MULTIDISCIPLINARY STUDIES
SUSTAINABLE AGRICULTURE

Dipartimento di Scienze Agrarie Alimentari e Agro-ambientali
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Multidisciplinary studies for sustainable agriculture:

The Farm to Fork Strategy

BOOK OF ABSTRACT

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Department of Agriculture, Food and Environment

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We acknowledge all the invited speakers for dedicating their time to us, allowing us to learn more about their research projects.

We are grateful to the University of Pisa and the Department of Agriculture, Food and Environment for providing us the funding and the location necessary to make this workshop possible.

Finally, thanks to our PhD supervisors and coordinators for believing in our work and all the participants to this workshop.

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Introduction

The Farm to Fork strategy, at the heart of the European Green Deal, aims to accelerate the transition to a fair, healthy, and environmentally friendly food system. Currently, the agriculture and livestock sectors are responsible for almost one third of global greenhouse gas emissions and our food systems consume large amounts of natural resources - causing loss of biodiversity and negatively impacting health (under- and over-nutrition) - and do not allow for fair economic returns and livelihoods for all actors, especially primary producers.

The 4th International Conference "Multidisciplinary Studies for Sustainable Agriculture: The Farm to Fork Strategy" organised by the PhD students of the programme in Agricultural, Food and Environmental Sciences was held on Thursday 1st and Friday 2nd December 2022. This workshop founded by the University of Pisa and the Department of Food, Agriculture and Environment provided all the participants an insight into the farm to Fork strategy. This book of abstract is a collection of all the speeches made on during the workshop.

1st December: "Agricultural practices for sustainable food production"

The first day opened with an overview of the sustainable management of water resources, given the current drought emergency affecting Italy and Europe, and energy inputs. It continued with speeches focusing on the agricultural practices promoted by the European Union and financed by the new Common Agricultural Policy (CAP) through eco schemes and sustainable strategies for precision agriculture and livestock farming.

2nd December: "Sustainable innovation in the food chain"

The second day focused on innovative agri-food production techniques and proposals. The current food production system is based on activities with a pronounced environmental impact, such as intensive livestock farming, the considerable use of polluting synthetic products, excessive food packaging, and the transport of goods over long distances. It is estimated that the world's population will reach 11 billion by 2100; therefore, the agri-food sector will have to ensure the food supply for an increasing number of individuals and will have to be based on more environmentally sustainable approaches.

Summary



AGRICULTURAL PRACTICES TO REACH SUSTAINABLE FOOD PRODUCTION

SESSION I

INTEGRATED RESOURCE MANAGEMENT IN FARMING SYSTEMS

Water resources management in drought prone area

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Keywords: flash drought, smart irrigation, water use efficiency, water productivity

Drought is a recurrent phenomenon of the climate that depends on a shortage in precipitation adequate to cover the crop water needs, or by high temperatures with a negative effect on the water balance due to increased evapotranspiration (ET) loss. The drought's magnitude may be aggravated by other environmental and or humanmade Impacts.

The complexity of the drought phenomena is also hidden in its definition, which depends on several induced effects on the precipitation regime (weather drought), hydraulic/hydrological system (hydraulic/hydrological drought), and the economic or social sector analysed (economic/social drought).

Meteorological drought is the trigger of the phenomenon and can be established when a specific statistically-based index defines a period with an abnormal precipitation deficit, in relation to the long-term average conditions of a region. Consequently, the hydrological/hydraulic drought starts when a reduction of natural (i.e. streamflow, lake levels, and groundwater) and/or artificial (i.e. reservoir and dam levels) surface/subsurface water flow/storage regime is observed. Therefore, the inescapable soil moisture deficit triggers the agriculture drought, where considerable yield loss is observed.

The main objective of this presentation is to understand the main natural and human-made causes affecting soil moisture drought: the main precursor of the agricultural, economic, and social limitations on the drought-prone areas. Practically, the speaker will emphasize the complexity of the drought-prone area and will introduce the so-called nested approach[1] to understand this phenomenon. The nested approach is a comprehensive framework to study the water destiny, by quantifying the water use efficiency (WUE) of the various sub-systems and allows to highlight specific spatial scales where some limitations are present.

Finally, smart water resource and distribution management will be presented as a powerful tool to cope with drought and mitigate its damage in the agricultural sector. The new smart techniques play a key role in any approach that seeks to monitor the drought and to improve WUE in agriculture. In this context, it is essential the digitalization of the agricultural sector, which incorporates new technologies to uphold the farmer decision making oriented towards efficient irrigation management. Moreover, the collection of large amounts of data on agro-environmental variables with the high spatial and temporal resolution are the main pillars for an expert decision making[2].

References

[1]Hsiao, T.C., et al., (2007). A systematic and quantitative approach to improve water use efficiency in agriculture. Irrig. Sci., 25, 209-231. https://doi.org/10.1007/s00271-007-0063-2

[2]Fielke, S.J., et al., (2019). Conceptualising the DAIS: Implications of the 'Digitalisation of Agricultural Innovation Systems' on technology and policy at multiple levels. NJAS – Wagen. J. Life Sc., 90, 1-11. https://doi.org/10.1016/j.njas.2019.04.002

Multifunctional landscapes: opportunities and challenges for sustainable agriculture

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Keywords: multifunctional landscapes, ecosystem services, complexity, food security, climate change

Sustainable agriculture is key to the transition and strengthening of resilient food systems that can face crises at local, national, and even global scale. To achieve this, the Farm-to-Fork Strategy[1] that is part of the EU Green Deal[2] has the aim to minimise impact on climate change, promote mitigation and adaptation strategies, combat the loss of biodiversity, reduce waste, ensure food security, access to healthy food that is also affordable.

Multifunctional landscapes bring a unique contribution to these ambitious goals. They provide a wide range of ecosystem services that can tackle environmental issues, as well as contribute towards sustainable and resilient value chains and infrastructures. Systems such as agroforestry provide ecosystem services that are supporting (soil enrichment, nutrient cycling), provisioning (biodiversity, biomass, e.g., food, timber), regulating (air/water quality, land degradation, climate change) and cultural (tradition, education, recreation). With the diversification of production and land uses, territories also contribute to diversified socio-economic pathways that lead to more resilient value chains and income and employment generation.

However, these benefits do not come without challenges. Assessing productivity in highly diversified systems can be very complex. Farmers and land managers need to adopt long-term land management strategies they may not be familiar with, causing potential barriers to transition to multifunctional, diversified systems. Risk management dealing with complexity and uncertainty then becomes a tangible challenge. Knowledge sharing and exchange can be one way to empower key actors to embrace transition. Nevertheless, the transition to sustainable and resilient food systems needs to not only tackle issues at farm level, but also promote value chains that are adapted and suitable, because in order to be effective, change does not only reside in agricultural practices.

Multifunctional landscapes can be very diverse and take very different forms. However, those systems that are based on agroecological principles adopt a holistic approach that can provide solid basis to overcome the complex web of challenges, such as mitigation and adaption to climate change[3], environmental-friendly land uses, fair trade, sustainable economies, and enabling policy landscapes that contribute towards the targets of the Farm to Fork Strategy, as well as the Millennium Sustainable Development Goals. Ultimately, the way forward is to learn to become comfortable with complexity and embrace the challenges we need to face to ensure long-term sustainable and resilient futures to our societies.

References

[1]Farm-to-Fork Strategy https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

[2]EU Green Deal https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/agriculture-and-green-deal_en

[3]Duguma, L.A., et al., (2014). Climate Change mitigation and adaptation in the land use sector: from complementarity to synergy. Environ. Manag. 54(3), 420-432. https://doi.org/10.1007/s00267-014-0331-x

Life Cycle Assessment analysis method

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Keywords: LCA, life, cycle, assessment, system

Life cycle assessment is an analytical tool, standardized by the International Organization for Standardization (ISO), that captures the overall environmental impact of a product, process or human activity. LCA is based on quantification, so it allows us to obtain results from a quantitative perspective in terms of both primary resource consumption and related waste.

This type of analysis provides a comprehensive view of the environmental aspects that occur during a production process and the potential consequences of changing one or more parameters. By highlighting the processes that contribute most to environmental impacts (hot spots), the results of LCA studies facilitate the identification of mitigation actions at the industry or company level. They also enable cross-cutting issues to be addressed, such as food losses along the supply chain, end-of-life treatment technologies, and the impact of different packaging materials. At the organizational and project level, LCA is a very current and useful tool for decision support, enabling us to conduct effective promotion of eco-innovation and sustainable competitiveness.

It has multiple potentials and fields of application, but it brings with it errors. Therefore, it is necessary to interpret the final results of the analysis well, try to follow the guidelines provided to standardize the method, make judicious choices toward the impact categories and the definition of the whole system on which to operate, and consider what are the inherent limitations of LCA by trying to reduce them.

References

Curran, M.A. (2013). Life Cycle Assessment: a review of the methodology and its application to sustainability. Curr. Opin. Chem. Eng., 2, 273-277. https://doi.org/10.1016/j.coche.2013.02.002

Rebitzer, G., et al., (2004). Life cycle assessment, Part 1: Framework, goal and scope definition, inventory analysis, and applications. Environ. Int., 30, 701-720. https://doi.org/10.1016/j.envint.2003.11.005

Pennington, D.W., et al., (2004). Life cycle assessment Part 2: Current impact assessment practice. Environ. Int., 30, 721-739. https://doi.org/10.1016/j.envint.2003.12.009

Nitrogen management of crops

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Keywords: N balance, N leaching, Fertilizers

Nitrogen fertilization is often viewed as a relatively cheap insurance against yield loss, resulting in application of fertilizer N often in excess of actual crop demand.
The combination of N application in excess of crop demand, the low N fertilizer recovery by crops and the often excessive irrigation in some crops may lead to both health risks (i.e. nitrate accumulation in leafy vegetables) and environmental risks associated with high nitrate concentrations in water leaving the root zone.
In Europe, the protection of natural waters from diffuse pollution by nutrients (N and P) is regulated by the Nitrate Directive (Council of the European Communities, 1991) and the Water Framework Directive (European Commission, 2000), and the main source of this pollution is agriculture.
A sound nitrogen management aimed at optimize N fertilization, maximize N use efficiency by the crop and minimize N losses in the environment should be elaborated on the basis of:

a. the determination of N demand from the crop;
b. the determination of fertilizer N rates to meet crop N demand;
c. the integration of different agronomic cropping practices for improving sustainability of N fertilization.

Crop nitrogen demand (i.e. the mineral crop N uptake at optimal N status) can be determined as the product of total biomass (highly correlated with fruit/grain yield) and critical N concentration (i.e. the minimum N concentration required for maximum plant growth). The critical N concentration (%Nc) declines during the entire crop cycle as a function of the cumulated above-ground crop dry weight (%Nc = a DW -b; where DW is the dry weight, as Mg ha-1). Coefficient a is highly different between C3 and C4 plants, reflecting the different metabolic pathways, but it is relatively constant within the same metabolic group (a = 4.8, as an average for C3 species; a = 3.6, as an average for C4 species). Coefficient b is a little bit more variable among species and it is most frequently comprised between 0.3 and 0.4, without any detectable differences between C3 and C4 species (b = 0.34, on average). However species-specific relationships have been found for several crops.
Science-based methods to determine fertilizer N rates can be based on different approaches and/or methods:

- N balance approach that calculates/estimates inputs (i.e. soil mineral N at crop planting; N from mineralization of soil organic matter and added organic materials; N supply from irrigation; N from rainfall, N from mineral fertilizer) and outputs (i.e. crop N uptake, N losses due to leaching, denitrification, volatilization) in the soil-crop-atmosphere system;
- fertilizer recommendation schemes based on soil analysis or soil N supply (e.g. Nmin, KNS and N-expert systems; Pre Side-dress Nitrate test, Root Zone N management, Soil N Supply, Dutch 1:2 volume soil:water extract method, nitrate concentration of the soil solution in the root zone) to assist with N crop fertilization and fertigation;
- methods based on destructive (i.e. leaf tissue N analysis, petiole sap test) and non-destructive (i.e. optical sensors) monitoring N status of the crop, mainly used to guide top-dressing N fertilization;
- simulations models and user-friendly Decision Support Systems (DSSs).

Main agronomic cropping practices to be integrated are: crop rotation, cover crops, intercropping, plant breeding, choice and application of mineral and organic fertilizers, tillage systems, biostimulants, grafting.

References

Gallardo M., Elia A., Thompson R.B., 2020. Decision Support Systems and models for aiding irrigation and nutrient management of vegetable crops. Agricultural Water Management 240, 106209.

Padilla F.M., Farneselli M., Gianquinto G., Tei F., Thompson R.B., 2020. Monitoring nitrogen status of vegetable crops and soils for optimal nitrogen management. Agricultural Water Management 241, 106356.

Tei F., De Neve S., de Haan J., Kristensen H.L. (2020). Nitrogen management of vegetable crops. Agricultural Water Management, Volume 241, 106316.

Nitrogen management and nitrogen emissions in grazing systems

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Keywords: nitrogen, livestock emissions, remote sensing

Cattle breeding in Italy is very important for an economic, social, and working point of view. The number of cattle in the first half of 2022 is about 5.59 million heads divided into 2.64 million dairy cattle and 2.47 million beef cattle, with a rather constant trend since 2012. These numbers refer to farms that over time have decreased in absolute terms and that today are over than 136 thousand. However, cattle breeding also involves emissions of climate-changing gases such as methane from enteric fermentation and nitrous oxide deriving from the management of manure. Methane from enteric fermentation of cattle represents, in 2020, about 60% of methane emissions related to the agricultural sector, and N_2O emissions less than 12%. In absolute terms, in 2020, we have a quantity for livestock emissions equal to 431 kt of methane and 5 kt of N_2O. In general, we are seeing a significant reduction in the environmental impact in terms of climate-altering gas emissions from livestock farming in our country and at the same time an increase in carbon sequestration by agro-ecosystems. The use of remote sensing and vegetation indices is increasingly widespread in the perspective of precision agriculture and on a large scale such as grazing; their use in estimating the quality of forage in terms of crude protein and fiber is important, especially for the interest in the estimation of nitrogen excretion by animals both in the form of nitrogen oxides in the atmosphere and for emissions at ground level that can potentially become nitrogen load subject to leaching. While proteins are important for estimating nitrogen released by animals, NDF in fodder is also very important as a quality parameter, especially in view of fermentation rates compared to starchy carbohydrates that lead to methane production; for purposes of estimation related to the quality of the forage, the NDVI index comes to our rescue, which is also the most used in remote sensing applications; these are reflectance sensors that doesn't directly measure N content in the leaf, for example, but it measures optical properties that are indicative of the N state of the crop. The most used equations, for the estimation of animal emissions, are those of the IPCC that allow the construction of models on a different scale according to the method used. At the regional level, there is a tendency to apply Tier 2, whereas it is more detailed and based on data that is not too complicated to collect; it considers, for the estimation of the annual N excretion rates, the amount of N ingested in the diet, and the N retained by animals which depends on several factors: milk production, % of proteins in milk, live weight of animals and energy consumption linked to growth. There are also equations that refer to the estimation of nitrogen lost by leaching considering the nitrogen excreted by animals and the manure management system. These aspects are also reported in the estimation of methane production from enteric fermentation and for the production of methane and nitrogen oxides deriving from the management of livestock manure. The use of modelling equations is necessary to georeferenced the data and apply them at the territorial level, considering nitrogen emissions in different forms as a continuum between soil and atmosphere, inserting the data in a territorial nitrogen balance context that considers all the input and output items of the balance in order to contextualize cattle breeding with other agricultural nitrogen sources and storage.

References

Lingra – N model developed by Michail Giannitsopoulos and Paul Burgess, Cranfield University (July 2020).

Serrano, J.; Shahidian, S.; Carapau, Â.; Rato, A.E. Near Infrared Spectroscopy (NIRS) and Optical Sensors for Estimating Protein and Fiber in Dryland Mediterranean Pastures. AgriEngineering 2021, 3, 73–91.

IPCC: Intergovernmental Panel on Climate Change guidelines for national greenhouse gas. Emissions from Livestock and Manure Management. Chapter 10, 2006, Agricolture for other land use, Vol. 4, p. 1 - 87.

Phosphorus fertilizers from by-products: closing the loop

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Keywords: peak of phosphorus, recycling, struvite, urine, polyphosphates

In many agroecosystems phosphorus (P) is the first or the second most limiting element for plants' production after nitrogen (N). To meet crops' demand, application of P fertilizers has been practiced for decades in cropping systems of industrial countries resulting in massive P surpluses accumulated in the cultivated soil (legacy P)[1]. The legacy P is mostly retained in the topsoil and is thus prone to being lost and transferred to surface waters with severe environmental impacts, such as eutrophication, which is currently a major global threat to fresh and coastal water[2]. The second major concern is that rock phosphate used to produce synthetic P fertilizers is a nonrenewable resource[3]. Its price is expected to rise in the coming decades, whereas its quality is already declining due impurities (cadmium, uranium). To address this major issues, human societies has to radically change the way this resource is sourced and employed. Scientists indicate two main way forward: the first is the increase of P use efficiency, and the second is P recycling and reuse[4]. This talk will explore a few promising examples of P fertilizers issued from by-products or human wastes.

References

[1]McDowell, R. et al., (2020). The ability to reduce soil legacy phosphorus at a country scale. Front. Environ. Sci. 8, 6. https://doi.org/10.3389/fenvs.2020.00006

[2]Sharpley, A. (2016). Managing agricultural phosphorus to minimize water quality impacts. Scientia Agricola. 73, 1-8. https://doi.org/10.1590/0103-9016-2015-0107

[3]Penuelas, J. et al., (2013). Human-induced nitrogen–phosphorus imbalances alter natural and managed ecosystems across the globe. Nat commun. 4, 2934. https://doi.org/10.1038/ncomms3934

[4]Cordell, D., and White, S. (2011). Peak phosphorus: clarifying the key issues of a vigorous debate about long-term phosphorus security. Sustainability. 3, 2027-2049. https://doi.org/10.3390/su3102027

Slow-release fertilizers combining by-products: a promising resource?

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Keywords: pyrolisys products, urine, nitrogen use efficiency, circular economy, Design of Experiment

Since 16th July 2022 the new EU Fertilizing Products Regulation (Regulation EU n°2019/1009, FPR) came actually into full effect also including the regulation of the use of organic fertilizers and biostimulants, that represent "promising raw materials for the production of innovative fertilizers in a circular economy". Recycling of waste materials to produce fertilizers is crucial, with the aim of ensuring this circularity. This is the case of biochar and wood vinegar, that are often studied and used as soil improvers, but even other human waste could be used. Up to 200 liter of wastewater per person/day are currently produced and about 500 liter per person/year are urine. Urine contains a lot of nutrients in a water-soluble form that is readily available for plants. Vuna Gmbh, a spin-off of the Eawag Insitute of Aquatic Research in Switzerland, produces Aurin, an urine fertilizer, since 2015. Another crucial problem is that nitrogen, the first most limiting nutrient for plants' production, is lost into the environment by leaching, volatilization and denitrification. Slow-release fertilizers could solve this issue creating a synchrony between the release of the plant-available nutrient form and the crop demand of it. In this talk we will illustrate a preliminary study about the interaction of wood vinegar and urea that could alter the N-cycle in soil. We will also present a project in wich biochar will be enriched with nutrient from different organic material (Aurin fertilizer, urine and pig slurry) in order to obtain a slow-release fertilizer. We will briefly show the use of Design of Experiment as a chemometric tool to reduce the number of experiments for the sake of the sustainability of research.

References

Bakshi, S., et al., (2021). Enhancing biochar as scaffolding for slow release of nitrogen fertilizer. ACS Sustain. Chem. Eng., 9, 8222-8231. https://doi.org/10.1021/acssuschemeng.1c02267

Viskari, E.L., et al., (2018). Nitrogen recovery with source separation of human urine-preliminary results of its fertiliser potential and use in agriculture. Front. Sustain. Food Syst., 2, 32. https://doi.org/10.3389/fsufs.2018.00032

Wald, C., (2022). How recycling urine could help save the world. Nature, 602, 202-206. https://doi.org/10.1038/d41586-022-00338-6

AGRICULTURAL PRACTICES TO REACH SUSTAINABLE FOOD PRODUCTION

SESSION II

FARMING PRACTICES TO REACH SUSTAINABLE DEVELOPMENT GOALS (SDGS)



Vegetation spectroscopy: a tool for the early detection and monitoring of plant diseases and stress

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Keywords: crop management, high-throughput plant phenotyping, precision agriculture, reflectance spectroscopy, spectral imaging

Ensuring a food-secure/safe future dictates changes in agriculture to cope with several plant diseases and stresses. Understanding how to achieve greater crop yield and quality, with minimized environmental footprint, requires advancements in high-throughput techniques to early and accurately detect and monitor the effects of biotic and abiotic stresses, as well as the effectiveness of plant protection strategies. Vegetation spectroscopy has emerged as a promising tool, being a non-destructive, rapid, and relatively low-cost technique to monitor vegetation status: it relies on the interaction of light with plant chemical/structural composition and water content. Reflection of light in the visible (400-700 nm), near-infrared (700-1100 nm), and short-wave infrared (1100-2400 nm) can provide a comprehensive assessment of shifts in macroscopic symptoms and the underlying morpho-anatomical and physio-chemical responses of plants to diseases and stresses. Actually, another benefit of this spectral approach is represented by its capability to monitor plant traits and functions over large geographic areas if scaled from leaf to remote sensing level with measurements acquired from a variety of airborne and space platforms, including UAVs, aircrafts and satellite. In this context, hyperspectral imaging integrates imaging and point spectroscopy to bring the hyperspectral approach to the pixel level, so allowing to map outcomes.

The present work aims to highlight the potential of vegetation spectroscopy for detecting and monitoring plant responses to environmental constraints, in order to increase crop yield and quality, as well as optimize management and input efforts. First, it briefly reports basic concepts of vegetation optical properties. It then reports some case studies from the Plant Pathology group of the Department of Agriculture, Food and Environment of the University of Pisa concerning the spectroscopic detection and monitoring of plant diseases (e.g., Verticillium wilt of eggplant) and stress conditions (e.g., aucuba under drought). These studies highlight the capability of spectral data to accurately monitor specific plant responses to stress conditions, even prior to the onset of visual symptoms. Furthermore, they show that vegetation spectroscopy can be a rapid, non-destructive, and relatively inexpensive tool to accurately estimate an array of leaf physiological, biochemical and morphological parameters commonly investigated to monitor plant/stress interactions. The presented results could be used in many frameworks such as precision agriculture, high-throughput plant phenotyping, and smart nursery management. Knowledge gaps and perspectives of the proposed approach are finally reported such as the need to (i) explore other major crop diseases/stress, (ii) develop spectral sensors, and (iii) advance algorithms for exploitation of spectral data.

Detection of temporal and spatial development of wheat blast disease by hyperspectral data

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Keywords: Magnaporthe oryzae pathotype Triticum; sustainable plant disease management, Triticum aestivum; vegetation spectroscopy

First reported in Brazil in 1985 and then in other countries of South (1996-2007) and North America (2011), Asia (2016) and Africa (2017-18), wheat blast (WB) disease, caused by the fungus Magnaporthe oryzae pathotype (pt) Triticum (MoT), represents an escalating global threat to wheat production. Wheat blast can cause 100% yield losses under conducive environmental conditions[1]. Although the main visible WB symptom is the spike bleaching, all above-ground parts can be impaired. Leaf symptoms are usually more inconspicuous if compared to head bleaching and their role into the epidemiological processes remains not yet well understood. As limited epidemiological information makes WB disease challenging to control with the current disease management strategies, optical sensors-based instruments are a promising strategy to support conventional disease detection and try to avoid massive outbreaks of WB to other traditionally wheat growing areas[2,3].

Since WB can be considered as both a spike and a leaf disease and leaf lesions may be a natural reservoir enforcing the conidial dissemination, this study evaluated the capability of hyperspectral data to detect the temporal (0-5 days) and spatial (old-young leaves) development of WB on leaves. The spring wheat cv. Bobwhite, susceptible both to MoT and M. oryzae (pt) Lolium (MoL), served as host plant. MoL isolate PL2-1 was used as a MoT surrogate. Plants grown under controlled conditions were inoculated 21 days after planting, i.e., at Feekes 6 stage, and 50 days after planting, i.e., at Feekes 10 stage, at three inoculum concentrations (1×10^3, 2×10^4, 1×10^5 spores/ml, using an airbrush). Using a full range spectroradiometer (400-2400 nm), hyperspectral reflectance profiles were collected for five consecutive days on upper and bottom leaves at Feekes 6 stage and on upper, medium and bottom leaves at Feekes 10 stage.

Regardless of the concentration, a significant inoculation effect was observed already at Feekes 6, when leaf spectral profiles were statistically different (Permutational Analysis of Variance: $P<0.05$) also for the 'inoculum concentration × day' combinations. Additionally, at Feekes 10, a significant 'inoculum concentration × leaf × day' effect was even observed, and older leaves infected by the highest spore concentration were mostly discriminated already at three days from inoculation, even in the absence of visible symptoms.

This study highlights the potential of optical sensors-based technologies to detect plant/pathogen interactions by means of altered amounts of reflected light, allowing the possibility to discriminate plant health conditions. Nevertheless, further efforts are needed to build an applicative tool that can be easier exploited by farmers to manage plant diseases.

References

[1]Hossain, M. (2022). Wheat blast: A review from a genetic and genomic perspective. Front. Microbiol., 13, 983243. https://doi.org/10.3389/fmicb.2022.983243

[2]Mahlein, A.-K., et al., (2018). Hyperspectral sensors and imaging technologies in phytopathology: state of the art. Annu. Rev. Phytopath., 56, 535-558. https://doi.org/10.1146/annurev-phyto-080417-050100

[3]Gongola-Canul, C., et al., (2020). Temporal dynamics of wheat blast epidemics and disease measurements using multispectral imagery. Phytopathology, 110, 393-405. https://doi.org/10.1094/PHYTO-08-19-0297-R

Biocontrol of Fusarium Head Blight in wheat: A meta-analysis

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Keywords: biological control, FHB, Fusariosis, mycotoxins, Triticum spp.

Fusarium head blight (FHB) is a major fungal disease affecting wheat (Triticum spp.) worldwide. Caused by species belonging to the Fusarium graminearum Species Complex (e.g., F. culmorum, F. graminearum and F. poae), FHB is responsible for huge wheat yield losses and mycotoxin contamination of grains. The use of biocontrol agents (BCAs) coping with fungal pathogens causing FHB is a compelling strategy for the disease management, but a better elucidation of their effectiveness is crucial[1]. Actually, to summarize BCA effects on FHB in wheat is complicated by marked differences in experimental settings (e.g., unrelated biological materials, treatment protocols, environmental conditions and timing of analyses) and findings among individual studies. Meta-analytic techniques may provide an objective means to quantitatively summarize the data provided by available studies focused on BCA-FHB-wheat interaction, so potentially further boosting the overall interest of researchers, farmers, agro-industries and policy makers on this biological approach[2,3].

This work reports results of a pioneering meta-analysis, including 25 pathometric, biometric, physiochemical, genetic and mycotoxin parameters reported in 50 studies, shows overwhelming evidence of the BCA effects on FHB in wheat. The effectiveness of BCAs of FHB in wheat in terms of pathogen abundance and disease reductions, biomass and yield conservation, and mycotoxin decontamination was confirmed. BCAs showed higher efficacy (i) in recent studies, (ii) under controlled conditions, (iii) in less susceptible wheat cultivars (not clear), (iv) when Fusarium inoculation did not occur directly on the plant, and vice versa for BCA treatment, (v) if Fusarium inoculation (not clear) and BCA treatment occurred by spraying spikes, (vi) at 15-21 days post Fusarium inoculation or BCA treatment, and (vii) if they were filamentous fungi. However, BCAs overall resulted less efficacious than conventional agrochemicals, especially in terms of pathogen abundance and FHB reductions, as well as of mycotoxin decontamination, although inconsistencies were reported among the investigated sources of variation. This study also highlights the complexity of reaching a good balance among BCAs effects, and the need of further research on this topic. Physiochemical and genetic responses should be especially investigated for a mechanistic understanding of the BCA-FHB-wheat interaction.

References

[1]Powell, A.J., and Vujanovic, V., (2021). Evolution of fusarium head blight management in wheat: scientific perspectives on biological control agents and crop genotypes protocooperation. Appl. Sci., 11, 8960. https://doi.org/10.3390/app11198960

[2]Rosenberg, M.S., et al., (2004). New applications of statistical tools in plant pathology meta-analysis in plant pathology: Synthesizing research results. Phytopathology, 94, 999-1003. https://doi.org/10.1094/phyto.2004.94.9.999

[3]Risoli, S., et al., (2022). Trichoderma-induced resistance to Botrytis cinerea in Solanum species: A meta-analysis. Plants, 11, 180. https://doi.org/10.3390/plants11020180

Practical experiences removing AMU in pigs

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Keywords: Antimicrobial resistance, antibiotics, biosecurity, disease, management

Antimicrobial resistance (AMR) is one of the 10 main international health issues listed by the WHO in 2021[1]. AMR is the result of inappropriate antimicrobial use (AMU) and its direct consequence is the lack of tools to control bacterial diseases in humans and animals. AMR is a One-Health issue and requires the involvement of all experts working in human, animal and environmental areas to successfully tackle it. On the animal side, the new EU animal health regulation and the legal restriction in ZnO use in pig farms due to environmental concerns will restructure AMU in the EU and it will be a good model for other countries. Applying husbandry good and best practice is very important to improve animal health and reduce AMU. Constant improvement of biosecurity, adequate vaccination and monitoring plans and improvements in nutrition are among the main actions to reduce AMU. However, as technical knowledge is deployed, the socio-economic aspects (eg. education and training, discussion groups) are becoming crucial to promote prudent AMU. Sharing and disseminating experiences between different countries and sectors when decreasing AMU is of great importance. This presentation summarises the experience in the Irish pig sector[2, 3] implementing and promoting prudent AMU including the establishment of national use and disease control programs, the adjustments in the management of animals at farm level and the importance of the socio-economic aspects in this area. The first farm experiences to control AMU in Ireland started in 2015 and several farms have already eliminated in-feed AMU which represent 90% of the use. Ireland did not have a data collection system for AMU until 2019. The process to establish such database, and the integration with the salmonella, slaughterhouse, welfare and biosecurity databases will be reviewed. Finally, the experience using social sciences in promoting prudent AMU will be discussed. This experience includes the advisory and veterinary services, training programs and the knowledge transfer activities to farmers.

References

[1]https://www.who.int/news-room/spotlight/10-global-health-issues-to-track-in-2021

[2]O'Neill, L. et al., (2021). Risk factors for antimicrobial use in Irish pig farms. Animals, 11, 2828. https://doi.org/10.3390/ani11113080

[3]Martin, H., et al., (2020). Current antimicrobial use in farm animals in the republic of Ireland. Ir. Vet. J., 73, 11. https://doi.org/10.1186/s13620-020-00165-z

Swine nutrition in the age of Holobiont

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To reach the full potential of mitigating the environmental impact of livestock production, several best practices must be combined[1]. However, animal nutrition has a key role in implementing the farm sustainability.

Over the years, the concept of diet based on the proper intake of macronutrients shifted to a micronutrient diet targeted to the physiological needs in the life stages. With the science progress and the development of new investigative techniques, among which genome sequencing has been relevant, the concept of diet is changing for both humans and animals.

In the Holobiont era, the pig is seen as the host of a multitude of microbial species living in or around it. Together they form a discrete ecological unit through symbiosis. In particular, the gastrointestinal tract contains trillions of microorganisms with different metabolic capacities. The symbiosis of these core microbiome plays an important role in regulating nutrient metabolism and immunity of the host, ultimately contributing to the health and production performance of pigs[2, 3]. Diet is one of the most important determinants that shape the profile of gut microbiota communities. Dietary composition, nutritional levels, energy sources and diet types had been widely proven to shape the gut microbiota communities. Additionally, the use of modulating substances, such as prebiotics and probiotics, allow both an improvement in animal welfare and an implemented environmental sustainability.

An important and highly topical aspect to reduce generates emission is the use of food industry waste or by-products as animal feed. Agro-food waste and by-products are rich sources of ingredients capable to provide physiological benefits beyond nutrition. However, there are only few evidence about the effect of by-products on swine microbiome. Another relevant perspective to reduce environmental impact is the use of insect meal in feed composition. However, again, there is a lack of studies attesting to the influence of the latter on the microbiome. Moreover, a key role in animal diet to decrease the environmental impact of farms is the balanced composition of micronutrients. For example, both the host and the symbiotic bacteria in the gastrointestinal tract require nitrogen sources for metabolism. The main sources of nitrogen in the gut microbiota are dietary proteins, amino acids, peptides, endogenous secreted proteins, and recycled urea. However, the composition of a nitrogen source can influence the net utilisation of amino acids. Therefore, providing an amino acids balanced diet can reduce the crude protein content of the ration and simultaneously decrease nitrogen excretion.

In conclusion, more studies are needed to fully understand the action mechanism of the gut microbiota on both swine health and the environmental impact of animal excretions when animal are fed with by-products or insect meal.

References

[1]Gerber, P.J., et al. (2013). Tackling climate change through livestock – a global assessment of emissions and mitigation opportunities. Rome: Food and Agriculture Organization of the United Nations (FAO).

[2]Geng, S., et al., (2018). Faecal microbiota transplantation reduces susceptibility to epithelial injury and modulates tryptophan metabolism of the microbial community in a piglet model. J Crohns Colitis, 12, 1359-1374. https://doi.org/10.1093/ecco-jcc/jjy103

[3]Kang, C, et al. (2017). Gut microbiota mediates the protective effects of dietary capsaicin against chronic low-grade inflammation and associated obesity induced by high-fat diet. mBio, Vol 8(3), e00470-17. https://doi.org/10.1128/mBio.00470-17

Development of knowledge on agroecosystem services through a multidisciplinary holistic approach: Ten years of agroforestry research in Pisa, Italy

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Keywords: sustainability, resilience, agrosilvopastoral, silvopastoral, agroecology

The development of agroforestry systems has been shown to be an appropriate strategy to improve the potential agroecosystem services generated by farming systems and to tackle the changing climate. Agroforestry is defined as "the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions"[1]. The sustainability of these systems relies on the following key aspects: combining food, feed, and timber production on the same land surface, stocking carbon in the above- and below-ground biomass of trees, reducing soil erosion soil and flooding risks, and improving nutrient cycling and animal welfare. Recent studies, carried out by the authors of this proceeding, showed the importance of both traditional and innovative agroforestry systems and their role to produce climate-smart food, feed, and timer[2]. The agroforestry research activities were conducted through the implementation of several research projects: innovation transfer project at local level, EIP-Agri operational groups and multi-actor European projects. The main object was to develop participatory approaches to unlock synergies in agroforestry systems to achieve agro-environmental and socio-economic sustainability and resilience in the context of climate change.

The main outputs of studies carried out in experimental and real farms highlight that: at the herbaceous level, the reduced light availability due to interception by the tree canopy is a limiting factor in crop agronomic performance with different magnitude according to plant species, the nutritive value of forage, such as alfalfa, could be improved by the presence of trees in Mediterranean rainfed systems, and legumes were more affected by the competition for light than for water. Moreover, trees can provide high-quality fresh forage during summer reducing the dependence to fodder without a decline of animal productivity. Grazing management remains crucial for the sustainable utilisation of resources in agrosilvopastoral systems and carbon sequestration by grazed woodland has the potential to mitigate a large portion of the overall GHGs emitted by livestock. Regarding animal welfare, the tree presence can significantly affect microclimatic conditions and in particular radiant heat load and wind speed. Thus, the design and the management of integrated crop-tree-livestock systems should consider the evaluation of local wind circulation patterns to obtain effective reduction of thermal stress. The realization of surveys, fuzzy cognitive maps and co-design workshops can support the transition towards climate-smart agroforestry systems recognizing at the same time issues but also drivers from a technical and social perspective.

Our outcomes should encourage researchers, advisors, policymakers and farmers to develop further experiments to increase knowledge on agroforestry.

References

[1]Burgess, P. and Rosati, A. (2018). Advances in European agroforestry: results from the AGFORWARD project. Agroforest Syst., 92, 801-810. https://doi.org/10.1007/s10457-018-0261-3

[2]Paris, P., et al., (2019). What is the future for agroforestry in Italy? Agroforest Syst., 93, 2243–2256. https://doi.org/10.1007/s10457-019-00346-y



Modeling agroforestry systems with Yield-SAFE

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Keywords: agroforestry, climate change, long-term experiment, simulation, models

Agroforestry has been defined as the “the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions”[1]. Because of the interactions between tree and crop components and the long duration of tree growth, it is difficult to quantify the processes within agroforestry systems, the outputs produced, and the possible negative or positive effects on the environment. As scientists, we are interested in increasing knowledge to improve the agroecosystems management. Biophysical models are a helpful tool to support this goal allowing the study of the main inputs, processes, and outputs of systems.

Three aspects to consider when developing or using an agroecosystem model are: (i) the purpose, (ii) the approach used to build the model, and (iii) the spatial and temporal scales. Models can be used to (i) increase scientific understanding, (ii) support decision-making processes, and iii) supporting education and training. Models used for research and training often tend to be mechanistic in that they represent biophysical processes. By contrast, decision support models can be based on statistical approaches developed using historical datasets. The spatial extent of agroforestry models typically range from plot or field to farm or landscape level[2], and the temporal scale is typically the length of a tree rotation.

Yield-SAFE (YIeld Estimator for Long term Design of Silvoarable AgroForestry in Europe) is an example of a biophysical dynamic model used to study agroforestry systems. The Yield-SAFE model was developed in the early 2000s as part of the EU-sponsored “Silvorable Agroforestry For Europe” (SAFE) project, and subsequent modifications were made in the EU-sponsored “AGFORWARD” project[3]. The model aims to simulate the development, growth and productivity of the tree and understorey crop components of an agroforestry system over the length of a tree rotation, and the outputs include predictions of tree and crop yields. These biophysical outputs can then be used for financial and economic analyses. The data required are daily temperature, radiation and precipitation, planting densities, initial biomasses of tree and crop species, and soil parameters[4].

Currently, within the EU Horizon 2020 AGROMIX project, we aim to predict long-term forage crop and tree yields for three agroforestry experiments under different climate-change scenarios. In Italy, the use of Yield-SAFE in predicting crop and tree yield will help us to simulate the feed availability as affected by the climate change and, as a consequence, to predict the animal response in terms of productivity and adaptative response to microclimate parameters. We aim to understand if the agroforestry development can help to mitigate climate change effects on the forage yield production addressing the challenge regarding the uncertainty of the forage availability.

References

[1]Burgess, P.J., Rosati A. (2018). Advances in European agroforestry: results from the AGFORWARD project. Agrofor. Syst. Vol. 92, Pages (801–810). 92:801–810 https://doi.org/10.1007/s10457-018-0261-3.

[2]Jones, J. W., et al., (2017). Brief history of agricultural systems modeling. Agric. Syst., Vol. 155, Pages (240-254). doi.org/10.1016/j.agsy.2016.05.014.

[3]van der Werf, W., et al., (2007). Yield-SAFE: A parameter-sparse, process-based dynamic model for predicting resource capture, growth, and production in agroforestry systems. Ecol Eng, Vol. 29, Pages (419-433). doi.org/10.1016/j.ecoleng.2006.09.017.

[4]Palma, J.H.N., Crous-Duran, J., Graves, A.R., Garcia de Jalon, S., Upson, M., Oliveira, T.S., Paulo, J.A., Ferreiro-Domínguez, N., Moreno, G., Burgess, P.J. (2018). Integrating belowground carbon dynamics into Yield-SAFE, a parameter sparse agroforestry model. Agrofor. Syst Vol. 92, Pages (1047–1057). doi.org/10.1007/s10457-017-0123.

Insects for feed: sustainability and circular economy

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The forecast increase in the consumption of products of animal origin will result in an increase in in livestock and production of feed. As the conventional raw materials used to formulate animal feeds (soybean meal, fishmeal) rise sustainability questions, the livestock sector is looking for alternatives.

There is a growing interest for the use of insects-derived nutrients in animal feeds. Insects have a high nutritional value (protein and essential amino acids, lipids, vitamins and mineral), and contain bioactive compounds (chitin, specific fatty acids, and anti-microbial peptides) having a positive effects on animal health and welfare (Gasco et al., 2021). Moreover, insects are considered as sustainable as they can be reared on organic waste, fully applying the circular economy concept and their rearing requires low amount of soil and water and produce low greenhouse gases and ammonia emissions.

Among the species studied for the production of livestock feeds, the black soldier fly (Hermetia illucens), the common housefly (Musca domestica), and the yellow mealworm (Tenebrio molitor) are considered as the most promising.

In Europe, insects kept for the production of food, feed or other purposes are classified as "farmed animals" (Regulation (EC) No 1069/2009); therefore only "feed graded" substrates can be used as insect' rearing substrate.

According to EU legislation, only eight insect species can be used to produce insect-derived proteins for aquaculture (Regulation (EU) 2017/893) and poultry and swine (Regulation (EU) 2021/1372) feeds, while for ruminants, the use of proteins from insect is forbidden.

Research performed so far indicates that partial or total substitution of conventional protein sources with insect meals in fish, poultry and pigs is possible with no major negative effects. Information on insect-fed ruminants is limited and investigation mainly addressed in vitro digestibility assessments.

Insect-derived products seem to be a good alternative to conventional feed sources and can make an important contribution to the sustainable development of the livestock industry.

Farmers' knowledge: what role in the crop breeding debate? A presentation of three case studies

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Authors in second case study (Women's empowerment and trait preferences among cereal and legume growers in Bangladesh): Occelli M.[1] and Tufan H.[1]

Authors in third case study (Group-Based and Crowdsourced Citizen Science Variety Testing Approaches for Bean Growers in Central America): Occelli M.[1], Sellare J.[5], De Sousa K.[6,11], Dell'Acqua M.[7], Mercado L.[8], Paredes S.[9], Robalino J.[8,9], Rosas J.C.[10], van Etten J.[11]

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Keywords: farmers' local knowledge, crop breeding, women's empowerment, crop trait preferences

Numerous studies report that despite important positive effects of crop breeding on overall agricultural productivity, marginalized farmers might benefit little from crop varietal innovations. Farmers often face steep barriers in adopting new varieties, when farmers' knowledge, habits and traditions are not addressed in trials. When farmers fail to adopt new varieties, they may miss out on potential food security benefits, dietary quality and on-farm agrobiodiversity for risk management. Participatory breeding approaches include farmers in setting breeding priorities, thus increasing the probability of farmers' adoption of new varieties. In these approaches, farmers are involved directly in selecting research priorities and express trait preferences.

This work investigates how farmers' knowledge can contribute to breeding priority setting. Through the presentation of three different studies, the work shows that farmers' engagement can take numerous forms and should be considerate of social dynamics, in primis gender. First, we present preliminary results of a scoping review among 333 studies focusing on tools and methods for engaging farmers in breeding priority setting. We show that farmers' engagement is polarized in some regions of the world and tools and methods fall frequently short in accounting for farmers' knowledge. Second, we present a case study among cereal and legume farmers in Bangladesh. Utilizing data on farmers' trait preferences from 2011 to 2018, we show that preferences are not static overtime, and they can be influenced by social transformations, such as changes in women's empowerment. If breeding programs fail to incorporate longitudinal crop preferences data, varietal improvements might be obsolete before reaching farmers' fields. Finally, we show evidence of benefits in farmers' engagement which go beyond receiving better performing varieties: utilizing a randomized control trial design in Costa

Rica, we prove that encompassing farmers' knowledge at farmers' fields lead to positive socioeconomic outcomes, in terms of food security and on-farm agrobiodiversity. To conclude, we argue that these three case studies advocate for further research on how farmers' knowledge can contribute to crop breeding research and, complementarily, how breeding programs can employ this knowledge and guarantee more suitable varieties delivered at farmers' field and plate.

SUSTAINABLE INNOVATION IN FOOD CHAIN

SESSION III

FOOD STRATEGY TO PROMOTE QUALITY PRODUCTION

Application and determination of the analytical results on the using NIR spectroscopy

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Keywords: NIR, wine, grape, composition, quality

Due to its complex nature, the analysis of grapes and wine is often a drawn out and arduous task. In recent years, the current nature of the wine industry where quality, brand production, tradition, consumer safety and satisfaction, and sustainability are paramount, are coming together with advances in technology (e.g. precision viticulture, on-line sensors, digitalization). These changes are highlighted in the need for novel analytical tools and methods to aid producers and winemakers at the multiple stages of the production process (from the vineyard to the consumer). Hand in hand with advances in machine learning methods and computational power the application of spectroscopic techniques such as near infrared (NIR) spectroscopy has also expanded in recent years. The potential of digital viticulture, machine learning tools and NIR spectroscopy together with the wide range of developments in computer science and instrumentation, is determining new applications in viticulture and winemaking. Examples of these applications and limitations will be presented and discussed.

References

Gishen, M., et al. (2005). Grape and wine analysis in the Australian wine industry — enhancing the power of spectroscopy with chemometrics. Aust. J. Grape Wine Res., 11, 296-305. https://doi.org/10.1111/j.1755-0238.2005.tb00029.x

Cozzolino, D., et al., (2009). Multivariate methods in grape and wine analysis. Int. J. Wine Res., 1, 123-130.

Cozzolino, D., et al., (2011). Technical solutions for analysis of grape juice, must and wine: the role of infrared spectroscopy and chemometrics. Anal. Bioanal. Chem., 401, 1479-1488. https://doi.org/10.1007/s00216-011-4946-y

Application of sensors and sprectroscopy for the evaluation of wine quality

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Keywords: biosensors, wine analysis, polyphenols, non destructive approaches

The use of sensors and new technologies can help to reduce costs and increase the reliability of analytical results with very low margins of errors. The chemical composition of wine is determined by numerous factors such as grape variety and maturity, environmental condition during the development stage and vinification technology, as well as fermentation and ageing conditions. Polyphenols are a family of compounds present in grapes, musts, and wines. Their dosage is associated with the grape ripening, correct must fermentation, and final wine properties. Several approaches have been used based on different transduction methods the use of surface acoustic wave (SAW) sensors or quartz crystal microbalances (QCM). Gagliardi et al., (2022)[1], functionalised quartz crystal microbalances with peptides and proteins, and were able to discriminate and quantify different tannin families. Different types of electrochemical sensors including potentiometric sensors, voltamperometric sensors of impedimetrisc sensors have been successfully used to the analysis of polyphenols in wines[2]. These sensors can be easily modified with different sensing materials that include enzymes. Another non-destructive approach widely tested in the wine industry for determining the chemical and physical properties of wine is VIS-IR spectroscopy[3]. Recently, the interest in non-destructive technology is shifting to the combination of sensors or spectroscopic data with efficient chemometric techniques to create predictive models based on indirect sensor measurements[4]. In the context of cost reduction, simplification and lower environmental impact, test different low-cost non-destructive approaches have to be applied in the wine sector, mainly focusing on polyphenols profile.

References

[1]Gagliardi, M., et al., (2022). Detection of oenological polyphenols via QCM-D Measurements. Nanomaterials, 12(1), 166. https://doi.org/10.3390/nano12010166

[2]Rodríguez-Méndez, M.L., et al., (2016). Electronic noses and tongues in wine industry. Front. Bioeng. Biotechnol., 4, 81. https://doi.org/10.3389/fbioe.2016.00081

[3]Cozzolino, D., et al., (2006). Analysis of grapes and wine by near infrared spectroscopy. J. Near Infrared Spectrosc., 14(5), 279-289. https://opg.optica.org/abstract.cfm?uri=jnirs-14-5-279

[4]Chandra, S., et al., (2017). The application of state-of-the-art analytic tools (biosensors and spectroscopy) in beverage and food fermentation process monitoring. Fermentation, 3(4), 50. https://doi.org/10.3390/fermentation3040050

Quality and sustainability in supply chain strategies

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To move to a truly circular economy in key sectors characterized by high complexity such as agri-food, there is the need for a transformative change triggered by the creation of new business models that through digitization. The application of advanced information and communication technologies (TAIC) and the Internet of Things (IdC), can favor the simultaneous economic improvement, social and environmental supply chains towards greater efficiency: efficiency (improving performance), effectiveness (ensuring that innovative supply chains effectively deliver on the promise of new economic opportunities), transparency and traceability, and values-based decisions (safeguarding social and environmental models and achieving higher standards).

With respect to these objectives, it is necessary to develop a new vision of "sustainable digitalization" that can have a very high potential for transformation with a positive impact on the SDGs through technological, organizational and social innovation. In this context, traceability is certainly the central theme to respond to the challenges of a future-proof agri-food system. Transparency and traceability are the fundamental prerequisites for greater sustainability, control, trust, efficiency, competition and value. The improvement of the ability of rural communities to understand the impacts and changes in their context and design sustainable digitalization pathways strongly depends on the correctness of the information provided, its accessibility and immutability, the institutional structures and related governance systems, and finally from the processes of communication and learning.

The key role of agricultural knowledge and innovation systems (AKIS) for the achievement of the CAP objectives

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The AKIS strategy contributes to the CAP cross-cutting objective of modernisation by fostering knowledge exchanges and strengthening the innovative capacities of actors in rural areas. In the 2023-2027 programming period, Knowledge and Innovation Systems (AKIS) are to be defined as a part of national CAP strategic plans. The AKIS strategy contributes to the modernisation (OT CAP), through innovation and digitisation of European agricultural and forestry systems, by fostering knowledge exchanges and strengthening the innovative capacities of actors in rural areas

Reuse of food waste derived from processing of fruit and vegetables

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Keywords: food waste, fruit and vegetable by-product, functional ingredients, bioactive compounds

Annual loss of fruits and vegetables is 6.7-15.8% and 4.58-12.44%, respectively, during various unit operations. Indeed, food waste is produced in all the phases of food life cycle, i.e., during agricultural production, industrial manufacturing, processing and distribution. Up to 42% of food waste is produced by household activities, 39% losses occurring in the food manufacturing industry and 14% in food service sector (ready to eat food, catering and restaurants), while 5% is lost during distribution. In case of fresh produces, the waste starts from the field and continues up to consumer plate due to the presence of pests, natural ripening process, mould, and other microbe's infestation as biotic factors and inadequate temperature or relative humidity or poor transportation as abiotic factors. In recent decades there have been numerous efforts to develop methods and to find different ways of using fruit and vegetable waste for therapeutic or dietary purposes.

Vegetable waste includes trimmings, peelings, seeds, shells, bran and residues remaining after extraction of juice, oil, starch and sugar. Different studies analysed the content in bioactive compounds of different plant processing waste. For example, bioactive phytochemicals like sterols, tocopherols, carotenes, and polyphenols extracted from tomato by-products are fitted with significant antioxidant activities[1] but also phenolic compounds, carotenoids, vitamin C and dietary fibre from mango peel[2]. These compounds contribute to lower the risk of cancer, cataracts, Alzheimer's disease, and Parkinson's disease[2]. Bioactive compounds from winery by-products have been shown to improve health promoting activities both in vitro and in vivo[3]. Many other food by-products were analysed in terms of bioactive compounds and antioxidant properties such as coffee waste, apple peel, banana peel, rice bran, etc.[4, 5, 6], confirming the richness in phytochemicals useful for the health status of human beings of food waste. New trends in human nutrition and the onset of new human diseases as allergies and intolerances is leading to the research of functional foods able to maintain the health status of human beings. For example, plant-based diet results deficient in proteins since the main source of proteins in an omnivorous diet is meat and meat derivatives. Several attempts are reported in literature for the recovery of phytochemicals from fruit and vegetable by-products and their possible application as functional food ingredients. For example, a percentage of pumpkin seed flour was proposed to substitute a part of wheat flour in bread product with the purpose to reduce the gluten content maintaining the rheological features of white bread[7]. Proteins extracted from sunflower press cake are considered a highly valuable food ingredient because of its otherwise well-balanced amino acid composition. For this reason and for their lower allergenicity if compared with soy and wheat proteins, the introduction of sunflower seed flour in bread was hypothesized to enrich a plant-based diet in proteins[8]. Due to its functional characteristics (water holding, gelling, thickening and stabilizing abilities), phytochemicals such as chlorogenic acid, phlorizin and quercetin, apple pomace has been used by researchers in a variety of food products such as sausages, jams and baked goods as functional ingredient[9]. To conclude, numerous opportunities can be identified to reduce food waste and to re-use it, even by enhancing dietary nutrient and nutraceutical intake.

References

[1]Kalogeropoulos, N., et al. (2012). Bioactive phytochemicals in industrial tomatoes and their processing by products. LWT Food Sci. Technol., 49, 213-216. https://doi.org/10.1016/j.lwt.2011.12.036

[2]Ayala-Zavala, J., et al. (2010). Antioxidant enrichment and antimicrobial protection of fresh-cut fruits using their own by products: looking for integral exploitation. J. Food Sci., 75, R175-R181. https://doi.org/10.1111/j.1750-3841.2010.01792.x

[3]Teixeira, A., et al. (2014). Natural bioactive compounds from winery by-products as health promoters: a review. Int. J. Mol. Sci., 15, 15638-15678. https://doi.org/10.3390/ijms150915638

[4]Zuorro, A., and Lavecchia, R. (2012). Spent coffee grounds as a valuable source of phenolic compounds and bioenergy. J. Clean Prod., 34, 49-56. https://doi.org/10.1016/j.jclepro.2011.12.003

[5]Bisht, T.S., et al. (2020). A novel approach towards the fruit specific waste minimization and utilization: a review. J. Pharmacognosy Phytochem., 9(1), 712-722.

[6]Helkar, P.B., et al. (2016). Review: Food industry by-products used as a functional food ingredient. Int. J. Waste Resour., 6(3), 1-6. https://doi.org/10.1016/j.tifs.2017.07.003

[7]Litvynchuk, S., et al. (2022). Conformational changes in the structure of dough and bread enriched with pumpkin seed flour. Plants, 11(20), 2762. https://doi.org/10.3390/plants11202762

[8]Škrbić, B., and Filipčev, B. (2008). Nutritional and sensory evaluation of wheat breads supplemented with oleic-rich sunflower seed. Food Chem., 108(1), 119-129. https://doi.org/10.1016/j.foodchem.2007.10.052

[9]Henríquez, C., et al. (2010). Development of an ingredient containing apple peel, as a source of polyphenols and dietary fiber. J. Food Sci., 75(6), H172-H181. https://doi.org/10.1111/j.1750-3841.2010.01700.x

Photomodulation of targeted secondary metabolites in planta

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Keywords: anthocyanins, Botrytis cinerea, light supplementation, polyphenols, volatilome profile.

Stress modulation is an advantageous practice to improve crop yield and quality. Modulation of light quantity as well as spectrum quality have indeed the potentiality of tuning photosynthesis and consequently drive the biosynthesis of primary and secondary metabolites. Moreover, targeted specialized metabolites can play a fundamental role in plant defence against pathogens.

Light spectrum can be modulated using (i) narrowband light lamps as the only source of light (i.e., monochromatic environment); (ii) supplementation of environmental light with narrowband light (i.e., light enrichment); (iii) filtering the solar spectrum with polycarbonate films (light filtering); (iv) using spectral-shifting films for converting less photosynthetic active wavebands into more active light (photonic improvement)[1].

Here are shown two studies which enlightened the possibility of applied narrowband LED light supplementation in order to modulate the production of targeted secondary metabolites and improve plant tolerance against pathogen infection/development.

In both the experiments, environmental light was supplemented with green (G; 530 nm), blue (B; 450 nm), red (R; 660) or white light (W; R:G:B 1:1:1) for 5 h d-1.

First experiment: Two cv. of basil (*Ocimum basilicum L.*), namely green-leafed 'Tigullio' (TI) and red-leafed 'Red Rubin' (RR), did not show biomass alteration after 21 days of treatment. Nevertheless, slight alteration in photosynthesis emerged as well as variation in secondary metabolites abundancies and profile. In fact, polyphenols, anthocyanins and volatilome profile underwent profound light-dependent and species-specific alterations. Noteworthy, in TI volatilome profile was observed a significant decrease of two toxic compounds, i.e., eugenol and methyl eugenol, induced by W, G and B light supplementation.

Second experiment: Strawberry (*Fragaria × ananassa* Duch.) was used as a model fruit species. As no stress symptoms were observed in leaf physiology, further analyses evaluated the effect in terms of fruit quality and primary and secondary metabolites. In addition, harvested mature fruits were inoculated with Botrytis cinerea, a widely spread and economic relevant post-harvest strawberry pathogen, to evaluate a possible tolerance increase promoted by pre-harvest LED light supplementation. Plants were treated with supplemental light from the beginning of the flowering to harvest time (about six weeks). It was observed that R light enhanced plant productivity and increased fruit anthocyanin content whereas barely influenced primary metabolism. Furthermore, R light supplementation decreased the disease progression of B. cinerea, likely through a R light-driven overexpression of some genes related to fruit cell wall integrity.

Taken together, these results provide the evidence that LED supplementation represents a valid tool to modulate the accumulation of targeted secondary metabolites and regulate defensive genes, thereby enhancing product quality and safety.

References

[1]Lauria, G., and Ceccanti, C. (2021). Effects of light modulation on plant photosynthesis process and secondary metabolism. Agrochimica. 65, Special Issue, 45-51.

Metabolomics elucidation of chemical fingerprints for the authenticity and traceability of food

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Keywords: untargeted profiling; terroir effect; chemometrics; food integrity

In a framework of the whole food chain, the set of conditions a food undergoes in his production cycle is able to affect its chemical profile. Starting from the field, a specific cultivar interacts with the environment (the so-called "genotype x environment" effect), and climatic and edaphic conditions, as well as agronomic and post-harvest management (including tradition and local common practices), significantly shape the metabolome of a food. Thereafter, processing and storage conditions also contribute to determining unique chemical fingerprints.

Starting from this concept, the hypothesis-free untargeted nature of metabolomics, due to its broad characterization of chemical profile in foods, may harvest information on the authenticity and geographical origin of foods. The downstream multivariate interpretations (unsupervised as cluster analysis and PCA, rather than supervised like OPLS-DA) and Artificial Neural Networks allow supporting food traceability and mining markers of origin.

The speech will present some basic concepts and a case study based on the use of UHPLC-ESI/QTOF-MS untargeted metabolomics to support the authenticity of agri-food products. The aspects related to MS profiling, as well as the relevance of multivariate statistics (both multivariate statistics and Artificial Neural Networks) will be introduced. The effect of environment (geographical origin and altitude) and the blending with different but genetically related cultivars on Taggiasca Ligure olive oil metabolomics profile will be described. The metabolomics dataset originated from about 300 samples over three consecutive seasons will be used to specifically point out the effect ascribable to the factors under study, and to identify markers of each condition.

Plant pathogens in hydroponics: impacts, diagnosis and management

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Keywords: soilless, soilborne pest and diseases, non chemical control management, biocontrol agents

Soilless cultivations have always represented a strategy to limit damages caused by soilborne pest and diseases, being able to exclude contact between host and parasite/pathogen. Despite this, however, there are numerous pest and diseases that can easily adapt to cultivation in the absence of natural soil or that can be facilitated in their spread by such growing system. The transition from soil to soil-less, therefore, cannot ignore the adoption of control strategies not only preventive and, in particular, brings to the foreground, as a key strategy, the development and adoption of efficient sanitization techniques and strategies to be applied at the end of the cultivation cycles or immediately before their start, as well as the careful control of the production chain of the propagation material.

The sanitization of growing environments essentially involves the use of physical and chemical means capable of breaking down and even eradicating the presence of resident inoculum. The use of physical means is generally limited to the use of steam or hot water and is often adopted for the treatment of reused artifacts (floating panels, cultivation supports, ...) compatible with heat treatments. The use of synthetic active ingredients, although it can be considered easier to adopt, sees as the main limitation the presence of residual phenomena capable of causing both direct damage (phytotoxicity) and indirect (unwanted residues on foodstuffs). Like sanitation, however, the supply of healthy propagating material is, even more than what happens in conventional crops, a fundamental pillar on which to base the management of a soilless crop health. In this sense, it is necessary to have precise, accurate, sensitive and robust diagnosis systems, in a word reliable or able to guarantee the health of the material with a very low level of uncertainty. Finally, soilless cultivation need adoption both preventive strategies and curative strategies and techniques able to face any infections and infestations before they became as an epidemic: limiting the brief discussion to soilborne pathogens and parasites, certainly the management of circulating nutrient solutions has always represented a certain aspect, but it cannot be considered the only one having a significant character. In the context of soilless crops, and in particular horticultural crops, in fact, the use of genetic means and grafting is probably one of the greatest successes that can be taken as an example. On the contrary, the possibility of developing defense techniques based on synthetic chemical means is increasingly questionable, for numerous reasons not only related to ecotoxicological aspects. This criticality, however, could lead to the rapid development and diffusion of biological control means whose effectiveness, known in conventional cultivation conditions, could quickly be transferred even to soilless crops.

Occurrence of fungal pathogens in hydroponically grown halophytic crops

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Keywords: Salicornia europaea, Atriplex hortensis, floating system, plant pathogens, mycotoxins

The Mediterranean basin hosts a prosperous reservoir of wild edible halophytic plants. These species colonize habitats typically subjected to flooding such as coastal salt marshes, inland marshes, and brackish areas. The use of halophytes as food is very ancient and they can represent key crops to help tackle soil salinization, a phenomenon that is affecting millions of hectares of soil all around the world. Greenhouse saline hydroponics cultivation is a very promising growing method for such crops. Protected horticulture is well-established in many Mediterranean countries; nevertheless, there is still a lack of awareness concerning plant diseases that can occur under greenhouse when growing halophytes. This work reports on the occurrence of different plant pathogenic microorganisms: Fusarium pseudograminearum and some Pythium species. F. pseudograminearum was isolated from symptomatic roots and crowns of mature Salicornia europaea plants grown in pot. To gain insights into this novel pathosystem, disease incidence and severity were evaluated in plants grown in pot and in hydroponics (raft floating system). Interestingly, in the latter method, both incidence and severity were significantly lower than in pot. Hydroponically infected S. europaea plants showed a disease severity index (expressed as McKinney index) of 45.8% whereas the severity for pot-infected plants was 62.5%. In raft floating system, only 70% of plants (17 out of 24) showed symptoms of F. pseudograminearum root and crown rot whereas all pot-grown S. europaea plants were susceptible. This suggests a dependence of plant susceptibility on the cultivation method. In addition, the ability of the isolate to produce two mycotoxins was tested in a model system (i.e. zearalenone and deoxynivalenol) using a lateral flow test kit. The fungus positively synthesized both toxins, with a concentration of >1000 ppb and 7.25 ppm for zearalenone and deoxynivalenol, respectively. On the other hand, severe wilting symptoms were observed in Atriplex hortensis seedlings grown in raft floating system with standard or saline nutrient solutions. Seven strains of Pythium spp. were isolated from diseased roots and crowns. They were characterized through molecular analysis and, according to a recent classification, they belong to clades A and B/B2a. This genus consists of over 200 species, most of which are plant pathogens and live in aquatic habitats. Pythium sp. is a well-known pathogen occurring in both hydroponic and aquaponic cultivations. Disentangling species and physiological responses to salinity and temperature are key aspects for the adoption of effective control strategies.

Edible Green Infrastructure: new opportunities for ecosystem services

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Keywords: urban agriculture, food production, Green infrastructure, ecosystem services

Urban agriculture provides a number of important ecosystem services (ESs) for the urban environment including air quality amelioration, biodiversity and fruit production for direct human consumption. Within city limits, fruit species differ in their capacity to promote different services, so it is important that the choice of fruit species into the urban context is evidence-based. However, exploring the mechanisms of contaminants present in the urban environment such as Heavy metals (HMs) and polycyclic aromatic hydrocarbons (PAHs) uptake by fruits is extremely limited. In this context, since air and soil pollution are a potential source of compelling contaminants in cities, our study would investigate the mechanisms to limit fruit contamination in urban settings. More specifically, we intend to (i) elucidate the role of Green infrastructure in enhancing quality life within cities and transforming vacant spaces; (ii) study the ESs detailed by literature and pinpoint the research gaps of food production ES; (iii) discuss the level of contamination risks of food grown in urban areas. In fact, there is a significant risk of contamination of edible parts of trees planted in polluted areas, in addition, both soil and air can be loaded of contaminants that end up translocated into the edible parts of contaminated crops. Yet, this study do not classify species into high or low accumulators of pollutants, but it suggests instead to distinguish between potential contaminated areas to be avoided for implementing Green infrastructure dedicated to food provision ecosystem service. Also, translocation patterns were developed for HMs and Polycyclic aromatic hydrocarbons linking fruit species, HMs and PAH accumulation capacity, which should make it easier for city dwellers or decision makers to identify suitable vacant areas for food production. In conclusion, information about how to successfully avoid fruit contamination in urban environment using controlled environment through soilless systems and greenhouses are also provided and discussed.

Worldcloud: some of the words most used in this workshop