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UNIVERSITÀ DEGLI STUDI DELLA TUSCIA

DIPARTIMENTO DI SCIENZE AGRARIE E FORESTALI

ROME TECHNOPOLE
INNOVATION ECOSYSTEM

SEEDS OF INNOVATION

SPVA PHD RESEARCH SYMPOSIUM

PhD Course in Plant and Animal Sciences

21st FEBRUARY 2025

University of Tuscia, Department of Agriculture and Forest Sciences (DAFNE)

Aula Magna Giovanni Giovannozzi Sermanni
Via S. Camillo De Lellis, Viterbo

Dear Participants,

We welcome you to "Seeds of Innovation: SPVA PhD Student Research Symposium", a special occasion dedicated to sharing knowledge, fostering collaboration, and strengthening the academic community within our PhD Course.

This event is an excellent opportunity to present research findings, engage in meaningful discussions with colleagues and lecturers, and receive valuable feedback. We hope this gathering will inspire new connections, spark insightful conversations, and contribute to academic and professional growth. The event also aims to be an educational tool for Italian and International students who want to join our PhD Course after completing their Master's Degree.

Participation is essential in making this event a dynamic and enriching experience.

We look forward to an engaging and productive event together!

The Organising and Scientific Committees

Organising Committee

Roberta Bernini
Daniel Savatin
Stefania Masci
Lorenzo Stentella
Antonella Cardacino
Leonardo Fiore
Noemi Villanova

Scientific Committee

Roberta Bernini
Valerio Cristofori
Angelo Mazzaglia
Loredana Basiricò
Raffaele Casa

Program

8:30 - 9:15 **Registration**

9:15 - 9:30 **Institutional greetings**

Prof. Stefano Ubertini - Rector of the University of Tuscia
Prof. Simone Severini - Director of the Department of Agriculture and Forest Sciences (DAFNE)
Prof.ssa Roberta Bernini - Coordinator of the PhD Course in Plant and Animal Sciences

9:30 - 11:00 **Oral communications - First session**

Chair: Silvia Turco and Nicolò Di Sora

Transcriptomic analysis of durum wheat responses to polystyrene nanoplastics

Giuliana Bruno, Panagiotis Liakopoulos, Petros Kolovos, Yiannis Kourkoutas, Francesco Sestili, Samuela Palombieri

Molecular approaches for Sicilian durum wheat conservation varieties supply chain valorization

Marco Bonarrigo, Francesco Sestili, Bernardo Messina, Giuseppe Russo, Stefania Masci

Modulation of brassinosteroid biosynthesis by genome editing: advancing sustainability and resilience in durum wheat production

Chiara D'Attilia, Arianna Frittelli, Valentina Buffagni, Samuela Palombieri, Stefania Masci, Francesco Sestili

A multifactorial perspective on Kiwifruit Vine Decline Syndrome: insights from microbial communities, gene expression, and hormonal dynamics

Antonella Cardacino, Silvia Turco, Leandro Pereira-Dias, Paulo Ricardo Oliveira-Pinto, Conceição Santos, Giorgio M. Balestra

Foliar Application of Biostimulants: A Strategy for Escherichia coli Reduction in Hydroponically Grown Lettuce

Leonardo Fiore, Mariateresa Cardarelli, Maurizio Ruzzi, Anna Grazia Ficca, Youssef Rouphael, Francesca Luziatelli, Giuseppe Colla

Biochelates: an eco-friendly alternative to synthetic chelates for micronutrient uptake in tomato

Marzia Leporino, Mariateresa Cardarelli, Paolo Bonini, Giuseppe Colla

Design and development of multifunctional phenolic compounds with biological properties

Noemi Villanova, Andrea Fochetti, Roberta Bernini

11:15-11:45 Coffee break and poster session

11:45-13:15 Oral communications - Second session

Chair: Noemi Villanova and Andrea Fochetti

Purification and identification of cardosins in pistils of Cynara cardunculus

Chiara Fabrizi, Katia Liburdi, Andrea Rodríguez Sanz, María Luisa Rúa Rodríguez, Marco Esti

Valorisation of Pomegranate Peel Extract for Sustainable Seed-Borne Black Rot Disease Management on Cabbage

Muhammad Amir Muawiya, Daniele Schiavi, Giorgio Mariano Balestra

Enhancing Beech Endophyte Metagenomics using PNA Clamps and Selective Primers

Irene Giubilei, Silvia Turco, Benedicte Albrectsen, Lovely Mahawar, Angelo Mazzaglia

Investigating iron acquisition and accumulation dynamics in a purple durum wheat (T. turgidum ssp. durum) genotype under drought

Giulia Quagliata, Maria Dolores Garcia Molina, Giuseppe Mannino, Eleonora Coppa, Mohamed Najib Saidi, Samuela Palombieri, Francesco Sestili, Gianpiero Vigani, Stefania Astolfi

Investigating ambrosia beetles species (Coleoptera: Curculionidae, Scolytinae and Platypodinae) and their associated fungal communities in differently managed beech forests of Abruzzo, Lazio and Molise National Park

Eleonora Cresta, Rachele Ricci, Irene Giubilei, Mario Contarini, Stefano Speranza

Management of an alien invasive pest: the case of Toumeyella parvicornis, a major threat for Pinus pinea in Europe

Nicolò Di Sora, Luca Rossini, Mario Contarini, Stefano Speranza

Innovating hazelnut cultivation in central Italy: evaluation the effects of plant biostimulants in tackling thermal stress in hazelnut trees through multispectral imagery analysis

Francesco Giovanelli, Giuseppe Scotolati Menechini, Cristian Silvestri, Valerio Cristofori

13:30-14:30 **Light lunch and poster session**

14:30-17:00 **Oral communications - Third session**

Chair: Antonella Cardacino and Leonardo Fiore

A Remote Sensing-Based Agricultural Land Use Intensity Index

Alessio Patriarca, Eros Caputi, Kato Vanpoucke, Stien Heremans, Ben Somers, Fabio Recanatesi, Maria Nicolina Ripa

Estimating Spatiotemporal Variability in Crop Yield Using Sentinel-2 Satellite-Derived Data: Spatial Relationships Analysis with Ground Yield Maps of Wheat

Luca Marrone, Federica Carucci, Riccardo Fazioli, Stefano Lo Presti, Davide Cau, Raffaele Casa

Soil Mapping of Small Fields with Limited Number of Samples by Coupling EMI and NIR Spectroscopy

Leonardo Pace, Simone Priori, Monica Zanini, Valerio Cristofori

Investigation of novel biosynthetic pathways and bioactive compounds in "Azafran de Bolita" (Ditaxis heterantha Zucc.)

Matteo Nava, Eleonora Fabene, Dorotea Ricci, Miriam Piccioni, Giuseppe Aprea, Debora Giorgi, Anna Farina, Chiara Portesi, José Luis Rambla Nebot, Stefania Crispi, Cruz-Cárdenas Carlos Iván, Luca Santi, Olivia Costantina Demurtas, Gianfranco Diretto

Improving food quality and safety by developing innovative antimicrobial packaging activated with natural bioactive compounds

Valeria Poscente, Claudia Zoani, Luciana Di Gregorio, Andrea Visca, Luigi Garavaglia, Francesco Salvadori, Gabriel Mustatea, Elena Ungureanu, Nastasia Belc, Roberta Bernini, Annamaria Bevivino

Plant cell cultures as ingredients for 3D-(bio)printing of next-generation health foods

Valentina Mastrobuono, Riccardo Pagliarello, Elisabetta Bennici, Raffaela Tavazza, Simona Errico, Paola Sangiorgio, Stefania Masci, Silvia Massa

Enhancing Soil Health and Sustainability: The Role of Soil Improvers in Mitigating Climate Change and Supporting Biodiversity

Lorenzo Nolfi, Luciana Di Gregorio, Manuela Costanzo, Arianna Bindo, Roberta Bernini, Ansa Palojärvi, Ioannis Manikas, Annamaria Bevivino

Multi-approach characterization of microgreens as a fresh food support for the astronauts' diet

Carla Sandri, Silvi Luca, Luca Nardi, Debora Giorgi, Anna Farina

17:00 **Awards: best oral communication and best poster**

Poster

P1 - Sustainable control of bacterial diseases through the use of innovative formulations of low environmental impact substances

Leonardo Albanese, Daniele Schiavi, Giorgio Mariano Balestra

P2 - New Frontiers in Olive Fruit Fly Control: Dynamic Models and Push-Pull Techniques

Mattia Animobono, Stefano Speranza, Mario Contarini, Luca Rossini

P3 - Mitigating Arsenic uptake in Durum Wheat (Triticum durum Desf.) through Sustainable Agronomic practices in Mediterranean Environment

Mariam Atait, Roberto Mancinelli, Ilenia Bravo, Emanuele Radicetti

P4 - Biological control of the Brown marmorated stink bug in the Lazio region through the parasitoid Trissolcus japonicus (Hymenoptera Scelionidae)

Lorenzo Austeri, Raffaele Sasso, Mario Contarini, Stefano Speranza

P5 - Elucidation of "Twig Canker and Shoot Blight" (TCSB) in peach caused by Diaporthe amygdali in Emilia Romagna (Northern Italy) and susceptibility of peaches cultivar on artificial inoculation

Federico Brugneti, Luca Rossini, Marco Cirilli, Antonella Cardacino, Angelo Mazzaglia, Silvia Turco

P6 - A dinamic online platform to manage and store Triticum germoplasm

Ida Colella, Giuseppina Angione, Fabio Fania, Salvatore Esposito, Riccardo Aiese Cigliano, Rosa Barcelona Cabeza, Francesco Sestili, Pasquale De Vita

P7 - New Techniques for Hop Cultivation in the Mediterranean Environment

Paolo Loreti, Roberto Ruggeri, Francesco Rossini

P8 - Restoring European Natural Lakes: The EUROLakes Project and the Case of Lake Vico

Giulia Mancini, Chiara Iavarone, Alessio Patriarca, Eros Caputi, Raffaele Pelorosso, Fabio Recanatesi, Maria Nicolina Ripa

P9 - Innovative low-impact strategies for the management of mites, agents of damage to hazelnut production

Roberto Masturzi, Domenico Valenzano, Eleonora Iezzi, Stefano Speranza, Mario Contarini

P10 - Erysiphe corylacearum: An Invasive Alien Species Causing the New Powdery Mildew of Hazelnut

Angelo Meloni, Angelo Mazzaglia

P11 - Cultivation of Cynara cardunculus L. var. altilis cv. «Bianco Avorio» in a floating system to produce extracts rich in phenolic compounds

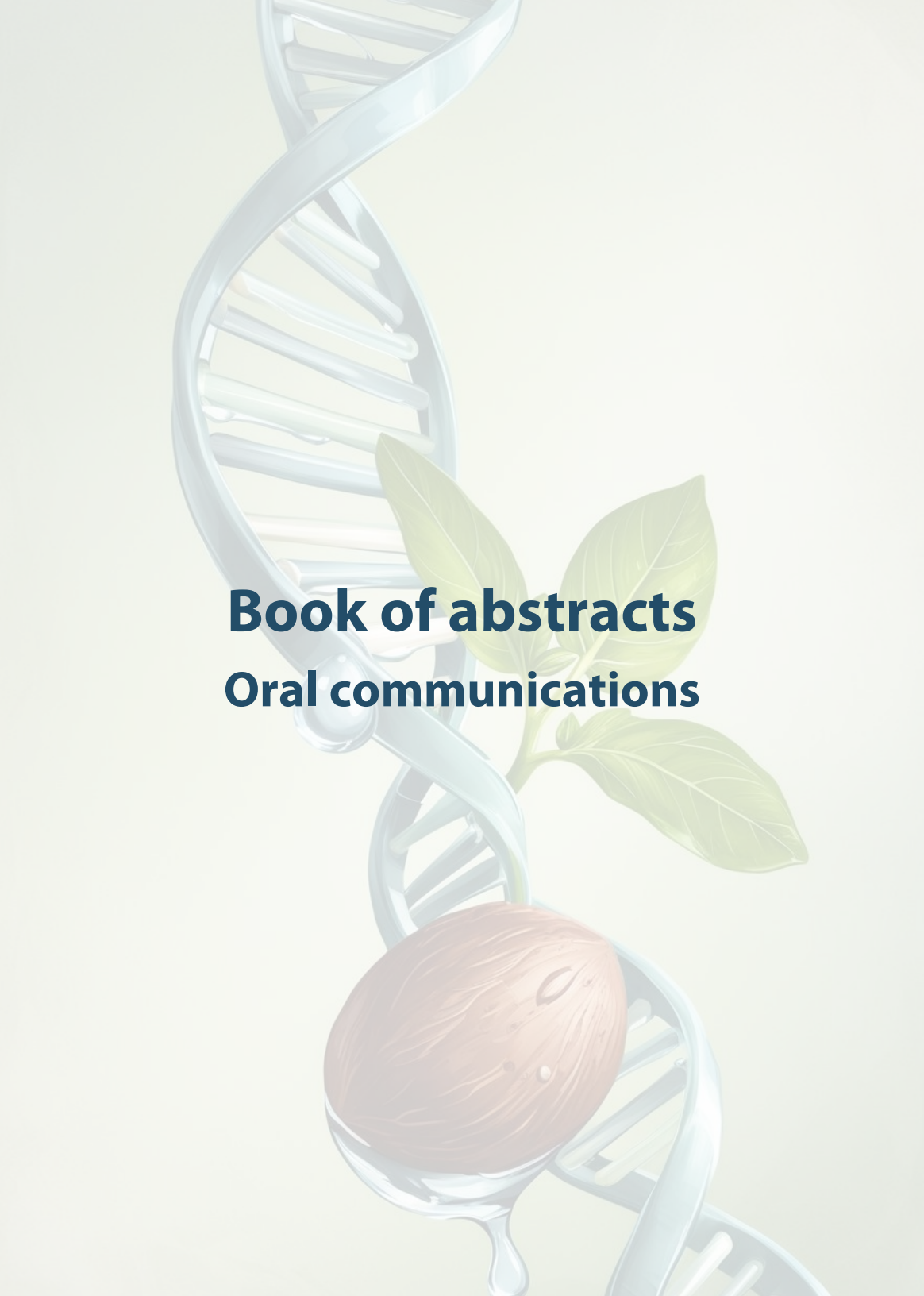
Giorgia Perelli, Mariateresa Cardarelli, Andrea Fochetti, Roberta Bernini

P12 - Innovative Approaches to the management of Tomato key Pathogens: detection and sustainable control solutions

Fatma Zohra Sennoun, Valentini Franco, Rocco Caracciolo, Anna Maria D'Onghia, Giorgio M. Balestra

P13 - Use of biostimulants for water stress mitigation in two durum wheat genotypes with different drought tolerance

Matteo Spada, Eleonora Coppa, Giulia Quagliata, Miriam Marín-Sanz, Francisco Barro, Valentina Bigini, Daniel Savatin, Roberto Ruggeri, Francesco Rossini, Stefania Astolfi



Book of abstracts

Oral communications

Transcriptomic analysis of durum wheat responses to polystyrene nanoplastics

Giuliana Bruno[1], Panagiotis Liakopoulos[2], Petros Kolovos[2], Yiannis Kourkoutas[2], Francesco Sestili[1], Samuela Palombieri[1]

[1]*Department of Agriculture and Forest Sciences, University of Tuscia, Viterbo, Italy*

[2]*Department of Molecular Biology and Genetics, Democritus University of Thrace, Alexandroupolis, Greece*

Over the past two decades, plastic production has surged due to high demand in industrial and agricultural sectors. Plastic polymers degrade slowly, persisting in the environment and posing long-term threats to ecosystems. Among the byproducts, polystyrene nanoplastics (PSNPs) are of particularly concerning for their ecological impact on agricultural soils and food chains, as they can accumulate in soil and be translocated into edible parts of crops, raising food safety concerns. This study explores the molecular effects of PSNPs on the transcriptome of two Triticum turgidum ssp. durum genotypes, Kronos (wild-type, wt) and MRP3 (Kronos TILLING mutant), exposed to PSNPs (10 mg/L). The MRP3 genotype, with a mutation in the gene encoding the phytic acid transporter, has distinct root characteristics and nutrient absorption capacity, making it suitable to assess its response to nanoplastic exposure compared to the wild-type.

To address this, RNA-seq analysis is employed to elucidate PSNP-induced changes in gene expression, using the new reference genome Svevo Platinum. The analysis of differentially expressed genes (DEGs) revealed that PSNPs differentially modulate gene expression in the leaves of the two analyzed genotypes. Specifically, the comparison between treated Kronos and the control identified 1697 DEGs, whereas the comparison between treated and control MRP3 highlighted 3622 DEGs. In Kronos, a greater number of upregulated genes (1010) were identified, whereas in MRP3, downregulated genes (2175) were predominant. The comparison between treated MRP3 and treated Kronos identified 3660 DEGs, most of which (2109) were downregulated.

Gene Ontology functional enrichment analysis revealed that durum wheat responds to PSNPs exposure with oxidative stress, genotoxic effects, cell cycle reprogramming and immune responses. Treated plants showed enrichment in photosynthesis-related terms, suggesting an increase in photosynthetic capacity to counter PSNP-induced damage. In MRP3, enrichment in sulfur and siderophore pathways indicated potential nutrient bioavailability interference, along with nitric oxide responsiveness, a marker of oxidative stress. Conversely, treated Kronos exhibited enrichment in "sequence-specific DNA binding", pointing to an adaptive transcription factor-mediated stress response, and "calcium ion binding", suggesting immune regulation via calcium signaling.

These responses highlight the impact of PSNPs on plant growth, development, and food safety, offering valuable insights for mitigating their risks and promoting sustainable farming practices.

Keywords: Durum wheat, polystyrene nanoplastics, RNA seq

Molecular approaches for Sicilian durum wheat conservation varieties supply chain valorization

Marco Bonarrigo[1], Francesco Sestili[1], Bernardo Messina[2], Giuseppe Russo[2], Stefania Masci[1]

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Durum wheat (*Triticum turgidum* ssp. *durum*) is one of the most important cereal crops globally, particularly in the Mediterranean region. Italy has a long history of cultivation of this crop and is currently the one of the largest producers of durum wheat globally and the leading producer of pasta.

The first breeding programs started at the beginning of the 19th century, consisting mainly of the selection of genotypes from landraces. Subsequently, advancement in hybridization procedures, the re-discovery of Mendel and the Green Revolution led to the release of varieties more productive and with enhanced technological quality. As a result, cultivation of local landraces and historical varieties decreased drastically, with the risk of losing biodiversity.

In recent years, however, there has been an inversion of this trend, mainly because of a new interest of the consumers and an increased awareness of the importance of biodiversity conservation. At present, local landraces and historical varieties can be inscribed in the Italian National catalogue of agricultural species as "conservation varieties". Currently, 28 durum wheat conservation varieties are registered and 24 of these are Sicilian. In this region, the conservation varieties supply chain fuels the local economy and their products are placed on high-value markets.

Given the importance of these varieties in the local economy, a certification strategy to ensure their identity is necessary. In our study, we performed the genotyping of 194 accessions belonging to 6 Sicilian conservation varieties (Bidì, Perciasacchi, Ruscia, Russello, Timilia reste bianche and Timilia reste nere) using a DNA microarray approach. Thirty-nine accessions comprising landraces, modern and historical cultivars were used as control. Principal component analysis (PCA), clustering methods and the population structure calculation have been performed to study the variability of the sample. Six distinct clusters have been identified, clearly separating 1) Timilia (no distinction between "reste bianche" and "reste nere"), 2) Ruscia, 3) Russello, 4) Perciasacchi and the other *T. turgidum* spp. *turanicum* landraces, 5) Bidì and the old cultivars, and finally 6) the modern cultivars. For traceability purposes, 18 SNPs able to discriminate Timilia, Ruscia, Russello, Bidì and *turanicum* varieties from the others were identified. For each of them, a KASP assay has been designed and tested on pasta and bread products made from pure semolina. This study helps to elucidate the genetic background of Sicilian durum wheat conservation varieties and paves the way for a molecular system of traceability to valorize their supply chain.

Keywords: Sicilian conservation varieties, genotyping, traceability

Modulation of brassinosteroid biosynthesis by genome editing: advancing sustainability and resilience in durum wheat production

Chiara D'Attilia[1], Arianna Frittelli[1], Valentina Buffagni[2], Samuela Palombieri[1], Stefania Masci[1], Francesco Sestili[1]

[1] Department of Agriculture and Forestry Science - University of Tuscia, Via Camillo De Lellis snc, Viterbo (Italy)

[2] John Innes Centre, Norwich Research Park, Norwich, NR4 7UH, (UK)

Durum wheat (*Triticum durum* spp.) is a staple cereal widely cultivated in Mediterranean Basin countries, where extreme climatic conditions are frequently compromising crop yields. This study aims to enhance durum wheat resilience to abiotic stresses by modulating brassinosteroid (BR) phytohormones, which regulate plant growth and stress responses. A genome editing approach was employed to knock out two transcription factors, *IBH1* and *GATA7*, pivotal in the BR biosynthesis pathway. Using Agrobacterium-mediated transformation, 14-days-post-anthesis embryos from the Svevo variety were engineered with four constructs targeting *IBH1* and *GATA7*, each with a pair of guide RNAs. Constructs were assembled via the Golden Gate (MoClo) method, incorporating essential components such as a hygromycin resistance gene, Cas9 nuclease, small guide RNAs under the *Triticum aestivum* ubiquitin-6 promoter, and a growth regulation factor.

The screening using a primer pair specific for the hygromycin resistance gene (hpt) permitted to identify 43 T0 plants positive for IBH1 constructs and 44 for GATA7, with 18 and 15 single-copy insertions, respectively. Sequencing analyses (NGS for *IBH1* and Sanger for *GATA7*) revealed five IBH1-edited lines in homozygous condition for genomes A and B and one line edited in genome A only. For GATA7, four lines exhibited double mutations, while two lines were single mutants.

The edited lines are expected to display improved agronomic traits, including increased yield, semi-dwarfism, and greater tolerance to abiotic stresses such as heat and drought—challenges exacerbated by climate change. Biochemical assays, phenotyping, and molecular analyses will further evaluate productivity trends and stress resilience, alongside detailed characterization of the edited lines.

This work underscores the roles of IBH1 and GATA7 in durum wheat and advances cereal genetics. Ultimately, this research supports the development of sustainable wheat breeding programs aimed at improving environmental adaptability and ensuring food security in an era of global climatic uncertainty.

Keywords: Abiotic stress resistance, brassinosteroids, durum wheat, genome editing.

A multifactorial perspective on Kiwifruit Vine Decline Syndrome: insights from microbial communities, gene expression, and hormonal dynamics

Antonella Cardacino[1], Silvia Turco [1], Leandro Pereira-Dias[2,3], Paulo Ricardo Oliveira-Pinto[3], Conceição Santos[3,] Giorgio Mariano Balestra [1]

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[2] Instituto de Conservación y Mejora de la Agrodiversidad Valenciana, Universitat Politècnica de València, Valencia, Spain
[3]Department of Biology, Faculty of Sciences, University of Porto, Portugal

Since its emergence in 2012, Kiwifruit Vine Decline Syndrome (KVDS) has posed a significant threat to the Italian kiwifruit industry. This complex and multifactorial disease presents substantial challenges for growers and production systems. Affected plants exhibit symptoms including root browning, loss of feeding roots, cortical layer hypertrophy and detachment, followed by rapid decline particularly during periods of increased summer temperature. While several biotic stressors have been implicated as potential contributors to KVDS, its multifactorial nature necessitates an integrated management approach. To gain a deeper understanding of this complex disease, this study employs a multi-omics approach, with the aim of uncovering novel insights into its etiology and potential control strategies. Root samples were collected from symptomatic and asymptomatic plants at two key phenological stages: end of flowering (June) and at fruit set (July). Metagenomic analysis revealed significant shifts in the microbial community composition of KVDS-affected roots, confirming the involvement of previously implicated genera. Gene expression analysis identified significant alterations in the expression of 17 genes associated with plant defense responses, including PRRs, ROS detoxification, PR and R proteins synthesis, and hormone signaling pathways. Furthermore, HPLC analysis revealed distinct phytohormone profiles in KVDS-affected plants compared to asymptomatic controls, suggesting perturbations in hormone homeostasis. These findings provide novel insights into the complex etiology of KVDS and could provide a foundation for developing effective management strategies.

Keywords: metagenomic, microbiome, gene expression, hormones

Foliar Application of Biostimulants: A Strategy for *Escherichia coli* Reduction in Hydroponically Grown Lettuce

Leonardo Fiore[1], *Mariateresa Cardarelli*[1], *Maurizio Ruzzi*[2], *Anna Grazia Ficca*[2], *Youssef Rouphael*[3], *Francesca Luziatelli*[2], *Giuseppe Colla*[1]

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[3] *Department of Agriculture Science, University of Naples, Federico II, Portici, Italy*

Compared to traditional agriculture, hydroponics system represents an alternative approach to optimize inputs and increase the quality and yield of vegetable production. These systems are particularly suitable for the cultivation of leafy vegetables for ready-to-eat products, a commercial category that demands a product with high nutritional value and an extended shelf-life. In addition, ready-to-eat products must be free from macro and microbiological contamination. Hydroponic systems aren't free from potential contamination, especially when untreated or improperly treated recycled sources are used. *Escherichia coli* (*E. coli*) contamination is the one that major concerns for consumers since as it has been the source of several outbreaks throughout the world that have led to multiple infections and deaths. The use of biostimulants is widely adopted in crop productions to mitigate the effects of abiotic stress but, is also important to consider their impact on the microbial population of leaves, especially since biostimulants can be applied just before harvest.

Two trials were conducted to analyze the effect of plant-based protein hydrolysate and a seaweed algal extract on the growth of *E. coli*. In the first experiment (Exp. 1), the growth of *E. coli* was assessed in liquid culture after 24 of incubation at 37 °C, while the second experiment (Exp. 2) investigated the effect of foliar application of biostimulants on lettuce grown in a floating system, previously inoculated artificially with *E. coli*. A non-pathogenic *E. coli* strain K12 was used in both trials.

The results obtained by the Exp. 1, showed that biostimulants didn't affect the growth of *E. coli* in LB medium amended with biostimulants. In the Exp. 2, biostimulant treatments improves the growth of total aerobic bacteria and significantly reduced the population of *E. coli* on the leaves. The protein hydrolysate showed the most inhibitory effect. Both treatments were not impacted the plant biomass (fresh and dry weight) or the nitrogen concentration (nitrate and total) in the leaves.

These results highlight that the application of biostimulants can be considered a valid sustainable strategy to enhance the microbiological quality of leafy vegetables for ready-to-eat products.

Keywords: floating system, lettuce, *Escherichia coli*, biostimulant

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Biochelates: an eco-friendly alternative to synthetic chelates for micronutrient uptake in tomato

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The presence of soluble salts in arid and semi-arid soils frequently leads to increased alkalinity, which has a detrimental impact on plant growth due to limited micronutrient availability. Synthetic chelates are commonly used to improve micronutrient bioavailability in alkaline conditions by forming stable complexes. However, concerns about their environmental impact, such as low biodegradability, required the search for environmentally friendly alternatives like biochelates derived from natural sources.

This study aimed to compare the effects of natural and synthetic chelates at varying concentrations on tomato plants grown under alkaline conditions. The experiment was conducted at the Experimental Farm of Tuscia University from March 10 to April 13, 2023, using a randomized block design. Tomato plants were grown in 1L pots filled with quartz sand and irrigated with an alkaline solution (pH 8.8). A biochelate-based fertilizer (B1, B2, B3) and a synthetic chelate (S1, S2, S3) were applied manually at three doses of micronutrients, with equal concentrations for each treatment rate. Phenomics data, including digital biomass, 3D leaf area, plant height, NDVI, chlorophyll index (NPCI), and senescence index (PSRI), were monitored using a high-throughput phenotyping platform during the growth cycle. At harvest, leaf samples were analyzed for untargeted metabolomics, and final biomass was measured. Micronutrient absorption was determined through elemental analysis of dried leaves. Data were analyzed using two-way ANOVA and post-hoc Tukey's test ($p = 0.05$). No statistically significant differences were observed between the biochelate (B1, B2, B3) and synthetic chelate (S1, S2, S3) treatments with respect to either fresh biomass or digital traits (digital biomass, 3D leaf area, and plant height). Although biochelates (B1, B2, B3) caused slight chlorosis symptoms, plants exhibited overall good health, as indicated by NDVI, NPCI, and PSRI. Elemental analysis revealed that micronutrient levels (N, P, K, Ca, Mg) were similar across treatments. Iron (Fe) was unaffected by treatments, while manganese (Mn), boron (B), zinc (Zn), and copper (Cu) showed dose-dependent effects. Low doses of biochelates (B1, B2) acted as biostimulants, while higher doses of synthetic chelate (S3) had a stronger effect on Zn and Cu uptake without improving growth. Metabolomics analysis revealed that biochelates (B1, B2, B3) modulated positively beneficial compounds involved in abiotic stress resilience (prenol lipids, phenols, and fatty acids), indicating their potential as sustainable alternatives to synthetic chelates. High doses of synthetic chelate increased micronutrient uptake but did not improve plant growth.

Keywords: biochelate, synthetic chelate, tomato, micronutrients

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Design and development of multifunctional phenolic compounds with biological properties by green chemistry approach

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[1]*Department of Agriculture and Forest Sciences, University of Tuscia, Viterbo, Italy*

The green chemistry approach, and 12 principles it is based on, involve sustainable design and the development of chemical methodologies that lead to the elimination or reduction of solvents and reagents harmful to human health and the environment. Molecules of biological and agronomic interest are naturally occurring compounds with a wide range of plant secondary metabolites. Bioactive molecules are those capable of exerting a range of activities and interacting with one or more components in living systems. Phenolic compounds are the most studied for their antioxidant, antifungal, and anti-inflammatory properties. In some cases, the potential health benefits and their uses are limited by certain physicochemical properties, such as their hydrophilic nature, which can impair, for example, their bioavailability in cellular environments and solubility in apolar media like oils and emulsions. Functionalizing the base structure of phenolic compounds and designing systems to deliver even polar molecules are promising strategies that enhance their properties and expand their potential uses. Phenolic compounds under analysis include phenethyl alcohols, phenylacetic acids, and cinnamic acids, which exhibit multiple biological activities, primarily antioxidant, anti-inflammatory, antifungal, and antitumoral. Organic chemistry allows the synthesis of new multifunctional phenolic molecules, using naturally occurring compounds as starting material. Synthesized molecules are tested *in vitro* assessing their activity and the antiproliferative effects, and in agronomic settings as antimicrobials.

Keywords: naturally occurring compounds, phenolic compounds, organic chemistry, green chemistry

Purification and identification of cardosins in pistils of *Cynara cardunculus*

Chiara Fabrizi[1], Katia Liburdi[1], Andrea Rodríguez Sanz[2], María Luisa Rúa Rodríguez[2], Marco Esti[1]

[1]*Department of Agriculture and Forestry Science, Tuscia University, Italy*

[2]*Department of Analytical and Food Chemistry, Faculty of Sciences, University of Vigo*

Proteolytic enzymes are widely used in the biotechnology field due to their broad applications in food processing, pharmaceuticals, cosmetics, leather, and textile industries. Specifically, in the food sector, proteases are valuable tools for managing processing technologies, as they can selectively act on substrates, enhancing their rheological, nutritional, and organoleptic properties. In the dairy industry, chymosin—a protease extracted from the abomasum of ruminants—is commonly used for milk coagulation, leading to the production of high-quality cheeses. However, the limited availability of this enzyme has driven research into alternative coagulants, including microbial and plant-based options. The principal plant-based coagulant used for artisanal ewe's cheese in European countries such as Italy, Spain and Portugal is obtained from the cardoon flowers of *Cynara cardunculus*. This study focuses on optimizing the extraction and stabilization processes of crude cardoon extracts to enhance their technological efficiency for milk coagulation. Additionally, purification and identification of cardosin A and B were performed to determine the optimal flowering period for harvesting. The results indicate that *C. cardunculus* extracts exhibit strong potential as milk-clotting agents for cheesemaking. Chromatographic analysis using a Mono-Q column revealed at least three cardosins with milk-clotting activity. The most aboundant (cardosin A) is eluted at 27% NaCl (0.27 M), but the most active in terms of coagulation (cardosin B) is the protein eluted at 37% NaCl (0.37 M).

Keywords: Proteolytic enzymes; Cardoon (Cynara cardunculus); Milk coagulation; Cardosin A and B

Valorisation of Pomegranate Peel Extract for Sustainable Seed-Borne Black Rot Disease Management on Cabbage

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Seed-borne diseases pose a significant challenge to global food security, particularly in crucifer crops, where black rot disease, caused by *Xanthomonas campestris* pv. *campestris* (Xcc), remains one of the most destructive threats. This disease, is primarily transmitted through infected seeds, leading to widespread crop losses and reduced productivity. Traditional control methods, including copper-based bactericides, antibiotics, and hot water treatments, have shown efficacy but come with notable drawbacks, such as environmental concerns, phytotoxicity, and the risk of plant pathogens resistance. Consequently, there is an urgent need for innovative, sustainable, and eco-friendly alternatives for effective seed-borne disease management. This study focuses on the valorisation of pomegranate peel extract (PPE), an agro-industrial by-product rich in bioactive phenolic compounds, as a sustainable approach to manage seed-borne black rot on cabbage plants. *In vitro* tests, PPE showed remarkable antimicrobial activity against Xcc inhibiting bacterial growth, motility, and biofilm formation. Notably, *in vivo* seed coating PPE application, effectively controlled Xcc seed-borne infections, with an efficacy comparable to hot water treatment, maintaining seed germination rates. In addition, PPE foliar treatment also reduced black rot disease severity on cabbage plants, without any phytotoxicity effect, highlighting its promising application also with respect to control of this disease for other susceptible crucifer crops. By valorising this agro-industrial waste, within the framework of circular economy principles, this study represents multiple benefits: a sustainable plant protection strategy, the reduction of synthetic pesticide in the environment as well as in final productions.

Keywords: Seed-borne disease management, bacteria, Pomegranate Peel Extract (PPE), Circular Economy

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Enhancing Beech Endophyte Metagenomics using PNA Clamps and Selective Primers

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In recent years, climate change has impacted forest species worldwide, including *Fagus sylvatica*, a deciduous tree species of great economic and environmental importance. Climate variability can influence plant health, particularly by altering the composition of endophytes residing within plant tissues. These microbial communities can have important effects on plant growth, stress tolerance, and overall fitness. To investigate the microbial community associated with *Fagus sylvatica*, amplicon sequencing was conducted using Illumina technology, targeting the bacterial V3-V4 region on the ribosomal 16S RNA gene and the fungal Internal Transcribed Spacer (ITS) region. However, metagenomic analysis targeting these conserved regions may lead to conspicuous amplification of the host DNA region related to chloroplast, mitochondria and ribosomal ITS, as confirmed by preliminary sequencing results. To mitigate host DNA interference, two complementary strategies were explored. Peptide Nucleic Acid (PNA) clamps were used to efficiently suppress host DNA amplification in the bacterial 16S ribosomal RNA region, while selective primers targeting the fungal Internal Transcribed Spacer (ITS) regions ITS1 and ITS2 were applied. These approaches facilitate a more accurate and comprehensive characterization of the *Fagus sylvatica* endophytic microbiome, providing valuable insights into the microbial communities that influence plant health and resilience, with important implications for forest management and climate adaptation strategies.

Keywords: *Fagus sylvatica*, metabarcoding, PNA clamp, endophytes

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Investigating iron acquisition and accumulation dynamics in a purple durum wheat (*T. turgidum* ssp. *durum*) genotype under drought

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Iron (Fe) is an essential nutrient for both plants and humans. Iron deficiency disorders, such as anemia, afflict over 2 billion people globally, since most plant foods, including the cereal grains, have low concentration of this nutrient. Fe availability in soils is usually limited, significantly hindering plant growth and development. Durum wheat is a staple crop of the Mediterranean area, where drought is a major challenge for wheat production. Drought stress could exacerbate Fe deficiency by reducing its ability to efficiently acquire and utilize Fe, further impacting its productivity. Therefore, understanding the mechanisms underlying Fe acquisition and accumulation in durum wheat under drought conditions is essential for improving both yield and nutritional quality of grains. Here, a pigmented durum wheat (*T. turgidum* ssp. *durum*) genotype with purple grain pericarp was used. Plants were grown hydroponically under adequate (80 µM) and limited (10 µM) Fe availability and half of the plants from each condition were subjected to water stress for 6 days, by adding 10% (w/v) PEG 6000 to the nutrient solution. Fe accumulation in plant tissues was obviously reduced by Fe deficiency treatment and to a similar extent by the combined stresses. Accordingly, the highest rate of phytosiderophores (PS) release was found in Fe-deficient plants. Interestingly, drought inhibited Fe accumulation in roots, even though the plants had adequate Fe availability, and this response was accompanied by an increased release of PS by the plant roots, but the increase was lower than that induced by single and combined Fe deficiency. Both TdIRT1 and TdYS1 genes were upregulated by single Fe deficiency, while they were downregulated by drought and combined stress. Regarding ABA, plants subjected to both drought stress and Fe deficiency showed an amplified production of phytohormone, reaching levels 250 times higher than that recorded in control conditions. The downregulation of TdIRT1 plants exposed to combined stress suggests a trade-off between water and Fe stress responses. Our findings showed that the response induced in plants by combined stress is different, and rarely additive, compared to that induced by a single stressor, reinforcing the complexity of the plant adaptation mechanisms to combined environmental stresses.

Keywords: combined stress, drought, durum wheat, iron

Investigating ambrosia beetles species (Coleoptera: Curculionidae, Scolytinae and Platypodinae) and their associated fungal communities in differently managed beech forests of Abruzzo, Lazio and Molise National Park

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Biological invasions are recognized as one of the greatest threats to biodiversity, causing many negative effects on forest and agro-ecosystems. Exotic ambrosia beetles (Coleoptera: Curculionidae, Scolytinae and Platypodinae) are increasing in Europe due to global trade and climate change, and they are currently considered a major concern due to their responsibility for serious ecological and economic damages. The impact they cause is related to both wood-boring activity and the introduction of associated fungi, which provide food for the insect development stages, as well as being pathogenic for the host plant. Protected areas (PAs) play a critical role in mitigating biodiversity loss by providing refuges for native species and buffering against the spread of invasive organisms. This study, funded by the National Biodiversity Future Center, was designed to assess the efficiency and performance of differently managed areas within the PAs in biodiversity conservation by controlling non-native species of scolytid beetles. We aim to provide an overview of the species composition of bark and ambrosia beetles and of xylophagous beetle community in ecosystems dominated by *Fagus sylvatica* L. in the Abruzzo, Lazio and Molise National Park. From May to October 2024, 24 cross-vane traps were deployed in 8 sites (4 old-growth beech forests and 4 managed high-forests). Traps were positioned in a triangular pattern and were inspected monthly for sample collection and ethanol lure replacement. To investigate the fungal community associated with the adult ambrosia beetles collected in the traps, amplicon sequencing of the fungal Internal Transcribed Spacer (ITS) region was performed using Sanger technology. Among the 7 trapped species (4 ambrosia beetles and 3 bark beetles), *Xyleborinus saxesenii* (Ratzeburg) was the most abundant, accounting for 83.2% of the total catches. No exotic species were captured, particularly those of the *Xylosandrus* genus, which includes three invasive species that are currently well-established in Lazio. Furthermore, the results show no significant difference in the mean number of catches between the two habitats, suggesting that forest management does not seem to influence the presence of these beetles.

Keywords: ambrosia beetles, invasive species, protected areas

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Management of an alien invasive pest: the case of *Toumeyella parvicornis*, a major threat for *Pinus pinea* in Europe

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Toumeyella parvicornis, the pine tortoise scale, is a significant pest that affect pine trees. During the last decade, has expanded its distribution even in the European continent as an alien species affecting mainly *Pinus pinea*. In some Italian regions, hundreds of stone pine trees have already been lost due to it. In the light of this concerning scenario, it has been investigated the biology, the distribution, and some feasible containment measures for this harmful pest. The species has been i) morphologically and molecularly characterized providing useful DNA barcoding tools, which made simpler its identification; ii) its potential distribution has been assessed through Species Distribution Modelling, allowing the detection of areas potentially at risk of occupation by the species in the future; iii) containment strategies have been evaluated: low-impact control strategy such as endotherapy, testing its efficacy on the pest, the duration of the beneficial effect and the best techniques to be used or iv) biological control strategy through the use of predators with a focus on local ladybugs species, considering the possibility to select candidate for an open-field release.

The outcomes of these studies highlight the crucial role of the investigations on effective management strategies to face invasive pests such as *T. parvicornis*. Their implementation in the available management guidelines for the pest may apport important improvements, providing valuable insights for mitigating the impact of that invasive species and safeguarding stone pine stands.

Innovating hazelnut cultivation in central Italy: evaluation the effects of plant biostimulants in tackling thermal stress in hazelnut trees through multispectral imagery analysis

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In order to meet the increasing demand for hazelnuts by the confectionery industry, improvements regarding the resilience and the productivity of both aging and newly established orchards will be indispensable. In this context, plant biostimulants, as defined by EU Regulation 1009/2019, have emerged as a promising agricultural innovation to enhance plant nutrient efficiency, abiotic stress tolerance, and qualitative characteristics. This study aimed to evaluate the efficacy of biostimulants in improving the productivity and physiological performance of hazelnut orchards under abiotic stress conditions, namely heat stress. The experimental trials were conducted on a private company based in Ronciglione (VT), Italy, and involved an adult hazelnut orchard (35 years old, cv 'Tonda Gentile Romana') which was divided into two treated plots, characterized by two different formulations, and a control plot.

The eco-physiological status of the plants within the experimental plots (2 ha each) was monitored using a combination of satellite-based multispectral acquisitions, used for NDVI extraction, and *in situ* leaf eco-physiological measurements with the Dualex® instrument as a means for validating data from multispectral imagery. Moreover, manual harvests for yield and quality assessments were performed on selected plants, while data concerning yield at plot scale were provided by the company.

Parameters evaluated included gross yield (t ha-1), chlorophyll content (µg cm-2), nitrogen balance indices (NBI), and nut quality traits such as kernel weight, shell weight, and the incidence of commercial defects. NDVI analyses revealed enhanced plant resilience in biostimulant-treated plots under thermal stress conditions; this evidence was also validated by Dualex® metrics obtained from the selected plants.

Treated trees exhibited an increase in gross yield, reaching up to 3.5 t ha-1 for Treatment A, compared to 2.7 t ha-1 for the control. Nut quality characterization showed minor variations in shell and kernel weights across treatments, while defect rates remained consistent, without noticeable changes among the three theses. The obtained results gave valuable evidence about the beneficial impact of biostimulants in hazelnut cultivation, promoting higher yields and improved stress resilience, without compromising nut quality. Future studies should explore the cumulative effects of repeated biostimulant applications over successive seasons to validate and expand these findings.

Keywords: *Corylus avellana*, NDVI, Sustainability, Horticulture

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A Remote Sensing-Based Agricultural Land Use Intensity Index

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After World War II, population growth led to an increasing demand for food, addressed primarily through the expansion of cultivated areas and the intensification of agricultural activities. However, these strategies pose significant risks to biodiversity and the environment. At a global level, contrasting trends are observed: in the southern hemisphere, agricultural expansion often occurs at the expense of forests, while in Europe, agricultural land abandonment is prevalent (120 million hectares since 1990), with an estimated 11% of farmland at risk of abandonment by 2030. Meanwhile, existing cultivated areas are experiencing an intensification of agricultural activities.

The objective of this study is to develop a methodology for assessing the Agricultural Land Use Intensity Index (ALUI) on a large-scale using cloud computing platforms and remote sensing techniques.

To evaluate the ALUI, the Google Earth Engine platform was employed to analyze time-series data from the multispectral Sentinel-2 satellite, leveraging its ability to detect vegetation phenology and disturbances caused by agricultural operations.

Crop growth cycle profiles and their corresponding peaks were extracted from multi-temporal datasets of the Normalized Difference Vegetation Index (NDVI). The results were validated using the Land Parcel Identification System (LPIS) dataset for the 2020–2021 agricultural year, selecting 100 random pixels for each crop within the study area. The algorithm was applied with differentiated thresholds to identify the most sensitive ones for peak detection, achieving an overall accuracy of 88%.

This study demonstrates that the combined use of Sentinel-2 data, phenological analysis, and cloud computing technology represents a powerful tool for assessing land use intensity at high spatio-temporal resolution. These results provide a valuable contribution to the development of agricultural policies and promising applications for large-scale territorial planning.

Keywords: Remote Sensing, Google Earth Engine, Time Series, Land Use Intesity

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Estimating Spatiotemporal Variability in Crop Yield Using Sentinel-2 Satellite-Derived Data: Spatial Relationships Analysis with Ground Yield Maps of Wheat

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Estimating the spatiotemporal variability of crop yield is crucial for improving agronomic management in precision agriculture. Identifying stable and unstable areas based on historical yield maps allows for creating prescription maps. In the absence of historical yield maps for many Italian farms, spatial and temporal models of crop productivity can be derived from Earth observation satellite data, such as Sentinel-2. In particular, the Copernicus High-Resolution Vegetation Phenology and Productivity (HR-VPP) suite, available on WekEO, provides data at a 10-meter resolution starting from 2017. The suite includes products such as total productivity (growth season integral; TPROD) and seasonal productivity (vegetative period integral above the start and end dates; SPROD). TPROD and SPROD are calculated as the growth season integral of the Plant Phenology Index (PPI): the sum of all daily values between the start and end of the growth season, and the sum of all daily values minus their baseline value. Additionally, other Sentinel-2 products, such as the Leaf Area Index (LAI), chlorophyll content (CAB), and fraction of absorbed photosynthetically active radiation (FPAR), were evaluated. By downloading data from the Biopar service on the openEO platform —which calculates biophysical indices on a large scale using a hybrid method— it was possible to obtain maps of each index for multiple years and the entire wheat cultivation period. To compare these indices with yield maps, the date corresponding to the maximum value of each index was selected.

The study explored the spatial relationships between Sentinel-2-derived products and the Maccarese spa (Central Italy) and Tolasi Pietro (Northern Italy) farms yield maps. Yield data were recorded using a combine harvester equipped with a GNSS system, preprocessed in R to remove anomalies, and geostatistically interpolated using the Precision Agriculture Tools in QGIS, with block kriging interpolation on a 10-meter grid. The pixel-based spatial correlation between satellite maps and yield maps was assessed by obtaining a linear model of coregionalization and assessing the codispersion coefficient against the hull of perfect correlation, and computing the Dutilleul t-test for the spatial processes of the SpatialPack package implemented in R. By carrying out a specific field-by-field analysis to evaluate the spatial correlation between yield maps and Sentinel-2 indices, significant results were obtained with a maximum value of r= 0.85 of the Dutilleul t-test with the SPROD index. Results showed a good correlation, suggesting that Sentinel-2-derived indices can effectively estimate yield and support precision agriculture management.

Keywords: Precision agriculture, Sentinel-2, Crop yield estimation, Spatiotemporal variability

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Soil Mapping of Small Fields with Limited Number of Samples by Coupling EMI and NIR Spectroscopy

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Precision agriculture relies on highly detailed soil maps to optimize resource use. Proximal sensing methods, such as EMI, require a certain number of soil samples and laboratory analysis to interpolate the characteristics of the soil. NIR diffuse reflectance spectroscopy offers a rapid, low-cost alternative that increases datapoints and map accuracy. This study tests and optimizes a methodology for high-detail soil mapping in a 2.5 ha hazelnut grove in Grosseto, Southern Tuscany, Italy, using both EMI sensors (GF Mini Explorer, Brno, Czech Republic) and a handheld NIR spectrometer (Neospectra Scanner, Si-Ware Systems, Menlo Park, CA, USA). In addition to two profiles selected by clustering, another 35 topsoil augerings (0–30 cm) were added. Laboratory analyses were performed on only five samples (two profiles + three samples from the augerings). Partial least square regression (PLSR) with a national spectral library, augmented by the five local samples, predicted clay, sand, organic carbon (SOC), total nitrogen (TN), and cation exchange capacity (CEC). The 37 predicted datapoints were used for spatial interpolation, using the ECa map, elevation, and DEM derivatives as covariates. Kriging with external drift (KED) was used to spatialize the results. The errors of the predictive maps were calculated using five additional validation points analyzed by conventional methods. The validation showed good accuracy of the predictive maps, particularly for SOC and TN.

Keywords: precision agriculture; digital soil mapping; electrical conductivity; spectroscopy.

Investigation of Novel Biosynthetic Pathways and Bioactive Compounds in 'Azafran de Bolita' (*Ditaxis heterantha* Zucc.)

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Ditaxis heterantha, a plant species from the Euphorbiaceae family, is native to the semi-arid regions of Mexico. Commonly referred to as "azafran de bolita" or "azafrancillo," its seeds possess a vibrant orange endosperm traditionally employed as a natural dye and food additive, analogous to *Crocus sativus* (saffron). Prior investigations have established that *D. heterantha* seeds are abundant in bioactive compounds, including fatty acids, tocopherols, and phytosterols, which confer significant antioxidant properties. In 2005, two novel apocarotenoids, Ditaxin (C31) and Heteranthin (C27), were identified in the endosperm, enhancing the phytochemical profile of the species.

To explore its therapeutic potential, we evaluated the bioactivity of *D. heterantha* endosperm extracts on various cancer cell lines. The extracts exhibited high cytotoxicity, reducing cell viability even at low concentrations, highlighting their potential as anti-cancer agents. To further characterize the species, targeted and untargeted metabolomic analyses were performed on its endosperm, peel and leaves revealing many bioactive compounds such as ricinine, epitulipinolide, zerumbone, capsiate, and annopurpuricin E. Volatile metabolomics profiling is ongoing to complement the metabolic landscape.

Cytogenetic studies, including DNA content and karyotype analysis via flow cytometry and fluorescence microscopy, were conducted to shed light on the species' genetic structure. Concurrently, one of the main objective of my PhD is to elucidate the biosynthetic pathways of Ditaxin and Heteranthin. High-performance liquid chromatography coupled with mass spectrometry (HPLC-MS) identified two major isomers of Heteranthin and four isomers of Ditaxin. Structural elucidation is being pursued using nuclear magnetic resonance (NMR).

To identify the genetic basis of these pathways, we are integrating metabolomics and transcriptomics approaches. Our initial focus is on carotenoid cleavage dioxygenases (CCDs) implicated in apocarotenoid biosynthesis, supported by “in silico” studies. Future research will extend to other enzymes involved in carotenoid and apocarotenoid biosynthesis in *D. heterantha*. Candidate genes will be validated through enzymatic assays in bacterial, yeast, and plant systems.

This multifaceted approach provides a comprehensive understanding of *D. heterantha*’s phytochemical and genetic potential, establishing its promise as a source of novel bioactive compounds for pharmaceutical and nutraceutical applications.

Keywords: *Ditaxis heterantha*, Apocarotenoids, transcriptomics, metabolic profiling

Improving food quality and safety by developing innovative antimicrobial packaging activated with natural bioactive compounds

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The prevalence of biofilm-associated microorganisms and the increasing use of ready-to-eat fresh products represent the current duality the food industry must address. Innovative and eco-friendly antibiofilm solutions and appropriate microbiological food control systems are urgently needed to improve food quality and safety. This study investigates the efficacy of antimicrobial active packaging developed using a combination of natural antimicrobial compounds to preserve fresh Italian *Favette* strawberries. The packaging consists of absorbent PADs treated with a colloidal solution containing chitosan, nisin (a lactic acid bacteria extract), and carvacrol at different concentrations, tested both individually and in combination. Five different treatment conditions were evaluated over seven sampling times, extending up to twelve days. Microbiological analyses were carried out to determine the total bacterial and fungi load, and ninety-five actively growing colonies were isolated for the subsequent identification using matrix assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS) and molecular techniques. Additionally, the overall migration of components from the antimicrobial films (absorbent PADs and BOPP foils) and trays (rPET) into aqueous simulants (10% ethanol and 3% acetic acid) was assessed in accordance with EU regulations. Specific metal migration and heavy metal content (Pb, Cd, and Cr) in the samples were also analysed, complying with Regulation (EU) 10/2011 and Directive 94/62/EC. Specific carvacrol migration in food simulants was also performed by applying the Fourier-transform infrared spectroscopy (FTIR) tests. The results revealed a notable antimicrobial activity of the PADs treated with the combination of carvacrol, nisin, and chitosan, outperforming the single treatments. This approach integrates advanced microbiological techniques with chemical analysis of packaging materials, offering a sustainable solution that reduces the environmental footprint of the distribution chain. Moreover, it adds value to Italian agricultural products like *Favette* strawberries, supporting both sustainability and the protection of national agricultural heritage.

Keywords: Antimicrobial active packaging, natural antimicrobial compounds, food safety and sustainability, biofilm-associated microorganisms

Plant cell cultures as ingredients for 3D-(bio)printing of next-generation health foods

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Cellular agriculture uses cell cultures from a wide range of organisms (animals, plants and microorganisms) to produce agricultural commodities, offering a novel and potentially sustainable production system completely different from conventional farming and cultivation. Plant cells cultivated under controlled conditions can generate standardized and tailored biomass, enabling production and accumulation of valuable metabolites along with the cell biomass, overcoming the limits of environmental factors, utilizing plant biodiversity without exploiting soil, preserving endangered species and standardizing food supplies chain.

In this study, a cell suspension of *Perilla frutescens* var. *shiso* purple was obtained from *plantulae* at edible stage, the so-called microgreens. The suspension was characterized in terms of growth kinetics, class of metabolites, antioxidant activity, and polyphenol content.

To produce high-value edible biomass, special attention was placed on optimizing the culture medium by minimizing or excluding potentially toxic components (e.g., chemical elicitors) and, thus, employing physical methods to improve cell biomass and specialized metabolites accumulation.

As a step towards pre-industrialization of prototype food products, a *Perilla frutescens* var. *shiso* purple suspension culture was incorporated into edible hydrogels suitable for 3D printing. This technology represents a promising frontier for the expansion of food sources, using non-traditional matrices such as cell cultures, and valorizing agro-food by-products. In order to obtain optimal gelation conditions, to enhance the sustainability of hydrogels and to enrich them with high-value molecules, extracts from agro-food by-products and fruit juices were included in the hydrogel formulations. These components were found to be compatible with the preservation of cell viability and functionality within the matrices, while also achieving optimal gelation conditions. Through preliminary tests, chemical and physical characteristics of hydrogel were defined and found to be suitable for 3D printing, paving the way for the future use of these materials through this technology and allowing the creation of customized foods in terms of structure, color, texture, flavor and nutrients.

The composite product obtained from plant cell cultures combined with added-value food industry by-products into hydrogels, was evaluated for sensory attributes and consumer acceptance through a panel test, a preliminary preference test, and an online questionnaire, demonstrating their potential to expand sustainable food options.

Keywords: plant cell agriculture; food by-products valorization; 3D-printable hydrogels; elicitation

Enhancing Soil Health and Sustainability: The Role of Soil Improvers in Mitigating Climate Change and Supporting Biodiversity

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This research investigates the complex interactions between climate change, biodiversity, and food security, emphasizing the promotion of climate change mitigation using soil improvers derived from food industry residues within a circular bioeconomy model. This approach not only aims to reduce the environmental impact of modern agriculture but also promotes the efficient use of renewable resources by transforming waste into valuable agricultural inputs. The research focuses on evaluating soil improvers, assessing their ability to enhance soil health and support biodiversity. Additionally, the research explores the ecological effects of these organic materials on soil ecosystems, aiming to develop application guidelines that ensure their safe and effective use in agriculture. This assessment is crucial for creating sustainable agricultural practices that can support long-term food security and biodiversity conservation. Moreover, the project assesses potential ecological risks associated with the application of soil improvers. Understanding how these materials influence soil ecosystems is vital for establishing guidelines that ensure environmental safety and enhance agricultural productivity. This risk assessment forms a critical part of developing strategies that support resilient agricultural systems capable of withstanding the impacts of climate change while supporting biodiversity. A key component of the research involves the extraction of DNA from the soil improvers, which is crucial for a thorough understanding of their microbial diversity. This DNA analysis is performed to ensure that the soil improvers contribute positively to soil health, optimizing their use for improving soil fertility and structure while maintaining or enhancing microbial health. By integrating rigorous scientific analysis with practical applications, the project seeks to bridge the gap between research and practical application in agriculture, enhancing our understanding of how to manage soil health effectively and sustainably.

Keywords: Circular Bioeconomy, Soil Improvers, DNA Analysis

Multi-approach characterization of microgreens as a fresh food support for the astronauts' diet

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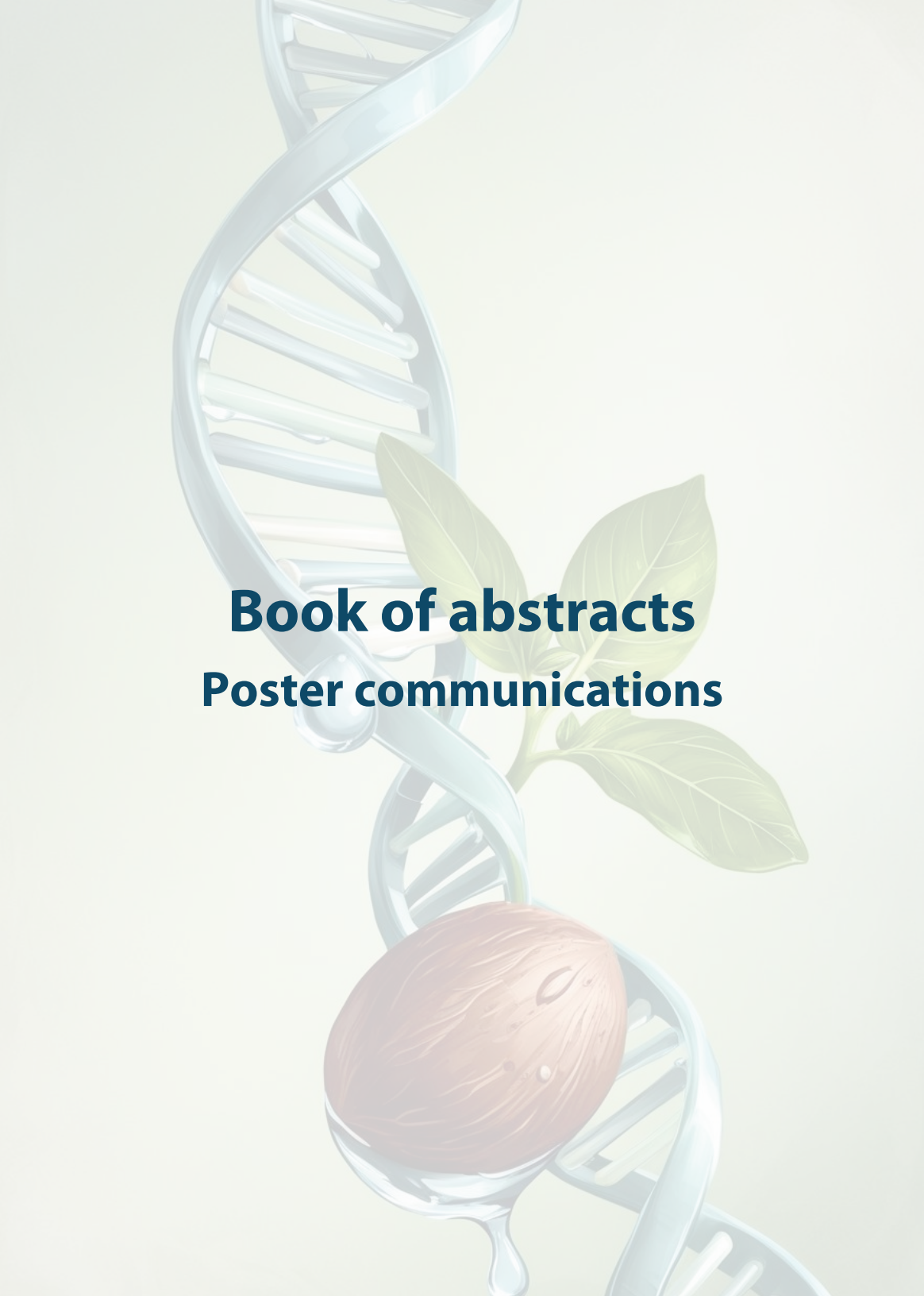
Microgreens, the early growth stages of edible vegetables and herbs harvested shortly after germination, have garnered attention for their superior nutritional profiles. In adverse conditions like space, oxidative stress can cause cellular damage, accelerating aging and increasing the risk of diseases such as cancer and cardiovascular disorders. Plant-based bioactive compounds are crucial to support daily and long-term health in extreme environments, like space, where plant-based food can sustain astronauts' physical and cognitive functions. NASA recently creates the Space Stressors Laboratory to study biological responses to space environment stressors, including neutron radiation, which constitutes a significant component of secondary radiation within the ISS. This study investigates the impact of neutron irradiation on two varieties of *Raphanus sativus* (*var. daikon* and *var. rioja*) through a multidisciplinary approach. Seeds were irradiated with an AmBe neutron source at two dose rates (20 µSv/h ±5% and 40 µSv/h ±5%) for four-time intervals: 15 days, 30 days, 6 months, and 1 year. After irradiation, seeds were cultivated under controlled conditions, and morphological, cytometric, and metabolomic analyses were performed. Results suggest that *R. sativus daikon* demonstrates tolerance to lower radiation doses, while higher doses may yield beneficial effects across multiple analyzed parameters. In cotyledons, exposure to 40 µSv/h significantly impacts antioxidant compounds such as β-carotene and violaxanthin, while exposure to 20 µSv/h increases these compounds. In roots, fatty acids showed significant reductions in seeds exposed to 20 µSv/h, while promoting primary metabolites involved in electron transport and cell signalling. Conversely, the higher dose (40 µSv/h) decreased primary metabolites like plastoquinone, ubiquinone 9, violaxanthin, and α-tocotrienol. In contrast, *R. sativus rioja* was negatively affected by radiation exposure, with significant decrease in cotyledon development, both in terms of physical extension and endoreduplication index. Statistical analyses, including ANOVA and 3D scatter plots, revealed distinct behavioural differences between the two varieties. This research highlights the resilience and adaptability of microgreens to neutron-induced stress and contributes to space agronomy by emphasizing radiation mitigation and the selection of radiation-tolerant plant varieties.

Keywords: Microgreens, neutron irradiation, space agriculture, cosmic radiation, flow cytometry



Book of abstracts

Poster communications

Sustainable control of bacterial diseases through the use of innovative formulations of low environmental impact substances

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The need to reduce dependence on copper has led to the development of alternative methods for the protection of agricultural crops, especially in high-value cultivation systems such as tomato (*Solanum lycopersicum* L.), where the reduced effectiveness of chemical agents has made it necessary to use integrated pest management programs. Bacterial spot, caused by *Pseudomonas syringae* pv. tomato (Pst) and bacterial speck, caused by *Xanthomonas* spp., are among the most economically significant bacterial diseases worldwide. *Xanthomonas* species are also able to evolve rapidly in the field and this leads to a significant increase in the genetic variability of the strains, making disease control difficult. In this context, an effective management plan for sustainable control of these bacterial diseases can be focused on the use of essential oils (OE) such as thymol and carvacrol to be applied to the aerial portion of the plant. These two monoterpene phenols contain an OH^- group in their molecular structure that is of fundamental importance for the exertion of antibacterial activity. In fact, these molecules, in contact with the cytoplasmic membrane of the bacterium, cause an acidification of the cell following the dissociation of the OH^- group and the entry of the H+ ion through the cellular proton pump which, in turn, extrudes a cation (e.g. K+) outside the cell.

The initial objective of this research project is to investigate the presence and incidence of tomato bacterial diseases caused by *Pseudomonas syringae* pv. tomato and *Xanthomonas* spp. through sampling and subsequent isolation to be carried out in the main national production areas located in Emilia Romagna, Puglia, Campania and Lazio (ISTAT 2023). This preliminary analysis aims to understand the progress of these pathogens on Italian territory and evaluate their level of resistance to copper-based chemical agents through in vitro analysis. Following this first survey, the effectiveness of some of the new sustainable control strategies for the indicated bacterial infections will be evaluated. In particular, the antimicrobial mechanisms of some natural molecules (e.g. carvacrol, thymol) will be evaluated through in vitro tests, and then their effectiveness will be evaluated through control tests in a controlled environment and in the open field. At the same time, the possible synergy of some organic polymers (e.g. starch, cellulose, alginate, chitosan) will be evaluated to facilitate the encapsulation, mixing and distribution of the molecules mentioned, in order to define a strategy for protecting tomatoes from bacterial infections as sustainable as possible.

Keywords: tomato, bacterial diseases, sustainable control

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New Frontiers in Olive Fruit Fly Control: Dynamic Models and Push-Pull Techniques

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Bactrocera oleae (Rossi) (Diptera: Tephritidae) is one of the main sources of yield losses in olive cultivation, requiring sustainable management strategies to fit the stricter regulations on chemical pesticide use. Mathematical models that simulate and predict pest population dynamics are increasingly essential, as they can play an important role in the optimisation of monitoring and control strategies. The model hereby presented describes the stage-development of *B. oleae* through a system of ordinary differential equations. Transitions between stages are ruled by development, fertility, and mortality rate functions that depend on the daily average temperature. This model represents a conceptual and technical extension of the spatialised model of Rossini et al. (2022). Cultivated fields can be divided in sub-areas, represented as nodes of a graph. Exchange of individuals between adjacent sub-areas is influenced by the attractiveness of traps, the repellence of treatments, and wind direction and speed, which not only affects the dispersion of the traps' olfactory cues but also directly transports insects. Migrations between sub-areas are ruled by specific migration rate functions. These rates are currently empirical; their accuracy will be validated through field trials carried out in olive orchards located in the Rieti area and the data collected will be used to refine the model parameters and evaluate its reliability under real-world conditions. To improve predictive accuracy, the model includes an Extended Kalman Filter (EKF), which represents a new and important enhancement to previous versions. This iterative algorithm combines simulation results with monitoring data to estimate the system's state more effectively. By using covariance, the EKF accounts for uncertainties from both the model and the measurements, balancing them to refine predictions. It periodically adjusts the model's forecasts based on differences between simulated and observed data, leading to more reliable predictions of population dynamics. The algorithm will also allow for the comparison of various trap placement schemes, providing insights into areas with greater uncertainty, thus optimising the allocation of resources spent for insect monitoring. This approach offers a strong foundation for developing a Decision Support System (DSS) to guide farmers in planning pest control actions both spatially and temporally. Combining this system with the "*push and pull*" method, which employs repellents and attractants strategically within olive orchards, has the potential to reduce insecticide use further while maintaining effective pest control.

Keywords: Physiologically based models, Spatial models, Extended Kalman Filter, Decision support systems

Mitigating Arsenic uptake in Durum Wheat (*Triticum durum* Desf.) through Sustainable Agronomic practices in Mediterranean Environment

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Cereal crops are an integral part of the human diet and livestock feed, necessary for fulfilling dietary needs. Rice, maize, and wheat are staple cereal food crops and are widely consumed worldwide; thus, food security is linked to the quality and production levels of these cereal crops. The accumulation of arsenic (As) in cereal crops is a serious threat to human safety. Therefore, organizations like the European Food Safety Authority (EFSA), the World Health Organization (WHO), and the U.S. Food and Drug Administration (FDA) have established specific regulations to control the contamination of food crops by establishing safety levels. Nowadays, arsenic (As) accumulation in agricultural soils and its transfer in crop yields is representing a growing concern that threatens food safety and security in the Mediterranean environment. Conventional soil tillage practices and fertilization methods used can affect the accumulation of As in plant tissues; therefore, there is a need to develop sustainable agronomical practices capable of supporting crop yield while mitigating As accumulation in plants. The current study was carried out with the aim of evaluating the effect of sustainable agronomic practices on As uptake by different parts of the durum wheat plant. The experimental treatments include the following: (i) three soil tillage practices (plowing, subsoiling, and spading) and (ii) two fertilization methods (mineral and organic). A factorial randomized complete block design with three replications was adopted. The experimental period refers to the 2018/2019, 2019/2020, and 2020/2021 growing seasons. The results suggest that the maximum level of As was found in plant roots and the minimum in wheat kernels. The chemical fertilization as 2020 × Mineral (1.522 mg As kg−1 d.m.) and 2020 × Plowing (1.855 mg As kg−1 d.m.) had the maximum As content in the roots. Conversely, the content of As was at a minimum in the wheat kernels for organic fertilization as 2021 × Organic (0.012 mg As kg−1 d.m.) and subsoiling tillage as 2021 × Subsoiling (0.008 mg As kg−1 d.m.). Moreover, the application of an organic fertilization source as a tool for enhancing the soil organic matter content also significantly decreased the As content. The results suggest that reduced tillage practices and the adoption of organic fertilization could significantly improve plant quality and assure a safe consumption of wheat kernels.

Keywords: soil tillage; soil fertilization; As uptake

Biological control of the Brown marmorated stink bug in the Lazio region through the parasitoid *Trissolcus japonicus* (Hymenoptera Scelionidae)

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Halyomorpha halys (Stål, 1855), also known as the Brown marmorated stink bug is an insect native to East Asia. At the end of the 20th century, the pest was introduced to the United States (Leskey et al., 2012), and the first reports in Europe occurred in the last decade in Switzerland. In Italy, it was first detected in 2012 in Emilia-Romagna (Maistrello et al., 2014), while in Trentino Alto-Adige (Fischnaller et al., 2022), it was confirmed in 2016. The pest feeds on the leaves and fruits of more than 300 species of host plants and can cause significant damage to agriculture. *H. halys* is an extremely polyphagous insect (feeding on over 170 plant species), equipped with a piercing-sucking mouthpart. This highly invasive species is controlled through chemical or biological control, primarily using the parasitoid wasp *Trissolcus japonicus* (Ashmead, 1904) described in 2009 in China. The *T. japonicus* has shown an egg parasitism efficacy ranging from 50% to 70%, increasing to 80% in the second generation. The aim of this work is to mitigate the damage caused by the BSMB, particularly in hazelnut groves in the Lazio region, through the release of the parasitoid *Trissolcus japonicus* in the field. Currently, in the Lazio region, following the activity timeline outlined in the "Risk Analysis Study" presented by the Lazio Region and authorized by the MASE (Ministry of Environment and Energy Security), two releases of the antagonist *T. japonicus* have been carried out in 22 release sites across the provinces of Viterbo, Rome, and Latina. Post-release monitoring was conducted to verify the establishment and effectiveness of *T. japonicus* by assessing egg masses of BSMB and native species collected at the release sites.

Keywords: *Halyomorpha halys*, parasitoid, biological control, hazelnut

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Elucidation of "Twig Canker and Shoot Blight" (TCSB) in peach caused by *Diaporthe amygdali* in Emilia Romagna (Northern Italy) and susceptibility of peaches cultivar on artificial inoculation

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Prunus persica L., is the second most cultivated fruit after apples, and Italy is the second country in the UE for peach production after Spain. However, peach production in Italy is gradually decreasing over the years due to climate change and the spread of new alien organisms and the resurgence of already established pathogens such as *Diaporthe amygdali*, the causal agent of "Twig Canker and Shoot Blight" (TCSB). Knowledge of the biological and ecological aspects of *D. amygdali* is of great value for pathogen control and breeding programmes, but information is still fragmented. This study was inspired by these two considerations, as an analysis of the thermal response of different isolates co-existing in the same environment and studies of cultivar susceptibility are still lacking. The activities were carried out in three steps: i) isolation and subsequent morphological and molecular identification using molecular markers of *D. amygdali* isolates from symptomatic trees in a highly productive area of northern Italy, ii) analysis of the mycelium growth at different constant temperatures under controlled conditions, to identify the most responsive (and aggressive, accordingly) isolate, and iii) artificial inoculation, under controlled conditions, of the most responsive isolate on peach twigs of different cultivars. These three steps together provided quantitative information on the thermal response of *D. amygdali* and an initial classification of the low and high susceptibility among the most common peach cultivars worldwide.

Keywords: peach, plant pathogen, breeding

A dinamic online platform to manage and store *Triticum* germoplasm

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Recently, SNP arrays and NGS-based genotyping methods have emerged as indispensable tools in modern wheat breeding programs. These platforms provide a large number of genome-wide markers necessary for constructing high-resolution genetic maps, conducting QTL mapping and genome-wide association studies (GWAS), and implementing genomic selection.

Unfortunately, SNP array platforms for wheat suffer from significant limitations, including an uneven distribution of markers within the genome, leading to over- or under-representation of certain regions. In this regard, the Diversity Arrays Technology (DArT) has emerged as a more versatile and cost-effective alternative, addressing several limitations associated with SNP arrays.

To address these challenges, we present a web-based platform for SNP marker management developed and hosted by the Research Centre for Cereal and Industrial Crops (CREA-CI) in collaboration with Sequentia Biotech SL. The "TETRAOMIX wheat database" is a digital repository designed to provide the scientific community with access to genetic and phenotypic information on various tetraploid wheat species.

To this end, approximately 2000 accessions of tetraploid wheat species (*Triticum turgidum* ssp.), have been catalogued and inventoried within the web platform. The genotypic data produced over time with various SNP arrays have been integrated, and 4737 SNPs were selected to reduce redundancies in the genetic markers. The interactive database developed in this study provides a practical tool for identifying the authenticity and purity of tetraploid wheat genotypes and valuable genetic information on current durum wheat varieties. Moving forward, the genotyping of the entire collection using approximately 4000 DArT probes will allow the online integration of additional genetic data for research purposes. Furthermore, the combination of the DArT and SNP-array probes will enable to development of a new genotyping array optimized for tetraploid wheat species. The database will be continually updated and will integrate new data as it becomes available.

Keywords: Online database, *Triticum* germplasm, Genomic approaches, Germplasm bank

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New Techniques for Hop Cultivation in the Mediterranean Environment

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The common hop (*Humulus lupulus L.*) is a flowering plant used mainly in the brewing industry. In the European Union, hops are grown on about 30,000 hectares, with Germany leading production. In Italy, hop cultivation has recently gained interest due to the rise of craft breweries, and the increasing attention of consumers towards foods and beverages made with local raw materials. Traditional cultivation methods, like the "Hallertau trellis" system, which involves a trellis system with poles reaching 6 meters above ground are effective in temperate climates but may need adaptation for Mediterranean conditions. Research on phenology, nutrient requirements, and sustainable practices, along with a broader characterization of Italy's wild hop germplasm, is essential to optimize production and address existing challenges in new growing regions. The research activity will consist in multi-year trials investigating high-trellis (6 m) and low-trellis (3 m) hop systems in central Italy, with the evaluation of phenological stages, yield, and cone quality. Quality will be assessed through α-acids, β-acids (via HPLC), and total oil content (via steam distillation). Novel and sustainable plant nutrition plans will be also tested. Additionally, wild hop germplasm will be collected, geolocated, and phenotyped over two years for future breeding plans. Nursery techniques and the response to biostimulants will also be investigated. The research activity will include international collaboration to study drought and heat resistance in hops. This work has manifold implications and holds significant potential for advancing the knowledge of hop cultivation in the Mediterranean area. First and foremost, this research will establish a solid foundation for conducting further in-depth studies on hop cultivation within the Mediterranean environment, addressing its unique climatic conditions. The field trial will contribute to the optimization of cultivation techniques, the improvement of cone yield and quality, as well as a better acquisition of sustainable practices tailored to our region. Furthermore, the project aims to foster and strengthen international collaborations, creating a platform for the exchange of innovative knowledge materials and practices. By connecting researchers, nursery practitioners, and growers from large scale agricultural enterprises to small scale producers, this work will encourage the sharing of expertise, tools, and strategies. Such collaborations are expected to drive the development of cutting-edge solutions that enhance both productivity and environmental sustainability. Ultimately, this work has the potential to support the growth of a resilient hop sector, suited to cope with the current and future challenges of global agriculture.

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Restoring European Natural Lakes: The EUROLakes Project and the Case of Lake Vico

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The restoration of wetlands is a strategic priority for the European Union, crucial for preserving biodiversity and enhancing environmental resilience. The EUROLakes project, funded under Horizon Europe, aims to protect and restore Europe's natural lakes and their ecosystems by developing sustainable and replicable management solutions. It adopts the '4 Returns Framework for Landscape Restoration', a model with four objectives: to raise awareness and motivate local communities (Return of Inspiration), to promote social inclusion and sustainable employment (Social Return), to implement nature-based solutions (NBS) for improving biodiversity, habitats and soil health (Natural Return) and to promote local economic opportunities through the sustainable use of resources (Financial Return).

The project follows a five-step approach: building landscape partnerships, promoting shared territorial understanding, developing a collaborative vision, implementing coordinated actions and continuous monitoring for constant improvement. The main objective is to restore Europe's natural lakes to 'good ecological and chemical status', in line with the Water Framework Directive, the European Green Deal and the EU's commitment to protect aquatic environments by 2030. The project focuses on three pilot areas: Lake Vico (Italy), Lake Bistreț (Romania), and Lake Dümmer (Germany). Best practices developed will be transferred to other European countries, including Denmark, Ireland, and Moldova, ensuring replicability. Lake Vico, in particular, is highly vulnerable, facing threats such as eutrophication, soil erosion, biodiversity loss, and anthropogenic pressures that endanger water quality, ecological resilience, and local economic activities.

To address these challenges, the initial months of the 'Nature-Based Solution (NBS) for the Protection of Lake Systems' PhD project focused on the social, environmental, and territorial characterization of the Lake Vico basin. A detailed analysis of the physical, chemical and ecological components of the lake was conducted, along with an examination of the interactions between local communities and their environment. Stakeholder engagement is central to the project, involving, for example, local authorities, NGOs, economic operators, farmers and residents. This participatory approach is essential for the success of the planned actions. Preliminary workshops will be organised to raise awareness of the issue. The objective will be the implementation of NBSs aimed at promoting biodiversity, mitigating eutrophication and restoring soil quality. A monitoring system will then be established to assess the effectiveness of these solutions and develop management strategies.

Keywords: Wetlands restoration, Nature-Based Solutions (NBS), EUROLakes project, Vico's Lake

Innovative low-impact strategies for the management of mites, agents of damage to hazelnut production

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The big-bud mite, *Phytoptus avellanae* Nalepa (Acari: Phytoptidae), is responsible for severe infestations of both vegetative and reproductive hazelnut buds, causing hypertrophic alterations in the tissues and the formation of pseudo-galls (big-buds), which result in decreased productivity. Despite the damage it causes in various hazelnut-growing regions, several aspects of the biology and management of this pest still require further investigation and improvement.

This study will involve extensive literature research on the biological cycle, spread, and control of these organisms in hazelnut groves, followed by a monitoring campaign in the Viterbo area to estimate the spread and composition of different mite species in sites with varying phytosanitary management practices (IPM, organic, and renaturalized).

The following monitoring traps will be used: a water trap consisting of a large funnel filled with water and 2% sodium hypochlorite, with an underlying tank that will be emptied periodically for mite counts. A multi-vial cyclone sampler trap, capable of sampling the air and conveying airborne pollen, spores, and mites onto test tubes, will be used in parallel. The effectiveness of these two types of traps will be compared with traditional methods, such as the collection of mites using double-sided adhesive bands placed on twigs to trap dispersing walking mites. This approach will allow for the quantification of mite populations and the assessment of their seasonal and annual variations.

Next, the predation potential of phytoseiid mites (globose mites with predatory habits) will be assessed. These mites will also be periodically collected and identified, enabling the evaluation of their role in controlling eriophioids during different seasons. Laboratory breeding of the most promising species will be initiated to identify the best candidates for mass breeding and subsequent field release. Control actions against eriophioid mites will then be conducted, including the evaluation of the numerical size of the galls in the following year and monitoring the presence of phytoseiids on the galls.

Additionally, innovative digital detection methodologies will be applied for the laboratory identification of the main species of hazelnut mites. A data-driven approach based on convolutional neural networks (CNNs) and the most compatible version of the YOLO architecture (an AI algorithm used for object recognition and localization in images and videos) will be utilized.

The data collected will be used for statistical analyses to help determine a specific intervention plan for mite management.

Keywords: *Phytoptus avellanae,* Big-bud mites, Phytoseiid mites, Monitoring

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Erysiphe corylacearum: An Invasive Alien Species Causing the New Powdery Mildew of Hazelnut

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Powdery mildew is a disease caused by obligate biotrophic pathogens belonging to the Erysiphaceae family, that occurs on many different plant species, including hazelnut. This disease in hazelnut has always been associated with *Phyllactinia guttata*, but in 2013, a pathogen capable of causing greater damage emerged in Eastern Europe and subsequently in Italy: *Erysiphe corylacearum*. The pathogen's life cycle can be described as follows: the pathogen survives the winter period through the production of sexual resistance structures, known as chasmothecia. Once favorable environmental conditions are reached, the chasmothecia release ascospores which, upon contact with the leaf, trigger the primary infection. During the spring and summer, conidia are produced and dispersed, leading to secondary infections. Before the autumn leaf fall, large quantities of chasmothecia, resulting from sexual recombination, are produced, allowing the fungus to survive until the following spring. The aim of this project is to deepen our understanding of the ideal environmental conditions for the transition from one stage of the pathogen's life cycle to another. Between October and December 2024, symptomatic hazelnut leaves were sampled in an orchard near Punta del Lago (VT). Both microscopic observations and molecular analyses were performed to confirm the presence of the pathogen on leaf tissues. Additionally, a protocol for collection and quantification of chasmothecia from infected leaves was developed. Part of the collected chasmothecia was placed on filter paper discs inside plastic boxes relocated to the sampling site to allow their natural overwintering phase. These samples will be used to conduct experiments such as: testing ascospore release under controlled conditions at different temperature and humidity ranges, estimating the quantity of ascospores released in the field, and assessing ascospores viability using fluorescence microscopy. Following conidia production, the pathogen's asexual phase will be examined by conducting germination tests of conidia under different conditions of temperature and humidity. Conidial inoculation will be performed on seedlings of different cultivars to assess potential differences in susceptibility between cultivars. Additionally, the project aims to develop a species-specific qPCR diagnostic assay to detect the pathogen even in the early stages of infection, when symptoms are not yet visible. The data gathered from these experiments, combined with consistent meteorological data collection in the field, will lay the foundation for the formulation of a mechanistic predictive model. This model will simulate the pathogen's developmental stages and provide information to enable timely interventions to limit its spread.

Keywords: *Erysiphe corylacearum*, hazelnut, powdery mildew

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Cultivation of *Cynara cardunculus* L. var. *altilis* cv. «Bianco Avorio» in a floating system to produce extracts rich in bioactive molecules

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Cynara cardunculus L. var. *altilis*, a typical Mediterranean plant from the Asteraceae family, is a versatile resource with a wide range of applications. It has long been used in food production, especially as a vegetable in Mediterranean cuisine, and for industrial purposes like natural fiber production. The plant is also known for its bioactive compounds, which contribute to its medicinal properties. Traditionally, *Cynara cardunculus* has been valued for its choleretic, hepatoprotective, antidiabetic, and anticholestatic effects. These benefits are linked to its antioxidant content and ability to support liver function.

The research focuses on the production of biomass from *Cynara cardunculus* L. var. *altilis* to obtain chemically characterized extracts, which will be utilized for biological and agronomic applications.

The cultivation was carried out in the greenhouses of the "Nello Lupori" Experimental Farm of Tuscia University. *Cynara cardunculus* L. var. *altilis* cv "Bianco Avorio" was selected for cultivation due to its high productivity and strong adaptability to floating systems. The floating system was chosen as it eliminates issues related to soil presence and allows for more precise control of nutrients through the nutrient solution. Additionally, to enhance biomass production, two different biostimulants were used. Five sampling events were carried out, which included cutting, drying, and measuring the dry weight of the biomass. Throughout the experiment, the physiological conditions of the plants were monitored, including the levels of chlorophyll, anthocyanins, and flavonols.

The collected data, both physiological and productive, were analyzed to determine the most effective treatment for cardoon cultivation in a floating system. The results indicate that the floating system is a promising method for enhancing cardoon productivity by reducing plant stress and accelerating the production cycle. The dry biomass obtained in this study was used to produce extracts using both conventional methods (solvent extraction) and innovative methods, particularly Microwave-Assisted Extraction, which is considered a green technique. The results will be compared in terms of yield and extraction times.

The phenolic content and antioxidant activity of the obtained extracts are currently being evaluated, with the aim of defining their potential applications.

Keywords: Floating system, biostimulants, bioactive molecules, natural extracts

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Innovative Approaches to the management of Tomato key Pathogens: detection and sustainable control solutions

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Tomato cultivation is threatened by several destructive diseases including *Verticillium dahliae* (Verticllium wilt), *Botrytis cinerea* (Grey mold) and *Clavibacter michiganensis* subsp. *michiganenesis* (Bacterial canker). These pathogens are responsible of substantial economic losses which pose a significant burden on tomato cultivation worldwide, with their management being particularly complex. Given the risk that is associated with chemical control and the lack of fully resistant tomato varieties, the management of these pathogens requires a comprehensive approach that integrates early pathogen detection and effective biocontrol strategies to minimize crop losses and ensure sustainable production.

This project focuses on the development of a rapid, accurate and onsite detection method for these pathogens using real time Loop-Mediated Isothermal Amplification (LAMP). Primers and protocols will be designed and optimized to allow the direct detection from plant tissues (flowers, seeds or stems).

This approach offers a promising solution for the early detection of *B. cinerea* enabling timely intervention to manage the disease and reduce potential post-harvest losses. Furthermore, this approach provides a valuable tool for screening pathogen-free planting material for both *V. dahliae* and *Cmm* for which certification is required in EU.

Additionally, this project will explore the efficacy of micro/nano formulated bioproducts in the suppression of these pathogens and the enhancement of plant resilience. These formulations, which are based on beneficial microorganisms and/or natural compounds, will be tested both *in vitro* and *in vivo* to evaluate their ability to reduce plant pathogen growth and their impact on the biological and biochemical attributes of tomato plants. This comprehensive approach aims to develop innovative tools for efficient disease management and promote sustainable production in horticultural crops.

Keywords: Tomato, LAMP, Biocontrol, Bacterial canker

Use of biostimulants for water stress mitigation in two durum wheat genotypes with different drought tolerance

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Agriculture is facing complex and unprecedented challenges, such as the climate change and global population growth, associated with increase of food demand. The Mediterranean region is identified as hotspot for the impacts of this phenomenon, with enormous implications on agricultural systems, which ultimately compromise crop yields in the fields. Durum wheat (DW) is an essential crop for food security of Mediterranean region. To cope with population growth and climate change, ensuring food security, and thus increasing food production, it is crucial to adopt alternative and targeted strategies, including the use of agronomic techniques that improve the resilience of crops to adverse environmental conditions. The use of biostimulants represents an intriguing approach, as these products not only increase nutrient use efficiency and crop quality characteristics but also influence tolerance to abiotic stresses. In this work, the effect of two biostimulants on drought response of two DW genotypes with different drought tolerance degree was evaluated. The genotype by sequencing (GBS) analysis revealed notable differences in the quantity and impact of genome-wide single nucleotide polymorphisms (SNPs) and Insertions/Deletions (InDels) detected between the tolerant genotype Svems 16 and the less tolerant cv. Iride. Both biostimulants, namely B1 and B2, contained glycine-betaine and vaterite, but the former contained a mixture of extracts from the seaweed *Codium fragile* (Suringar) Hariot and the plant *Opuntia ficus- barbarica* A. Berger, and the latter *Pseudomonas protegens*. The products were applied by foliar spraying four days after drought stress imposition. Drought significantly hinders growth of cv. Iride by increasing oxidative stress and diminishing stomata density and thus gas exchange. This difficulty can be mitigated through application of biostimulants. In particular, B1 induced a significant higher development of the root system, whereas B2 revoked the drought-induced inhibition of shoot growth, associated with root morphological changes, and both products increased stomata density. On the other hand, the growth of Svems16 seedlings was not significantly affected by drought, confirming its significant degree of tolerance toward the stress compared with Iride. As a result, both biostimulants showed limited efficacy when applied to Svems16 stressed plants. In conclusion, the application of biostimulants emerges as a valuable strategy for managing drought stress in sensitive DW cultivars.

Keywords: Biostimulant, Drought stress, Durum wheat, MDA, Stomata

Awards

The Scientific Committee awarded Antonella Cardacino and Matteo Nava the prize for the best oral communication and Federico Brugneti for the best poster. It also awarded Giuliana Bruno, Nicolò Di Sora, Chiara Fabrizi, Francesco Giovanelli and Valeria Poscente a mention for the excellent communication skills and technology transfer of research activities.

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See you at the next edition!!!