingness to pay at various price points. Additionally the potential motivations that might encourage consumers to adopt NoLo wines, such as health benefits, responsible drinking, sustainability concerns, or simply the desire to try something new are explored. Given Italy's deep-rooted wine culture, a lower propensity to try or buy NoLo wines is expected, although some less traditional consumers could be more open to these new products. The data collected will help identify distinct consumer segments based on their preferences for NoLo wine attributes, enabling targeted product offerings and tailored marketing approaches. Ultimately, this research endeavors to contribute to the understanding of consumer behavior in the rapidly evolving landscape of NoLo wines.

Keywords: *Totally and partially dealcoholized wines, consumer acceptance, consumer preferences*.

Session P2: Food, Environment and Consumption: Multilevel Approaches to Sustainability Communication.

Thursday 5th June. Chair: Mario Amato.

The effect of social media exposure on prompting sustainable food choices.

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Over the years, social media have become an integral part of our daily routine, significantly influencing interactions and relationships, while also serving as key sources of information and communication. Among the most innovative tools in digital communication introduced by Artificial Intelligence (AI) is the AI influencer – a digital, non-human character designed to create content and engage with consumers. In this context, this study aims to explore the role of social media exposure in shaping consumer behaviour, specifically regarding sustainable food consumption patterns. We investigate how socially endorsed food images in social media posts and the use of an AI influencer impact consumer preferences and their willingness to pay for sustainable products. In addition, this research examines consumer reactions to the introduction of a holistic sustainability certification based on a scoring system that includes two indicators: one for the environmental dimension and another for the socioeconomic dimension. This is important for policy, as the European Commission is working to harmonize sustainability certifications as part of the Farm to Fork strategy. The study is conducted through an online survey using a Discrete Choice Experiment (DCE) involving a representative sample of 1,000 Italian consumers. A between-subjects design is applied, randomly allocating participants to two different social media exposure conditions before the DCE. The first treatment exposes participants to an Instagram post featuring the holistic sustainability label on pasta, while the second treatment mirrors this exposure, but incorporates a hypothetical AI influencer endorsing the same label. The results indicate that the first treatment has a positive and statistically significant effect on consumers exhibiting a premium willingness to pay for the environmental dimension, whereas the second treatment produces a comparable effect among those with a positive willingness to pay for the social dimension. Findings will guide retailers in leveraging social media to increase their markup and assist policymakers in promoting informed and sustainable food consumption through digital engagement.

Keywords: Social media; AI influencer; Digital marketing; Sustainability labelling; Premium price.

Advancing sustainable and personalized product development through the integration of co-creation and sensory science

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The growing demand for innovative, healthy, sustainable, and personalized food products reflects the diverse needs of consumers, particularly vulnerable groups such as children, patients, and those adopting plant-based diets. However, resistance to alternative food solutions remains a challenge, often driven by food neophobia, taste alterations due to clinical conditions, and concerns about health implications, especially when consumers perceive plant-based products as unfamiliar or less beneficial. Overcoming these barriers requires integrating familiar ingredients with healthier alternatives to ensure both convenience and appeal while promoting adherence to balanced diets.

Personalization plays a crucial role in this process, accounting for individual psychological traits, taste perceptions, and dietary preferences. Co-creation, a core principle of Citizen Science, actively involves consumers in product development, increasing acceptance and market success. Despite its potential, the practical application of co-creation in food innovation remains underexplored, particularly in sensory-driven approaches.

To address this gap, we present an iterative product development model that integrates co-creation with Sensory Science techniques and the Jobs-to-be-Done framework. This model fosters continuous refinement through real consumer feedback, optimizing both sensory appeal and nutritional value. The model's effectiveness is demonstrated through three case studies conducted in hospitals, school canteens, and retail settings. The first case focused on cancer patients experiencing taste alterations, developing products that ensured both sensory acceptability and nutritional adequacy. The second case involved children, where co-creation strategies enhanced the acceptance of healthy plant-based dishes, even among neophobic individuals. The third case developed meat-reduced products for flexitarians, facilitating the transition to a plant-based diet without compromising sensory appeal.

By fostering continuous product refinement through iterative feedback loops, this model supports the development of sustainable, personalized food solutions. Its structured and scalable approach offers a concrete strategy for addressing emerging nutritional and environmental challenges while promoting long-term adherence to healthier eating patterns.

Keywords: Sustainable product development, Co-creation, Sensory science, Personalized nutrition, Consumer engagement

Discovering consumers who search for cheese with “mountain product label”: evidence from latent class.

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The production of mountain products, especially cheese, enhances local economies and sustains historical and cultural traditions. Mountain product manufacturing, particularly cheese, boosts regional economies and upholds cultural and historical customs. Additionally, because of the qualities of the raw materials, traditional knowledge, and processing conditions, it provides high-quality food.In this regard, the European Union has introduced the optional quality term "mountain product label" to support such productions. However, alternative designations like Protected Designation of Origin may also safeguard mountain products, which could cause confusion for consumers. This paper aims to analyze the characteristics of consumers who choose the mountain label and to ascertain whether they conflate the various labels associated with mountain products. A survey, featuring a discrete choice experiment, was conducted with 511 Italian cheese consumers. The data was analyzed using latent class analysis. The analysis identified three consumer categories, two of which expressed interest in the mountain product label. The first group consists of people acquainted with the label, mindful of local production, and invested in the development of mountainous areas. The second group consists of consumers who generally favor premium products, demonstrate limited environmental consciousness, and have less familiarity with the mountain label. The third group of people indicated unfamiliarity with the labels and a disinterest. The differences that emerged between the three groups suggest that the limited knowledge of the mountain product label confuses consumers, leading to the phenomenon of information asymmetry. As consumers become more knowledgeable, their interest in the mountain label grows, solidifying it as a pivotal label for promoting the value of mountainous regions. It is also crucial that policymakers fill in the knowledge gaps of producers and consumers by educating them about the label's existence and features through focused incentives for the spread of private and public campaigns.

Keywords: *Cheese, Mountain Product Label, Protected Designation of Origin, Consumer Behavior, Latent Class Analysis*

Italian consumers' preferences for honey sustainability and traceability.

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Sustainability and traceability are increasingly crucial factors influencing consumer choices in the agri-food sector. In the honey supply chain, these aspects ensure product authenticity, environmental responsibility and ethical production practices. Consumers perceive honey as healthy and safe product, but concerns about fraud and unclear origins reflect a growing demand for greater transparency. Understanding how consumers value sustainability and traceability provides key insights into their purchasing behavior and expectations, highlighting the role these factors play in shaping market preferences. In this context, this research aimed to assess the importance consumers attribute to economic and social sustainability, evaluate their perception of traceability factors and explore their interest in new honey certification schemes in the Italian market. An online survey was conducted, collecting a representative sample of Italian consumers. Participants were evenly distributed across four Nielsen's regions of Italy: Northwest, Northeast, Central and South & Islands. This geographic affiliation, together with gender, were used as covariates to analyze their influence on the importance attached to four items related to economic and social sustainability, four aspects of honey traceability and interest in four types of new certification schemes. Respondents provided their answers using Likert scales, which were then analyzed through a probabilistic model, known as the Combination of a discrete Uniform and a shifted Binomial distribution (CUB). These models analyzed the level of liking for each selected attribute and the impact of uncertainty on their judgment. Our results showed that gender significantly influences the importance consumers attach to sustainability and traceability aspects, with different patterns in different regions. For example, supporting beekeepers was significantly more important to women than men in the Northwest and South & Islands regions, whereas in Central Italy the situation was reversed: this aspect of social sustainability was more important to men.

Keywords: *Honey, CUB models, consumer behavior, sustainability, certifications.*

An Exploratory Analysis of Media Coverage on the Presence of Large Carnivores: A Case Study in the Italian Context.

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In recent years, the discourse surrounding the presence of large carnivores in Italy has undergone a significant transformation. Initially celebrated as a conservation "success story" with the return of these species, the narrative has gradually shifted to emphasize concerns regarding their economic and social impacts—especially within the agricultural sector—and has become increasingly politicized. In this context, the brown bear (*Ursus arctos*) and the wolf (*Canis lupus*) have emerged as central figures in media debates, symbolizing both natural heritage and sources of conflict. Our hypothesis is that this evolving narrative follows a trajectory influenced by a series of catalytic events, resembling a natural experiment. As part of the *Feraltalks* project, we aimed to assess whether specific events—such as the periods of reduced human activity during the COVID-19 pandemic, which led to a marked increase in wildlife sightings, or isolated incidents, including the death of a runner in Trentino—have modified the language and framing used in media reports. These events appear to have shifted the portrayal of these species from icons of conservation success requiring intervention. To test this hypothesis, we conducted a detailed analysis of articles published between 2014 and 2024 in eight major Italian national newspapers. Each article was systematically classified by publication date, newspaper title, headline, link, and event type (e.g., sightings, incidents, human–wildlife conflicts, political decisions, and stakeholder involvement) to compile a comprehensive dataset. Our preliminary findings indicate that these key events significantly shape public discourse by fostering a dynamic interplay among environmental, socio-political, and economic perspectives. Furthermore, ongoing legislative debates at the European level further intensify these tensions. These preliminary results are instrumental in establishing the context for further exploration of public perception regarding the return of large carnivores. By understanding media framing, our study lays a sound foundation for future research and policy development.

Keywords: *media framing, event-driven narrative, human–wildlife coexistence, integrated management, socio-political dynamics.*

Sustainability Labels in European Food Systems: A Systematic Evaluation of Barriers and Drivers.

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The sustainability of the agri-food system is a growing priority, particularly within the European Union (EU), initiatives such as the EU Green Deal and Farm to Fork Strategy focus to promote environmentally sustainable food systems. The EU's regulatory framework, including directives like the Corporate Sustainability Reporting Directive (CSRD) and the Green Claims Directive, plays a pivotal role in fostering transparency while imposing operational challenges, and sustainability reporting within the supply chain. Harmonizing these regulations with international standards is essential to reducing duplicative efforts and enhancing credibility. Environmental labeling is a critical tool in this transition, offering transparency and empowering consumers to make sustainable food choices. However, its implementation faces several challenges, including fragmented regulations, financial constraints, and consumer skepticism. This study investigates the drivers and barriers influencing the adoption of sustainability labels in the EU food supply chains through a systematic literature review based on PRISMA methodology. A search of Scopus and Web of Science identified 1,969 studies, narrowed to 18 after rigorous screening. To complement this, a mapping and categorization of sustainability labels in Europe was conducted using data from the Ecolabel Index and EU reports. Findings reveal drivers and barriers across three stages: adoption, implementation, and development. In the adoption stage, trust among supply chain actors emerges as a key driver, while financial costs pose significant barriers. During implementation, labeling reduces transaction costs but requires investments in training and knowledge. At the development stage, competitive advantage drives uptake, yet consumer indifference limits effectiveness. By offering insights into these dynamics, the study provides actionable recommendations for policymakers and industry stakeholders to strengthen environmental labeling and accelerate the transition toward a sustainable food system.

Keywords: *food supply-chain, labels, drivers, barriers, sustainability*

Taste of the future: Sensory optimization and consumers' preferences of novel snack enriched with cricket powder

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Acheta domesticus offers potential for global food security, but Western acceptance is unknown. Acceptance gaps and familiarity's influence on choices highlight the need for preference-aligned products. Consumer acceptance depends on improvements in rheological, technological, physical, and sensory properties, ensuring quality and appeal. Indeed, it is well known that cricket powder affects those properties, reducing the consumers' preferences. The objective of this study to characterise the sensory profiles of cocoa cookies and *taralli* using the Ideal Profile Method (IPM). For this study, both snacks were formulated by replacing traditional flour with cricket powder (5% in cookies, 6% in *taralli*), with flavour enhancers added to improve acceptability: vanilla, orange, and almond for cookies; chilli, tomato, and oregano for *taralli*. Sensory evaluation involved 66 judges (35 women, 31 men) for *taralli* and 47 (22 women, 25 men) for cookies. Participants rated perceived and ideal intensities of 13 attributes for *taralli* and 10 for cookies on a 10 cm scale, followed by overall liking on a 9-point hedonic scale. Data were analyzed for sensory-hedonic consistency to ensure reliable evaluations. ANOVA and Tukey's test showed no significant differences between the perceived and ideal intensities of both products. ANOVA and Duncan's test ($p<0.05$) revealed that consumers preferred tomato and oregano-flavored *taralli* 6%, regardless the control (without any flavour). Vanilla insect cookies were the most preferred ones, compared to the orange- and almond-flavoured samples. These results suggest that the optimisation of the formula is necessary to meet the consumers' preferences and efficiently use cricket powder as a new ingredient in snacks.

Keywords: *Acheta domesticus powder, Ideal Profile Consumer acceptance, Sustainable foods, novel food.*

The effect of lighting on shopping behavior in a virtual reality supermarket

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A shift in dietary patterns can be attributed to multiple factors, including increased production of processed foods, urbanization, and changing lifestyles. This has led to greater consumption of energy-dense foods high in fats, free sugars, and sodium, while the intake of fruits, vegetables, and dietary fiber has declined (World Health Organization, 2020). This shift underscores the importance of dietary modifications in preventing and managing chronic diseases (Gropper, 2023). In Europe, 80% of food and beverage purchases occur in supermarkets (Stuber et al., 2022), making them essential settings for interventions aimed at promoting healthier choices. However, real-world supermarket experiments are difficult to control, while laboratory and online studies, despite their standardization, often lack ecological validity. Virtual reality (VR) presents a promising middle ground, offering a controlled yet immersive environment replicating real-life shopping experiences. This solution removes the need for physical store visits, saving time and effort. It also enhances engagement compared to online shopping, which lacks the interactivity of VR (Stecula et al., 2024). This study examines how supermarket lighting in VR influences breakfast food choices in terms of nutritional quality. A total of 103 participants completed a virtual shopping task under bright or dim lighting. Afterward, they had to choose between two "thank you" bags—one healthier and one less healthy—while being exposed to the same lighting condition experienced in VR. This study provides insights into how environmental factors like lighting affect consumer food choices and post-decision behaviors, contributing to the development of VR-based interventions for healthier eating habits.

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Keywords: *Virtual Reality; Supermarket; Healthiness; Dim; Light*

Session P3: Challenges and future directions of plant protection under global change.

Thursday 5th June. Chair: Andrea Brandano.

Assessment of phyto-compounds from agricultural wastes against the growth of severe soil-borne fungi and weeds on wheat crop

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One of the most difficult challenge for the modern agriculture is to provide a sustainable production capable to fulfill the world population growth, which is expected to reach 9.8 billion of people in 2050. In the past, chemical management guaranteed these levels of productivity, but nowadays the environmental, economic and ethical issues of this approach enforce the need to find sustainable alternatives for the plant protection against fungal diseases and for management of weeds. For these purposes, agricultural wastes (AWs) could represent promising sustainable tools including the opportunity to recycle the refuses of the industries. The research activities have been carried out in both *in vitro* and *in vivo* conditions for the sustainable management of wheat crop. A preliminary *in vitro* test consisted of performing media containing 2% of two putative phyto-compounds from six AWs (bergamot and pomegranate) and a commercial product (EP) as bio-stimulant against ten fungal pathogens (*Athelia rolfsii*, three *Fusarium* spp., *Fusarium graminearum* [F30], *F. oxysporum* [F1B], *F. solani* [F18], *Rhizoctonia* spp., *Sclerotinia sclerotiorum*, *Verticillium dahliae*). The same phyto-compounds were used as aqueous extracts (1:10) to prevent the germination of weeds. The effectiveness of AWs was assessed by an inhibition index (%) against both fungal growth and seed germination. The experimental trials were also performed in greenhouse using wheat as crop target. The experimental trials aimed to control three *Fusarium* species (*F. graminearum* [F30], *F. oxysporum* [F1B], *F. solani* [F18]) and three weeds (*Alopecurus myosuroides*, *Lolium multiflorum subs. italicum*, *Papaver rhoeas*) by the setting of 80 different experimental treatments, each replicated four times. The data obtained were analysed by statistical software using one-way anova. The *in vivo* experiment highlighted that the AWs were significantly able to control the fungal infections and to prevent the germination of the weeds.

Keywords: *Sustainability, plant pathology, weed management, cycling economy, agricultural wastes valorization*

Unraveling the role of Phytophthora inundata in Citrus root and collar rot.

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Citrus cultivation represents a key sector of Mediterranean agriculture, with Sicily being one of the most important production areas, historically recognized for its extensive orchards and the high quality of its fruit. However, soilborne pathogens pose a significant constraint to citrus production, affecting tree health and long-term orchard sustainability. Waterlogging and poor soil drainage create favorable conditions for the development of Phytophthora species, influencing their role in citrus decline. Among them, Phytophthora nicotianae and P. citrophthora are widely recognized as the main causal agents of root and collar rot in citrus worldwide. This study reports, for the first time, the occurrence of P. inundata in the rhizosphere of declining mature citrus trees in eastern Sicily, in association with P. nicotianae. The species was identified through morphological and multi-gene phylogenetic analyses, based on internal transcribed spacer (ITS), β-tubulin, and cytochrome c oxidase subunit 1. Pathogenicity tests demonstrated that P. inundata, while less aggressive than P. nicotianae, can contribute to disease severity in co-infections, suggesting a synergistic interaction between these species. As P. inundata had not previously been reported on citrus in Europe, but only in Chile and India, these findings highlight the need for further investigation into its role in citrus decline, particularly in the context of synergistic infections with other Phytophthora species. These results provide new insights into the presence of additional Phytophthora species affecting citrus, emphasizing the importance of monitoring their interactions. In the face of climate change and the emergence of Phytophthora species previously unassociated with citrus, understanding these dynamics is crucial for assessing disease risks and improving long-term orchard management.

Keywords: *Phytophthora* clade 6; Citrus rhizosphere; Root rot; *Phytophthora* interaction; Complex diseases.

Nitrogen source influences extracellular pH modulation and secondary metabolism in Trichoderma harzianum.

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Trichoderma species are well-known biocontrol agents, widely used in agriculture for disease suppression, plant growth promotion, and bioactive compound production. Although much research has focused on the strategies used by Trichoderma spp. to control plant pathogens, the mechanisms underlying their environmental adaptability, particularly regarding nutrient sensing and pH modulation, remain poorly understood. This study investigates how different nitrogen sources (nitrate and ammonium) influence extracellular pH (pHex) and the production of secondary metabolites in Trichoderma harzianum, a renowned producer of bioactive metabolites, and Trichoderma asperellum, a powerful biocontrol agent, with a focus on harzianic acid (HA) production. Our findings demonstrate that nitrogen sources significantly regulate the physiology and metabolism of Trichoderma harzianum through pH-dependent mechanisms. In the presence of ammonium, a rich nitrogen source, T. harzianum showed a biphasic pH response, initially acidifying the environment followed by alkalinization, which was associated with increased sporulation. Further investigation revealed that sodium nitrate induced environmental alkalinization, while ammonium nitrate caused prolonged acidification. These pHex changes were linked to different physiological effects: alkaline conditions promoted sporulation, while acidic conditions stimulated mycelial growth and triggered specific metabolic responses. Particularly, acidic conditions stimulated the production of HA and other bioactive compounds, indicating pH-dependent regulation of secondary metabolism. This nitrogen-driven pH modulation pattern was conserved across Trichoderma species, as shown by similar responses in T. asperellum. These findings highlight nitrogen source availability as a key factor in the regulation of Trichoderma physiology, influencing both development and secondary metabolism through pH-dependent mechanisms. The generated knowledge represents a fundamental tool to optimize the activity of Trichoderma-based bioformulates by adjusting nitrogen sources and pH conditions to improve fungal growth and enhance the production of beneficial metabolites.

Keywords: *Trichoderma spp., Nitrogen sources, Extracellular pH, Harzianic acid, Biocontrol.*

Mycotoxin contamination in citrus and pomegranate fruit: detection and sustainable control strategies

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Mycotoxins are toxic secondary metabolites produced by fungal pathogens that pose a serious threat to food safety and quality, particularly in post-harvest fresh produce. Among these, *Alternaria* and *Penicillium* species are responsible for significant contamination in citrus and pomegranate, two key crops in Mediterranean agriculture. In citrus, *A. alternata* and *P. digitatum* have been detected in symptomatic and asymptomatic blood oranges (Rovetto et al., 2023). UHPLC-Q-TOF-MS analyses have detected the presence of patulin and rubratoxin B, especially in mummified and hail-injured fruits, raising concerns about their persistence mainly in the supply chain of orange juice production. Similarly, in pomegranate, *A. alternata* is the primary agent of heart rot, with high levels of tenuazonic acid, alternariol, and alternariol monomethyl ether (AME) detected in affected juice samples, compromising both food safety and fruit nutraceutical value (Riolo et al., 2025). To mitigate fungal contamination and reduce the risk of mycotoxin accumulation, we explored the use of *Lactobacillus*-based bioformulations as a sustainable preventive biocontrol strategy. A novel formulation, developed from citrus peel and enriched with *Lactiplantibacillus plantarum*, demonstrated strong antifungal activity against *A. alternata* and *P. digitatum*, significantly inhibiting their growth and sporulation (La Bella et al., 2024; Riolo et al., 2024). While the direct impact on mycotoxin levels was not assessed, it is well established that LAB strains can adsorb or degrade several mycotoxins, including patulin, ZEA, and TeA, via enzymatic transformation and binding mechanisms (Sadiq et al., 2019). These findings suggest that limiting fungal proliferation, combined with the known detoxification capacity of LAB, could help prevent mycotoxin contamination at an early stage. This study highlights the importance of integrating advanced detection techniques with biological control strategies to improve post-harvest food safety. The implementation of *Lactobacillus*-based bioformulations supports a circular economy model, reducing chemical inputs and promoting sustainability in citrus and pomegranate production.

Keywords: *Mycotoxins, citrus, pomegranate, biocontrol, Lactobacillus-based bioformulations.*

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Modulation of Root Exudate Recognition and Virulence in Fusarium oxysporum by a Secondary Metabolite from Beauveria bassiana

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Numerous soil-dwelling microorganisms release organic acids (OAs) into their surroundings. These low-molecular weight compounds perform various ecological roles including pH modification, ion availability regulation, mineral uptake facilitation, and cross-species communication. Nonetheless, the mechanisms by which these compounds influence tritrophic interactions among pathogens, plants and biocontrol agents remain largely obscure. In this study, we examined the production of OAs among different isolates of the endophytic biocontrol fungus *Beauveria bassiana* (*Bb*) and discovered a novel compound, Bb1993, that serves a dual function: at high concentrations it lowers the environmental pH while at low concentrations it inhibits the formation and growth of germ tubes from the fungal plant pathogen *Fusarium oxysporum* f. sp. *lycopersici* (*Fol*). Root treatment with either Bb spores or Bb1993 modified root exudates (REs), making them repellent to *Fol* germ tubes despite the higher peroxidase activity, a major fungal attractant. Dual confrontation assays between *Fol* and *Bb* colonies, and direct application of Bb1993, enhanced *Fol*'s invasive growth on cellophane membranes. Our findings indicate that Bb1993 exerts both direct and plant-mediated effects on *Fol* by influencing spore germination, plant recognition, and penetration. Ongoing research aims to identify the biologically active compounds from REs of Bb1993-treated tomato plants that convert REs from attractive to repellent against *Fol*. These findings offer new insights into the chemical communication mediating plant-microbe interactions and propose novel approaches for metabolite-based biological control.

Keywords: *Beauveria bassiana, Secondary metabolite, Root exudates, Fusarium oxysporum, Biological control.*

Climate change and foliar pathogens in leafy vegetables: the case of Spinach

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Italy, particularly its southern regions, is experiencing a climate shift beyond global warming, marked by persistently high temperatures and increasingly frequent, intense, and localized rainfall. These extreme conditions significantly impact agriculture, with serious economic consequences for farmers.

Spinach production in Capitanata is among the most affected, facing major challenges due to foliar diseases. High-density planting creates a dense canopy, prolonging leaf wetness from overhead irrigation, poor air circulation, and high humidity. This microclimate fosters foliar pathogens like downy mildew (*Peronospora effusa*), anthracnose (*Colletotrichum spinaciae*), white rust (*Albugo occidentalis*), and Stemphylium leaf spot (*Stemphylium botryosum*).

These diseases significantly reduce yield and quality, making spinach less marketable. Productivity losses can exceed 30-40%, and in severe cases, harvesting may not be possible.

Chemical control, using systemic and contact fungicides, is effective but presents challenges such as pathogen resistance, environmental concerns, pesticide residues, and growing regulatory restrictions. Conversely, biological control—relying on antagonistic microorganisms and resistance inducers—is gaining interest as an eco-friendly alternative.

However, field experiences reveal some limitations: the efficacy of biological products can be inconsistent, depending on climatic and agronomic conditions, and their action is generally slower compared to chemical fungicides.

A comparative analysis of different disease management strategies highlights that an integrated approach offers the most effective solution. The adoption of Integrated Pest Management (IPM) allows for a balanced combination of targeted chemical treatments, biological control techniques, and good agronomic practices. This approach minimizes pesticide use while maintaining productivity, aligning with the European Green Deal, which aims to reduce chemical pesticide use by 50% by 2030.

In this study, IPM is identified as the most effective strategy for *P. effusa* management, ensuring a balance between disease control, crop productivity, and environmental sustainability in accordance with European regulations.

Keywords: *Spinach, Peronospora effusa, fungicides, Integrated Pest Management, agricultural sustainability.*

Session P4: Innovative Approaches to Sustainable and Functional

Thursday 5th June. Chair: Vincenzo Valentino.

Pulses for cereal-based reformulation: effect of the particle size

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Pulses, such as lentils and chickpeas are increasingly incorporated into food products due to their nutritional benefits, including high protein, fiber, and micronutrient content. However, the role of particle size in modifying the properties of pulses for food applications remains underexplored. The aim of this research is to assess how different milling processes, resulting in various particle sizes, influence the technological performance of pulses in bread and pasta formulations. The study involved milling pulses into fine and coarse particle sizes, followed by their incorporation into bread and dry pasta. Key parameters such as starch organization, dough rheology, functional properties, and texture were evaluated. Bread was produced using fine and coarse chickpeas flour while pasta was produced using conventional and micronized yellow lentil flour.

Results showed that finer particle sizes generally improved dough consistency and led to better water retention, but in the case of bread, overly fine particles resulted in reduced loaf volume and crumb structure. Coarser particles, on the other hand, positively affected the bead properties. In the case of pasta, finer particle size positively changes the pasta aspect due to the better hydration properties of the micronized flour.

This research highlights the significance of particle size in pulse-based food products, demonstrating that tailoring particle size can optimize the technological and functional properties of both bread and pasta. These findings offer valuable insights for the food industry to develop healthier and more sustainable alternatives to traditional wheat-based products.

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Keywords: *Pulses, Rheology, Bread, Pasta, Food-Reformulation*

Enhancing techno-functional properties of pea flour through combined enzymatic and lactic acid fermentation for a novel vegan spread

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This study aimed to optimize a biotechnological process for designing a pea flour-based ingredient and assess its potential for producing a plant-based spread, addressing challenges in the agri-food sector by promoting sustainable alternatives to animal products. The research combined enzymatic treatment and fermentation with selected lactic acid bacteria to enhance the nutritional, technological, and sensory qualities of pea flour. The process involved: enzymatic hydrolysis using a commercial protease (VERON PS) to release bioactive peptides and enhance protein digestibility; fermentation with *Leuconostoc pseudomesenteroides* DSM 20193 and *in-situ* synthesis of dextran, using sucrose, to improved viscosity, overall texture, and further enhanced the nutritional profile. The optimized ingredient made of yellow pea flour enzymatically treated and fermented (YPVF) showed the best performance and was selected to be included into a plant-based spread (PBS) formulation. To increase protein content and healthy fats, defatted durum wheat germ and almond flour were also used. The resulting spread was characterized for its physicochemical, rheological, microbiological, and sensory properties. The PBS demonstrated an interesting protein (12.49g/100g; 38.5% of the total energy value) and fiber (11.01g/100g) content achieving the nutritional claims "high fiber", "high protein" and "high content of unsaturated fatty acids" (85% of the total fatty acids) according to the EC Regulation 1924/2006. The sensory evaluation confirmed a favorable profile, masking the typical off flavors associated with legumes, with a balanced flavor and stable texture, eliminating the need for additional structuring ingredients. The PBS maintained stability and microbiological safety during 10 days of refrigerated storage. Addressing the increasing consumer demand for plant-based options, this study showed that the *in-situ* produced dextran could serve as a "clean label" thickener providing a nutritious and sustainable alternative to dairy-based spreads.

Guided fermentation of sprouted wheat and barley flours and their application in bread making: a sustainable and healthy alternative to conventional approaches

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In recent years, recommendations on whole grain consumption have been added to the general dietary guidelines of many countries worldwide. In this context, the study examines the development and application of type III sourdoughs, made of whole wheat and barley flour, for bread large-scale production, aiming to deliver nutritionally important and/or bioactive compounds. An integrated biotechnological approach, combining germination and fermentation with selected lactic acid bacteria, was optimized and validated to valorize wheat and barley grains. Bacterial strains were selected according to pro-technological and nutritional properties and used in combination for tailored fermentation of sprouted wheat (Furfurilactobacillus rossiae CR5, Weissella confusa T6B10, and Lactiplantibacillus plantarum SB88.B4) and barley (Leuconostoc pseudomesenteroides DSM 20193, L. plantarum 7A, and F. rossiae CR5) flour. Fermentation led to an improved peptide profile and increased phenolic compounds, along with enhanced antioxidant activity (100% in wheat and 40% in barley). Among breads, those made with sprouted barley sourdough showed the greatest nutritional and functional benefits, attributable to their dietary fiber content (6.53 g/100 g), higher in vitro protein digestibility (IVPD, 81.14%), lower in vitro predicted glycemic index (pGI, 84.78%), and strong angiotensin-converting enzyme (ACE) inhibitory activity (73%). Additionally, sensory panel tests revealed that bread made with type III sourdough from sprouted wheat flour was particularly appreciated for its improved crust and crumb color, while bread made with sprouted barley sourdough stood out for its intense bran aroma, toasted notes, and balanced acidity. This study highlights the potential of the integrated biotechnological approach as powerful tool to enhance the technological, nutritional, and functional properties of whole grains while reducing weak attributes and thus resulting in breads with high acceptance by both consumers and producers.

Keywords: *Lactic acid bacteria, Sprouted flours, Bioactive compounds, Baking industry, Whole grain.*

Development, optimization and integrated characterization of plant-based gurts enriched with roasted and non-roasted sprouted barley flour

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Plant-based yogurt substitutes ("gurts"), whose market growth is steadily increasing, have emerged as a promising option to promote more sustainable diets and food systems, especially when produced with locally sourced or low-input crops like barley. In this study, a novel gurt made with rice and sprouted barley, was designed. Four lactic acid bacteria strains, selected based on their acidification kinetics and proteolysis, were used as starters for making prototypes. Although with some differences, all the strains adapted to the matrix. Then the formulation and production process were optimized. The use of sprouted barley, compared to raw flours, provided a content of amino acids 9-fold higher, further increased (up to 35%) by the fermentation, and a more complex aroma profile characterized by the presence of furans and aldehydes. However, the high amylolytic activity in sprouted barley interfered with starch gelatinization, thus decreasing the viscosity of the products from 3.3 to 0.08 Pa*s. To overcome this challenge and obtain a creamy and spoonable product, sprouted barley flour was roasted, deactivating the enzymes and conferred a nutty and toasted flavor to the gurts due to the presence of pyrazines. The stability of the key biochemical and microbiological parameters during refrigerated storage was also assessed. Hence, plant-based gurts made with sprouted barley, emerge as a sustainable and health-promoting substitute to traditional dairy yogurts.

Keywords: *Sprouted barley, germination, plant-based gurts, viscosity, GABA*

Combination of lactic acid bacteria and legume flours as bio-preservative in baking industry

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The shelf life of baked goods is a crucial challenge for the food industry and especially for bakery products because, due to their chemical-physical characteristics, they are particularly susceptible to microbial contamination and organoleptic alteration over time.

As consumer demand for healthier and more natural foods, i.e., those with reduced levels of additives and chemical preservatives, grows, there is an increasing need to identify innovative solutions that can extend the shelf life of these products without the use of synthetic chemicals. This project aims to optimize the production of sandwich bread, with an extended shelf life, by exploiting the lactic fermentation of legumes for the release of antimicrobial compounds. In the preliminary phase of the project, in vitro tests conducted to assess the antimicrobial efficacy of legume type-II sourdough extracts derived from legumes flours.

The results demonstrated a significant antifungal activity against common spoilage fungi found in bakery products, including those responsible for early spoilage.

The observed antifungal effects suggest that legume-based sourdough contains bioactive compounds capable of extending the shelf life of bread without the need for synthetic preservatives.

The next steps will be the (i) evaluation of shelf life of sandwich breads made with type-II sourdoughs, (ii) investigation of the main antifungal compounds; and (iii) the scale-up of the sourdoughs and bread production processes, up to industrial scale.

This project represents a meaningful advancement in sustainable and innovative baking practices, addressing the growing consumer demand for natural, clean-label, and safe food products. Furthermore, the potential use of fermented legumes provides an exciting opportunity for the valorization of nutrient-rich matrices, thereby fostering greater integration between food science and industrial innovation.

Keywords: *antifungal activity, legumes-based sourdough, baked products, sandwich bread, natural preservatives*

Enhancing the Value of Green Lentil Flour Processing By-Product from Altamura through the Development of an Innovative Ice Cream Cone

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In recent years, research has focused on sustainable and nutritious food alternatives such as lentils, although the problem of the large amount of discarded food waste persists. This by-product, mainly composed of seed coats, germ, and fragmented cotyledons, would represent a potentially usable novel source of nutrients. This study aimed to utilise green lentil flour from Altamura (LF) and its main by-product (LW) to prepare and develop ice cream cones. The cone batter formulation included the following ingredients: flour fractions (LF or LW) (26.60-23.90%), water (39.36-44.93%), sugar (12.55-11.28%), eggs (11.70-10.52%), oil (9.15-8.80%), and salt (0.2%). The chemical composition and technological properties of LF and LW were evaluated. Specifically, farinograph indices, thermal properties, and functional properties — such as water-holding capacity (WHC) and oil-holding capacity (OHC) — were assessed. LF and LW exhibited excellent nutritional profiles, showing high protein (25.0–24.0%), fibre (22.4–34.6%), and ash (2.84–4.23%) contents, along with a low glycemic index (46.7– 44.15), respectively. Farinographic analysis revealed statistically relevant differences ($p \leq 0.05$) between the two flours in terms of water absorbance, dough development time and stability time, being higher in LW due to the greater content in terms of fibre, which could affect those parameters. WHC and OHC values were significantly different ($p \leq 0.05$), with LW displaying higher values ($p \leq 0.05$), being higher in fibre content. Meanwhile, the thermal properties of LF revealed a greater ($p \leq 0.05$) enthalpy variation associated with starch gelatinisation compared to LW. The physicochemical properties (moisture content and pH) of the cones were influenced ($p \leq 0.05$) by the type of flour fraction used, whereas water activity and mechanical properties showed no significant differences ($p \leq 0.05$). In conclusion, the data obtained provides valuable insights into using these flour fractions in the bakery sector.

Keywords: Lentil waste, novel product, wafer cone, circular economy, up-cycling

Exploring sea fennel as functional aromatic ingredient in extra virgin olive oil.

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In an era where culinary innovation merges technological advancements, biodiversity preservation is essential for shaping the future food. It enhances territorial and population resilience against climate challenges like the Mediterranean basin water crisis, highlighting the potential of underutilized plants that thrive under water scarcity and soil salinization as healthy, sustainable ingredients. Halophytes, plant species adapted to live in environments with high salt concentrations, have been valued since ancient times for their health benefits. Among them, sea fennel (SF, *Crithmum maritimum L.*) is a coastal plant rich in bioactive compounds, minerals and essential oils that stand out as promising functional innovative ingredients also due to its exceptional and underexplored nutraceutical and technological properties. Historically, aromatic plants infused in olive oil played a significant role in culinary, medicinal, and religious practices. Today, growing consumer interest in innovative products has driven research on sea fennel SF-infused olive oil, promoting the use of local, wild aromatic plants over conventional herbs. This research assessed an infusion-based oil flavoring process using oven-dried Apulian SF powder, considering the impact of infusion durations (15 or 30 days) and SF concentrations (5% or 10%) on the sensory, chemical and functional properties of Apulian extra virgin olive oil, also used as control. Analyses included phenolic, pigments and flavonoid quantification, LC/MS phenolic identification and antioxidant activity, alongside physico-chemical and organoleptic assessments. Results showed increased volatile compounds, carotenoids (+100%), and chlorophylls (+360%), enhancing nutritional and sensory value. However, oxidative stability and sensory acceptance were affected. Further optimization is needed to optimize stability and consumer appeal. This study was conducted within the Agritech National Research Center founded by European Union Next-GenerationEU (PNRR–Mission 4 Component 2, Investment 1.4—D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions; neither the European Union nor the European Commission can be held responsible.

Keywords: Sea Fennel, Oil infusion, Antioxidant compounds, Bioactive compounds, Sensory properties

Session P5: Sustainable Intensification of Agriculture: Novel Inputs and Technologies for Crop Enhancement

Thursday 5th June. Chair: Ester Scotto di Perta.

Evaluation of Prohexadione-Ca as a Growth Regulator in High-Density Sweet Cherry System.

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INTRODUCTION: Sweet cherry (*Prunus avium* L.) cultivation in Italy, and particularly in the Piedmont region, is a growing industry with high commercial interest. However, several environmental and physiological factors limit productivity. Currently, orchard management techniques are defined by highly specialized systems with high-density plantings on dwarfing rootstocks. Although these methods guarantee high profitability, there are still challenges related to fruit set and excessive vegetative growth. In particular, the vigorous elongation of shoots complicates pruning practices, as severe pruning (needed in a high-density orchard) can significantly reduce the number of flower buds on one-year-old shoots. The inability to control vegetative growth may accelerate orchard decline, ultimately reducing overall profitability.
OBJECTIVE: The present study evaluates the efficacy of Calcium Prohexadione (Prohexadione-Ca) – Regalis® on sweet cherries as a growth regulator capable of limiting vegetative growth and improving fruit set.
METHODS: The experiment was conducted in a commercial orchard in Piedmont on two cultivars: cv. 'Sweet Valina' and cv. 'Sweet Saretta'. The treatment was applied via foliar spray at a dose of 1.5 l/ha in correspondence with the floral bud stage and petal fall stage. Treatment effectiveness was assessed based on several parameters, including fruit set rate, shoot elongation, leaf pigment concentration, marketable and non-marketable yield, fruit size, and fruit skin color.
RESULTS: Results demonstrated a significant increase in fruit set and a growth-suppressing effect on treated plants, leading to improved yield and enhanced fruit quality.
CONCLUSIONS: This study provides evidence of how Prohexadione-Ca may support the management of sweet cherry plants in high-density orchards by optimizing production and extending the orchard productive lifecycle, justifying the significant initial investment required for these cultivation systems.

Keywords: Sweet cherry, Prohexadione-Ca, fruit set, yield, quality

Influence of biochar and mineral N addition to organic fertilizers on nitrogen mineralization dynamics

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A challenge for improving nitrogen use efficiency in agroecosystems is to understand patterns and kinetics of nitrogen (N) release. With this aim, a short-term soil incubation experiment was made in growth chamber with compost from different organic materials, with and without biochar and in different combinations with mineral N.

The doses were calculated on the full N requirement of rocket.

The organic materials were pomace (OP), buffalo slurry (BS), and digestate from buffalo slurry (DB) composted with and without the addition of biochar.

The six fertilizers obtained were mixed with different proportions of mineral N: 100%, 66%, 33% and 0% of N from NH_4NO_3. Treatments without application of nitrogen as negative control and a double dose of N from compost were added.

Nitrate content into the soil in the treatments with 33% of N from composts was not different from the ones measured with 100% of mineral N. The soil nitrates in the treatments with 66% of N from DB and OP were 15% and 5% higher than the ones with only mineral N.

Ammonium soil content showed a rapid increase after soil amendment, particularly in the organic-mineral treatments, reaching a maximum of 19% of total mineral N in treatments with 33% of N from OP, BS and DB.

Subsequently, ammonium levels decreased over time, while nitrate-N concentrations increased reaching 98% of total mineral N on day 16. The addition of biochar in the organic matrices resulted in a reduction in soil nitrate levels in the treatments with only organic N (-31%, -25%, and -11% in BS, DB and OP, respectively) as compared with same treatments without biochar.

This study shows that using mineral fertilizer and organic amendments together is the more effective strategy. Co-composting organic materials with biochar could interfere with nitrification, thus reducing nitrogen availability to crops.

Keywords: *Nitrogen mineralisation, organic amendment, biochar, N release kinetics*

Fate and uptake of pharmaceuticals in water-soil-plant systems: a short-term study on artichoke in apulia region

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Pharmaceuticals (PhACs) are regularly introduced into agricultural ecosystems through irrigation with treated wastewater (TWW). Although this practice is becoming more widespread in regions facing water scarcity, only limited information is available on the behavior of PhACs within the soil-plant system. For this purpose, a two-year study was carried out, using drip irrigation of artichoke crops with water containing PhACs at different concentrations. The experiment, conducted in both open-field and pot conditions, sought to assess the potential accumulation of these molecules in soil and plant tissues. Results indicated that PhACs concentrations were influenced by the physic-chemical properties of the compounds and the duration of irrigation. The study included both non-inoculated plants and those inoculated with two types of arbuscular mycorrhizal fungi (AMF). It showed minimal accumulation of contaminants in the soil and non-edible parts of the plants, only at the end of the second growing season when the plants were irrigated with TWW containing low levels of PhACs. In contrast, during both pot cultivation cycles, PhACs that accumulated in the soil were absorbed by the plants when irrigated with water enriched to 200 μg L^{-1} with eight different pharmaceuticals. By the end of the trial, climbazole (CLZ) had the highest concentration in the soil (765.1 ng g^{-1}), while carbamazepine (CBZ) and fluconazole (FCZ) accumulated more in the plant tissues compared to the other PhACs. In both trials, plants inoculated with Septoglomus viscosum (MSE) absorbed fewer PhACs than those inoculated with a commercial AMF mixture of Rhizophagus irregularis (syn. Glomus intraradices) and Funneliformis mosseae (syn. Glomus mosseae) (MSY). These findings suggest that while long-term use of TWW containing PhACs may enhance artichoke yield, it could pose varying risks to both environmental and human health, depending on the levels of contamination.

Keywords: *plant uptake; globe artichoke; pharmaceutical active compounds; soil accumulation; wastewater reuse*

The use of untargeted metabolomics coupled with supervised statistics and machine learning unravels crop-specific versus generalized effects of biostimulants: Towards sustainable approaches

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Introduction

Synthetic agrochemicals have traditionally been used to mitigate environmental stress in crops. However, evolving European regulations are driving a shift toward sustainable agricultural practices. Biostimulants offer a promising alternative, yet their mechanisms of action remain insufficiently characterized, limiting their standardization and broader adoption.

Objectives

This study aims to use an integrative metabolomics approach to identify shared metabolite signatures induced by different biostimulants across Solanum lycopersicum (tomato), Cucumis sativus (cucumber), and Capsicum annuum (pepper).

Methods

Untargeted metabolic profiling was performed using ultra-high-performance liquid chromatography coupled with quadrupole time-of-flight mass spectrometry (UHPLC/QTOF-MS). Tested biostimulants included both single-component and multi-component formulations. Data analysis employed hierarchical cluster analysis (HCA), ANOVA-multiblock orthogonal partial least squares (AMOPLS), and the DIABLO framework for data integration and biomarker discovery.

Results

Distinct metabolic profiles were associated with each biostimulant. Notably, the multi-component formulation consistently induced three common metabolite markers—betaine, N-caffeoylputrescine, and 2-amino-4-hydroxypyrimidine-5-carboxylic acid—across all three crops. Single-component biostimulants did not exhibit such cross-species consistency. The integrative statistical approach demonstrated that the multi-component formulation modulates multiple metabolic pathways.

Conclusions

This study highlights the effectiveness of combining untargeted metabolomics with advanced multivariate analysis to uncover universal biochemical markers of biostimulant action. The reproducible metabolic signature linked to the multi-component formulation supports its broad efficacy and offers potential for standardized application across diverse crops. These findings

lay a scientific foundation for the development of robust, sustainable biostimulants to address environmental stress in agriculture.

Keywords: *Integrative analysis, Multi-component formulation, DIABLO. Biomarker discovery, Sustainable agriculture*

Microalgae Extracts as Novel Biostimulants

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The rising global population must simultaneously meet the growing demand for food and ensuring the sustainability of production. In this context, microalgae-based biostimulants are emerging as an innovative and eco-friendly solution to enhance plant health and crop yields even under sub-optimal conditions. Through their unique properties and bioactive molecules, microalgae improve plant performance thus enhancing growth, yield and quality. However, compared to macroalgae-based products, their composition and mechanisms of action remain only partially understood. This study focused on the effects of four novel microalgae extracts, (MC110D, MC112D, MC113D, MC140D), tested in *in vitro* bioassays on seedlings of *Lactuca sativa* L. cv. Grand Rapids at three doses (0.1, 0.2 and 0.4%) comparing them with a commercial biostimulant (AlgaEnergy, AG) ans a non-treated control (NTC). MC110 (0.1%) and MC113 (0.4%) significantly increased leaf area (+33% and 64%+), fresh biomass (+15.8% and +42%) and leaf number (+20% and +24%) compared to NTC, reaching or surpassing AG. MC110 (0.1%) also increased total and essential amino acids (+16 and +1213% compared to AG) suggesting an osmotic/oxidative-related stress response. While this adaptation improves the nutritional profile, particularly via essential amino acids (included BCAAs) accumulation, it suggests a metabolic shift at the expense of structural growth (leaf area and fresh biomass). BCAAs likely support anaplerotic pathways and act as ROS scavengers. MC112, on the other hand, increased polyphenols, total proteins, and H_2O_2 levels, indicating the presence of oxidative stress and activation of plant defence response.

These findings highlight the significant potential of microalgae extracts as alternative biostimulants for promoting both plant growth and endogenous defence mechanisms against stress.

This work is carried out with the support of a grant co-funded by DM 118/23 PNRR (M4C1 - Inv. 3.4 TDA) and the GREENHORT (PRIN 2022-grant2022WHTNZT) funded by MUR Italy.

Keywords: *microalgal extracts,biostimulants, metabolic profile, Lactuca sativa L. cv. Grand Rapids, essential amino acids*

PTF4Med: make hydro-pedotransfer functions easily accessible to everyone

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Pedotransfer functions (PTFs) are tools that convert readily available data into essential yet often unavailable information, which may be more complex or challenging to acquire through routine soil analysis. In the last 30 years a plethora of functions have been produced to predict crucial soil properties, such as water retention curve, bulk density, saturated hydraulic conductivity, organic carbon and many others. Despite their usefulness, they remain little used both due to the difficulty of extending the prediction in different environments due to the limited training set, and due to the material difficulty of reusing the same function, especially when it comes to machine learning algorithms.

Based on our previous work, still unpublished, in which we developed two Artificial neural network-based pseudo-continuous PTFs for the water retention curve in the Mediterranean Region, we developed a user-friendly web application using Flask in Python environment. The application integrates the pre-trained Artificial Neural Network (ANN) model based on user-provided inputs such as clay, sand, organic carbon and soil matric water potential. The application includes automated pre-processing steps – such as normalization and logarithmic transformations – to ensure consistency with the model's training pipeline. Additionally, the platform features an interactive interface where users can easily input data and retrieve predictions, enabling non-expert users to benefit from advanced machine learning models. This tool offers a practical solution for farmers, researchers, agronomists and soil scientists to make accurate predictions while simplifying the application of complex computational models.

Keywords: *Pedotransfer functions, web app, user-friendly, water retention curve, Mediterranean Region*

Biochar as feed supplementation: effect on ghg and ammonia emission from manure produced by holstein calves fed with biochar

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Agro-zootechnical systems require innovative strategies to mitigate greenhouse gas (GHG) emissions and ammonia volatilization in livestock waste management. Biochar has emerged as a promising feed supplement to reduce the impact of livestock.

We investigated the effect of biochar on GHG and ammonia emissions considering the manure pit storage produced by Holstein calves fed with biochar.

We used manure produced by pre-weaning calves randomly assigned to a control group (CTRL, n calves=12, the basal diet consisting of milk and ad libitum feed) and a treated group (CHAR, n calves=12, the basal diet consisting of milk and ad libitum feed + 10 g/calf/day of biochar).The solid manure was collected from individual pens and pooled into a dynamic chamber (30L) to simulate manure storage after 56 days of biochar feeding.

Manure emissions of CO_2, CO, CH_4, N_2O, and NH_3 were monitored by FTIR portable gas analyser (GasmetGT5000Terra) during 28 days of incubation. Gas fluxes were calculated ($g/m_2/h$) on 0, 1, 2, 7, 14, 21, 28 days. Data were analysed by PROC GLIMMIX (SAS 9.4). Under experimental conditions, manure produced by Holstein calves fed with biochar exhibited a different profile of GHG and ammonia emissions. On day 0, carbon emissions (CO_2, CH_4) were significantly lower in CHAR manure (-29% CO_2, -15% CH_4), whereas during incubation, an increase in CO_2, CH_4, and CO emissions was observed, compatible with organic matter decomposition and fermentation. Overall nitrogen emissions (NH_3 and N_2O) showed a reduction of 20% ($P<0.05$) for N_2O emissions and 46% ($P<0.001$) for NH_3 in CHAR manure compared to CTRL manure.

These findings indicated that biochar influenced GHG and ammonia emissions, organic matter fermentation, and manure stabilization, showing potential implications for agro-zootechnical systems. Further studies are necessary to fully understand its long-term impacts and efficacy across different livestock management systems.

Keywords: *biochar, livestock feed, GHG emission, Ammonia emission*

Session P6: Smart Farming, Authenticity, and Technological Adoption: New Frontiers in Agri-Food Systems

Thursday 5th June. Chair: Maria Elena Marescotti

The Role of Heuristics in Agricultural Risk Management: Insights from an Experimental Study on Apple Producers

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Traditional decision-making paradigm assumes that farmers have full knowledge of alternatives, outcomes, and probabilities, with fixed preferences and cognitive capacity. However, information asymmetry causes real-world farming decisions to deviate from these assumptions (Daydé et al., 2014). Farmers rely on heuristics, mental shortcuts that simplify complex decisions by focusing on key information, to prioritize relevant factors and facilitate decision-making (Tversky & Kahneman, 1974). While heuristics enhance efficiency, they can also introduce biases, such as overestimating the probability of salient or recent events, which can influence risk management decisions.

Despite its relevance, this area of research remains underexplored. To address this gap, the present study examines how heuristics influence farmers' willingness to pay (WTP) for the Income Stabilization Tool (IST), an innovative risk management instrument designed to mitigate income fluctuations. A between-subject online experiment is conducted with 130 apple growers, randomly assigned to one of three groups: Control, General Past (GP), and Individual Past (IP). Farmers in the GP group receive historical data on average apple income and past significant income drops. Those in the IP group recall their own past income and identify years with substantial declines, while the Control group answers unrelated questions with no heuristic activation.

Farmers' WTP for IST coverage is measured using a BDM auction (Becker et al., 1964) to minimize estimation biases. Future income expectations are assessed via a quadratic scoring rule (Harrison et al., 2017), while risk preferences are evaluated using the Bomb Risk Elicitation Task (Crosetto & Filippin, 2013).

Preliminary results suggest that farmers in the IP group, especially those with recent income losses, exhibit higher WTP for IST coverage, while the GP group shows a smaller increase compared to the Control group. These findings contribute to understanding heuristic-driven biases in agricultural financial decisions, informing policies to help farmers manage income volatility and improve financial resilience.

Keywords: *Risk Management, Heuristics, Behavioral Economics, Income-Stabilization-Tool*

Seeing is believing: farmers' perceptions of innovative technologies as tools for enhancing transparency

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Over the years, public trust and endorsement of intensive animal production have steadily declined. A key factor contributing to this decline is the way farming is typically portrayed to consumers, which tends to be polarized and inaccurate, oscillating between negative narratives or idealized stereotypes. To address these issues, enhancing the transparency of farming processes seems to represent a potential solution, with one promising strategy being to leverage visual information tools to provide insights into farm operation. However, so far, the perspective of farmers on the use of technologies to virtually "open the gates" of their farms has never been analyzed.

Within the framework of the *AWare* project, this study aims to explore farmers' perceptions of how their work is communicated and their views on the role of innovative technologies in enhancing transparency within the livestock supply chain. Two focus groups, involving a total of 15 dairy farmers, were conducted to examine their perspectives on consumer trust, transparency, and the potential of digital tools, such as immersive 360° videos, to bridge the gap between producers and consumers.

Findings reveal a paradox: farmers tend to conflate communication with education, assuming that providing factual information about their work should, in principle, lead to more positive public attitudes. However, they also recognize that consumers are often "not ready" to fully grasp these facts, and that education alone is insufficient to counteract the power of emotionally driven external narratives. This tension suggests that while transparency initiatives are important, they must be accompanied by a strategic communication approach that actively engages consumers. Although digital tools offer potential in this regard, farmers express concerns about their possible misinterpretation and the limitations of individual efforts in reshaping public perceptions.

This study contributes to the growing field of the application of innovative technologies to increase transparency in the livestock sector, fostering greater trust between consumers and producers, and bridging the gap between farm realities and public perceptions.

Keywords: *dairy farmer, focus group, immersive 360° videos, transparency, innovative technologies.*

Preliminary Comparative Analysis of Autonomous Robots and Traditional Tractors for Mechanical Weed Control in Wheat

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Mechanical weed control provides a sustainable alternative to herbicide use, offering notable environmental and economic benefits. However, traditional methods often require significant labour and resources, challenges that innovative technologies like agricultural robots aim to address. This study evaluates the performance of the autonomous robot Robotti 150 D (Agrointelli, Denmark) compared to a traditional tractor in managing weeds in wheat fields at the University of Padova's experimental farm in northeastern Italy. Both the robot and the tractor performed mechanical weed control using a tine harrow. The field was divided into 4 plots for each method, and weed presence and density were assessed within 24 randomly selected 1 x 1 m quadrat frames using image analysis in ArcGIS Pro (v3.3.2, ESRI). Weed control efficiency was calculated by comparing weed densities before and after the mechanical operations. Long-term effects were evaluated by measuring weed biomass before harvest and comparing wheat yields between robot- and tractor-managed plots. The results indicated limited overall weed control efficiency in wheat for both methods, with no significant differences in species-specific control or biomass reduction. However, robot-managed plots consistently achieved higher wheat yields than those managed by the tractor. These findings suggest that autonomous robots can deliver comparable weeding performance to traditional tractors while offering additional advantages, such as reduced soil compaction and improved labour efficiency. While these preliminary results highlight the potential of robotic systems for precision agriculture, further trials under diverse conditions are needed to refine their effectiveness and address user requirements.

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Keywords: *Autonomous Agricultural Robots; Mechanical Weed Control; Wheat Production; Precision Agriculture; Sustainable Farming Practices*

Authenticity and Traceability of Pomodorino del Piennolo del Vesuvio PDO: A geochemical fingerprinting approach

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Nowadays consumers are more aware of food safety issues due to numerous food scandals over the last two decades. Soil represents the primary source of mineral elements for plants, which can be transferred to agricultural products depending on their bioavailability and pedoclimatic conditions. Therefore, differences in element distribution across geographic regions are reflected in agriproducts. For this reason, geochemical fingerprinting is one of the most widely used techniques to discriminate the geographical origin of food. In this study, multielement analysis and chemometric methods were proposed to discriminate the *Pomodorino del Piennolo del Vesuvio* PDO according to its geographical origin. The peculiar cultivation environment strongly influences the quality and organoleptic properties of this tomato, which, due to its typicity, is a product susceptible to origin fraud. In 2021, 2022 and 2023 soils and tomato samples were collected from representative farms both within and outside the PDO area. These samples were analyzed for their multielement profiles by ICP-MS, in particular, soils were characterized for physical chemical properties and extracted for potentially and readily bioavailable elements. Principal Component Analysis of the geochemical fingerprints grouped tomatoes from PDO farms, revealing a differentiation even at small geographical scale. Stepwise Linear Discriminant Analysis classified tomatoes with a high degree of accuracy and evidenced Ca, Rb and Cs as predominant mineral elements discriminating the geographical origin of this tomato. The strong correlation between tomato and soil geochemical profile and the soil discrimination by not-essential elements suggested the use of these elements as reliable indicators of tomato provenance. The research activities are supported by the METROFOOD-IT Project “Strengthening of the Italian RI for Metrology and Open Access Data in support to the Agrifood”, funded under the National Recovery and Resilience Plan (NRRP), Mission 4 “Education and Research”.

Keywords: *Multielement, soil, chemometrics, origin fraud*

Optimization of artificial light strategies for baby leaf lettuce growth under Vertical Farming system (VFs)

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The production of leafy vegetables in Vertical Farming systems (VFs) under artificial light (LED) involves an energy-intensive process. Light is an essential factor for plant growth and the success of indoor systems depends on the quantity and quality of it. The aim of this study was to define the optimal combination of photoperiod and photosynthetic photon flux density (PPFD) for *Lactuca sativa* L. in terms of energy use efficiency (EUE) in VFs to optimize the management of LED. Three experimental trials were conducted in a growth chamber using two lettuce varieties - 'Falstaff' (green) and 'Copacabana' (red) -, grown in 0.5 L pots with a 50:50 of fine and coarse perlite mixture. A closed-cycle ebb-and-flow fertigation system was used. Three light treatments (light/dark) with the same Daily Light Integral (DLI) of 14.4 $mol \cdot m^{-2} \cdot d^{-1}$ and BGR spectrum were tested: 16/8 h (A), 12/12 h (B), and 24/0 h (C); the PPFD was 250, 340, and 170 $\mu mol \cdot m^{-2} \cdot s$, respectively. Temperature and Relative Humidity were set at 24 °C and 65%, respectively. Physiological, morphological and energy parameters were taken. In all the experimental trials, the plants grown under C treatment showed a fresh weight (39.04 g), yield (1,300 $g \cdot m^{-2}$) and EUE (11 $g \cdot kWh^{-1}$). The morphological parameters, like leaves number and leaves area, did not show a significant difference between light treatments. Furthermore, the highest leaf chlorophyll content value (331 $\mu mol \cdot m^{-2}$) was observed in C treatment, as well as the photosystem II efficiency [Y(II): 0.52]. According to our results, the photoperiod of 24 hours of light for an optimal growth of baby leaf lettuce varieties under a VFs is required. Despite this, more physiological, morphological and post-harvest features must be considered to define the optimal combination of photoperiod and spectrum (type and intensity) to enable a sustainable and energy-saving production of leafy vegetables in a VFs.

Keywords: *photoperiod, PPFD, photosynthesis, energy use efficiency (EUE)*

Densimetric sorting of olives to control olive oil quality

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Extra virgin is the most valuable commercial category among olive oils, and its quality is influenced by various factors, with the olive fruit playing a fundamental role. The olives that enter the mill exhibit significant variability in their physical and chemical characteristics, potentially impacting the quality of the extracted oil. Therefore, selecting olives post-harvest could be a crucial step, particularly for differentiating the final product and producing high-quality oil. This study aimed to conduct post-harvest densimetric sorting of olives. For this purpose, a saline solution with different salt concentrations was used over three days of harvesting, allowing the initial olive batch to be divided into two sub-batches with different densities. Oil was then extracted from each sub-batch, referred to as low- and high-density oils, respectively, followed by appropriate physical and chemical analyses to characterize both the olives and the oils. Although both oils were classified as extra virgin, significant differences were observed. The low-density oil exhibited higher concentrations of phenolic and volatile compounds, which are associated with positive sensory attributes. Densimetric sorting of olives could represent a novel approach in the field of extra virgin olive oil production, enabling differentiation of the final product.

Keywords: *extra virgin olive oil, extraction, quality, post-harvest sorting, physical–chemical properties*

Session P7: From Local to Global Pressures: Mapping and Mitigating Environmental and Economic Risks in Agriculture

Thursday 5th June. Chair: Oscar Rosario Belfiore

Assessing Soil Ecosystem Services in Mediterranean Olive Farming

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Introduction and objectives

Ecosystem Services (ESs) are essential for agricultural sustainability, providing benefits such as soil stability and carbon sequestration. Soil Erosion Resistance (ER) and Soil Organic Carbon (SOC) are particularly critical in Mediterranean olive growing, where soil degradation threatens long-term productivity. Life Cycle Thinking (LCT) integrating Geographic Information Systems (GIS), enables a spatially explicit evaluation of these services. This study assesses ER and SOC in 12 Mediterranean olive farms from the international project SustainOlive, which involved six countries across Europe and North Africa with different management systems, quantifying the environmental and economic impact of sustainable practices.

Methods

The assessment was conducted using the LANCA® model, with spatial data analysis in QGIS v3.14.15 "Firenze." Erosion resistance was quantified through the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997), with Mediterranean-specific correction factors from Panagos et al. (2014) for European farms, while alternative methodologies were applied for North African farms. Soil organic carbon was assessed following De Laurentiis et al., (2024), considering climatic conditions, management, and input variables. The economic valuation used restoration costs for ER and the social cost of carbon for SOC.

Farms were classified into Sustainable Technological Solutions (STS) farms, adopting agroecological practices, and conventional farms, using intensive tillage and synthetic fertilizers. The Functional Unit (FU) was 1 ha of olive grove per year and 1 ton of olives per year, with gate-to-gate system boundaries.

Main results and conclusions

The STS farms showed a 65% reduction in soil erosion and 2.2 times higher SOC levels compared to conventional farms, improving soil fertility and reducing restoration costs. Their higher financial returns reinforce the need for policy incentives such as subsidies, tax reductions, and carbon credit integration. Including ESs in LCA supports greener agricultural transitions and aligns farming incentives with the European Green Deal, ensuring climate-adaptive and economically competitive Mediterranean olive farms.

Keywords: Ecosystem Services, Soil Erosion Resistance, Soil Organic Carbon, Life Cycle Assessment, Sustainable Agriculture

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Economic analysis of the potential adoption of agrivoltaic systems in dairy sheep farms in Italy.

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The ecological transition is a broad and integrated process aimed at ensuring environmental, social, and economic sustainability. It includes biodiversity protection, the responsible management of natural resources, and rural development. Within this framework, the energy transition plays a key role by promoting renewable energy sources and the decarbonization of production systems, in line with the European goal of achieving climate neutrality by 2050 [3]. In a context of increasing competition for land use, agrivoltaic (AV) systems offer an innovative solution that enables the dual use of land for photovoltaic energy production and agricultural activities [2,4]. The integration of photovoltaics with sheep farming appears particularly promising, as it requires minimal changes to existing infrastructure and can enhance animal welfare by creating favorable microclimates and offering protection from heat stress [1].

To date, scientific literature on agrivoltaics has focused mainly on the technological and agronomic aspects of AV systems, while few studies have thoroughly analyzed the economic impacts on farms. In particular, no studies have been found that specifically examine the integration of agrivoltaics with dairy sheep farming, highlighting the need to explore this topic to fill an important knowledge gap.

This study aims to assess the economic impact of adopting AV systems on dairy sheep farms in the province of Sassari, Sardinia—an area strongly specialized in livestock production and marked by significant environmental heterogeneity. Using 2022–2023 data from the Italian Farm Accountancy Data Network (FADN) and the FEAD-Plus model, the analysis compares scenarios with and without AV, considering the percentage of pasture area used and the type of investment (by the farm itself or third parties). The goal is to understand whether, and under what conditions, AV can support the economic resilience of farms without compromising livestock activities, offering valuable insights for public policy.

Keywords: agrivoltaic, dairy sheep, economic analysis, dual land use, renewable energy

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A gis-based approach for estimating and mapping agricultural plastic waste in italy

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The rise in global population and the consequent increase in food demand have required greater efforts from the agricultural sector, leading to increased production of agricultural plastic waste (APW). Plastics are widely used in agriculture due to their benefits in enhancing both the quantity and quality of products. The primary challenge associated with their extensive use is the management of plastics at the end of their lifecycle. APW mismanagement practices are very common largely due to the absence of a proper management system. This study aims to set the basis of a possible APW management system. The proposed approach is based on estimating the APW quantity and mapping it on the territory using a geographic information system (GIS). Italy was selected as the case study, with the analysis conducted at the regional NUTS 2 level. Specific indices were developed for estimating APW generation per crop type and plastic application. Data on crops distribution, plastic applications and related properties were obtained from different sources. The integration of collected data with plastic waste indices allowed the APW to be quantified. Base map was then manipulated by adding APW values through GIS. The results showed the hotspots of APW production across the Italian regions. Considering the whole yearly amount of APW, Sicily (114,523 tons) and Apulia (96,832 tons) are the regions with the highest generation. This study proposes a scalable approach that could be also extended to other countries. The application of this methodology allows the identification of critical areas for APW production and can serve as a tailored tool for planning a proper collection and disposal system. Ultimately, this study can contribute to enhancing the sustainability of the agro-ecosystem by reducing plastic pollution.

Keywords: *agricultural practices, plastic pollution, GIS, waste management, sustainability*

Land degradation in sub-Saharian regions: assessment, monitoring and restoration strategies.

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Land degradation poses a significant risk to communities that rely on natural resources and to the broader ecosystem. A key challenge is the decline in soil fertility, which can progress to irreversible loss. The two primary drivers of land degradation are human exploitation and climate change. While climate change cannot be directly altered, it can be monitored; the human behaviour can be managed and adapted. For this reason, monitoring conservancies and degraded areas is essential for informing policymakers about where and how to apply restoration policies and investments. To date, numerous global studies have developed models to map and to monitor land degradation in susceptible regions. However, efforts to restore land degradation in sub-Saharan Africa remain underexplored. This is particularly concerning given the region's high demographic growth rates, as anthropogenic impacts and efforts are often overlooked in existing land degradation control strategies. This research aims to develop a model tailored to sub-Saharan conditions that integrates key variables influencing land degradation, compares restored and overexploited ecosystems, and identifies degradation hotspots to guide ecosystem restoration planning. The study focuses on sub-humid, arid, and semi-arid regions of sub-Saharan Africa. The analysis combines the Land Degradation Surveillance Framework, which underpins the field sampling and analyses already conducted—with remote sensing and participatory approaches involving local communities. The expected outcomes include identifying successfully restored areas, assessing the most effective land rehabilitation practices, and pinpointing regions in urgent need of intervention. Ultimately, this model could be adapted for use in other data-scarce regions seeking high-quality research methodologies for land degradation assessment and restoration planning.

Keywords: *Land degradation, sub-Saharan Africa, Remote Sensing, Data-scarce*

Economic risk assessment of agricultural drought: implementation of the ADERA model for sunflower cultivation in central Italy

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Climate change is increasingly amplifying the frequency and intensity of droughts, significantly affecting agricultural productivity and economic viability of farms. Among European regions, the Mediterranean area is particularly vulnerable, especially for rainfed crops. This study examines the economic risk associated with agricultural drought by applying and refining the ADERA model (Agricultural Drought Economic Risk Assessment), a tool designed to quantitatively assess crop vulnerability and estimate economic losses. The ADERA model approaches agricultural drought not as an isolated event but as an intrinsic element of local agro-climatic systems, with a given recurrence probability. It identifies critical thresholds for water availability and economic impact, calculating the critical operating margin which makes the economic viability of crops at risk. The analysis is based on long-term climate data (1950–2023), combined with pedological information from the European LUCAS database and economic data from Italian Farm Accountancy Data Network. The study focuses on sunflower, a key rotation crop in Central Italy, that is particularly sensitive to water deficits due to its non-irrigated nature. In detail, the FAO AquaCrop Software was used to simulate sunflower yields under both rainfed and irrigated conditions in the Marche Region. AquaCrop, specifically designed to model the impact of water stress on crops, enabled yield estimation and helped define critical thresholds for both yield and economic sustainability. In addition to mapping drought risk, the study assesses the technical and economic feasibility of supplemental irrigation during the sunflower flowering stage. Results offer a comprehensive and practical perspective on the challenges posed by climate variability. Likewise, they provide insightful indications for developing adaptive strategies to a key rotation crop in the Italian context, so as to strengthen the resilience and sustainability of the agricultural sector.

Keywords: *Climate Change; Drought; Economic Risk Assessment; ADERA Model; Italy.*

Land Use Challenges: Balancing Agricultural Needs and Renewable Energy Goals

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Nowadays society is confronted with the difficult task of balancing food security for a rising population meanwhile tackling climate change. To face climate change, the EU is encouraging the uptake of renewable energy generation throughout a set of policies aiming at reaching net zero carbon emissions by 2050. Renewable energy production presents significant challenges, particularly concerning land use allocation (Schindele et al., 2020). Biofuel production necessitates the cultivation of energy crops, which compete upon arable land traditionally used for food and feed agriculture. For instance, the expansion of bioenergy has been identified as a major driver of recent land use changes in developed regions (van de Ven et al., 2021). An improper implementation of large-scale bioenergy production may lead to an increase in food prices and elevate the risk of food insecurity in various regions worldwide (Hasegawa et al., 2020). Concurrently, the establishment of wind and solar power plants requires considerable areas, potentially overlapping with agricultural lands, further exacerbating land use conflicts. In regions like Lombardy (Italy), notable for its agricultural productivity, this dual demand intensifies competition for finite land resources. Furthermore, according to the Italian energy service operator (GSE – Gestore Servizi Energetici), Lombardy has the highest installed photovoltaic capacity among Italian regions (7.49% of the total capacity), contributing to 8.75% of the national gross output (Gestore dei Servizi Energetici and Direzione Mercati, 2024). Ensuring a sustainable implementation of renewable energy sources (RES) implies the avoidance of significant trade-offs with the food and feed agricultural sector. Through an econometric spatial analysis of regional land use data, this study aims to assesses the extent of land competition between food-feed agriculture and RES development. Examining the specific context of the Lombardy region (Italy), this paper contributes to the ongoing discussion of balancing agricultural needs with renewable energy priorities, underlining the importance of a coordinated land use planning that promote sustainable coexistence of RES and food-feed agricultural production.

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Keywords: Land Use, RES, Bioenergy, Food-Feed Agriculture

Session P8: Agri-Food By-Products as a Resource: Biostimulants, Biofertilizers, and Functional Ingredients

Thursday 5th June. Chair: Domenico Ronga

Biostimulant effects of pumpkin seed extracts on the growth and quality of baby leaf lettuce (Lactuca sativa L.)

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Modern agriculture is seeking eco-friendly solutions to enhance crop yield and quality while reducing the use of synthetic fertilisers. Biostimulants derived from agri-food waste, such as pumpkin seed extracts, represent a promising option to promote plant growth and optimise nutrient uptake. The approach of obtaining biostimulants from food and agro-industrial waste addresses the contradiction between population growth, declining food production, and global environmental degradation, offering opportunities for the utilisation of organic waste resources and providing benefits to farmers, consumers, food industry, distributors, and the global environment. The aim of this study was to evaluate the effects of foliar application of various enzymatic extracts from pumpkin seeds, obtained through digestion with pepsin and trypsin, on the growth and physiological and qualitative characteristics of baby leaf lettuce (Lactuca sativa L. var. Eden). Agronomic, physiological, and qualitative parameters were monitored to determine the biostimulant potential of these extracts. The results demonstrated that foliar treatment with pepsin-digested pumpkin seeds increased leaf area, chlorophyll content, and both shoot and root biomass, thereby enhancing photosynthetic efficiency. Foliar treatment with trypsin-digested pumpkin seeds improved soil water availability. Furthermore, the treatments influenced key physiological parameters, such as stomatal conductance and leaf temperature, indicating increased metabolic activity. From a qualitative perspective, the pepsin-treated pumpkin seed extract reduced nitrate content compared to the control, making the product safer. Finally, the green index and dry weight of the plants were higher in the trypsin-treated group, confirming the role of pumpkin seed extracts in improving both yield and quality of baby leaf lettuce.

Keywords: Nutrient uptake efficiency, plant biostimulation, agricultural waste valorisation, yield optimisation, quality improvement.

Acknowledgements This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR)—MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4—D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

From Waste to Wealth: Transforming agricultural waste into a Powerful Biofertilizer for Sustainable Agriculture

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This study, conducted in Calabria (Southern Italy), explores the potential of repurposing olive oil production residues into high-quality compost as a sustainable alternative to synthetic fertilizers. Olive oil waste, often seen as an environmental burden, is rich in biomolecules that enhance soil fertility while reducing chemical inputs. This research aligns with key sustainability frameworks, including the UN Sustainable Development Goals, the EU Green Deal, and the Farm to Fork Strategy, promoting circularity and environmental resilience. Three composts were produced in 300 L bins: OWC1 (90% olive oil waste from a three-phase extraction process + 10% straw), OWC2 (90% olive oil waste from a two-phase centrifugation system + 10% straw), and OWC3 (34% olive oil waste from a two-phase decanter system + 33% buffalo manure + 33% straw). After 180 days, chemical and biological analyses showed that all composts improved soil fertility, with OWC3 delivering the greatest boost to microbial activity and soil health. OWC1 outperformed OWC2, highlighting how extraction methods influence compost quality. A life cycle assessment (LCA), according to UNI EN ISO 14040:2021 and UNI EN ISO 14044:2021, revealed that OWC3 had the lowest environmental footprint compared with OWC1, OWC2, and synthetic and commercial organic fertilizers commonly used by local producers, while offering the highest fertilizer potential. This study demonstrates how agro-industrial waste can become a valuable resource, transforming an environmental challenge into a solution that enhances soil regeneration, reduces pollution, and supports a circular bioeconomy. By integrating waste valorization into sustainable agricultural practices, this approach not only improves soil health but also mitigates environmental impact, representing a crucial step toward a greener, more resilient food system.

Keywords: Olive pomace; sustainable agriculture; soil fertility; Environmental impact; Life Cycle Assessment

Green approaches to recover biomolecules from wheat bran

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Cereals are one of the most significant crops in the world, used for both human and animal feed. The FAO's biannual publication *Food Outlook* (2024)[1] reported that grain production has reached 3 billion tons. Milling industry by-products have substantial nutritional potential, among them wheat bran is one of the most abundant. Today's challenge is the recovery of biomolecules, through bran structure disassembly, implementing green technologies[2]. Enzymatic-assisted extraction represents a sustainable alternative to chemical treatments; the most common strategy for extracting compounds from biomass is the use of hydrolases[3]. The present study focuses on the recovery of proteins and antioxidant compounds, from wheat bran, through enzymatic-assisted extraction process (EAEP) with alcalase protease, compared with aqueous extraction process (AEP). Box-Behnken design (BBD) by response surface method was employed to investigate the effects of extraction parameters and to determine optimum process conditions. The following conditions were explored: enzyme concentrations (1500-500 U/g), temperature (30-20°C) and time (60-20 min), by fixing pH at 8.60 and solute-liquid ratio at 1:10 w/v. Protein yield, degree of hydrolysis, antioxidant capacity values and zeta potential were chosen as dependent variables. Predicted optimal condition, based on the response surface methodology, was considered to validate the model. Results demonstrated that EAEP significantly affected protein yield (17.49% to 53.82%), degree of hydrolysis (22.93 to 48.83%), antioxidant capacity (11.72 to 38.15%) and zeta potential (-5.86 to -13.02 mV) compared with lower results obtained for AEP: protein yield (15.13% to 26.40%), degree of hydrolysis (17.50 to 21.85%), antioxidant capacity (14.27 to 17.79%) and zeta potential. In conclusion, these findings suggest that EAEP is a promising green technology to valorize the nutritional value of wheat bran. This approach may be used to standardize further hydrolysis from wheat bran, moving from a laboratory to an industrial scale.

***Keywords**: Wheat bran**,** Enzyme-assisted extraction, Valorization food by-products, Box-Behnken, Response surface method*

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Bioconversion of food industry side-streams into polyunsaturated fatty acids through microalgae in the era of circular economy

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The increasing global demand for polyunsaturated fatty acids (PUFAs), particularly omega-3 fatty acids such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), has driven research toward sustainable and cost-effective production alternatives. This study presents the results of extensive research into the feasibility of cultivating microalgae using food waste and by-products as nutrient sources, integrating waste valorization with high-value lipid production. By adopting a biorefinery approach, we observed that food industry residues such as dairy effluents, molasses, and lignocellulosic hydrolysates can effectively support the growth of lipid-rich microalgal strains, including Phaeodactylum tricornutum, Aurantiochytrium sp., and Nannochloropsis oculata. The choice of species is critical and should be aligned with the specific PUFA targets, whether DHA, EPA, or a balanced profile of both. We emphasized the importance of pre-treatment processes, such as enzymatic hydrolysis, in enhancing the nutrient bioavailability of complex food waste materials, thereby optimizing microalgal growth and productivity. The results revealed that these alternative media not only support biomass growth comparable to conventional synthetic media but also enhance the accumulation of essential fatty acids, with EPA yields reaching up to 45.5% and DHA concentrations exceeding 40% in optimized conditions. Additionally, the integration of food waste substrates led to a significant reduction in production costs, aligning with circular economy principles and promoting sustainable bio-based industries. Despite the promising results, challenges such as the variability of waste composition and potential contamination risks remain critical considerations for large-scale implementation. To address this, we developed a decision-making framework for optimizing resource utilization, process standardization, and economic viability. Our findings confirm that food waste-derived cultivation media provide a scalable and sustainable alternative to traditional methods, fostering innovation in biofuel production and nutraceutical applications.

Keywords: Microalgae, Food waste valorization, Bioconversion, Techno-economic analysis.

OPTIMIZING INSECT FARMING FOR LOCAL FEED PRODUCTION: A PILOT STUDY IN CIRCULAR ECONOMY

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The high market price of insect-based proteins remains a significant barrier to their widespread use in animal feed, despite their potential as a sustainable alternative to traditional sources like soy. As demand for alternative protein sources grows, exploring viable solutions becomes increasingly important. This study examines the feasibility of small-scale, locally produced insect flour as a cost-effective option for livestock feed, with a particular focus on aquaculture. Specifically, it assesses whether insect flour derived from local waste materials can serve as a viable and sustainable alternative to imported proteins, reducing environmental impact and enhancing food system resilience. The research is based on a pilot facility for breeding and processing black soldier fly (Hermetia illucens) at the Experimental Center of Tetto Frati (Carmagnola -Piedmont; Italy) within the part of the AGRITECH project (PNRR). The facility integrates local waste streams into insect farming, promoting circular economy principles. By utilizing and processing organic by-products on-site, this approach aims to lower production costs, decrease reliance on external protein suppliers, and contribute to the local economy through waste valorization. Key economic factors influencing the viability of this supply chain include fixed costs, which remain constant regardless of production levels, and variable costs, which depend on whether raw materials are sourced as waste or purchased. While utilizing waste can reduce expenses, additional costs may arise from standardizing row materials for different production cycles to ensure consistent nutritional quality. Scaling up production to compete with conventional protein sources like soy requires continued research and innovation in farming, processing technologies, and supply chain optimization. This study provides valuable insights into the economic sustainability of insect farming for feed applications, demonstrating its potential to contribute to more resilient, cost-effective, and environmentally sustainable food systems.

Keywords: economic feasibility, pilot plant, insect-based feed, circular economy, supply chain.

Session P9: Soil Health and Agroecological Transitions: Innovative Approaches for Sustainable Land Use

Thursday 5th June. Chair: Antonio Giandonato Caporale

Soil health and innovative practices at support of traditional agrifood products in marginal areas

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The Mediterranean basin is considered a hotspot of climate change, being interested by an average annual temperature increase of 1.4 °C since late 19th-century and by an increased frequency in extreme events, like heat waves and drought. These environmental changes, together with socio-economic transformations, endanger the agricultural practice mainly in marginal areas, as small islands are. In this context, the island of Ventotene (central Tyrrhenian Sea) represents a model area for assessing the effects of climate change on the chemical-physical fertility, prerequisite for developing adaptation strategies.

In the study area, a soil monitoring activity is ongoing with the aim to characterize the soils diversity and identify innovative soil management practices. Soil samples were collected in different traditional agro-systems (*Lens culinaris* Medik. and *Vitis vinifera* L.) based on diverse types of soils. Through a local network of prototypal sensors (Prospecto S.r.l.) the seasonal variability of physical-chemical soil traits was monitored. Furthermore, as climate change adaptation strategy, the soil application of basalt powder, a corroborant produced by mechanically grinding of the pure mineral, was tested.

The physical-chemical analysis of the diverse island's soil types showed several critical issues, including: i) low organic matter content (<1.5%), ii) low total nitrogen content (<1 g/kg), iii) significant sodium content (300 mg/kg) and a SAR ratio classifying the soils as sodic (>13). The water potential and soil temperature reached stressor values close to -250 Kpa and 30 °C respectively, already at the flowering time of both lentil and grapevine. Finally, the application of the basalt powder to the soil, resulted in a significant improvement in the biometric traits of the root system of the lentil plants, when applied at sowing time.

The increase in soil's trait knowledge and the promotion of innovative agronomic strategies may contribute to safeguard the endangered agricultural systems in Mediterranean marginal areas.

Keywords: *Soil fertility, Mediterranean sensitive areas, Local soil monitoring, Abiotic stress, Agronomic strategies.*

Assessing the Impact of Regenerative Agricultural Practices on Soil Health: A Comparative Study of Different Systems

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The increasing demand for sustainable and low-impact agri-practices makes regenerative agriculture's approach more interesting. In fact this model aims to restore and enhance soil health, promoting biodiversity and contributing to mitigate climate change. To evaluate regenerative practices effects on soil health, two comparative trials have been conducted: (1) a study comparing regenerative versus conventional agri-practices; (2) within the regenerative system, a comparison between strip-cropping and monoculture systems.

Soil sampling has been done at the EROC experimental field in Parma (44° 50' 58.2108" N, 10° 16' 46.4376" E).

In the first experiment, samples have been categorized based on the management system: CC (Conventional Cereals), CT (Conventional Tomato), CMS (Conventional Mixed System), RC (Regenerative Cereals), RT (Regenerative Tomato), and RMS (Regenerative Mixed System).

In the second experiment, samples have been classified as RV1 and RV2 (Regenerative Vegetables Strip-Cropping Systems) and RMON1 to RMON6 (Regenerative Vegetables Monocultures).

The experiments findings indicate that regenerative agriculture significantly changes key soil properties. Moreover, all regenerative treatments (RC, RT, RMS, RV1, RV2, RMON1–6) have shown changes in soil organic matter (SOM) and microbial activity, making it clear the positive impact of practices like minimal tillage, organic amendments, cover crops and strip-cropping. In particular, soil respiration rates has been consistently higher during all regenerative treatments, with RMS and strip-cropping systems (RV1, RV2) showing the most significant microbial activity, thereby highlighting the effects of these practices on soil health.

This study highlights the potential of regenerative agriculture as a sustainable alternative to conventional practices, offering substantial changes in soil health while supporting productive and resilient agricultural systems.

Keywords: *Regenerative organic agriculture, Soil quality, Agricultural sustainability, Agroecology*

Soil Amendment Strategies Using Agroecological Practices in a Long-Term Experiment in Tuscany (Italy)

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Organic farming systems in the Mediterranean area are often stockless. The stockless management eventually results in a scarcity of soil organic matter, which in turn is thought to be the main hurdle in coupling soil quality with crop nutrition. Therefore, it seems necessary to investigate fertilization solutions that can reconnect crops and animal production, thus allowing the local unfolding of nutrient element cycles.

This study, conducted as part of the ECOCAFFE' project, aims to perform a comprehensive soil quality assessment using a systemic approach. It incorporates a broad set of indicators encompassing chemical, physical, and biological soil properties to evaluate the effects of different organic amendments, including pelleted manure, fresh manure, and biodynamic compost. The research is carried out at the Montepaldi Long-Term Experiment (MoLTE) in Tuscany, Italy. Soil quality was evaluated through the following indicators: i) chemical (Olsen P, Kjeldahl N and, OM); ii) physical (penetrometry, aggregate stability); iii) biological (earthworm abundance and QBS-ar index).

Throughout this three-years study (2020-2023), the tested soil amendments have not influenced the tested indicators, probably due to the relatively short timeframe of the experiment.

The primary effects were linked to crop rotation, specifically the transition from a cereal crop (Triticum aestivum L.) to a perennial leguminous species (Medicago sativa L.).

Among the soil quality indicators assessed, our findings suggest that biological indicators, such as earthworm abundance and the QBS-ar index, are the most informative and valuable for monitoring in the MoLTE experiment. These indicators demonstrated high sensitivity to soil management practices, highlighting how diversified crop rotation can enhance soil quality.

Keywords: *Soil quality, Biodynamic agriculture; Organic agriculture; Mediterranean area; Compost*

Subclover (*Trifolium subterraneum* L.) Cover Cropping as a Soil Management Strategy to Enhance The Sustainability Of Pear (*Pirus communis)* Orchards

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Introduction

Given the growing challenges of climate change and increasing consumer demand for high-quality fruits, optimizing agricultural management practices is crucial to achieving high yields and ensuring the sustainability of orchards. Bare soil management exacerbates the loss of soil organic carbon (SOC), whereas cover crops (CCs) are recognized as an effective agronomic practice for enhancing SOC sequestration in orchards.

Objective

The objective of this study is to assess the effects of subclover cultivation in the inter-row of pear orchards as an alternative to conventional soil management practice.

Material and methods

A two-year field experiment was conducted in the pear orchard of the "Fondazione Navarra" in Ferrara, Italy. Three inter-row soil managements were evaluated: (1) tilled soil at 30 cm depth (TILL); (2) natural grassing (NAT); and (3) controlled grassing using subclover as a legume CC (CLO). A randomized block design with three replicates was adopted in both years. Regular soil monitoring of carbon dioxide (CO_2) emissions, moisture and compaction were conducted at 15 days interval using EGM-5 Portable gas analyser, a TDR FieldScout 350 soil moisture meter, and a FieldScout SC-900 soil compaction meter, respectively.

Results and discussion

Results showed that, in 2023, soil CO_2 emissions were similar across all treatments. Peaks of soil CO_2 emissions were observed under TILL management after the initial soil treatments. However, CLO soil management has recorded higher CO_2 emissions for the May-September period. In 2024, no significant differences in CO_2 emissions were observed between treatments. Soil moisture at a depth of 7.5 cm was slightly higher under CLO management in 2024, likely due to the late establishment of clover in 2023, which created a mulch that reduced soil evapotranspiration. Furthermore, at pear harvest, soil under CLO management was less compacted than soil under TILL and NAT managements, probably due to the effect of subclover roots that improved the soil aeration and structure.

Keywords: *Subclover, Sustainability, Pear orchard, Inter-row grassing, Soil management*

Living Labs for Future Healthy Soils: a Review

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Soil is fundamental to life on Earth through the provision of ecosystem services that involve the production of biomass (terrestrial ecosystems, food, fodder, fibre and fuel), the regulation of water flows and climate-altering gases (CO_2, N_2O, CH_4), anchoring for infrastructure, the provision of building materials, as well as the aesthetic value of landscapes, which enable people's habits, recreation and inspiration. The current model of our societies exerts significant pressure on this resource, resulting in its degradation, accelerated by the effects of climate change. This situation hinders the achievement of the Sustainable Development Goals, and some regions of the world have initiated efforts to reverse this trend, including the European Union, which has adopted the Living Lab (SHLL) approach. Given the growing interest within the EU and the lack of synthesis, the following review aims to fill this knowledge gap, also providing information regarding the SOILL-Startup project that supports the presence of a SHLL network at European level. The review seeks to answer the following questions: What are the characteristics of an SHLL?; What are its fields of application?; What is their global and European diffusion? The review was conducted according to the PRISMA method and highlights the characteristics of SHLL (definitions, stakeholders, field and scale of application) as well as their geographical distribution. This work provides information for the scientific community, civil society and policy makers who give priority to soil health, regardless of their specific context (urban, peri-urban, rural, natural areas).

Keywords: *soil health; soil health living lab; lighthouse; SDGs; SOILL-Startup*

Influence of soil management on fruit quality and soil fertility in olive groves from sardinia

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In Sardinia (IT), most of the olive groves have traditional cultivation systems characterized by low plant density, rainfeed conditions, and tillage, used to avoid weed competition for water and nutrients. Among the soil management techniques with low environmental impact, cover cropping are known to provide advantages in terms of protection from erosion, organic matter content, and biodiversity. The aim of this work is to compare the effect of traditional soil management (tillage, TT) and cover crop management (CC) on soil physico-chemical properties and quality of production in Sardinian olive groves. Four groves in two sites in north-western Sardinia (Sassari and Alghero) were selected, two of them managed with CC and two with TT. In both sites, the TT and CC orchards were adjacent and with same environmental conditions. Bulk density, pH, total carbon and nitrogen, and soil carbonate content were measured at two depths (0-10 and 10-30 cm). Morphometric parameters, maturation index, oil yield and phenolic content were determined in the olive drupes, harvested in November 2024. Soil pH (7.1 - 8.1) was lower in CC in Alghero, while soil organic carbon (higher in TT) and bulk density (higher in CC) were observed only in Alghero. Fruit characteristics, were affected at first by site and interaction with soil management. Fruit and pit weight in Sassari were higher in TT than CC, whilst the opposit occurred in Alghero. Fruit to pit ratio was higher in CC in both sites. Fruit maturation, was not affected by soil management. In conclusion, soil management can affect both soil and olive fruit characteristics, however site specific environmental and plant conditions should be takent into account. This research was funded by SANCHOSTHIRST project (pci2023-143374), EU Horizon 2020 research and innovation programme (Grant Agreement No. 862696).

Keywords: *Olea europaea; soil management; SOC stock; fruit composition*

Session P10: Innovations in Soil Health Assessment: From Microbial Insights to Open-Source Monitoring

Thursday 5th June. Chair: Mauro De Feudis

Effects of Salinity Stress on Hydroponically Grown Sweet Basil and Mint species in Indoor Farming

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The increasing salinization of irrigation water poses a major challenge to sustainable agriculture. Hydroponic cultivation provides a viable solution, particularly in regions increasingly affected by climate change. Additionally, when hydroponics is integrated into an indoor farming system, they offer a totally controlled environment, allowing salinity effects to be isolated from other abiotic and biotic stressors. Using a Floating System in a monitored indoor setup (i3FarmTech), this study evaluates plant growth, physiological traits, and biochemical responses to assess the impact of salinity stress on two sweet basil cultivars (Ocimum basilicum "Italiano classico" and O. basilicum "Violetto") and two mint species (Mentha x piperita, peppermint, and M. spicata, spearmint), which hold economic and gastronomic value. The experimental design was set separately for each species and consisted of applying three salinity levels (EC 2, 4, 8 dS m^{-1}) to the selected species, with an ensured gradual exposure to increasing salinity levels for EC 4 and 8 dS m^{-1} to avoid osmotic shock. The design was a randomized complete block design with 3 salinity levels and 2 blocks. Basil plants produced less yield than mints, regardless of the treatments. Results indicate a general reduction in plant height, root length and fresh yield under the highest salt stress condition, albeit dry matter content was not affected. Basil "Violetto" demonstrated greater tolerance, than "Italiano classico", which conversely experienced higher plant growth reduction. In mint species, peppermint had higher photosynthetic stability and nitrate accumulation than spearmint, which conversely exhibited increased phenolic compound syntheses. Understanding how salinity affects these crops in hydroponic conditions is relevant for sustainable cultivation strategies. Identifying resilient genotypes and optimizing techniques is essential to maintaining aromatic plant productivity under salinity stress.

Keywords: *Osmotic stress, soilless system, Lamiaceae, physiological traits*

THE IMPACT OF COMPOSTABLE BIOPLASTICS ON SOIL-PLANT-MICROBIOTA SYSTEM

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The integration of bio-based materials into agroecosystems is crucial for enhancing interactions among plants, soil, and microorganisms. This approach not only addresses the urgent environmental challenges posed by conventional plastics but also promotes sustainable agricultural practices. My PhD project investigates the effects of compost derived from municipal organic waste containing varying amounts of Biodegradable and Compostable Plastics (BDCPs) on soil health and plant growth, with a particular focus on the interactions among plants, soil, and microorganisms. This research adopts a circular economic approach aimed at transforming waste into a valuable resource while promoting sustainable agricultural practices.

The characterization of three Mixed Compost Amendments (ACM) with different content of BDCPs was conducted: ACM0 (no bioplastics), ACM1 (1.43% bioplastics), ACM2 (2.84% bioplastics). Chemical analyses revealed that ACM0 and ACM1 exhibited lower moisture content compared to ACM2, while all amendments met regulatory standards for total organic carbon (TOC), total nitrogen (TN), and pH levels. Notably, despite ACM2 containing double BDCPs content of ACM1, it complied with national regulations regarding heavy metal concentrations, indicating effective degradation during composting. Stability analysis indicated that the presence of BDCPs in the composted materials does not significantly negatively affect the amendment and fertilizing functions of the tested materials.

However, some functional aspects related to soil microbial activity, such as basal respiration, showed notable effects that warrant further investigation, including the measurement of extracellular enzymatic activities. Experiments are ongoing; having established the effects on soil health, we are now testing the impact of these matrices on soil plant-microorganism interactions in mesocosms. Increased benefits in terms of plant growth and biomass and diversification of the microbial community due to bio-stimulation triggered by these matrices are expected.

Keywords*: soil functionality, biodegradable plastic, compostable plastic, circular economy, soil-plant-microbiota interactions.*

EVALUATING SOIL ECOSYSTEM SERVICES THROUGH A PROCESS-BASED MODELING APPROACH

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Globally, soil plays a crucial role in delivering multiple soil-based ecosystem services (SESs), such as food provisioning, water regulation and purification, nutrient cycling, and others. However, around 60 to 70% of soils in the EU are currently in an unhealthy state, highlighting the urgent need for concrete and immediate actions. Ultimately, a variety of soil health indices have been proposed, based on physical, chemical, and biological measurements, both in the field and in the laboratory. However, many of these indices, being derived from single measurements at specific points in time, fail to fully capture the complexity of the diverse and interconnected ecosystem services provided by soils. Consequently, evaluating SESs in a comprehensive spatio-temporal framework remains a significant challenge. This study introduces an integrated approach to evaluating SESs using the ARMOSA (Analysis of cRopping systems for Management Optimization and Sustainable Agriculture) process-based model. ARMOSA enables the quantification of the effect of several agronomic practices on a broad set of crop and soil-related variables, on a daily time scale. Various indicators were assessed in relation to key SES, including yield for food production, infiltration for water regulation, carbon stock changes for climate regulation, and nitrate leaching for nutrient cycling. By utilizing multiple integrated indicators rather than isolated measurements, this approach captures the dynamic interactions within the soil-plant-atmosphere system—including water, carbon, and nitrate balances—across both spatial and temporal scales. The results of this study highlight the potential of the integrated SESs evaluations to support sustainable soil management and inform strategies that align with global soil health objectives. This provides a more robust framework for soil health assessment tailored to site-specific characteristics. The approach is demonstrated in a hilly area of the Campania region (southern Italy), which encompasses five distinct climatic zones where durum wheat is the predominant crop.

Keywords: *Soil Health, Ecosystem Services, ARMOSA, modelling*

Soil organic matter pattern in an olive orchard with different management practices for 21 years

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Climate change and resource depletion due to population growth emphasize the need for conservation-based agricultural practices to prevent soil degradation. Studying soil organic matter (SOM) dynamics across different land uses is essential for assessing soil health and guiding sustainable agriculture. This study examined the physicochemical properties of soils from a Mediterranean olive orchard sustainably (S_{mng}) and conventionally (C_{mng}) managed for 21 years. The focus was on SOM in aggregates at three depths (0-5, 5-15, 15-30 cm) and across three aggregate size classes (1-0.250, 0.250-0.063, <0.063 mm). S_{mng} soils had higher total carbon (+50.7%) and nitrogen (+74.9%), as well as a greater aromatic OM component (+76.0%) in the 0-5 cm layer compared to C_{mng} soils, suggesting slower transport of organic matter into deeper layers. This effect was especially pronounced in micro-aggregates (<0.063 mm), with increases in carbon (+59.3%), nitrogen (+86.7%), and aromatic OM (+87.7%) in S_{mng} soils, likely due to their ability to bind small colloidal particles. S_{mng} soils also showed increased bacterial abundance and different accumulation of organic compounds from microbial fermentation, reflected in the OM's qualitative profile. Soil tillage in C_{mng} caused mineral alterations, whereas S_{mng} soils retained higher crystallinity. Examining the quality, stability, and interaction of SOM with mineral components, helps to understand its degradability and ecological behavior, which is crucial for mitigating climate change impacts and promoting land conservation. This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This work reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Keywords: Aggregate-associated organic matter, Soil metabolomics, Soil mineralogy, Sustainable soil management, Agroecology

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Unveiling the citrus rhizosphere: Microbial diversity and functional insights in organic and conventional soils

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Plants interact with diverse microbial communities that play a crucial role in their health, nutrient acquisition, and stress tolerance. The rhizosphere harbors a complex microbiota composed of both beneficial and pathogenic microorganisms. This study investigates how environmental conditions and agronomic practices shape rhizosphere microbiota composition in commercial citrus orchards across eastern Sicily, providing insights into sustainable soil management strategies. A comparative analysis was conducted between organically and conventionally managed orchards to assess the impact of organic fertilization, reduced tillage, and alternative pest control strategies on microbial diversity. A total of 150 rhizosphere soil samples were collected from fifteen orchards during summer and winter, encompassing various soil types, irrigation systems, and rootstock varieties. High-throughput Illumina sequencing, combined with advanced bioinformatic analyses (BeCrop®), was used to characterize both prokaryotic and fungal communities.The findings indicate that orchard location is the primary determinant of microbial community composition. However, soil management practices also influence microbial diversity and functionality. Organically managed orchards exhibited greater microbial diversity, enhanced network modularity, and increased co-exclusion patterns, indicative of a more resilient soil microbiome. Moreover, organic management was associated with a higher prevalence of microbial functions related to nitrogen fixation and phosphorus solubilization compared to conventional management. Fungal community composition, primarily dominated by Ascomycota, differed significantly between organic and conventional orchards, particularly in winter. Organically managed soils harbored a greater number of fungal taxa (54 vs. 25), including the biocontrol agent *Chaetomium convolutum*. Additionally, the bacterial genus *Nitrospira*, essential for nitrification, was detected exclusively in organically managed soils during winter, suggesting improved nitrogen use efficiency. Other beneficial microorganisms, such as *Sphingobacterium* and *Arthrobacter globiformis*, were also more abundant in organic systems.These results highlight the role of organic management in

enhancing microbial functional diversity, thereby contributing to increased citrus resilience and promoting sustainable agricultural practices.

Keywords: Rhizosphere microbiota, Soil management, Microbial diversity, Sustainable agriculture, Citrus orchards

SOS – Soil Observation System. A digital and open access alternative for soil data collection and management

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Introduction

In the last decade, several efforts have been made to improve soil datasets, institutions, companies and universities spend large number of resources to collect and store data on soil profiles and properties. However, the process of collection, storage, display and analysis often shows lack of efficiency and accessibility to the international audience.

Goals

In this scenario, the aim of the research is to generate and improve a tool to manage in open access environments, the above-mentioned process. Indeed, the "Soil Observation System" (SOS) is a digital, open access system for collecting, managing, storing and analysing of soil data.

Method

The system is based on other software such as *R studio* and the *Open Data Kit* (ODK). Through these tools, it can guide operators and researchers in the collection of soil data, in particular profiles and samples, to describe, monitor the condition of a soil and/or classify it. Using the appropriate forms, it is possible to collect all the data necessary to describe a soil and classify it according to the World References Base for Soil (WRB). The data is uploaded to the server and stored in a relational database (DBMS). The data stored in the database can be collected in the field or the result of analysis in the laboratory. Once the data is stored in the database, the user can view and download it immediately. If the user needs to check the data before downloading, he/she can automatically generate reports to check the quality of the data.

Conclusion

The system is already functioning, but it is still in the testing phase. In the short to medium term, the interface will migrate to the official domain, allowing access to the data collection tools in a more open and automated manner.

Keywords: *Soil Data Collect, Data Management, Open Data Kit, Open Access*

An open-source platform for tracking carbon dioxide levels in soil: proof of concept and prototype

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Carbon dioxide monitoring sensor technology has found applications in many sectors, including environmental monitoring. Its development and dissemination have been driven by the potential danger of carbon dioxide in enclosed, poorly ventilated, and crowded spaces. This need has led to the development a wide range of low-cost sensors. In this study, an open platform based on open-source hardware was created using the Sensirion SCD30 sensor to monitor carbon dioxide emissions from agricultural soils, with the aim of correlating emissions with microbial activity. The first objective was to verify the sensor's reliability at concentrations higher than those for which it is designed. To achieve this, the experimental design shown in Figure 1 was followed, generating incremental levels of CO2 from 100 to 20000 ppm through the controlled introduction of pure gas. As further validation, the levels were also measured by the Innova 1512 from LumaSense Technologies. After validation, a comparative performance test between the two sensors was conducted. For the experiment, 18 pots with a diameter of 260 mm and a volume of 12 L containing 6 soil samples each, for 3 replicates, were used. Static chambers were used to allow gas accumulation, as shown in Figure 2. The low-cost open-source prototype demonstrates the potential of a new tool in agricultural research, with high versatility, adaptability, and user-friendly functionality. The collected data opens the possibility for a microbiological study.

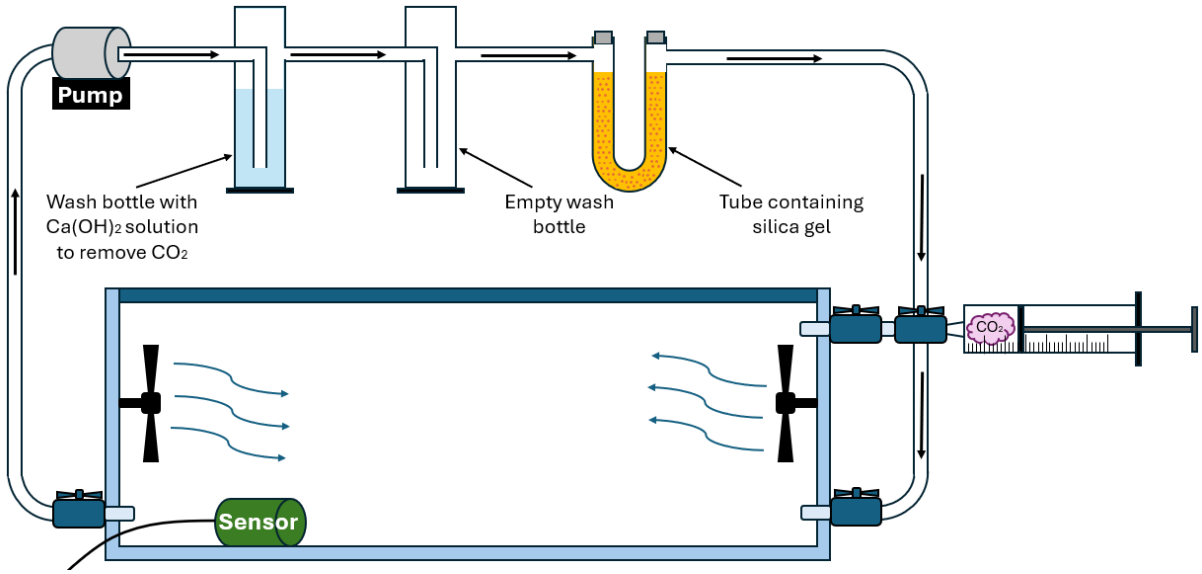

Figure 1: *Representation of the instrumentation and methodology used to calibrate the sensors*

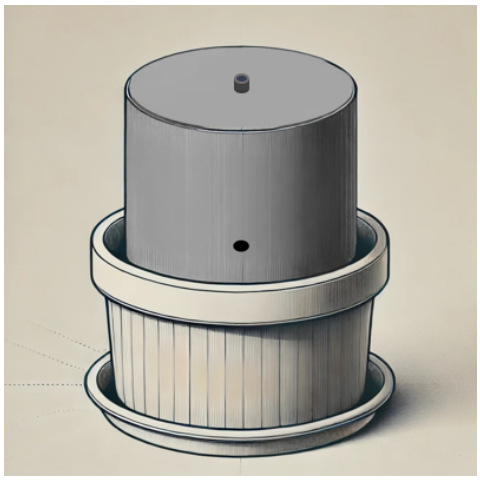

Figure 2: *Representation of static chambers and their operation*

Keywords: *Environmental monitoring, Soil health, Microcontrollers, Precision agriculture, Static chamber.*

Session P11: Biotech-Enabled Crop Development: Enhancing Genetic Diversity, Adaptation, and Traceability

Thursday 5th June. Chair: Elisa Cappetta

KASTRACK-DB – un database a supporto dell'identificazione varietale, della tracciabilità e dell'analisi della diversità genetica in castagno.

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Il castagno europeo (Castanea sativa Mill.) rappresenta una specie di grande importanza ecologica ed economica in numerosi Paesi europei. Un'identificazione accurata delle sue varietà è fondamentale per promuovere una gestione sostenibile, tutelare la biodiversità e valorizzare il germoplasma castanicolo anche in un'ottica commerciale. Il fingerprinting genetico costituisce uno strumento efficace per l'identificazione anche di individui giovani o in fase dormiente. I recenti progressi nelle tecnologie molecolari, come la genotipizzazione dei polimorfismi a singolo nucleotide (SNP) mediante la tecnologia Kompetitive Allele Specific PCR (KASP), hanno notevolmente incrementato l'efficienza e l'affidabilità di queste analisi. In questo contesto, è stato sviluppato KASTRACK db, un database MySQL dotato di un'interfaccia intuitiva, progettato per tradurre i risultati delle analisi KASP in informazioni pratiche e facilmente consultabili. Il sistema permette l'esplorazione di dati genotipici e fenotipici relativi a oltre 150 accessioni di castagno e 38 marcatori SNP, offrendo tre principali modalità di interrogazione:

- Ricerca combinata, che consente il filtraggio incrociato per marcatori SNP e caratteri morfologici;

- SNP più discriminanti per cultivar, che consente di individua il set minimo di marcatori necessari per distinguere le diverse varietà;

- Stringa di genotipi, che permette di confrontare un profilo genetico specifico con quelli archiviati nel database, facilitando l'identificazione varietale e l'analisi delle relazioni genetiche.

KASTRACK-DB rappresenta il primo database interattivo dedicato al castagno europeo, basato su dati di genotipizzazione ottenuti tramite la tecnologia KASP, finalizzati alla discriminazione delle cultivar. Si configura come uno strumento innovativo per l'identificazione varietale, offrendo un valido supporto alla tutela della proprietà intellettuale, ai processi di certificazione e commercializzazione delle piante, nonché alle attività del settore vivaistico. Inoltre, il database si rivela particolarmente utile per la progettazione di nuovi protocolli KASP, contribuendo in modo significativo alla conservazione, alla gestione sostenibile e al miglioramento genetico delle risorse castanicole nel lungo periodo.

Parole chiave: *Castanea sativa*, genotipizzazione, polimorfismi a singolo nucleotide, Kompetitive Allele Specific PCR, biodiversità.

The characterization of the complete panel of CRISPR/Cas9-edited lines targeting the core genes of strigolactone biosynthesis revealed novel phenotypic effects and identified DWARF27 (D27) as a key gene for conferring resistance to parasitic weeds in tomato

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Strigolactones (SLs) are an emerging class of phytohormones that regulate plant development and architecture through crosstalk with other hormones. Moreover, they serve as key signals that trigger the germination of parasitic weed seeds. To generate tomato lines resistant to *Phelipanche ramosa* and *P. aegyptiaca* – parasitic weeds causing severe yield losses in the Mediterranean Region – we used the CRISPR/Cas9 system to generate knock-out (KO) lines targeting the core genes involved in SL biosynthesis (*D27*, *CCD7*, *CCD8* and *MAX1*). In all the edited lines, SLs were undetectable in the root exudates, leading to a significant reduction in parasitic weed germination. Thirteen phenotypic traits were evaluated, revealing specific variations among the different KO lines. Notably, lines edited for the β-carotene isomerase *D27* performed similarly to the non-edited control. Furthermore, this study highlights novel effects of SL biosynthesis manipulation on fruit quality. While fruit carotenoid composition remained largely unchanged across all SL-deficient lines, the fruit volatilome was notably affected, with prominent variations observed in the *ccd8* and *max1* KO lines. Overall, this study identifies the *D27* gene as a promising target for conferring resistance to parasitic weeds in tomato, with no observed negative effects on plant phenotype and fruit quality. The control-like phenotype of the *d27* lines may result from the activity of additional *D27*-like genes, whose presence was confirmed by phylogenetic analysis. To investigate this further, we generated CRISPR/Cas9 KO lines for two predicted *D27* β-carotene isomerase – *D27*-LIKE 1 and -LIKE 2. Future analyses will determine their role on plant phenotype, development, and fruit quality.

Keywords: *strigolactones, genome-editing, phenotypic characterization, volatilome, Dwarf27*

Exploring agro-qualitative traits and metabolic compounds in cultivated pepper towards dissection of underlying genetic basis

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Pepper (*Capsicum* spp.) is a widely cultivated crop, valued for both its economic importance and its bioactive compounds, which are crucial for human health. This study analyzed 230 genotypes from two intra-specific F_2 populations (namely 23PT1 and 23PT2), derived from highly diverse and genetically distant parental lines belonging to the cultivated species *Capsicum annuum*. with the aim to understand the genetic basis of key traits related to fruit quality of pepper. Over 40 agro-qualitative traits, including fruit weight, color, size, and shape, were phenotypically characterized using high-resolution digital imaging techniques. Metabolite profiling of key compounds, including sugars (glucose, fructose, sucrose), organic acids (citric acid, malic acid, succinic acid), β-carotene, and ascorbic acid, was conducted via high-performance liquid chromatography (HPLC). The analyses revealed a strong predominance of red and elongated fruits across both populations. Principal component analysis (PCA) of the first two dimensions showed an overall variance of 57.7% and 59.8% for 23PT1 and 23PT2, respectively and revealed a clear separation between the two populations, suggesting significant metabolic differences between them. Indeed, a higher levels of fructose, glucose, ascorbic acid and citric acid was found in the 23PT2 population. These results highlights the potential for targeted selection based on metabolic profiles to improve fruit quality traits. In parallel, over a hundred thousand SNP markers were identified using double digest restriction-site associated DNA sequencing (ddRAD-seq), enabling comprehensive genomic coverage of the pepper genome.

Further analysis will be performed to detect novel QTLs underlying the variation of main metabolites and key qualitative attributes demanded by consumers and the market. This approach not only enhances our understanding of the genetic and metabolic basis of fruit quality but also provides a foundation for the development of improved peppers contributing to increase the value of agricultural production.

Keywords: *bioactive compounds, pepper, metabolite profiling, ddRAD sequencing, breeding*

Transcriptional reprogramming and growth enhancement in pepper seeds mediated by iron oxide nanoparticle priming

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Nanomaterials (NMs) offer promising applications in agriculture, enabling advancements in pesticides, fertilizers, biostimulants, and nucleic acid delivery systems. However, their widespread application remains limited due to high costs, a lack of comprehensive knowledge of NM-plant interactions, and unpredictable biological effects on both crops and the environment. One promising application of nanotechnology in agriculture is seed nanopriming, which involves the application of NMs on seeds before sowing during seed imbibition. Recent evidences have shown that this technology contributes to improve seed germination, seedling growth, stress tolerance, and ultimately crop yield, even under suboptimal conditions. Herein, we employed a multidisciplinary approach, integrating ultrastructural, physiological, morphological, and molecular analyses, to investigate the intricate interaction between magnetic nanoparticles (MNPs) and seeds in pepper (*Capsicum annuum*), one of the world's most economically important crops. Advanced imaging techniques enabled precise mapping of MNP distribution within the seeds, while phenotypic and physiological assessments revealed that MNP priming significantly promoted root and vegetative growth. Finally, global gene expression by RNA sequencing identified more than 2,200 differentially expressed genes in nanoprimed seeds, most of them involved in plant defence mechanisms, that might enhance the capacity of young seedlings to counteract fluctuating external growth conditions. Collectively, this study provides compelling evidence linking structural seed changes to extensive transcriptional reprogramming, which enhances plant growth and primes the embryo to better withstand environmental challenges during subsequent developmental and growth stages.

Keywords: *Iron oxide magnetic nanoparticles, Capsicum annuum, nanopriming, seed-nanoparticle interactions, RNA-seq*

A smart workflow for chestnut variety identification by snp genotyping

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BACKGROUND:

An effective molecular characterization of chestnut genetic resources can help proper management of propagation material. Accurate variety identification minimizes the risk of misguided investment, fosters trust in nurseries, and supports informed decisions. Kompetitive allele specific PCR (KASP) has revolutionized cultivar identification by making it faster, more affordable, and reliable (Nunziata et al., 2020). However, advanced genotyping techniques typically require purified DNA, whose extraction can be both costly and time-consuming, especially when processing many samples or operating in resource-limited environments.

Crude or simplified DNA extraction methods offer a cost-effective alternative solution, eliminating the need for liquid nitrogen and ultra-low temperature storage.

OBJECTIVE:

The objective of the present work was to optimize the workflow - from sample preparation to data collection - to accommodate the capabilities of under-equipped laboratories and enhance chestnut genotyping.

METHODS:

Two simplified techniques were compared to traditional DNA extraction methods, with a focus on their practical applications, benefits, and limitations.

The first involved fixing leaf tissue onto DNA-stabilizing cards followed by sequential purification washes (Mbogori et al., 2006). The second method used alkaline lysis to release DNA from cells, followed by neutralization with TE buffer (Garcia-Abolafio et al., 2023). The effectiveness of each method was assessed through KASP genotyping using two different reaction mixes.

RESULTS:

Crude DNA proved sufficient for KASP genotyping, yielding results comparable to those obtained from purified DNA. The genotyping data were clear, accurate, and consistently coded using standard IUPAC notation. The first extraction method was compatible with all the tested

reaction mixes but was more labor-intensive. In contrast, the second method was faster and simpler, though it required specific reagents to avoid PCR inhibition. Furthermore, strategic use of KASTRACKdb helped streamline the genotyping process by reducing the number of alleles needed for effective identification (Fruggiero et al., 2025).

CONCLUSION:

The optimized workflow substantially reduces both time and costs, making it especially well-suited for field-based management of chestnut genetic resources.

Keywords: *Castanea sativa; KASP; DNA isolation; genomic resources; fingerprint database*

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Nanotechnology-based approaches for improving delivery of genome editing reagents in plants

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The development of genome editing technologies in plants offers effective potential for rapid, precise and effective crop improvement, however several challenges currently hinder genome editing-based plant breeding. Traditional methods for delivering CRISPR-based genome editing tools often rely on conventional genetic transformation procedures and subsequent plant regeneration *in vitro*. Therefore, they face limitations in terms of efficiency, particularly in species recalcitrant to shoot regeneration from tissue cultures. In addition, these methods often result in stable genetic modifications, requiring backcrossing steps to remove the T-DNA cassette. Thus, the efficient, standardized use of Genome Editing for breeding purposes is currently limited to small number of crops and cultivars. Our project aims to overcome these limitations, by developing innovative nanotechnology-based delivery systems that enable transient, DNA-free expression of genome editing reagents in planta. Specifically, we are focusing on using Cell Penetrating Peptides (CPPs), which have demonstrated potential for efficient delivery of proteins and nucleic acids into plant cells. In preliminary experiments, we have successfully demonstrated the delivery and expression of recombinant proteins and peptides in *Arabidopsis* roots via CPPs. We also performed GFP complementation assays indicating peptide internalization. Building on these findings, the project will expand to deliver CRISPR-associated tools such as Cas9 ribonucleoprotein (RNP) complexes, sgRNAs, and DNA constructs to induce gene editing in plant tissues. The ultimate goal is to refine and optimize CPP-based delivery protocols for *in planta* genome editing, ensuring minimal DNA integration and maximal efficiency to advance the development of CPPs and their application in plant systems. This research could pave the way for more accessible and versatile genome editing techniques in plants, addressing current challenges in crop improvement, particularly in species with low regeneration capacities.

Keywords: *Genome editing, Nanotechnology, Cell Penetrating Peptides (CPPs), CRISPR-based tools, Plant cells*

Breeding Novel Varieties of Camelina sativa L. and Investigating Its Potential as an Intermediate Crop

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Camelina sativa, an oilseed crop in the Brassicaceae family, has gained attention due to its adaptability to marginal lands, low input requirements, and oil rich in omega-3 fatty acids. It has applications in biofuel production, animal feed, and the food industry, while also serving as a cover crop that improves soil health and biodiversity. However, its genetic improvement is limited by low variability. This study aimed to enhance camelina through two breeding strategies: (i) developing a synthetic population by crossbreeding two spring varieties and evaluating their agronomic and nutritional traits, and (ii) implementing marker-assisted selection to create high-yield, high-quality oil lines with reduced antinutritional compounds. Results showed that autumn-winter cultivation in Northern Italy significantly increased yields (2 t/ha) compared to spring sowing (0.6 t/ha). However, a negative correlation between spring and winter yields was observed, with winter-adapted varieties performing poorly in spring. The synthetic population demonstrated strong adaptability and lower glucosinolate levels (17 mmol/kg), making it a promising candidate for commercial use. Additionally, molecular characterization using SSR markers and genotyping-by-sequencing (GBS) distinguished winter and spring varieties at the genetic level. Parental lines were selected to generate new variability through the bulk method. Among the developed lines, C1244 stood out for its early maturity, high thousand-seed weight (1.46 g), and oil content (33.62%), making it suitable for intermediate cropping systems and valuable for human and animal consumption. This research underscores camelina's potential as a sustainable energy and rotational crop. The integration of classical breeding, molecular-assisted selection, and genome editing techniques like CRISPR-Cas9 could further improve its yield, disease resistance, and industrial applications. Future studies should refine these approaches to improve their stability and application in the new frontiers of modern agriculture.

Keywords: Camelina sativa, genetic improvement, intermediate crops, marker-assisted breeding

Session P12: The role of remote sensing in supporting agricultural and selvicultural management

Thursday 5th June. Chair: Luigi Piemontese

Assessing Soil Variability in Citrus Orchards Using Electromagnetic Induction and Satellite Remote Sensing

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The increasing climatic instability represents a significant challenge to Mediterranean agriculture, particularly to citrus orchards, which are sensitive to pedoclimatic variations that directly affect crop productivity and quality. Addressing these challenges requires the adoption of advanced technologies capable of accurately characterising soil variability, providing detailed information to optimise agronomic management and ensure crop sustainability.

This study focused on the *Tango* mandarin variety, cultivated at the KiwiSud farm in Eboli (SA), to compare the effectiveness of two technologies for soil variability characterization: satellite remote sensing and induced electromagnetic systems (EMI).

Using Copernicus satellite imagery acquired in the absence of vegetation cover, it was possible to exploit the reflectance properties of soil surface to calculate pedological indices as Clay Gyroxides Index (CGI), indicative of the clay fraction distribution in the surface soil.

In parallel, the EMI system, using the EMP-400 Profiler operating at three frequencies (14kHz, 7kHz and 3kHz), enabled the measurement of apparent electrical conductivity (EC_a).

EC_a is closely correlated with the presence of conductive substances such as clay and salinity, providing direct insights into soil composition and physical properties.

The EMI data were processed using kriging to produce detailed georeferenced maps. Integration of the results in a GIS environment highlighted a significant correlation between CGI and EC_a ($R^2 = 0.78$, Pearson = 0.88), demonstrating the complementarity of the two techniques in investigated conditions.

The results suggest that EMI analysis, with its ability to investigate deeper soil layers, is essential in contexts with high vertical variability, whereas satellite remote sensing provides an efficient and cost-effective solution for preliminary assessments in more homogeneous areas. Future research will focus on integrating these soil characterization methods with plant-level monitoring to assess their impact on citrus growth, yield, and fruit quality.

This approach will enhance precision agriculture strategies, supporting more sustainable and efficient orchard management.

Keywords: *Precision Agriculture, Soil Electrical Conductivity, Pedological Indices, GIS Analysis, Agronomic Monitoring.*

Virtual Fencing and Remote Sensing: Enhancing Herd Management Efficiency in Alpine Grazing

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Pastoral systems play a key role in supporting mountain farmers while providing essential ecosystem services, such as biodiversity conservation and carbon sequestration. Effective management is crucial to preserving these environments, and Virtual Fencing (VF) presents an innovative solution. VF uses GNSS collars to confine animals within predefined grazing areas without physical barriers. When an animal approaches the virtual boundary, the collar emits an acoustic warning of increasing tone, followed, if necessary, by an electrical pulse. This study aimed to (i) evaluate animal response to VF and (ii) test the feasibility of integrating VF data with remote sensing (RS) to estimate feed intake in alpine grazing systems. The research was conducted in the Eastern Italian Alps (Mount Zoncolan, Italy, 1600 m altitude), where the animal grazed consecutively on three diverse grazing areas: first, two summer pastures (Malga Pozof and Malga Tamai), and then on ski slopes repurposed for grazing. VF collars (Nofence®, Norway) were used to regulate their movement, with grazing areas expanded daily based on forage availability. Results showed that cows adapted well to VF, with differences only in the number of acoustic warnings, which were lower in the first grazing period (Malga Pozof), while electrical pulses remained consistently low across areas. Furthermore, the integration of VF with RS techniques provided valuable insights into forage consumption. Thus, by analyzing vegetation spectral responses, by means of the Normalized Difference Red Edge Index (NDRE), feed intake estimates were derived by comparing pre- and post-grazing remote sensing images acquisition. These findings highlight the potential of combining VF technology with RS data for sustainable pasture management, facilitating monitoring in remote alpine environments and supporting the continued use of mountain pastures.

Research founded by Autonomous Region of Friuli-Venezia Giulia under the SISSAR program (Programmazione del Sistema Integrato dei Servizi di Sviluppo Agricolo, 2022 - 2024 – Research activity, LR 5/2006)

Keywords: *Virtual Fencing, NDRE, Remote Sensing, Alpine pastures, Dairy Cows*

Identifying Potential Old-Growth Forests with Remote Sensing in Northen Italy

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Old-Growth Forests (OGFs) are important reservoirs of carbon, biodiversity and sources for the knowledge of ecological processes. The identification and strict protection of OGFs is a goal of the European Biodiversity Strategy and a pillar of the new EU Nature Restoration Law. This study uses a suite of indicators to accomplish a preliminary identification and mapping of potential OGFs in Lombardy Region, Northern Italy. Our workflow includes prediction of the geographic location of OGFs, their spectral and ecological characterization, and field-based validation according to nationally determined criteria. We calculated six different Vegetation Indices (EVI, AVI, SI, NDII, RENDVI, GLCM) based on Sentinel-2 spectral bands, alongside more standard data based on remote sensing or derived layers (NDVI, Aboveground biomass, LAI and Canopy Cover). Vegetation Indexes and texture-based indicators helped us to identify dendrometric characteristics and characterize the structural complexity of potential OGFs. By integrating all of these layers with expert knowledge we are able to delimit the OGFs. Our results show very limited area potentially hosting OGFs, likely due to the high accessibility of forests and past forest harvesting. However, smaller patches with potential OGFs characteristics can be found where forest development and spontaneous senescence were allowed to occur. Field-based validation was the final step, necessary to verify our predictions, define the structural, developmental end ecological characteristics of OGFs, and ascertain their real conservation status. The next steps will be the definition of monitoring, conservation and sustainable forest management guidelines for all confirmed OGFs in the region.

Keywords: *Old-Growth Forest, Remote Sensing, Forest Management, Forest biodiversity, Forest mapping, EU Restoration Law*

Precision Weed project: innovative approaches to site-specific weed management in maize using advanced sensing technologies

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Effective weed management is crucial for agriculture, as weeds significantly reduce crop yields *[1]*. To reduce herbicide reliance of cropping systems and the risk of weed resistance, innovative solutions like precision agriculture and data analysis support the shift to low-chemical methods *[2]*.

In 2024, a trial was conducted on a maize field at "Angelo Menozzi" experimental farm (Landriano, Italy). Two adjacent experimental fields (one treated in the pre-emergence phase, the other intentionally left untreated) were set up, each arranged in forty-two plots managed using different post-emergence weed control approaches.

To investigate the spatial and temporal variability of weeds, surveys were carried out on July 9th during the V3-V4 maize phenological stage using two detection methods: Proximal (PS) and Remote (RS) sensing systems. PS consisted in three RGB cameras implemented on a tractor-coupled structure, acquiring high-resolution georeferenced images from 2 meters above ground. RS used a DJI Mavic 3 quadcopter to acquire georeferenced RGB and multispectral images from 40 meters above ground.

Images were processed to calculate vegetation indices, including Excess Green and the derived Fractional Green Canopy Cover (FGCC), to assess field-level infestation and create an infestation map. This map was used to generate a prescription map, assigning treatments based on a combination of three factors: control system (uniform vs. site-specific), FGCC threshold (low vs. high), and detection system (RS vs. PS). Treatments were organized following a split-plot design.

Precision applications were conducted using an RTK-GPS-enabled boom sprayer (iXter B16biXtra, Kverneland) with individually controlled nozzles.

Detection systems accuracy was assessed by comparing PS and RS, while site-specific spraying efficacy was assessed through maize yield analysis under the different treatments.

Preliminary findings indicate that site-specific management reduced herbicide usage compared to uniform management without significant yield reduction. The application of pre-emergence treatment was most effective in controlling infestation, regardless of the control systems adopted in post-emergence.

***Keywords**: Site specific weed management (SSWM), Remote sensing (RS), Proximal sensing (PS), Prescription map, Precision spraying.*

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Comparison of vegetation indexes obtained by remote sensing and uav in viticulture: a case study

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In viticulture, it is known that there is physiological and agronomic variability within a single vineyard plot. Managing this variability is the basis of precision viticulture and allows an increase in its environmental, economic, and social sustainability. To understand this variability, it is essential to detect vegetation indexes and biometric characteristics of the vine canopy. This study compares the data of vegetation indexes such as Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge Index (NDRE) detected by an Unmanned Aerial Vehicle (UAV) equipped with RGB and multispectral camera with centimeter terrestrial resolution and by a satellite multispectral remote sensing platform (Sentinel-2) with 10 m spatial resolution. Furthermore, the UAV detection generated a Canopy Height Model (CHM). The tests were carried out on three vineyards with different soil management, i.e., tilled, grassed inter-rows, and in the phase of full canopy development. The results show how the vegetation indexes obtained from the satellite platform are strongly influenced by the soil, which lowers the value of the calculated indexes by about 55% compared to the values obtained from the UAV platform, in which only the pixel values referred to the canopy were considered. Furthermore, from the CHM generated, it was possible to obtain the volume of the canopy present, thus offering the winemaker additional information on which to base the differentiated management of the vineyard. New remote sensing technologies, such as UAVs, are more effective in showing the variability of vegetation in the vineyard because the output obtained has a higher resolution than satellite data. The presence of tilled or grassed inter-rows significantly influences the values of the vegetation indexes obtained from the satellite platform, which are distorted compared to the actual value referred to the canopy of the vineyard only.

Keywords: drone, precision agriculture, Sentinel-2, spatial variability, CHM

Exploring the Use of Drones for Corn Borer Management: a Case Study in Central Italy

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Maize is one of the most important agricultural cash crops in the world involving three different chains: food, feed, and bioenergy production. Nowadays, the European corn borer (ECB), Ostrinia nubilalis (Hübner, 1796), is the most important pest to control for maize growers. The ECB is harmful to maize; young larvae are responsible for minor damage to the leaves, while the most serious damage is tunneling by older larvae that burrow into the stock. Soon after, larvae can affect cobs and it was found that ECB can foster mycotoxin contamination, this is why it is crucial to control it. There are multiple control methods available: agronomic, biological, and microbiological means, agrochemicals, and genetically modified plants. Meanwhile, the European Union's policy focuses on the transition to sustainable supply chains and translates into the goal of reducing the use of agrochemicals by 50%. The current work aims to compare the agrochemical treatment of ECB and biological control through beneficial insects released by drone. The methodology used includes field trials of both chemical and biological control, considering a farm in central Italy as case study. To assess the mechanical and technical efficacy of drones with respect to standard machinery, the available literature was consulted. The findings are positive because drones allow farmers to get in the field promptly, in difficult conditions and with lower costs if compared to traditional techniques. At the same time, it is important to consider the limits of drones regarding pilot certification, no fly zones. In the future it will be necessary to deepen the topic with real application in the field of both systems, expanding the scenarios in which drones can be used and the type of material distributed.

Keywords: *beneficial insect, Trichogramma brassicae, corn borer, precision agriculture*

Evaluation of Optimal Irrigation Volumes for an Industrial Tomato Season in a Sample Area of Campania Through the Analysis of Satellite Imagery, Reanalysis Data, and Agro-Hydrological Model

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Industrial tomato is one of the most widely grown crops in Campania and Italy. However, one of the most underestimated aspects by farmers is the volume of water used for irrigation, a crucial issue that struggles with the need to optimize its use, especially considering low rainfall and increasingly dry summers that characterize Campania. On average, a farmer in Campania uses about 800 mm of water per irrigation season, while the actual water requirement is significantly lower. This study aims to identify the optimal irrigation volumes for a sample of industrial tomato fields, covering approximately 400 hectares, located in the northern area of Naples, the main tomato-growing region in Campania. The goal of analyzing a larger number of fields is to identify different growth patterns. To better describe crop development, the Canopy Cover curve was derived for each field by analyzing Sentinel-2 multispectral images from the Copernicus project. Characteristic curves representing the different growth trends of the fields were then identified. Meteorological reanalysis data from ERA5-LAND were acquired and further refined based on latitude, longitude, and altitude. These data were used to parameterize the agro-hydrological model AquaCrop for each field, including the actual date and crop development and transplantation, which was approximated from satellite imagery. An analysis of the irrigation volumes required for these fields was then conducted, comparing this approach with other scenarios that did not consider the use of satellite images to define the actual crop development. The study demonstrated that integrating satellite imagery can be very useful in better defining the irrigation scenario for industrial tomato cultivation in Campania.

Keywords: *Irrigation scheduling, Optimizing water utilization, Processing tomato crops, Remote sensing technology, Water management.*

Remote sensing modeling of evapotranspiration of herbaceous irrigated crops in California.

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Deriving evapotranspiration is essential for determining crop water requirements and optimizing irrigation water management. Various studies have proven that Remote Sensing (RS) is a useful tool for estimating evapotranspiration and supporting irrigation and water resource management at different scales.
This study presents a framework based on the Shuttleworth-Wallace canopy model for estimating the evapotranspiration in herbaceous irrigated crops.
The approach fully utilizes the high-resolution and multi-spectral capabilities of the Sentinel-2 (S2) sensors to derive key surface parameters including hemispherical shortwave albedo (α), Leaf Area Index (LAI), and the water status of the soil-canopy ensemble using the OPTRAM model. Proposed by Sadeghi [1], the OPTRAM model uses the pixel distribution in the Shortwave Infrared Transformed Reflectance (STR)-NDVI space, where the STR index exhibits a linear correlation with the water content of the soil-canopy system.
In detail, the proposed approach estimates the contributions of soil and canopy to the total evapotranspiration by incorporating the OPTRAM model to assess the water status of the surface and adjust the resistance terms in the combination equation [2].
The results are validated by using Eddy Covariance data collected within the AmeriFlux network [3].

[1] Sadeghi, Morteza, Scott B. Jones, and William D. Philpot.: A linear physically-based model for remote sensing of soil moisture using short wave infrared bands. Remote Sensing of Environment 164, 66-76 (2015).

[2] D'Urso, G., Bolognesi, S. F., Kustas, W. P., Knipper, K. R., Anderson, M. C., Alsina, M. M., ... & Belfiore, O. R.: Determining evapotranspiration by using combination equation models with sentinel-2 data and comparison with thermal-based energy balance in a California irrigated Vineyard. Remote Sensing, 13(18), 3720 (2021).

[3] AmeriFlux - https://ameriflux.lbl.gov/

Keywords: Crop Evapotranspiration, Eddy Covariance, Earth Observation, OPTRAM model, Sentinel-2

Session P13: Novel strategies to study the health of forest soils

Thursday 6th June. Chair: Marialaura Bancheri

Assessing the effects of different forest management practices on soil health and forage supply in a mediterranean silvopastoral system

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Mediterranean silvopastoral systems represent a model for integrating forestry and livestock production, offering multiple ecosystem services such as biodiversity conservation, carbon sequestration, and sustainable forage supply.

This research aims to evaluate the effects of different forest management practices on soil health and forage supply within a Mediterranean silvopastoral system at the Tenuta of Paganico farm (GR, Italy). In the early '80s two thinnings types were applied in the study area: one approach involved a 6 m wide clear-cut leaving 10 m of forest strip, while the other had a 4 to 6 m ratio. Between 2018 and 2020, new thinning operation was performed. The study focuses on implementing an experimental protocol to assess the impacts of the aforementioned silvicultural practices on both soil health, (evaluating structure, quality, biodiversity, and water availability) and forage production, (considering quantity, forage value, and composition of understory vegetation).

Inside different treatments, 16 plots (2x2 m) were settled, namely, i) 4 in the 8-10 m forest strip; ii) 4 in the 6 m clear-cut strip; iii)4 in the 4 m clear-cut strip; iv) 4 in the forest strip not subjected to the recent thinning, so as to have four replicates for each treatment. Within the plots, seasonal field sampling campaigns have been conducted to measure grass dry matter production, and shrub component under different forest canopy densities. Hence, forage supply and pastoral value will be assessed, so as to estimate carrying capacity of grazing animals (*Maremmana* race).

This research, part of the PNRR program (National Centers - CN2 AGRITECH SPOKE 7), contributes to enhancing our understanding of how different forest management practices may influence the sustainability and productivity of Mediterranean silvopastoral systems. By assessing both the biological and physical aspects of soil and vegetation, the research provides valuable insights on which thinning practice could improve forage availability, while maintaining soil health, and enhancing the overall resilience of the ecosystem services.

Keywords: silvopastoral system; livestock grazing; soil health; forestry, Sustainable Forest Management (SFM).

Long-Term Biochar Effects in Mediterranean Forests: Soil Chemistry and Microbiota at Ancient Kiln Sites

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Ancient charcoal production sites, featuring charcoal-amended topsoil within former kilns, provide a valuable model for investigating the long-term effects of biochar on soil. Two kiln platforms, situated on Mount Gelbison and Mount Vesole in Southern Italy, were chosen for this study due to their similar climatic conditions but contrasting bedrock geology. Standard soil chemical analyses and next-generation sequencing were employed to characterize the bacterial and fungal communities. Charcoal species were identified through anthracological analysis, while particle characteristics were examined using scanning electron microscopy (SEM) coupled with energy dispersive X-ray spectroscopy (EDS). Biochar surface oxidation was assessed using diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS). A plant growth bioassay, utilizing soybean, maize, and tomato, evaluated the influence of kiln soil on plant performance. The results indicated that kiln soil did not exhibit significantly elevated pH, cation exchange capacity, or cation content/concentrations. EDS and FTIR analyses revealed substantial oxidation of the charcoal over decades of burial in forest soil, demonstrated by an increased oxygen-to-carbon (O/C) ratio and the presence of oxygen-containing functional groups. Selective enrichment of charcoal surfaces with calcium (Ca^{2+}) was observed on limestone-derived sites, whereas aluminum (Al) and silicon (Si) enrichment occurred on sedimentary (flysch) substrates. Although discernible differences existed between the kiln soils and those of the surrounding forest, microbial diversity and community composition were not drastically different. Notably, the bioassay demonstrated a more pronounced positive effect of the kiln soil microbiota on plant growth compared to the adjacent forest soil. In summary, this research emphasizes the distinct properties of kiln microsites and provides initial insights into the persistent influence of charcoal accumulation on forest soil chemistry and microbial communities.

Keywords: *Anthracology; Charcoal kilns; Biochar; Soil chemistry; Microbiome*

Effect of fire burning on microplastic particles lying on the forest soil surface

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Currently, microplastics (MPs, range 1 µm - 5 mm) pollution is recognized as a major environmental issue in terrestrial ecosystems and, particularly, in soil, which is considered to be the largest global pool. In forests, MPs reach the soil by wind, even at great distances from the original source, accumulating and impacting soil properties and functions. However, little is known about plastic cycles in forest soils, and in combination with wildfires normally occurring in the Mediterranean area. Indeed, the characterization of MPs is not simple because of their interaction with the soil organic compounds, making the isolation hard to perform. Fire modifies plastic particles attributes displaying altered characteristics and impacting on the isolation process. Therefore, the goal of this research was to investigate the effect of fire burning on several MPs, differing for composition and shape. In addition, different methods were tried to isolate plastic particles from the resulting ashes.

MPs were burnt during fire simulations, using as substrate litter collected from a pine forest. After the fire simulations, plastics were weighted and, to include the fraction just partially combusted, the MPs were extracted from the ash residues by different methods: density-hydrophobicity (oil flotation), density (NaCl and $ZnCl_2$) and oxidation (different concentrations of H_2O_2, mix HNO_3:H_2O_2, KOH).

Fires reached peaks of 600°C leading to different MPs consumption, allowing to define three groups of polymers: 58-72% mass loss (e.g. polyethylene and polypropylene), 45-50% mass loss (e.g. polyamide 6.6) and 25% mass loss (styrene-butadiene rubber). The oil flotation, as well as both density and oxidation with H_2O_2 and KOH methods, were not able to extract MPs from the ash residues, which were still rich in organic residues. Conversely, the oxidation with mix HNO_3:H_2O_2 showed a good efficiency in MPs extraction, oxidating most of organic compounds present in the ash. Unfortunately, this method has some limits as it degrades also plastics, altering their chemical structure.

Keywords: *microplastics; soil; fire; extraction; oxidation*

Digital soil mapping in mountain environments: insights into soil genesis, diversity, and evolution

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Monitoring ecosystems and their interactions is crucial for managing both natural and agricultural landscapes. Soil, a vital component of terrestrial ecosystems, plays a key role in processes like nutrient cycling, water regulation, and carbon storage. Despite its importance in sustaining biodiversity and providing ecosystem services, soil often lacks sufficient attention in ecological research and policies. Soil formation is shaped by factors such as climate, organisms, parent material, morphology, and time, resulting in diverse soil types across various regions. Geographic Information Systems (GIS) are valuable tools for analyzing these factors and assisting in soil surveys, especially in complex environments like mountainous areas. In Italy, mountains cover over a third of the land, offering essential ecosystem services, including water regulation, carbon storage, and supporting diverse habitats. However, climate change, land use changes, and hydrogeological instability threaten these areas, leading to frequent natural disasters like floods, landslides, and wildfires. Mountain soils in Italy are under-studied and often overlooked in environmental policies. This study introduces a digital soil mapping approach using a Random Forest model to enhance soil surveys in mountainous environments and produce accurate soil maps. Among numerous remotely sensed and topographic data related to soil-forming factors, the most relevant covariates are selected via iterative elimination, and a final map is produced by combining several predictions. The model offers accurate results and valuable insights into the impact that the different soil-forming factors have on the environment, the diversity of soils that may be found, their possible paths of evolution, and the ecosystem services that they can provide. This method also aids in planning future soil surveys in unsampled areas, providing critical information for managing vulnerable landscapes. Such a tool is increasingly needed as the current challenges call for a thorough assessment of ecosystem health and for the sustainable management of threatened environments.

Keywords: *pedodiversity; digital soil mapping; mountain areas; soil ecosystem services; soil evolution*

Session P14: Advancements in managing water use efficiency for crops grown under water stress

Thursday 6th June. Chair: Chiara Amitrano

Effects of water stress on agronomic, morphological and physiological parameters of maize hybrids with different drought tolerance

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Maize (*Zea mays* L.) is a major global source of food, feed and bioenergy production. However, increasing drought is causing problems for its cultivation, representing the main limitation to maize productivity. The present study aims to investigate the agronomic and physiological performance of maize hybrids with different drought tolerance under different soil moisture conditions. A field experiment was conducted in 2024 with two hybrids (FAO 400), one conventional (P0362) and one drought-tolerant hybrid (DT, P0217), grown under full irrigation (I100, 100% ETc), deficit irrigation (I50, 50% ETc) and rainfed (I0), with water supplied via drip irrigation. Morphological and physiological responses to water deficit were assessed on 10 dates across the growing season. Plant height of the conventional hybrid decreased significantly at I50 and I0 compared to the DT hybrid. Under water stress, the DT hybrid had better stay-green performance, with a significantly higher chlorophyll index. During the ripening stage, the NDVI was, on average, higher in the DT hybrid, particularly under non-irrigated conditions, where values were 22% greater than those observed in the conventional hybrid. Relative water content (RWC) showed a better maintenance of leaf hydration status in the DT hybrid under water stress. Grain and biomass yield was significantly reduced in I50 and dropped in rainfed, with no significant differences between the two hybrids. However, at I50, the DT hybrid achieved 20% higher water productivity (WP) than the conventional hybrid. Moreover, irrigation WP was significantly higher in the DT hybrid (6.02 kg m^{-3}) compared to the conventional one (5.01 kg m^{-3}). Preliminary results indicate that the DT hybrid can maintain better vegetative and physiological performance under limited water availability. A reduction in irrigation inputs, especially during the vegetative phase, combined with DT hybrids, can be a viable solution for the economic and environmental sustainability of maize.

Keywords: Deficit irrigation, Drought-tolerant maize hybrid, Sustainable agriculture, Water productivity

Exploring the Impact of Stomatal Density and Morphology on Water-Use Efficiency in barley

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Barley is one of the most important small grain cereals, ranking fourth in global production. In the context of climate change, abiotic and biotic stresses have increased and consequently, this caused an impact on the agricultural aspects and productivity of crops. Among the abiotic stresses, drought represents a major threat. For this reason, studying the response of crops to drought stress is vital to select tolerant genotypes which behave better in terms of plant growth and yield. Given the complexity of drought response, there is still a gap of knowledge concerning its genetic basis. For this reason, the project aims to investigate specific drought response related traits of barley in a broad panel of accessions from the WHEALBI collection and other genetic resources such as a biparental population Chanell x Formula, that showed contrasting behaviour when under drought. In this context, stomatal density has been already associated to water use efficiency and drought stress tolerance in other crop species and thus the panel will be characterized for this relevant trait on flag leaves at flowering time using a handheld microscope and AI tools for the ultimate analysis of the images. For the WHEALBI collection, genomic regions controlling this trait will be detected through GWAS, by exploiting available SNP from exome sequencing. Meanwhile, the Chanell × Formula population will be employed to conduct QTL mapping aimed at identifying genetic loci associated with transpiration-related traits.

Keywords: Barley; drought; stomatal density; GWAS; QTLmapping;

Maximizing polyphenols in leaf extracts: Sustainable insights from *Arbutus unedo* trees under water stress

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Arbutus unedo L., a Mediterranean evergreen shrub well-adapted to environmental stresses such as drought, produces leaves rich in phenolic compounds, including arbutin, which can potentially be applied in many industrial sectors.

This study aimed to maximize polyphenol content in *A. unedo* leaf extracts by (i) optimizing ultrasound-assisted extraction (UAE) via response surface methodology (RSM) to enhance the yields of total arbutin (ARB) and total polyphenolic content (TPC); (ii) the elicitation of the production of these compounds by applying drought during the cultivation; and (iii) evaluating the seasonal impact on ARB and TPC leaf content through a field experiment conducted at four time points: February (T1), May (T2), July (T3), and October (T4). Five-year-old plants were cultivated under well-watered (WW) and water-stress (WS) conditions. Physiological responses were assessed by measuring leaf relative water content (RWC), stomatal conductance (g_{sw}), and maximum efficiency of photosystem II (F_v/F_m). In addition, epidermal leaf flavonoid (Fla_i) and chlorophyll indexes (ChL_i) were monitored with a Dualex device. Optimized extracts were then analyzed using HPLC-DAD.

The RSM model identified two optimal UAE conditions: ARB yield was maximized with 17.5 mL of 75% EtOH: H_2O for 15 minutes, while TPC yield was optimized with 20 mL of 75% EtOH: H_2O for 5 minutes, both at a temperature of 25°C.

In terms of physiological responses, WW plants exhibited higher RWC than WS plants, while WS plants progressively reduced g_{sw} values throughout the experiment. Despite a significant decrease in ChL_i, no photoinhibition was observed, as reflected by stable F_v/F_m values. Instead, WS plants showed increased flavonoid index (Flai) levels, suggesting a metabolic adaptation to drought stress.

Water stress triggered ARB and TPC accumulation at T3, as the optimal harvesting time for maximum yields. Moreover, polyphenol levels continued rising under stress until early autumn (T4).

These findings offer valuable insights into sustainable cultivation strategies for *A. unedo* in drought-prone Mediterranean areas, promoting the valorisation of this undervalued species and supporting the production of leaf polyphenol-rich extracts for pharmacological, cosmetic, and nutraceutical applications.

Keywords: *Arbutin, Arbutus unedo, optimization of extraction, physiological responses, polyphenols, water stress.*

Assessment of soybean water productivity and grain yield under optimal and regulated deficit irrigation

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Soybean (*Glycine max* L.) is a legume employed for both human and animal nutrition with great economic importance. However, its productivity is strictly linked to the availability of water resources, whether from rainfall or irrigation. In the context of climate change, characterised by increased occurrences of drought, the implementation of regulated deficit irrigation (RDI) emerges as a promising strategy to enhance water use efficiency in soybean cultivation. A field experiment was conducted near Arezzo (Italy) in 2024 to assess the impact of RDI on soybean water productivity, agronomic yield and seed quality. Therefore, soybean was subjected to three irrigation levels: full irrigation (FI), 100% ET_c (crop evapotranspiration); RDI according to phenological phase, 70%-100%-70% ET_c during growing, flowering and ripening phase respectively; and rainfed condition. Irrigation was carried out using a self-propelled boom sprinkler. Key meteorological parameters were monitored, including reference evapotranspiration, which was used to estimate irrigation requirements. Phenological surveys, crop height, chlorophyll index, canopy cover and NDVI (Normalised Difference Vegetation Index) were carried out throughout the crop cycle. Preliminary results show no significant differences in the growth phase for health status indices. However, significance was observed at flowering for the chlorophyll index ($p < 0.0001$) and canopy cover ($p < 0.01$). At seed development, significance was observed for canopy cover ($p < 0.0001$) and crop height ($p < 0.01$). In terms of productivity, RDI has been shown better results than FI for all the parameters studied, i.e. grain yield, biomass production, harvest index, water productivity and irrigation water productivity. No differences emerge in terms of seed quality. The study will be repeated in 2025 for validation and ground-based data will be compared with data from remote sensing.

Keywords: Regulated deficit irrigation; crop water requirement; water productivity; climate change; *Glycine max* L.

Using treated wastewater in agriculture: water and nutrient resource

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Water scarcity and water pollution have become critical issues in many regions across the globe. Manage, conserve and secure water sources in the years to come will be crucial to guarantee human activities and protect ecosystems. Using unconventional water sources, such as wastewaters in harmony with nature, will be essential to answer to water stress. In addition, wastewater is also a source of nutrients that could contribute in reducing fertilizers use. This paper aims to analyse the impact of agriculture and point sources (WWTPs) on surface waters and to evaluate the treated wastewater as a potential resource of water and nutrient for use in agriculture. The ecohydrological model "Soil and Water Assessment Tool" (SWAT) was used to simulate hydrology and water quality in the Triolo basin (Apulia, Italy). Triolo catchment is an agricultural area under water scarcity. The results of this study indicate that in surface waters TP and $_{NO3}$ concentrations are above the threshold values for a good water quality status. The dry season is critical for TP pollution when the WWTP discharge into the river constitutes the main pressure for surface waters. NO_3 pollution is the main pollutant during the rainy season when agriculture is the main pressure. The results also indicate that treated wastewater could represent an important resource of water and nutrients capable of contributing the seasonal irrigation requirements and reducing chemical fertilizers.

Keywords: *wastewater reuse, agriculture, hydrological and water quality model, SWAT, temporary river*

Session P15: Effects of biostimulant application on plant growth and development

Thursday 6th June. Chair: Giulia Franzoni

Evaluation of fermented kiwifruit by-product as biostimulant for tomato plants, cv. Solarino, grown in soilless conditions

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Reducing the use of synthetic fertilizers by identifying more sustainable alternatives is crucial for achieving sustainability in agriculture and food industry. Biostimulants have recently gained attention for their capacity to enhance plant metabolism, productivity, and soil nutrient retention. Experimental biostimulants, derived from agricultural and food waste, fall into the principles of the circular economy by valorizing materials that would otherwise be discarded. In the Kiwifruit supply chain, over 4 million tons are produced worldwide yearly, and around 1 million tons of waste are generated due to strict quality standards. Italy is also the most important European kiwi producer, accounting for around 45% of total production. This study explored the potential of fermenting, with lactic acid bacteria (LAB), kiwifruit by-products—such as seeds, skins, and unsold fruits from large-scale retailers—to produce an innovative high-value biostimulant (FKB), that was, subsequently, tested on tomato (*Solanum lycopersicum* L.) plants (cv. Solarino) grown under soilless conditions. The biostimulant was applied directly to the substrate, close to each plant, every two weeks, at concentrations of 50 ml/L and 100 ml/L, and its impact on vegetative growth and fruit yield was evaluated. Moreover, chemical and technological analyses evaluated fruit quality traits. Finally, the influence of the tested biostimulant on the microbial soil community was also examined. The results indicated that the FKB, at both concentrations, impacted more on fruit quality than vegetative parameters, with positive effects specifically on firmness, skin color, titratable acidity, antioxidant activity, and lycopene content. These findings highlight the potential of using LAB-fermented agri-food by-products as sustainable biostimulants to be used again in agriculture. Future research should further investigate the effect of fermented biostimulants on different crops cultivated in innovative agricultural systems and/or new biostimulants derived from different by-products.

Keywords: Agri-food by-products, *Solanum lycopersicum* L., sustainability, vegeto-productive performances, fermentation

Effects of Plant-Based Biostimulants on Processing Tomato 'Heinz cv. 1534' Over Two Years of Cultivation in Southern Italy

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Climate change is redefining global environmental and agricultural landscapes, with the Mediterranean basin as one of the most vulnerable regions. This area is warming 20% faster than the global average, experiencing reduced precipitation and more frequent extreme weather events, threatening natural resources and agricultural productivity, particularly in Southern Italy. The tomato (*Solanum lycopersicum* L.), a key crop for the local economy and culture, is one of the most affected. Rich in health-beneficial bioactive compounds, tomato faces environmental stresses that increase oxidative stress, accelerate ripening, and alter yield and quality. Innovative solutions, including biostimulants and optimised irrigation, are essential. Plant-based protein hydrolysates (PH) have shown promise in enhancing plant resilience and maintaining yield and quality under stress. This study evaluates the efficacy of two commercial plant-based biostimulants, MaturUp® and Sunred®, on processing tomato (cv. 'Heinz 1534') over a period of two years (2019-2020) in open field conditions in Southern Italy (Foggia). The results showed that year-to-year variability strongly influenced yield, with a 45% reduction in total yield and an increase in defective fruit (+37%) in 2020 compared to 2019. In 2020 there was also a significant decrease in °Brix (-41%), polyphenols (-21%), lycopene (-130%) and total sugar index (-20%), indicating stress condition. In this context, MaturUp® significantly increased polyphenols (+27%), and essential and branched chain amino acids (BCAAs) (+50%) in 2020. Sunred® also increased BCCAs (+35%) in 2020. The study highlights the strong impact of environmental conditions on tomato yield, fruit quality and metabolism. Biostimulants act as metabolic regulators rather than direct growth promoters, adapting physiological responses to environmental conditions. Their effectiveness depends on external conditions, emphasising the need for targeted application strategies. Further research should explore the biostimulants-stress interactions to optimise their role in sustainable agriculture.

Keywords: *Solanum lycopersicum* L., climate changes, amino acids, biostimulants, secondary metabolites.

Different mycorrhiza strains and inoculation methods provide distinct metabolomic and lipidomic responses in tomato plant

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Plant biostimulants, like arbuscular mycorrhizal fungi (AMF), are widely used in agriculture for their ability to improve plant fitness. The effectiveness of AMF in shaping plant physiology depends on various factors, including fungal strain and host specificity. In this work, we tested the functionality of two *Rhizoglomus irregulare* strains on tomato plants for 35 days by a combination of metabolomic, lipidomic and morphological analyses. Two application methods were also evaluated: a seed-priming treatment, and an inoculation at germination stage.

The results showed that AMF reduced the growth of the root system in every condition tested, but the shoot biomass was instead improved by the second AMF strain (AMF-2) for both application methods; specifically, seed primed plants had an increase of 26% compared to the control, while the inoculation led to an increase of 11%. The root system of mycorrhized plants is less developed than the control, both in terms of length (-31% on average) and volume (-33% on average). This result confirms that some AMF strains have strong host preferences, in relation to which they express their greatest potential.

Metabolomic analyses showed that the interaction with AMF strongly modifies the secondary metabolism of the plant, regardless of the treatment used. Seed-priming with AMF-2 boost the secondary metabolism of the plant, also resulting in root development conditions much more similar to control than any other treatment. The symbiosis with AMF also modulates the lipidomic profile of the plants, that require special lipids to interact with the fungi.

In conclusion, our data demonstrate that *Rhizoglomus irregulare* strains have strong host preferences and do not improve the growth of other plant species, but in particular AMF-2 can however interact with tomato plants, modifying their metabolism towards a greater synthesis of aromatic compounds, isoprenoids and polyketides.

Keywords: *biostimulants; secondary metabolism; lipidomic; Rhizoglomus irregulare*

Biostimulant Effects of Auxin-Producing Bacteria on Tomato and Olive Growth: Studies on Seed Priming and Soil Inoculation

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The study explores the effects of seven auxin-producing bacteria strains (Azospirillum spp., Methylobacterium symbioticum, Bacillus spp.) and two combinations of these strains on tomato (Solanum lycopersicum L.) and olive (Olea europaea L., cv Leccino). Microbial seed priming was tested on two Italian tomato varieties ("Canestrino di Lucca" and "Pisanello") verifying the germination ability. Treated seeds showed a general increase in germination rates and root elongation. The obtained seedlings were then transplanted and maintained in greenhouse conditions. The potted tomato plantlets were treated as well with soil microbial inoculation. After 60 days, treated plants exhibited notable improvements in fresh and dry biomass, root length, and root count (1). As regard the experimental trials on olive, soil inoculations were monthly applied on one year old olive potted plants, for a total of three applications. A foliar treatment with Methylobacterium symbioticum was also performed. Measured parameters included root number and length, fresh and dry weights of roots, leaves, and stems, as well as leaf number, surface area and chlorophyll content. The most significant effects were observed in the number and length of secondary roots, particularly in treatments with Azospirillum spp. strains. All treatments led to an increase in plant dry mass, with the polymicrobial mixes showing the most pronounced effect. Only the foliar application of Methylobacterium symbioticum resulted in increased chlorophyll content (SPAD) and leaf area. These findings highlight the potential of auxin-producing bacteria as microbial biostimulants for seed priming and soil inoculants, supporting sustainable agriculture practices for both herbaceous and arboreal plants development (2–4).

Keywords: *Microbial biostimulants, Seed priming, Soil inoculation, Olive, Tomato*

Effects of plant growth-promoting and phosphate-solubilizing microorganisms on tomato (Solanum lycopersicum L.)

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Phosphorus (P) is one of the major macronutrients required for proper functioning of plants. Yet, the availability of soluble forms of P for plants in the soil is limited because large proportion is bound to soil constituents. Phosphate-solubilizing microorganisms (PSMs) can hydrolyze insoluble P compounds to soluble P form that can easily be assimilated by plants.

The aim of this study was to evaluate the ability of different selected P-solubilizing bacteria (i.e. *Bacillus megaterium*, *B. pumilus*, *Pseudomonas putida* and *P. salmasensis*) to promote the growth and production and improve P absorption of tomato plants (*Solanum lycopersicum* L.) grown in soil with low P content. Greenhouse experiments were carried out by inoculating plants with bacterial cell suspensions and different inorganic insoluble (phosphorite) or soluble (KH_2PO_4) P sources. Hoagland solution and P were added every week, whereas bacteria were applied every two weeks through irrigation. Plants inoculated with bacteria and phosphorite showed increased yield, total soluble sugar and dry matter contents compared to uninoculated control, as well as root and stem dry weights. Interestingly, plants inoculated with *B. megaterium* in presence of phosphorite showed a +26% increase of both root and stem dry weights, respectively, compared to uninoculated control. Analyses of P absorbtion by plant roots and stem are currently in progress. Our results underline the importance of using PSMs as biofertilizers in sustainable crop production and that PSMs provide an ecofriendly approach to overcome the P scarcity and its subsequent uptake by plants.

Keywords: *rock phosphate, phosphate-solubilizing microorganisms, phosphorus, tomato*

Session P16: Cross-Disciplinary Approaches to Agroecological Sustainability: From Product Quality to Ecosystem Restoration

Thursday 6th June. Chair: Giovanni Ricci

Analytical framework for High Throughput Plant Phenotyping pipelines

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High throughput plant phenotyping (HTPP) aims to give new insights on plant phenotyping through the intensive accumulation and management of data.

Such achievement relies on the improvement of the data collection platforms and the application of machine learning (ML) algorithm to extract useful information from this. ML model and training dataset are intrinsically tied: collected datasets embed the implicit environmental context and the trained data models may not generalize properly when they are confronted with new contexts.

In the ML field the training algorithms are benchmarked using a reference dataset and shared training protocol whereas current contributions in HTPP provide generally a standalone pipeline from the plant management to data collection and then the ML algorithm selection. This limits any comparison between the models trained and a correct outline of their extent. The present work proposes an analytical framework to detail an HTPP pipeline according to eight common features. These features extend usual nomenclatures of domain review starting from the sensors and going up to the data model assessment.

These guidelines attempt to highlight the peculiarities of each proposal and help the reader to embrace their scope.

Keywords: *High Throughput, Plant Phenotyping, Machine Learning, Automation, Methodological framework*

Microbial-Based Strategies for Sustainable Crop Protection: Deciphering Plant Responses Through Multi-Omic Approaches

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The transition to sustainable agriculture requires innovative solutions to reduce chemical inputs microbial biocontrol agents (BCAs) offer a promising approach, not only by directly contrasting pests and pathogens but also enhancing plant defense responses. This study investigates the capacity of *Trichoderma afroharzianum* T22 (Ta) and *Beauveria bassiana* Bb74040 (Bb), applied individually or in a microbial consortium, to mitigate biotic stress in tomato plants caused by the foliar pathogen *Botrytis cinerea* or the aphid pest *Macrosiphum euphorbiae*. Bioassays indicated that BCA-treated plants exhibited a significant reduction in disease incidence and severity, as well as lower aphid infestation and fertility rates compared to untreated controls. To gain deeper insight into the plant response to these interactions, metabolomic, proteomic, and hormonomic analyses were performed. Multi-omics profiling highlighted a complex modulation of plant metabolism and hormonal pathways in response to both microbial treatments and biotic stressors. In the pathogen infection bioassay, infected plants exhibited stress-associated metabolic signatures, including high levels of botrydial, a pathogen-linked phytotoxin, and proteins related to plant starvation and oxidative damage. In contrast, the presence of BCAs led to a metabolic shift favoring the accumulation of defense-related compounds such as oxylipins, tomatin, and capsaicin, along with a marked activation of the jasmonic acid pathway. This highlights a systemically regulated plant defense response induced by microbial interaction. Additionally, in aphid-infested plants, microbial treatments altered the accumulation of secondary metabolites, corresponding with reduced aphid survival and reproduction rates. These findings support the hypothesis that beneficial microbes modulate plant defense pathways in a context-dependent manner. Further analysis of multi-omic data will help to decipher how plants perceive and respond to beneficial microbes and biotic stressors. This study highlights the potential of microbial consortia as viable, sustainable alternatives for crop protection, aligning with agroecological principles and sustainable pest management strategies.

Keywords: *Microbial Consortia; Biocontrol; Trichoderma afroharzianum; Beauveria bassiana; Induced Systemic Resistance (ISR)*

Wool enhancement for sustainable development of Piedmont's Alpine valleys

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In the current social context, the renewed interest in natural products that were historically valued, is a positive trend for sustainable development. Local Alpine wool, which was previously overlooked in favor of fine wools from specialized breeds and later replaced by industrial alternatives, is now unfortunately treated as production waste. However, it is a versatile, thermos-insulating and biodegradable material that can be considered in the perspective of a circular economy. In parallel, the externalities from the sheep farming system provide various social, environmental, and economic benefits and services for the local production systems. Zootechnical activities preserve the alpine ecosystem, provide employment opportunities and related occupations, and finally maintain the cultural identity of local communities.

This research aimed to investigate the preferences that potential buyers of local wool attribute to different factors when making a purchase and to assess their willingness to pay (WTP) a higher price for local wool, while exploring possible influencing factors. To achieve this, an online questionnaire was distributed to 400 individuals in the Alpine areas of Piedmont. The survey was divided into four main areas of investigation: a) socio-demographic characteristics; b) preferences for choice attributes when purchasing wool products; c) awareness of various environmental issues; and d) willingness to purchase the product at a higher price. Through factor analysis and cluster analysis, four groups were identified based on two distinct orientations: sustainable and aesthetic purchasing. A chi-square test was used to assess WTP, revealing no significant differences between the clusters; in general, respondents were in favor of a price increase of up to 10%. Using ANOVA analysis, significant cluster differences were observed regarding environmental concerns. The results suggest that the current knowledge and perceptions of the sample are insufficient to differentiate the clusters or encourage the purchase of the product. This research underscores the need for public communication and information strategies that highlight the most relevant attributes to promote the purchase of native wool products.

Keywords: *Italian local wool, choice analysis, conscious consumption, waste prevention*

Monitoring of soil bioengineering interventions for the restoration of coastal dunes in southern Italy

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Introduction

Low-impact techniques, such as soil bioengineering, are used to restore threatened ecosystems. Among these, coastal dunes are particularly vulnerable to erosion, with significant consequences on biodiversity.

Objectives

This study analyses the long-term effects of soil bioengineering interventions carried out on a heavily eroded portion of a dune in southern Italy. The intervention included the remodelling of the dune profile, the construction of a wattle and the planting of herbaceous and shrub autochthonous species.

Methods

The monitoring was conducted by combining remote sensing techniques and field surveys. PlanetScope and Sentinel-2 satellite images were used to calculate NDVI and assess vegetation trends, comparing the intervention site with an adjacent control site. The NDVI values were correlated with climate data from a weather station located near the intervention area.

Results

The intervention showed positive results. An accumulation of sand was observed, that completely covered the wattle and, the NDVI values increased at the intervention site compared to the control site. Field monitoring instead, showed a reduction of some planted shrub species. Nevertheless, the accumulation of sand and the increase in NDVI indicate an overall improvement in vegetation conditions due to a return of native vegetation.

Conclusions

The results confirm the effectiveness of soil bioengineering techniques in restoring coastal dunes. Trends in vegetation indices were similar in both satellite datasets, with Sentinel-2 imagery standing out as a more cost-effective option for large-scale vegetation monitoring.

Keywords: soil bioengineering, Sentinel-2, PlanetScope, dune restoration, NDVI

Nergi® delight: preliminary evaluation of fresh and transformed baby kiwi by-products

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Cultivation of baby kiwi (Actinidia arguta), commercially presented as Nergi®, in the Piedmont region has a significant role in terms of production, contributing to a growing but still niche market. The berries' metabolism has not been completely understood yet, resulting in difficulties in storage management that lead to high quantity of by-products that do not meet fresh market requirements. This study addresses these challenges by exploring the key attributes of Nergi® through the development of a standardized sensory vocabulary that effectively describes both fresh and processed baby kiwi (dried, freeze-dried blended pulp, freeze dried pieces).

Berries (Nergi® cv. Rua) non-compliant with fresh market have been collected post-storage from the packhouse. Part of them have been dried and freeze-dried in the DISAFA laboratory. Sensory description and quantitative descriptive analysis (QDA) have been performed by a semi-trained panel organized inside the department.

Vocabulary was built to describe all the products. The transformed product was recognized different specifically in terms of taste, aroma and flavor from the initial fresh Nergi®, highlighting the development of umami taste and changes in the fruity profile. The pungent sensation was an issue according to the panelists for the freeze-dried product and may be related to the inflammation produced by polyphenols in the mouth and the presence of tannins. In some cases, the bitter taste was also recognized as compromising the overall assessment.

The sensory characterization of A. arguta is related to the investigation of overall berries quality and defining selling criteria. The sensory vocabulary developed could potentially be used as a tool to infer the level of other physico-chemical characteristics based on the presence, absence or intensity of specific descriptors, offering an integrative method for fruit evaluation and product sensory standardization with attention towards consumer appreciation.

Keywords: Actinidia arguta, sensory analysis, quality, by-products, circular economy

Session P17: Abiotic Stressors and Their Influence on Plant growth Oral

Thursday 6th June. Chair: Mariano Crimaldi

Nickel Toxicity and Uptake in Hydroponic Lettuce

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Nickel (Ni) is a metal found in the environment whose concentration can increase due to anthropogenic activities, with potential adverse effects on human health and the ecosystem. Vegetables are a major source of dietary exposure to Ni, with concentration influenced by environmental factors and agricultural practices. For this reason, the European Union has initiated monitoring of Ni in food for the three-year period 2025-2027, promoting the adoption of mitigation strategies. The research activity described is part of an industrial Phd thesis whose objective is to study the physiological processes of Ni uptake and translocation in vegetables in order to limit its accumulation. In this context, the present study evaluated the toxic effects of Ni on lettuce grown using the Nutrient Film Technique (NFT), a hydroponic system that allows the study of heavy metal bioaccumulation without substrate interference. The experimental trial was conducted at the experimental farm "La Noria" of the National Research Council Institute of Food Production Science (Mola di Bari, Italy (41.062156° N, 17.066914° E)) on two lettuce (*Lactuca sativa* L.) varieties - 'Lisbon' and 'Monza' (Rijk Zwaan) -, using a split-plot experimental design with three repetitions. Plants grown in a standard nutrient solution (NS, control) and with two concentrations of [$(CH_3COO)_2Ni_4H_2O$] - 75 and 150 μM -, in a closed-loop NFT system. The results showed that increasing the concentration of Ni in the nutrient solution resulted in a significant reduction in plant growth. Lettuce grown with 150 μM of Ni had 71.6% lower leaf fresh weight than control. Furthermore, increasing the Ni content in the NS the leaf length and width decreased by 36% and 38%, respectively, compared to the control. In addition, the lettuce plants grown with the highest Ni content in the NS reduced NS uptake by 43% than control. The data collected from this trial allow us to identify "toxicity concentrations" of Ni in lettuce grown in NFT.

Keywords: *Nutrient Film Technique (NFT), Heavy metal, Greenhouse, Crop physiology*

Activation of retrotransposons by salt stress and seaweed extracts in Micro-Tom genome

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Tomato (*Solanum lycopersicum* L.) is a native herbaceous plant of southwestern America, belonging to the *Solanaceae* family. Micro-Tom, a model dwarf tomato variety, has a genome composed of 62% retrotransposons, mobile genetic elements that can move within the genome, influencing gene expression and genomic structure. These elements are sometimes activated under stress, which can lead to changes in genome size. In this study, we identified a new Ty1-copia-like retrotransposons family, named Tvv1 like in the Micro-Tom genome. We examined how different concentrations of salt (NaCl) and Ascophyllum nodosum-based extracts affect the activation of this family. To analyze the Tvv1 retrotransposon family, we used S-SAP (Sequence-specific Amplified Polymorphism) profiling, which enabled them to detect polymorphic bands in treated plants. This technique helps to assess the activation and movement of retrotransposons. Plants were treated with a basic nutrient solution (BNS) at two different concentrations (100% and 70%), combined with three levels of NaCl. We investigated the effect of salt stress and Ascophyllum nodosum-based extracts on retrotransposons activation, first separately and then combined. Moderate salt stress (42.5 mM NaCl) and the combination of algal extracts with a 100% nutrient solution were most effective in activating retrotransposons mobilization, while high salt concentrations (85 mM NaCl) suppressed this activation. In silico analysis revealed that the Tvv1 promoter contains stress-responsive cis-acting elements such as GATA, TCT, CAAT, and TTC-rich. These are similar to elements involved in the activation of stress-responsive genes, suggesting that Tvv1-like retrotransposons may play a role in enhancing plant stress responses. This research highlights the intricate role of retrotransposons in plant stress responses and opens up possibilities for improving crop resilience using natural genetic mechanisms.

Keywords: *Solanum lycopersicum* L., retrotransposons, salt stress, Tvv1-like, S-SAP

Microplastics extraction from sandy soils of southern Italy: ATR spectroscopy and SEM analysis evaluation

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Microplastic pollution is a growing environmental concern due to its persistence and widespread presence in various ecosystems. The extraction and quantification of microplastics from complex matrices, such as soils, require efficient and validated methodologies. This study, funded by the 2022 PRIN Project titled "Role of wildfires on microplastics in forest soils" (RODOLFO) reviews and evaluates two different procedures for microplastics extraction and quantification, from sandy soil located in a forest coastal area of Campomarino, in Molise region, subjected in the past few years to wildfires.

Following an initial screening of the main physicochemical parameters of the analyzed soils selected in four case study, the potential presence of macroplastics was assessed by sieving the samples at 2 mm. After sieving, the density separation method using sodium iodide (NaI) solution was applied, and then the supernatant of the mixture, ultrasonic treated and 12 h shaken, was filtered at a pore size of 2.5 µm. The extracted samples were treated with 30% hydrogen peroxide (H_2O_2) for oxidation to remove the organic materials. In parallel, an analysis was performed on undisturbed soil samples collected using metal cylinders. Deionized water was added three times to each column, sealed with a 0.125 mm mesh metal screen, until saturation, and subsequently filtered under vacuum condition at 11 µm pore size. ATR spectroscopy and scanning electron microscope (SEM) were used for the identification and characterization of the small plastic particles, comparing them with the responses of the certified plastic polymers. These extraction methodologies address key challenges in microplastics separation from a complex matrix as soil. The proposed methodology include a better recovery efficiency, polymer characterization and methodological validation, providing robust approaches for environmental monitoring.

Keywords: Microplastics pollution, separation procedure, ATR spectroscopy, SEM analysis

Phytotoxic effect of chilli pepper (*Capsicum annuum* L.) extract on germination and growth of different plant species

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Agriculture faces the challenge of sustainable weed management due to increasing resistance to chemical herbicides and regulatory restrictions on their use. In this context, using plant extracts derived from agro-industrial waste represents an innovative and sustainable strategy. Among the sources of plant extracts with potential herbicide effects, chilli (*Capsicum annuum* L.) stands out for the presence of bioactive compounds, such as capsaicin and dihydrocapsaicin, known for their phytotoxic properties. The objective of this study was to evaluate the bioherbicidal effect of by-products of chilli water extract on the germination and root growth of four plant species: watercress (*Lepidium sativum* L.), lettuce (*Lactuca sativa* L.), ryegrass (*Lolium perenne* L.) and amaranth (*Amaranthus retroflexus* L.). The obtained extracts were tested for phytotoxicity at different concentrations to determine their impact on the selected plants in Petri dishes. The results showed that chilli extract had a significant phytotoxic effect on the germination of the tested species. In particular, high concentrations completely inhibited the germination of watercress, indicating a strong potential as a natural bioherbicide. However, lower concentrations showed variable effects, suggesting the need for further studies to optimise field application. These results confirm that chilli extract can be an environmentally friendly alternative to chemical herbicides, contributing to the reduction of environmental impact and the valorisation of agro-industrial waste.

Keywords: *Natural herbicides, phytotoxicity, innovation, environmental sustainability, plant extracts*

Session P18: Development and nutraceutical aspects of Mediterranean crops

Thursday 6th June. Chair: Gelsomina Manganiello

Unveiling the Hidden Potential of Six Rosemary Cultivars: Phenolic, Terpenic Profiles, and Antioxidant Capacity

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Rosemary (*Salvia rosmarinus* Spenn., syn. *Rosmarinus officinalis* L.) is a Mediterranean aromatic species of significant interest due to its dual use as a medicinal herb and culinary spice. The phytochemical variability among cultivars highlights the need for comprehensive chemical characterization leading to better utilization of cultivars with superior bioactive profiles. This study evaluated the phenolic and terpene composition, content, and antioxidant activity of leaf extracts from six Mediterranean rosemary cultivars: Alba,' 'Arp,' 'Ginger,' 'Gorizia,' 'Tuscan Blue,' and 'Roseus.'

Rosemary cultivars were grown outdoors in pots filled at the GEA Park common garden in Pistoia, Italy, under natural lighting and on-demand irrigation. Leaves of four-year-old plants were manually collected from different branch positions. HPLC-DAD analysis revealed a consistent phenolic profile across all cultivars, dominated by carnosic acid derivatives, flavonoids (e.g., luteolin, apigenin, and quercetin glucosides), rosmarinic acid, caffeic acid, and hydroxycinnamic acid derivatives. However, quantitative differences were observed, with 'Alba' exhibiting the highest phenolic content, predominantly carnosic acid derivatives, while 'Ginger' and 'Gorizia' recorded the lowest levels.

GC-MS analysis indicated significant quantitative variation in terpene content among the cultivars. 'Alba' displayed the highest terpene concentration, whereas 'Arp' and 'Gorizia' exhibited the lowest. Antioxidant activity showed strong positive correlations with phenolic and terpene content. Specifically, 'Alba' exhibited the highest phenol-driven antioxidant activity, while 'Ginger' and 'Tuscan Blue' showed superior antioxidant activity attributable to terpenes. The chemical characterization of these cultivars offers valuable insights with potential for diverse industrial applications.

Keywords: *Salvia rosmarinus Spenn., polyphenols; terpenes, antioxidant activity.*

The nutraceutical potential of chia, Salvia hispanica L. mutant and wild genotypes: a comprehensive metabolomics study of seeds and by-products

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Salvia hispanica L., commonly known as chia, has emerged as a valuable crop in the food industry, recognized for its rich dietary fiber content, functional properties and nutraceutical potential. Traditionally cultivated by ancient civilizations such as the Mayans and Aztecs, chia is gaining global recognition for its health-promoting properties such as antihypertensive and antioxidant functions[1]. Our research aims to investigate the metabolic profiling of natural and mutant genotypes of chia, to assess the adaptability of mutant varieties to high latitudes and explore the potential of its by-products. Using advanced spectroscopic techniques (NMR, GC-MS, and LC-MS) chemometric analyses, and molecular networking, we profiled the metabolome of natural genotypes of chia and its early flowering mutants (G3, G8, G17, W13.1) in different parts of the plant. Significant genotypic differences were observed between seeds in omega-3 fatty acids, polyphenols, flavonoids, and amino acids, highlighting opportunities for varietal selection to enhance nutraceutical properties. Early flowering genotypes, particularly G8 and G17, stood out for their high omega-3 and polyphenol content, positioning them as promising resources for food and feed applications. Beyond seeds, our investigation of chia leaves using molecular networking of LC-HRMS data showed distinct flavonoid profiles, including vitexin and orientin derivatives. Additionally, flowers and stems revealed their potential as sources of antioxidants, omega-3 fatty acids, and flavonoids. Notably, chia flowers exhibited strong antioxidant activity, suggesting novel uses for these plant parts in nutraceuticals and functional foods. This research highlights how the genetic selection coupled to a comprehensive metabolic profiling can drive varietal innovation in *Salvia hispanica* L., while supporting both local biodiversity preservation and global nutraceutical markets.

[1] Orona-Tamayo, D. and Paredes-López, O., 2024. Chia—The new golden seed for the 21st century: Nutraceutical properties and technological uses. In Sustainable protein sources (pp. 443-470). Academic Press.

Keywords: *Salvia hispanica, chia, metabolomics, molecular networking, antioxidant activity*

Exploring wild *Thymus* sp. (L.) chemotypes provides thyme-derived products preventing fungal proliferation on paper

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The genus *Thymus* belongs to the *Lamiaceae* family and encompasses over 500 aromatic species widespread in the Mediterranean area. *Thymus* sp. (L) grows on dry, rocky soils, up to 1800 meters above sea level, and its intense aroma makes this plant one of the most appreciated herbs. Thyme plants belonging to the *serpyllum* group, of five different provenances of the Pistoia Apennines (Butale, Donagaccia, Melo, Osservatorio, and Pracchia), were georeferenced and sampled to determine their foliar terpene profile. Studying the chemotype diversity of such area provided key information to drive the selection of the plant material for thyme essential oil (EO) extraction. An additional objective of this work involved the experimentation of the EO and its hydrolate as antifungals. The GC-MS analysis of the leaf terpene profile of 94 samples led to the classification of seven distinct chemotypes on the basis of the prevailing terpenes. The thymol-chemotype class was the most represented across all the considered areas. Thyme EO was steam-distilled from the fresh biomass collected in the area of Osservatorio, and the hydrolate obtained as byproduct of the distillation process was also recovered and chemically characterized. The main terpene was thymol plus its precursors, representing about 75 % and 62 % of the total terpenes in EO and in the hydrolate, respectively. The antifungal efficacy of these products was evaluated against *Alternaria alternata* and *Cladosporium cladosporioides*, two filamentous fungi found to degrade paper objects. The tests were performed *in vitro* on Whatman paper inoculated with a $1x10^5$ conidia/mL fungal suspension, and for both fungi, a significant growth reduction was observed with 4mL and 10 µL of hydrolate and thyme essential oil, respectively. Further research is necessary to explore the broader applicability of such thyme-derived products, and the prerequisite is an accurate selection and chemical characterization of the plant material.

Keywords: *Thymus sp., chemotype, GC-MS, essential oil, hydrolate*

Germination performances of twelve native Mediterranean wildflower species in different urban soils under climate change scenarios

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Increasing urbanization and anthropogenic pressures create a high heterogeneity of land use, offering ideal habitats for the growth and spread of numerous Invasive Alien Plant species. Climate change further exacerbates this dynamic, contributing to the homogenization of urban flora and posing a significant threat to urban biodiversity. However, cities can be important in biodiversity conservation by using native species for urban greening. To maximize the effectiveness of urban greening efforts, it is necessary to study native plants most suited to stress relating to soils and increasing temperatures. This research, funded by the National Biodiversity Future Center, aimed to evaluate the germination traits of twelve herbaceous species native to the Mediterranean regions, exploring their potential for ecological restoration and urban greening in the context of climate change. Seeds of Anethum foeniculum L., Asphodelus ramosus L., Bituminaria bituminosa (L.) C.H.Stirt., Calendula arvensis L., Centaurea diffusa Lam., Heliotropium europaeum L., Malva sylvestirs L., Misopates orontium (L.) Raf., Scabiosa atropurpurea (L.) Greuter & Burdet, Sinapis alba L., Teucrium capitatum L., and Verbena officinalis L. were collected in Athens (e.g. urban green areas, semi-natural areas) during the autumn of 2024. In February 2025, a total of 450 seeds per species were sown in Petri dishes containing different soils and placed in growth chambers under constant light/dark conditions (16h/8h). The treatments comprised combinations of three soils (demolition waste soil, topsoil, and brownfield soil) and three temperatures (15, 25, and 35°C). Results were evaluated using the main germination indices: the final germination percentage, the time of first germination, the time to reach 50% of germinated seeds, the germination period, and the mean germination time. The results will provide insights into the germination behavior of these native species, informing their use in urban greening strategies, and enhancing our understanding of the role of cities in biodiversity conservation.

Keywords: germinability, autochthonous plant species, climate change, urban biodiversity, ecological restoration

Evaluation of rye (secale cereale l.): nitrogen use efficiency, agronomic potential and sustainability in matese regional park

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Rye is a cereal not widely grown in Italy. The interest in this cereal is mainly due to its nutritional characteristics and its remarkable nutraceutical properties, thanks its high content of micronutrients and fiber. Furthermore, it is highly valued as a crop because of its resilience, as it thrives even in poor, sandy, and acidic soils. It demonstrates moderate tolerance to salinity; however, it is particularly susceptible to water stagnation and lodging. Currently, the land dedicated to the cultivation of this autumn-winter cereal in Italy remain extremely limited. The experiment was conducted from September 2023 to July 2024 in the municipality of Letino (CE) located in the Matese Regional Park. Experiments are being carried out to recover a local variety of rye, the Sècena del Matese, because these areas are traditionally suitable for this type of cultivation. Mountain areas represent an important source of ecosystem services for the territory. When combined with the recovery of local varieties, become an opportunity for the revitalization of ancient villages that are underutilized. The experiment aimed to identify a cultivation method suitable for these areas that allowed a good relationship between changing climate conditions and production. Data were collected through non-destructive surveys using precision digital tools such as TDR, MPM-100, and thermal cameras. Meanwhile, at harvest, destructive surveys were necessary to evaluate rye's nutritional profile and the nitrogen content in both the plant and the soil. The final objective was to evaluate the nitrogen use efficiency of the crop, a key parameter for assessing environmental sustainability. The results highlight the potential of Sècena in the mountain agricultural context, offering new perspectives for the enhancement and sustainability of these areas.

Keywords: Resilience, Agroecosystems, Biodiversity, Local variety, Land Revitalization

Session P19: Sustainable agronomical practices in a changing climate

Thursday 6th June. Chair: Paolo Dessì

Zea mays L. landraces under climate change: the effect of different growth environments on morphology and yield

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Maize landraces are dynamic populations with historical origin, distinct identity, lack of formal genetic improvement, and often being genetically diverse, locally adapted and associated with traditional farming systems (Camacho Villa et al., 2005). These populations, compared to modern hybrids, are characterised by high genetic variability that increases their potential resistance to biotic and abiotic stresses. Therefore, they are considered reservoirs of interesting alleles to be used in breeding programs.

Seven Italian maize landraces and one hybrid were selected and tested for two years in two different growing conditions: in the Po plain (Landriano, PV, 80 m asl) and Valtellina Alps (Valfurva, SO, 1339 m asl).

This study aimed to characterise these landraces to identify those that are tolerant to cold stress and thus able to grow in mountainous areas. For this purpose, agronomic and morphological data were analysed in the different fields.

Despite the ongoing climate change characterised by rising temperatures, the experimental field in Valfurva was still above the limit for maize cultivation for almost all the accessions tested. The only exception was the very early landrace Agostanello, which even in the mountains was able to grow and provide a yield comparable to that obtained on the plains.

The characterisation of these landraces also provided useful data for their future registration as Conservation Varieties, an important step for their conservation and the promotion of their cultivation.

Keywords: Maize, landraces, mountain, climate change, stress tolerance

Camacho Villa, T. C., Maxted, N., Scholten, M., & Ford-Lloyd, B. (2005). Defining and identifying crop landraces. Plant Genetic Resources: Characterisation and Utilisation, 3(3), 373–384. Scopus. https://doi.org/10.1079/PGR200591

Impatto delle pratiche sostenibili sulle radici di Actinidia con sintomi di KVDS e caratterizzazione di nuovi portinnesti

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Introduzione

Negli ultimi anni, la coltivazione italiana dell'actinidia è stata gravemente minacciata dalla diffusione di una sindrome che causa un rapido deperimento delle piante, nota come sindrome del declino dell'actinidia (*Kiwifruit Vine Decline Syndrome* - KVDS). Tra le ipotesi che si stanno diffondendo negli ultimi anni, una gestione impropria del suolo e dell'irrigazione, in sinergia con i cambiamenti climatici, ha svolto un ruolo chiave nell'insorgenza di questa sindrome, creando condizioni di eccesso e ristagno idrico, compattazione e destrutturazione del suolo. L'impiego di portinnesti più tolleranti agli eccessi idrici, insieme all'adozione di pratiche agronomiche e irrigue sostenibili, potrebbe rivelarsi decisivo per contenere il fenomeno e salvaguardare la produzione nazionale di actinidia.

Obiettivi

Caratterizzazione delle risposte morfologiche e fisiologiche di portinnesti tolleranti e sensibili a eccesso idrico;

Analisi dei principali processi metabolici coinvolti nella sopravvivenza in condizioni di eccesso idrico, con particolare attenzione al ruolo del sistema delle gliossalasi nella detossificazione del metilgliossale.

Metodi

È stata condotta una prova sperimentale in vaso per il confronto di due portinnesti: Hayward (*Actinidia chinensis* var. *deliciosa*), portinnesto tradizionale e sensibile all'ipossia, e Bounty (*Actinidia macrosperma*), innovativo e tollerante. Entrambi i genotipi sono stati sottoposti in vaso a eccesso idrico per 8 giorni. Durante il periodo della prova è stata misurata l'efficienza fotosintetica (0, 3, 8 giorni) e osservate le modificazioni morfologiche, oltre a raccogliere campioni di foglie e radici per le successive analisi metaboliche (0, 1, 2, 3, 8 giorni).

Risultati attesi o principali

Nella prova in vaso, il portinnesto tradizionale ‘Hayward’ ha manifestato alterazioni morfologiche e fisiologiche sotto stress idrico, a differenza del ‘Bounty’, suggerendo in quest’ultimo una risposta metabolica più efficiente in condizioni di eccesso idrico.

Conclusioni

L’introduzione/applicazione di pratiche innovative sostenibili potrebbe non solo prevenire, ma anche mitigare i problemi legati al KVDS, specialmente negli impianti già esistenti. Inoltre, nei nuovi impianti, la scelta di portinnesti tolleranti agli eccessi idrici potrebbe rappresentare una strategia sinergica alla gestione agronomica sostenibile.

Parole chiave

Actinidia, gestione sostenibile, portinnesti, KVDS, eccesso idrico.

Trait-Based Adaptation of Durum Wheat to Future Climate Scenarios

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Durum wheat (*Triticum turgidum* subsp.*durum* Desf.) is a key crop in Mediterranean regions, where rising temperatures and increasing precipitation variability challenge yield stability. This study examines the influence of phenological and physiological traits on durum wheat adaptability under future climate scenarios. We focused on two contrasting trait combinations: semi-dwarf early-flowering genotypes with a high grain number per unit area (representing the wheat cultivars grown today) and tall, late-flowering genotypes with a higher grain weight and lower grain number than semi-dwarf genotypes (representing old wheat cultivars). To assess their response to climate change, the DSSAT-CERES model was calibrated and validated using five years of field experiments (2011–2017) conducted in northern Sardinia. Long-term simulations (2010–2100) based on five global climate models (GCMs) revealed distinct trends. The climate scenarios used in this study are based on Shared Socioeconomic Pathways (SSPs), which describe possible future developments in greenhouse gas emissions and climate conditions. Among the GCMs, UKESM1-0-LL projects the most extreme warming and climatic variability, while MPI-ESM1-2-HR depicts more gradual trends. Yield projections indicate that early-heading genotypes achieve higher productivity under favorable conditions but are more susceptible to climatic variability. In contrast, late-heading genotypes demonstrate greater yield stability, likely due to their prolonged grain filling phase. Additionally, high-input management mitigates yield losses more effectively than low-input strategies. Anthesis and maturity dates are expected to occur earlier, with reductions of up to 10 days under the SSP5-8.5 high-emission scenario. Rising temperatures are also projected to shorten the grain filling period, potentially affecting grain quality. These findings highlight the importance of selecting durum wheat genotypes based on combination of traits more than on single traits, emphasizing breeding strategies that enhance climate resilience in Mediterranean environments.

Keywords: *Durum wheat, phenology, grain filling, climate adaptation, crop modeling*

Agronomic Performance in Durum Wheat-Vetch Intercropping: an Agroecological Strategy for Resource Use Efficiency

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Crop diversification is a fundamental agroecological strategy to enhance resource use efficiency, improve soil fertility, and increase the resilience of agricultural systems to climatic variability. Intercropping between durum wheat (*Triticum durum* Desf.) and common vetch (*Vicia sativa* L.) represents a viable approach to achieving these objectives in Mediterranean organic farming. This study investigates the agronomic interactions between wheat and vetch under simultaneous sowing and harvesting, focusing on yield performance, nitrogen (N) dynamics, and overall system efficiency. A two-year field experiment was conducted in southern Italy, in the Basilicata region, using an additive intercropping model, optimizing species densities to balance complementarity and competition. Results demonstrate that intercropping enhances nitrogen use efficiency and increases total N uptake compared to monocultures. The land equivalent ratio consistently exceeded 1, confirming superior resource utilization. Moreover, intercropping improved wheat grain protein content, indicating enhanced N availability. Despite inter-annual climatic variability, intercropped systems exhibited greater yield stability than wheat monocultures, mitigating the effects of drought stress.

Economic assessment revealed that intercropping maintains a competitive gross production value, supporting its feasibility under low-input conditions. However, logistical challenges, particularly post-harvest grain separation, limit broader adoption. These findings underscore the potential of wheat–vetch intercropping to improve agronomic performance, reduce dependence on synthetic fertilizers, and enhance system resilience, contributing to more sustainable Mediterranean cropping systems.

Keywords: *Cereal-legume intercropping; Nitrogen use efficiency; Land Equivalent Ratio; Agroecological strategy; Nitrogen dynamics.*

Evaluating the joint impacts of weather conditions on crop yields and quality: an application to durum wheat in Italy with implications for index-based insurances

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CONTEXT. Agricultural production is closely linked to weather conditions, posing significant risks to yields and quality, especially for typical Mediterranean crops such as durum wheat. To mitigate these risks, weather index-based insurances (WIIs) have emerged as a vital tool for agricultural risk management. Unlike traditional indemnity-based insurance, WIIs rely on predefined thresholds of weather variables associated with damages. When the threshold is reached or exceeded, a pre-agreed payout is triggered, regardless of the actual physical and/or economic loss. Such a feature can lead to faster indemnities and reduced administrative costs for farmers.

OBJECTIVE. This study aims to examine the role of WIIs in addressing risks related to both yields and quality damage for durum wheat. It analyses and assesses the feasibility of WIIs, based on meteorological variables linked to yield and quality parameters (such as hectoliter weight and protein content).

METHODS. Official data were used, related to yields and qualitative parameters from multiple experimental trials on durum wheat across Italy over the period 1994-2023. First, damage thresholds related to rainfall and temperature were identified using Boundary Line Analysis (BLA). Canonical Variate Analysis (CVA) was then applied to determine which weather variables have the greatest influence on yield and quality reductions.

RESULTS AND CONCLUSIONS. The results indicate that developing a unique typology of WII for a highly heterogeneous area (such as Italy) is unfeasible, due to extremely variable factors such as crop phenology, paedology, and local microclimatic conditions that affect durum wheat differently. However, the study is particularly relevant because it innovatively contributes to identifying key weather variables – such as rainfall and temperature – which significantly and consistently affect yields and quality parameters during specific phenological phases and production stages.

Keywords: insurance, risk, quality, durum wheat, boundary line analysis

Session P20: Light, Soil, and Sustainability: New Horizons in Crop Physiology and Management

Thursday 6th June. Chair: Ferrero Francesco

Physiological and productivity responses of green and red lettuce under Pulsed Light

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The growth of indoor farming in recent years is accompanied by the increasing usage of LED lighting. LED lights have multiple benefits, such as long lifetime and faster switching. On the other hand, the cost of LED lighting is higher if compared to other horticultural lighting source. A possible way to enhance energy use efficiency could come from the application of pulsed light, by modulating the frequency and duty ratio.

This study investigated the effects of pulsed LED light on two lettuce cultivars, green and red (Lactuca sativa L., var. "Multifoglia"), over a 48-days growing cycle. Two conditions were compared: pulsed light with 50% duty cycle (D50), with a frequency of 1000 Hz, a photoperiod of 16 hours, and a PPFD of 122 µmol m-2s-1, and a greenhouse with natural light during autumn season, that served as a control. After harvest the quality was evaluated over 10 days at 4°C. Results showed that at harvest the red-leaf cultivar had the highest fresh weight compared with the green lettuce. Leaf pigments such as total chlorophyll and carotenoids were higher under D50 treatment in both cultivars. Nitrate concentration was also higher in pulsed treatment compared to plants in greenhouse but remained under the EU limits (4000 mg kg-1 FW). Maximum quantum efficiency of photosystem II (FV/FM) showed that plants under pulsed lighting has better light use efficiency compared to the greenhouse conditions. During postharvest, Ethylene and CO2 production, particularly after 7 days of cold storage, were significantly reduced under the D50 treatment.

The study highlights the effectiveness of pulsed LED lighting for improving growth and physiological traits in lettuce cultivars. Further analysis of amino acids, polyphenols, and antioxidant system (e.g. Ascorbic acid content) will be conducted to better understand the plant response and to enhance the effectiveness of pulsed light treatments.

Keywords: chlorophyll fluorescence, duty cycle, indoor, Lactuca sativa, vertical farming.

Towards herbicide-free cover crop management: mathematical modeling frost winterkill termination

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Cover crops are cultivated to provide agro-ecological services, including reduction of nitrate leaching, weed control, and improving soil fertility by returning organic matter to the soil. They must be terminated before subsequent cash crop. Winter frost termination is a sustainable alternative to herbicides and mechanical operations to kill cover crops. However, its effectiveness depends on the interaction between weather, genotype, and phenology. This study presents a simplified model to simulate frost damage in Sinapis alba L., a widely used winter cover crop in Italy. The model uses temperature data to simulate crop development, hardening and dehardening to estimate the crop resistance temperature to frost, and predict the timing and intensity of frost damage. Calibration of model parameters was performed using measurements at six sites in Lombardy (northern Italy) during 2021-2022, distinguishing between live and damaged biomass. Model validation was carried out by comparing simulated damage dates to satellite-observed damage dates in 41 fields across Lombardy (2018-2021, 16 sowing dates). The model performed well, showing a strong ability to reproduce observed frost damage, simulating frost event dates within a 5-day window in 95% of cases, with performance comparable to more complex models (p-value > 0.05). It accurately predicted the temporal evolution of frost damage intensity (R^2: 0.94, RMSE: 10.0%), enabling precise identification of the cover crop termination time using only hourly air temperatures and crop parameters as input. Moreover, the study underscores the importance of the sowing date on crop susceptibility to frost and cropping system management. The model proves to be a valuable decision-support tool for optimizing the sowing time for terminating the cover crop through frost damage, simplifying management and reducing costs. Future applications should focus on integrating, calibrating, and validating the model within cropping system models to assess the broader effects of cover crop use in agricultural systems.

Keywords: cover-crop, frost termination, modeling, remote sensing, decision-support tool

Behaviour of olive suckers against xylella fastidiosa: resistance and differences between cultivars

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Xylella fastidiosa (Xf) is a gram-negative bacterium infecting several plant species, including olive trees, causing Olive Quick Decline Syndrome (OQDS). This bacterium colonises the xylem vessels, obstructing water and nutrient transport, leading to the drying and eventual death of the plant. Despite the canopy of infected trees withering, new shoots, called suckers, often appear at the base of the trunk, often reported as asymptomatic by growers

Suckers can sprout for multiple reasons, the most common being field abandonment, where the lack of agricultural management amplifies this olive tree's natural processes. However, sucker development also represents a defence mechanism: when canopy is severely damaged, the tree attempts to survive by producing new shoots. This work aims to understand whether suckers activate more effective defence strategies by analysing samples of different ages from Cellina di Nardò, Ogliarola, and Leccino cultivars. Preliminary findings reveal that, in Cellina suckers less than five years of age, about 70% of the analysed samples were negative. In contrast, the positive samples exhibited Xf concentration ranging from 10^3 to 10^6 CFU/mL.

In Ogliarola, negative suckers older than five years were rare (about 10% of samples), whereas among younger suckers (<5 years) more than two third of samples are negative. At the same time, positive samples displayed Xf concentration between 10^3 and 10^7 CFU/mL.

For Leccino, only young suckers were negative, while suckers older than five years showed bacterial concentration between 10^4 and 10^6 CFU/mL.

This preliminary observations show that the suckers of the olive cultivars analysed behave differently in relation to cultivar and Xf infection. Generally, younger suckers show a lower incidence of Xf infection than older ones, indicating a possible temporary resistance that varies between cultivars.

Keywords: suckers; Olive Quick Decline Syndrome; resistant cultivars

Exploring the Spatial Variability of Nitrogen Balance and Its Relationship with Soil Properties

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Nitrogen (N) fertilisation is one of the primary factors contributing to increased crop yield. Furthermore, spatial variability in the field influences the crop yield. Soil properties, including texture, soil organic matter, pH, and topography, can vary within the same field and this variability may result in different yields across different areas. Although yield spatial variability has received a lot of attention, only a limited number of studies have addressed the consequences of spatial variability on N balance. For precise N fertilisation, various N pathways, such as N losses and soil mineral N variation, must be considered in addition to crop uptake. To investigate the effect of soil properties on nitrogen balance, we compared linear multivariate regression (LMR), which does not consider the spatial variability, with a geographically weighted regression (GWR) model, which evaluates the spatial variability. The data were collected in Denmark over a field cropped with potato and barley for two years. We observed that crop N uptake was the primary driver of the N balance. Clay, pH, and clay were the most important soil drivers in both models. The regression coefficients were statistically significant in almost all cases in the GWR model, whereas they depended on the year in the LMR model. Overall, the GWR outperformed the LMR in terms of explained variability and mean error in both years. Understanding the spatial variability of soil properties can help optimise N fertilisation to enhance potential crop yields and reduce N losses.

Keywords: nitrogen balance, soil properties, spatial variability, geographically weighted regression

Growth and antioxidant capacity of four Tuscan landraces under different wavelengths of LED light

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Conventional agricultural practices threaten long-term food security and biodiversity. Aeroponic cultivation is a promising alternative to reduce environmental impact. This study investigates the effects of different red:blue light ratios, with and without the addition of far-red light, on the growth, physiological performance and antioxidant content of four Tuscan landraces (Cicoria del Marzocco, Rossina di Pescia, Radicchia di Lucca and Foglia di Cerro della Garfagnana) grown for the first time in the aeroponic system.

The aim of this study is to identify the most suitable light conditions for improving the productivity and nutritional quality of these valuable genetic resources, to support the conservation of these landraces and to contribute to their valorisation and rediscovery.

Seeds of four Tuscan landraces were germinated and then transplanted into an aeroponic growth chamber and exposed to different red (R) and blue (B) light ratios, with and without the addition of far red (FR) light. Plants were grown under seven different LED light treatments: white (w), 87:13 (R:B), 75:25 (R:B), 60:40 (R:B), 87:13+FR (R:B), 75:25+FR (R:B), 60:40+FR (R:B). Leaf area, fresh and dry weight, gas exchange, photosynthetic activity, antioxidant capacity, polyphenol content and flavonoid content were measured.

The light treatment factor was found to be significant in relation to the parameters considered. Light treatment had a significant effect on the antioxidant properties of all landraces, but the significance changed in a landrace-dependent manner when morphometric and physiological parameters were considered, e.g. far-red (FR) light improves morphometrics in *L. sativa* but not in *Cichorium*.

The study concludes that specific light parameters can differentially influence the growth, physiological performance and antioxidant content of the selected Tuscan landraces. Therefore, tailor-made "light recipes" can be developed to achieve specific cultivation objectives.

Keywords: aeroponic, light quality, red:blue ratio, Tuscan landraces, antioxidant capacity.

Session P21: Innovative Approaches in Plant tree Phenotyping and Environmental Stress Mitigation

Thursday 6th June. Chair: Pierluigi Mazzei

MRI and NIR spectroscopies to correlate hazelnuts morphological and structural characteristics with agronomic treatments, bedbug occult damage and varietal features

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Research in the hazelnut field aims to identify agronomic treatments capable to preserve, control or even improve the quality of hazelnut fruits. At the same time, it is also important to identify new analytical techniques to assess and certify reliably the hazelnut quality. Therefore, we have combined innovatively magnetic resonance imaging (MRI) and near-infrared (NIR) spectroscopy with several multivariate statistical techniques (PCA and DA) to investigate on important quality aspects of hazelnuts. We have explored the suitability of such a composite analytical approach to correlate structural characteristics of hazelnut to factors such as (i) variety-specific peculiarities, (ii) the effects induced by specific agronomic treatments, or (iii) the presence of any bedbug occult damages. This work was carried out by considering Camponica and Tonda di Giffoni, which are two representative varieties of the Campania region. MRI analyses produced 2D and 3D representations that, not only revealed interesting structural and anatomical hazelnut characteristics, but also allowed the visual identification of bedbugs occult damage in apparently intact fruits. Also MRI T1 and T2 relaxation times produced promising results. In fact, hazelnuts with bedbug damages exhibited relatively lower values for almost all of explored MRI variables in the affected fruit areas. MRI relaxation times also discriminated significantly the two studied varieties, as well as enabled the individuation of structural effects deriving from agronomic treatments (compost, without and combined with the inoculation of microbial biostimulants). On the other hand, also NIR spectroscopy, which is a more common and easy-to-use technique, produced interesting results on most of the investigated aspects, although it was not as effective as MRI in discriminating between the different hazelnut types. In conclusion, the proposed techniques represent an innovative analytical approach to provide data potentially useful for hazelnut producers to certify the fruit quality, trace different varieties and identify bedbug occult damage.

Keywords: Camponica, Tonda di Giffoni, Biostimolanti microbici, Cimiciato occulto, MRI, & NIR, analisi multivariata.

3D Characterisation of Hazelnut Varieties through Innovative Technologies for Biodiversity Valorisation

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Agricultural biodiversity is a fundamental component for ecosystem sustainability and crop resilience, particularly in agricultural regions such as Basilicata. However, the progressive genetic erosion caused by habitat loss and climate change threatens local plant genetic resources. In this context, this study applies innovative methodologies for varietal characterisation, integrating advanced 3D acquisition and modelling technologies. Artec Spider, a high-precision structured light 3D scanner, was used for the digitisation of hazelnut varieties, generating high-resolution three-dimensional models with accurate texture and structural fidelity. In parallel, photogrammetry using the iPhone 13 Pro camera was employed for the 3D reconstruction of leaves, enabling an accurate representation of leaf morphology. To validate the proposed methodology for future applications on native cultivars, data acquisitions were conducted using three well-established reference varieties: Tonda di Giffoni, Camponica and Mortarella.

The creation of a digital catalogue constitutes an essential tool for the conservation and valorisation of local germplasm, improving varietal documentation and supporting traceability strategies.

The integration of three-dimensional survey technologies in varietal characterisation not only represents a strategic opportunity for innovation in the agricultural sector but also provides essential tools for an in-depth understanding and conservation of Basilicata's hazelnut biodiversity.

This approach not only strengthens the territorial identity of agricultural production but also supports farms in improving traceability, obtaining quality certifications, and developing targeted strategies for enhanced competitiveness, fostering sustainable agricultural development based on digital innovation.

Keywords: *Corylus avellana,* Biodiversity, 3D modeling, Varietal Characterisation, Sustainability.

Seasonal variations in wood starch concentration as key physiological markers associated with *Quercus ilex* L. crown defoliation

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The increase in drought occurrence and intensity is contributing to rising rates of *Quercus ilex* L. (holm oak) mortality. Key physiological traits involved include hydraulic dysfunction and carbohydrate depletion. This study monitored xylem embolism and non-structural carbohydrates (NSCs) availability in adult holm oaks under harsh environmental conditions to identify thresholds of physiological impairment associated with increased mortality risk. Seasonal measurements of percentage loss of hydraulic conductivity (PLC), xylem water potential (Ψ_x) and NSCs were conducted over two years in trees categorized by defoliation severity: non-defoliated (CL1), moderately defoliated (CL2) and severely defoliated (CL3). Increased crown defoliation correlated with higher PLC, lower Ψ_x and reduced NSC availability, with significant differences observed primarily in summer and autumn. Xylem embolism and carbon uptake (inferred from NSC content) showed asynchronous patterns across seasons. In summer and autumn, CL2 and CL3 trees experienced 40-50% PLC, coinciding with reduced carbon uptake. Over the two years, the physiology of CL2 trees deteriorated to a similar level to that of CL3 trees. PLC remained stable in non-defoliated CL1 trees, while decreased seasonally in CL2 and CL3 trees during winter and spring. Interestingly, CL2 and CL3 trees showed delayed starch reserve recovery, which occurred in winter rather than autumn, as observed in CL1 trees. This delayed recovery suggests the absence of autumn NSC replenishment as a potential early warning sign of physiological impairment leading to holm oak decline. Our findings suggest that moderate crown defoliation may conceal severe physiological damage, leading to PLC, Ψ_x and NSC values comparable to those of severely defoliated trees in later stages.

Keywords: *crown defoliation; non-structural carbohydrates; percent loss of hydraulic conductivity; Quercus ilex L.*

New streetlamp solutions to reduce the impact of urban light pollution on trees: can tailored lighting spectra mitigate adverse effects?

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Nighttime light pollution in urban areas impacts the night sky and alters the natural rhythms of organisms, including urban trees. To investigate these effects, four urban tree species, including *Platanus* × *acerifolia* (PL), *Populus nigra* (PO), *Prunus cerasifera* cv. nigra (PR) and *Liriodendron tulipifera* (LI) were grown in complete darkness (Cnt) or under nighttime exposure to LED streetlamps with three distinct lighting spectra: neutral- (N-Trt), warm-white (W-Trt) and a prototype spectrum enriched in green light (G-Trt), specifically designed to investigate it potential for reducing the impact on tree species. Physiological and leaf water potential (Ψ) analyses were conducted across different treatments during summer and autumn at dawn, midday and night. In both seasons, at night, the leaves of illuminated trees showed positive net CO_2 assimilation rate (P_n) values, irrespective of light spectra, while Cnt trees exhibited typical nighttime respiration. During summer, N-Trt and W-Trt trees generally exhibited reduced P_n values at dawn, primarily due to stomatal limitations. These limitations in N-Trt and W-Trt were unrelated to potential plant water imbalances. Moreover, PO and LI species also showed reduced P_n at midday, especially N-Trt and W-Trt. Notably, all G-Trt trees exhibited dawn and midday P_n values similar to Cnts, indicating that the green-enhanced spectrum partially reduced the disturbance of streetlamps. During autumn, nighttime exposure to streetlamps (NES) notably delayed leaf winter dormancy in all illuminated trees, displaying higher P_n than Cnts. While these findings underscore the physiological alterations induced by NES on trees, they also highlight the promising potential of modifying lighting spectra to reduce disturbance. The green-enhanced spectrum showed encouraging results, but further advancements are needed to develop an efficient lighting solution that fully minimizes impacts on trees. This reinforces the importance of advancing sustainable lighting solutions to support the resilience of urban trees under NES.

Keywords: LED Light, Photosynthesis, Plant Physiology, Streetlight, Urban trees

Biochemical and Nutraceutical Characterization of Different Accessions of the Apricot (*Prunus armeniaca* L.)

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This study was conducted in the germplasm field of the Department of Agriculture at the University of Naples Federico II. The research aims to counteract genetic erosion while enhancing, promoting, and protecting the typical products of the Campania region. Among these valuable resources, the Vesuvian apricot stands out as one of the most significant, and it is the focus of our investigation, characterized by exceptional organoleptic qualities thanks to the soil and climate characteristics of the Vesuvian territory.

The term "Vesuvian apricot" encompasses multiple varieties cultivated in the same region at the foot of Mount Vesuvius, where they have a long-standing tradition of cultivation. The health benefits of apricots and their derivatives are well-documented, largely due to the presence of various secondary metabolites, many of which have antioxidant properties.

This study analyzed 12 Vesuvian apricot accessions through both chemical-physical (fruit weight, pulp firmness, total soluble solids, titratable acidity, pH, skin color, organic acid, sugar content, and nutraceutical parameters (antioxidant activity and polyphenol content). All analyzed accessions can be classified as high-quality apricots, thanks to their chemical and nutraceutical characteristics. Among the various quality parameters analyzed, TSS-F (soluble solids content-to-pulp hardness ratio) exhibited values equal to or greater than 12. The total sugar content varied significantly, ranging from 260.40 mg/g d.w in 'Vincenzo e Maria' to 744.59 mg/g d.w in 'Scassulillo'. In all accessions, the sugar content followed the order: sucrose > glucose > fructose. Antioxidant activity varied widely among the different accessions. Our results confirm that Vesuvian apricots not only preserve a remarkable genetic heritage but also possess unique nutritional and functional qualities, reinforcing their role as a key product of the Campania region and making them ideal candidates for genetic improvement programs to further enhance their commercial and nutritional value.

Keywords: Vesuvian apricot; germplasm; antioxidant activity; total polyphenols; acid and sugar content.

Session P22: Advances in Microbiome Interactions, Biocontrol Strategies, and Breeding for Resilient Tomato Cultivation

Thursday 6th June. Chair: Silvia Proietti

Decoding the endophytic bacterial microbiota of tomato to construct in silico microbial consortia

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Primary food production relies on massive use of chemical synthesis products that undermine the resilience of soil and water ecosystems, therefore putting human health at risk. Microbial plant biostimulants could be a viable alternative since they can reduce or even substitute traditional products in crop management strategies. Here, we carried out an in-depth large-scale analysis on tomato roots endophytic prokaryotic communities, analysing 16S amplicon data from the totality of real cultivation conditions used for tomato crops. The microbial system was dominated by Actinobacteriota and Proteobacteria phyla, while less represented phyla were Bacteroidota, Verrucomicrobiota, Patescibacteria and Firmicutes. Identification of the core microbiota and discriminant analysis among different plant growth stages allowed us to select the most prevalent and abundant ASVs that established long-term or transient relationship with the host plant. So, we predicted in silico a microbial consortium that could be reliable under different conditions and highly specific for tomato crops. Among others, we identified Streptomyces, Shinella, Pseudoxanthomonas and Pseudarthrobacter genera as among the most important components of tomato roots endophytic microbiota.

Keywords: 16S amplicon data; core microbiota; discriminant taxa; endorhizosphere; tomato

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Impact of Polyethylene Nanoplastics on Plant–Rhizosphere Interactions in Lettuce (cv. Canasta) and tomato (cv. Microtom): A Multi-Omics Approach.

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The presence of nanoplastics (NPs) in agricultural soils is an emerging concern, yet their effects on plant physiology and rhizosphere dynamics remain poorly understood. This study investigates the impact of three concentrations of polyethylene nanoplastics (0, 20, and 200 µg/kg soil) on plant–rhizosphere interactions in *Lactuca sativa* cv. Canasta (lettuce) and *Solanum lycopersicum* cv. MicroTom (tomato).

To thoroughly assess NP-induced alterations, we determined plant growth and development and their photosynthetic performance to investigate the overall impact on plant wellness. A deeper focus was placed on the plant-soil interaction affected by NP contamination. In this sense, using two-dimensional root images, root development and morphology were assessed to investigate the potential direct effect of NP on root shape and development. Afterward, soil enzymatic activity (dehydrogenase activity, protease activity, and acid and alkaline phosphatase activity) investigated differences in the capacity of the soil microbiomes to cycle carbon, nitrogen, and phosphorous in the presence of NPs pollutants.

To investigate plant-soil communication, root exudates and rhizosphere microbial communities were characterized to evaluate potential shifts in microbial diversity and function. These were integrated through a multi-omics data integration approach to identify significant features specifically correlated with plant communication under NPs exposure. Our findings reveal a critical reduction in plant growth and performance in a NPs dose-dependent manner. Interestingly, increased enzymatic activities were observed with higher NPs dosage, suggesting an imbalance in soil microbiomes for nutrient cycling. Furthermore, specific exudate metabolites were emphasized as crucial for plant communication with the rhizosphere's microbial community, depending on the specific dosage of NPs contamination. This suggests a specific microbial shift influenced by NP exposure correlated with the dosage. These insights offer a deeper understanding of how polyethylene nanoplastics impact below-ground ecological processes, potentially affecting plant health and soil functionality.

Keywords: *nanoplastics, polyethylene, root exudates, rhizosphere, metabolomics, metagenomics, multi-omics integration*

Harnessing breeding selection and heat tolerance in tomato: constitution of resilient hybrids for climate change adaptation

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In plant breeding, the development of superior hybrids through the selection of homozygous lines and their crossing, is a common strategy to harness heterotic effects. This approach has significant potential for improving crop resilience, particularly in the context of climate change, which increasingly affects tomato cultivation through rising temperatures. In this study, a breeding program was developed to constitute new heat-tolerant tomato hybrids using the E42 genotype as the parental line. E42 is a cherry tomato type with a determinate plant habitus, selected following many years and environments of evaluation as a thermotolerant and high fruit quality genotype. In the present study, it was crossed with three indeterminate and already known thermotolerant genotypes and five F1 hybrid combinations were obtained and evaluated for 14 traits in two distinct environments (open field and under tunnel) over two years. A multi-trait stability index (MTSI) was applied to assess hybrid stability, leading to the selection of two hybrids, HY1 and HY5, which exhibited superior stability and performance for productive and fruit quality traits under high-temperature conditions. These hybrids also presented positive heterosis for yield, total soluble solid content, and titratable acidity in comparison to the parental lines across all environments. Additionally, genomic analyses based on ddRAD-sequencing data revealed heterozygous variants and hotspot regions associated with genes and QTL regions that may contribute to heterosis. Our findings underscore the importance of carefully selecting parental combinations to achieve heterosis and heat tolerance, ultimately enhancing the development of resilient tomato hybrids capable of facing the challenges posed by changing environmental conditions.

Keywords: Tomato hybrids, Heat stress, Multi-traits selection, Heterosis, ddRAD-sequencing

Stepwise screening of effective new fungal and bacterial biocontrol agents of soilborne tomato diseases using high-throughput digital plant phenotyping

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Intensive tomato farming systems are exposed to the recrudescence of soil-borne pathogens. The use of microbial biological control agents (BCAs) can be a viable alternative to synthetic fungicides to push for non-chemical disease management. In this context, the research's crucial goal is to select new effective microbial antagonists, to be used alone and/or assembled in consortia. High-throughput digital phenotyping technologies can provide a decisive boost for targeted, non-invasive, and rapid screening of BCAs candidates. In this work, a novel stepwise plant phenomics-assisted approach is proposed to accelerate the screening of new and effective solutions. Two microbial collections constituted by fungi of the genus *Trichoderma* and beneficial bacterial species were assayed both *in vitro* and *in vivo* against two of the most important tomato pathogens, *Sclerotium rolfsii* and *Fusarium oxysporum* f. sp. *lycopersici*. Moreover, a bacteria collection was also evaluated in terms of plant growth promotion. Plant response to microbial treatments was assessed by morphometric and multispectral parameters acquired with a 3D multispectral dual scan. Multivariate statistical processing of the datasets from fungi and bacteria, referring to 16 different phenotypic parameters, guided the selection. Summarizing, *T. harzianum* strain T2, *Peribacillus* spp. Strains TR12 and C5NA were found to be effective against *F. oxysporum* sp. *lycopersici*, whilst *T. harzianum* strain PB3, *Peribacillus* spp. strains TR2 and C6 were selected as biocontrol agents of *S. rolfsii*. Growth parameters including 3D leaf area, surface angle and digital biomass as well as vegetative indices associated with chlorophyll content such as NDVI and GLI were among those that most significantly discriminated the plant's health status. Finally, *Microbacterium* sp. strainTR9 increased plant height and digital biomass, thus indicating a potential biostimulant activity. This study provides a valuable method to screen useful microorganisms and enhance microbial-based innovations for sustainable tomato disease management.

Keywords: Digital agriculture*, Fusarium oxysporum f. sp. lycopersici*, *Sclerotium rolfsii*, 3D multispectral scan, Phenomics.

Session P23: Sustainable Forest and Agroforestry Management: Integrating Biomass, Ecosystem Services, and Climate Resilience

Thursday 6th June. Chair: Fabio Boncinelli

Geospatial Analysis of Agroforestry Biomass for Sustainable Bioenergy Supply Chains: Insights from the Lazio Region

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Biomass represents a crucial resource for renewable energy production and environmental sustainability. Organic material from agro-forestry and agriculture, from waste and residues of biological origin as well as the biodegradable fraction of waste, it can be used for energy generation (heating, biogas and electricity), and the production of by products such as digestate and biochar.

This study focuses on the analysis of geospatial data related to agroforestry biomass in the Lazio region (Italy), aiming to assess its availability and optimize its utilization for the development of local bioenergy supply chains. Particular attention has been given to the types of biomasses suitable for conversion into energy carriers. Specifically, the study examines an agricultural residue (straw) and a forestry residue (pruning), which can be processed through gasification/pyrolysis, into biogas, bioethanol and syngas, and bioproducts such as: digestate and biochar.

To support this analysis, multiple official databases were utilized, including the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) Biomass Atlas, agricultural area and production statistics from the Italian National Institute of Statistics (ISTAT), and SINFOR, the forestry data system managed by the Council for Agricultural Research and Economics (CREA).

The processing of this information led to the development of a detailed provincial-scale cartographic representation for the Lazio region, allowing for the visualization of biomass distribution and the identification of the most suitable areas for establishing bioenergy supply chains. This mapping serves as a critical tool to support decision-making strategies and promote the sustainable development of the sector.

Furthermore, this study evaluates the environmental, economic, and social sustainability impacts of the bioenergy supply chain. The analytical model developed, currently applied to the Lazio region, can be extended to the national scale, providing a reference framework for the efficient and sustainable management of biomass resources in Italy.

Keywords: Renewable Resources, Data-analysis, Pyrolysis, Gasification, GIS

Community Economic Losses from Forest Fires: A Focus on Environmental Assets and Ecosystem Services

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Recent years have recorded a significant increase in the frequency and intensity of forest fires in Europe, particularly in Mediterranean countries such as Italy. This phenomenon is additionally intensified by the impacts of climate change, and seriously affects the availability of the benefits provided by forests, commonly referred to as “ecosystem services” (ESs) (Costanza et al., 1997, 2024; Millennium Ecosystem Assessment 2005). Quantifying the economic value of ESs can raise awareness, encourage respectful behavior and help decision-makers plan activities and counter harmful events. In this context, the present study provides a financial evaluation of the ESs lost due to fires in the "Aspromonte National Park" (Calabria region - Southern Italy), where 5,000 hectares of forest, also within a UNESCO site, were destroyed in 2021. From a methodological point of view, the Total Economic Value (TEV) approach (Peterson & Sorg, 1987; Merlo & Croitoru; 2005; Pettenella et al., 2008) was used in conjunction with the procedure for the economic estimation of fire damage described by Ciancio et al., (2007), combining the use of the Geographical Information System (GIS) and primary data collected through field surveys. The results showed an estimated damage of €26 million, representing the total value of the six ESs (wood and non-wood forest products; forest based recreation; hydrogeological protection; climate change mitigation; biodiversity) identified for the specific study context. The ES with the highest economic impact was hydrogeological protection with 39% of the total damage, followed by wood loss 19%, naturalistic value 17%, climate change mitigation 16%, non-wood forest products 8% (mushrooms, oregano and pastures) and recreational value 1%. The results obtained from the study can be useful to inform forest policy and support the planning of more effective and intelligent prevention strategies, taking into account the productive function of forests and the benefits to the local community.

Keywords: *Ecosystem services (ESs); Economic value; Forest fire; Decision support system (DSS); Protected area*

Towards a sustainable and modern silvicultural management for direct protection forests

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Forests with a direct protective function primarily serve to protect people, settlements, or infrastructure from catastrophic natural events. The accepted definition implies that direct protection forests have the potential to mitigate damage to people or assets caused by natural hazards or adverse climatic conditions. They represent an effective countermeasure within the framework of Ecosystem-based Disaster Risk Reduction by reducing frequency, magnitude, and/or intensity of natural hazards.

As a result, forests with direct protective functions require specific management plans tailored to the "level" of protection (i.e. degree of hazard mitigation) provided by the forest stands and the associated "level" of risk. This study proposed a procedure to delineate and classify the protective effectiveness of forests by integrating geospatial data on (i) multi-hazard susceptibilities, (ii) elements at risk, and (iii) commonly available forest stand characteristics (e.g., forest cover, tree species). Forest stand polygons were also categorized based on the types of natural hazards they mitigate, their level of protection, and the key variables to monitor.

Satellite imagery and field observations were employed to enhance the accuracy of assessing protective effects across large areas. At a regional scale, different silvicultural operations were planned and programmed based on forest conditions to improve or maintain protective function over medium- to long-term horizons. At a site-specific scale, the impacts of human and natural disturbances were evaluated combining future scenarios and GIS-based natural hazard models.

This approach was tested on the forested areas (~6,200 km²) of the Lombardy Region, where 16% of the territory is classified as high susceptible to landslides and floods. The outputs of this procedure can serve as decision-support tools for risk-based protective forest management and ecosystem-based integrated risk management of natural hazards. They can assist regional authorities, practitioners, and decision-makers in their efforts.

Future research on protective forests should focus on advancing knowledge and tools to compare the effectiveness and cost-efficiency of protective forests with traditional engineering measures.

Keywords: *protection forests, natural hazards, forest management.*

Sustainable Forest Management: Multi-Objective Strategies in the European Forest Sector

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The study proposes a combined three-stage multi-objective programming approach to the European forest sector, marking a pioneering effort in this domain. This novel research conducts an analysis for 27 EU state forest countries to assess how these countries can concurrently achieve diverse Sustainable Forest Management (SFM) goals despite conflicts among objectives, including two desirable goals—wood removal (economic aspect) and recreation area (social aspect)—and one undesirable output: forest damage area (environmental aspect). In the modeling phase, Multi-Objective Particle Swarm Optimization (MOPSO) is applied to deliver a set of Pareto-optimal solutions by iteratively optimizing particles to maximize desirable outputs and minimize undesirable ones. In the benchmarking phase, Data Envelopment Analysis (DEA) computes the efficiency scores of MOPSO particles, serving as a filter to reduce the optimal solutions to a manageable number. In the final stage, DEA results are ranked using the multiple criteria decision-making (MCDM) method, measuring the proximity of each solution to ideal and anti-ideal points. The results indicate that forest managers in the 27 EU countries should increase wood removal to 74665 (10^3 m^3/year) and recreation area to 2926.80 (10^3 ha), while reducing forest damage to 10 (10^3 ha). Based on the MCDM method, Latvia, Finland, and France ranked first, second, and third, respectively, while Ireland, Portugal, and Croatia ranked last, with their improvement values estimated. As the major conclusion, our hybrid three-stage multi-objective model not only determines optimal SFM goals but also offers practical recommendations for enhancing sustainability and efficiency in the EU forest sector. These findings underscore the model's potential as a managerial tool for balancing economic, social, and environmental objectives in forestry.

Keywords: European forest sector, Meta-heuristic optimization, Multi-objective programming, Multiple criteria decision-making, Sustainable forestry practices

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Urban Reforestation Perspectives in the Fight Against Climate Change

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In recent years, several initiatives have highlighted the importance of increasing the number of trees, among them the urban forestation activities envisaged by the PNRR for Metropolitan Cities. The aim of these actions is to mitigate the effects of climate change, through the expansion of urban green areas, the recovery of degraded ecosystems, containing the spread of invasive alien species and selectively favoring the development of those considered most suitable for future climatic conditions. The demand for forest seedlings can be interpreted as a growth opportunity for the entire nursery sector, however, carefully examining the variables that could have the greatest impact on production, including regulatory provisions, the quality of nursery material and its suitability for specific uses.

A concrete example of an operational approach is represented by the VIVI4ROMA project, born from an agreement between CREA and Roma Capitale, aimed at identifying and producing forest nursery material suitable for growth under urban and peri-urban conditions of Rome, as response to challenges posed by climate change. The climatic analysis of the recent past (1981 – 2010 period) shows in the Roman territory an increasing thermal gradient from the coastal strip (26-27 °C, mean of maximum temperature of the hottest month) towards the inland areas (32-34 °C), with a pattern, according to future forecasts 2041-2070, that will tend to even out as temperatures rise towards the 32-34 °C maximum levels. The aim of this work is to present the main aims of the VIVI4ROMA project, analyzing the possible sites from which collect the forest multiplication material and the forest species with ecological characteristics most suitable for the city of Rome.

Keywords: Urban forestry; forest nursery; city of Rome; climate change; reforestation

Session P24: From Genetic Variability to Market Preferences: A Multidisciplinary Approach in Viticulture

Thursday 6th June. Chair: Riccardo Baroncelli

Communicating sustainability in wine: the influence of environmental and social messages on PIWI wine preferences

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Introduction and purpose: Sustainability concerns are increasingly shaping the agricultural and viticultural sectors, driven by rising consumer interest in environmentally friendly products, growing awareness of climate change impacts, and intensifying policy pressures for more responsible farming practices. Fungus-resistant grape varieties, also known as PIWI (an acronym derived from the German *PilzWiderstandsfähig*) offer a promising solution for enhancing sustainability by minimizing pesticide use, reducing carbon emissions, and promoting biodiversity. However, their adoption remains limited due to regulatory barriers and low consumer familiarity. While previous research (Borrello et al., 2024; Kiefer & Szolnoki, 2024) has demonstrated that informing consumers about PIWI wines' environmental advantages increases their acceptance, little attention has been given to how different sustainability narratives—especially those emphasizing social sustainability—affect consumer perceptions. This study aims to broaden the understanding of consumers' acceptance and preferences for PIWI wines by examining how sustainability-related messaging—specifically highlighting environmental or social benefits—influences consumer behaviour and promotes PIWI wine adoption.

Methodology: A choice experiment was conducted in December 2024 with 748 wine consumers from the Veneto region (Italy) through an online survey. Participants were randomly assigned to one of three treatments groups: a control group receiving no information, a first treatment group receiving information on PIWI's environmental benefits, and a second treatment group receiving information on social sustainability benefits. Random Parameter Logit (RPL) models were employed to analyze the determinants of consumer preferences and the impact of sustainability messaging on attitudes toward PIWI wines.

Findings: The results confirm that providing sustainability information significantly affects consumer purchasing choices, with PIWI wines being more likely to be preferred when sustainability benefits are communicated. Notably, there is no significant difference in effect between the group exposed to social sustainability messaging and the group receiving environmental information. These findings highlight the critical role of strategic communication in promoting sustainable wine choices.

Keywords: Choice experiment, wine, PIWI, fungus-resistant, consumer behaviour

References:

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Genome editing applications on grapevine cvs. Aglianico and Falanghina for the knockout of susceptibility genes

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Italy is a rich hub of viticultural biodiversity, hosting hundreds of indigenous grape varieties. Preserving this biodiversity is essential to maintaining a diversified genetic pool and addressing future challenges such as climate change and the increase in phytopathologies. Currently, disease control primarily depends on chemicals and fungicides, which pose significant environmental impact. Biotechnological approaches, such as genome editing through the CRISPR/Cas9 system, can result in a more sustainable solution to enhance resistance while maintaining quality and production traits. This strategy requires propagable plant material capable of regenerating an entire potentially modified plant. This work focuses on developing *in vitro* regeneration protocols for the Campanian cultivars, Aglianico and Falanghina, facilitating genetic manipulation of calli and protoplasts. Consequently, two genes involved in susceptibility to downy mildew and powdery mildew were selected. Specifically, the gene *Downy Mildew Resistant 6.1* (DMR6.1) plays a role in regulating salicylic acid levels. Studies in vines show that its knock-out enhance downy mildew tolerance by increasing hormone levels and strengthening defense responses. *CERK1-Interacting Protein Phosphatase 1* (CIPP1), on the other hand, encodes a phosphatase responsible for the dephosphorylation, and thus inactivation, of the membrane chitin receptor CERK1. To knock out these genes, both conventional and innovative genome-editing techniques were employed. In addition to the traditional *Agrobacterium tumefaciens*-mediated transformation, transfection methods were used with plasmid DNA (pDNA), containing an overexpression cassette for Cas9 and gRNA, as well as pre-assembled ribonucleoprotein particles (RNPs). This study demonstrates the possibility of using fruiting cuttings as a constant source of floral explants, from which embryogenic calli can be obtained for *in vitro* plant regeneration through somatic embryogenesis. The embryogenic material obtained enabled successful isolation of viable protoplasts providing an excellent platform for transfection with both pDNA and RNPs, paving the way for sustainable viticultural advancements.

Keywords:*Vitis vinifera, Somatic embryogenesis, Protoplasts isolation, CRISPR/Cas9, Susceptibility genes*

Genomic strategies for identifying genetic factors underlying resistance to Xylella fastidiosa in olive trees

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Since 2013, the bacterium *Xylella fastidiosa* subsp. *pauca* (*X.f.*) has profoundly impacted the economic, society, and landscape heritage of the Apulia region in southern Italy. *X.f.* is transmitted by *Philaenus spumarius* and infects the xylem vessels of olive trees. Currently, no substances are authorized in Italy to combat *X.f.* Disease management efforts focus primarily on containment and compliance with European Union regulations, which include disease monitoring, eradication of infected plants, and vector control. However, despite these measures, the disease continues to spread northward through Apulia, highlighting the need for more effective strategies. Biparental linkage analysis has become a powerful strategy to disclose the genetic architecture of complex agronomic traits in crops, such as olive. Advances in high-throughput sequencing and genotyping techniques, supported by the availability of olive reference genomes, have significantly enhanced the accuracy of QTL mapping methods. This research is part of the RIGENERA (Approcci IntegRati per il mIglioramento GENEtico, la selezione e l'ottenimento di materiali vegetali Resistenti a *Xylella fastidiosA*) project. It aims to investigate the genetic basis of susceptibility and resistance in olive trees by using mapping populations derived from the cross of two parental lines with contrasting disease responses. The parental lines and F1 offspring were analyzed using microsatellite markers to exclude individuals resulting from self-pollination and uncontrolled cross-pollination. Propagation and infection of the confirmed progenies are ongoing. The F1 offspring will also be characterized using Single Primer Enrichment Technology (SPET) to develop a cSNP panel for constructing a linkage map. Integrating linkage map data with phenotypic characterization of plants infected with *X.f.* will be crucial for identifying key genes and loci involved in the plant's response to the disease.

Keywords: *Olea europeae, biparental population, Single Primer Enrichment Technology (SPET), Single Nucleotide Polymorphisms (SNPs), linkage map*

STOMATAL VARIATIONS IN *VITIS VINIFERA* L.: VARIETAL/CLONAL DIFFERENCES AND RESPONSE TO CLIMATIC CONDITIONS

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This 2-year study investigated the stomatal characteristics of grapevine (*Vitis vinifera* L.) in order to understand the role of stomatal density (SD) and stomatal size (SS) towards environmental adaptation and plant resilience, with implications either for a sustainable viticulture under climate change scenarios or new agricultural systems (i.e., agrivoltaics). The research was conducted in Puglia in 2019 and 2020 on various varieties/clones trained to bilateral Guyot system and drip irrigated. Fully developed leaf samples, collected in summer, were subjected to analysis at the microscope to quantify both SD and SS. The results showed a significant reduction in both parameters in 2020 compared to 2019, with a decrease of either SD from 178.3 to 152.2 stomata/mm² (-14.6%) or SS from 508.8 to 481.7 µm² (-5.3%), suggesting a plastic and adaptative response of grapevine to the warmer climatic conditions observed in 2019. SD varied from 133 stomata/mm² in the Verdeca clone #13 to 220 stomata/mm² in Moscatello Selvatico, while SS ranged from 284 µm² (Verdeca #19) to 726 µm² (Negramaro #12). Significant differences were also observed between clones of the same variety, such as Uva di Troia #13 (660 µm²) with respect to Uva di Troia #2 (416 µm²), highlighting intra-varietal variability that could be useful for selecting resilient genotypes for the different environments. The ability of grapevine to modulate stomatal parameters in response to environmental conditions may represent a key factor for optimizing water use efficiency (WUE) and crop management in water-limited contexts and in agrivoltaics systems. These preliminary findings provide crucial insights for breeding strategies and varietal selection aimed at adapting grapevine to the challenges posed by climate change, promoting a more sustainable and resilient viticulture.

Keywords: Stomatal density, Water use efficiency (WUE), Climate change adaptation

Preliminary study on the physical characteristics of the fermentation cap and their relationship to grape must extraction parameters

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In red winemaking, the presence of berry skins during alcoholic fermentation results in the transfer of phenolic compounds and pigments into the liquid phase. At this stage, it is useful to control the extraction of grape skin components ensuring the contact between the juice fraction and the pomace cap by means of punching-down or pumping over systems.Cap management is not a standard operation, but it is planned according to the product to be obtained and adjusted through the winemaker's experience. However, none of the several parameters measurable on grape must is yet used to manage the frequency of pumping over or punching-down. The aim of this preliminary study was to track the evolution of the pomace cap over the fermentation and, secondly, to find any correlation with quality parameters, in order to give the winemaker an objective tool for the processing choice.

During experimental trials carried out in the winery, the characteristics of the fermentation cap were tracked throughout the red winemaking process by the punching-down method, through physical measurements taking either the penetration force directly on the cap by penetrometer, or monitoring the mechanical work of the plunger at any punching-down cycle. A similarity with the fermentation curve was described for the peak penetration force (N) while the average work (J) of the plunger peaked at the maximum fermentation activity and then plummeted. In addition, color indexes, taken daily on the liquid, were well-correlated with the physico-mechanical parameters. This preliminary study, suggests that pomace cap undergoes a different evolution over the fermentation stages, and the use of wine quality parameters, such as color, can be exploited to optimize cap management techniques and control the extraction of grape skin components.

Keywords: *red winemaking, alcoholic fermentation, punching-down, cap management, color*

Session P25: Emerging Technologies in Circular Bioeconomy: Waste Derived Solutions for Agriculture

Thursday 6th June. Chair: Ida Romano

Development of biotechnological processes for bioplastics production from dairy waste using selected microrganisms

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The increasing demand for sustainable materials has driven interest in bioplastics produced by microorganisms using industrial byproducts as substrates. Polyhydroxyalkanoates (PHA), produced from different carbon sources and stored in microbial cells in the form of granules as energy reserves, are currently the most studied biopolymers. PHA synthesis occurs, during the fermentation process, in deficiency of essential nutrients (N, P, S) and excess of a carbon source. Before the cultivation process, food waste were subjected to several pre-treatments to reduce the nitrogen and lactose content. This study investigates the potential of *Azohydromonas lata* DSM 1123 for the biosynthesis of polyhydroxyalkanoates using *scotta* (ricotta cheese exhausted whey), a lactose-rich dairy by-product, as a carbon source. The fermentation process has been optimized to enhance PHA yield, assessing microbial growth, and evaluating polymer accumulation. Fermentation conditions (culture medium for the microorganism propagation, inoculum size, time, and temperature of incubation) were selected according to the maximization of polymer synthesis, under in-flasks experiments.The PHA production was then tested using a bioreactor system, under stable and monitored pH, temperature, and stirring conditions. Results demonstrate that *scotta* is overall a suitable substrate for *A. lata* PHA production. The maximum amount of polymer recovered (with a 32.7% yield PHA / dry biomass weight), was achieved using a substrate consisting of 75% pasteurized scotta and 25% sterilized scotta, thermal treatments employed to modulate the concentration of nitrogenous sources, as well as lactose, in the growth substrate. GC, GPC and differential scanning calorimetry (DSC) analyses revealed polyhydroxybutyrate (PHB) as the polymer synthesized. The interest in optimizing this production system contributes to the valorization of dairy industry waste, promoting circular economy principles while offering an eco-friendly solution for bioplastic manufacturing.

Keywords: *Scotta; Azohydromonas lata; Bioplastic; PHA*

The AFRODITE® process: High-agronomic value of selected poultry manure valorized through aerobic fermentation

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Organic amendments, deriving from the spontaneous aerobic transformation of livestock manure, contribute to improve soil fertility and organic carbon storage. Microbial activity, within manure, plays a focus role in organic matter degradation and humification. The Afrodite process (Aerobic Fermentation and Revaluation of Organic matrix to Develop and Improve The Essence of soil) represents a valorisation of an industrial waste that, otherwise, has to be disposed. Some bacteria involved in such process maintain their viability in the final stable manure and they may have plant growth-promoting activities. This study aimed at investigating the role of the emerging microbial components and the chemical proprieties of poultry manure along the fermentation process. Poultry manure were collected in two years, during the aerobic fermentation and after pelleting. The pelletized final product reached in both years stable value of pH (6.5–7.5), moisture (17.0–13.8%), total nitrogen (3.0–3.8%) and C/N ratio (10.46–10.66); total eubacteria population decreased (from 10 to 11 to about 7 Log_{10} CFU/g), with the selection of a thermophilic/hyperthermophilic microbiota due to the high temperatures during the process. The commercial product is microbiologically safe and rich of bacteria mainly belonging to *Bacillus* genus, able to solubilize phosphate, produce siderophores and indol-3-acetic acid. Biolog phenotyping evidenced interesting metabolic compounds. Moreover, the final stable poultry manure was added as fertilizer in lettuce and eggplant; at harvest, a significant increase in fresh weight and productivity was evidence in lettuce and eggplant respectively. This work has highlighted that poultry manure fermentation followed by pelletization allows the obtainment of a stable product, rich in beneficial bacteria and nutritional elements, possessing growth-promoting effects on horticultural plants. The process represents a virtuous example of circular economy.

Keywords: *Poultry manure; Aerobic fermentation; Bacillus spp.; Lettuce; Eggplant*

Microalgae cultivation on biogas digestate fractions: a sustainable pathway for biostimulants production

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In recent years, the development of biostimulants as a sustainable tool for agriculture has provided opportunities to enhance nutrient use efficiency, tolerance to abiotic stresses and crop quality, while advancing circular economy models. Algae-derived biostimulants have shown potential in enhancing plant growth and resilience. However, most studies have focused on macroalgae, leaving the potential of microalgae underexplored. Cultivating microalgae on nutrient-rich fractions from biogas digestates offers an innovative solution combining waste valorisation with environmental benefits. These systems facilitate the recovery of essential nutrients (N, P, K) from farming and livestock wastes while sequestering CO_2 through microalgae photosynthesis. The resulting algal biomass represents a valuable resource for biostimulant production. This study investigates the biostimulant properties of microalgae belonging to genera Nannochloropsis, Euglena and Chlorella grown on standard media or nutrient-rich fractions recovered from digestates. Dry algal biomass was applied as a seed priming agent and drench treatment to assess its effects on the germination and growth of hydroponically grown tomato plants (Solanum lycopersicum). Different concentrations (0.02, 0.1, 1, 10, 25 g/L) were tested to determine the optimal dose to enhance seed germination. Lower concentrations (0.02–1 g/L) of algal biomass, whether grown in standard media or digestate fractions, were most effective in promoting root development. Based on these findings, 0.1 g/L was selected for subsequent hydroponic trials. The observed effects were genus-specific, with some algae exhibiting a pronounced stimulation of root development while others primarily promoting shoot elongation. Furthermore, microalgae grown on ultrafiltrate digestates exhibited comparable biostimulant properties to those cultivated in standard media, highlighting the potential for nutrient recycling. Finally, untargeted metabolomic analysis is underway to characterise the profile of microalgae and better understand their biostimulant potential. These findings provide valuable insights into producing microalgal biostimulants through an innovative system to valorise agricultural waste products.

Keywords: biostimulants, microalgae, digestate, sustainability

Exploring the impact of human urine derivatives on gene expression in soilless lettuce

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The exponential population growth and the increasing demand for food have intensified the use of chemical fertilizers in agriculture, exerting an enormous pressure on natural resources. Thus, the recent challenges are to limit the use of chemical fertilizers by favouring waste recycling and obtaining organic raw materials for agriculture, following a circular economy perspective. For this reason, we studied the effects of the use of human urine derivatives (UDs) vs commercial fertilizers on the metabolic profile and antioxidant activity of lettuce (*Lactuca sativa* L.) cv. Grand Rapids in soilless cultivation (Nicastro et al., 2024). However, to better understand the effects of UDs on plant metabolism through gene regulation, this study also examined the impact of the UDs on gene expression, with a focus on genes encoding for enzymes involved in key biochemical pathways, assessing potential stress responses or other regulatory effects. Treatment with K-Struvite resulted in the highest expression levels of genes encoding key enzymes involved in nitrogen metabolism, nitrate reductase (NR), glutamate synthase (GOGAT X1) and glutamine synthetase (GS), with the lowest expression levels in plants treated with Hydrolyzed urine. The latter, however, showed increased expression of genes encoding stress-related enzymes like GOGAT X2, catalase (CAT) and glutamate decarboxylase (GAD). Additionally, the expression of *P5CS* (*Δ1-pyrroline-5-carboxylate synthase*), a key gene in proline synthesis, decreased across all treatments compared to the control, with the most significant reduction in ED concentrate and K-Struvite. Genes encoding for CHS2 (chalcone synthase), AGPase (ADP glucose pyrophosphorylase) and cytGR (glutathione reductase cytosolic) enzymes showed higher expression in plants treated with K-Struvite. Whereas genes for PAL (phenylalanine ammonium lyase) and chlGR (Glutathione reductase, chloroplastic) enzymes were significantly overexpressed after treatment with ED concentrate compared to the NPK control. Fertigation with UDs in soilless lettuce cultivation not only induces variable morphological and metabolic responses thanks to their peculiar composition but also influences gene expression levels reflecting the different forms of nitrogen they provide.

Keywords: *waste recycling, plant metabolism, gene expression, circular economy*

Session P26: Sustainable Livestock Production: Environmental Monitoring and Product Quality

Thursday 6th June. Chair: Francesco Serrapica, Claudia Lambiase

Characterization of Grass-fed Bergamasca sheep products.

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The Bergamasca sheep is an autochthonous Italian breed defined as an Alpine breed. It's known by its large size and is bred for meat production. The main method of rearing Bergamasca sheep is the transhumance system on alpine pastures, given the animal's ability to adapt to different environments. The transhumance practices are characterized by an efficient use of natural resources. The aim of the present study was to evaluate the quality parameters of cooked ham and dry-cured neck from grass-fed Bergamasque sheep, monitored by means of a collar provided with a GPS tracking system with SAT communication. In September, at the end of the transhumance season, ten sheep of an average age of 5 years and a live weight about 94.5 kg were slaughtered. Knuckle and chuck samples were collected and sent to the processing plant for the production of cooked ham and coppa. On cooked ham and coppa samples the physical and chemical parameters, fatty acid composition and sensory profile were evaluated. The nutritional composition showed that in cooked ham the dry matter was about 40% with a protein content of 22% and an ether extract of 13%. The dry cured neck showed a dry matter about 68% with a protein content of 30% and an ether extract of 31%. The fatty acid composition revealed that in both sheep products the polysaturated fatty acid content was well represented and with a healthy ratio of omega6/omega3. The sensory pa analysis of coppa showed high scores for the intensity and wild aroma and flavour, characteristic of sheep meat. In cooked ham high values were obtained for spicy and cooked meat aroma and flavour. These data characterize the quality of derived products from Bergamasca sheep products and highlight the potential to valorize the Bergamasca-based products through a traceable, sustainable and health-conscious supply chain.

Keywords: sustainable farming system, Bergamasca sheep, grass-fed, products characterization.

IoT-Based Monitoring System of Ammonia Emissions in Naturally Ventilated Buffalo Barns: Sensor Network Development

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Introduction

Ammonia (NH_3) emissions from livestock farming pose significant environmental challenges, contributing to air pollution, ecosystem acidification, and eutrophication. The livestock sector is a major NH_3 source and must actively mitigate emissions. The European Directive 2016/2284/EU (NEC Directive) sets binding national reduction targets to improve air quality across the EU. Achieving compliance requires accurate emission monitoring. However, measuring NH_3 emissions from naturally ventilated barns, such as those housing Italian Mediterranean buffalo, is challenging due to variable climatic conditions.

Objectives

This study aims to develop an IoT-based monitoring network to measure NH_3 and CO_2 concentrations in buffalo barns in Campania, Italy. CO_2 data will help estimate ventilation rates, enhancing understanding of NH_3 emission dynamics and dispersion.

Methods

The system uses electrochemical DOL 53 sensors for ammonia and DOL 119 sensors for CO_2, chosen for their accuracy and durability in harsh agricultural environments. Data transmission is via LoRaWAN technology, ensuring stable, secure communication up to 15 km. Sensors are housed in certified enclosures resistant to dust, humidity, and corrosive agents. Data are sent to a central gateway, then to a dedicated IoT platform for real-time processing, management, and visualization. This setup enables continuous, non-intrusive monitoring, capturing daily and seasonal variations. Airflow dynamic modeling will guide sensor placement and improve sampling quality.

Expected Results

e IoT network is expected to provide reliable, continuous data on NH_3 and CO_2, allowing precise ventilation rate estimation and emission pattern analysis. This will improve understanding of emissions in naturally ventilated buffalo barns.

Conclusions

The IoT monitoring system is a necessary step toward better environmental management in livestock farming, supporting EU regulatory compliance. By enabling real-time monitoring, it

provides a basis for targeted mitigation strategies to reduce NH3 emissions and improve air quality and ecosystem health.

Keywords: *ammonia emissions, naturally ventilated barn, environmental monitoring, IoT sensor network.*

Land occupation to produce milk: relationship between on-farm and off-farm feed production, nitrogen balance and carbon footprint

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Land occupation (LO) is one of the most frequently discussed aspects of livestock competition with agricultural activities, because globally, around 30 percent of arable land is used to produce feeds for animal nutrition. Purchased feed is considered one of the most impactful categories of milk production in terms of carbon footprint (CF) and nitrogen (N) surplus on-farm surfaces. Therefore, a precise measurement of land required to produce purchased feeds used by dairy farms is needed. This study aimed to calculate the actual land occupied to produce milk and the relationship with the nitrogen surplus and GHG emissions to assess and improve the environmental sustainability of dairy sector. The LO was divided between ON-FARM LO (utilized agricultural area by farms) and OFF-FARM LO (area required to produce crops from which animal feeds are derived). Fourteen dairy farms in northern Italy were analyzed as a key study and two years of data were collected. A great variability of LO was found due to the different farm management and animal feeding strategies. Half of the surface needed to produce milk was due to the purchased feeds, especially protein feeds (e.g. soybean meal) which were also one of the main N inputs causing N surplus problems. Moreover, the farms with the higher OFF-FARM LO were those with higher CF. The increase of efficiency of farm management is one of the most important factors to decrease the LO due to milk production, as the amount of purchased feed is reduced. This approach leads also to a reduction of N surplus and GHG emissions, increasing the environmental sustainability of dairy sector.

Keywords: *Land occupation*, *land use impact, nitrogen surplus, carbon footprint, dairy farms.*

Monitoring GHGs fluxes following slurry distribution in three alternative forage system managements

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The main greenhouse gases (GHGs) emitted from non-flooded agricultural soils are carbon dioxide (CO_2) and nitrous oxide (N_2O). N_2O contributes about 6% of annual global GHGs emissions in CO_2 equivalents. Since anthropogenic N_2O emissions are largely associated with agricultural activities, their assessment is increasingly important for evaluating the mitigation potential of alternative management practices. To understand the effects of cropping system management on GHGs emissions and carbon sequestration, comprehensive experimental studies and process-based model approaches, which require extensive measured data, are needed. A sizeable set of measured data of GHGs fluxes is desirable for calibrating a model able to accurately and efficiently simulate SOC dynamics and GHGs emission under a range of environmental and soil management conditions. The objective of this research is to calibrate ARMOSA process-based model to optimize the comparison and the evaluation of agronomic strategies aimed at reducing GHGs emissions and increasing SOC stocks through conservative soil management practices. The field trial was established in September 2023 in Landriano (Lombardy, Italy) to investigate a two-year crop rotation with double cropping (barley, soybean, and maize) and three management levels (conventional, semiconservative, no-tillage). Crops growth season were characterised by waterlogging due to frequent and intense rainfall events: the tested management did not influence barley (10.68 ±2.03 t DM ha-1) and soybean (5.99 ±0.98 t DM ha-1) productivity in terms of AGB accumulation. Statistical analysis of total cumulative CO_2, from December 2023 to February 2025, confirmed significant differences among the investigated management strategies: the semi-conservative system exhibited the highest CO_2 emissions (2237.82 ±779.77 g CO_2 m^{-2} a), followed by the conventional system (1644.25 ±744.78 g CO_2 m^{-2} ab), while the no-tillage system recorded the lowest emissions (1590.49 ±626.85 g CO_2 m^{-2} b). Preliminary N_2O results show no management effect on emissions, with an average monthly emission of 2.83 ± 1.63 mg N2O m^{-2} $month^{-1}$.

Keywords: *greenhouse gases, conservative agriculture, cropping system simulation model, carbon sequestration, nitrous oxide emissions*

Impact of Metodo Nobile pasture on the chemical, physical, and sensory properties of goat Caciotta cheese

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Pasture remains a key component of sustainable animal feeding systems, reducing competition for arable land and food resources by allowing animals to graze on land unsuitable for human food production. Additionally, consumer demand for certified "grass-fed" and "pasture-fed" dairy products is increasing, creating new research and market opportunities. This study aimed to evaluate the impact of a high forage-to-concentrate pasture-based diet on the chemical, physical, and sensory characteristics of goat Caciotta cheese. Twenty Saanen goats were randomly assigned to two homogeneous groups (10 goats each) at 60 days in milk (DIM). The pasture-fed group (P) grazed on high-biodiversity mixed forage, following the Metodo Nobile guidelines, while the stall-fed group (S) was fed alfalfa hay. Both diets were supplemented with 500 g/head/day of a concentrate mixture and the forage-to-concentrate ratio was 70:30. Cheese from both groups was produced twice, at 75 DIM and 135 DIM, to obtain two biological replicates. All cheeses were analyzed after 25 days of ripening at 10°C. Chemical composition was similar between cheeses, except for a higher ash content in P cheese. While no significant differences were observed in olfactory, gustatory, or colour sensory descriptors, P cheese exhibited lower hardness and higher friability. Texture profile analysis and instrumental colour measurements supported the sensory analysis results. P cheese contained higher levels of polyunsaturated fatty acids (such as alpha-linolenic and gamma-linolenic), conjugated linoleic acid (CLA) isomers, and total phenolic compounds, whereas S cheese had higher concentrations of saturated fatty acids. Terpene compounds were exclusively detected in P cheese, while S cheese showed higher concentrations of ketones and corresponding secondary alcohols, likely derived from the catabolism of saturated fatty acids.Our findings suggest that a pasture-based diet with a high forage-to-concentrate ratio can enhance the nutritional profile of goat cheese while maintaining its sensory properties with only minor changes.

Keywords: *Sustainable dairy production*; *grazing; grass-fed cheese;cheese volatile compounds; SPME-GC/MS.*

Session P27: Assessing Soil Carbon Stocks and Fluxes: Methods and Applications in Cropping Systems

Thursday 6th June. Chair: Beatrice Giannetta

Soil carbon sequestration in different cropping systems: A mid-term field experiment

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Implementing agricultural practices that improve soil quality and carbon sequestration is one of the major environmental challenges of our time. In this regard, it's necessary to carefully determine the impact of agricultural management on soil over time and in both topsoil and subsoil. The aim of this work was to assess the effects of different cropping systems (CONV—integrated management without cover crops, and conventional tillage; ORG—organic management with cover crops, temporary intercropping, and conventional tillage; NOTILL—integrated management with cover crops, and no-tillage) on the distribution and quality of organic matter along the soil depth in a 10-year wheat-maize rotation trial. Soils were sampled by horizons up to 60 cm depth and samples were physically fractionated to isolate particulate (POM) and mineral-associated (MAOM) organic matter. Organic C (OC) content and stock, microbial biomass and activity were determined, and MAOM was analyzed by solid-state 13C CPMAS-NMR spectroscopy. The results of the study showed that total OC stocks (0-60 cm) were similar among the cropping systems, although the lack of tillage in NOTILL concentrated OC mainly on topsoil. Conversely, soil mixing by tillage in CONV and ORG allowed a more homogeneous OC distribution along the soil depth. Most OC was associated with MAOM in all systems and contributed similarly to the total OC content. Further, as shown by NMR, the chemical characteristics of MAOM did not differ among systems, except for Ap1 horizon of NOTILL, which showed higher proportions of O-alkyl C due to a greater presence of labile compounds (e.g., polysaccharides, cellulose). The absence of a significantly greater OC stock in ORG and NOTILL compared to CONV was attributed to the promotion of enhanced mineralization processes, also supported by their higher microbial activity stimulated by the incorporation of N–rich fresh legume cover crop residues, that exceeded the rate of OC stabilization.

Keywords: Cover crops, no-tillage, MAOM, C stock, subsoil

Thirty years of soil organic carbon and land use changes in central Apennines (Molise region) using vis-NIR soil spectroscopy.

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The decline in soil organic matter (SOM) is a major factor affecting ecosystem biodiversity, with land-use changes—especially deforestation for agriculture—playing a crucial role. Increasing SOM levels in agricultural soils (Soil Carbon 4 per Mille) could significantly reduce atmospheric CO_2, with estimated reductions between 16% and 30%. In Italy, agricultural land abandonment has led to expanding forest cover, yet SOM depletion continues to impact ecosystems and global carbon reserves. This study examines the Molise region (central Italy), where land-use changes over the past 30 years have significantly influenced SOM dynamics. Based on 101 soil profiles across 3,000 km², the analysis investigates SOM variations from 1993 to 2023 in relation to land-use changes and increasing climatic aridity. Results show significant SOM differences across soil orders, with increases in Vertisols and decreases in younger soils like Inceptisols and Entisols, mainly due to water erosion. The study also highlights the influence of geomorphological factors, particularly altitude, revealing that higher elevations have greater SOM concentrations. Additionally, soil evolution in the study area reflects long-term anthropogenic pressure, with cropland, forests, and pastures undergoing continuous transformation. Abandoned agricultural lands, now transitioning into grasslands and woodlands, exhibit distinct SOM patterns that contribute to regional carbon fluxes. By integrating pedological surveys with advanced predictive models, this research enhances the understanding of SOM distribution across diverse landscapes. Machine learning and soil spectroscopy demonstrate high accuracy in SOM estimation, reinforcing their potential for large-scale soil monitoring. These findings underscore the importance of sustainable soil management and restoration efforts for enhancing SOM sequestration, mitigating climate change, and supporting carbon storage and ecosystem resilience.

Keywords: Soil organic matter (SOM), Land-use changes, vis-NIR spectroscopy, carbon sequestration

The Roots Awakens: modelling root autotrophic respiration to enhance soil CO_2 fluxes for cropping systems C balance assessment

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Agroecosystems function as both sinks and sources of greenhouse gasses emissions; therefore, their C balance must be assessed by considering all the components and environmental factors that regulate it. Soil CO2 emissions

(Rs) derive from the sum of autotrophic (Ra, originating from root growth and maintenance metabolism) and heterotrophic (resulting from soil organic matter decomposition) respiration components. We developed a new module for the process-based ARMOSA model to explicitly simulate root autotrophic respiration, with the aim of improving the quantification of cropping systems soil C balance. Root respiration is simulated as influenced by the interactions between crop growth, root senescence and management practices. The new module was tested using daily measured soil CO2 fluxes collected in two temperate Mediterranean sites (moist and dry) during multi-year crop rotations, using automated non-steady-state measurement chambers. According to the new module sensitivity analysis, root respiration is a crop-specific process driven by soil conditions, as highlighted by the top-ranked parameters that are respectively the crop maintenance respiration potential and the optimal soil temperature for respirations. The new module performance in simulating CO_2 emissions during calibration was satisfactory, with an average relative root mean squared error (RRMSE, %) of 10.9% and a modelling efficiency (EF, unitless) of 0.95. The validation results remained stable in terms of efficiency (EF = 0.51), with a slight loss of accuracy (RRMSE = 45.1%). For both datasets, the integration of the new module resulted in an improvement over the previous model version (without root Ra simulation): the systematic (RMSEs) and the random (RMSEu) errors decreased respectively from 1.14 to 0.32 and from 0.46 to 0.38. The assessment of the cropping systems C balance is currently ongoing to evaluate the improvement achieved by applying the new module in quantifying the actual crops contributions to the balance under varying management and pedoclimatic conditions.

Keywords: Soil respiration; Crop modelling; Carbon balance; Cropping systems; Automatic GHG station

Savanna ecosystem restoration: soil carbon and nutrient dynamics in Kenya's Maasai Mara

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Savanna ecosystems, covering approximately 50% of Africa, range from grasslands with sparse trees to bushy thickets. The savanna of the Greater Maasai Mara Ecosystem (Mara) in Kenya is notable for its richness in biodiversity but increasingly affected by overgrazing from livestock. Such degradation leads to a reduction in vegetation cover, exposing soil to erosion and organic matter loss. To face the soil degradation in the Mara, afforestation using native plant species has been proposed as a potential restoration method. Research has focused on identifying the best tree species for soil recovery through experimental treatments. Three 50 m x 50 m treatment plots were established: the Savanna Mimic, replicating native woodland patterns; the Diversity-Rich plot, with 30 tree species; and the Themed Species Assortments, which emphasized bioculturally significant species. A control plot was located outside the fenced area, representing degraded conditions. The control plot had the lowest soil organic carbon (SOC) stock, approximately 40% lower than the treatment plots. This reduction was attributed to overgrazing, which limits plant growth and rhizodeposition. The control area also had the highest Carbon Quality Index (CQI = 0.64), indicating the presence of more resistant organic matter, and a high dsDNA:SOC ratio (4.20 mg g_{-1}), suggesting that microbial communities were under stress due to a lack of organic carbon. The Diversity-Rich plot proved to be the most successful restoration approach, fostering SOC accumulation with better carbon quality (CQI = 0.57). This treatment avoided N and P limitations and showed the highest ratios of microbial C:N, N:P and C:P acquiring enzymes, along with the highest available phosphorus concentration (18.7 mg kg_{-1}). In conclusion, the study demonstrates that overgrazing significantly depletes SOC and disrupts ecosystem functions. High-diversity planting strategies offer the most promising results for restoring soils, improving carbon storage, nutrient availability, and microbial activity.

Keywords: *soil degradation, Africa, soil enzymes, overgrazing, afforestation*

Session P28: Optimizing Irrigation and Water Use Efficiency in Open Field Tomato Production.

Thursday 6th June. Chair: Christophe El-Nakhel

Optimizing open-field tomato irrigation: A data driven approach

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Introduction Among the horticultural species, processing tomato (*Solanum lycopersicum* L.) is the first yielding crop in the Italian context, with over 5.2 million tons harvested in 2024. Water availability, which is crucial for this irrigated crop, will face severe constraints by 2050 in relation to climate change effects.

Aim Thus, in the present study, smart irrigation practices were adopted to both reduce water consumption and maintain crop yield.

Materials and methods An on-farm experiment was carried out in 2024 in southern Italy (Mondragone, CE) to test the potential irrigation water rationalization using digital tools (soil mapping, soil moisture probes, weather station, decision support system – DSS) on "Vulspot" tomato hybrid. The data-driven approach ("Smart", ~1.5 ha) was compared with the local business-as-usual practice ("BAU", ~1.5 ha). Before transplant, a Sentinel-2-based digital soil mapping was performed, and three soil zones were defined. The field was monitored during the crop cycle through high-resolution satellite imagery (PlanetScope). At harvest, 9 replicates per treatment were sampled. Linear mixed models were chosen for the statistical analysis of the samples, considering treatment (as fixed effect) and replicates nested within soil zones (as random effects).

Results A reduction of 10% in seasonal irrigation volume was obtained in "Smart" with respect to "BAU" without affecting crop yield and fruit technological quality. Accordingly, PlanetScope imagery revealed no differences between treatments in terms of average Modified Soil-Adjusted Vegetation Index (MSAVI) and Normalized Difference Red-Edge Index (NDRE) values. Therefore, "Smart" management considerably boosted the crop water productivity (+23%) and brix yield (+14%) with respect to "BAU", while reduced the total number of rotten fruits (−15%).

Conclusion These findings highlight that the usual practice based on farmers' experience may be successfully outdone by implementing a data-driven approach on processing tomato crop, especially under dry season conditions such as 2024.

Keywords

Solanum lycopersicum L.; Irrigation scheduling; DSS; Sustainable production; Water productivity

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Water Management by Mulching on Processing Tomato Yield and Quality

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Global water demand for agriculture will increase by 35% by 2050. Mulching practices are a strategy to mitigate water loss and demand, and improve soil microclimate; in particular, the use of biodegradable films also reduces the environmental impact due to traditional plastic materials. Our experiment aimed to evaluate the effect of the biodegradable mulching on water management, as well as the yield and quality traits of a processing tomato.

The soil water content and temperature were monitored by probes (Zentra). Three biodegradable mulching films (a paper mulch 80g m^{-2} -PPR, two biodegradable mulches -MB1 and -MB2) were compared to a bare soil (BS), used as a control. Specifically, MB1 film was composed of a mixture of starch and synthetic polymers, while MB2 of a copolyester. The experiment was a completely randomized design; each treatment was replicated three times. The trial was carried out in 2024 spring-summer, in open field, at the experimental site of Department of Agricultural Sciences, Portici (Naples, Italy). The transplant of the intermediate cycle "*Dobler*" processing tomato variety was made on May 5 and the harvest on July 30. Water consumption ranged from 2972 to 3371 m^3 ha^{-1}, for the PPR and MB2 treatments, respectively. Mulching, regardless of type, increased commercial production by 48% in comparison with unmulched soil, and the best performance was observed in MB1 and MB2. All three mulches also showed a 58% increase in the number of fruits per square meter compared to BS. In the case of not marketable berries, only MB1 recorded a significant increase of 60% compared to the other three treatments. Finally, no statistically significant differences were found in the quality parameters (texture, pH, total soluble solids and dry matter). Based on these preliminary results, it seems that biodegradable films improve yield without affecting the quality of tomato berries.

Keywords: *Solanum lycopersicum L., sustainable agriculture, water management, biodegradable mulch.*

Evaluation of new biostimulants effectiveness on tomatoes grown under water stress conditions

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Water resources for agriculture in the Mediterranean region are decreasing due to climate change, endangering crops that are high water demanding and sensitive to water deficits, such as tomato (*Solanum lycopersicum* L.); which can suffer growth damage and a reduction in yield and fruit quality when stressed. Biostimulants, however, can help in the stress mitigation. The aim of this study is to evaluate the effects of new kiwi-derived biostimulants on the morphological, anatomical and chemical properties of field-grown tomatoes under water stress conditions. Tomato plants (cv. Heinz 1301) were arranged in three experimental rows in open field conditions, with each row subjected to a distinct water regime. Irrigation was set using the Irriframe service to evaluate water excess (WE) and water deficit (WD) conditions. Boundary rows were used to avoid water leakage. The water stress trial started one month after transplantation (July) and ended at harvest (September). Each experimental row was subdivided into 18 subplots (13 plants each) to randomly received six treatments (3 replicates each). Two fermented juices (using *Lactiplantibacillus plantarum* 4193 and *Companilactobacillus farciminis* 4841), one non-fermented juice and a protein hydrolysate were obtained from undersized kiwi fruits and sprayed on tomato leaves four times in July. Biostimulants were compared to water, used as control, and a selenium-based commercial solution (1%). Tomato fruits were harvested at ripeness and then morphologically (size and weight), chemically (e.g. proximate composition, sugars, lycopene, free amino acids), and anatomically characterised. Under water stress, plant response to biostimulants has been variable; for example, fermented juices increased the fruit weight. Biostimulants notably affected the amino acids profile, as well as the glucose and fructose contents in WD tomatoes, which also exhibited anatomical changes (e.g. thicker fruit cuticle and smaller epidermis cell area).

Keywords: *biostimulant, water stress, tomato*

APPLICATION OF THE WATER FOOTPRINT IN SUSTAINABLE MANAGEMENT AND PROTECTION OF WATER RESOURCES FOR PROCESSED TOMATO CULTIVATION IN MEDITERRANEAN ENVIRONMENTS

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The water footprint is an environmental sustainability indicator gaining increasing importance for certifications and labels in agricultural production. Processed tomatoes require considerable amounts of water, and existing studies on water footprint present methodological uncertainties, often failing to account for the impact of different calculation strategies for water requirements. Furthermore, the growing challenges of water scarcity demand smart and innovative irrigation solutions. The aim of this study was to explore the impact of the calculation method and water requirement return strategy on the water footprint of processed tomatoes. The study was conducted during the spring-summer periods of 2022, 2023, and 2024 in two different coastal areas of Sicily. The processed tomato variety tested was Tayson F1 (Nunhems®). Water requirements were estimated using the FAO's CROPWAT 8.0 model, calibrated and validated for field data, as well as moisture (TEROS 12) and matric potential (TEROS 21) sensors placed in the soil. Additionally, two different irrigation strategies were evaluated for each of the two-water requirement return methods: full restoration of crop water requirements (FULL: 100% CWR) and regulated deficit irrigation (RDI: 70% CWR from transplanting to first flower emission; 100% CWR from first flower emission to fruit enlargement; 70% CWR from fruit enlargement to harvest). The CWR values, obtained for each calculation method and irrigation strategy, were used to calculate the total water footprint according to the guidelines of the Water Footprint Assessment Manual. Specifically, the CROPWAT 8.0 model overestimated the CWR by approximately 50 mm compared to the moisture sensors, resulting in an increase in all components of the water footprint. The results suggest not only inconsistencies in the classification of tomato production systems based on water footprint but also recommend the development and broader implementation of smart systems for determining CWR.

Keywords: CROPWAT 8.0; Moisture sensors: Crop water requirement; Water productivity; Environmental sustainability

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