Universitat de Lleida

20TH EUROPEAN WEED RESEARCH SOCIETY SYMPOSIUM

Lleida, 1-4 July 2025

Joint Approaches for Sustainable Weed Management



Edició
European Weed Research Society
ISBN electrònic (Edicions de la Universtat de Lleida)
978-84-9144-572-2
DOI 10.21001/20.weed.research.society.symposium.2025

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Invited speakers

50 years of weed research in Europe

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In 1975, when the European Weed Research Society (EWRS) came into existence, weed control was largely dominated by the use of herbicides. Fifty years later **agriculture** in Europe still relies on using high volumes of herbicides to maintain crop yields.

During these 50 years weed research has evolved considerably. In the late 70´s practically all the research in this area was related with herbicide use. In contrast, at the advent of this millennium research on biological aspects received similar attention than that on chemical weed control. Research on cultural and biological control was a growing trend. In the last EWRS meeting that took place in Athens in 2022 an almost equal number of papers dealt with weed biology, non-chemical weed control and herbicide related issues.

Looking at the current situation, it seems to me that there are four key factors that will condition the future of weed management:

a) Sustainability policies. There is considerable disagreement on the parameters to measure sustainability and, more particularly, on the specific targets to be used. The EU Commission, following the Farm & Fork strategy, established an obligatory set of 2030 targets, including one that established a 50% reduction in the use of pesticides. This rule was recently withdrawn. In the coming months the Commission is expected to put forward a new proposal for the sustainable use of pesticides.

b) Herbicide regulations. Due to the stringent EU regulations, from 2018 to 2022 practically no new pesticides were introduced whereas the number of products lost was very high. In the specific case of herbicides, in these 11 years there were 17 gains and 35 losses (we lost 18 herbicides!). This reduction of compounds it is likely to lead to more resistance cases and to new weed control problems.

c) Increasing focus on more sustainable solutions. Although IWM is considered a key concept for more sustainable management, the research conducted on IWM systems has increased very slowly in the last 35 years. However, there is considerable research on some of its components (e.g. weed biology and ecology, development of control tactics). A recent trending topic is agroecology. Agroecological research for weed management may be of 3 types: increase diversity, many little hammers and limit resource availability.

d) Penetration for digital agriculture. Numerous public and private entities are currently involved in the development and commercialization of decision technologies (ground & aerial scouting, DSS, farm management systems, apps). In addition, there is a growing market of smart sprayers, physical weeders and weeding robots.

Apparently, nowadays there are two diverging paradigms: agroecology and digital agriculture. However, digital technologies can be applied to manage agroecosystems more efficiently by understanding the essential principles of ecological systems and ensuring minimal costs and harm to the environment. In other words, technology can, and should, cooperate with ecology.

Status, potential, and challenges in discovery and development of a breakthrough bioherbicide

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Biopesticides (commonly called Biocontrol or more recently bioprotection) have been experiencing double digit growth and now comprise about 10% of the global pesticide market driven by increased return on investment, restrictions on chemical pesticides, and pesticide resistance and residue management. However, despite the large need for new herbicides due to widespread and increasing resistance to herbicides with almost most of the chemical modes of action, bioherbicides are an insignificant percentage of the total. The technical difficulty in finding bioherbicides that can compete with the spectrum and price of chemical herbicides has left agriculture with a paucity of new bioherbicides. Billions of dollars of investment capital are being invested in new, innovative startups, but only a small number focus on bioherbicide discovery and development, due to the perceived higher risk than plant biotech, biostimulants, bionutrients and other categories of biopesticides. What does it take to find a breakthrough bioherbicide that can compete with chemicals on efficacy, spectrum and cost? There are exciting new tools and technologies that are enabling the discovery and development of bioherbicides to drive cost and efficiencies, including genomics, AI, machine learning, precision fermentation and synthetic biology.

Acknowledgement(s) / funding: Invasive Species Corporation.

From site-specific weed management to robotic weeding

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Precision Farming means “managing agricultural fields with respect to the spatial and temporal variability rather than overcoming heterogeneity” (Mortensen, 1998). Weed populations in agricultural fields are distributed heterogeneously. They often occur in aggregated patches or strips. Weed maps deliver insights in soil characteristics and farming history of agricultural fields and improve our understanding of weed population dynamics.

Spatial and temporal variations in weed population require site-specific weed management practices and offer a high potential for herbicide saving. Weed control methods can be targeted to weed patches with densities above the economic weed threshold (patch application). Another approach is to target single weed plants (spot application).

Weed mapping and site-specific patch spraying has resulted in 23-89% herbicide savings in a series of 58 European field experiments of the EWRS Working group “Precision Weed Management” in cereals, maize, sugar beet and peas. Patch spraying did not cause crop yield losses of uncontrolled weeds and additional costs for weed control in the following crops.

Advances in sensor, information and application technologies enabled a new era in weed management with autonomous robots. Some systems can be considered as completely autonomous. Other systems are tractor mounted and partly require human operation. For automatic guidance of inter-row hoeing, simple imaging algorithms for crop row detection or RTK-GPS-based steering are sufficient. Automatic row guidance for weed hoeing increased weed control efficacy from 70% to 85%. It is robust, safes the crop and can be realized at higher forward speed.

Most weeding robots use Artificial Intelligence (AI)-based imaging software for weed/crop detection. Some robots localize the position of crop plant with RTK-GNSS. Robots can be grouped into hoeing and spot spraying robots. Few robots use other physical weed control methods. Robotic weeders can be separated into online-applications when the sensor simultaneously controls an actuator and offline-applications when mapping/decision and weeding takes place in two separate operations.

Robotic weeding significantly reduces herbicide use, increases productivity in organic farming systems, reduces greenhouse gas emissions, may increase weed species diversity, helps understanding the temporal and spatial dynamics of weeds and gives economic weed thresholds new importance. Weeding robots have reached a high level of accuracy and selectivity. However, they are still slow and expensive and need much support and maintenance. They are extremely useful when they replace manual weeding. In future, fleets of robots may do weeding also in big arable crops.

Acknowledgement(s) / funding: The author acknowledges the support of the working group members "Precision Weed Management".

Industry session

SI-O1. Indaziflam - Broad spectrum herbicide for use in established permanent crops

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Indaziflam is the leading soil residual herbicide globally in permanent and semipermanent crops in temperate, sub-tropical and tropical regions worldwide. The active has been submitted for registration in Europe roughly 4 years ago with France being the rapporteur member state. Market introduction across Europe is expected towards the end of decade.

Indaziflam is a cellulose-biosynthesis-inhibiting (CBI) herbicide (HRAC group 29) and belongs to the class of alkylazines. It is a unique mode of action for resistance management and has broad spectrum activity at low application rates. Indaziflam provides an excellent control of emerging weeds in permanent crops like pome and stone fruits, vines, citrus and olives. The new compound controls a broad spectrum of monocot and dicot weeds, including cumbersome weed species which are difficult to eliminate such as annual bluegrass, barnyard grass and goosefoot and also controls (multiple) resistant weeds like ryegrass or marestail. It has to be applied on firm soils prior to weeds breaking through the soil surface or if combined with a post-emergent mixing partner such as glyphosate or flazasulfuron also on emerged weeds.

Another advantage is its low application rate. Due to its strong action and the broad spectrum of activity, the overall number herbicide applications and active ingredient used in a given orchard can be reduced. This makes indaziflam to an environmentally benign and pioneering active ingredient in the European herbicides market in plantations and orchards and provides farmers and agronomists with a new tool in the toolbox for weed control.

SI-O2. Isoflex™ active a new isoxazolidinone herbicide: key highlights

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FMC's bixlozone herbicide, trademarked ISOFLEX™ active, is a unique selective herbicide developed for use in a wide range of crops. First registered in Australia in 2020, it is currently undergoing the registration process at the European level. ISOFLEX™ active belongs to the isoxazolidinone class of chemistry and is classified by Global HRAC as a Group 13 herbicide due to its inhibition of Deoxy-D-Xylulose Phosphate Synthase (DOXP synthase), which is a component of the carotenoid biosynthetic pathway. ISOFLEX™ active is highly effective on a wide range of grass and broadleaf weeds when applied from pre-emergence to very early growth stages, and demonstrates good selectivity on cereals, oilseed rape, potato and corn.

SI-O3. Using artificial intelligence to assess field trials for the research and development of herbicides

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Background**:** Herbicides research and development requires field trials to evaluate the effect of herbicides on crops and weeds over different conditions. These evaluations rely on time-consuming and labor-intensive visual assessments. Creating a computer model to identify species, assess damage is particularly challenging due to the subtle differences between species and types of damage but can help improve efficiency and objectivize trial assessment.

Objectives**:** 1) To design a computerized image-based system to locate, quantize and pixel-wise segment the presence of 15 different crop and weed 2) quantize the presence of different damages caused by herbicides and 3) validate the system under unseen conditions and locations.

Methods**:** We have extended the model developed in [1] and [2] by incorporating large visual model (DinoV2) [3] and a hierarchical inference method that considers the botanical taxonomy for species and damage types. Model was trained with the dataset in [2] taken in Germany and Spain. It contains annotated images of *Abutilon theophrasti, Amaranthus retroflexus, Chenopodium album, Digitaria sanguinalis, Echinochloa crus-galli, Portulaca oleracea, Setaria viridis, Zea mays, Datura stramonium, Echinochloa colona, Glycine max, Helianthus annuus, Polygonum convolvulus, Solanum nigrum*among other species annotated as "*other*". A new validation dataset was generated in 2023 with drone and camera based zenithal images in the United States, Germany and Spain. These images were manually annotated, and the algorithm was validated against the images of this validation dataset.

Results and discussion: Current model clearly improved the results of [2] on their testing dataset both for species identification (F1-Score=0.52->0.85, R^2 =0.75->0.98) and damage identification task (F1-Score=0.28->0.44, R^2= 0.71->0.87). When evaluating the model with the data taken in 2023 in new locations and conditions unseen by the model, we can appreciate good algorithm resiliency with just a small performance decrease on the species task (F1-Score= 0.60, R^2 =0.80) and a small-moderate reduction on the damage task (F1-Score 0.41, R^2 0.62).

Conclusions: The proposed model achieves good species and damage identification capabilities under novel and unseen conditions even in locations not seen previously by the model and can help increase the efficiency on field trials assessment for the research and development of novel herbicides.

PI-01. Pledge® in the control of *Conyza* spp, *Lolium rigidum and Kochia scoparia*

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Pledge® is an herbicide based on flumioxazin and owned by Sumitomo Chemical.
Flumioxazin is a broad-spectrum contact herbicide. It works by interfering with the plants' production of chlorophyll. Treated plants will respond quickly to treatment and rapidly decompose.
The mode of action in this family of herbicides is believed to be inhibition of protoporphyrinogen oxidase (HRAC Group 14).

Pledge® provides a residual control on a broad range of small seeded broadleaves as well as active on certain annual grasses. On Olives and Grapes, it also provides a good control on weeds that developed resistant to glyphosate (*Lolium rigidum, Conyza sp.)*

The objectives of our studies were: (1) to determine the efficacy of flumioxazin on different *Conyza* spp populations on bioassays and field trials, (2) to confirm the efficacy of flumioxazin on different *Lolium rigidum* resistant populations to oxyfluorfen and glyphosate with laboratory and field trials and (3) to investigate the efficacy of flumioxazin on *Kochia scoparia* in autumn applications.

Key words. Flumioxazin, *Lolium rigidum, Conyza sp., Kochia scoparia,* weed resistant.

1. Agroecological weed and crop management

S01-O1. Pea traits for agroecological weed management in pea-wheat intercrops

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Keynote session

Background and objectives. Pea (*Pisum sativum* L.) is a key diversification crop but current pea varieties are not very competitive against weeds. Intercropping pea with cereals reduces weed infestation. However, past pea varieties were bred for sole crops. The objective of this study was to identify, depending on the type of cropping system and weed flora, (1) the key pea parameters that drive crop production and weed control in pea intercropped with wheat (*Triticum aestivum* L.), (2) optimal combinations of pea and wheat parameter values ("ideotypes") to maximise these goals.

Material and methods. Virtual experiments were run with FLORSYS. This mechanistic individual-based 3D model simulates daily crop–weed seed and plant dynamics over the years, from cropping system, weather and soil, focusing on plant–plant competition for light. FLORSYS includes 5 winter pea and 3 winter wheat varieties. Virtual varieties (5 pea and 10 wheat) were created by randomly combining variety-parameter values according to a Latin Hypercube Sampling (LHS) plan, respecting parameter ranges and correlations observed in the actual varieties. A global sensitivity analysis was run, using another LHS plan to combine pea and wheat varieties, crop rotations and management techniques. Further simulations were run with only sole crops. Simulated data were analysed with classification and regression trees (CART).

Results. Intercropping reduced pea yield loss due to weeds (by up to 30%) and field infestation (by up to 14%). Key pea parameters for potential (weed-free) yield and competitivity against weeds were biomass allocation rate to leaves, increased plant width per unit biomass when shaded, frost tolerance. The best pea ideotypes had a small root system to prioritise above-ground plant growth and light interception, except in no-till where a large superficial root system left less soil moisture for superficial weed seeds. In summary, a high pea yield in weedy intercrops required a pea variety with a high yield potential combined with a weed-suppressive wheat variety and weed-preventive management.

Conclusions. The present pea-parameter rules provide guidelines for farmers to choose their pea varieties in cereal–legume intercrops and for breeders to screen existing germplasm collections and to identify traits to guide breeding.

Funding. INRAE, European Union's Horizon 2020 Research and innovation programme ReMIX (N 727217), Horizon Europe IntercropVALUES (N°101081973), SPECIFICS (ANR-20-PCPA-0008) and MoBiDiv (ANR-20-PCA-0006) funded by the Agence Nationale de la Recherche, and COPRAA funded by the Office Français de la Biodiversité (OFB).

S01-O2. Agroecological weed management in perennial crops – First year's trial results of GOOD project

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GOOD is a 4-year EU Horizon project aspired to evaluate agroecological weed management (AWM) practices in Living-Labs (LL) in annual and perennial crops in conventional, organic and mixed farming systems. This study presents field trial results from perennial crops in conventional farming systems in Mediterranean countries.

The field trials were conducted during the 2023–2024 growing season to evaluate AWM practices in vineyards in Greece and Italy, olive groves in Portugal and Cyprus and a citrus orchard in Italy. Treatment list included: untreated control, at least three cover crops (monocultures and mixtures), application of herbicide at the recommended and reduced rate and mechanical or/and cultural weed control.

In Greece, the cover crop mixture *Vicia sativa* + *Avena sativa* had the highest biomass production (≥ 5,000 kg ha^{-1}) andreduced winter weed biomass by up to 78% compared to cover crop monocultures. Herbicide application was the only treatment that controlled summer perennials (≥ 90%). Similar results were obtained in the vineyard in Italy where *Vicia villosa* + *Avena sativa* mixture was the most weed-suppressive cover crop (*P <0.05). These results were confirmed in the citrus orchard.Among the tested practices in the Portuguese LL, mulching resulted in notable weed suppression (>70%).A six-species cover crop mixture increased weed diversity compared to mowing and herbicide treatments. In the olive grove in Cyprus,the cover crop mixture *Vicia*spp. + *P. sativum*+ *T. durum*produced about three times the biomass of *P. sativum* monoculture. The combination of *Vicia*spp. + *P. sativum*+ *T. durum* with mulching resulted in a very low weed biomass (28.8 g m^{-2}).

The results of the field trials in LLs conducted in Mediterranean countries highlight the role of AWM practices as an alternative to chemical weed control in major perennial crops grown in conventional farming systems.

This research was supported by the European Union's Horizon Research and Innovation Action (RIA) project under the grant agreement no. 101083589 (GOOD project – https://www.goodhorizon.eu/).

S01-O3. Insights into weed proliferation in strip cropping systems

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Strip cropping systems (e.g., in the Netherlands with 3-27 m wide strips) are being explored as an innovative approach to enhancing agricultural sustainability. These systems offer ecological benefits, including increased crop diversity, while maintaining practical feasibility through conventional farming machinery. While results for pest control under reduced use of chemicals have been promising, those for weeds have been variable. A particular agronomic challenge is the weed density along the strip edges. This may, in part, be linked to microhabitat conditions on these edges as well as the limitation in the arduous agronomics management of weed control on these edges. As a result, there is an urgent need to understand the effects of cropping systems with more field edges on weed dynamics. This study investigated the role of strip edges in weed proliferation within an oats-cabbage strip cropping system. The data collection took place in a strip cropping system with 3-meter-wide strips at the Droevendaal experimental farm in Wageningen. Throughout the growing season, weed establishment, management efficiency measured through soil cover, and weed biomass were compared between the strip centres and their edges. Results revealed significant differences in weed species composition between cabbage and oat strips. Notably, weed species at the edges partially overlapped with those found in each crop type, while markedly higher weed biomass was observed along the edges. The main factor affecting weed proliferation at strip edges relies on mechanical constraints associated with weed control practices, reducing efficacy and leading to collateral damage in adjacent crops. Additionally, reduced crop competition at the edges, due to differences in harvesting times between crops, further facilitates weed growth. These findings provide valuable insights for improving strip cropping systems and optimising weed management practices.

This research forms part of the project CropMix, file number NWA.1389.20.160, of the research programme Research along Routes by Consortia (NWA-ORC) in the context of the Dutch Research Agenda, which is (partly) financed by the Dutch Research Council.

S01-O4. Cover crop synergies: palmer amaranth (*Amaranthus palmeri* S. Wats) demographic response

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Palmer amaranth (*Amaranthus palmeri* S. Wats) is a prevalent and fecund across United States field crops. Cover crop usage has been of interest to reduce weed populations and slow the development of further resistance. This study integrates annual and perennial cover crops in conjunction with herbicides to determine population trajectories under integrated management. An initial cotton study from 2020 to 2021 observing the effects of two annual cover crops (cereal rye [CR] and crimson clover [CC]), a perennial living mulch (Durana® white clover, [LM]), and a bare ground (BG) control on Palmer amaranth demographics was implemented in Watkinsville, Georgia, USA. No herbicides were used in the first two years to examine cover crop effect on weed population dynamics separately. To determine the effects of integrated practices, post-emergence herbicides were added in years 2022 and 2023 for impacts of on Palmer amaranth demographics. In the fifth year, corn was grown to determine the effects of crop rotation Palmer amaranth dynamics. Data collected included cover crop biomass, Palmer amaranth seedling emergence, end-of-season plant counts, biomass, as well as, yield, and its components. In the initial study, LM and CR provided coverage that suppressed Palmer amaranth emergence considerably compared to CC and BG in all years. In 2022 and 2023, CR produced 66% and 64% more biomass than LM and BG, respectively. The majority of Palmer amaranth cohorts emerged at 3 WAP for both years. Survival of emerged Palmer amaranth plants in 2022 never exceeded >1.25% for CC, CR, and BG, while plants in LM had 23% survival after emergence. In 2023, the percent survival of Palmer amaranth was 2.4% successful with 0.7% more chance of survival than CC, and 2.1% more than in BG scenarios. Cotton yield was similar across all cover crop treatments from 2020 to 2023. This indicates that cover crops and living mulches provide additional weed suppression of Palmer amaranth without affecting cotton productivity. Cover crop systems and herbicide synergism provide weed suppression while affecting Palmer amaranth population dynamics.

Acknowledgement(s) / funding: Cotton Incorporated (USA).

S01-O5. Weed management with cover crops in Italian organic rice farming

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The use of cover crops may be an alternative to chemical inputs to suppress weeds in organic rice farming. In Italy, some rice farmers started to grow winter cover crops (i.e. *Lolium multiflorum, Vicia sativa, Secale cereale*) in the intercropping period and terminate them right after rice seeding to create a mulching layer. When the field is flooded, the cover crop biomass degrades and some organic acids potentially phytotoxic are released. Field and a mesocosm trials were performed in 2023 and 2024 to test the efficacy of this technique in suppressing weeds using different cover crops, along with the effect on the crop growth; moreover, some of the organic acids released were identified and quantified. Three fields located in the Vercelli province (north-west Italy) were selected and in each field the cover crop was removed in four areas to get mulch-free controls. In the first year, weed density was significantly reduced only in one field (27.7 plants m^{-2} in the field with the mulch, 113.5 plants m^{-2} in the control), however no differences in rice yield were observed (about 5 t ha^{-1}). In field conditions, the most abundant organic acid found was acetic acid and its highest concentration was reached in one field five days after flooding (158.2 mg l^{-1}). The mesocosm trials included two cover crops, *L. multiflorum* and *V. sativa*, and two termination techniques, rolling or shredding. In the first year, thanks to the high amount of biomass produced, all cover crops and termination techniques significantly reduced weed density compared to the mulch-free control (on average 22.0 and 290.7 plants m^{-2} respectively). Rice yield was also significantly lower in the control (4.5 t ha^{-1}) compared to the other treatments (> 10 t ha^{-1}). The high amount of cover crop biomass also led to higher organic acid concentrations; acetic acid peaked in the shredded treatments 5 days after flooding, reaching > 900 mg l^{-1} concentrations. This technique can be helpful to reduce weed density in organic rice farming, but the efficacy may vary depending on the initial seedbank and on the amount of cover crop biomass produced.

S01-O6. Innovative practices in managing weed populations by agroecological service crops in organic horticultural systems

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The introduction of agroecological service crops (ASC) in crop rotations is a widely recognised strategy for improving the environmental performance of vegetable cropping systems. European organic farmers have managed ASC as green manure. In recent years, the use of the roller crimper for ASC management has attracted the interest of European farmers and researchers, because it flattens the ASC creating a dense layer of plant residue on the soil surface without soil disturbance. Despite the important effect of ASC management by roller crimper on the control of weed flora both during the ASC and the cash crop period, negative effects were also observed in crop production.

In order to overcome this yield gap, we evaluated the performance of different types of ASC distributed in three experimental fields during the years 2021, 2022 and 2023 and the effect of their termination on weed control, pumpkin crop production, external renewable and non-renewable inputs, the energy efficiency, as well as the production cost. The analysed ASC terminations were: 1) the incorporation of the ASC into the soil by chopping and ploughing and the establishment of the biofilm and mechanical and manual weeding (control treatment), 2) flattening of the ASC by roller-crimper and manual weeding (roller treatment), and 3) flattening of the ASC, installation of the biofilm on the cover crop and manual weeding (hybrid treatment).

The results provide solid evidence of the effectiveness of roller treatments on weed control (in terms both of abundance and species richness), contributing to reduce the reliance on tillage for weed management. The results show that management of the ASC with the roller leads to the reduction of the use of non-renewable external energy compared to the control mainly due to the reduction of the mechanical control of the weed populations. The surface deposition of ASC is compatible with the maintenance of a pumpkin production equivalent to that obtained with traditional management (control). Overall, the energy efficiency is lower in the control treatment, due to the fact that the higher external inputs are not compensated by the cash crop production, which is similar to that of roller treatments.

The study has been funded by the Department of Agriculture, Livestock, Fisheries and Food of the Generalitat de Catalunya through grants to promote applied research in the field of organic agri-food production.

S14-O1. AGROecological strategies for SUStainable weed management (AGROSUS): insights from stakeholder co-creation

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Keynote session

This study explores the implementation of agroecological strategies (AS) for weed management in key European crops through a multi-actor approach. The research was conducted within the AGROSUS project (AGROecological strategies for SUStainable weed management in key European crops), involving surveys, in-person interviews, and co-creation workshops with farmers, advisors, local sellers, policymakers, and other stakeholders. Stakeholders participated in Crop-Linked Groups (CLGs) across the eleven biogeographic regions from Europe, identifying current weed management challenges and evaluating AS alternatives.

Results indicate that while agroecological weed management can improve crop profitability and environmental sustainability, several economic, social, and regulatory barriers hinder widespread adoption. Farmers cited increased costs, lack of technical knowledge, and uncertainty about AS effectiveness as primary concerns. However, potential benefits, such as reduced dependence on herbicides, improved soil fertility, and higher consumer demand for sustainable products, were recognized as strong incentives.

Conclusions highlight the need for targeted policy support, farmer education, and incentive programs to enhance AS adoption. Collaborative stakeholder engagement proved effective in tailoring solutions to regional agricultural needs, emphasizing the role of participatory decision-making in promoting sustainable weed management practices.

Acknowledgement(s) / funding: AGROecological strategies for SUStainable weed management in key European crops (AGROSUS). EU-Horizon Europe Framework Programme (HORIZON-CL6-2022-FARM2FORK-02-01). Proposal ID: 101084084.

S14-O2. Optimizing vineyard cover crops: balancing weed management, vine performance, and ecosystem services in Switzerland

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Sustainable vineyard weed management requires minimizing adverse effects on vines, yield, berry quality, soil, and biodiversity. However, herbicide use and frequent tillage negatively affect soil health. This study explores how cover crop composition and management strategies influence vineyard performance in a cool-climate in Switzerland. Over three years, we assessed cover crop and weed community dynamics, and their combined effects on vine growth and must composition.

The experiment started in autumn 2021 and consists of four treatments:
A) Treatment 1: spontaneous grass cover in the inter-rows with tilled under-rows.
B) Treatment 2: spontaneous grass cover in one inter-row, a winter cover crop in the other, and tilled under-rows.
C) Treatment 3: a permanent high-biodiversity cover crop (MCS 9) in one inter-row, a winter cover crop in the other, and a low-competitive permanent cover crop (NoGlyphos) under the row.
D) Treatment 4: MCS 9 in both inter-rows and NoGlyphos under the row.

We monitored botanical composition, vine physiology (photosynthesis, water status, vigor), berry quality (organic acids, sugars, nitrogen), microclimate (temperature, relative humidity), and soil parameters (temperature, water potential, structure, and vegetation cover) over three years (2022-2024).

During the exceptionally dry 2022 season, under-row tillage (A and B) alleviated water and nitrogen stress, whereas treatments C and D experienced the most severe stress, as indicated by lower stem water potential and leaf nitrogen content. Yield, berry weight, and assimilable nitrogen were higher in treatments A and B.

In contrast, during the second and third years— which were respectively moderately drier and wetter than the 30-year average— yield and fruit quality showed no major differences among treatments. However, ecosystem services such as soil protection and botanical biodiversity were significantly enhanced in treatments without under-row tillage and with diverse cover crop mixtures in certain years.

Overall, this study suggests that grapevine, as a perennial crop, may adapt to weed and cover crop competition. Initial differences among treatments likely resulted from drought and a root system not yet adapted to the new management system. These findings highlight the importance of a holistic approach in assessing both the services and disservices of weed communities in vineyard ecosystems.

Project funded by the Federal Office for Agriculture (FOAG) of Switzerland.

S14-O3. Linking weed functional space to effective management approaches

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Increased functional diversity in arable plant communities typically reduces their detriment, as different arable plants occupy different niche spaces which dictate competitiveness to the crop. Management can modify the functional space of these communities. This functional diversity can be examined using Grime's CSR triangle; most common arable plants are thought to have high tolerance of disturbance and preference for abundant nutrition. Prior research has, however, only examined this with regard to specific management practices or cropping systems, rather than the ecological conditions they generate, the 'agronomic filters' applied. We therefore aimed to identify differences in preference for these agronomic filters amongst Swedish arable plants.

We analysed a dataset of all arable plant species in Sweden, derived from a larger dataset of all vascular plants from Tyler et al. (2021), using multivariate statistics such as principal components analyses (PCAs) and PERMANOVAs. These analyses identified the functional characteristics of these plant species, specifically their preference for nutrition, disturbance, moisture, and light, as well as their Grime's life strategy, perceived detriment, and conservation status.

Our results demonstrated that high levels of nutrient input and soil disturbance constrain the agroecological niche, limiting the functional space of the non-crop community. This manifests in an absence of stress-tolerators (S), and an overrepresentation of competitive and pure ruderals (CR and R respectively). CR strategist species preferred high levels of nutrition and light, tolerated soil disturbance, and were more often considered problematic. R strategists were more often rare and non-weedy, probably due to their lesser preference for high-nutrient environments, and, as a result, their lesser competitiveness. Applying Grime's classifications to arable weeds is complicated by its rigidity, however; many weeds are highly adaptable, so a single classification may be an oversimplification.

Nevertheless, the agronomic filters favoured by problematic weeds can be modified. More efficient nutrient management would break the 'agronomic trap' that benefits dominant, competitive weeds, while increased grazing or mowing could also be effective in managing tall-growing species. These agronomic filters therefore provide a theoretical guide to achieving ecological weed management, providing knowledge to specifically target problematic weeds while favouring benign species occupying different niche spaces.

S14-O4. An attempt to holistically evaluate services and dis-services of fall vegetation in 30 cropping systems

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With increasing pressures from population growth and climate change, there is growing interest in assessing both the potential benefits and drawbacks of in-field, non-crop vegetation (i.e., weeds). This study evaluated fall non-crop communities in 30 replicated cropping systems over two consecutive years, incorporating three tillage methods (minimum, surface, inversion), two residue management strategies (retained, removed), and five cover crop systems (Lolium perenne and Trifolium repens mixture sown early- and mid-season, Raphanus sativus (radish) sown mid-season and post-harvest, and a no cover crop control). Four metrics were used to capture potential services and harms: (1) percent soil cover (soil protection), (2) total aboveground biomass (potential soil carbon input and nitrate leaching mitigation), percent-cover-weighted species (3) contributions (ecological benefits), and (4) potential agronomic harm. The study coincided with Denmark's driest (2018) and wettest (2019) growing seasons in 30 years. Results showed that soil cover remained stable (~75%) across treatments and years. Cropping system had some influence on total aboveground biomass (increasing biomass with decreasing tillage intensity), but more strongly affected the proportion of biomass attributed to cover crops. Radish cover crops consistently contributed over 50% total biomass, while the mixes' contributions varied (0–80%) within both planting timings. Radish treatments produced neutral vegetation communities, with neither high potential benefits nor harms. In contrast, the mixes and no cover crop treatments displayed both high potential harm and high potential benefit. These results underscore the complexity of defining 'beneficial' vegetation in agricultural systems, highlighting the interplay between multiple ecological and agronomic indices.

Acknowledgement(s) / funding: Novo Nordisk Foundation.

S14-O5. Poor evidence that more diverse cover crop mixture offers better biomass accumulation and weed suppression either in conventional or conservation tillage

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The integration of cover crops into cropping systems has proven to be an effective agroecological strategy for suppressing weeds, enhancing soil health, and reducing reliance on chemical herbicides. However, the seasonal dynamics of weed competition, influenced by cover crop selection and tillage practices for cover crop establishment, remain underexplored.

This study, conducted in Slovenia from 2020 to 2022, aimed to quantify the competitive relationships between different levels of cover crop diversity and weeds throughout the cover crop growing period. The experiment considered variations in soil tillage (conventional and conservation) and cover crop type, including single-species cover crops (oilseed radish and berseem clover), a simple five-species mixture, and a functionally diverse seven-species mixture.

More intensive pre-sowing conventional tillage moderately favored both cover crop and weed growth, resulting in only a minor influence on the competitive relationship between cover crops and weeds. The highest levels of weed suppression across years (82–86%) were achieved by oilseed radish and the simple cover crop mixture, demonstrating the potential of cover crops as a key non-chemical strategy for managing weeds and enhancing crop diversity.Conversely, the functionally diverse seven-species mixture did not enhance weed suppression or outperform other cover crop treatments in biomass production.

These findings emphasize the potential of cruciferous cover crops, such as oilseed radish, for short-term weed management and underscore the importance of species selection in optimizing cover crop benefits. Our results highlight the role of cover crops in the transition to herbicide-free agricultural production. However, further research is needed to develop trait-based cover crop mixtures that improve cover crop-weed competition under specific resource availability, management practices and desired ecosystem services.

This research was funded by the Next generation agriculture research program (P4-0431) which provided the PhD grant for Sergeja Adamič Zamljen.

S14-O6. Comparing different soil management techniques under organic farming on their agronomic and ecological values: a weed perspective?

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The ecology of weeds in agroecosystems managed with less intensive agricultural practices remains complex and poorly understood. Reduced tillage aims to reduce environmental impacts and preserve soil health. However, managing weeds in organic reduced tillage systems presents more challenges compared to conventional farming, as the absence of tillage prevents weed seed burial. Nevertheless, arable plant communities are recognized for their ecological and environmental importance, contributing to biodiversity and providing essential resources for insects, birds, and small mammals. To assess their ecological value, synthetic indices based on species traits, such as the ArEco index (Fanfarillo & Kasperski, 2021), have been developed to quantify weed functions in agroecosystems.

This study evaluates the ecological value of weed communities in spring (maize (Zea mays L.)) and winter (winter wheat (Triticum aestivum L.) - faba bean (Vicia faba L.)) crops under organic management, comparing tilled and reduced tillage systems. Both the realized flora and soil seed bank were evaluated from functional and taxonomic perspectives. The survey was conducted on six plots of 200 x 12 meters at Gembloux (Belgium), each under annual crop rotation. The realized flora was surveyed from 2021 to 2023 during the crop flowering period, while the seed bank was sampled in January 2022 and grown in a greenhouse until March 2023. The ecological value of arable plant communities was assessed using the ArEco index, which considers species richness, preservation, and support for birds and insects. Multivariate analyses revealed distinct weed community structures between tillage and reduced tillage systems, with weaker differences in the seed bank. Reduced tillage systems had more taxonomically diverse realized flora, with significantly higher diversity indices and a higher ArEco index. Reduced tillage increased species richness in the seed bank without affecting total seed density, and significantly improved the mean ArEco index, indicating greater ecological value. In conclusion, reduced tillage in organic systems enhances the ecological value of weed communities by increasing species richness and diversity, promoting biodiversity, and contributing to more sustainable agroecosystems.

PS1-01. Agroecological strategies for sustainable weed management in vineyards: insights from the AGROSUS project

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Weed management is a key challenge in sustainable viticulture, influencing both crop productivity and environmental impact. Within the AGROSUS project, this study aims to evaluate four agroecological strategies—pine husk, biofilm, mulching, and bioherbicide—for sustainable weed control, compared to conventional herbicide application. The experiment was conducted during the vine growth cycle, following from level 0 to level 7 of BBCH scale, to assess the impact of these strategies on weed suppression and vine development. The trial was structured to monitor weed presence by identifying and counting monocotyledonous and dicotyledonous species in both inter-row and in-row areas. In addition, vine growth parameters—including budburst, flowering, cluster formation, and berry development—were recorded. Plant health was evaluated using fluorescence and transpiration analysis to detect potential physiological stress induced by different weed management strategies. Preliminary weed assessments indicated a various spectrum of species between inter-row and in-row areas, with *Crepis setosa, Plantago lanceolata, Trifolium repens* being among the most frequently observed species in inter-row spaces, while *Conyza canadiensis, C. setosa, Sonchus oleraceus and T. repens*, were prevalent in the row. As the experiment progressed, differences in weed control efficacy, vine growth, and physiological responses have been observed, supporting the potential of these agroecological strategies for sustainable vineyard management as treatments do not negatively impact vine growth and may improve plant health. These findings are expected to contribute to the development of more sustainable weed management practices in viticulture, reducing reliance on synthetic herbicides while maintaining vineyard productivity and ecological balance.

The European EU-Horizon project "AGROSUS: AGROecological strategies for SUStainable weed management in key European crop" funded the research under Grant Agreement Number 101084084.

PS1-02. Assessing the effects of cover crops in a semiarid almond orchard

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Background and objectives: Regenerative agriculture is based on practices that promote agricultural management that restores soil, improves water management and promotes biodiversity. In our rainfed agroecosystems where almond trees are grown, there is a growing interest in regenerative practices (RP) to improve productivity and achieve ecological balance. Among the RP, the use of cover crops is gaining importance in our agroecosystems, but it is also scarcely studied. The objective of this work was to evaluate the early influence of cover crops, selected as RP, on weed biomass and leaf area index (LAI) of almond trees as preliminary indicators of biodiversity and productivity. The RPs were co-designed by the farmer land manager and the research group INIA-CSIC and UPM with the support of the Aland Foundation and AlVelAl Territory.

Methods: In central Spain, an almond orchard was monitored during two seasons, with six RPs implemented: 1) minimum tillage (MT); 2) organic amendments (MT&OA); 3) legume crop (MT& Leg); 4) mixed rye and legume crops (MT& Mix); 5) Brachypodium as a green manure (MT& Bra) and 6) rye crop (MT& Rye). Weed biomass and LAI sampling followed a simple randomised design. For each RP, 4- weed biomass samples were taken randomly, the plants were dried at 80°C for 48 h and the total weed biomass per unit area was determined. LAI values were achieved from 12 leaves/tree randomly taken from 3 almond trees/RP.

Results: Weed biomass was significantly affected by the regenerative techniques during the period of study (PR factor, F: 14.88; p-value: 0.0001). Weed biomass increased with ML&OA plots compared to ML&Rye, ML&Leg and ML&Mix plots.

LAI values varied also significantly with the RP (F: 53.63; p-value: 0.0001). The highest values, during the first year, with ML&Leg, ML&OA, ML&Mix and ML&Rye; and the second year, LAI values were significantly reduced with legume-cover crops (F: 17.46; p-value: 0.0001).

Conclusions: Our results confirmed the early efficacy of rye and legume-cover crop to control weeds. However, LAI values of almond trees decreased with legume use in the second year of the study. Therefore, more information is needed to implement RP with leguminous species.

This study was funded by Aland Foundation and supported by FARMS4CLIMATE project (PRIMA H2020). We are grateful to Luis Ballesteros (©Biovállega), the farmer owner of the field, for helping to manage the experiment.

PS1-03. One crop health for next-generation crop protection

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The simplification of agricultural landscapes and intensification of crop production has led to a range of detrimental outcomes including depletion of farmland biodiversity, soil degradation, and the evolution of pesticide resistance. Because of this, modern agriculture faces an unprecedented challenge from pests, weeds, and diseases, which threaten the sustainability of these high-input systems. There is now a broad consensus that new ways of farming need to be found that moderate our reliance on synthetic pesticides, and that better reconcile food production with biodiversity.

The "One Crop Health for Next-Generation Crop Protection" programme is a six-year project that has recently been launched, funded by the Novo Nordisk Foundation. This initiative, running from 2024 to 2030, is an international collaboration between Danish (University of Copenhagen, Aarhus University), and UK institutes (Rothamsted Research, University of Sheffield). Our goal is to address the challenge of escalating pest, weed, and disease pressure in current agricultural systems, and provide an evidence-base for redesigning arable crop protection in Denmark and the UK. Paralleling the “One Health” concept in medicine, our aim is to draw upon agroecological principles, empirical science, data-driven monitoring and modelling, and advanced technologies such as machine learning and digital twins, to develop systems which better integrate plant, soil, and agroecosystem health.

Central to this work are networks of commercial arable farms (50 farms, 100 fields) and large-scale farming systems experiments, established this year in both Denmark and the UK. These will serve as platforms for integrated research exploring the relationships between agronomy, biodiversity, and productivity. Emerging technologies with application in surveillance and monitoring of pest, weed, disease and broader agroecosystem biodiversity will be explored, alongside data science and machine learning tools which offer the potential for more precise, site-specific crop protection strategies. Finally, a cohort of 12 PhD students is being established, to provide focused experimentation and hypothesis-driven research in specific aspects of these agroecosystems. Although only in our first year of monitoring, this poster characterizes the overall aims and ethos of our “One Crop Health” approach, as well as detailing the nature of our coordinated monitoring campaigns in both countries.

Acknowledgement(s) / funding: Novo Nordisk Foundation - Future Agri-Food Systems Challenge Programme.

PS1-04. Identifying agroecological weed management strategies in the french dephy farm network

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Background, objectives. A number of levers have already been identified to simultaneously reduce herbicide use, and weed infestation and maintain crop production. These include crop diversification, permanent crop cover, tillage, mechanical weeding, etc. But how these levers should be implemented and combined depending on the local pedoclimatic and floristic context remains unknown. The objective of this study is to evaluate existing cropping systems in 12 French regions with a simulation model in terms of crop production, herbicide use, weed damage to crop production and contribution to biodiversity. Simulations produce numerous crop and weed variables which are impossible to monitor in actual fields.

Methods. FLORSYS (Colbach *et al.*, 2021) is a "virtual-field" model which simulates daily biophysical processes driving seed bank dynamics as well as individual plant growth and development of crops and weeds in 3D over years or decades. Thirty-two crop species and 32 weeds are parameterized. Inputs include daily weather, soil characteristics and an initial weed seedbank. About 2500 cropping systems were extracted from the Agrosyst database which is fed by farmers and their advisors in the DEPHY network (Demonstration, Experimentation and Production of references on low phytosanitary systems). For each cropping system, the crop succession and the detailed list of operations (e.g., tillage tool, date, depth, speed) are entered into FLORSYS. The systems are simulated over 30 years, repeating the basic rotational pattern over time, and repeated with 10 weather series from their region. The simulations will produce indicators evaluating crop production (e.g., yield), weed disservices (e.g., yield loss, field infestation), weed services (e.g., species richness, trophic resources for pollinators) and herbicide use. These outputs will be analysed with data mining (Classification and Regression Trees, Random Forests).

Expected results. The simulations will identify the key levers influencing the performance indicators, and rules on how to combine these levers in order to reconcile crop production and biodiversity with reduced (or zero) herbicide use and reduced weed harmfulness. Additional rules for reducing tillage intensity will be identified.

Conclusions. This method combining a farm network with simulations allows tracking farmers' innovations to provide guidelines for designing agroecological cropping systems.

Acknowledgement(s) / funding: INRAE.

PS1-05. Assessing the predictive capability of Italian non-parametric models for summer weed emergence in the Iberian Peninsula

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Understanding the emergence patterns of weed species is crucial for optimizing control methods, as the seedling stage is the most vulnerable period for most weeds. Common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), velvetleaf (*Abutilon theophrasti* Medik.), johnson grass (*Sorghum halepense* L.), barnyard grass [*Echinochloa crus-galli* (L.) Beauv.] and large crabgrass [*Digitaria sanguinalis* (L.) Scop.] are main problematic weeds in summer crops such as maize. The objective was to test the extrapolation capability of the Italian non-parametric weed emergence models (Masin *et al.*,2010, 2012, 2014) for these species to the Iberian Peninsula. These models were tested at seven experimental sites:Barcelona, Lleida, Madrid, Navarra, Sevilla and Valencia in Spain, and Oeiras in Portugal. Seeds from local populations were collected at each site during the summer. The sowing was carried out in October 2023 before the first rainfall, distributing 300 seeds in the upper 2 cm of the soil, in four replicates. To simulate the seedbed preparation for maize, a soil disturbance was performed in each location between mid-February and mid-April. The weed emergence was monitored monthly before soil disturbance and, after, every week until no emergences were observed for one month.

The emerged seedling varied across species. *Echinochloa crus-galli* showed the highest average emergence of 15.1%, with a range from 1.2 to 29.3%. This corresponding value was 13.2% for *D. sanguinalis*, with a range from 0 to 58.8%, indicating the widest population variability. On the other hand, *A. theophrasti*, *A. retroflexus*, *C. album* and *S. halepense* had similar average emergence percentages (12.3–14.4%), though *A. retroflexus* and *C. album* showed zero emergence at 4 locations.

The models' accuracy was poor for all species, with an average RMSE of 45. The model for *E. crus-galli* obtained the best results (RMSE = 37.1) and was the only species with RMSE values below 15, specifically in Lleida (10.9) and Sevilla (13.3). The lack of accuracy observed might be attributed to the population variability between Italian and Spanish populations, and it highlights the necessity of a recalibration of the model parameters before employing them in the Iberian Peninsula.

Acknowledgement(s) / funding: Spanish Society of Weed Science (SEMh).

PS1-06. Function of winter service crops in vineyards: weed management and soil microorganism composition

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This study aimed to evaluate the impact of various cover crops on weed management and soil microbial diversity in vineyards. Cover crops could play an important role as service crops by controlling weeds and increasing microbial biodiversity and rhizosphere populations of beneficial bacteria and fungi. Field experiments were conducted in Askri (38.314194; 23.111889) of Boeotia during the 2024 growing season. The following service crops' systems were studied such as: T1: *Lathyrus sativus,* T2: *Pisum sativum,* T3: *Hordeum vulgare,* T4: *Trifolium subterranum,* and T5: *H. vulgare* + *Vicia sativa*. Two soil samplings were carried out; the 1st prior to cover crop termination, and the 2nd one a month after plant incorporation into soil (i.e. 96 mixed samples) were obtained. The weed survey identified the five (5) most dominant weed species such as *Stellaria media, Fumaria officinalis, Urtica* spp., *Calendula officinalis,* and *Veronica persica.* Above ground biomass was calculated for both service crops and weeds. Weed suppression, expressed as a ratio of the weed/service crop above ground biomass, was in the following ascending order: T3 (0.10) < T5 (0.15) < T2 (0.28) < T1 (0.47) < T4 (0.82). Active soil carbon, as an index of soil health was measured with the standardized permanganate test. The study of bacterial and fungal biodiversity was performed using the Illumina and Oxford Nanopore Technologies platforms, respectively. Bioinformatics analysis for the V3-V4 16S rRNA gene locus revealed the structure of soil bacterial communities. Different ecological metric indices were calculated such as: alpha diversity, differential abundance, and Simpson diversity. This study highlights the complex interaction between cover crop practices and weed management as related to soil microbial ecosystems, which may influence the productivity of vineyards in the Mediterranean.

PS1-07. Management and Ecosystem Function: The Role of Weeds as Mediators

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Changes in agricultural management impact agroecosystem function. Ecosystem Service Providers (ESPs) can be directly affected by management changes—for instance, tillage practices that disrupt ground beetle populations. This study hypothesizes that management changes exert both direct effects on ESPs and indirect effects mediated through alterations to weed communities. We aim to disentangle these pathways to clarify the role of weeds in shaping agroecosystem dynamics.

The study employs structural equation modelling (SEM) to link changes in management practices to impacts on ESPs. Weed and ESP communities are characterized using a functional traits approach, focusing on key traits that influence ecological interactions. The SEM partitions effects into direct impacts of management and indirect impacts mediated by changes in weed communities and their traits.

We used data from 2 studies to investigate different management options: 1) The ASSIST trial included several sites with 3 fields at each site were assigned to each of three treatments with varying levels of agri-environment measures, including in-field flowering strips, margins and the use of green manure; and 2) The Farm-scale evaluations trial includes data collected from 4 different crops at multiple sites across the UK.

Preliminary results indicate that weed functional traits significantly mediate the relationship between management practices and ecosystem service providers. Weed response traits varied according to the management practices implemented and the effect traits varied according to ESP type. The relative importance of direct and indirect effects on the ESP community varied according to the study system.

Weeds are critical mediators in the link between management practices and ecosystem services. This study highlights the importance of examining the comprehensive biological community, rather than isolating individual taxa, when evaluating the impacts of agricultural management. By understanding the interconnected roles within these communities, more holistic and sustainable agroecosystem outcomes may be achievable.

PS1-08. Innovative seed coating with arbuscular mycorrhizal fungi: a cost-effective agroecological approach to enhance cover crop performance

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In recent years, microbial seed inoculation has received increasing interest as an effective method for enhancing plant-microbe interactions. By applying beneficial microorganisms, such as Arbuscular Mycorrhizal Fungi (AMF), directly on the seeds early colonization of seedling roots may be facilitated. This study aimed to compare seed inoculation and soil inoculation with AMF and assess whether microbial seed coating effectively promotes early AMF colonization and crop growth.

AMF inoculum was applied onto the seeds of 5 crop species sown in pots filled with sterilized soil. Along with the seed coating inoculation treatment, a negative control (non-inoculated) and a positive control (conventional soil inoculation) were also established. Plants were grown for 5 weeks and at the end of the experiment plant growth and AMF root colonization were measured.

Different species were affected differently by the inoculation method. For *Avena sativa*_PT, the root length in the positive control (19.67 ± 7.66 cm) showed similar values to those observed in the seed coating inoculation (15.88 ± 5.44 cm), but higher than those of the negative controls (11.15 ± 7.84 cm). For the shoot length the same trend was observed. The fresh weight of the seedlings of *Secale cereale*_PT showed statistically higher values in plants inoculated via seed coating (0.346 ± 0.103 g) compared with the negative control (0.232 ± 0.108 g). In terms of root AMF colonization, significant differences were observed between inoculated plants and the negative control in *Vicia* spp._GR and *S. cereale*_PT. However, no significant differences were detected between the two inoculation methods. Therefore, these results show that, by using 4 (*Vicia* spp._GR) and 12 (*S. cereale*_PT) times less amount of inoculum than the conventional soil inoculation system, this new seed coating method could be a simple and cost-effective way to improve plant growth and performance.

This work was part of the GOOD-Agroecology for Weeds European Project and the Authors want to thank the Soil Microbiology Lab of University of Pisa for providing the AMF inoculum.

PS1-09. Legume cover crop species and planting method effect on weeds at a maize monoculture field

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Reduction of nitrogen fertilizer in maize (*Zea mays*) monoculture can be attained by growing legume cover crops during the winter period. These cover crops can affect the weed flora. The objective of this study was the evaluation of the effect of the species and sowing method of cover crops on the weeds of a maize crop.

Maize was grown in the Ebro River valley during four years with conventional practices (tillage and herbicides) and it was sprinkler irrigated. Three cover crop species[winter peas (*Pisum sativum*), common vetch (*Vicia sativa*) and hairy vetch (*Vicia villosa*))] and a control (without cover crop) were tested using two cover crops sowing methods (conventional and no tillage). Weed density was measured before maize harvest each year and all data were analyzed with ANOVA.

Main weeds were *Cynodon dactylon*, *Cyperus rotundus*, *Diplotaxis eucoides*, *Poa annua*, *Sonchus oleraceus* and *Stellaria media*. The highest weed densities were found for *P. annua*, that was higher in the control. Besides, *P. annua*density was higher with conventional sowing of cover crops in one year, but lower with this sowing system in another year. *S. media* was the second most abundant weed, with very variable density and with higher density in two years when the cover crops were conventionally sown. *C. dactylon* density was affected by the interaction of cover crop species and sowing method, with the conventionally sown hairy vetch resulting in higher densities than most of the other treatments. *C. rotundus* density almost doubled every year as the experiment progressed, and the common vetch cover crop resulted in higher *C. rotundus* densities than the control and winter peas cover crop. *D. erucoides* density decreased as the experiment progressed, and in half of the years the density was higher when the cover crops were sown with conventional tillage. *S. oleraceus* density decreased as the experiment progressed and was higher when the cover crop was common vetch conventionally sown or winter peas sown with no tillage. The study showed the relevance of experiment duration, cover crops species and sown method to the dynamics of the different weed species.

Acknowledgement(s) / funding: Spanish Ministry of Science, Innovation and University (AGL2017-84529-C3-2-R project).

PS1-10. Agro-ecological soil optimization for integrated weed management - an introduction to the European AGROSOIL project

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In European cropping systems, most weed management practices rely on herbicide use and/or intensive tillage. However, these practices have great environmental impacts and may negatively affect soil quality and the activity and diversity of the soil microbiome (SM).

The objective of the Agroecology Partnership funded European project 'AGROSOIL' (Agro-Ecological Soil Optimization for Integrated Weed Management)is to explore the beneficial role that soil and plant microbiomes can play in weed control strategies, integrating functional and ecological principles into practical agroecological weed management (AEWM). AGROSOIL aims to foster a significant shift towards AEWM across Europe by 1) optimising the diversity and functionality of the SM through AEWM, 2) identifying soil microorganisms and microbial functions that support AEWM, and 3) developing holistic AEWM approaches that significantly reduce herbicide inputs and tillage-intensity and support ecosystem service delivery and beneficial biological interactions within agro-ecological cropping systems.

The project intends to build and strengthen regional networks of stakeholders in a LivingLab (LL) setting to promote the adoption of AEWM in the participating countries. In the LLs, agro-ecological research is combined with real-world experimental settings where farmers, researchers, and other stakeholders collaboratively create, implement, evaluate and refine sustainable soil and AEWM practices.

From 2025-2028, the project AGROSOIL will involve eight partners from five countries representing diverse European climatic and arable production conditions. AGROSOIL will disseminate its findings widely, empowering stakeholders with the knowledge and tools necessary for transitioning to more agro-ecological cropping practices.

The project "AGROSOIL-Agro-Ecological Soil Optimization for Integrated Weed Management" is funded by the Agroecology Partnership.

PS1-11. Alternative methods for weed control in apple orchards

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Weed management in apple orchards is crucial to maintain fruit yield and quality. Glyphosate applied twice is the usual strategy in apple orchards in Norway. Due to an recurring debate about the future of glyphosate use and Farm to Fork strategy aiming to 50% reduction in pesticide use by 2030, alternative solutions are needed.

Two field trials conducted in 2023 in orchards (A: two- and B: eleven-year-old trees) are presented here. Six alternative strategies were tested: 1) hot water at 3 L m-2 x 3 (spring, early summer, summer), 2) hot water at 6 L m-2 x 3 (times as previous), 3) pelargonic acid at 10.9 kg a.s. ha-1 x 2 (early summer, summer), 4) pelargonic acid at 5.44 kg a.s. ha-1 x 2 (spring, summer), 5) acetic acid 10% at 25 kg a.s. ha-1 x 2 (early summer, summer) and 6) rotary hoe x 3 (spring, early summer, summer). Glyphosate at 1.08 kg a.s. ha-1 x 2 (early summer, summer) for a reference. Hot water (80 C, 0.1 bar) was applied with a commercial machine (Heatweed Technologies, Norway). For mechanical treatment “Orizzonti Mira” rotary hoe was used. Dry biomass and visual assessments of a percentage of ground covered by living vegetation (TWC) were used to estimate weed control efficacy. Dominating species were Epilobium sp., Taraxacum officinale, Rumex longifolius in both fields, Aegopodium podagraria and Senecio vulgaris in A field and Geranium sp. in B field.

Visual assessed in mid-July, 3 weeks after the last application, resulted in the highest level of weed control of 3 hot water strategies with 6 L m-2 (6 to 9% TWC) 3 L m-2 resulted in 16% and 20% TWC in field B and A, which was better than the glyphosate strategy (23% and 55% TWC in field B and A and much better than other treatments: 3, 4, 5 and 6. These results showed very good efficacy of hot water, especially against annual weeds. The increase of hot water volume from 3 to 6 L ha L ha-1 gave no significant benefit.. Dry biomass was in the same order as visual assessments.

This work was part of project SOLUTIONS financed by FFL-JA (RCN, grant No. 319588.), Grofondet (grant No. 190029), A-K maskiner, Heatweed Technologies, Kilter, Norwegian Agricultural Extension Service and producers. M. Meland (NIBIO), E.

PS1-12. Solutions for weed control in strawberries (*Fragaria* x *ananassa*) with a matted-row cultivation system

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Strawberry cultivated in open fields is an important crop in Norway. Strawberry fields are usually kept for 3 years mainly in a mated-row system with control of weeds and runners to obtain a high yield. Due to diquat withdrawal, producers urgently need new solutions for controlling of runners and weeds in their fields.

Two trials were conducted in one- and two-year-old strawberry fields. Seven alternative strategies in 4 treatment times, 2 pre-harvest (A: late spring, B: early summer) and 2 post-harvest (C: late summer, D: autumn) were tested: 1) hot water at 3 L m-2 preceded by mowing x 4 (A, B, C and D), 2) hot water at 6 L m-2 x 4 (as previous), 3) pelargonic acid at 5.44 kg a.s. ha-1 x 2 (A and B) and pyraflufen-ethyl at 0.01 kg a.s. ha-1 x 2 (C and D), 4) pelargonic acid at 5.44 kg a.s. ha-1 x 2 (as previous) and carfentrazone-ethyl at 0.02 kg a.s. ha-1 x 1 (C) and pyraflufen-ethyl at 0.05 kg a.s. ha-1 x 1 (D), 5) mixture of pelargonic acid at 10.9 kg a.s. ha-1 and alcohol ethoxylate propoxylate at 0.01 kg a.s. ha-1 x 1 (A) and mixture of acetic acid 10% at 25 kg a.s. ha-1 and paraffin oil at1 kg a.s. ha-1 x 3 (B, C and D), 6) acetic acid 10% at 25 kg a.s. ha-1 x 4 (A, B, C and D), 7) mixture of acetic acid 10% at 25 kg a.s. ha-1 and paraffin oil at 1 kg a.s. ha-1 x 4 (as previous). Hot water (80 C, 0.1 bar) was applied with a commercial machine and a lawnmower was used for mechanical mowing. Visual assessments of the percentage of ground covered by living vegetation and runners' number between strawberry rows were used to estimate efficacy. Percent damage of the culture was recorded after all spraying times.

The results showed a promising effect of hot water alone or combined with mechanical mowing against weeds and runners, with lawnmower mowing enhancing the effect. Bioherbicides were weak. The repeated hot water treatments seem to be a good solution.

This work was part of project SOLUTIONS financed by FFL-JA (RCN, grant No. 319588.), Grofondet (grant No. 190029), A-K maskiner, Heatweed Technologies, Kilter, Norwegian Agricultural Extension Service and producers. M. Meland (NIBIO), E. Bjotveit, G. Myre.

PS1-13. Environmental friendly control of *Ambrosia artemisiifolia* L. with phenolic acids and reduced doses of herbicides

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Common ragweed is an invasive and one of the most harmful species in Europe. The allergenic pollen it produces is a public health concern, and its large presence in spring crops makes it an economically important species that is usually controlled with herbicides. Recently, however, resistant populations of common ragweed have been detected in soybean and maize crops in the Republic of Croatia, making them difficult to control and consequently preventing the cultivation of these important agricultural crops. Alternative solutions for weed control that are less dependent on herbicide use are imperative. The selection of common ragweed as a model species to explore this approach is justified from both agricultural and medical perspectives. The main objective of the project is to investigate the possibility of foliar application of phenolic acids and their combination with significantly reduced herbicide doses for common ragweed suppression. Previous *in vitro* research has selected three phenolic acids (*p*-coumaric acid, ferulic acid, and vanillic acid) that are naturally present in the tissues of crop species for green manuring and can inhibit common ragweed germination and seedling growth. The dynamics of common ragweed germination at different concentrations of phenolic acids and the amount of carotenoids, phenols, antioxidant activity, and chlorophyll fluorescence in common ragweed plants foliar treated with phenolic acids will be determined. To determine the selective effect of phenolic acids on non-target organisms, indicators of soil biological fertility, minimum inhibitory, minimum bactericidal/fungicidal, and minimum insecticidal concentrations of phenolic acids for selected representatives of soil microbiota and fauna will be determined by *in vitro* and *in situ* studies. The selective dose of phenolic acids to nontarget organisms will then be combined with reduced doses of the six maize and soybean herbicides studied to determine the effective dose of each herbicide on common ragweed and compare it to independent (without phenolic acid addition) application of the same herbicides. Finally, the selectivity of maize and soybean crops will be determined after combining a reduced herbicide dose + phenolic acid, which is effective for common ragweed and selective for beneficial organisms in the soil.

This work was supported by the Croatian Science Foundation under the project number HRZZ-IP-2022-10-6639.

PS1-14. Agroecologicaly based weed management in maize and soybean living labs in Serbia in terms of the GOOD project

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The reduction of herbicide use and risk has become major policy targets of EU, aiming to promote agroecology and the transition to sustainable and resilient farming systems. Within the "Agroecology for weeds-GOOD" Project, two Living Labs focusing on maize and soybeans were established in Serbia, applying the multidisciplinary approach to create and evaluate Agroecological Weed Management (AWM) systems, and demonstrate that AWM adoption enhances sustainability and resilience of cropping systems.

Both Living Labs are grown under either organic or conventional system. In the first experimental year, three cover crops (CC): oat, rye, and winter vetch were sown in autumn, and incorporated into the soil after the termination in spring. The control was without CC. They were followed by maize or soybean as the main crops. In each main crop, various weed management practices were evaluated: mechanical weeding, mulching, false seedbed, bio-based herbicide, and untreated control for the organic system; as well as in the conventional system: herbicide application in either recommended or reduced rate (0.5x rate), mechanical control, bio-based herbicide, and the control plot (untreated). The efficacy of combined application of CC and weed control measures was assessed on a weekly basis, up to four weeks.

According to the results, the best performing CC, rye was selected for the 2nd and 3rd year. In the organic system, the best weed control method was mechanical control, while in the conventional, both herbicide treatments provided high efficacy (90-95% of weeds biomass reduction). Owing to the influence of drought and weed presence in other treatments, yields were low, especially in soybeans, where 100% yield loss occurred in the organic system.

These results indicate that agroecological weed management is challenging, and therefore it is suggested that subsidies could be used in order to support farmers to adopt agroecological strategy for weed control.

Funded by the European Union under Grant Agreement No. 101083589 (GOOD project).

PS1-15. The perennial nightmare: challenges in managing white-top hoary cress (*Lepidium draba* L.)

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Background and Objectives: Perennial rhizomatous weeds pose significant challenges in agricultural and natural ecosystems, contributing globally to substantial yield losses. Among these, *Lepidium draba* L., a species native to Eurasia, has become an aggressive invasive weed across both its native and introduced ranges. Sustainable management practices are crucial to mitigate the economic and ecological impacts of this species, ensuring agricultural productivity while preserving biodiversity and ecosystem health. Our aim was to: 1) collect existing evidence and identify knowledge gaps regarding effective strategies to control *L. draba, and* 2) experimentally evaluate the potential of lavandin (*Lavandula x intermedia*) straw, a by-product of industrial distillation, as a natural herbicide against *L. draba* and other weeds in organic chickpea fields. Although this practice has shown efficacy against annual weeds, its effectiveness on perennial species remains unexplored.

Methods: A systematic review of literature indexed in the Web of Science was conducted. The search string comprised the species name and its synonyms. Results were filtered by language and research area, focusing on: (1) the biology of the species to inform species-specific management practices, (2) its ecological interactions to explore biological control options, and (3) the efficacy of various weed management approaches. We used a SWOT matrix to identify key drivers associated with *L. draba* management. In the experimental phase, weeds in ten 50x50 cm plots were manually cut, dried, and weighed. Lavandin straw was applied immediately after chickpea sowing. The emergence and biomass of both weeds and chickpeas will be recorded at the flowering stage. Preliminary results will demonstrate the potential benefits of using lavandin straw as a natural herbicide, contributing to sustainable agriculture and the circular economy.

Results & Discussion: Most studies on *L. draba* focussed on control strategies (53.5%) and ecological interactions (30.3%). Findings highlight the limitations of synthetic herbicides for long-term control. Integrated Weed Management approaches, such as combining livestock grazing on resprouts with plant-derived mulches, show promise. Further exploration of innovative strategies, such as the targeted application of plant hormones or lavandin straw at specific plant developmental stages, deserve exploration. Efficacy and cost-benefit analyses are essential for assessing the feasibility of these methods.

Conclusion: Validating management strategies in diverse contexts will provide stakeholders with robust frameworks for implementing sustainable *L. draba* control solutions.

PS1-16. Use of agroecological approaches to reduce weed growth in winter wheat

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Agricultural weed management continues to depend heavily on synthetic herbicides, despite rising concerns about their environmental and health effects, as well as the growing issue of herbicide-resistant weeds. Agroecology seeks to revolutionize farming by integrating sustainable approaches that harness natural processes to create alternative solutions. Through agroecological practices, farmers can minimize or eliminate the use of chemical herbicides while maintaining or even enhancing crop yields. The research examined weed dynamics in monocultures of bread wheat, faba bean, and field pea, as well as in mixed cropping systems combining bread wheat with either field pea or faba bean. In addition, it utilized advanced weed monitoring technologies, such as Unmanned Aerial Vehicles (UAVs), alongside field-based assessments including hyperspectral images, biomass, and yield measurements to determine the weed growth in winter crops and explore ecological weed suppression strategies using intercropping systems. The experiments were conducted during the 2023–2024 growing season at the Aristotle University of Thessaloniki's experimental farm in northern Greece (40°32'07.7"N 22°59'20.5"E), the study followed a Randomized Complete Block Design (RCBD) with three replications to evaluate weed growth across different cropping systems. No chemical pesticides or fertilizers were used throughout the season. At harvest, weed biomass was recorded for each plot, revealing that the wheat-field pea intercrop was more effective at suppressing weeds than both the wheat-faba bean intercrop and the bread wheat monoculture. Additionally, the field pea monoculture demonstrated the highest Leaf Area Index and dry yield, followed closely by the wheat-field pea intercrop. These findings suggest that strategic crop selection, intercropping, and optimized planting densities can significantly reduce weed pressure, lessen reliance on herbicides, and promote more sustainable agricultural practices.

This research was supported by the European Research Council under the European Union's Horizon Europe research and innovation program in the framework of the project 'Conserwa', grant number 101081802. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the REA can be held responsible for them.

PS1-17. Exploring the effect of extracted and powdered pistachio hulls as bioherbicide under in vivo conditions

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Weed management poses a significant challenge in agriculture, primarily due to issues like herbicide resistance and environmental concerns. As a result, there is a growing need for natural and sustainable alternatives, such as bioherbicides, which are known for their rapid degradation and minimal or no toxicity to the environment and human health. These bioherbicides typically work by releasing allelopathic compounds into the environment, which can inhibit seed germination or plant growth. Some studies suggest that the phenolic compounds present in the pericarp of the pistachio fruit (*Pistacia vera* L.) may have an inhibitory effect on plant growth, indicating the potential for using these pistachio by-products as a natural weed management solution. Thus, the main objective of this research was to evaluate the bioherbicidal effect of the dried and ground pericarp and the aqueous extract in *in vivo* bioassays with two main crops (*Lens culinaris* and *Zea mays*) and three weeds (*Lactuca serriola*, *Lolium rigidum* and *Solanum nigrum*). To do so, two seeds of the crop (*L. culinaris* or *Z. mays*) and 15 seeds of each of the three weeds were placed per pot, and the bioherbicide (10% extract or dry powder using in both the same quantity of pistachio hulls) was applied at pre-emergency. Six replications per treatment were conducted. The results showed a general reduction in the number of germinated plants, fresh weight and dry weight of broadleaf weeds, with the exception of *Lactuca serriola* in the maize bioassay. Furthermore, the application of the powder resulted in a notable reduction in fresh and dry weight of *Lolium rigidum*. Neither of the two crops was impacted by the application of any of the bioherbicides. Overall, the results demonstrated that both the extract and the ground skins hold potential as effective tools for integrated weed management.

Grant (2-2022) “DESAFIO Universidad-Empresa” Program, Junta de Castilla y León, co-funded by the European Regional Development Fund (ERDF) and the Junta de Castilla y León.

PS1-18. Is crop diversification correlated or causal in weed control? A systematic review

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Background and objective: Cereal crops in the semi-arid Mediterranean agroecosystems of central Spain face the challenge of balancing productivity with environmental sustainability. These regions, where cereal profitability is limited and require low inputs, the challenge is to find strategies that improve production under variable climatic conditions, maintain soil fertility, and conserve biodiversity. In this context, crop diversification has been proposed as a strategy for weed control, although its effectiveness in semi-arid conditions is still under debate. The objective is to explore the state of the art regarding the correlation or causality of increased diversification strategies in crop rotation on variations in weed populations under Mediterranean semi-arid conditions.

Methods: The hypotheses to study are: (1) correlation: The increase in crop diversification in a rotation is related to presence or absence of weeds; and (2) causality: The increase in crop diversification causes a change in weed populations (measured by their density). For this review, the time period, geographical region, crops in rotation, and experimental studies are prioritised. Web of Science and PubMed are used to perform a selection and critical evaluation of the studies. Keywords related are: "crop diversification", "weed control", "intercropping", "crop rotation", "mixed crops" and "crop competition against weeds".

Results: Reviewed studies have been classified into three categories: (1) **Correlation vs causality:**Synthesis of studies showing correlation between crop diversification and weed control, and those demonstrating causality through experimental design. (2) **Moderating factors:** Analysis of variables influencing the relationship, such as crop type, climate, agronomic management, and species diversity. (3) **Gaps in the literature:** Detection of areas with a lack of evidence on the sustainability of diversification for weed control.

Conclusions: This study has examined if crop diversification correlates with or has a causal effect on weed control, emphasizing the need for further studies in semi-arid Mediterranean conditions in the context of climate change.

This study is supported by the Spanish Ministry of Science, Innovation and Universities, grant number PID2023-150863OR-I00.

PS1-19. The effect of increased intraspecific diversity in chickpea (*Cicer arietinum* L.) on the abundance and diversity of weed communities in Mediterranean drylands.

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Chickpea is a strategic crop in Mediterranean rainfed arable systems, but its cultivation is hindered by low yields and limited alternatives for managing weeds. Crop diversification, through cultivar mixtures, can be an option for weed management in these systems. Simultaneously, maintaining weed diversity has been suggested to reduce weed negative effects on crops. In this context, our objective was to identify whether chickpea cultivar mixtures are an effective strategy for weed management, while maintaining the diversity of their communities. Further, we assessed whether the diversity of weed communities were related to crop performance.

To address this, we established an experiment at El Encín experimental station (Madrid, Spain), in which mixtures of two, four and eight cultivars were compared with monocultures. In each plot, we assessed the abundance, the diversity (effective number of species), and the functional structure of weed communities (functional diversity -FDis- and the community weighted mean –CWM- of seven functional traits). We registered crop yield. The effect of cultivar mixtures on weed communities and the relationship between weed communities and crop yield were analysed by generalized linear mixed models.

A total of 38 weeds species were registered. No significant differences were found in the abundance and the weed species diversity between the different cultivar mixtures. The eight-cultivar plots showed higher FDis of functional types. The abundance (CWM) of therophytes, compared to hemicryptophytes and geophytes, was higher in the four and eight than in the two mixture plots or in monocultures. Regarding the effect of weed abundances on crop yield, we found no significant relationship. A greater diversity in the height of the weed community (FDis of height) was associated with higher chickpea yield.

In the context of weed management, although no significant effect on weed abundance was detected, it is important to note that cultivar mixtures enhance functional diversity. Additionally, the proportion of hemicryptophytes and geophytes, species that are more challenging to manage, decreases in more diverse mixtures. Furthermore, our findings suggest that functional diversity, particularly in terms of plant height, plays a crucial role in mitigating negative impacts on crop yield.

This research was funded by the FP24CEREDIV project, financed by IMIDRA.

PS1-20. Agroecological strategies for weed control in tomato in the Mediterranean biogeographical area

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This study is part of the European project "Agroecological Strategies for Sustainable Weed Management in Key European Crops" (AGROSUS). The project aims to identify the most adequate agroecological strategies for weed management in the main extensive, perennial and horticultural crops of the European Union (EU), and covers the eleven biogeographical regions of the EU and associated countries (Continental, Mediterranean, Atlantic, Macaronesian, Pannonian, Anatolian, Black Sea, Boreal, Alpine, Steppic, and Arctic). The assay was carried out in a tomato crop in the Mediterranean biogeographical area (Meliana, Valencia province, Spain). Three different agroecological strategies for weed control were tested: 1) Crop rotation + biofilm + mechanical control; 2) Crop rotation + rice straw mulch + mechanical control; 3) Crop rotation + maize straw mulch + mechanical control. These strategies were compared with two conventional cropping systems: 1) crop rotation + black plastic mulch 2) crop rotation + herbicides. The experiment was carried out using a randomized block design, with five replicates per treatment, five treatments in total (the three agroecological strategies and the two conventional cropping systems). Each replicate contained seven plants in six rows (42 plants in total). The inter-row spacing was 0.6 m and the distance between plants was 0.4 m. Crop monitoring was performed from establishment to harvest, assessing weed flora (species identification, coverage, and phenological stage), as well as crop productivity parameters (SPAD, flowering and fruiting onset, fruit number) and fruit quality parameters (weight, size, firmness, etc.) to determine the effects of the agroecological strategies on both weed flora and crop performance. The different agroecological strategies assayed did not affect significantly the crop productivity, but the fruits obtained showed a weight higher than those from the conventional treatments. The conventional treatment with the use of herbicides maintained the lower weed coverage during the assay. The agroecological strategies tested could be an alternative for weed management in tomato crops. However, the cost of their implementation and the long-term benefits for the agricultural ecosystems should also be considered.

Funded by European Comission, HORIZON-CL6-2022-FARM2FORK-02-two- stage.

PS1-21. Agroecological weed management in annual crops – first year's trial results in organic fields of good project

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GOOD is an EU Horizon project aspired to evaluate agroecological weed management (AWM) practices in Living-Labs (LL).This study presents field trial results from annual crops in organic farming systems.

The field trials were conducted during 2023–2024 to evaluate AWM practices in soybean and maize (Serbia), rice (Spain), wheat (Greece), triticale (Italy) and cowpea (Portugal). In all LL fields, a Randomized Complete Block Design was established according to the split plot arrangement. Four cover crops were assigned to the main plots: non-cover crop control and three different cover crops. Five weed management strategies were assigned to the subplots: untreated control, false seedbed, stale seedbed, mechanical weed control, bio-herbicide application and mulching.

In terms of weed suppression, the cover crop that showed the best performance in Serbia was rye that produced 100–200 g m^{-2} of biomass in maize and soybean LLs. The best weed control treatment was mechanical weed control with 50–60% of the efficacy in combination with cover crops both in soybean and maize. In Italy (triticale) the treatment that received mechanical weed control was effective in containing the weeds but the grain production was higher in the plots with *Medicago truncatula* cover crop (7,319.0 kg ha^{-1}). In Greece (wheat) the lowest weed biomass (10.8 g m^{-2}) and the highest crop yield (3,366.2 g m^{-2}) was observed in the interaction plots of *Trifolium alexandrinum* + *Lolium perenne* × false seedbed.Stale seedbed and false seedbed reduced weed biomass by 65% (125.2 g m^{-2}) and 67% (111.8 g m^{-2}), respectively, compared to the untreated control. In Portugal (cowpea) the six-species mixture showed the best ground coverage (oat + rye + lupin + turnip, mustard + flax) while in Spain (rice) the *Avena sativa* cover crop achieved a significantly higher ground cover (P-Value ≤ 0.01), and weed suppression, as well as the best soil indicators.

The results revealed that the combination of cover-cropping along with other cultural and mechanical methods is a promising strategy for developing sustainable AWM strategies in organic annual crops.

This research was supported by the European Union's Horizon Research and Innovation Action (RIA) project under the grant agreement no. 101083589 (GOOD project – https://www.goodhorizon.eu/).

PS1-22. Identification of agroecological weed management strategies in Estonia

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Agroecological weed management practices are essential for sustainable agriculture, helping to reduce dependency on synthetic herbicides while maintaining soil health and biodiversity. However, the adoption of these strategies is influenced by factors such as access to equipment, financial support, and awareness of alternative methods.

In 2024 we conducted a survey among local farmers to assess their current status and expectations regarding agroecological weed management. Results indicate that crop rotation is the most extensively implemented agroecological weed management strategy. The use of high-quality seed material is also widespread, followed by mechanical weeding (harrowing). In contrast, techniques such as flame weeding and weed mapping remain largely underutilized, with limited awareness among farmers. Stakeholders and participants in co-creation workshops emphasize the agronomic benefits of crop rotation, cover cropping, and mechanical cultivation in enhancing weed suppression. Additionally, mowing is identified as an effective method for weed control in apple orchards. Despite the potential advantages of agroecological approaches, their broader adoption is constrained by barriers such as inadequate access to specialized equipment and limited financial resources, including insufficient subsidies and economic support mechanisms.

In Estonia, two experiments on agroecological weed management practices are currently being conducted - one in oat fields and another in an apple orchard. Harrowing and higher seed density have been selected as primary methods to enhance weed suppression and improve crop competition in oat trial. The trial variants include: conventional plowing with herbicide application; minimum tillage with herbicide application; minimum tillage with mechanical weeding by harrowing one week after sowing; minimum tillage with mechanical weeding by harrowing at the three-leaf stage; minimum tillage with high seed density and mechanical weeding by harrowing one week after sowing; minimum tillage with high seed density and mechanical weeding by harrowing at the three-leaf stage. The weed management strategies implemented under the apple tree canopy include the following: a control treatment involving the application of glyphosate for effective weed suppression; mowing, where weeds are cut 1-2 times during the vegetation period to manage their growth; sod destruction, in which weeds are mechanically crushed and incorporated into the soil; mulching, where the area beneath the trees is covered with straw to provide a physical barrier against weed growth and conserve soil moisture.

ACKNOWLEDGEMENTS. The research was supported by the HORIZON project “Agroecological strategies for sustainable weed management in key European crops (AGROSUS)“.

2. Biological control of weeds

S02-O1. 10 yrs after the release of the gall wasp *Trichilogaster acaciaelongifoliae* in Portugal – where do we stand?

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Keynote session

Trichilogaster acaciaelongifoliae (*Hymenopterae: Pteromalidae*) was the first biocontrol agent intentionally introduced against an invasive alien plant in continental Europe. This small wasp promotes the formation of galls at flower and vegetative buds of the target plant, *Acacia longifolia*(*Fabaceae*), whichis one of the most widespread invasive plants along coastal areas in Portugal. The wasp was introduced in Portugal in 2015, in a collaboration with the University of Cape Town, South Africa, where the agent had been released before. When introduced, the agent came from the austral spring, with the host plants having tiny buds, adequate to oviposition, and faced boreal winter with host plants having much larger buds and adverse weather conditions. As such, it had to synchronize its life cycle with the seasons and phenology of the host plant in this new location. We present results of establishment almost 10 years after release, including the levels of establishment across the country (and Spain), assessment of the life cycle alignment of *T. acaciaelongifoliae,* effects on the target species and monitoring of non-target species. Geolocation data provided by citizen scientists increased locations registered by researchers, revealing that the agent is now established along the coast, from the most northern location (Minho, crossing to Galiza in Spain) to the most southern region (Algarve). *Trichilogaster acaciaelongifoliae* has synchronized the life cycle with the boreal seasons and maintains the univoltine life cycle, but the generations are not completely synchronized in different sites. The alignment of the life cycle may not yet be stabilized and is apparently more advanced in the sites located further south, where adults emerge earlier. Reproductive galls dominate over vegetative galls in almost all months and locations, as in the South Hemisphere, promoting significant reductions of seed production and vegetative growth. In sporadic situations galled plants are dying, without confirmation that this is a direct effect of the biocontrol agent. No galls were found on non-target species. The results so far are encouraging for the management of *A. longifolia*, confirming the specificity and efficacy of the agent in South Africa.

The authors thank the Portuguese Foundation for Science and Technology (FCT) for the financial support to the Research Centre for Natural Resources, Environment and Society — CERNAS (UIDB/00681/2020; DOI: 10.54499/UIDP/00681/2020).

S02-O2. Connecting hemispheres through biological control: sharing knowledge and aligning efforts

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Classical biological control reduces non-native invasive species populations by introducing specific natural enemies from their regions of origin, thereby limiting the growth and/or reproduction of the pest species. Although implementing a safe and effective program requires significant initial investment, collaboration between partners can lower costs by sharing expertise and resources. This work outlines the roadmap which Portugal has followed in its long-term collaboration with South Africa to advance biological control efforts.

The collaboration began in 2004 with the importation of the galling wasp *Trichilogaster acaciaelongifoliae* targeting the invasive alien tree *Acacia longifolia*, for specificity testing with species of interest in Portugal; this culminated with the release of the agent in mainland Portugal in 2015. This agent is now widely established along the Portuguese coast, effectively reducing the seed production and growth of the invasive species.

Building on this success, Portugal has extended its biological control efforts to other invasive plants. Specificity tests are underway with two species of seed feeding weevils, *Melanterius acaciae* and *M. maculatus*, to control *A. dealbata*, *A. mearnsii*, *A. melanoxylon*, and *A. retinodes*. Other agents, including the water hyacinth hopper, *Megamelus scutellaris* stem mining weevils, *Neochetina*spp.,for the floating invasive *Pontederia crassipes*, and *Stenopelmus rufinasus* for *Azolla filiculoides*, are being considered for future programs.

Portugal is also the source of biological control agents, e.g., the pine cone weevil, *Pissodes validirostris*, native to Europe, is being investigated for release against the invasive *Pinus pinaster* in

South Africa. The weevil larvae specifically develop in 2nd year pine cones, destroying their seeds. In 2024, surveys were conducted in central Portugal's pine forests to identify key locations for *P. validirostris* collection.

Portugal's collaboration with South Africa has successfully advanced biological control programs, optimizing costs and efforts, and the partnership continues to explore new agents to manage invasive plant species in both countries.

Research Centre for Natural Resources, Environment and Society — CERNAS UIDB/00681/2020 (DOI: 10.54499/UIDP/00681/2020); Cooperation protocol "Colaboration in the biocontrol of Pinus pinaster", between ESAC/Polytechnic University of Coimbra.

S02-O3. Classical biological control – an opportunity to support reduced herbicide use for weed management in Europe

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Sustainable and reduced use of pesticides is of utmost importance to protect agricultural ecosystems, biodiversity as well as human and animal health. To achieve this goal it is essential to incorporate non-chemical alternatives into an integrated weed management strategy. Biological control, an environmentally friendly, economic, and sustainable approach to weed management, offers such an alternative.

The specific strategy of classical biological control (CBC) is best suited to control introduced plant species, which have become invasive and troublesome in areas outside their native ranges. Based on the use of highly specific co-evolved natural enemies (arthropods and fungal pathogens) associated with a weedy species in its native range, CBC aims to reduce invasive populations in the introduced range below the threshold where they are exerting detrimental impacts on biodiversity and local economies. CBC has long played a significant role managing non-native invasive weed species in North America, South Africa, and Australasia. Several such species of European origin have been successfully controlled using CBC agents sourced from Europe, e.g. *Chondrilla juncea* (skeleton weed) impacting on agriculture in Australia with the rust *Puccinia chondrillina* and spurges, *Euphorbia virgata* and *E. cyparissias,* invading pastures and rangelands in North America with *Aphthona* flea beetle species. In contrast Europe has been lagging behind in exploiting CBC for weed control. Following initial attempts in the late 20th century undertaken predominantly by Eastern European countries to target *Ambrosia artemisiifolia* (common ragweed), a highly allergenic North American species affecting agricultural land, the strategy subsequently fell into disregard.

Recently, however, CBC has experienced a revival In Europe and research into opportunities to employ the strategy for weed management has led to the release of five biocontrol agents, four arthropods and one fungal pathogen, against as many non-native invasive weeds species in three European countries. Furthermore, additional potential weed targets for CBC are currently under investigation.

This talk will summarize the current status of weed CBC in Europe and highlight future prospects as well as limitations of the strategy for weed management.

Acknowledgement(s) / funding : EWRS, CABI.

S02-O4. A decade of biological control against the invasive weed *Impatiens glandulifera* in GB – challenges and successes

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Impatiens glandulifera (Himalayan balsam) is an annual plant originating from the foothills of the Himalayan mountain range. Introduced into Great Britain (GB) as an ornamental in 1839, it is now widespread throughout GB and is considered an invasive species. *Impatiens glandulifera*out-competes native species creating dense monocultures, reducing plant diversity and pollination of native plants. Himalayan balsam often colonises riverine habitats and, due to its annual nature, can cause erosion and sedimentation of watercourses. Manual and chemical control methods are labour intensive, costly and environmentally damaging and thus, alternative control methods are needed. Classical biological control utilises highly specialised natural enemies (arthropods or pathogens) from the native range of the target plant for the control of the invasive species in its introduced range.

In 2014, after extensive safety testing and ministerial approval, the highly specific rust fungus *Puccinia komarovii*var. *glanduliferae*was approved for release in GB.Today, more than a decade after the first releases, the rust has been released at over 120 sites through collaboration with over 40 organisations.To overcome variations in the susceptibility of individual populations to the rust,two rust strains have been released. Pre-release susceptibility testing of potential release sites is necessary to determine which strain is most virulent and pathogenic. However, additional strains from the native range are required to target rust-resistant populations.The performance of the rust in the field during the summer has been impressive, with high levels of leaf infection observed, particularly at the end of the growing season.Despite this, the ability of the rust to overwinter and re-infect the following spring has been lower than anticipated, particularly in certain regions. Using Earth Observation data and pot-based experiments the impact of temperature, precipitation, soil moisture and soil type isbeing investigated. Nevertheless, the rust has successfully overwintered for up to 7 yearsat several sites with anecdotal evidence of impact in the field. To accurately measure this, long-term monitoring is required.

This presentation will explore some of the challenges experienced with releasing the first fungal biocontrol agent for the classical biological control of an invasive plant in Europe.

Since 2011, this work has been funded by the Defra (UK Department for Environment, Food and Rural Affairs) in partnership with the devolved administrations and other donors has been funding specialist science to the biological control of Himalayan balsam.

S02-O5. Assessing the host range of the biological control agent *Ophraella communa* in central and eastern Europe, to predict its safety in the control of the invasive alien *Ambrosia artemisiifolia*

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Ambrosia artemisiifolia, common ragweed (Asterales: Asteraceae) is an annual weed species that causes problems in public health and agriculture both in its native (America) as well as in the invaded range (e.g., Europe and Asia). *Ophraella communa*, ragweed leaf beetle (Coleoptera: Chrysomelidae) is a herbivorous potential biocontrol agent feeding on *A. artemisiifolia*. Before mass releases into non-native environments of Europe can be approved by national authorities, it is necessary to assess the specificity of *O. communa* considering plant communities of different regions of Europe. Several studies on the host specificity of *O. communa* have been and are being conducted by American, Asian, and European scientists. However, some Asteraceae species from Eastern and Central Europe, such as from the vast area of the Pannonian ecoregion have not been assessed so far. We provide results from a literature review that suggest plant genera from the Pannonian ecoregion potentially at risk, including *Achillea, Centaurea, Erigeron, Helianthus, Inula*, and other species. We then started to test feeding behaviour of *O. communa* on some of those plants using no-choice and choice gauze cage tests in the greenhouse. Preliminary results from a first series of no-choice tests confirmed that *O. communa* adults and larvae exhibit strong feeding preferences for *A. artemisiifolia*, with minimal feeding on most non-target plants. Interestingly, some prominent feeding by adults and larvae was recorded on *Inula* spp. Many eggs and egg clusters are usually found on *A. artemisiifolia*, while both were minimal or none on all non-targets. In general, high mortality of adults and larvae, and negligible egg laying on all tested non-target plant species, suggest the insect`s dependence on *A. artemisiifolia* for its population survival. These results support the narrow host-range of *O. communa* (or in other words, negligible risk to non-target plants) as a biocontrol agent under field conditions in Europe. Further investigations will focus on its impact on local non-target plant species. We hope that our studies will help finalizing the European-wide risk assessment of this biocontrol agent.

We acknowledge funding from Stipendium Hungaricum (Tempus Foundation LOA: 2024_792690) under the Doctoral School of Plant Sciences at MATE, and the Horizon Europe project ADOPT-IPM, EU-CHINA joint action.

S02-O6. Evaluation of *Fusarium* and *Rhizoctonia* isolates as biocontrol agents against Egyptian broomrape

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Phelipanche aegyptiaca is an obligate root-parasitic plant of the Orobanchaceae family that constitutes the most threatening weed for major crops in regions with a Mediterranean climate zone, as well as in Asia, Southern and Eastern Europe. The pre-attachment stage is crucial for its successful attachment and parasitism, making this phase a key target for biological control strategies. In this study, the effect of 79 fungal isolates, 49 *Fusarium* and 30 *Rhizoctonia* isolates, on the pre-attachment stage of *P. aegyptiaca* were investigated. According to the experimental results, the *Fusarium* isolates inhibited seed germination of *P. aegyptiaca* by 17.9% to 97.1%, while the disease severity values were between 21.3% and 99.8%. Approximately 19 of the 49 *Fusarium* isolates exhibited high inhibition effects (70-100%) and around 35 of the isolates caused high disease severity (70-100%) on the radicle. Moreover, a positive correlation was observed between the inhibition rate and disease severity for the *Fusarium* isolates. On the other hand, the seed inhibition rate varied from 1.2% to 37.6%, and the disease severity values were between 0% to 66.0% for the *Rhizoctonia* isolates. None of them exhibited a high effect on any pre-attachment stages. These findings suggest that the *Fusarium* isolates have a greater potential to be used as a biocontrol agent against *P. aegyptiaca* compared to the *Rhizoctonia* isolates , which may be due to differences in their secondary metabolite profiles or other pathogenicity-related traits. These findings pave the way for future research to optimize *Fusarium*-based biocontrol strategies and better understand the broader potential of these fungal isolates in managing *P. aegyptiaca*.

This study was supported by Scientific and Technological Research Council of Türkiye (TUBITAK) under the Grant Number 123O933. The authors thank to TUBITAK for their supports.

S17-O1. A patented herbicidal composition comprising eucalyptus, broom and apple mint biomass

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The work presented here includes the patent for the product titled “Herbicide composition comprising biomass of eucalyptus, broom and apple mint” (ES 2 957 062 B2), which belongs to the University of Vigo. The inventors are the signing authors, who are EWRS members. The Spanish Patent and Trademark Office (OEPM) published this patent in May 2024, and it is currently being extended to the European phase.

The herbicide is a 100% natural herbicide of biological origin based on allelopathy. It focuses on the effect of one plant on another by releasing bioactive substances in its environment (allelochemicals), which is helpful for weed control. The product comprises *Eucalyptus globulus*, *Cytisus scoparius*, and *Mentha suaveolens* biomass in pellet format to save volume and facilitate its application. It does not require adjuvants or stabilisers, and the plant tissues provide the natural encapsulation of the bioactive compounds, allowing their gradual release as the pellet loses density and the material decomposes in the soil.

This patent is the result of more than 14 years of research. It has been based on the following study examples: (i) discovery of the synergies among allelopathic compounds present in the three plant biomass species, (ii) assessment of the effectiveness of the herbicide mixture in greenhouse horticultural production, (iii) testing the feasibility of densifying the biomass into pellets, (iv) comparison of the suitability of the pelletized format compared to non-densified biomass, showing greater effectiveness and duration of the herbicidal effect of pellets, (v) evidence of the herbicidal effect of pellets in the field, (vi) establishment of the ideal proportions and optimal mix of allelopathic biomass species, and (vii) demonstration of its herbicidal activity in a bean crop.

Due to the allelopathic nature of its component species, this product has a pre-emergence effect on germination and early growth of weed species but without adverse effects on most of the tested crops (e.g. corn, bean, strawberry, tomato, turnip and onion). It is presented as an easily integrable tool in integrated weed management (IWM), as the product can be applied to the soil in combination with the bottom dressing in seedbed preparation or applied as a mulch in the crop lines, interrow and passageways, in addition to other non-agricultural uses. This new product offers a particularly innovative basis of operation, setting it apart from the herbicides available on the market.

Acknowledgements to the R&D office of the University of Vigo for its consulting and technical support, particularly José Jato.

S17-O2. Influence on bacterial inoculants on weed germination depends on weed species and developmental stage

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Weeds cause tremendous problems in crops. Therefore, a huge effort is taken to handle them in an efficient way. The most efficient and widespread measure is the application of herbicides. However, these substances have strong environmental impacts and may negatively affect soil quality, leading to long-term consequences for crop production. This highlights the need for alternative methods of weed management. Instead of focusing on weed control alone, integrated weed management considers also the crop and its variety, tillage, fertilization and other so-called indirect measures.

A potential alternative is the targeted use of bacteria for weed control. This study aimed to investigate the effects of three bacterial strains, isolated from rhizosphere, with high Indol-3-Acetic Acid production (IAA) (*Pseudarthrobacter* sp., *Pseudomonas* sp., and *Streptomyces* sp.) on the germination of four common weed species. The focus was on assessing whether these strains, through the overproduction of IAA, negatively affect germination stages. To test this, seeds were inoculated with bacterial suspensions (OD_{600} = 0.8-1.0) and incubated at 20°C for 14 days under sterile conditions on filter paper. The three treatments were compared to a non-inoculated control.

First results showed that the effects of bacterial strains were depending on weed species and developmental stage. *Pseudomonas* sp. promoted root emergence in *Apera spica-venti* and *Galium aparine*, while *Streptomyces* sp. had the strongest promoting effect on *Alopecurus myosuroides*. Shoot formation was accelerated by *Streptomyces* sp. in *A. myosuroides* and by *Pseudomonas* sp. in *G. aparine*. For cotyledon development, *Pseudomonas* sp. enhanced germination in *G. aparine*, whereas *A. spica-venti* and *A. myosuroides* where positively influenced by *Streptomyces* sp. and *Pseudarthrobacter* sp. In terms total germination rate, *Streptomyce*s sp. showed the highest effect in *A. myosuroides*, while *Pseudomonas* sp. influenced *G. aparine* the most. No effect was observed for *Tripleurospermum inodorum*.

Contrary to our expectations, some strains promoted germination, particularly in early stages. These findings highlight the complexity of bacterial interactions with weed seeds, demonstrating that bacteria influence germination processes in a weed-specific and stage-dependent manner.

S17-O3. A novel generation of bioherbicides based on essential oils

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The Integrated and Urban Phytopathology Laboratory (LPIU) has been studying the protective properties of essential oils as biological fungicides and herbicides for 15 years, focusing on the development of appropriate formulations that maximize their effectiveness. A pre-selection of 90 essential oils from a catalogue of 3000 essential oils was carried out based on their low price and availability in sufficient quantity.

Thus, a screening of these 90 essential oils was carried out on several weeds under controlled conditions (greenhouse), identifying the 3 most appropriate essential oils (EO1, EO2, EO3) with a broad-spectrum and a complementary activity against the weeds most present in our regions in gardens and major crops. In comparison with other herbicides available on the market (including the biological herbicide based on Pelargonic Acid), our essential oils present a more diversified action profile and a more advantageous eco-toxicological profile. Thus the 3 selected essential oils (EO1, EO2, EO3) show excellent practical application prospects given their efficacy, affordable cost and availability.

Based on these promising results, APEO, a spin-off of the University of Liege, was created in 2021. APEO stands for “Agronomical Plant Extracts & Essential Oils”. APEO is developing a portfolio of biological herbicides and fungicides based on natural essential oils for use in home & garden and professional agriculture.

The first product, based on E01, is a ready to use herbicide for the home & garden market. It presents a non-selective activity. All the ingredients (including adjuvants) are fully biobased. After 5 years of practical and GEP trials in Europe and US, we determined that EO1 has a broad and high global efficacy against both mono- and dicotyledons. An in-depth study of mode of actions demonstrated at least 7 cell targets affected by the active ingredient, decreasing the probability of development of resistance weed populations. The active ingredient and related product are under registration process in US and Europe. APEO is now developing concentrated bioherbicides formulations for professional uses.

Acknowledgement(s) / funding: APEO, Walloon Region.

S17-O4. Evaluating cerato-platanin of fungal origin as a potential bioherbicide on weeds

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Weeds are among the most worrying pests of arable crops and herbicides are used globally to control them. However, the withdrawal of numerous herbicides due to strict EU regulation,the lack of new products with novel mechanisms of action and the increasing evolution ofherbicide resistancereduce the chemical options available and make weed management increasingly difficult.In this context there is the need to develop new molecules with herbicidal activity having a novel mechanism of action to meet the demand for more eco-friendly and toxicologically safe herbicides and to improve crop sustainability.

As no herbicidal mechanism described to date acts by manipulating the plant immune response, the present study investigated the potential phytotoxic effect on weeds and crop germination ofa fungal protein named cerato-platanin (CP) which has long been known for its ability to trigger defenses in plants.Defense deployment in plants entails metabolic expenditure and antagonistic hormonal cross-talks that may negatively affect growth, a phenomenon well-known as “growth-defense tradeoff”.

Germination tests on Petri dishes were conducted to evaluate the phytotoxic potentialeffect of the water-soluble CP toward germination, root and shoot length of the weeds *Amaranthus hybridus*, *Amaranthus tuberculatus*, *Digitaria sanguinalis*, *Lolium multiflorum* and the wheat crop *Triticum aestivum*. Furthermore, the expression of defense-related genes was also analyzed by RT-qPCR in seedlings of *L. multiflorum* growing in the presence of CP.

Concentration-dependent reduction in root and shoot length was recorded for *L. multiflorum* with respect to the controls (water and Bovine Serum Albumin) and this inhibition was associated with an overexpression of the genes ethylene-biosynthesis (*ACO1*)and chitinase 1 (*CHI1*). The application of CP to seeds was also highly effective in inhibiting root growth in *D. sanguinalis* and moderately in *A. hybridus* while the CP treatment did not significantly affect *A. tuberculatus.* Interestingly, the germination test carried out on wheat seeds showed complete insensitivity to the protein elicitor applied at 150 µM.

This work gives the first evidence of the potential herbicidal activity of a natural protein elicitor of fungal origin and lays the foundation for the development of new natural herbicides.

This study was carried out within the PEP-HERB project of the Italian Ministry for University and Research (PRIN 2022 PNRR) funded by the European Union – Next Generation EU.

PS1-23. Suppression of weeds with the help of micro-organisms (here with the product 'Unkrautbarriere')

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New, innovative methods for weed control, are based on micro-organisms for weed control. These are capable of forming biominerals, comparable to coral or bone formation. Neudorff's commercial product 'Unkrautbarriere' uses naturally occurring micro-organisms. These micro-organisms produce carbonates. They consolidate the soil surface so that germinating seed weeds cannot penetrate the barrier. This also applies to flying seeds. However, water and air can still circulate freely. According to the label instructions, the area must be completely free of weeds before application. Unkrautbarriere product is simply stirred into water and poured evenly over the area. The effect of the product on weed suppression has been tested in four trials at the Julius Kuehn Institute in Braunschweig, Germany:

1. The effect on four plant species (*Avena sativa*, *Sinapis alba*, *Bromus sterilis* and *Stellaria media*) was tested in photographic trays at two depths (0.5 cm, 2 cm) and two soil types (loamy sand, standard soil-sand mixture).
2. In the field, the efficacy was tested with different application rates (50 %, 100 % and 200 % of the prescribed application rate).
3. The ability of the seeds of 10 weed species to germinate was tested after the application of the product.
4. The efficacy of the product on *Sinapis arvensis* and *Stellaria media* was tested on already emerged plants (BBCH 12).

The results of the trials showed that there was no effect on complete emerged plants. In contrast, the effect on germinating plants was good. However, there were differences between species, with grasses being significantly less suppressed than dicotyledonous species. When applied directly to weed seeds, germination was completely prevented. Overall, it was shown that there is future potential for using microorganisms to control weeds.However, there is still a considerable need for research, as high costs and high water consumption have so far only allowed limited use (house gardens), and applications in agricultural and horticultural practice have not yet been fully developed. ‘Unkrautbarriere’ is no longer commercially available in Germany, but several similar research projects are underway.

PS1-24 Effects of invasive *Ludwigia* species aqueous extract on weed germination and root growth

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Ludwigia hexapetala (ongoing classification), a macrophyte native to Central and South America, has become invasive in several European countries, including Italy. It is a freshwater amphibious plant typified by aquatic and terrestrial morphologies. Its phenotypic plasticity enhances invasiveness, allowing it to colonize different habitats. The rapid growth, the high biomass production, and the coverage in drainage canals of *L. hexapetala* pose a threat to hydraulic safety and local biodiversity. Typically, *L. hexapetala* is removed mechanically, resulting in substantial biomass waste.

This study investigates the potential herbicidal effect of aqueous extracts from both aquatic and terrestrial forms of *L. hexapetala* using biomass waste. The extracts were tested on the germination and root elongation of six weed species: *Abutilon theophrasti, Amaranthus retroflexus, Chenopodium album, Sorghum halepense, Echinochloa crus-galli* and *Digitaria sanguinalis*. Seeds were placed in Petri dishes on filter paper imbibed with the extract at different concentrations (from 0% to 100% v/v) and incubated at alternate temperature 18°C/30°C and 12h/12h light/dark photoperiod. The germination was monitored daily for 7 days and the root length of all seedlings was measured. Statistical analysis was conducted on germination, root length and t50 data. The germination decreased for almost all extract - dose combinations as the dose increased. Both extract and dose factors showed significant effects on germination for *A. retroflexus*, *S. halepense* and *D. sanguinalis*. Specifically, the terrestrial extract (LT) significantly reduced the germination of *A. retroflexus* and *D. sanguinalis* (34.25% and 15.63% respectively at 100% v/v), whereas the aquatic extract (LA) was more effective for *E. crus-galli* and *S. halepense* (50.00% and 37.50% respectively at 100% v/v). Moreover, for all species, the LT extract caused considerable root length reduction starting from 50% v/v concentration, which was more effective than LA.

The allelopathic properties of *L. hexapetala* indicate a potential natural herbicidal effect of its extracts and the results suggest that the terrestrial form of *L. hexapetala*is more effective in reducing weed germination. In conclusion, employing the waste biomass of *L. hexapetala* to produce aqueous extracts could provide a sustainable, environmentally friendly alternative for plant protection products, aligning with circular economy principles.

“Progetto di studio e sperimentazione su un ambito territoriale pilota interessato dallo sviluppo della specie Ludwigia hexapetala” funded by the Veneto Region.

PS1-25. Scaling up a new herbicidal composition based on allelopathic biomass. Pilot production and demonstration in an operational environment

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A new allelopathic biomass-based herbicide in pellet format (Patent ES 2 957 062 B2) has been tested for weed control in ornamental crops. Ornamental plant cultivation demands durable and high levels of weed control for growing woody plants that remain in the same container for weeks to months once potted or repotted. In addition, shipments of live plant material must comply with applicable international, European, and national phytosanitary regulations. Of course, for aesthetic reasons, commercial ornamental plants must be free of weeds at the time of transport and marketing. Weed control is done mainly by hand-weeding at a high investment cost.

The trials were carried out in an ornamental plant nursery (Viveiros Río Tollo, S.L., Galicia, Spain), which specialised in producing and marketing acidophilic ornamental shrubs, with an extensive production of *Camellia japonica*, among others. The effect of the herbicide (eucalyptus pellets and mixed eucalyptus, broom and apple mint pellets produced in pilot plant) on camellia cultivation was studied in two trials: 1) for a first evaluation of efficacy, two doses of eucalyptus pellets (5% and 10% w/w) were applied to 680 g of substrate in 3L pots and compared to pots without pellets devoted to hand-weeding. Weed biomass sampling was carried out for all pots on the dates that the nursery considered necessary to apply hand-weeding for accurate production; and 2) to evaluate a possible saving in the number of hand-weeding operations, 1.5L pots were prepared with 380 g of substrate mixed with the two cited doses of eucalyptus pellets besides another treatment consisting in 10% mixed pellets. In this case, the number of emerged weeds was counted for each treatment when it was necessary to weed out the pots with the herbicide. The control consisted of herbicide-free pots sampled simultaneously as the treatments and all of them were compared to pots hand-weeded according to nursery requirements.

In the first trial, both herbicide doses significantly reduced weed biomass by more than 65% compared to hand-weeded pots scheduled by the nursery. In the second one, the different formulations and doses exerted a notable weed control similar to hand-weeding, and, compared to the nursery schedule, the use of the herbicide saved two hand-weeding operations without undesirable side effects on camellia plants.

We thank the collaboration and services provided by the company Viveiros Río Tollo S.L., especially José Collazo and Cristina Barbosa. Project PDC2022-133375-I00 funded by MCIN/AEI/10.13039/501100011033 through Next Generation EU/PRTR

PS1-26. Impact of landscape heterogeneity on the spatial and temporal dynamics of weed seed predation

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Weed seed predation is a valuable ecosystem service that can reduce reliance on chemical and mechanical methods for weed control. While several field experiments have investigated the potential of the surrounding landscape to enhance weed seed predation by providing food resources and overwintering habitats for seed predators, most rely on limited spatial and temporal replication. As a result, the variability of weed seed predation across space and time, particularly in relation to landscape characteristics within large agricultural fields, remains poorly understood.

To address this knowledge gap, we conducted a three-year experiment in a 30-hectare field in Sweden. Weed seed predation was measured using seed cards at approximately 200 sampling points across the field periphery, edge, and centre. Invertebrate seed predator abundance was monitored at one-third of these points. Additionally, we assessed the impact of landscape heterogeneity by measuring the distance of each sampling point to three types of semi-natural habitats (shrubby, woody, and grassy) as well as urban features.

Our results showed that weed seed predation levels varied significantly across years and field locations. Predation rates were consistently higher when seed cards were accessible to all predators, compared to when they were accessible to invertebrates alone. While we found a weak but positive effect of proximity to semi-natural habitats on predation rates, our findings suggest that the presence of such habitats does not necessarily translate into higher weed seed predation. Other variables, such as the availability of trophic resources and climatic conditions, potentially play a critical role in shaping weed seed predation patterns.

These findings underscore the complexity of promoting ecosystem services like weed seed predation in agricultural landscapes. Although semi-natural habitats are important for supporting seed predators, their contributions to weed seed predation may be context-dependent and can vary between years.

PS1-27. Weed seed predation reduces the population growth of *Alopecurus myosuroides*

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Weed seed predation is a valuable ecosystem service that helps to reduce weed abundance in agricultural fields. *Alopecurus myosuroides Huds.*(blackgrass*),* is a winter annual weed that thrives in the temperate agroecosystems of Northern and Western Europe. While various weed control methods have been explored to reduce the growth of this species, the potential of weed seed predation to limit *A. myosuroides* population growth remains unclear.

To address this, we used a stage-classified stochastic matrix population model, parameterised with empirical demographic data from long-term Swedish experiments with winter wheat. The model also included data on weed seed predation by vertebrate and invertebrate seed predators.

We found that in agroecosystems managed with a combination of both chemical and mechanical weed control, seed predation must result in at least 78% seed loss at peak seed shedding to significantly reduce *A. myosuroides* population growth. Field data demonstrated the key role seed predation occurring in July, during the peak of seed shedding, and before harvest, for weed regulation. Among the seed predators, vertebrates have the strongest impact on reducing *A. myosuroides* population growth, though both vertebrates and invertebrates were essential for effective weed control.

Our results highlight that in intensively managed agroecosystems, weed seed predation can reduce the population growth of winter annual weeds like *A. myosuroides*. Therefore, developing management strategies that protect weed seed predators is essential for reducing the dependence on chemical and mechanical methods for weed control.

PS1-28. Promoting safe classical biological control of invasive alien plants in Europe

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A COST Action proposal (PlantBioncontrol4EU) was submitted in 2024 by a consortium of 42 proposers aiming to engage experts in major scientific innovation and transfer of knowledge amongst 22 European Countries and other 5 International Partners to facilitate the consideration of Classical Biological Control (CBC) as a key and safe alternative, for successfully and sustainably manage invasive alien plants (IAPs). Classical Biological Control is recognized as important to the urgently needed management of IAPs. Yet, despite its long history of success in the management of IAPs in other regions of the world, IAP CBC is still in its infancy in Europe and needs innovative approaches from these regions. If funded, PlantBiocontrol4EU will ease communication, increase expertise and support CBC to be considered a reliable nature-based solution for the control of IAPs in Europe, contributing to implementing Regulation (EU)1143/2014 on IAS and providing an alternative to chemicals. But even if not funded, this network is expected to help build-up expertise and foster IAPs CBC around Europe. PlantBioncontrol4EU includes 5 Working Groups (WG) articulated to boost the critical use, efficacy, safety and success of IAP CBC in Europe through cooperation. WG1 will collect information on CBC projects in Europe and involve experts in an (in)formal European network. WG2 will collect information on CBC standards and procedures adopted around Europe, filling in gaps, ensuring quality control, safety and reliability of CBC, and making information more easily accessible. Innovation in CBC will be explored by WG3, through literature review, horizon scan and experiments. WG4 will identify obstacles, inform policies and decision-makers, and harmonize legislation. Finally, WG5 will assess public perceptions through culturomics and focus on communication and knowledge transfer, including clarification of misconceptions and information from WG1-3, e.g., CBC integration into school curricula, awareness campaigns, training and citizen science. Everyone interested in joining this network is most welcome.

*A.Anđelković, I.Bazos, H.Beismann, A.C.Cardoso, K.Constantine, R.Ćušterevska, N.Desneux, J.Fagúndez, Ž.Fišer, A.Gazda, E.Gervasini, R.Groenteman, Y.Gümüs, M.Hill, S.Jelaska, S.Kovačević, V.Lesieur, V.Lozano, R.Mangan, F.Marini, M.Marzano, D.Matosevic, H.Mueller-Schaerer, A.Novoa, D.Peci, J.Pergl, K.Pollard, M.Prokopuk, Z.Rousset, J.Rydlewski, M.Seier, RFH.Sforza, R.Shaw, I.Stiers, E.Strange, Y.Sun, R.Tanner, R.Tomov, D.Uogintas, J.van Valkenburg, D.Veríssimo, G.Cabrera Walsh, P.Weyl, A.Yazlık, M.I.Zilio, S.Ziller

PS1-29. Occurrence of *Ophraella communa* in the Panonian basin

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The invasive plant *Ambrosia artemisiifolia* (Asteraceae), originally from North America, has become a growing issue in Europe since its introduction in Western Europe in the mid-19th century and in Eastern Europe in the early 20th century. This species poses an ecological and agricultural threat due to its rapid spread and high allergenic potential. *Ophraella communa* (Coleoptera: Chrysomelidae), ragweed leaf beetle, was accidentally introduced to Europe and first observed in northern Italy and Switzerland in 2013. Subsequently, it has expanded its range to Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Hungary, and beyond. Both adult and larval stages of *O. communa* feed intensively on *A. artemisiifolia* by "skeletonizing" leaves, consuming flower heads, and often devastating plants before they can flower, thereby significantly reducing pollen production.In 2024, a study was conducted across 176 locations in the Pannonian Basin, including Serbia, Croatia, Slovenia, Austria, Slovakia, Hungary, and Romania. The purpose of the study was to investigate the presence and spread of *O. communa*. The results revealed the presence of *O. communa* at 89 locations, collecting a total of 1069 adults using sweep net and manual collection methods. In addition to *O. communa* there were other insect species identified, like *Acontia candefacta* (Lepidoptera, Noctuidae), an additional herbivore of *A. artemisiifolia*. The study also identified two predatory species, *Perillus bioculatus* and *Zicrona caerulea* (Hemiptera, Pentatomidae), which may act as natural enemies of *O. communa*.This study aims to show the occurrence of *O. communa* across the Pannonian Basin and its potential as a biological control agent for *A. artemisiifolia*.

This research was funded by "Horizon Europe project ADOPT-IPM „EU-CHINA joint action to increase development and adoption of IPM tools, 10106430: HORIZON-CL6-2021-FARM2FORK-01".

PS1-30. Feeding of *Ophraella communa* on weedy and cultivated sunflower

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Ambrosia artemisiifolia (ragweed) is an alien, invasive weed species that is very harmful in arable land and affects people's health and quality of life due to its extraordinary allergenic potential. It is one of the most important allergenic plant species worldwide. Ragweed spreads very quickly (6-20 km/year), making it a highly invasive species. Previous studies have shown that the ragweed leaf beetle (*Ophraella communa*) feeds intensively on ragweed plants; the greatest damage to the plants is being caused by the larvae, which are extremely voracious and can completely destroy the plant in large numbers.

The weedy sunflower (*Helianthus annuus*) arises from spontaneous hybridization between the same/different generations of a volunteer cultivated plant maintained in an area, resulting in an exchange of genetic material and the emergence of robust, branched plants with a large number of small heads. In northern Serbia, there are large populations of weedy sunflower along roads, on field edges, in non-arable areas, but also in many row crops. *Ophraella communa* is an oligophagous species that feeds on plants from the *Asteracerae* (*Compositae*) family, so that despite some research the question arises whether it also attacks crop sunflower. Based on our study this insect can only attack and develop on a sunflower if there is no ragweed nearby. The ragweed leaf beetle rarely lays eggs on sunflower, and if it does, numbers are much smaller than on ragweed, and the survival rate of the larvae is low. We confirmed, that if the beetle has a choice between ragweed and sunflowers, it will choose ragweed as its host and lay its eggs there. Even if it has the choice between weedy and crop sunflower, *O. communa* chooses the weedy sunflower. We consider, *O. communa* could be used as a biological agent to control ragweed.

PS1-31. Inhibitory effects of *Chenopodium a*lbum extract on seed germination and seedling growth of crops and weeds

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This study investigates the allelopathic effects of an aqueous extract derived from the dried aerial parts of *Chenopodium album*(common lambsquarters) on seed germination and seedlings growth of the selected cultivated and weed species. The tested species included: *Medicago sativa*(alfalfa), *Trifolium pratense* (red clover), *Amaranthus retroflexus* (pigweed) and *C. album*. The extract was prepared by mixing 5 g of ground dried aerial parts with 100 mL of water, followed by 2 hours of shaking and subsequent filtration. The extract was used in the experiments at concentrations of 25, 50, 75 and 100%, while distilled water was used for the control. The extract significantly inhibited seed germination in red clover and alfalfa, with complete inhibition observed at concentrations of 50, 75 and 100%. The application of 25% concentration reduced the germination by 90% in red clover and 38% in alfalfa. Pigweed seeds showed high sensitivity, with 82% reduction in germination at the application of 50% concentration and complete inhibition when higher concentrations were applied, while no significant effect was noted in case of 25% concentration. The inhibition of *C. album* seed germination ranged from 59% at 25% concentration to 91% at 100% concentration. Seedling growth, assessed by epicotyl and hypocotyl lengths after 10 days, was similarly suppressed. In alfalfa and red clover, the 25% extract reduced the epicotyl elongation by 92% and 93%, and hypocotyl elongation by 74% and 89%, respectively. Pigweed epicotyl growth was reduced by 83% at 25% concentration and 99% at 50% concentration, with corresponding hypocotyl reductions of 85% and 94%. The seedlings of *C. album* exhibited a 57% reduction in epicotyl elongation at 25% concentration and complete inhibition at 100% concentration, while hypocotyl elongation decreased by 86% and 97%, respectively. These findings underscore the strong allelopathic effects of *C. album* aqueous extract, suggesting its potential application in weed management. However, its negative impact on the germination and seedling growth of the tested crops highlights the need for further research in order to evaluate its effects on a broader range of cultivated and weed species and careful consideration of its prospective use in the agriculture.

PS1-32. Allelopathic effect of some weed species against *Phelipanche aegyptiac*a and *Orobanche cumana*

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Broomrapes (*Orobanche* spp. and *Phelipanche* spp.) are root holoparasitic weeds threatening many crops. As no single method effectively controls broomrapes, allelopathy offers promising, eco-friendly alternative for bioherbicide development. This study evaluated water and methanol extracts from *Ailanthus altissima*, *Convolvulus arvensis*, *Inula viscosa*, *Ipomoea triloba*, and *Plantago lanceolata* at three concentrations (100%, 50%, and 25%) against *Phelipanche aegyptiaca* and *Orobanche cumana*, which cause significant damage to tomatoes and sunflowers. Laboratory tests assessed their effects on parasitic and crop seed germination, followed by pot trials to determine non-phytotoxic doses and evaluate their effects on broomrape and crops.

In general, water extracts exhibited a stronger inhibition effect on broomrape seed germination than methanol extracts. The 100% water extracts reduced *P. aegyptiaca* germination by 77%-98% and *O. cumana* germination by 90%-100%. None of the extracts negatively affected tomato or sunflower seed germination. In 0.4 L pot trials, 100% concentrations of *A. altissima* and *I. viscosa* caused phytotoxicity in tomatoes but not in sunflowers. Thus, 50% concentrations of these extracts were used for tomatoes in subsequent trials.

In 20 L pot trials with tomatoes, 100% concentrations of *C. arvensis*, *I. triloba*, and *P. lanceolata* and 50% *I. viscosa* did not significantly affect *P. aegyptiaca* shoot numbers or dry weight. However, 50% *A. altissima* reduced *P. aegyptiaca* shoot numbers by 17% and dry weight by 44%. In sunflowers, 100% concentrations of *P. lanceolata*, *A. altissima*, and *I. viscosa* reduced *O. cumana* shoot numbers by 42%, 48%, and 60%, respectively, and decreased fresh and dry weights by 57–65%. In contrast, *C. arvensis* and *I. triloba* showed no significant effect.

The allelopathic potential of *A. altissima* against *P. aegyptiaca* in tomatoes and of *I. viscosa*, *A. altissima* and *P. lanceolata* against *O. cumana* in sunflowers was notable. Field trials could further validate these findings and support the development of effective bioherbicides against broomrape.

Acknowledgement(s) / funding: This study was supported by Scientific and Technological Research Council of Türkiye (TUBITAK) under the Grant Number 124O134. The authors thank to TUBITAK for their supports.

PS1-33. Can herbicide resistance have fitness costs when plants coexist with biotrophic pathogens? The case of large crabgrass-smut interaction

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The phenomenon of herbicide resistance in weeds offers the possibility of studying numerous questions related to evolution. The continued use of herbicides to control weed populations is an important selection factor. The causes of this phenomenon are extremely complex and are affected by numerous factors, the most substantial being those of a biological nature. The biotic interactions that can be established between weeds and pathogens or phytophagous insects represent an interesting scenario for studying herbicide resistance from an eco-evolutionary perspective.

The objective of the contribution is to know the capacity that herbicide-resistant and herbicide-sensitive *Digitaria sanguinalis* biotypes can have to counteract infection with and systemic development of the pathogen *Ustilago syntherismae*.

A greenhouse trial was performed during autumn 2023 near Barcelona with: (1) spikelets of two biotypes of *D. sanguinalis*, resistant and sensitive to acetolactate synthase (ALS)-inhibiting herbicides (2) teliospores of *U. syntherismae* from fully smutted plants. The spikelets were processed as follows: washing to disinfect, vacuum inoculation with teliospores, and incubation at 20ºC 12h / 30ºC 12h in dark for 2 days plus 8 days under dark/light conditions. The seedlings were transferred to the greenhouse in pots with universal substrate and irrigation with micro-sprinklers to complete their development following a completely randomized design with 3 replications, each containing 12 pots with one or two plants, resistant or sensitive. Individuals were counted by separating entirely smutted, partially smutted and apparently non-smutted plants.

The results obtained show that the resistant population presented an average percentage of entirely smutted plants significantly (P=0.05) higher, almost double, than that of the sensitive population, 75.2% versus 43.9%.

Although it is unknown whether the two biotypes compared differ in aspects other than sensitivity/resistance to ALS-inhibiting herbicides, something that we hope to find out in the near future, the results indicate that the two biotypes respond differently when they come into contact with the smut.

Acknowledgements: we are indebted to C. Delye for the large crabgrass populations. This work has been funded by the Spanish Research Agency, PID2022-136920OR-C43/AEI/10.13039/501100011033/ERDF, EU.

PS1-34. Development of bioherbicides combining essential oils with organic acids

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As part of the European CONSERWA project (https://conserwa.eu), which promotes agroecological weed management strategies, the University of Liège is developing an innovative bioherbicide based on a synbiotic approach. This strategy aims to promote the synergistic combination of microbial and plant-derived compounds to optimize herbicidal efficacy, particularly against resistant weeds. By integrating natural bioactive molecules, this approach seeks to reduce reliance on synthetic herbicides while ensuring sustainable weed control solutions.

Within this study, volatile aromatic compounds from essential oils (monoterpenes and phenylpropanoids) were combined with organic acids (e.g., acetic, lactic, or citric acid) to assess their potential for weed control. A selection of monoterpenes and phenylpropanoids was first screened based on their known herbicidal properties through in vitro germination assays and post-emergence tests. The most effective compounds were then combined with organic acids to evaluate potential synergistic interactions. Certain combinations exhibited significant synergy against weed species such as Lolium perenne.

Additionally, associations between the fermentation product of a lactic acid bacterial strain and essential oils were explored. Promising results were observed on ryegrass, clover, and mustard, demonstrating enhanced herbicidal effects. Ongoing research aims to further elucidate the synergistic mechanisms between bacterial metabolites and essential oil components.

Acknowledgement(s) / funding: Conserwa project (European Union’s Horizon Europe research and innovation programme under grant agreement No 101081802).

PS1-35. Insect-based bioherbicides: exploring the phytotoxic potential of Hermetia illucens extract-based bioherbicidal formulations

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Weed control is a significant economic and ecological challenge in global agriculture. Societal and political pressures to reduce synthetic chemical herbicide use have increased interest in bioherbicides as sustainable alternatives in integrated weed management. *Hermetia illucens* (black soldier fly), mass-reared using organic waste, is a promising sustainable source of active ingredients for bioherbicidal formulations. This study evaluated the phytotoxic potential of aqueous formulations containing *H. illucens* extracts from dead adult flies.

In 2023, post-emergence dose-response pot trials, arranged in a randomized complete block design with four repetitions, were conducted in a greenhouse under controlled conditions (20/15 °C day/night, 12-hour lighting, daily watering, no fertilizer). Six different concentrated formulations (80-0 mg *H. illucens* extract per ml deionized water) were applied post-emergence (3–4 true leaves) to two cereal crops (*Triticum aestivum* , *Zea mays*) and four weeds (monocotyledons: *Alopecurus myosuroides*, *Echinochloa crus-galli*,dicotyledons: *Chenopodium album*, *Stellaria media*) using a precision spray chamber (200 L ha^{-1}, 3.6 bar, speed: 788 mm s^{-1}, nozzle rate: 0.8 L min^{-1}).

The study assessed phytotoxicity of the insect-based formulations on plant physiological processes, the relationship between extract concentration and phytotoxicity, and differences in species sensitivity. Plant damage was evaluated at 7 and 14 days post-application, while above-ground biomass was harvested 14 days post-application and dried (80°C, 48 h). Maximum quantum yield of photosystem II was measured on days 0, 1, 3, and 7. ANOVA ($p < 0.05$) and Tukey-adjusted pairwise comparisons were conducted using R.

Results showed dose-dependent plant damage, with the highest concentration causing severe effects 7 days post-application, varying by species: *T. aestivum* (9%) < *A. myosuroides* (28%) < *E. crus-galli* (36%) < *Z. mays* (39%) < *S. media* (89%) < *C. album* (97%). Significant shoot dry matter reductions (39%, 89%, 87%) occurred in *Z. mays*, *S. media*, and *C. album*. Maximum quantum yield of PSII decreased significantly in all species except *T. aestivum* on days 1 and 3 but recovered by day 7.

These findings underscore the strong phytotoxic potential of *H. illucens* extracts, particularly against dicot weeds, supporting their suitability for bioherbicidal development.

PS1-36. The effect of *Artemisia dracunculus* essential oil on *Chenopodium album* and *Sorghum halepense*

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The application of secondary metabolites produced by plants (allelochemicals) has great potential as a tool for integrated weed control. The species of the family Asteraceae and especially the genus *Artemisia* are characterised by a high production of allelochemicals that can have a phytotoxic/herbicidal effect on other plants.

The aim of this study was to determine the chemical composition and to evaluate the effect of *Artemisia dracunculus* essential oil on the aboveground fresh mass of *Chenopodium album* and *Sorghum halepense*. The essential oil was extracted from the dried aerial plant material of cultivated *A. dracunculus* by steam distillation. The gas chromatography–mass spectrometry technique was used to identify the constituents of the essential oil. The *in vivo* experiment included 5 treatments with different concentrations of oil (1, 2.5, 5, 7.5 and 10%) and one control treatment (distilled water with Trend 90 surfactant at a concentration of 0.2%). All treatments were applied at the stage of the first pair of developed leaves of *C. album* and at a height of 8 cm of *S. halepense* using an automatic pesticide application chamber (Lechler nozzle 110-02; 2bar; 20 ml/m^2). Visual damage was assessed 1, 7, 14 and 21 days after application of the treatments and after 21 days the fresh mass was measured.

The main compounds in the oil were methyl eugenol (52.70%), sabinene (28.60%) and terpinen-4-ol (2.40%). On the first day after application, examined treatments caused visual injuries observed as leaf chlorosis and necrosis and the degree of visual damage was 11.67-96.67% in *C. album* and 0.00-61.67% in S. *halepense*, compared to the control plants. However, the treated plants were able to overcome the damage up to a certain percentage, especially at lower concentrations. The inhibition of fresh mass was between 6.57-82.45% for *C. album* and 4.46-40.26% for *S. halepense* for the applied treatments.

The results obtained showed the herbicidal potential of the essential oil of *A. dracunculus* with a greater sensitivity of *C. album* compared to *S. halepense*. The phenylpropanoid methyl eugenol as the main component of the oil could be responsible for the phytotoxic effect, which will be tested in further experiments.

PS1-37. Spreading dynamics of mycoherbicide *Sclerotium rolfsii* in controlling *Monochoria vaginalis*

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Sclerotium rolfsii is a soil-borne fungal pathogen that causes stem rot in plants and kills host plants. The pathogen has potential as a novel mycoherbicide for controlling certain broadleaf weeds, particularly *Monochoria vaginalis,*a noxious paddy weed with increasing herbicide resistance. Considering its spreading capability through mycelium, which differs from chemical herbicides, this studywas conductedto investigate the spatiotemporal spreading dynamics of *S. rolfsii* on *M. vaginalis* under controlled growth chamber and paddy field conditions, and to explore optimal application methods to enhance its practical use in rice cultivation. In the controlled growth chamber condition, the recommended dose (20 kg/ha) of sclerotia was spot-applied at the center of the trays (0.21 g for a rectangular tray of 25 cm x 41 cm and 0.3 g for a square tray of 39 cm x 39 cm) planted with *M. vaginalis* plants fully grown in the growth chamber maintained at 35/25ºC and 60% relative humidity. *Sclerotium rolfsii*exhibited a circular spreading from the application spot, with spreading dynamics well-described by the Gompertz model. The infection expanded at a rate of 118.72 cm^2/day, with the infection radius increasing by 1.59 cm/day, and controlled all *M. vaginalis*by 21 days after treatment (DAT). Under field conditions where 0.3 g of sclerotia (the same amount as used for the square tray) wasspot-applied at the center of each plot in a paddy field, *S. rolfsi* showed similar circular spreading as observed in trays. The infection expanded at a rate of 79.09 cm^2/day until 12 DAT,and thereafter at a rate of 434.28 cm^2/day. *Sclerotium rolfsii* effectively controlled *M. vaginalis* across an area of approximately 1 m^2 by 40 DAT, indicating that 0.3 g can control *M. vaginalis* in 1 m^2, equivalent to the dose of 3 kg/ha and 15% of the recommended sclerotia dose. Two different spot application methods compared with broadcast application showed comparable *M. vaginalis* control by 30 DAT, however initial infection rates were slightly slower than that of broadcast application, suggesting the need for refining application methods and the development of suitableformulations of *S. rolfsii* for spot application. Our findings suggest that the use ofsclerotia can be significantly reduced by refining the application method and the spreading dynamics provides valuable guidance for the practical use of *S. rolfsii* in sustainable herbicide resistant *M. vaginalis* management.

This work wassupported bythe Korea Institute of Planning and Evaluation for Technology in Food, Agriculture and Forestry (IPET) (321056-05-1-HD050).

PS1-38. Phytotoxic activity of essential oils components

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In searching for new herbicides based on natural products, investigating plant secondary metabolites is increasingly crucial. In this regard, essential oils and volatile aromatic compounds produced by plants could be particularly attractive. In a previous study, thirteen oils extracted from six wild *Lamiaceae* species were tested *in vitro* for phytotoxic activity, and the oil composition was determined. In the present studynine pure compounds (namely: camphor, carvacrol, eugenol, α-pinene,ϒ-terpinene, linalool, thymol, trans-anethole, tridecane), mostly identified as the majoressential oil components (EOC) in a previous study, were tested on the seeds of two plant species, one monocotyledon and one dicotyledon. Specifically, we conducted *in vitro* bioassays of the vapours of each substance on seed germination and root elongation tomato and common sorghum (*Sorghum vulgare*). Both species proved to be highly sensitive to most of the tested compounds. The substances were tested at different doses to determine the minimum active quantity. The most active substances proved to be camphor, carvacrol, eugenol, linalool, thymol, and trans-anethole. Joint applications were also tested to evaluate possible synergistic activities.

In our experiments, the vapours of most of the tested EOC applied at very low doses inhibited germination and initial radicle growth of both tested species. The results of our study, conducted within the PNRR Agritech National Research Center (CN00000022), confirm the potential of EOC for use in weed seed control. Localized application methods, such as drip irrigation to reduce product usage, or more advanced and cheaper extraction procedures to reduce treatment costs, could facilitate and encourage the adoption of those products in weed control. Research in this direction is of utmost importance.

Acknowledgement / funding: PNRR Agritech National Research Center (CN00000022).

3. Herbicide resistance

S03-O1. Resistance in driver weeds against protoporphyrinogen oxidase-inhibitors (PPO, HRAC group 14) & design and chemical approaches to identify new resistance-breaking lead structures

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Keynote session

Firstly, a brief overview of the evolution of resistance events in Amaranthus species against commercial PPO-inhibitors is given. Secondly, recent approaches to identify new chemical lead structures with resistance-breaking properties are outlined. The SAR-study outlined herein is inspired by molecular modelling studies based on a wild-type *Amaranthus tuberculatus* PPO-crystal structure and has afforded a series of novel PPO inhibiting compounds that contain a pyrazol moiety as uracil isostere, and a substituted thioacetic acid sidechain attached to the core phenyl group.[1,2] These compounds show promising herbicidal activity against important weeds in warm season crops like corn and rice, allow the use of low application rates, show promising selectivity and have the potential to mitigate and affect weeds that have become resistant to various market standards, in particular broadleaf driver weeds such as palmer amaranth and waterhemp. Whilst one of our 4-chloro-5-difluoromethoxypyrazoles showed a broad activity against broadleaf and grass weeds combined with the strongest resistance-breaking potential against target site-resistant *Amaranthus palmeri*, a related 4-bromo-5-trifluoromethylpyrazole revealed outstanding efficacy against *Amaranthus tuberculatus* carrying metabolic resistance towards established PPO-inhibitors.[2] Furthermore, introducing unprecedented structural modifications of the thioacetic acid side chain, e.g. tied back motifs or alkenyl substituents, afforded compounds with enhanced crop safety and improved efficacy against resistant monocotyledon driver weeds such as *Alopecurusmyosuroides* and *Lolium rigidum*.[3] In our view, these results underline that chemical innovation is a valuable and indispensable tool to address herbicide resistance.

S03-O2. Herbicides differentially affect plant growth, cuticular wax composition, and fatty acid metabolism in Blackgrass biotypes

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Herbicides have been a mainstay of weed control since they became commercially available in the 1940s. Despite this long history of use, much remains unknown about precisely how they act *in planta*. To inform growers on how to maximize efficacy while reducing the risk of evolved resistance through appropriate combination and rotation of Modes of Action (MoA), classification systems that group MoAs have been made. Since the 1980's, the groupings have changed to reflect the most up-to-date information about the chemical's herbicidal effects. A 2020 reconfiguration of the groupings by the Herbicide Resistance Action Committee led to a modified "Group 15" combining compounds predicted to "inhibit very long-chain fatty acid (VLCFA) synthesis". These VLCFA inhibitors were grouped together despite limited or no understanding of their target sites and indications that they may act on multiple sites or targets. Our research aimed to fill in some of the knowledge gaps for a subset of these Group 15 MoAs. We focused on analyzing how herbicide application altered plant growth and lipid metabolism. We measured the roots and shoots of two well-characterized blackgrass biotypes in an agar-based, closed, sterile system. Our data shows that when applied to blackgrass seeds, different herbicides lead to distinct physiological and metabolic phenotypes. Our data shows that each herbicide differentially affects wax and VLCFA compositions. Moreover, we see that the two different blackgrass biotypes respond differently to a given treatment; however, neither biotype has capacity to fully resist the herbicides we tested. Our data measuring efficacy, physiological impacts, biochemical changes, and biotype-specific responses support the suggestion that these Group 15 herbicides operate through different MoAs and that blackgrass biotypes have evolved differences in how they respond to them.

This work was funded by Gowan Crop Protection Limited. Rothamsted Research receives strategic funding from the Biotechnology and Biological Sciences Research Council of the United Kingdom (BBSRC). We acknowledge support from the Growing Health Institute Strategic Programme [BB/X010953/1; BBS/E/RH/230003A].

S03-O3. Understanding gene regulation in flufenacet resistant ryegrass (*Lolium* spp.)

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Intensive use of herbicides has led to the selection of resistant weed populations across the globe, which poses a significant challenge to sustainable weed management. Ryegrass species (*Lolium* spp.), especially *L. rigidum* and *L. multiflorum* have evolved resistance to multiple herbicide chemistries, often due to enhanced metabolism. Resistance to flufenacet, an inhibitor of very-long-chain fatty acid (VLCFA) synthesis is an example of rapidly evolving metabolic resistance. While the detoxification of this herbicide through glutathione transferases (GSTs) is well characterized, the regulation of GSTs remains poorly understood. Therefore, a weighted gene co-expression network analysis (WGCNA) based on RNA-Seq data was conducted. The analysis revealed co-regulated GSTs, genes involved in glutathione metabolism, and associated transcription factors as potentially critical elements of resistance. Additionally, promoter sequences of a flufenacet-detoxifying in susceptible and resistant individuals were sequenced using Nanopore technology. Promoters of both groups contained potential binding sites for some, but not all, co-regulated transcription factor families. These findings offernew insights into the regulatory mechanisms underlying the evolution of metabolic herbicide resistance.

The project was funded by DFG (project number 521767580).

S03-O4. Understanding the mechanisms underlying herbicide synergy

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Herbicide treatment contributes to the elimination of weeds, but their overuse has caused resistance/tolerance to develop. Using combinations of herbicides represents one approach to overcoming the emergence of resistance due to a phenomenon called synergy. Synergy is established when two or more compounds have a greater response together compared to the sum of their individual responses. Despite its rarity, synergistic effects have been found between 4-hydroxyphenylpyruvate dioxygenase (HPPD) and photosystem II (PSII) inhibitors. Atrazine, a PSII inhibitor, and Mesotrione, a HPPD inhibitor were one of the earliest identified combinations to display synergy. HPPD inhibitors, inhibit the biosynthesis of plastoquinone (PQ) and PSII inhibitors, impair the D1 subunit, therefore blocking the reduction of PQ and electron gradient. The carotenoid biosynthesis is also affected as there is a lack of pigment in the plant and no photoprotection is available, leading to necrosis. Plastoquinone is a common molecule which plays a vital role in both mechanisms therefore its study is also key in understanding synergy. This present study aims to understand the molecular and biochemical mechanisms underlying PSII/HPPD herbicide synergy by (1) establishing *in vivo* cultivation procedures to identify synergy and (2) metabolite profiling material to identify potential biomarkers using multiple analytical platforms.

To search for synergy, sub-lethal doses have been identified for atrazine and mesotrione, and 16 combination treatments at various sub-lethal dosages were tested in media and in soil using *Nicotiana tabacum* as the model plant. The two approaches led to different EC50s for each herbicide. Therefore, differing working concentrations for each approach was required. Furthermore, in media, synergy was identified when the lowest concentration of atrazine (0.3µM) was tested with mesotrione concentrations ranging from 0.002µM to 0.01µM. In soil, synergy identification was more prominently identified throughout atrazine (47.2µM to 80.2µM) and mesotrione (7.2µM to 9.6µM) combinations. Metabolomic profiling of the treated and freeze-dried *N. tabacum* material was conducted on a range of analytical platforms to assess perturbations in steady state level of metabolites across metabolism. Understanding these changes will hopefully contribute to the underlying metabolic mechanisms associated with synergistic effects resulting from atrazine and mesotrione combinations.

Acknowledgement / funding: Syngenta.

S03-O5. The Aux/IAA gene family plays a critical role in auxin herbicide resistance

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Background: Auxin herbicides are important in the control of broad-leaved weeds and instances of herbicide resistance to this group of chemistries are steadily on the rise. We have a growing body of evidence pointing to the *Aux/IAA* gene family as the causal basis for auxin herbicide resistance.

Results and discussion: Our group has identified *Aux/IAA* mutations in several weed species that are resistant to auxin herbicides. Some of these mutations provide cross-resistance to multiple auxin herbicides, while others only to one. There is no metabolic breakdown of the herbicides but, a reduction in herbicide translocation is observed in several species that have the *Aux/IAA* mutations. We suggest a novel decoy mechanism resulting from the mutations that prevent the translocation of the auxin herbicide from the treated tissues to the rest of the plant.

Conclusions: Deeper understanding into auxin herbicide-Aux/IAA dynamics will better illuminate the inherent risk of auxin herbicide use but, also opportunities to mitigate and manage that risk.

Acknowledgement(s) / funding: GRDC and Nufarm.

S03-O6. Exploring the interactions of target and non-target site mechanisms of glyphosate resistance in *Conyza canadensis*

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Glyphosate resistance in *Conyza canadensis* (Canada fleabane) poses a significant challenge to sustainable weed management. This study explores the genetic mechanisms behind this resistance, focusing on the interplay between target-site resistance (TSR) and non-target-site resistance (NTSR). To investigate these mechanisms, a segregating F2 population was generated using parental biotypes with confirmed resistance (PR) and susceptibility (PS). Dose-response assays revealed that the PR biotype exhibited up to 15-fold greater resistance compared to PS. Genotyping F2 individuals surviving 7200 g ae ha^{-1} glyphosate for the P106S mutation in the *EPSPS2* gene identified homozygous Proline individuals, confirming that PR harbors both TSR and NTSR. These NTSR individuals were selfed to create F2S1 lines for further study. The combined TSR and NTSR mechanisms in the PR conferred resistance levels 2- to 10-fold higher than NTSR alone, as observed in the F2S1 lines. Genotype-by-sequencing (GBS) of 479 individuals identified 212,419 single nucleotide polymorphisms (SNPs), later filtered to 21,121 SNPs across 455 individuals. Statistical analyses, including Haley-Knott regression and linear mixed models (using standard kinship matrices and the Leave One Chromosome Out (LOCO) method), identified significant loci associated with glyphosate resistance. A major quantitative trait locus (QTL) on chromosome 4 was found, spanning over 5 megabases (~37–42.3 Mbp) and containing 581 annotated genes. A smaller QTL on chromosome 1, within a region lacking annotated genes, was also identified.

S03-O7. Development of glyphosate resistant tomato

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Glyphosate (N-[phosphonomethyl]-glycine) is a broad spectrum, globally dominant herbicide. It's mode of action is the competitive inhibition of the chloroplastic enzyme 5-enolpyruvylshikimate-3phosphate synthase (EPSPS), a key enzyme in the biosynthesis of aromatic amino acids. Glyphosate is used as a foliar-applied, non-selective herbicide, which is effective against the majority of annual and perennial grasses and broad-leaved weeds. It has no pre-emergence or residual soil activity and is not prone to leaching, degrades in soil over time, and has minimal toxicity to mammals, birds and fish. But tomato is extremely sensitive to glyphosate. Therefore,our goal was to develop glyphosate-resistant tomato.

Based on the literature and on the sequence of the preferred target (Solyc01g091190) among the three EPSPS genes in tomato we designed synthetic genes (the donors) with a similar sequence as Solyc01g091190, but with base substitutions that generated the double a.a. substitutions TIPA and TIPS as well as the triple a.a. substitution TAP/IVS. In addition to the proposed mutations in the coding sequence, we swapped the endogenous EPSPS Solyc01g091190 promoter with the strong and constitutive UBQ10 tomato promoter.

We generated transgenic plants of the all gene models. Plants of the second generation were tested for glyphosate tolerance and the fitness cost of the mutations. We could not detect glyphosate tolerance in the lines driven by the endogenous S/EPSPS promoter, indicating that the EPSPS TIPA, TIPS, and TAP/IVS mutations are ineffective without overexpression. Promoter swapping resulted in increased expression. No glyphosate tolerance was found in gene models of EPSPS and TIPA driven by UBQ10. Only the TIPS and TAP/IVS mutation combined with the increased expression resulted in strong glyphosate resistance with minimal resistance cost.

Acknowledgement(s) / funding: National Center for Genome Editing in Agriculture, Israel.

S18-O1. How genomics contributes to improve herbicide resistance evolution modelling prediction in the fields

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Weed control contributes to guarantee crop yield and quality in modern agriculture. Integrated Weed Management (IWM) based on the right combinations of agronomic measures and herbicide uses is the major approach to insure crop production sustainability. The rare new herbicide modes of action found during the last decades and the intensive use tolerant crops to few herbicides have contributed to resistance evolution with new unique resistant cases observed every year (Weedscience.org database). Herbicide resistance involved several resistance mechanisms which evolve independently and can be observed alone or in combinations in the weed resistant populations. Either the target can be modified by mutations (Target Site Resistance, monogenic trait) or the herbicide cannot any more reach its target either because it is detoxified (enhanced metabolism), or its transport or its uptake can be inhibited, or it can be transported directly into the vacuole (sequestration). These non-target site resistance mechanisms are still poorly understood and in many cases are under the control of multiple genes (polygenic traits). Models to predict resistance evolution in the fields can be of two kinds. They can rely on mathematical equations mimicking the weed development cycle (mechanistic models) or on AI, like a random forest approach, based on field history. The number of genes involved in the resistance is one key parameter to improve the existing models, especially the mechanistic ones. Genomic can be of great help to find these genes and understand their activity and regulation. Examples will be presented using black-grass (*Alopecurus myosuroides*) resistant to post emergence ALS-inhibitor herbicides (HRAC Group 2) and pre-emergence herbicides inhibitors of the synthesis of Very Long Chain Fatty Acids (HRAC Group 15). Genomic analyses related to the characterization of cytochrome P450 and glutathione transferase gene families will be discussed. Finally, it will be shown how to use this new knowledge to improve the modelling approaches aiming to choose the best strategies to mitigate the resistance evolution in the field in a cost efficiency way for the farmers.

S18-O2. Target-site resistance diagnosis reimagined: a new high-throughput method and its application to analyze hundreds of weed populations

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Herbicide resistance in weeds is threatening crop yields worldwide. Molecular techniques help to diagnose target-site resistance (TSR), a main mechanism for herbicide resistance. However, current methods are costly, slow, and lack scalability, limiting full assessment of resistance in weed populations. Also, because of high false negative rates, low TSR levels may go undetected. We present a cost-efficient, highly scalable method that combines sample pooling with compact and affordable Nanopore sequencing. We investigated the quantitative and qualitative distribution of TSR in hundreds of *Alopecurus myosuroides* (blackgrass) populations in Germany and *Eleusine indica* (goosegrass) populations in Mauritius. To estimate how TSR frequencies change in *A. myosuroides* after a single herbicide treatment in real-world conditions, we collaborated with German farmers to sample before and after spring application. Furthermore, we present the method's power to assess homeologue-specific TSR allele frequencies in polyploids and a workflow to detect low TSR in seed samples of commercial *Lolium* spp., which could represent a possible source of dispersal of resistant weedy *Lolium* spp. As herbicide resistance management becomes more complex, high-resolution diagnosis becomes increasingly important. We are confident that our new method can make significant contributions to addressing herbicide resistance in both research and the crop value chain.

S18-O3. EPPO database on resistance cases to plant protection products

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The EPPO Database on Resistance Cases is a collection of more than 900 documented cases of diseases/pests/weeds resistant to Plant Protection Products (PPPs). All cases in the database are based only on resistance occurring in the field. It provides information to authorities responsible for the registration of PPPs and other stakeholders such as the agrochemical companies across the EPPO region (52 countries) that apply for registration of PPPs, researchers, scientists, extension officers and other users of EPPO Standard PP 1/213 (Resistance risk analysis). It also facilitates a common understanding of the evolution of resistance to PPPs across the EPPO region, including the early identification of resistance trends. In addition, it helps to develop resistance management strategies that consider national and regional resistance contexts. Since its launch in 2021, the Database has been updated annually with new cases validated by the EPPO Expert Working Group (EWG) on Resistance to PPP. Up to now, the EPPO Database already lists 330 weed resistance cases from 16 countries within the EPPO region and covers more than 80 different weed species. Each resistance case corresponds to a given Crop (or Crop group)/Weed species/Mode of Action/Country combination. The highest number of resistance cases are reported for ALS inhibitors (HRAC group 2, 127 cases), PS II inhibitors (HRAC group 5, 88 cases) and ACCase inhibitors (HRAC group 1, 58 cases), being *Alopecurus myosuroides, Apera spica-venti, Papaver rhoeas, Lolium rigidum and Echinochloa crus-galli* the most reported ones. The Database also contains information on the mechanisms of resistance, the spread of resistant weed populations and provides a source of information for each case. With an increasing number of resistance cases entered each year, the EPPO Database on Resistance Cases is expected to become an important reference Database within the EPPO region over the coming years.

We thank all national contact points for entering resistance cases in the database and all experts from the EPPO EWG on Resistance to PPP for discussion and validation of the entered cases.

PS1-39. Expanding virus-mediated reverse genetic techniques to *Lolium* spp. using bsmv vectors

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Herbicide-resistant weeds pose a significant threat to agricultural productivity by reducing the effectiveness of chemical controls. To combat this, we need to gain a mechanistic understanding of herbicide resistance. Genes correlated with herbicide resistance have been identified in key weed species including *Lolium* spp. However, few have been functionally validated and even fewer shown to be necessary or sufficient to confer herbicide resistance. Virus-Induced Gene Silencing (VIGS) transiently reduces gene expression and therefore can be used to functionally validate gene targets in non-model plants. VIGS against *PHYTOENE DESATURASE* (BSMV:asPDS) induces photobleaching in black-grass (Mellando-Sanchez et al., 2020) and wheat (Lee et al., 2015), therefore we hypothesized it could also work in *Lolium*.

Inoculation with BSMV:asPDS induces photobleaching at variable efficiencies in *Lolium multiflorum, Lolium rigidum* and *Lolium* spp. biotypes, with some biotypes exhibiting 0% or low photobleaching whilst others exhibit up to 70-100% even within the same species. Moreover, we show sequence specificity is important; photobleaching is tenfold more efficient when the *PDS* sequence comes from *Lolium multiflorum* compared to *PDS* sequences from either wheat or blackgrass. Our data demonstrate it is possible to induce photobleaching in *Lolium* via VIGS, however the variable efficiencies we observe between biotypes may make further applications difficult. We are now in the process of developing VIGS vectors targeting suspected herbicide resistance targets. To test hypotheses related to sufficiency, virus vectors can also transiently drive overexpression *in planta*, and therefore we are testing virus-mediated overexpression (VOX) in *Lolium.*

PS1-40. Role of GSTs in the non-target site resistance to sulfonylureas in *Amaranthus palmeri*

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Non-target-site-based resistance (NTSR) to herbicides in weedy species is one of the worrisomes issues in crop production globally. The resistance can be the result of different physiological processes, such as herbicide metabolism. This mechanism has been reported in many weeds, such as *Amaranthus palmeri*, one of the extremely difficult weeds to manage nowadays. Glutathione S-transferases (GSTs) are one of the main classes of enzymes known for being responsible for herbicide degradation, such asacetolactate synthase (ALS) inhibiting herbicides. The objective of this study was to characterise the possible role of GSTs on the NTSR in *A. palmeri* to sulfonylureas, specially focusing on Phi and Tau class GSTs, as these are considered to be the most important GST classes in plants.

To this purpose, *A. palmeri* sensitive (S) and non-target-site resistant (R) seedlings were grown in vertical agar plates in the presence of the ALS inhibitor nicosulfuron and with or without NBD-Cl (a known inhibitor of GSTs). Both populations were grown hydroponically and were treated with different doses of nicosulfuron for seven days. GST activity was measured spectrophotometrically, and the expression of several GSTs was measured by qPCR. Root length of all germinated plants in vertical plates was measured. Root growth was significantly arrested by nicosulfuron in the S plants, no matter the NDB-Cl. R plants did not show a significant growth arrest with the nicosulfuron treatment, but this occurred when nicosulfuron was combined with NBD-Cl, evidencing that inhibition of GSTs (with NBD-Cl) allowed nicosulfuron to effectively suppress root growth. GST activity in resistant plants showed higher basal levels than in sensitive plants and it was induced by the herbicide, although it was not possible to identify the Phi or Tau GST whose expression would be related to such induction. This is the first study where the role of GSTs in the NTSR to ALS inhibitors is reported.

This work was funded by the Spanish Ministry of Science and Innovation (2020 117723-RB-100) and by the Public University of Navarre (PJUPNA04-2022). M.V.E and C J-M received funding from PhD fellowship from the Basque Government and a research staff contract in the “Investigo program”, by the Public University of Navarre/Government of Navarre, respectively. E.T-A was the beneficiary of an Initiation in Research grant (IMAB-Public University of Navarre).

PS1-41. First Report of ACCase Resistant *Avena fatua* L. (Common Wild Oat) in Sudan

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Sixteen *Avena fatua* L. (common wild oat) populations suspected of being resistance to Acetyl-CoA carboxylase (ACCase) inhibitors were collected in the Northern State of Sudan. The research aims to elucidate resistance status of *Avena fatua* populations under laboratory and greenhouse condition. Laboratory experiment was carried out using agar medium (0.9% *w/v*) dissolved in an autoclave at a temperature of 121ºC, and after decreasing the agar temperature to 35ºC, clodinafop-propargyl and pinoxaden were added at concentrations of 0, 0.2, 0.4, 0.8 and 1.6 µm/l; 0, 0.225, 0.45, 0.9 and 1.8 µm/l respectively. Eventually ten seeds were placed in each Petri-dish (9 cm in diameter) and the plates were kept at 18-25 ºC for 15 days. Greenhouse experiment was conducted in pots containing silt, sand, and manure. At the growth stage of 3-4 leaves, using knapsack sprayer, clodinafop-propargyl and pinoxaden were applied at four concentrations of 0, 0.148, 0.297, 0.595, and 1.19 L ha^{-1}; 0, 10.12, 20.25, 40.5 and 81g a.i ha^{-1} respectively, with untreated control plots lefts without herbicide application. Plant height was measured before herbicide application and on the 1, 3, 5, 7, 14 and 21 days after herbicide treatment. All experiments were performed using a complete randomized design CRD with 3 replicates. The degree of resistance of wild oats was calculated using the statistical analysis program Sigma-Plot 10.0. In the laboratory test, a highest germination rate was recorded at 18ºC for both treatments and the resistance indices were 6.8-fold for clodinafop-propargyl and 5.9-fold for pinoxaden compared to the sensitive population depending on the coleoptile length. In greenhouse experiment, resistance indices for clodinafop-propargyl and pinoxaden were 11.3 and 8.6-fold, respectively, compared to sensitive samples. This study concludes that common wild oats are resistant to ACCase-inhibiting herbicide with high degree of resistance.

PS1-42. Impact of TAP-IVS resistance and EPSPS amplification on the shikimate pathway in *Amaranthus hybridus* from Brazil

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Smooth pigweed (*Amaranthus hybridus* L.), native to South America, is now one of the main weeds in agricultural systems due to its rapid growth, high fecundity, stress tolerance, and genetic variability. Its global relevance has increased, along new cases of glyphosate resistance. In southern Brazil, resistant biotypes have been found to possess two target-site resistance mechanisms: a triple amino acid mutation (TAP-IVS) in the EPSPS (5-enol-pyruvylshikimate-3-phosphate synthase) gene sequence and EPSPS copy number variation (CNV). This enzyme, targeted by glyphosate, is crucial in the shikimate pathway, which is responsible for producing essential aromatic amino acids (AAAs) phenylalanine, tyrosine and tryptophan, important for protein synthesis and as precursors of secondary metabolites. However, the regulation of the shikimate pathway and how glyphosate affects it in *A. hybridus* populations with mutated EPSPS or EPSPS CNV remain unclear.

This study aims to assess the impact of EPSPS CNV and TAP-IVS mutation, and glyphosate treatment on the shikimate pathway and free AAA content. To achieve this, three populations of *A. hybridus* will be studied: sensitive (GS), resistant with TAP-IVS mutation (GR1) and resistant with TAP-IVS mutation and EPSPS CNV (GR2). The plants will be grown hydroponically and treated with increasing doses of glyphosate (0, 1x and 3x the field dose, equivalent to 0.84 kg a.e. ha^{-1}). After three days, the leaves will be collected. Shikimate content will be measured spectrophotometrically and AAA content will be measured by capillary electrophoresis. The expression of several key enzymes of the shikimate pathway (3-Deoxy-D-arabinoheptulosonate 7-phosphate synthase (DAHPS), EPSPS, and anthranilate synthase (AS)) will be evaluated by qPCR. The hypothesis suggests that the GS population will experience a greater impact on the shikimic pathway regulation than in the GR1 and GR2 populations. In resistant populations, less interference in the AAA pathway is expected. However, the pathway may respond differently in each population, which justifies the study. This work will contribute to a better understanding of the physiological impacts of target-site resistance mechanisms, going beyond the analysis of the herbicide's target enzyme, improving our knowledge of metabolic regulation in *A. hybridus*.

The authors would like to thank the Coordination for the Improvement of Higher Education Personnel (Capes), the Universidad Pública de Navarra (UPNA) and the Federal University of Viçosa (UFV).

PS1-43 In vitro seed bioassay to uncover single and double EPSPS glyphosate resistance mutations in *Eleusine indica*

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Herbicide resistance is the heritable ability of a populationto survive and reproduce after the application of a herbicide dose that would normally be lethal to the original population. Early diagnosis is key to managing resistant populations. One of the most commonly used methods for diagnosing resistant populations is the dose-response of young plants, but requiring significant time to observe the response and large infrastructure. *In vitro* tests involve a much quicker phenotypic resistance diagnosis consisting of assessing germination and growth of seeds growing in a medium with herbicide.

The aim was to propose an alternative methodology to reduce the time, space, and equipment needed to diagnose glyphosate resistance in naturally evolved populations with target-site mutations. In this study, calibration curves were used to determine the discriminant glyphosate concentration capable of differentiating between glyphosate-susceptible and -resistant *Eleusine indica* (L.) Gaertn. plants. Homozygous resistant populations with one (P106S) or two target-site EPSPS resistance mutations (TIPS), and susceptible (WT) were used.

In the first trial eight glyphosate concentrations (31.25, 62.50, 125, 250, 375, 500, 750, 1000 µM) were analyzed, along with an untreated control (no herbicide). A second trial was carried out testing concentrations of 600, 700, 800, 900, and 1000 µM. Thirty-six seeds from each population were tested with three replicates. Seeds were incubated at 30/20°C with a 12-hour photoperiod (60 µmol m^{-2} s^{-1}). Seed germination, length of coleoptile and fresh weight were analyzed.

Among the variables analyzed, we determined that the number of seedlings with a coleoptile length equal and higher than 0.75 cm was a useful trait for better discriminating of populations. Starting at a concentration of 250 µM, the WT population can be differentiated from the two resistant populations after 7 days. For the resistant populations, starting at a concentration of 800 µM, a differentiation between P106S and TIPS populations can be observed after 7 or 9 days. At a concentration of 1000 µM, only TIPS population seedlings survived. This method allows for a reduction in the time needed for data collection, which would facilitate agronomic management decisions.

This work has been funded by the Foundation Carolina.

PS1-44. Deciphering the mechanisms of reduced sensitivity to metazachlor in *Tripleurospermum perforatum*

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Tripleurospermum perforatum (Mérat) Lainz (MATIN) is an annual dicotyledonous weed species wide spread in Europe. Hitherto, herbicide resistance to acetolactate synthase (ALS) inhibitors has been reported in eight Central and Northern European countries (Czech Republic, Denmark, France, Germany, Norway, Poland, Sweden, United Kingdom).

During a Germany-wide herbicide resistance survey, a MATIN population (M363) with reduced sensitivity to metazachlor, an active substance inhibiting the synthesis of very long chain fatty acids (HRAC group 15), was identified. Two resistant individuals of this population were crossed to generate an F1-population (M363-1). The M363 and M363-1 populations showed reduced metazachlor sensitivity in soil- and agar-based bioassays. Our understanding of resistance mechanisms to HRAC group 15 is limited. From literature, glutathione-S-transferases (GSTs) is suggested to play a key role in herbicide detoxification process during phase two of metabolism. As GSTs form a large protein family, genomic data are needed to further investigate their role in herbicide detoxification. Until now, only a few individual genetic sequences are known for MATIN. Thus, RNA sequencing of plants from the M363 population was conducted. Leaf material for RNA isolation from 15 MATIN seedlings with reduced sensitivity to metazachlor was harvested and pooled at one, two, and seven days after metazachlor treatment in four replicates each. Untreated replicated controls were also included for each time point. Extracted RNA were prepped and sequenced using paired-end 150bp Illumina sequencer. The raw reads were filtered, trimmed and aligned to a de-novo assembled transcriptome to gain insights in possible differentially expressed GST sequences.

At the same time, the metabolism of metazachlor in MATIN was further investigated. MATIN M363-1 plants with reduced sensitivity to metazachlor and sensitive reference plants were germinated and treated with metazachlor in a nutrient solution-based test system. Plants were harvested at defined time points and will be analysed using UHPLC-ESI-Q-TOF-MS. This will lead to the identification of quantitative or qualitative differences in metazachlor degradation in the genotype with reduced sensitivity.

PS1-45. Resistance to als-inhibitors or glyphosate in populations of *Amaranthus palmeri* from Aragon (Spain)

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Amaranthus palmeri is considered a highly dangerous weed in agricultural systems due to its rapid growth rate, high seed production and competitive advantage. Moreover, it is particularly harmful partly due to its propensity to evolve resistance to multiple herbicide sites of action. In Spain it was first identified in 2007 in Lleida, but it is now found in regions like Aragon and Extremadura, primarily affecting cornfields. Resistance to glyphosate or ALS-inhibitors in several populations of Catalonia or Extremadura has been reported, all of them due to target-site resistance mechanisms. Nevertheless, the resistance pattern in populations from Aragon has not been extensively studied. The main objective is to characterize the possible resistance of five populations to the EPSPS inhibitor (glyphosate) and ALS inhibitors (nicosulfuron and imazamox). All of them have been collected in different locations of the autonomous community of Aragon: Albelda (population A), Bujaraloz (B), Caspe (C), Altorricón (R) and Tamarite (D).

For this purpose, different experimental approaches have been made. First, plants were grown in hydroponics and treated with different doses of glyphosate. Leaves were collected to determine shikimate content (spectrophotometrically) and the number of EPSPS gene copies (target-site resistance, TSR) by qPCR. Second, seedlings were grown in vertical plates in the presence of the herbicides (glyphosate or one of the two ALS-inhibitors: nicosulfuron and imazamox) which allowed the measurement of root length in response to the different herbicides. Preliminary results reveal that resistance to glyphosate or ALS-inhibitors has appeared in Aragon. Only one population (pop. B) was described as glyphosate-resistant, as shikimate content was lower in plants treated with glyphosate than in other populations, and root growth in vertical plates was not affected by the herbicide. Most populations were resistant to ALS-inhibitors and cross-resistance was screened. Molecular analysis in order to evaluate the resistance mechanism will be performed and discussed.

This work was funded by the Spanish Ministry of Science and Innovation (2020 117723-RB-100) E.T-A was the holder of a postgraduate research fellowship (call 2024) of the Sociedad Española de Malherbología (SEMh). The authors would like to thank the Plant Health and Certification Centre (CSCV) from Aragon for providing the plant material for the trials.

PS1-46. Susceptibility of *Echinochloa crus-galli* populations from Spanish maize fields to the herbicides S-metolachlor, dimethenamid-P and isoxaflutole

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Echinochloa crus-galli is one of the most troublesome weed species in agriculture. Although herbicide resistance for *E. crus-galli* in maize fields is not very widespread in Europe, resistance to ALS and to photosystem II (PS II) inhibitors has been reported. Very long chain fatty acids (VLCFA) and 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors are among the most frequently used preemergence herbicides in maize fields. The goal of this study was to investigate the variation in the response of six *E. crus-galli* populations from maize fields in Castilla y León,the region with the largest area of maize cultivation in Spain,to the soil-applied herbicides S-metolachlor, dimethenamid-P and isoxaflutole. These populations had been previously classified as susceptible.

Twenty seeds of each population were sown in 1 L pots containing a mix of 3/4 of manure, sand and soil (1:1:1 by volume) and 1/4 of vermiculite, and watered as required. The preemergence (PRE) treatments were done 24 hours after sowingwith 7 different doses for each herbicide: S-metolachlor (0, 2.8, 5.6, 15, 45, 180 and 1440 g ha^{-1});dimethenamid-P (0, 2, 4, 10.5, 31.5, 126 and 1008 g ha^{-1}); isoxaflutole (0, 0.75, 1.5, 3, 12, 48 and 96 g ha^{-1}). Doses were selected to cover the whole range of herbicide responses, from no visible effects to completely dead plants. For each population and dose, 3 replicated pots were sprayed in three independent spray events. After spraying, the pots were placed randomly ina growth chamber with a photoperiod of 16 h light, with 300 µE $m^{-2}s^{-1}$PAR and 8 h of darkness and 25ºC ± 2°C / 20ºC ± 1°C (day/night). Three weeks after the herbicide treatment, surviving plants were cut and weighted to assess the fresh weight and oven-dried for 48 h at 80°C to obtain the dry weight. Dose-response curves based on the Seefeldt *et al.* (1995) log-logistic model were used to determine the herbicide response.

The dose-response curves generated in this study provide a benchmark for detecting changes in the susceptibility of *E. crus-galli* populations to the most commonly used preemergence herbicides in maize fields in Castilla y León.

This work has been funded by the Spanish Research Agency, PID2022-136920OR-C41.

PS1-47. The use of population models and machine-learning models in the prediction of herbicide resistance

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Model-aided predictions of herbicide resistance provide important information to weed management strategies and agricultural practices. Weed population models are knowledge-based and constructed based on weed biology, genetic mechanisms and weed control practices. They are useful in comparing different candidate weed control programs, promote best management practices and point to knowledge gaps in weed research. Machine-learning models, on the other hand, are data-driven, and requires long-term and large-scale collection of data. They are useful in resistance landscape predictions, addressing uncertainty and providing localised recommendations. In Syngenta, we build and apply both types of models to further our understanding of weed population dynamics and their evolutionary processes. We have used population models to compare the resistance risk and sustainability of different weed control strategies, including herbicide mixtures, early weed management, integrating agronomic practices in both annual and perennial weeds. We have also built machine-learning models to predict future resistance hotspots in terms of weed species, location and chemical mode of action. In this talk, I will give some examples of how we have built and applied these models and discuss the perspectives of combining the two modelling approaches for better and more efficient predictions based on some of our research attempts.

PS1-48. Resistance to nicosulfuron-methyl in Spanish populations of *Panicum dichotomiflorum* is based on enhanced metabolism

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Panicum dichotomiflorum Michx is an annual Poaceae that is considered allochthonous and expanding in Spain. In the summer of 2022, ineffective chemical control of P. dichotomiflorum were reported in maize fields in Gerb, Catalonia (GB-R), and Sodeto in Aragon (SO-R) with a history of repeated use of nicosulfuron. The objectives of this study were: (1) determine nicosulfuron resistance levels using a whole-plant dose-response bioassay, and (2) characterize target and non-target site resistance mechanisms by PCR and partial sequencing in the ALS gene and pretreatment with metabolite inhibitors. A sensitive population was obtained from Torres de Segre (TS-S) in Catalonia and used as sensitive control. The results of dose-response bioassays showed that GB-R and SO-R populations presented 23 (GR50= 66.3 g a.i. ha-1) and 29 (GR50= 83.8 g a.i. ha-1) times higher resistance, respectively, compared to TS-S, which required 2.9 g a.i. ha-1 of nicosulfuron-methyl to reduce its biomass by 50%. Sanger sequencing of the ALS gene in resistant and sensitive populations confirmed the absence of point mutations at positions previously associated with resistance to ALS inhibitors. The levels of resistance to nicosulfuron-methyl in GB-R and SO-R populations decreased by 76% and 80%, respectively, after pretreatment with piperonyl butoxide (PBO), a cytochrome P450 inhibitor (Phase I). Similarly, when pretreated with 4-chloro-7-nitrobenzofurazan (NBD-Cl), an inhibitor of GST enzymes (Phase II), the resistance levels decreased by 90% and 81.3%, in GB-R and SO-R respectively. This study demonstrated the role of P450 and GST enzymes in the metabolism of nicosulfuron-methyl highlighted their function as a resistance mechanism in two Spanish population of *P. dichotomiflorum*.

PS1-49. Weed resistance status in *Echinochloa phyllopogon* from Portuguese rice fields

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Rice is an important crop in Portugal covering an area of 30 000 ha, with a mean production of 9 t /ha that is not enough to cope with consumers demand of 15,9 kg per capita. Weeds are main phytossanitary problem particularly *Echinochloa* spp., *Cyperus difformis*, *Heteranthera* spp, *Alisma plantago aquatica* and more recently *Leptochloa fusca* subsp. *fascicularis*. Populations of *Echinochloa phyllopogon* (syn. *Echinochloa oryzicola*) resistant to ALS-inhibitor herbicides have been identified in rice fields from three main production regions– north, center and south Portugal. The level of resistance was confirmed with dose-response bioassays however the resistance mechanisms were not yet fully elucidated. Therefore, we studied the resistance of 21 biotypes under greenhouse and laboratory conditions. The objective of this study was to confirm whether target site resistance could explain the differences between sensitive and resistant *E. phyllopogon* biotypes. In order to confirm this hypothesis, sequencing of acetolactate synthase (ALS-1) gene and the estimation of its number of copies were carried out. After being exposed to penoxsulam, DNA was extracted from R and susceptible populations. The sequencing of cDNA sequence encoding the ALS enzyme revealed that the most frequent point mutations responsible for ALS-inhibitors resistance [Ala122Thr/ Pro197Thr/ Ale205Val/ Asp376Glu/ Arg377His/ Trp574Leu/ Ser653Thr /Gly654Glu] were not present. The estimation of the relative ALS gene copy number, by means of quantitative real time-PCR and ΔΔCt value, revealed a two-fold amplification of the ALS-1 gene. The overexpression of the ALS gene contribution as a mechanism of resistance to penoxsulam was not previously mention in the literature. Cross resistance to other mode of action herbicides is also discussed related to non-target site resistance. Further studies on resistance mechanisms are in course

This research was funded by Study financed by the project PEI-AGRI Operational Group +ARROZ PDR2020-1010, grant number: PDR2020-101-031998.

PS1-50. Resistance to glyphosate and accase inhibitors in Johnsongrass from Argentina

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Sorghum halepense (Johnsongrass) is one of the most important weeds in spring/ summer crops in Argentina. It is widely distributed in different agricultural regions of the country, mainly in the core soybean zone (provinces of Santa Fe, Cordoba and north of Buenos Aires) and on the grain crop production region of northwestern Argentina. In this area the first case of glyphosate resistance was recorded in 2005. Since then, populations resistant to this herbicide have expanded significantly. As a result, the use of graminicide herbicides (ACCase inhibitors) for the control in soybean crops.In this context, a long-term study was carried out between 2014 and 2024 with the aim of characterizing the response of different johnsongrass to the herbicides glyphosate and ACCase inhibitors (haloxyfop methyl and clethodim). Around 400 populations were studied and for each population, twenty-five individuals were treated with each herbicide (glyphosate, haloxyfop-methyl and clethodim) at the recommended and half label doses (x and 0,5x). The treatments were carried out with a constant pressure backpack at an average of 6 expanded leaves. Sowing was done manually, and the seedlings were subsequently transplanted to 1,2 l pots.Survival for each treatment was recorded 30 days after the treatments were applied, and the population with survival equal to or greater than 30% was considered resistant to each herbicide. Seventy-eight (78%) of the populations were resistant to glyphosate and 17% and 7% to haloxyfop methyl and clethodim, respectively. Ten (10%) were susceptible to all treatments and 47% were resistant only to glyphosate. The area with the least evidence of resistant populations is Buenos Aires province. Interestingly, different genetic mutations were identified on samples resistant to haloxifop methyl and clethodim and only haloxifop methyl.

Acknowledgement(s) / funding: Syngenta Agro- Facultad de Agronomìa. Universidad de Buenos Aires.

PS1-52. The effect of climate change on the efficacy of acetyl-CoA carboxylase inhibitors - L*olium rigidum* and *Alopecurus myosuroides* as a case study

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Climate change is predicted to significantly affect agricultural ecosystems by increasing weather unpredictability and food insecurity. It may also reduce herbicide efficacy by altering plant physiology and environmental conditions. Our research aims were to investigate reduced herbicide sensitivity in *Lolium rigidum* and *Alopecurus myosuroides*, two of the most competitive grass weeds in European agriculture, under changing climatic conditions.

We tested how fluctuating post-herbicide-application temperatures, simulating climate change, may affect the sensitivity of herbicide-resistant and -sensitive populations of *L. rigidum* (Israel) and *A. myosuroides* (Germany) to two acetyl-CoA carboxylase (ACCase) inhibitors. Therefore, we have exposed plants of resistant populations of *L. rigidum* and *A. myosuroides*, characterized by target site (TS) and non-target site (NTS) resistance mechanisms and a sensitive reference population, to two rates of pinoxaden and clodinafop-propargyl. After herbicide application, plants were exposed to one of three temperature regimes – control (15°C/8°C, day/night) or extreme (30°C/26°C, day/night) temperatures (heat wave) for 24 or 72 hours (h), then transferred them back to control conditions. In addition, untreated plants were also exposed to the three different temperature regimes. To assess the influence of different temperatures on herbicide efficacy, survival rate and biomass were measured 21 days after herbicide application. As expected, both *L. rigidum* and *A. myosuroides* sensitive populations did not survive the herbicide treatments regardless of the temperature treatment. However, for the resistant populations, an increase in survival rates were recorded when plants were exposed to 72h of extreme temperatures. Moreover, plant biomass of the plants exposed to the 72h extreme temperature interval was higher than those exposed to the 24h interval, corresponding to their higher survival rates.

The results of this work show that extreme temperatures can reduce herbicide efficacy, especially in metabolism-based resistant populations. These results emphasizes the urgent need for adaptive weed management strategies to sustain agriculture in the face of climate change.

Acknowledgement(s) / funding: EWRS, University of Haifa, Julius Kühn-Institut (JKI), Volcani Institute Newe-Ya'ar Research Center.

PS1-53. A growing nightmare: dicamba resistance in *Amaranthus palmeri* populations from Spain

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*Amaranthus palmeri*S. Watson is one of the most problematic weeds in the American continent drastically reducing summer crops production. This species can easily evolve resistance to multiple herbicide mode of action (MoAs), including auxin mimics like dicamba. This is a selective post-emergence herbicidegenerally used for controlling broadleaf weeds causing abnormal cell division and growth. *A. palmeri* resistant populations to dicamba have been reported in North America, but not in Europe. However, the presence of multiple herbicide-resistant *A. palmeri* populations has been confirmed in the Mediterranean Region (Spain, Italy and Turkey) and the resistance to dicamba is also suspected. This research was carried out to characterize the resistance profile to dicamba in three *A. palmeri* populations (R1, R2 and R3) from corn fields in Spain. To assess this, sensitivity to dicamba was evaluated in three *A. palmeri* populations compared to one from Georgia (USA) used as the susceptible standard (S) population. Dicamba was applied at rates: 0, 36, 72, 144, 288, and 576 g a.i. ha^{-1} for R1, R2 and R3, and 0, 9, 18, 36, 72, and 144 g a.i. ha^{-1} for S. Fifty days after treatment, the survival rate and fresh weight reduction was calculated. The S population was fully controlled at minimum recommended field dose (MRFD; 144 g a.i. ha^{-1}) while the 90% of individuals from R3 and 80% from R2 and R1 populations survived. The 80% of individuals from R3 population survived to double RFD (maximum recommended field dose, 288 g a.i. ha^{-1}). The LD_{50} values (herbicide dose needed to control 50% of a population) was 79 g a.i. ha^{-1} for the S population and 461, 280, 253 g a.i. ha^{-1} for R3, R2, and R1 populations, respectively. At RFD the fresh weight reduction (%) values were 34 % for R2, 44 % for R3 and 87% for R1. The GR_{50} values (herbicide dose needed to reduce biomass by 50%) was 9 g a.i. ha^{-1} for S population and ranged from 76 to 224 g a.i. ha^{-1} for Spanish populations. This research confirmed that three *A. palmeri*Spanish populations from corn fields have developed resistance to dicamba. However, further investigations are needed to describe the resistance mechanisms of these populations. Finally, R1, R2 and R3 populations have been previously reported to be resistant also to ALS inhibitors. The presence of multiple herbicide-resistant populations of *A. palmeri* from Europe highlights the need for integrated weed management approaches and preserve the efficacy of chemical control.

PS1-54. Evolution of resistance to ALS inhibitor herbicides in *Amaranthus palmeri* in the region of Extremadura (Western Spain)

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Amaranthus palmeri is one of the most competitive, problematic and economically damaging weeds due to its high genetic diversity, high seed production and high vigour. This weed has been found in different regions in Spain, mainly Catalonia and Aragon. In 2019, the first populations of *Amaranthus palmeri* were detected in Extremadura (Western Spain), in corn fields. From that year on, periodic surveys have been carried out. Until today, its presence has been confirmed not only in corn, but also in sunflower, industrial tomato, and almond trees.

The objective of this work was to study the evolution of resistance to ALS inhibitors in different populations in this region, at the gene sequence level (TSR), from 2019 to 2024. For this purpose, both the first locations found in 2019 were monitored, sampling each year in the same place, as well as adding new locations.

The results show that in the populations included in this work, a high frequency of mutations has been found at the ALS gene level, mainly at positions Trp574 and Pro197. A correlation has been made between the presence of TSR and crop rotation in different areas, and relationships have been found between crop rotation and TSR evolution. This work has been complemented with greenhouse trials of the different populations sampled to ALS inhibitors.

The project MIP3 is part of the Operational Program FEDER Extremadura 2021-2027. Action 1A1103. Development of scientific research, technological development and innovation capacity, co-financed at 85%.

PS1-55. Response of Spanish *Setaria* spp. populations from maize fields to the preemergence herbicides S-metolachlor, dimethenamid-p and isoxaflutole

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REGRAMA ("*Herbicide REsistance in GRAss weeds in MAize cultivation"*) is a research project funded by the Spanish Ministry of Science and Innovation to determine the current status and nature of herbicide resistance in most important maize grass weeds in Spain, to gain knowledge about the potential fitness costs associated with resistance and to develop detection assays to be used in resistance detection. The project started in September 2023, with four research groups involved: INIA-CSIC, CICYTEX, UPC and US.

Setaria species are among the most prevalent and damaging grass weeds in maize growing areas in Spain. Although several active substances are available for grass weed control in maize, VLCFA (very-long chain fatty acid)- and HPPD (4-hydroxyphenyl-pyruvate dioxygenase)-inhibiting herbicides are among the most used modes of action in pre-emergence. Their widespread and repeated use, due to their effectiveness and residual effect, coupled with limited crop rotation in maize cropping systems, is contributing to the emergence of resistant populations. The objective of this study was to determine the response of eighteen *Setaria* spp. populations randomly surveyed across Castilla y León, the region with the largest area of maize cultivation in Spain, to S-metolachlor, dimethenamid-p and isoxaflutole. The herbicide treatments were done 24 h after sowing at 1440 g a.i. ha^{-1}, 1008 g a.i. ha^{-1} and 96 g a.i. ha^{-1}, respectively. Herbicide screening was conducted under controlled greenhouse conditions. Six weeks after treatment, plant survival (%) was assessed and plants were classified as dead or surviving. In addition, surviving plants were visually assessed for herbicide injury and were cut at the soil surface and weighted. The fresh and dry weight parameters were calculated as percentage relative to the untreated controls. Biomass reduction was used as a measure of herbicide resistance. Accessions were classified using the 'R' resistance rating system (Moss *et al.* 1999).

All the screened *Setaria* populations were susceptible to both VLFA-inhibiting herbicides. However, while seventeen populations were susceptible to the HPPD-inhibiting herbicide isoxaflutole, one *S. pumila* population was classified as resistant,which must be confirmed in subsequent studies. The study emphasizes the importance of continuous monitoring to detect early signs of resistance development.

This work has been funded by the Spanish Research Agency, PID2022-136920OR-C41.

PS1-56. Cultivar contamination and herbicide resistance in ryegrass populations

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Ryegrasses (*Lolium* spp.) are competitive grass weeds that are prone to developing resistance to various herbicide modes of action. While these weeds were once predominantly confined to areas with intensive cultivation of ryegrass cultivars, they are now becoming increasingly widespread. To investigate the role of ryegrass cultivars in this expansion, 39 German weedy ryegrass populations were screened for resistance along with 34 commercial cultivars of the Festuca-Lolium complex available in Germany, and 18 commercial cultivars from the United States. Additionally, the ploidy levels of weedy ryegrass populations were assessed using flow cytometry, and crossing experiments were conducted between resistant weeds and various cultivars. A population genetics analysis was performed using a genotyping-by-sequencing (GBS) approach with 133 ryegrass accessions, including weedy, cultivar, wildtype, and historical herbarium samples. Greenhouse trials revealed that resistance was prevalent in 77% of weedy populations for ACC-CoA carboxylase (ACCase) inhibitors, 59% for acetolactate synthase (ALS) inhibitors, and 18% for very-long-chain fatty acid (VLCFA) inhibitors, including flufenacet. Resistance was observed in both diploid and tetraploid weedy samples. Two cultivars from Germany were found to be resistant: one *L. hybridum* cultivar exhibited resistance to ACCase inhibitors due to two independent point mutations in the ACCase gene, and another cultivar, initially classified as tetraploid *L. perenne*, exhibited resistance to all three herbicide modes of action, partly due to point mutations in the ACCase and ALS genes. However, this cultivar was recalled by the breeder before it could be marketed. Subsequent analyses revealed that this ‘cultivar’ clustered with *L. multiflorum* samples in the GBS analysis and was also diploid, similar to the majority (87%) of the weedy ryegrasses tested. These findings suggest that contamination with resistant weedy *L. multiflorum* may have occurred. Furthermore, the GBS analysis indicated a close genetic relationship between *L. multiflorum* weeds and cultivars. These results imply that gene flow between weeds and cultivars can occur under both controlled and field conditions, highlighting the need for caution in the use of ryegrass cultivars in agriculture. Systematic resistance testing and the use of tetraploid cultivars may help mitigate the risk of resistance geneflow.

The project was funded by DFG (project number 521767580).

PS1-57. Investigating allelic variations of the HPPD Inhibitor Sensitive 1 gene in *Oryza* sp. for application of benzobicyclon herbicide in rice systems

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Herbicide resistance in common rice weeds causes problems for EU rice producers. Currently, most of the herbicides used in this crop belong to 2 modes of action, ALS and ACCase inhibitors, but many cases of resistance to those herbicides have been reported. Benzobicyclon is an herbicide belonging to the group of HPPD enzyme inhibitors (group 27), a new mode of action among those currently used for rice cultivation in the EU. It controls a broad spectrum of problematic rice weeds, including aquatics, broadleaves, grasses, and sedges, including those currently resistant to ALS/ACCase herbicides. The *HPPD Inhibitor Sensitive 1 gene* (*his1*) is responsible for tolerance in rice. Sensitivity to benzobicyclon in certain rice cultivars is the result of a 28-bp deletion or from a nonsense mutation (T1510G). Weedy rice is a problematic weed in rice, the control of which currently depends largely on the use of herbicide-resistant rice varieties. Previous studies in U.S. rice growing areas have shown that benzobicyclon has some potential to be a complementary piece of the weedy rice control program, with its effectiveness depending on the *his1* gene. The objective of this study was to study the *his1* gene in different commercial rice varieties and weedy rice accessions to detect the presence of different changes in this gene related to herbicide sensitivity. Of the 124 commercial rice varieties included in the study (from different parts of Europe and Latin America) only one (CL125HP) showed the T1510G change. Concerning the weedy rice accessions included in the study, only 1 out of 120 from Spain showed this the T1510G change. However, 10 out of 16 weedy rice accessions from Colombia showed changes in the *his1* gene related with sensitivity to the herbicide (2 with 28 bp deletion and 8 with the T1510G).

In conclusion, the addition of benzobicyclon to current rice weed control programs provides a new effective mode of action for growers, by contributing to control of a broadened spectrum of weeds helping to mitigate further evolution of herbicide resistance. On the other hand, the inclusion of benzobicyclon in management programs, can provide some protection against weedy rice.

PS1-58. New tools for rapid ALS resistance detection in *Papaver rhoeas*

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Papaver rhoeas L. (common poppy) is a widespread and economically important weed of winter cereal crops in Europe, with a high incidence of target-site resistance to ALS-inhibiting herbicides. Several substitutions at codon Pro197 result in poor efficacy mainly against sulfonylureas, while the relatively uncommon Trp-574-Leu substitution confers resistance to all ALS-inhibiting chemical families. Aiming to develop a high-throughput detection system for ALS resistance mutations, three TaqMan qPCR assays were designed, optimized for annealing temperature and primer/probe concentration, and validated against samples with known genotypes previously assessed by Sanger sequencing. For this purpose, four *P. rhoeas* populations, one susceptible (S) and three with putative resistance to ALS inhibitors (R) were grown in pots and subjected to field-rate applications of tribenuron (sulfonylurea) and florasulam (triazolopyrimidine). All S population plants were controlled with both herbicides. Genomic DNA was extracted from the leaf tissue of 4-5 surviving plants per R population and from non-treated plants of the S population, and was amplified for Pro197 and Trp574 *als* codons. Sanger sequencing revealed that plants from the three R populations contained point mutations at the *als* gene resulting in the substitution of Pro197 to Arginine, Serine, Alanine and Threonine in one or two alleles, and of Trp574 to Leucine in one allele. No mutations were found in the S population. The developed TaqMan assays enable precise differentiation of resistance mutations at codons Pro197 and Trp574 using fluorescently labeled probes and were configured in the following setup: (1) Pro197a: A 5-plex assay that detects the wild-type (Pro) allele labeled with HEX, along with four mutant alleles: Ala (FAM), Thr (TexasRed), Arg (Atto647N), and Gly (Cy5.5), (2) Pro197b: A 4-plex assay that detects the wild-type (Pro) allele (HEX) and three mutant alleles: Ser (FAM), His (TexasRed), and Leu (Atto647N), (3) Trp574: A 2-plex assay that detects the wild-type (Trp) allele (HEX) and the mutant Leu allele (FAM). Ultimately, these assays will be integrated into 'ready-to-use' lyophilized pellets that will require only the addition of biological material (e.g., crude weed tissue homogenate) for immediate qPCR analysis, thus enabling the rapid and accurate detection of ALS resistance in *P. rhoeas.*

The study was part of the project “Innovations in Plant Protection for sustainable and environmentally friendly pest control, InnoPP - TAEDR-0535675 that is ¨Funded by the European Union- Next Generation EU, Greece 2.0 National Recovery and Resilience plan, National Flagship Initiative “Agriculture and Food Industry”.

PS1-60. How do herbicide restrictions increase the incidence of herbicide-resistant weed populations

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Background: Legislative measures within the European Union regarding pesticide use are becoming increasingly stringent, particularly for herbicides. These restrictions are primarily driven by scientific assessments of herbicides' effects on human health, biodiversity, and the environment. While outright bans are uncommon, limitations on application rates and usage frequency are widespread. The slow development of new active ingredients and novel modes of action further exacerbates weed management challenges, leading to unintended agronomic consequences, including shifts in weed populations and herbicide resistance.

Materials and Methods: This study analyzes the implications of EU herbicide regulations on weed management strategies, focusing on the Czech Republic. The assessment includes the expected impact of restrictions on soil-applied herbicides and the subsequent increased reliance on acetolactate synthase (ALS) and acetyl-CoA carboxylase (ACCase) inhibitors. Specific attention is given to key problematic weed species, such as *Bromus sterilis* and *Vulpia myuros*, as well as resistance trends in *Amaranthus*, *Chenopodium*, and *Papaver* species.

Results and Discussion: Findings indicate that restrictions on soil-applied herbicides will shift weed control strategies toward post-emergence applications, primarily using ALS and ACCase inhibitors. This shift is expected to heighten selection pressure on weed populations, accelerating resistance development. *Bromus sterilis*, already difficult to manage, exhibits significant tolerance to most soil-applied herbicides, making deep plowing one of the few remaining effective control measures. The anticipated ban on flufenacet further complicates *Vulpia myuros* control, potentially leading to its increased prevalence. Farmers are expected to rely more heavily on spring herbicide applications, where regulatory restrictions are less severe, but this strategy may further contribute to resistance selection. Additionally, herbicide-resistant weed populations in wide-row crops are increasing, with resistance cases in *Amaranthus*, *Chenopodium*, and *Papaver* species projected to rise further.

Conclusion: Tightening herbicide regulations in the EU will lead to significant agronomic shifts, increasing reliance on post-emergence herbicides and alternative control strategies. This transition, however, is likely to intensify resistance evolution in multiple weed species, necessitating integrated weed management approaches, including mechanical control and crop diversification, to sustain effective weed suppression.

The study has been financially supported by the Ministry of Agriculture project No. QL24010167.

PS1-61. New control options for management of ALS and ACCase resistant *Echinochloa* spp. in rice

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Rice is one of the most widely grown cereal crops in the world. It's grown in over a hundred countries, and 90% of the world's production is from Asia. Europe has several important rice-producer countries and Turkey is one of the leading countries regarding production and yield. This review aims to provide an overview of herbicide resistance in rice-growing areas in Europe. *Echinochloa oryzoides (Ard) Fritsch*and *Echinochloa crus-galli*L. resistance to herbicides with different modes of action (MoAs) has been reported previously.

Baloric 310 EC (Pretilachlor + Florpyrauxifen-benzyl) is a new tool for controlling ALS and ACCase-resistant *E. oryzoides* and *E. crus-galli* in IWM and resistance management strategies.

Florpyrauxifen-benzyl active is classified as an auxin herbicide (WSSA Group 4; HRAC Group O) and Pretilachlor inhibits Inhibition of Very Long-Chain Fatty Acid Synthesis (WSSA Group 15; HRAC Group 15). These trials involved collecting Echinochloa seeds from 83 locations where problems were encountered in rice fields in 2022. In 2023, under laboratory conditions, tests were conducted using The Syngenta Resistance In Season Quick (RISQ) Test developed by Syngenta, with Baloric 310 EC and 2 control products. As a result, samples with suspected resistance were detected in 60 locations, while Baloric 310 EC samples proved to be resistance-breaking. In Echinochloa species that developed resistance to different herbicides, Baloric 310 EC did not develop any resistance and suppressed Echinochloa species at the recommended dose. Although crop rotation is the most important agronomic practice to prevent herbicide resistance, it is not preferred by farmers because of the high profitability of rice and the difficulty of growing other crops in rice fields (high groundwater level, salinity, and pH). Therefore, the introduction of new herbicides with modes of action is the key element for weed control in the rice crop under integrated weed management.

PS1-62. Evolutional insight into the metabolism-based broad-spectrum herbicide resistance in *Echinochloa oryzicola*

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Metabolism resistance is recognized as one of the greatest threats to crop production because it often involved in broad-spectrum herbicide resistance (BSHR). An US strain of the noxious paddy weed *Echinochloa oryzicola*, R511, has evolved metabolism-based BSHR through the overexpression of three herbicide-metabolizing P450 genes. Recent genetic analysis identified a single locus on chr. 5A that controls the overexpression of these P450 genes. In this study, we analyzed BSHR strains discovered for the first time in Japan and examined the driving forces behind the evolution of BSHR in *E. oryzicola*.

Six *E. oryzicola* strains Eoz1814, Eoz212, Eoz214, KU01-9, KU05-2 and KU04-1 collected from geographically distinct paddy fields in Japan, exhibited decreased sensitivity on MS media containing ALS inhibitor (10 mM of bensulfuron-methyl) or ACCase inhibitor (70 nM of cyhalofop-butyl). While no mutation was identified in the target-site genes in all strains, the three herbicide-metabolizing P450 genes responsible for BSHR in R511 were overexpressed in all tested Japanese BSHR strains. Genetic mapping using the F2:3 population of Eoz1814 and a sensitive strain identified a single locus spanning 0.52 Mbp on chr. 5A associated with BSHR, partially overlapping with the reported causal region in R511. These results suggest that the Japanese BSHR strains share the same resistance mechanism as the US strain. SNPs composition of 160 *E. oryzicola* strains within the identified locus revealed that all the BSHR strains clustered together (BSHR-cluster) with some sensitive strains from paddy fields. Moreover, all 34 strains collected from outside paddy fields, which were sensitive to herbicides, also clustered in the BSHR-cluster, while the whole genome SNPs composition of these 34 strains were significantly different from those living within paddy field. The analysis suggests that the populations living outside paddy fields could be the genetic source of BSHR evolution, providing significant insights into the rapid evolution of BSHR in weeds and guiding future weed management strategies.

Acknowledgement(s) / funding: JSPS DC Research Fellowships, The ANRI Fellowship.

PS1-63. Efficacy of different pre- and post-emergence herbicides on *Echinochloa crus-galli* populations from maize fields in Spain

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REGRAMA (“*Herbicide REsistance in GRAss weeds in MAize cultivation”*) is a research project funded by the Spanish Ministry of Science and Innovation. The main objectives are to evaluate the existing levels and characteristics of herbicide resistance in key grass weeds that impact maize farming in Spain, to understand the possible fitness costs tied to this resistance, and to develop methods for detecting resistant weed populations.

Echinochloa crus-galli is one of the most harmful weed species in the world mainly due to its ecological plasticity and adaptability. Moreover, the rise of herbicide-resistant *E. crus-galli* poses a major challenge for farming practices. Resistance to ALS, ACCase and and photosystem II inhibitors has been reported in several European countries.In 2019, the first case of ALS resistance in *E. crus-galli* in a maize cropping area was reported in Spain.

The objective of this study was to determine the response of eighteen *E. crus-galli* populations randomly surveyed across Castilla y León, the region with the largest area of maize cultivation in Spain, to the herbicides S-metolachlor, dimethenamid-p and isoxaflutole (pre-emergence) and nicosulfuron (post-emergence). The pre-emergence treatments were done 24 h after sowing at 1440 g a.i. ha^{-1}, 1008 g a.i. ha^{-1} and 96 g a.i. ha^{-1}, respectively; the nicosulfuron treatment was done at 45 g a.i. ha^{-1} at 2-3 leaves stage. Herbicide screening was conducted under controlled greenhouse conditions. Six weeks after treatment, surviving plants were cut at the soil surface and weighted. The fresh and dry weight parameters were calculated as percentage relative to the untreated controls. Biomass reduction was used as a measure of herbicide resistance. Accessions were classified using the 'R' resistance rating system (Moss *et al.* 1999).

All the *E. crus-galli* populations tested showed susceptibility to the pre-emergence herbicides. However, only 8 out of the 18 populations evaluated were susceptible to the ALS-inhibiting herbicide nicosulfuron, while 6 populations of *E. crus-galli* were considered developing resistance, with the remaining 4 classified as moderately resistant. The study highlights the need for ongoing monitoring to identify early indicators of resistance development.

This work is financed by the REGRAMA project funded by the Spanish Ministry of Science and Innovation (PID2022-136920OR-C42).

PS1-64. Pollen-mediated transfer of herbicide resistance alleles from grain sorghum (*Sorghum bicolor*) to johnsongrass (*S. halepense*)

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Pollen-mediated gene flow (PMGF) from cultivated sorghum to its weedy relative johnsongrass can cause ecological and environmental problems, especially if novel traits such as tolerance to abiotic and biotic stresses are transferred to johnsongrass. In 2023, field experiments were conducted in a Nelder-wheel design to quantify the distance and frequency of PMGF from acetyl-CoA carboxylase (ACCase)-inhibitor-resistant grain sorghum (resistant to fluazifop herbicide) to susceptible johnsongrass. The sorghum was planted at the center of the wheel (15 m x 15 m plot), and a naturally occurring johnsongrass population was used as the pollen recipient. Pollen flow was assessed in eight directions and at 14 distances (0.5, 1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 75, and 100 m) from the sorghum plot. The johnsongrass plants in flowering synchrony with sorghum were tagged on a weekly basis. The tagged johnsongrass seeds were then harvested, processed, and planted in trays in a greenhouse. The seedlings were sprayed with fluazifop at the discriminant dose on three-to-four leaf seedlings. Survivors from the herbicide spray were then transplanted into pots and tested for ploidy. Results confirmed the occurrence of gene flow from sorghum to johnsongrass up to 50 meters, and all the survivors were found to be tetraploids. Polymerase chain reaction assays are being performed to positively confirm the hybrids based on the presence of mutation specific to the herbicide-resistant sorghum genotype. Screening of johnsongrass seeds harvested from the Nelder-wheel study during the 2024 field season is currently ongoing. The findings from this study will provide valuable insights for developing effective strategies to mitigate gene flow from sorghum to johnsongrass.

Acknowledgement(s) / funding: USDA-NIFA Biotechnology Risk Assessment Grant Program (Award #2021-33522-35357).

PS1-65. The population genomics of *Amaranthus palmeri* from Spain

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Amaranthus palmeri (A. palmeri) S. Watson is a highly adaptable and invasive weed species that has rapidly expanded beyond its native range, posing a growing threat to agriculture worldwide. While previous studies have characterized its genetic diversity in American populations, little is known about its genomic variation in European populations. In Spain, *A. palmeri* has established in both roadside (edge) and cultivated field (non-edge) habitats, where it may be undergoing adaptive genetic changes.

The objectives of this study are: (1) to characterize the genetic structure and differentiation among four Spanish *A. palmeri* populations, (2) to determine whether target-site resistance (TSR) mechanisms have arisen independently across populations or share a common origin, and (3) to investigate genomic traits of selection associated with adaptation to novel environments.

Seeds were collected from four different location in Catalunya (Spain) from at least fifteen different mother plants. Twenty plans were growth (100 samples in total), and the DNA was extracted and purify. We sequence whole genomes of all the individuals and the filtered VCF files were obtained after performing a qualitative filtering, mapping to the reference genome and SNPs calling. Population genomic analyses, including F_{ST} estimation and K-means clustering, were used to assess genetic structure and differentiation between environments.

Genome-wide analyses revealed significant allele frequency shifts between habitat types, with FST and K-means clustering supporting environment-driven genetic divergence. Preliminary scans suggest the presence of herbicide resistance alleles, raising concerns about local adaptation under strong selection pressures. Further haplotype analyses are underway to examine the number and origins of independent TSR evolution events in *acetolactate synthase* (ALS), *acetyl-CoA carboxylase* (ACCase), and *5-enolpyruvylshikimate-3-phosphate* (EPSP) synthase, as well as to identify rare variants potentially linked to demographic bottlenecks.

Our findings provide the first genomic insights into *A. palmeri* populations in Europe, demonstrating how local environments shape genetic diversity in invasive species. Moreover, this study contributes to our understanding of the structural genomic changes that occur when a species expands beyond its native range, offering valuable insights into the evolutionary dynamics of rapid adaptation under extreme selective pressures.

PS1-66. Occurrence of resistance dicots weeds in Czech fields with HT crops

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In recent years, farmers have reported cases of dicot weeds surviving herbicide treatments in herbicide-tolerant (HT) crops. These crops rely on tolerance to acetolactate synthase (ALS) inhibitors. HT technologies are widely adopted in the Czech Republic, particularly the Conviso Smart system, which uses foramsulfuron and thiencarbazone in sugar beet, and the ExpressSun system, which employs the tribenuron-based herbicide Express 50 SX in sunflower. These reports have raised growing concerns about the emergence of herbicide resistance in these systems.

Our study confirmed the presence of herbicide resistance in *Amaranthus retroflexus, Chenopodium album,* and *Tripleurospermum inodorum*, which are common weeds in HT crops. We also investigated the mechanisms driving this resistance. Pot experiments showed that certain biotypes of these weeds displayed strong resistance to foramsulfuron + thiencarbazone and tribenuron. Dose-response experiments revealed that *Amaranthus retroflexus* exhibited a resistance factor (RF) of 351.67 to foramsulfuron + thiencarbazone. Pre-treatment with malathion reduced the RF by 50%, suggesting the involvement of cytochrome P450 enzymes in the resistance mechanism. However, pre-treatment with NBD-Cl increased the RF, indicating that glutathione S-transferases (GSTs) were not involved.

Future research will focus on understanding the resistance mechanisms in *Chenopodium album* and *Tripleurospermum inodorum*. These studies aim to develop effective strategies for managing herbicide resistance and preserving the long-term efficacy of HT technologies in agricultural systems.

4. Crop-weed interactions

S04-O1. Modelling multi-species weed competition

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Modern weed management is more and more precise. The traditional practice of applying herbicides uniformly across fields is given way to site-specific applications and even first approaches of targeted treatment of individual weed plants exist. Consequently, a decision to remove or not remove a specific plant is needed for every weed plant. This allows a completely new thinking of weed management. The transition to single-plant weeding opens up opportunities for reducing environmental impacts while optimizing management efficiency. Currently, our understanding of ecological and competitive effects of individual weeds within crop stands is limited. Thus, the decision for a specific plant is made with very simple rules. To enable a better decision making, we developed an individual-based model that simulates the growth and interactions of hundreds of weed and crop plants simultaneously.

Here, we present an enhanced model that builds upon the initial version, which was limited to competition between crop and one weed species, without accounting for weed life cycle dynamics. This model now includes multiple weed species, their life cycle stages, seed dispersal, seed bank dynamics, and the effects of soil disturbance. These enhancements enable us to study not only short-term completion but also long-term population dynamics. While empirical data for parametrization of the model is currently available for wheat and *Viola arvensis* Murray, we used artificial data for the additional weed species to explore generalizable dynamics.

Simulation results demonstrate the potential of such a model to evaluate various weed management strategies. Outcomes include the effects on crop yield, weed infestation levels, and seed bank contributions over time. This approach allows for estimating long-term risks and benefits, offering valuable insights for sustainable weed management.

Future developments will focus on incorporating the ecosystem services and disservices provided by weed communities. By addressing both ecological and economic aspects, this model aims to support the development of efficient and environmentally friendly weed management strategies.

S04-O2. Effects of the design of cereal-legume intercrop systems on weed suppression and crop production

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Cereal-legume intercrops offer a sustainable alternative for weed suppression and crop productivity, reducing reliance on herbicides, which pose risks to ecosystems and human health. Mechanisms such as complementarity, where crops collectively utilize more resources, and facilitation, where crops positively influence each other, have been proposed as drivers of weed suppression in intercrops. However, evidence highlights the process of *selection* as the dominant driver. Selection occurs when the more competitive crop species disproportionately acquires resources, causing the intercrop to resemble this species' behavior. This study evaluated cereal-legume intercrops in four experiments over three years (2022–2024) under weed-infested and herbicide-treated conditions. We explored mechanisms of weed suppression, yield responses to herbicide use, and quantified the contribution of plant trait plasticity to weed suppression through plant modeling.

Cereals dominated intercrops, suppressing weeds and shaping canopy cover and light interception. Weed biomass in intercrops was significantly lower than the averages of the respective sole crops, aligning more closely with predictions from the harmonic mean, which accounts for selection effects. Canopy traits were primarily driven by cereals, which intercepted more light and suppressed weeds effectively. Weeds influenced crop yields differently depending on species and cropping system. In herbicide-treated areas, legumes produced yields below their proportional contributions relative to sole crops. In weed-infested conditions, 1:1 intercrops achieved legume yields comparable to sole crops, despite half the legume density. Notably, legumes experienced yield gains in intercrops under weed pressure, while cereals maintained yields similar to or exceeding their proportional contributions across treatments. This suggests indirect facilitation of legumes in weed-infested intercrops due to reduced competition. Models exposed how cereal trait plasticity contributed to enhanced light capture in intercrops, driving the selection effect and overall weed suppression outcomes.

This study confirmed that selection is the key mechanism underpinning weed suppression in cereal-legume intercrops and emphasizes the importance of crop species composition, mixing ratio, and spatial design. By directly comparing herbicide-treated and weed-infested conditions, and incorporating plant modeling to quantify trait contributions, we show that cereal-legume intercrops can be effectively combined to optimize weed suppression and yield, offering a sustainable, resilient alternative to conventional, herbicide-dependent cropping systems.

Funding and conflicts of interest: The Synergia project is organized and led by Wageningen University and Research in close cooperation with Next Food Collective as well as the Universities of Delft, Twente, Eindhoven, and Nijmegen. The authors have declared that no competing interests exist in the writing of this publication. Funding for this research was obtained from the Netherlands Organisation for Scientific Research (NWO grant 17626), IMEC-One Planet and other private parties.

S04-O3. Are parasitic weeds becoming more prevalent in European agriculture?

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Parasitic plants depend on host plants to fulfill (part of) their life cycle or to enhance their reproduction. When such plants invade arable fields, they can become weed problems with high associated crop losses and few effective control options. The extent of these losses depends on infestation level, species and the crop or cultivar they attack. The main European parasitic weed species are broomrapes (*Orobanche cumana, O. crenata, O. cernua* and *Phelipanche ramosa*) and dodder (*Cuscuta campestris*). They are most common in the Mediterranean, the Balkans and Central Europe, however these species are likely becoming more widespread in other parts of Europe too, due to climatic, agricultural and ecological factors. Increasing temperatures following climate change likely pushes the frontiers of parasitic plant distributions to more northern parts of Europe. Arising from the adoption of more sustainable food production, cropping systems are diversifying. More diversity in arable crop rotations offers a greater range of potential hosts. In addition, the more frequent use of seed mixtures for cover cropping, rotational environmental habitats and diversified field margins may introduce parasitic plant species through accidental contamination. Apart from the aforementioned five parasitic weeds, there are at least 30 more species of parasitic plants present in Europe, divided over 15 genera. These species may also become more prevalent in the future and turn into new weeds. To assess the past, current and future distributions of parasitic weeds in European agriculture, we have reviewed the scientific peer-reviewed literature and explored data of the Global Biodiversity Information Facility (GBIF). Using the collection years of GBIF herbarium specimen or observations, current species distributions were mapped and compared with historic ones to assess the extent and direction of spread. In addition, an online survey was launched in a range of European countries aimed at understanding awareness of parasitic weeds, past and current presence and incurred yield losses in (West) European farms. The first results of these investigations are presented and discussed here and we make some preliminary observations regarding the future risk to European Agriculture from increasing prevalence of parasitic weeds.

S04-O4. Cover crop legacy effects on weed biomass and yield of the subsequent maize crop

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Cover crops can affect yields of following cash crops by altering soil nutrient availability and influencing weed growth. However, the interactions between these effects have not been widely explored and are difficult to disentangle. In this study we measured yield, soil inorganic N, and weed biomass in a maize (*Zea mays*) crop following a no cover crop control and 11 different cover crop (CC) treatments consisting of 6 species from three functional groups, legumes, grasses, and brassicas, grown as monocultures and mixtures over six cropping seasons in central Pennsylvania (USA). The first three years, maize was grown for silage while in the second experimental period, it was grown for grain. Each year, cover crop biomass and weed biomass in cover crop, cover crop C:N ratio at peak biomass, peak soil N in maize, weed biomass in the maize, weed community composition and maize yield were measured. A path analysis was used to identify the legacy effects of the cover crop on the weediness and yield of the following maize. An increase in weed biomass in the preceding cover crop increased weed biomass in the following maize and negatively impacted maize yield. Soil N and cover crop C:N ratio influenced weed biomass in the maize but only in the second experimental period. Weed – crop competition in the maize depended on the preceding cover crop functional group, with maize grown after a legume cover crop being more tolerant to weed competition than maize following a grass cover crop. Maize following cover crop mixtures that comprise multiple functional groups, showed a good compromise of weed control and high yields. The results of this study show that cover crop functional groups and the weeds they harbor can have cascading effects on the following cash crop.

Acknowledgement(s) / funding: USDA National Institute of Food and Agriculture, Organic Research and Extension Initiative (Grant #s 2011-51300-30638, 2015-51300-24156).

S04-O5. Neighbour-induced alterations in root exudate composition of cover crops

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Over the past decade, extensive research at Agroscope has aimed to understand the mechanisms by which cover crops (CC) suppress weeds in both field and controlled conditions, attempting to separate the factors involved in weed suppression. A split-root setup was developed to study the effect of CC root exudates.

Field trials demonstrated that shading alone was not the primary mechanism for pigweed (*Amaranthus retroflexus*) growth suppression, as biomass remained similar under different light conditions. Additionally, under controlled conditions, buckwheat (*Fagopyrum esculentum*), black oat (*Avena strigosa*), and forage radish (*Raphanus sativus*) significantly suppressed pigweed growth through direct root interactions. These findings suggest that root exudates may mediate CC–weed interactions.

We investigated how buckwheat and black oat modify their root exudates and influence weed root architecture when interacting with intra- and interspecific neighbors like pigweed and blackgrass (*Alopecurus myosuroides*). When applied to weeds, root exudates from buckwheat and black oat led to a complex pattern of changes in weed root morphology. We characterized metabolomic changes in CC root exudates and assessed their effects on neighboring plants and weeds. Among 2,843 compounds, our results showed that plant neighbors induced significant shifts in root exudate composition, with 92 and 89 more accumulated compounds in black oat exudates in the presence of pigweed and blackgrass, respectively, compared to the black oat control. The responses varied depending on the identity of the neighbor. However, identifying compounds of interest proved challenging due to limited data on CC root exudates in existing databases. Molecular network analysis identified clusters of significant differentially accumulated metabolites, including hexose sulfate derivatives, aromatic amino acids, and organic acids, which were enriched in black oat exudates when grown with another neighbor. Transcriptome analysis revealed that the phenylpropanoid pathway was consistently enriched in black oat leaves, while flavonoid biosynthesis and circadian rhythm pathways were activated in roots in response to neighbors. These pathways are known to be involved in plant defense and allelopathic interactions.

These results provide new insights into the role of root exudates in plant–plant interactions and demonstrate the potential of CC to suppress weeds through belowground chemical signaling.

Acknowledgement(s) / funding: Swiss National Science Foundation (SNSF) (205321L-189174) and Austrian Science Fund (FWF) I4527-B.

S04-O6. Critical period of weed interference in pineapple crop in Reunion Island

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As the first fruit produced, the 'Queen Victoria' pineapple (*Ananas comosus* [L.] Merr.) holds an important role in the economy of Reunion Island. Pineapple cropping systems rely heavily on synthetic inputs, such as herbicides or plastic mulch to suppress weeds that are one of the most significant biotic constraints for pineapple producers. Sustainable alternative solutions are needed, but studies on weed control in these cropping systems are limited. The objectives of this study were to assess i) the critical period of weed interference, *i.e.* the period that can reduce the crop production, ii) how weeds affected pineapples, and iii) which weed species are mainly present.

We conducted a field experiment in Reunion Island in 2022. The 3-replication design included 2 factors: weed-pineapple coexistence duration (8 levels: 0, 2, 4, 6, 8, 10, 12 and 14 months) and weeding period (2 levels: weeds are controlled before or after weed-pineapple coexistence).

The results showed that the longer weeds grow in the field, the higher the yield loss: weed-free plot yields reached 33.9±5.9 $t.ha^{-1}$, compared with 0.14±0.13 $t.ha^{-1}$ for the plots with the most weeds. The critical periods of weed interference were from 91 to 341 and 104 to 259 days after planting corresponding to 5% and 10% yield losses, respectively. At flower induction, pineapples in weed-free plots had almost three times of leaves as in weedy plots, and D-leaf, the diagnosis leaf used as an indicator of crop growth, was 1.3 times longer and 3.4 times heavier. The pineapple quality at harvest was also affected by weeds, but with highly variable results. Finally, we observed forty-one species, but only five were highly frequent and abundant, including two Poaceae considered as particularly noxious, *Panicum maximum* and *Urochloa distachya*.

These results suggest that reducing pineapple yield losses requires an appropriate weed management especially at the beginning of the crop cycle. Knowing the critical period of weed interference and the effect of crop/weed competition on pineapple production and quality will contribute to develop appropriate weed management practices and more sustainable cropping systems.

Acknowledgement(s) / funding: EU FEADER (European Agricultural Fund for Rural Development).

PS2-01. Nitrogen form and N-pool composition influence competition in a simple weed-crop community

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The degree to which soil resource form and pool composition influence competition between weeds and crops is not well understood. We conducted a manipulative experiment in which *Setaria faberi* (giant foxtail) and Sudangrass (Sorghum x drummondii) were grown alone and in mixture, in pots semi-hydroponically with a sand substrate. Nitrogen (N) was supplied to the substrate as either NO_3^-, NH_4^+, or whole amino acids in all possible one-, two-, and three-way combinations while holding total N applied constant. A nitrification inhibitor (DMPP) was included with each application of fertility and above-ground biomass of each individual plant was quantified at the end of the experiment. Relative biomass yields of the mixtures against the monocultures indicate competition intensity was dependent on N-form and N-pool composition. Competitive effects were asymmetrical; sudangrass biomass was more affected by both intra- and interspecific competition than was foxtail biomass. Conversely, foxtail biomass was more responsive to N-form and pool composition. The apparent relationship between N-pool complexity and biomass yield was positive or negative depending on which N-form was considered as being at the “simple” end of the N-pool complexity gradient, which may help explain variability in results reported in studies aiming to test the resource pool diversity hypothesis (RPDH). Understanding how soil resource pool composition influences competitive outcomes between plant species has implications for a wide range of applications, including the development of alternative weed management strategies and more effective intercropping systems.

This project was supported by USDA-NIFA Hatch Project 1006827 and USDA-NIFA AFRI grant no. 2013-67014-21318.

PS2-02. Comparing nitrogen use efficiency between maize and weeds under different plant densities

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The Mineral Ecological Cropping System (MECS), developed and tested over the past six years as an alternative to conventional cropping systems, utilizes mineral fertilizers to improve crop yield and quality while completely eliminating synthetic pesticides. This study aimed to evaluate the competition between maize (ZEAMX) and two weed species, i.e., *Chenopodium album* L. (CHEAL) and *Echinochloa crus-galli* (L.) P. Beauv. (ECHCG) for mineral nitrogen (N) in the MECS. Four different ZEAMX + weed density combinations [1:0 (1 ZEAMX + 0 CHEAL or ECHCG per pot), 1:2 (1 ZEAMX + 2 CHEAL or ECHCG per pot), 1:5 (1 ZEAMX + 5 CHEAL or ECHCG per pot), and 0:1 (0 ZEAMX + 1 CHEAL or ECHCG per pot)] and four N doses (0N, ½N, N, and 2N) were included in the study. Nitrogen was applied at three distinct intervals to reduce the possibility of leaching due to irrigation. Data relating to root and shoot growth of both maize and weeds, and their N contents were collected. Increasing the nitrogen doses promoted biomass accumulation in both maize and weeds. However, higher weed densities significantly reduced maize biomass. CHEAL had a greater adverse effect on maize root growth than ECHCG, irrespective of N doses. Nevertheless, there was no significant difference in the competitiveness of the two weeds in terms of their effects on maize shoot development. The weeds benefited more from the increase in N dosage compared to maize, particularly under higher weed densities. The results indicate that management of N, problematic weed species and their densities is crucial for maize cultivation in the MECS. Furthermore, comprehensive field trials are necessary for understanding the competition between weeds and crop plants based on ecological factors in the MECS under changing climate conditions.

The APC was funded by Bundesministerium für Bildung und Forschung (BMBF), grant number 031B0731A.

PS2-03. Balancing weed suppression and crop persistence in mowing strategies to control *Cirsium arvense* in *Medicago sativa*

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The rapid spread and persistence of the perennial weed *Cirsium arvense* (L.) Scop (creeping thistle) challenges agricultural systems, leading to significant crop yield losses unless controlled. Effective control of *C. arvense* is achieved by combining competitive crops like *Medicago sativa* with frequent mowing. Mowing disrupts the growth of *C. arvense* and depletes its carbohydrate reserves while enhancing the competitive advantage of *M. sativa* as it recovers more quickly after mowing than *C. arvense*. Since *M. sativa* is primarily mown for forage production, weed control can often be achieved without significant additional effort. *Cirsium arvense* is most effectively controlled when targeted at low levels of root reserves, specifically at the compensation point. However, the ideal timing to control *C. arvense* might not coincide with the ideal timing for mowing *M. sativa*, which seeks to maintain crop vigor. The relationship between suppressing *C. arvense* and maintaining the persistence of *M. sativa* has not been thoroughly investigated and represents a knowledge gap. We conducted a field experiment in Rostock, Germany, from September 2019 to October 2021. The aim was to determine the optimal mowing timings for controlling *C. arvense* while balancing its suppression with fostering the persistence of *M. sativa*. *Medicago sativa* ('Dakota') was sown at 20 kg/ha following a winter wheat crop in 2018. Mowing treatments were conducted from 2019 to 2021 based on the growth stages of *C. arvense*: Compensation point, bud stage and post-flowering mowing. Data on shoot density and height of both species were collected monthly. Mowing three times per year at the compensation point was the most effective treatment, resulting in almost 100% reductions in density and height of *C. arvense*, but negatively affected *M. sativa* persistence. Mid-season mowing at the bud stage offered the best balance, minimizing crop density and height reduction while reducing *C. arvense* density by approximately 90%. Late-season mowing post-flowering had minimal impact on *C. arvense* control but fostered *M. sativa* vigor. We conclude that different mowing strategies are needed depending on the farmer's goals, of either prioritizing *C. arvense* control, balancing between *C. arvense* control and *M. sativa* persistence, or prioritizing to foster *M. sativa* persistence.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 771134. The project AC/DC-weeds was carried out under the ERA-NET Cofund SusCrop (Grant N°771134), being part of the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI).

PS2-04. Investigating competitive ability of wheat and barley varieties with weed communities in Western Canada

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Herbicide-resistant weeds have expanded in frequency and acreage on the Canadian Prairies. Their impact has increased the need for integrated weed management strategies to improve management. One management strategy that has often been suggested is the selection and growth of competitive crop varieties. While a sound theory, there is limited practical information on the competitiveness of varieties to allow selection of varieties with enhanced competitiveness. The objective of this study was to investigate competitiveness of spring wheat (Triticum aestivum) and spring barley (Hordeum vulgare) varieties to weed communities, and, as protocol development, to a single species.

Field studies were conducted over three years (2022-2024) in Lacombe and Lethbridge, AB and two locations in Saskatoon, SK. The Alberta locations and one of the Saskatchewan locations utilized a weed community representative of the growing region for weed competition; the second Saskatchewan location utilized only Brassica napus as a representative weed to determine if a weed community is necessary in competitiveness studies. Each variety was grown under weedy and weed-free conditions to evaluate their ability to compete and ability to withstand competition. Varieties were selected based on insured acres grown on the Prairies, but also to proportionally represent wheat and barley classes grown on the Prairies. In the barley study 13 varieties from three different classes were investigated, while in the wheat study 16 varieties from five different classes were investigated.

Results to date indicate environmental variability within varietal competitiveness. However, there is some consistency over year and environment in varietal ability to compete with weeds and ability to withstand competition. Single species trial results are not consistent with those under a weed community, suggesting that a weed community is recommended for a program ranking varieties for competitiveness. There is potential to develop a ranking system for both wheat and barley varieties that are grown on the Canadian Prairies, making selection and growth of competitive varieties a viable integrated weed management strategy for producers. Additional protocol development needs to take into account environmental challenges such as wheat stem sawfly that can confound or complicate evaluation of varietal competitiveness.

Acknowledgement(s) / funding: Manitoba Crop Alliance, Saskatchewan Wheat Development Commission.

PS2-05. Examining the competitive dynamics of *Parthenium hysterophorus* populations and summer crop species in Israel

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The impact of weeds on crop plants is influenced by various factors; weed density, weed type, and the specific crop being cultivated. *Parthenium hysterophorus* (Asteraceae) is a noxious weed species that invaded over 50 countries. This plant has a high seed production potential, and can grow up to 2m tall. In Israel, it was first detected in 1980 at Tirat-Zvi (TZ), located in eastern-northern Israel. In recent years, there has been an increasing concern about the spread of this weed in agricultural regions across the country. Here, we examine the competitive abilities of two populations, TZ, a well-established population, and Ha'hotrim (HT), a new introduction site. Furthermore, we have compared the competitive dynamics of both populations with two crops, corn (*Zea mays*) and cotton (*Gossypium hirsutum*). The experiments took place in a glasshouse, using 60L Styrofoam boxes. Crop plants were grown with transplanted seedlings at low and high weed density (six or twenty-two plants per $0.25m^2$, accordingly). For the control treatment, weed or crop plants were grown alone. Biomass and height of both weed crop plants were measured at the end of the experiment. Our results show that 92 days after transplanting, weight of cotton plants grown with low density of HT plants was higher than of those grown under low density of TZ plants ($p=0.0298$). The average weight of cotton plants grown in low density was 50% lower than control and in high density 70% lower than control. However, under high density of *P. hysterophorus* no significant differences were observed between the two populations. Examining the weight of corn plants under competition, no significant differences for both densities and different populations. corn plants grown with high density of TZ plants where shorter compared to those grown under low density ($p=1.08e^{-5}$). From these results we can assume TZ population plants are a stronger competitor against both corn and cotton crops. We may also conclude that cotton plants are more sensitive to *P. hysterophorus* competition compared to corn plants. The differential responses of corn and cotton plants to competition highlight the importance of crop selection in areas with high *P. hysterophorus* infestation.

PS2-06. The presence of weeds poses a significant threat to rice cultivation, reducing yields and production quality

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The presence of weeds poses a significant threat to rice cultivation, reducing yields and production quality. Some species, such as largeflower umbrella sedge (*Cyperus difformis*, CYPDI), barnyardgrass (*Echinochloa* spp., ECHCG), and red rice *(Oryza sativa*, ORYZA), stand out for their competitive ability, and yield reduction which makes them essential for identification. This study involved establishing 30 pots of each weed species and cultivated rice (Indica long sperm / CL111 variety) in the greenhouse of the Benaki Phytopathological Institute for the sole purpose of weed / crop identification and classification. In order to create an extensive dataset, high-resolution photographs were taken at various stages of weed development. With the help of advanced image analysis techniques and machine learning, these data are used to develop digital weed recognition models. For the differentiation and classification of weeds, two different machine learning (ML) models were used. Specifically, Support Vector Machines (SVM) were used to separate cultivated rice from weeds in the Hue-Saturation-Value (HSV) color space. Using the RGB color space, an evaluation was made of the Convolutional Neural Network YOLO (YOLOv8), which is used to detect objects in images and classify them. Various evaluation metrics, including Precision, Recall, mAP50, and F1-score, were used to measure system performance in both models. These metrics were calculated both for each weed type individually and for all weeds collectively. The distinction between cultivated rice and red rice or barnyardgrass was satisfactory in both cases, with YOLOv8 providing better results; however, smallflower umbrella sedge did not prove to be as successful. By using these methods, weed detection systems become more accurate, bridging the gap between laboratory and field conditions. Thus, rice cultivation can become more efficient and sustainable in terms of weed management.

PS2-07. Coulter selection impacts weed establishment and seed placement in organic no-till soybeans (*Glycine max* (L.) Merr.)

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Cover crop-based reduced tillage cropping systems offer a path towards improving weed management while maintaining and enhancing soil health and reducing labor in organically managed soybean (*Glycine max* (L.) Merr.) systems. Planting soybeans into high biomass roller crimped rye mulches has proven technically challenging, with low plant stands often reported. While managing the planting row could offer a strategy to facilitate soybean placement and seed-to-soil contact, management practices could also impact soil exposure, weed seed germination, and weed establishment. An experiment conducted at Arlington, WI, USA from 2023 to 2024 compared four coulter types on a gradient of wavy to smooth edges including 1) 8-wave, 2) ripple, 3) 13-wave, and 4) straight. Two control treatments were also included: 5) no coulter (only in 2024) and 6) Tilled/no coulter. Treatments were established in a randomized complete block design and replicated 6 times. In-season measurements included soybeans seeds on soil surface, hairpinning, furrow closure, soybean stand counts, weed biomass, and soybean grain yield. Soil moisture conditions at planting varied between study years with 0.15 and 0.42 m^3/m^3 for 2023 and 2024 respectively. In 2023, soybean seeds on surface were statistically highest with the 8-wave coulter; however, no differences were observed in 2024. Final plant stands did not differ by treatment but trended towards higher plant stands with straighter edged coulters. In 2024, there was a linear trend towards a greater number of seeds on surface with wavier edged coulters as straight coulters demonstrated the significantly lowest seeds on surface. Weed biomass was greater for the 8-wave coulter as compared to the straight coulter, with overall higher weed biomass in the tilled control; however, no significant difference between treatments were observed for grain yield. Results from this experiment suggest that straighter edged coulters may improve seed placement and lower weed biomass when compared to wavy edged coulters. However, the magnitude of effects differs depending on soil moisture. While the coulter type ultimately did not influence grain yield despite differences in weed biomass, optimizing coulter selection could still provide the opportunity to decrease weed seed rain and prevent seeds from entering the weed seedbank.

This project was funded by a United States Department of Agriculture Conservation Innovation Grant.

PS2-09. Competitive interactions between cotton and troublesome weed species in diverse mixes

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Crop-weed competition is an ecological phenomenon that negatively impacts the growth and yield of cotton (*Gossypium hirsutum*). Previous research typically focused on interactions between cotton and individual weed species, but the dynamics of multi-species weed mixes remain poorly understood. This study elucidates the competitive interactions between cotton and two troublesome weeds, Palmer amaranth (*Amaranthus palmeri*) and barnyardgrass (*Echinochloa crus-galli*), focusing on understanding the effects of multiple weed communities growing together. We hypothesized that multi-species weed communities would have a greater negative impact on cotton yield than the effect of individual weed species combined. We also hypothesized that higher weed densities would amplify these competitive effects. An additive (target-neighbor) design was employed, keeping cotton density constant while varying weed densities per pot. The treatment design was a completely randomized factorial, including two factors: 1) species combination (cotton with one or both weed species); 2) density levels (low, moderate, and high). Each treatment was replicated six times. Results showed significant density-dependent reductions in cotton biomass and lint yield due to both single and combined weed species. Palmer amaranth reduced cotton biomass by 33–39% at densities of one to five weeds per pot, stabilizing at higher densities. Barnyardgrass reduced biomass by 28–45%, with lint yield losses ranging from 10.5% to 38.3% as density increased from 2 to 10 plants per pot. The presence of both Palmer amaranth and barnyardgrass caused the most severe reductions, with cotton biomass decreasing by 51.5% at low densities and 63.81% at high densities. Lint yield losses ranged from 54.7% to 64.1%. While cotton exhibited moderate competitive ability against single-species weeds, the combined presence of both species intensified competition, magnifying yield losses. These findings offer novel insights into multi-species crop-weed interactions and underscore the importance of considering multi-species competition in yield-loss prediction models. Future research should validate these findings under field conditions.

This research was supported by funding from GROW (Getting Rid of Weeds) and the USDA National Institute of Food and Agriculture (NIFA). We extend our gratitude to our collaborating institution: Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Institute for Plant Protection in Field Crops and Grassland, Braunschweig, Germany.

PS2-10. Effect of bio- priming in legumes crops and cover crops systems for weed management

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This research work studies the effect of seed priming with bacteria species in different systems either growing legumes or legumes as a cover crop. The aim objective is to enhance crop growth as well as plant competition with weeds. The results are presented from field experiments in two areas in Central Greece a) Fthiotida, for the study of minor legume crop development, and b) Boeotia, in a non-irrigated vineyard for cover crop systems as service crops, with the main objective the competition with weeds. The bacterial suspension of *Bacillus subtilis* (strain NCBI 3610; ATTC 6051), standardized by the collaborators from the University of Pavia, Italy. A specific protocol was applied to seed priming with the *B. subtilis* spore suspension. Four seed treatments were generated as follows: control (T1), hydropriming (T2), biopriming (T3) and hydro-bio priming (T4). For the legume experiment, *L. sativus, P. sativum, T. foenum graecum* were used. The results revealed that the seedpriming (T3) and (T4) reduced weed biomass in all 3 species, with a statistically significant ($p<0.05$), while variability was recorded between varieties of the same species. Among the species, fenugreek showed the highest competitive ability. TheNDVIevaluated to indicate the developmental effects of seeds. The cover crops experiment was designed in a (RCB) with two replications and two treatments: control (T1) and hydro-bio priming (T4). The following species were sown: *Lathyrus s., Pisum s., Hordeum v., Trifolium s.,* and *Hordeum* v.+ *Vicia s.* Weed surveys, growth characteristics and weed: crop biomass, were measured during the growing season (7, 11, 15 WAS). The most dominant weed species were: *Stellaria media, Fumaria officinalis, Urtica spp., Calendula officinalis, Veronica persica*. The weed above-ground biomass had the following ascending order: *Hordeum v.* T2 (77/ m^{-2}) < T1(155 g/m^{-2}) *Pisum s.*T2 (97g/m^{-2}) < T1 (249 g/m^{-2}),Hordeum v.+*Vicia s.* < T2 (108 g/m^{-2})< T1 (184 g/m^{-2}) *Lathyrus s.* T2(150 g/m^{-2}) < T1(357 g/m^{-2}) *Trifollium s.* T2(323 g/m^{-2}) < T1(405 g/m^{-2}). The field experiments were repeated in the present growing season 2024-2025.

PS2-11. Are weeds the foremost yield reducing factor in wheat under on-farm integrated weed management?

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Numerous studies have quantified weed-related yield and economic losses in wheat cropping. This study evaluates results of the first four years on-farm experimentation in 94 winter wheat fields (47 farms) across three regions of Switzerland. A diversified six-year crop rotation (2020 to 2025) was implemented with reduced pesticide use (-75%), aiming at a maximum 10% yield loss compared with the national average. Each farm has one field conventionally cultivated, and another strictly restricting pesticides and implementing agroecological crop protection strategies. The objectives were to determine (i) how management influenced weed biomass and grain yield, and (ii) how weed biomass and grain yield interacted with two climatic variables, four soil-linked variables, and eight variables describing the used management. The analysis approach consisted of four steps. (1) The nonlinear Cousens model was fitted to yield against increasing weed biomass to cluster farms fitting the expected yield-reduction response (*in*), and farms above (*upper*) or below (*lower*) its 98% confidence limits. (2) Principal component analysis (PCA) grouped variables associated with weed biomass and yield, considering separately outcomes for*in*, *upper* and*lower* clusters. (3) Random Forest (RF) classification highlighted the variable importance at the three clusters, using a weed dry biomass < 50 g m-2 as indicator of poor weed pressure. (4) Kruskal-Wallis and Chi-square tests described the extent to which the most important variables influenced yield and weed biomass. Results showed a substantial number of farms not fitting the Cousens-*in* cluster, suggesting weeds are not the driving yield loss agent. Climatic data, nutrient input, and mechanical soil cultivation were the key variables explaining higher yields at poor weed pressure (*i.e.*, *upper* cluster) and at a lesser degree, herbicide use. Growing degree days (GDD) and rainfall were the two decisive variables explaining low yields in the events of poor or no weed pressure (*i.e.*, *lower* cluster). Reducing mechanical weeding activities was somewhat related to lower yield effects under poor weed pressure. Nevertheless, it is too early to draw definitive conclusions and recommendations, because the six-year rotation is undergoing and requires a similar analysis approach.

PS2-12. Estimating differential effects of climate change on competitive ability of two annual grass weeds against wheat

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Expected increases in atmospheric CO_2 concentrations (e(CO_2)) and temperature (e(T)), may positively affect the potential for agricultural production in the Nordic region by extending the growing season. Differential responses to climate changes in weeds may however change the competitive ability between weeds and crops, hence reducing the potential benefits of climate change.

The effect of increased temperature and CO_2 on the competitive ability of the noxious weeds *Avena fatua* (wild oat, a C_3 species) and *Echinochloa crus-galli* (barnyard grass, a C_4 species) against the crop *Triticum aestivum* (wheat, a C_3 species), was examined in growth chamber pot experiments using a partial additive competition design.

This design was replicated in three growth chambers, one with ambient temperature (18/12 °C (day/night)) and ambient CO_2 concentration (450ppm), one with e(T) (20.5/14.5 °C (day/night)) and ambient CO_2 concentration and one with e(T) and e(CO_2) (800ppm) and the whole experiment performed twice. Main responses recorded were seed number and seed weight (g plant^{-1}) of focal plants harvested when approximately half of the focal wheat plants had mature spikes. Competitive ability of each species under the effect of each climate condition was calculated based on the Beverton-Holt competition model and the metric "competitive ability" and modelled using generalized additive models.

Our preliminary results show tendencies that the effect of a 2.5 °C increase in temperature will increase seed number and seed weight of *E. crus-galli* in absence of competition, while decreasing the seed weight of wheat in the absence of competition. The increase in temperature will also give a slight increase in reduction of wheat seed weight per *E. crus-galli* competitor and of *E. crus-galli*seed weight per wheat competitor. There was little effect of climate on either response in absence of competitors, or on the effect of reduction per competing plant for *A. fatua*. This indicates a reduction of wheat competitive ability against both weeds in terms of seed weight and an increase in *E. crus-galli* competitive ability in terms of seed number under elevated temperatures. Elevated CO_2 concentration had little effect on responses.

This work was a part of the project "Weeds vs. Crops: the winner of climate change" financed by the Norwegian Institute of Bioeconomy Research (NIBIO) base funds from the Research Council of Norway (Contract number 342631/L10).

PS2-13. Crop-weed interactions in maize: impact of different *Zea mays* varieties on growth and biomass of *Sinapsis alba* in a greenhouse experiment

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Weeds compete with crops for limited resources, potentially endangering crop yields. Sustainable weed management seeks to reduce herbicide use by exploring natural competition. Therefore, we compare maize varieties to assess their competitive abilities against weeds and identify morphological traits responsible for this competition. However, most research focuses on above-ground interactions, leaving a gap in understanding both above- and below-ground factors.

To address this, two greenhouse experiments were conducted in 2024 to investigate competition between maize and *Sinapis alba*. Three maize varieties (KWS Johaninio, KWS Curacao, and SY Liberty) were paired with mustard as the model weed. The first experiment (May-July) included seven replicates and eight treatments: each maize variety tested alone, with mustard, and mustard as a control. The second experiment (August-September) had 18 replicates and four treatments: maize varieties with mustard and mustard alone as a control. Plant growth was monitored by measuring height, and above-ground biomass and root measurements were taken at harvest. Samples were dried at 60°C for 4 days before reweighing.

The first analyses of mustard plants showed significant height differences, with mustard in the control (mustard alone) being taller than those grown with KWS Johaninio and KWS Curacao. No significant height differences were found between the maize varieties. The control also had significantly higher dry mass (2.09 g above-ground) than mustard grown with maize, which ranged from 0.39 to 0.76 g above-ground. A slightly significant difference in above-ground dry mass was observed between mustard with KWS Johaninio and SY Liberty, excluding the control. In the second experiment, mustard grown with KWS Johaninio had significantly longer roots than those grown with other maize varieties and the control. A slightly significant difference in root length was found between mustard with KWS Johaninio and SY Liberty, excluding the control. No significant differences in above-ground dry mass were observed.

The results suggest maize may suppress *Sinapis alba* growth, though further analysis is needed. The observed differences between the maize varieties highlight the importance of morphological traits in competition. Further evaluation, including field data, is necessary to fully understand maize-weed competition dynamics.

PS2-14. Effect of seed inoculation with arbuscular mycorrhizal fungi on cover crops' early seedling development

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There has been a growing need for more sustainable agricultural practices in recent times. In agroecology, cover crops, planted between the growing seasons of main crops, offer a promising alternative. They improve soil protection and fertility, support crop establishment, and can replace conventional chemical growth supplements. These beneficial effects may even be maximized when in symbiosis with Arbuscular Mycorrhizal Fungi (AMF). The main goal of this study, in the scope of the GOOD-Agroecology for Weeds project, was to evaluate the effect of AMF inoculum on the germination and early seedling development of 15 cover crop species.

The inoculum (a mixture of *Funneliformis mosseae*, *Funneliformis coronatum*, *Septoglomus* sp. and *Rhizoglomus irregulare* with spores, mycelium and roots) was applied directly onto the cover crops' seeds and these were sown in Petri dishes with wet filter paper. After one week, the number of germinated seeds, root and shoot length and dried biomass were assessed.

Inoculation significantly enhanced several growth parameters in specific species, particularly *Vicia*_IT and *Secale*_PT. These species showed substantial growths in root development, with increases of 64.1 and 60.9%, respectively, and in shoot development, with increases of 51.8 and 58.8% compared to the control group. Inoculation also enhanced overall biomass accumulation in the same species, with a 59.2 and a 53.9% increase, respectively. These findings are particularly valuable for cover crops, where biomass is critical for soil health and erosion control.

Conversely, other species, such as *Pisum sativum*_CYP and *Phacelia*_NL exhibited significant reductions in some parameters, indicating potential sensitivity to inoculation.

These findings emphasize the species-dependent nature of inoculation effects and suggest the need for adapted applications to maximize benefits in agricultural and ecological settings. This study has demonstrated the potential of inoculation to improve some cover crops' productivity and sustainability, but further research is required. Future studies should focus on the effects of AMF inoculation in the development of adult plants in cover crops that have shown positive responses, providing valuable insights into the long-term impacts of AMF inoculation.

This work was part of the Good - Agroecology for Weeds European Project.

PS2-15. Effects of weed diversity on crop performance under varying water availability

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Understanding the relationship between weed diversity and crop performance is essential for comprehending agroecosystem's functioning and resilience. Studies suggest that diversified weed communities might be less competitive than those dominated by one or a few species. While species richness is commonly used to measure diversity, it may not fully explain the variability in biodiversity-productivity relationships. Functional aspects of weed communities, such as functional diversity and dominant trait values, could provide additional insights. Here we investigate the effects of three aspects of weed community structure: species richness (S), functional diversity (computed as functional dispersion, FDis), and the community-weighted mean (CWM) of functional traits on crop performance under two water availability scenarios. A greenhouse experiment was conducted with winter wheat (*Triticum aestivum* L.) grown in pots with different combinations of weed species (1, 2, and 4) and functional groups (grass, forb, and legume) under well-watered and drought-stressed conditions. Weed traits were measured at flowering, and aboveground biomass of weeds and crops, and crop yield, were recorded at harvest.

We analysed the data using generalized linear mixed-effects models. Well-watered pots exhibited significantly higher weed biomass, crop biomass, and crop yield than drought conditions. Weed biomass negatively impacted crop performance, particularly in well-watered conditions, indicating intensified resource competition when water was not a limiting factor. Higher weed species richness and functional diversity were associated with increased crop biomass (S: 0.05±0.02; *$p<0.05$; FDis: 0.06±0.02; *$p<0.05$) and yield (S: 0.18±0.04; ***$p<0.001$; FDis: 0.15±0.04; **$p<0.01$). This effect was more prominent under drought conditions, suggesting that functionally diverse weed communities may alleviate competitive pressure through different resource acquisition strategies. Conversely, higher CWM values for leaf dry matter content, flowering onset, and plant height were linked to reduced crop performance, implying that weeds with resource-acquisitive strategies or overlapping with crop phenology, can outcompete them.

These findings highlight the potential of diverse weed communities to mitigate negative crop-weed interactions and maintain productivity, especially in water-limited environments. To better understand crop-weed dynamics, weed community structure should be considered alongside weed abundance. While promoting diverse weed communities may reduce competition and support sustainable agriculture, careful management is necessary to prevent the proliferation of weed species with competitive traits.

This research was partially funded by the project "Effect of weed diversity and its interaction with soil microbiota on wheat yield and quality" (PID2019-103929RB-100) led by José Luis González-Andújar. We gratefully acknowledge his contribution and the support provided through this project.

PS2-16. Can we drive crop-weed competition in low herbicide cropping systems by applying nitrogen fertiliser in the crop sowing row?

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Introduction. With the need to reduce mineral nitrogen fertiliser use, better managing crop-weed competition for nitrogen may become crucial to promote biological weed regulation. Especially, applying nitrogen fertiliser locally on the crop sowing row (rather than broadcasted across the whole field) could make more nitrogen available to the crop to the detriment of weed plants (mainly located in the inter-row). However, the effects of this technique have been poorly investigated. The present study determined: (O1) to which extent placing nitrogen fertiliser on the sowing row affects the dynamics in space and time of nitrogen in soil, and (O2) the consequences on crop-weed competition.

Material and methods. A field experiment was conducted to address both objectives. In addition, a systematic review of the literature was performed to address O2. The field experiment was conducted on sugar beet (North-Western of France). Two nitrogen application treatments were compared: a field-wide broadcast vs. an on-row application. Soil mineral nitrogen dynamics and crop and weed biomass were monitored.

Results and discussion. Results from our field experiment showed that the amount of nitrogen in the soil was greater around the point of application when nitrogen fertiliser was applied on the sowing row (vs. broadcasted). This effect persisted over time but faded away. It was visible in the superficial soil layer in both years, but was visible in the deeper layer only the rainy year. Despite effects on soil nitrogen dynamics, applying nitrogen fertiliser on the sowing row (vs. broadcasted) did not significantly affect sugar beet and weed biomass in our field experiment. This finding contrasted with that of our systematic review of the literature showing that, in most cases, crop growth was increased and/or weed growth decreased when nitrogen fertiliser was applied on the sowing row.

Conclusion. Placing nitrogen fertiliser on the sowing row does modify soil nitrogen dynamics, but the consequences on crop-weed competition vary. So, this technique can help to promote crop vs. weed growth, but further studies are needed to determine the conditions of success.

Funding. INRAE, Agrotransfert Ressources et Territoires, andCOPRAA project funded by the Office Français de la Biodiversité (OFB).

Acknowledgement(s) / funding: INRAE, Agrotransfert Ressources et Territoires, and COPRAA project funded by the Office Français de la Biodiversité (OFB).

PS2-17. Root system explains the competitive capacity of camelina against *Lolium rigidum* and *Papaver rhoeas*

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The increasing interest in camelina (*Camelina sativa* (L.) Crantz) arises from its ability to thrive on marginal soils and withstand cold and frost. However, managing weeds in camelina is challenging due to limited herbicide options. Effective weed management in camelina relies on integrated cultural and mechanical weed strategies, as well as on using the natural weed-suppressive capacity of the crop. This study aims to assess the competitive capacity of camelina against two problematic weed species, namely *Lolium rigidum* Gaudin and *Papaver rhoeas* L., in dryland cropping systems in Southern Europe at three different growth stages of camelina (BBCH: 10, 19, and 50). The trial was conducted in season 2023-24 at the University of Lleida, Spain. The experiment was set up in pots (30 cm diameter and 40 cm depth), each filled with a mixture of 50 % peat and 50 % soil. For each weed species and studied crop growth stage, five pots were used with five different proportions of camelina and weeds, with four replicates per treatment (resulting in 20 pots per treatment). Once camelina reached the target stage, all plants were removed, and samples were taken to the laboratory for growth and biomass measurements. The results indicate that camelina exerted stronger competition against *P. rhoeas* than against *L. rigidum*, particularly at early growth stages and at higher densities. At BBCH 10, camelina significantly reduced the growth stages of both weeds, with higher density of the crop leading to lower weed biomass and delayed phenological development. At BBCH 19, the trend remains for *P. rhoeas*, but it is less evident for *L. rigidum*, which develops longer roots and heavy underground biomass than camelina, even under strong crop-competitive pressure. At BBCH 50, *P. rhoeas* still has reduced growth with crop-competition treatments, while *L. rigidum* is less affected. The presence and density of camelina reduced the growth and biomass of *P. rhoeas*. However, the deeper root system and underground biomass of *L. rigidum* allow it to access nutrients from deeper soil layers than camelina, negatively impacting the crop.

PS2-18. Wheat mixtures as a new approach to weed management in organic farming

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Wheat mixtures have been demonstrated to benefit the cropping system by delivering agroecosystem services such as pest control. Nevertheless, their role in weed suppression has rarely been investigated, particularly under Mediterranean conditions. In light of these considerations, we conducted a field experiment in five organic cereal fields in the periurban area of Gallecs, near Barcelona (Spain), over two growing seasons. We evaluated the effect of five wheat crops, three monocultures (Triticum aestivum L. subsp. aestivum cv. Florence-Aurora (FA), Triticum aestivum L. subsp. aestivum cv. Montcada (MO) and Triticum turgidum subsp. durum Desf. (Husn.) cv. Forment (FO)) and two wheat mixtures (FAMO and FAFO), thereafter referred to as treatments, on weed abundance and weed species diversity. Additionally, we explored the relationship between competition-related wheat traits and weed biomass. We assessed weed aboveground biomass and species richness at wheat harvest. Key wheat variables were recorded at various stages throughout the growing period. Wheat establishment was evaluated at the stem elongation stage, wheat cover was measured biweekly during the growth period, and height and final tiller count were taken at the ripening stage. Wheat traits were correlated with weed aboveground biomass using Kendal correlation coefficient.

The results indicated that wheat treatments differ in their effectiveness in reducing weed abundance. Specifically, FO and FAFO treatments displayed significantly lower weed biomass while only FO led to reduced weed species richness compared to the other treatments. Weed biomass presented a moderate negative correlation with wheat establishment, cover and wheat height. However, final tiller number and weed biomass were not correlated. The wheat trait analysis showed that wheat establishment was poorest in MO and FAMO while cover and height were highest in FO and FAFO. Finally, the number of tillers was higher in monocultures than in mixtures. FAFO outperformed FAMO in the traits most correlated to weed biomass, which may explain FAMO's poorer efficiency in weed suppression.

To conclude, mixing wheat species with complementary competition-related traits is an adequate strategy for improving weed management without compromising weed species richness in Mediterranean organic cereals fields.

We are extremely grateful to the Gallecs Consortium for its support and the local farmers, especially Salvi Safont for their cooperation throughout the study in agricultural tasks. The research leading to these results received funding from the European Union.

PS2-19. Adaptation of the FLORSYS model for weed management in sugarcane cropping systems on Reunion Island

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The development of alternative management practices with less reliance on herbicides is a critical challenge for sugarcane production in La Réunion Island. Long-term effects of management practices on seedbank dynamics and weed communities must be considered. However, field experiments to address these questions are time-consuming and expensive, delaying actionable insights. The FlorSys model, initially designed for arable cropping systems in temperate regions, is a promising tool for overcoming this deadlock. The aim of this study is to assess the performance of the FlorSys model under tropical conditions and its ability to account for the characteristics of semi-perennial sugarcane cropping systems and tropical weeds.

So far, we have parameterized one sugarcane variety and 15 dominant tropical weed species using a combination of previously measured functional traits, existing literature, and expert knowledge. To refine key parameters, we set up dedicated experiments to characterize the early growth phase of sugarcane and to assess its morphological plasticity under light competition, a critical factor in weed-crop interactions.

The model, along with our parameterization, is currently being evaluated against historical experimental datasets to test its ability to accurately simulate weed competition effects on sugarcane yield. In preparation for the congress, we compare different weed parameterization approaches and their impact on yield prediction: (i) using average values to represent the weed flora without species discrimination, (ii) clustering weeds into broad functional types (e.g., tall grasses, small dicotyledons, perennial weeds), and (iii) explicitly parameterizing individual weed species to reflect weed-flora diversity.

This work will provide a sugarcane–weed model parameterized and evaluated for La Réunion Island. In the future, the model will be used to assess various weed management strategies in relation to the objectives and constraints of different sugarcane farm typologies. This approach could also be applied to other tropical cropping systems.

Acknowledgement(s) / funding: European Union: Intercrop Values project (grant number 101081973), Feader program (grant n◦ AG/974/DAAF/2016-00096) and Feder program (grant n◦ GURTDI20151501-0000735).

PS2-21. Effect of inter-cropping of canola (*Brassica napus*) with two clover species (*Trifolium alexandrinum* & *T. pratense*) on reducing damage of broomrape (*Phelipanche mutelii* & *P. aegyptiaca*)

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The broomrapes (*Orobanche* and *Phelipanche* spp.) are considered one of the most important parasitic weeds in Iran and other parts of the world. Recently, a severe decline in the yield of rapeseed has been induced by broomrape infection in some parts of Iran. During the years 2019 to 2022, for control of broomrape in canola three experiments were carried out. The objectives of our studies were: (1) to investigate the effect of inter-cropping of canola with two types of clover (*Trifolium alexandrinum* & *T. pratense*) in the control of broomrape, (2) can these species of clover in crop rotation reduce the damage caused by broomrape in canola infected fields? In the first and second experiments, which were carried out under greenhouse conditions, the effect of inter-cropping of a winter rapeseed variety (Okapi) and a spring rapeseed variety (Hayola 50) with berseem clover (*Trifolium alexandrinum*) and red clover (*Trifolium pratense*) were studied in the pots that infected with broomrape, respectively. The results of these two experiments showed that inter-cropping of berseem clover with canola reduced the damage of broomrape ***(****Phelipanche mutelii & P. aegyptiaca****)***. The third experiment was carried out based on the results of the first and second experiments in canola fields infected with broomrape in five regions of Iran (Zarghan, Kermanshah, Shahrekord, Gorgan & Dehloran). The results showed that inter-cropping with a weight seed ratio of five kg ha^{-1} seeds of rapeseed four kg ha^{-1}seeds of berseem clover can reduce the density of broomrape by 65-70% and increase the canola grain yield by 25-55%. In addition, the cultivation of berseem clover in rotation with canola for fodder production in the recommended number of seeds of this crop (20 kg ha^{-1}) in the land contaminated with the broomrape caused an 84% decrease in the number of aerial stems of the broomrape and also an 83% decrease in the dry weight of the broomrape. Therefore, berseem clover in rotation with canola that is infected with broomrape, in addition to producing fodder, can also reduce the population of broomrape as a trap crop.

This experiment was supported by Iranian Research Institute of Plant Protection, Agricultural Research, Education and Extension Organization (AREEO).

PS2-22. What could allelopathy contribute to arable weed management? An agroecosystem-scale perspective

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Arable weed management is challenged by tightening herbicide regulation and widespread resistance. It may be possible to circumvent these challenges, but this will require a diversification of management strategies. The chemical interactions between plants, both antagonistic (allelopathy), and benign (allelobiosis), may therefore become valuable for weed management, in spite of limited application to date. In this work, I have considered our current knowledge of these interactions as ecological phenomena, and interrogated what this may mean for widespread, generalised application, as well as what it says of the scientific paradigm surrounding weeds.

Allelopathy in agriculture is typically examined in reductionist terms: a specific crop or compound against a specific plant species, often as a substitution for a herbicide. Such findings do have value, especially where they can be used within a cropping system to target a highly problematic weed species. That said, it is common for the application of these findings to be hindered by confounding factors that influence the agroecosystem, such as the degradative effects of the soil microbial community. We therefore know many specific cases where allelopathy can influence plant-plant interactions, but not how best to harness it beyond these cases.

Allelopathy and allelobiosis have also been considered in less intensively managed, non-agricultural environments, where they are more often viewed on a community scale, and where they contribute to the regulation of individual species. This contrasts with the historical aims of weed management to eradicate all non-crop species, but does cohere more closely with more ecologically minded management strategies. In order for these interactions to reach their potential in application, I therefore argue that we must prioritise their holistic ecological effects at the scale of the arable plant community and beyond. Widespread application of allelopathy would therefore benefit from a shift in focus, in favour of its potential to complement other ecologically-minded agricultural practices.

Plant-plant interactions will only be effective in regulating arable weeds if we see them in the light of the ecosystems in which they can, or should, function. A generalised, agroecological context for allelopathy as a phenomenon must therefore be targeted to facilitate its wider application.

PS2-23. Developing a novel management strategy for reintroducing sesame cultivation in Israel

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Crop rotation is a sustainable approach to improving soil properties and managing weeds and pests. Integrating a new summer crop, such as sesame (*Sesamum indicum*), is crucial for expanding the limited crop rotation in Israel. Driven by expanding culinary applications and increasing consumer awareness of its nutritional benefits, sesame has become a strategically important crop with escalating global market demand. While most sesame production occurs in developing countries using traditional cultivation methods, our laboratory has recently developed high-yield sesame varieties adapted for mechanized harvesting, enabling the reintroduction of this crop to Israel agricultural. The primary objective of this research was to examine the impact of incorporating sesame into crop rotation through innovative agronomic approaches. The research investigated double cropping strategies on a 2-hectare experimental platform, with a primary focus on sesame cultivation and agricultural field optimization. Comprehensive measurements analyzed crop performance, soil nutrient and carbon dynamics, weed seed bank composition, sesame physiological characteristics, and detailed yield components under diverse tillage conditions. Findings from the first two growing seasons revealed a decline in sesame yield under a double-crop management system (8% average reduction) following forage wheat. Notably, an examination of three post-winter crop tillage treatments (deep, shallow, and no-till) demonstrated no significant impact of tillage type on sesame physiological-developmental characteristics and yield components. Furthermore, perennial species establishment was observed under no-till treatment, with wheat regrowth being a primary factor in growth inhibition. The research also investigated seeding architectures, comparing conventional (two rows per bed) with twin-row and three-row bed configurations. Seeding method influenced plant structure, light use efficiency, and competitive potential against weeds. As hypothesized, the twin-row architecture resulted in faster canopy closure, evidenced by plant height compared to the infested control (p=0.34) and final yield relative to conventional management (10% increase). In conclusion, this study contributes to developing an agronomic framework for the reintroduction of sesame into crop rotation systems in Israel, offering insights into sustainable agricultural practices and crop diversification strategies.

PS2-24. Development of novel bioassay for quantification of strigolactone transport distance in soil

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Strigolactones are plant metabolites that are exuded by roots to soil and induce germination of parasitic weeds like *Striga* and *Phelipanche* spp. Due to their low mobility and rapid degradation in soil, strigolactones are thought to induce germination only a few millimeters from its host's roots. However, the transport distance in different soils is largely unexplored. Thus, this study aimed to: a) develop a bioassay to quantify strigolactone transport distance in soil, and b) test the effects of soil type and microbial activity on this distance. The bioassay included low volume soil columns (diameter: 12 mm; length: 1-9 mm) packed with autoclaved or non-autoclaved soils (clay, loamy sand and pure quartz sand). A paper disc moistened with a 0.1 mM solution of the synthetic strigolactone GR24 was placed at the bottom of each column. A second paper disc with pre-conditioned *Phelipanche aegyptiaca* seeds was placed on top of each column, and the columns were incubated for one week (25˚ C) before germination was counted. Germination rates were normalized to the maximum germination rate observed when seeds were placed directly on a GR24 paper disc. In the clay and loamy sand soil, the normalized germination rate sharply decreased at a distance of 1 mm from GR24 application point, with normalized germination (±SE) of 32.2% (±7.9) and 59.0% (±8.1), respectively. In pure sand, however, germination rate was not significantly reduced up to 9 mm from the GR24 application point. Soil sterilization had no effect on germination dynamics in clay and pure sand soils. In contrast, sterilization of loamy sand soil increased germination rates, extending the effective transport distance to 7 mm. Results of this study indicate that the transport distance of strigolactones varies between soils and is co-dependent on soil texture and microbial activity, with seemingly extended transport in coarser textured and less biologically active soils. The parasitic-weed seed germination bioassay proved to be a robust method for studying the transport distance of GR24 and could be used in future studies to test the transport of other (natural or synthetic) strigolactones.

PS2-25. How do perennial crop phases impact weed communities in annual grain-based systems? A review.

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Current agricultural practices and intensification threaten biodiversity at multiple scales. While a decline in biodiversity is inherently concerning, losing key species such as pollinators or natural enemies of pests present agronomic challenges as well. An absence of native pollinators may result in crop yield decline, and as extensive herbicide use selects for resistant weed populations, difficult to manage species may replace less problematic, and more diverse, weed communities. In response to these, as well as other environmental concerns, holistic agricultural management practices are gaining favor societally. Perennial alternatives to annual crops are promising in terms of reducing environmental impacts and have the potential to alter weed communities. Weed research has historically mainly focused on weed control, assuming that all non-crop plants have detrimental effects on crop productivity. It is however evident that weeds are able to offer beneficial services to agroecosystems, especially in terms of in-field support of biodiversity. Notably so-called “neutral weed communities”, that coexist with crops without negatively affecting yield, exist. Assessing the differences in weed communities supported by different cropping systems, the ecological values they may provide and how that compares to potential losses in yield is therefore necessitated. The objective of this review is to summarize the available research on weed communities associated with perennial crops. Of interest are cropping systems where perennial crops (grains, forages or biomass crops) are included in cropping systems that are based on annual grains. The focus of the review will be the following: (a) perennial crops’ effects on weed life cycle and thus weed community composition, weed density as well as weed species diversity and abundance; (b) how those impacts are affected by the management of the perennial crop; (c) ecological value provided by those weed communities in terms of services and dis-services. Patterns elucidated by the literature review will be analyzed and discussed, and conclusions as well as recommendations for further research will be provided.

PS2-26. Mixed cropping as a tool for weed suppression: A winter grain crops case

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Mixed cropping can be an ecological tool for weed management. There is a limited information in this aspect. Therefore, a field experiment in two consecutive growing seasons - 2022/2023 and 2023/2024 was conducted. The trial was situated on the experimental field of the department of Agriculture and Herbology at the Agricultural University of Plovdiv, Bulgaria. The aim of the study was to evaluate the positive and the negative sides of growing different winter grain crops as sole and mixed crops. One of the tasks was to determine the competitiveness of the sole and mixed crops against the weeds *Lactuca serriola* L. and *Consolida regalis* Gray. Variants of the experiment were: 1. Winter wheat - variety "Sofru" (sole crop); 2. Winter wheat - variety "Solindo" (sole crop); 3. Winter wheat - variety "Sofru" + winter wheat - variety "Solindo" (mixed crop 50:50 of the sowing rates); 4. Winter barley - variety "Odyssey" + winter wheat - variety "Solindo" (mixed crop 50:50 of the sowing rates); 5. Winter barley - variety "Odyssey" + winter wheat - variety "Sofru" (mixed crop 50:50 of the sowing rates); 6. Winter barley - variety "Odyssey" (sole crop); 7. Rye, variety "Millennium" (sole crop). It was found that in the plots of the two winter wheat varieties grown as sole crops the weeds *L. serriola* and *C. regalis* were in higher growth stage than in the plot where the winter wheat varieties were grown as a mixed crop. In the sole crop of barley and in the mixed crops of barley with the two winter wheat varieties, these weeds were significantly suppressed and were lagging behind in their development. In comparison to the sole crops of both wheat varieties, the fresh weight of *L. serriola* and *C. regalis* was severely decreased in the mixed cropping system of the wheat varieties as well as in the mixed crops of barley with the winter wheats. The weed suppression was due to the increased tillering of the two winter wheat varieties together. The weed suppression was more severe in the mixed cropping system of barley and the winter wheat varieties.

This study was financially supported by the Centre of research, technology transfer, and protection of intellectual property rights at the Agricultural University of Plovdiv, Bulgaria - Project 03-24.

PS2-27. The composition and density of weed species in winter crops in a sustainable agricultural interface

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The rise of herbicide-resistant weeds and increasing environmental concerns have driven the adoption of mechanical weed control methods to enhance sustainable weed management. However, these methods can increase soil erosion, organic matter loss, and reduction in beneficial soil biota. Weeds might take advantage of the crop's initial slow growth, to utilize more resources and dominate crop plants. Early vigor (canopy produced on early stage), is a key trait for improved weed competitiveness. Our study examines two competition-based weed management approaches in grain crops. The first approach investigates Service Crops (SC) grown during the fallow season, combined with zero tillage practice. SC biomass can reduce weed presence through resource competition. Allelopathic plants within the SC mixture may contribute to weed suppression. The second approach evaluates competitive grain crops, leveraging traits such as early vigor and allelopathy to mitigate weed growth during the cropping season. We conducted two field experiments: (1) A comparison between wheat grown in plots where SC was grown in the previous winter combined with no-tillage vs. conventional farming with a bare soil approach (BS). (2) An evaluation of weed suppression capabilities among four winter cereal crops: wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), triticale *(Triticosecale)*, and oat (*Avena sativa*). The composition and coverage of weeds were recorded using vegetation surveys conducted throughout the growing season. We found higher weed species diversity and coverage in SC plots compared to BS plots. This discrepancy may be attributed to historical differences in weed management. The BS plots had herbicide-tillage management, while no such management was performed in the SC plots. Thus, contributing to greater diversity in weed species within the SC plots. In SC plots the most abundant weed was *Convolvulus arvensis*, while in BS plots the most abundant was *Cyperus rotundus*. Among grain crops, barley showed superior weed suppression capabilities, followed by triticale and oat. Wheat demonstrated the least weed suppression capabilities. This study contributesto our understanding of sustainable weed management practices and provides valuable insights into the effectiveness of different integrated weed management strategies in Mediterranean cropping systems.

PS2-28. Management tactics for control of *Poa annua* to reduce herbicide reliance

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Poa annua thrives in all crops and germinates year-round often with multiple generations per year. It can develop into a very dense competitive population, especially in open crops such as maize. It is also a troublesome weed in grass seed production as the seeds can pollute the harvested seeds, decreasing the value of the crop. Resistance against ALS-inhibitors has been observed in a variety of crop rotations in Denmark.

The objective was to study tactics for alternative management strategies with less dependence on chemical herbicides including mechanical weeding in maize, competitive ability of cereal crops and the percentage of *Poa annua* seed surviving in different soil depths.

In maize, the row width enables a variety of mechanical weeding tactics both inter- and intra-row. A conventional strategy is to apply glyphosate before emergence and follow-up with herbicide application. In the field trials, false seedbed and tine harrowing replaced the pre-emergence glyphosate application and post-emergence herbicide application was replaced by varying mechanical strategies to evaluate the efficacy of alternative strategies on control of *Poa annua*. Tine harrowing around maize emergence was as effective as glyphosate application and can be applied after the maize emerges, which provides a longer window for early season weed control. A combination of inter- and intra-row weeding resulted in high control levels, only slightly less efficient than the standard herbicide treatment. Maize tolerated the mechanical practices well and yield was maintained in the alternative strategies with high weeding efficacy.

No major competitive differences on *Poa annua* were observed among cereal crops in the field trial, but delaying establishment of winter wheat approximately 3 weeks decreased the weed coverage in spring. In a controlled target-neighbourhood experiment, the number of crop plants had larger influence on the dry weight of *Poa annua* than the crop species.

The results showed that there were some alternative tactics for control of Poa annua in maize, and that the depth of burial matters for the ability of seeds to germinate. No major differences were observed in competitiveness of winter oilseed rape, winter or spring cereals.

Funded by the Danish Environmental Protection Agency.

PS2-29. Studying the relationship between nitrogen fertilization and weed-crop interactions

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Nitrogen is a key nutrient element that usually becomes deficient under crop-weed competition. The rate of crop-weed competition becomes more severe under nitrogen-deficient conditions as compared with excess nitrogen rates. The objective of the current study was to evaluate interaction between N fertilization and weed Communities. The response to N fertilization varies between weed species. For example, without N fertilization saramollagrass (*Ischaemum rugosum* Salisb.) was 100% taller than rice but was only 50% taller than rice with N fertilization. In contrast, itchgrass [*Rottboellia cochinchinensis* (Lour.) W.D. Clayton] was 174% taller than rice without N fertilization but was 233% taller with added N. With an increase in N dose from 110 to 220 mg N kg^{-1} soil, redroot pigweed (*Amaranthus retroflexus* L.) biomass increased by 6.5% compared with only 1.9% in maize (*Zea mays* L.). At the lowest rate of 60 mg N kg^{-1} soil, *A. retroflexus* was less competitive than spring wheat, but with an increase in N level to 240 mg N kg^{-1} soil an inverse relationship was observed; that is, the weed became more competitive than the crop. With the application of 50–150 kg N ha^{-1}, weed biomass increased 82–160%, whereas a 92–229% increase was observed in rice biomass, indicating that added N benefitted the crop more than the weed. In vegetable crops, yellow nutsedge (*Cyperus esculentus* L.) and purple nutsedge (*Cyperus rotundus*L.) compete more aggressively at higher N rates. Increasing the N application rate up to 150 kg ha^{-1} caused a significant improvement in the grain yield of direct-seeded rice when weeds were well controlled; however, under poor weed control conditions, it resulted in a drastic reduction in the crop yield. So, fertilization alone, without weed management, will not help with achieving higher net returns, and additional fertilizer application cannot compensate for yield losses due to weed competition.

PS2-30. Competitive ability of soybean cultivars against invasive weeds: The role of competitive varieties in integrated weed management strategies

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The spread of invasive weeds poses a a major challenge in agriculture due to their aggressiveness, adaptability, and competitiveness. Integrated weed management strategies, including the use of competitive crop varieties, can mitigate their impact by enhancing crop competitiveness for resources. This study aimed to assess the competitive ability of different soybean cultivars against invasive weeds by analyzing soybean and weed dry biomass, as well as crop canopy coverage.
Field trials were conducted from 2020 to 2022 in Novi Sad, using three soybean vareties (NS Apolo, Fortuna, NS Zmaj) and three invasive weed species (*Abutilon theophrasti*, *Ambrosia artemisiifolia*, and *Xanthium strumarium*). The experiment was arranged in a split-split plot design with four replications, employing an additive competition model. After soybean sowing, weeds were sowed on the same time in four densities by hand (0.5, 1, 5, and 10 plants m^{-1}). Soybean and weed dry biomass, as well as crop canopy coverage in weed-free plots, were measured during the growing season.
The results revealed that the early-maturing cultivar, Fortuna, characterized by larger aboveground biomass and oval leaves, demonstrated superior canopy coverage compared to NS Apolo and NS Zmaj. Fortuna had 1.49 times greater odds of achieving higher canopy coverage at the fourth week after emergence (WAE), 1.41 times at the sixth WAE, and 2.23 times at the eighth WAE. Additionally, Fortuna exhibited the least dry biomass reduction compared to the other cultivars. In 2020, Fortuna showed losses between 11% and 23% in competition with *A. theophrasti* and *A. artemisiifolia*, while NS Apolo and NS Zmaj had higher losses (16–32% for *A. theophrasti* and *A. artemisiifolia*, and 22–39% for *X. strumarium*). In 2021, Fortuna experienced a reduction of 11% to 31% at lower weed densities, with higher losses observed in competition with *X. strumarium* (24–45%). In 2022, Fortuna demonstrated the lowest dry biomass losses (6% to 21%) under lower weed densities, showing the greatest resilience to weed competition. At higher densities, all cultivars had increased losses, with Fortuna maintaining the smallest reductions (37% to 54%) in competition with *A. theophrasti* and *A. artemisiifolia*. *X. strumarium* emerged as the most aggressive weed, leading to significant dry biomass reductions across all cultivars, highlighting the need for integrated weed management strategies, especially in regions where this species is prevalent. Although Fortuna cultivar demonstrated greater competitiveness, the results indicate that relying solely on competitive soybean cultivars is not sufficient for effective weed management. This strategy should be implemented as part of an integrated weed management system.

Keywords: varieties, *A. theophrasti, A. artemisiifolia, X. strumarium,* competition

Acknowledgments: This research was supported by the European Union's Horizon 2020 Project ECOBREED - Increasing the efficiency and competitiveness of organic crop breeding under grant agreement number 771367.

PS2-31. Impact of forage crop mixtures on weed dynamics and forage productivity under conservation agriculture in Morocco.

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Weed management in conservation agriculture (CA) is challenging, particularly in low-input systems with minimal herbicides application. Integrating forage legumes into cereal-based farming systems provides a long-term strategy for successful weed control. This study aimed to evaluate the effect of forage crop mixtures on weed dynamics and forage productivity under conservation agriculture. Conducted over two growing seasons (2020-2021 and 2022-2023) in Sidi El Aidi, Morocco, using a randomized complete block design (RCBD) with three replications, the experiment tested four forage mixtures (barley-vetch, barley-pea, triticale-vetch, and triticale-pea) at five different ratios: 100% cereals, 100% pulses, 70% cereals-30% pulses, 30% cereals-70% pulses, and 50% cereals-50% pulses.

Results showed significant variations in weed density and dry biomass among mixture types and ratios across the seasons. The Pea-Barley mixtures, particularly the P50B50 and P70B30 ratios, exhibited the lowest weed densities (17 and 28 plants/m²) in 2020-2021, with the P70B30 ratio achieving the lowest weed density in 2022-2023 (105 plants/m²). Similarly, the Vetch-Barley and Triticale-Pea mixtures with appropriate ratios (B50V50, T50P50) consistently reduced weed densities and dry biomass. In contrast, the sole pea treatment (P100) resulted in the highest weed biomass. In terms of forage productivity, the Pea-Barley mixtures, particularly the P50B50 and P70B30 ratios, produced the highest dry matter in both seasons, with values ranging from 7.83 to 8.61 t/ha in 2020-2021. The Vetch-Barley and Triticale-Vetch mixtures also demonstrated favorable forage yields, particularly the T100 treatment, which produced the highest forage dry matter (7.65 t/ha) in the first season. The total dry matter in the Pea-Barley and Vetch-Barley mixtures ranged from 7.83 to 9.58 t/ha, with the highest values recorded in the 2022-2023 season for specific ratios such as P30B70 (8.28 t/ha). These findings highlight cereal-forage legume mixtures potential as an effective technique for weed suppression and biomass improvement in CA systems, providing a sustainable alternative to traditional weed management practices.

Keywords: Forage mixtures, weed dynamics, conservation agriculture, crop rotation, weed control.

PS2-32. Functional characterization and differentiated harmfulness of sugarcane weeds

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Weed-related yield losses are challenging to measure and predict but are estimated to be up to 34% in temperate environments and over 50% in tropical regions. Weed impact depends on their abundance but also on their trophic resource acquisition strategies. This study aims to: (i) assess the response of sugarcane yield to different weed communities shaped by three weed-management strategies, (ii) classify weed species as a function resource competition strategy (defined from their functional traits), and (iii) link these strategies to their effects on sugarcane yields.

We performed two controlled sugarcane field trials in La Réunion island from 2021 to 2023. In these trials, we artificially created different weed communities using weed control interventions (chemical and manual), and then measured the sugarcane growth obtained on these plots. We also measured various aboveground and root functional traits linked to competition for light and soil resources on major weed species. Linear mixed models were used to assess the effects of treatments on biomass and cane yield components, and a Principal Component Analysis followed by hierarchical classification were used to group species according to their traits. Finally, an RLQ and fourth-corner analysis explored the links between weed traits, species and sugarcane yield components.

Sugar cane growth was significantly influenced by the weed communities in both trials. The impact of weed cover was clearly visible, but some differences could be attributed to the weed resource acquisition strategies. Creepers were mostly associated with acquisitive aboveground strategies and conservative belowground ones. Some dicotyledonous weeds were more likely to be associated with conservative aboveground strategies level and acquisitive belowground ones. However, these strategies did not have the same impact on the sugarcane growth depending environmental conditions. Under optimal fertilization and irrigation, sugarcane growth was mainly reduced by weeds with acquisitive aboveground strategies (i.e. creepers), while without fertilization and irrigation, sugarcane biomass was mostly decreased by weeds with belowground acquisitive strategies.

This study illustrates the complexity of weed harmfulness, which varies significantly depending on the composition and characteristics of weed species, particularly their resource acquisition strategies, as well as their interactions with environmental conditions.

5. Non-chemical weed control tools

S05-O1. Alternative methods to herbicides for weed control: a systematic literature review

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Weeds significantly threaten crop yields, with reductions of up to 95% in some cases. They compete with crops for resources, produce allelochemicals that inhibit crop growth, and decrease market and nutritional value. Modern agriculture relies heavily on herbicides due to their cost-effectiveness and lack of viable alternatives. However, their overuse causes environmental damage, soil biodiversity loss, and health risks. The European Green Deal and Biodiversity Strategy aim to reduce pesticide use by 50%, enhance organic farming, and restore ecosystems. In this perspective, research increasingly focuses on Integrated Weed Management (IWM), which employs multiple strategies to control weeds holistically. IWM emphasizes collaboration among farmers, researchers, and extension services to share knowledge and best practices, facilitating the transition to sustainable weed management while maintaining productivity.

This systematic review examines recent scientific publications (2013–2022) on alternative weed control methods to herbicide use within the EU-27 and the UK across major cropping systems. Following the PRISMA protocol, the review utilized Scopus for its comprehensive coverage of peer-reviewed journals. Methods were classified using the IWM framework developed within the context of the IWMpraise project (https://iwmpraise.eu/), which comprises five pillars: direct control, field and soil management, cultivar choice and crop establishment, diverse cropping systems, and monitoring and evaluation. Herbicide-based tactics were deliberately excluded. Search criteria were defined for each tactic, generating specific queries combining keywords and performance indicators. The search yielded 6,246 papers, which underwent a two-phase screening process. In the first phase, titles, abstracts, and keywords were analyzed, excluding papers outside the geographical scope, lacking agronomic indicators, or not isolating single-tactic effects. After this phase, 1,765 papers remained. In the second phase, full-text screening verified eligibility, resulting in the inclusion of 569 papers. Data extracted included the IWM pillar, tactic details, study location, crop type, and experimental setup.

This state of the art enables the identification of i) which IWM tactics have been extensively studied by researchers,and ii) the specific conditions and most common European crop types for which alternative solutions (eg., arable crops, field vegetables crops, vineyards) to herbicides have been tested. OPER8 Project - funded from the European Union Horizon 2021 Food, Bioeconomy Natural Resources, Agriculture and Environment Programme under grant agreement 101060591.

S05-O2. Bio-efficiency of weed control with a blue diode laser

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Laser radiation can be an efficient thermal weed control method as an alternative to herbicides. This study investigated the effectiveness of a blue diode laser for controlling small weed targets. A series of dose-response pot experiments were conducted in which complete seedlings and fresh seeds of various annual weed species (3 grasses, *Poa annua*, *Echinochloa crus-galli*, *Digitaria sanguinalis* and 3 dicot weeds *Solanum nigrum*, *Chenopodium album* and *Senecio vulgaris*) were exposed to various energy doses (obtained by adjusting the energy intensity of the laser beam). For seedlings, the overall aim was to investigate the impact of plant species, phenological growth stage (cotyledon, 2-leaf) and leaf wetting by dew or rain (dry, wet) on biological efficiency of laser heating. For seeds, the effects of weed species, burial depth (0 mm, 4 mm) and imbibition (non-imbibed, imbibed for 48h) on bio-efficacy were examined. Bio-efficiency was determined as the energy dose required for 70 to 90% reduction in living aboveground biomass, leaf area and number of living plants or seeds. Living biomass was determined 21 days after laser treatment. Leaf area was determined using MATLAB software on images taken prior to and 72 hours after treatment. Seed vitality was assessed with a germination test followed by a tetrazolium test. Experiments were carried out under controlled conditions, using pot-grown weeds.

Results show that laser treatment of whole seedlings caused significant dose-dependent growth reduction and mortality (up to 100%), irrespective of species. However, seedlings were most susceptible at their very early growth stage (cotyledon stage) and when not wetted by moisture (in case of easy-to-wet surfaces). Efficiency was highly species-dependent with grasses requiring higher energy doses for comparable control. Grasses have more protected meristems indeed. Laser heating was highly effective in reducing vitality of unburied fully exposed weed seeds (up to 100% kill). However, seeds were clearly less susceptible when imbibed.

Results indicated that laser weeding is a promising sustainable alternative weed control method for controlling young weed seedlings and reducing weed seed return. Further research will optimize laser settings and field applicability.

S05-O3. Low-energy weed control - selectivity between weed and crop

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There is a need to reduce the reliance on herbicides and tillage for direct weed control. Electrical weed control could be a complement, especially since it is one of the few non-chemical control methods that potentially can control the underground storage organs of perennial weeds. However, the selectivity between the targeted weeds and nearby crop plants has not been sufficiently studied. In two outdoor pot trials a low-energy weed control method was tested to study the selectivity between 1) *Chenopodium album* (White goosefoot) and potato and sugar beet, and 2) between *Elymus repens* (Couch grass) and winter wheat. In the *C. album* trials the electrodes were both placed on the weed or one on the weed and one in the soil. In the *E. repen*s trial, there were three different application methods: 1. both electrodes on the weed, 2. one electrode on the weed and one in the soil next to the weed, and 3. one electrode on the weed and one electrode behind one of the winter wheat plants. In both experiments, 5 kV was applied for 0.2 s. *Chenopodium album* plants were treated at three treatment times (26, 33 and 46 days after sowing) and *E. repens* at two (22 and 46 days after sowing). All *E. repens* shoots that emerged from the 5-cm long rhizomes were treated.

Results: The electrical treatment had high efficacy (>96%) against small *C. album* plants, but efficacy decreased at later treatment times. The treatment had no effect on sugar beet or potato shoot or beet/tuber biomass when both electrodes were on the weed plant. When one electrode was in the soil there was tendency towards reduced sugar beet biomass (not tested in potato). The electrical treatment killed the majority of *E. repens* shoots, resulting in reduced shoot and rhizome biomass and a reduced number of shoots, compared to the untreated control. No treatment method had a higher efficacy on *E. repens* than the others, and none of the treatments reduced winter wheat shoot biomass. In conclusion, the electrical treatment has high efficacy against *C. album* and *E. repens* and has high selectivity, especially when both electrodes are on the weed plant.

Acknowledgement(s) / funding: Swedish farmers' foundation for agricultural research.

S05-O4. Thermal weed control using steam, osmotic pressure and microwaves

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The combination of steam, osmotic pressure and microwaves (SOP) applied in the same pass and in the sequence mentioned is a new thermal weed control concept. Steaming denaturates and ruptures proteins and cell walls in plant tissue and the salt, sodium formate, creates osmotic pressure that accelerates withdrawal of water from plant cells. Finally, microwaves kill surviving plant tissue through the condensated water from the initial steam application. The first tests of the concept showed superior weed control over current thermal methods. However, optimal adjustments of steam, salt dose and microwave inputs according to the weed problem of concern are lacking. Greenhouse studies with weeds established in pots were made in 2024 to clarify an efficient use of SOP against annual weeds with and without protected growing points and perennial weeds with the ability to resprout from belowground propagules. SOP killed small-sized *Tripleurospermum perforatum*, *Centaurea cyanus*, *Stellaria media*, *Poa annua* and even *Cirsium arvense*, while *Elytrigia repens* was mostly unaffected irrespective of the SOP dose (forward speeds 1-8 km h-1). The high effectiveness against particularly annual dicotyledonous weed species with unprotected growing points was achieved at both salt doses studied, 10 g m-2 and 5 g m-2. Even the perennial species *Cirsium arvense* was surprisingly sensitive to both salt doses since aboveground shoots were completely controlled with no resprouting of shoots taking place during the post-treatment period. SOP is commercially employed on hard surfaces in amenity areas but might have wider application for agricultural and horticultural crops.

Acknowledgement(s) / funding: GUDP grant no. 34009-23-2134.

S05-O5. Effectiveness of cutting methods to reduce weed seed return into the soil

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Due to political demands for reducing pesticide use and the increasing resistance of key weed species such as *Alopecurus myosuroides* and *Lolium* species, innovative non-chemical weed control methods are required. In situations with high weed pressure, cutting seed heads above the crop canopy can reduce weed seed input into the soil and help decrease weed density over time.

Field trials were conducted in 2022 to evaluate the efficacy of the cutting device "Top Cut collect" (TCC) from the company Zürn to remove *A. myosuroides* and *Lolium*seed heads in winter wheat fields with high weed densities. Weed seed heads were cut at various heights above the wheat canopy at the start of the wheat heading. Additional experiments in 2022/23 examined the regrowth of *A. myosuroides* after cutting and the germination capacity of cut seeds at various cutting times.

For *Lolium* species, cutting at a height of 90–97 cm removed 68% total seed head weight, while cutting at 68 cm removed 84%. Since *Lolium* stems are generally taller than *A. myosuroides*, more seed heads protruded above the crop canopy, making them easier to cut.

For *A. myosuroides*, cutting at 95 cm removed 44% of seed heads, whereas cutting at 91 cm increased removal to 84%. However, a few weeks after cutting, new *A. myosuroides* seed heads emerged above the wheat canopy.

The regrowth (development of new seed heads) of *A. myosuroides* was highest at a late cutting date (early June) compared to earlier cutting dates (late June).

The TCC system represents a novel tool for alternative weed control strategies in various crops. It can help limit weed spread and reduce weed pressure over time. The TCC system is therefore one of several non-chemical strategies that could partially replace chemical weed control as herbicide resistance increases and fewer effective herbicides remain available.

S05-O6. Short-term response of weed seed bank to reduced tillage systems

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Increasing soil degradation has led to the adoption of reduced soil tillage practices with environmental and economic benefits. This study, conducted from 2020 to 2022at the Infrastructure Centre Jablje pri Mengšu (Agricultural Institute of Slovenia, 46°08’33.9’’ N, 14°34’21.5’’ E, 309 m a.s.l.), on silty-loam alluvial soils in a temperate climate, examined the germinable and persistent components of the weed seed bank during the initial transition from conventional (CN) to conservation (CS) and no-tillage (NT) systems. The experiment took place in a single field, with 50 × 25 m plots in a randomized block design with four replicates of each tillage. Soil sampling was performed before tillage operations each spring and autumn. To quantify weed seed abundance and species composition, germination tests were conducted in a greenhouse, while the persistent seed bank was assessed in spring 2022 using the flotation method. The average persistent weed seed bank across all treatments (117,000 seeds m^{-2}) was substantially larger than the average germinable weed seed bank across years (27,000 seeds m^{-2}), highlighting the role of dormancy in seed bank dynamics.In the spring cropping period, the germinable seed bank was up to four times larger than in autumn, and NT consistently reduced germinable seed densities by 45–75% compared to CN and CS. Moreover, bothNT and CS enhanced species diversity and evenness, particularly in the spring. While the vertical distribution of the germinable seed bank remained relatively uniform across soil layers regardless of tillage, the persistent seed bank displayed a more stratified pattern. Four years after the tillage change, a higher proportion of persistent seeds had accumulated in the intermediate (5–10 cm) and bottom (10–20 cm) soil layers under CN and CS, whereas in NT, seeds concentrated in the topsoil (0–5 cm). The rapid response of the germinable seed bank to tillage changes and observed shifts in seed bank indices emphasize the need for comprehensive seed bank studies when transitioning to reduced tillage, especially under high weed pressure. The overall response of the germinable weed seed bank to less intensive tillage caninform agroecological soil management strategies that favour diverse weed species communities within CS and NT systems, contributing to the overall resilience and stability of the agroecosystem.

This research was funded by the Next generation agriculture research program (P4–0431).

S10-O1. Growing a living mulch in maize interrow for sustainable weed management

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Cover crops (CC) can be grown as living mulches along with a cash crop to limit weed development and potentially reduce herbicide use. A two-year field study was conducted in northwestern Italy in 2023-2024 by growing two CC in maize inter-row. The aim of the trial was to combine an in-row chemical weed control (performed with a pre-emergence herbicide only, a.i. mesotrione 150 g/ha + s-metolachlor 1250 g/ha + terbuthylazine 750 g/ha) with an inter-row living mulch of *Secale cereale*(rye) or *Trifolium alexandrinum*(Egyptian clover), seeded respectively at 180 kg/ha and 50 kg/ha, either one month before maize (mid-March) or on the same day (mid-April). A chemical control broadcast sprayed with the same pre-emergence herbicide used on the row and an untreated control with spontaneous weeds were also included. Both CC and weeds were either not mowed or mowed with a string trimmer once during the season. Data was collected twice on CC and weeds, and it included density, soil cover and biomass (dry matter per m^2); as for the crop, maize height, growth stage, some vegetation indices and final grain yield were assessed. In June, rye developed a biomass of 78.4 g/m^2 when seeded in March and 81.3 g/m^2 when seeded with maize, while Egyptian clover had significantly higher values (184.7 g/m^2 and 230.4 g/m^2, respectively). In fact, when seeded with maize, Egyptian clover was able to significantly reduce weed biomass (19.0 g/m^2) compared to the untreated control (182.0 g/m^2). In terms of competition between the crop and the living mulch, rye seems to be more competitive compared to Egyptian clover during the first growth stages. Maize height was on average the lowest (42.5 cm) when grown with rye seeded one month before maize, and the highest (48.0 cm) when grown with Egyptian clover seeded with maize; in the herbicide treated plots maize height was on average 46.3 cm. Overall, seeding CC on the same day as maize provided better results in terms of weed suppression compared to seeding the CC one month before, especially for Egyptian clover, which on the other hand showed a less competitive behavior against maize.

S10-O2. A Bayesian network model based on knowledge expert elicitation for integrated weed management assessment in cropping systems

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Integrated weed management (IWM) is the combination of mechanical, cultural, chemical and biological levers to control weeds at cropping-system (CS) scale and reduce the reliance on one farming practice.This combinatorial, multi-crop approach makes it difficult to predict the outcomes of the IWM strategy. Primary knowledge on IWM in arable land is fragmented, and there are few examples of expertise being mutualized at CS level. In the present work, we use expert-based elicitation to build a Bayesian network (BN) model aiming to assess IWM strategies. The BN is composed of a directed acyclic graph that represents qualitative variables, whose interdependencies are linked by probabilistic values. Fifteen weed management experts from French and Swiss research organizations, specialized in various crops and farming practices, set up the foundations of the model during 20 design workshops over 18 months. The inputs are farming practices divided in four groups: crop diversification (e.g. crop type, intercropping), pre-sowing interventions (e.g. soil tillage, delayed sowing date), curative weeding (e.g. mechanical and chemical) and pre-harvest weeding (e.g. weed seed exportation). Weed variables (e.g. soil seedbank, early density before weeding, late biomass after weeding) are calculated according to the effect of farming practices through tables of probability. The model computes the probability for CS to generate weed harmfulness such as yield loss, harvest difficulties (percentage of surface non harvested because of weeds) and weed seed production. The model was evaluated by the same experts using fictitious CS and confronting the output to the expectations. The model was also evaluated using observed data from CS experiments of the partners involved in the project. Validation with fictitious CS was done in a top-down and progressive manner by creating strategies to endorse the levers one by one. Once tested, the lever was approved when the result corresponds to the upstream expertise or corrected if there is a deviation from the expected result (e.g. overestimation of the chemical weeding efficiency of weed grass resistance). Comparison with experimental data showed discrepancies between observed and predicted results, because few data sets from CS trials exist over several rotations.

Acknowledgement(s) / funding : Ecophyto call for projects - ‘Combining alternative operational levers’. Funding provider: French Office for Biodiversity.

S10-O3. Controlling overwintered cover crops and weeds before sowing spring cereals

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Use of cover crops providing plant cover the whole year has gained a large interest in recent years. Cover crops can be killed by frost or survive winter and need to be controlled by glyphosate or spring ploughing before sowing spring crops to avoid that they become weeds. In unploughed fields also overwintered perennial and annual weedsneed to be controlled prior to sowing. Two field trials aimed to investigate control of overwintered cover crops (sown in spring or autumn in year 1) and weeds by alternative herbicides and methods before sowing spring cereals (year 2). In Trial 1 (2023-2024), spring ploughed and sown with spring barley in 2023, five cover crops mixtures (none, spring-sown: *Lolium perenne* / *Trifolium repens* / *T. incarnatum*, *Dactylis glomarata* / *Cichorium intybus* and *Festuca pratensis* / *T. repens*, autumn-sown: *Secale cereale* / *Vicia villosa* / *Raphanus sativus subsp. oleiferus*) were combined with 10 control treatments (2024: untreated, mid-winter: microwaves (prototype, pat. pend.), spring: 1.44 kg glyphosate ha^{-1} (GL), 10.88 kg pelargonic acid ha^{-1} (PA), 60 kg acetic acid ha^{-1} (AA), 0.125 kg propaquizafop+ 0.3 kg fluroxypyr ha^{-1} (PF), rotary harrow (1 time, RH1), rotary harrow (2 times, 2 d interval, RH2), KvickFinn-harrow (1 time, KF), and PA+ rotary harrow (2 d after PA)) in a split-block design with three replicates (plot size 2.5m x 5m). The whole field (including previous harrowed plots) were rotary harrowed and spring oats sown. Ground cover of weeds, cover crops and cereals were visually assessed in summer both years and spring year 2, and cover crop biomass in summer year 2 (0.5 m^2 per plot). Cereals were not harvested. Trial 2 (2024-2025) was sown with slightly other cover crops in 2024 with treatments planned in spring 2025. Preliminary results of Trial 1 were that GL and PF provided 84-100% control and RH2 and KF 51-97% control of weeds (*Elymus repens)* and cover crops present at treatment. RH1 tended to give poorer control for most species (significant for *F. pratensis)*. Microwaves controlled *L. perenne* only by 50%. PA and/or AA gave moderate control on *D. glomerata* and *F. pratensis*. Without ploughing, we conclude that harrowing strategies performed better than alternative herbicides for control of overwintered plants .

This work is part of the project SUSWECO funded by Research Funding for Agriculture and Food Industry (Project No. 336475) and project partners.

S10-O4. Can we control weeds with RNAi?

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Spray-Induced Gene Silencing (SIGS) employs foliar-applied RNA molecules to trigger gene silencing in target pests, potentially addressing critical challenges such as resistance and the lack of new modes of action. While at the lab scale it is effective against many pests, the only commercial product available is an insecticide. And what about weeds? Which are the challenges for the development of efficient RNAi herbicides?

Reviewing the bibliography (please see https://doi.org/10.1002/ps.8729), we observed that two major limits for the development of the technology are: a) identifying targetable sequences and b) increasing the stability and delivery of RNA molecules. Our lab is actively working on both issues.

To identify candidate target genes, whose silencing cause severe phenotypes, we are applying VIGS (Virus-Induced Gene Silencing) in the model species *Nicotiana benthamiana* (NIOBE) and in five weeds, two dicots, *Solanum nigrum* (SOLNI) and *Amaranthus hybridus* (AMACH), and three monocots, *Echinochloa crus-galli* (ECHCG), *Echinochloa oryzicola* (ECHCR) and *Oryza sativa var. sylvatica* (ORYSA).

The tobacco rattle virus (TRV-VIGS) successfully caused the silencing of *PDS* (phytoene desaturase) in both NIOBE and SOLNI, resulting in the typical bleaching phenotype. The silencing of *ALS* (acetolactate synthase) resulted in death of NIOBE, and stunting of some SOLNI plants. Affected plants all resulted in decreased expression of target genes (PDS and ALS) by 70-90 %.

Instead, AMACH resulted very recalcitrant to the TRV-VIGS; as alternative, on AMACH we also tested the cucumber mosaic virus (CMV) (unsuccessfully, but more tests are ongoing).

No specific VIGS protocols exist for the three monocot weeds, therefore experiments are ongoing using the barley stripe mosaic virus (BSMV). The same sequences validated with VIGS will be targeted also by naked and nano-encapsulated dsRNA (see the abstract Milani et al., “Investigating the use of dsRNA as innovative strategy for weed control in Italian rice system”).

In the next months, other genes which encode for proteins that cannot be inhibited by traditional drugs (undruggable) will be evaluated.

To obtain a working RNAi-herbicide proof-of-concept, demonstrating sequence efficacy would be key. Therefore, the development of affordable VIGS protocols in weeds will very valuable to weed biologists.

This research has funded by the European Union - Next Generation EU, Mission 4 Component 1, CUP B53D23017800006.

S10-O5. Challenges and opportunities for integrated weed management in pome fruit

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Conventional pome fruit growers keep the black strip, i.e., a 1.5-m wide strip in the tree row, nearly weed-free at low cost through two to four annual applications comprising soil-acting and/or foliar herbicides. However, aligning with the European Green Deal's objective to cut chemical pesticide use and risks by 50% by 2030 and promote integrated pest management, widely used herbicides are being phased out, thus generating demand for viable integrated weed management systems.

Our ongoing study assesses the impact of distinct weed management systems on weed flora dynamics, fruit yield, and quality, while considering technical feasibility in terms of treatment frequency and labour requirements. Systems were applied in a well-established intensive pear (*Pyrus communis* L. cv. Conference) and apple (*Malus domestica* Borkh. cv. Golden) orchard, and included an untreated control, two benchmark systems (a standard chemical control and a standard mechanical control used by organic growers) and five integrated systems combining no or reduced herbicide use (through narrowing the black strip or restricting herbicide choice, more specific glyphosate) and non-chemical tactics (cords mower, hot air). Weed flora was studied through three-weekly monitoring of weed coverage, species importance, and composition. From the end of flowering until 80% fruit size,

treatments were applied whenever weed coverage in the black strip surpassed a 20% threshold. Fruit yield (weight, number) per tree and fruit quality (size distribution, mineral content, firmness, sugar content) were analysed at fruit ripening.

Yield differences between systems were minimal, with higher yields in 2023 compared to 2024. In pear, no significant differences in fruit quality were observed, whereas in apple, non-chemical systems produced smaller fruit sizes across both years. Non-chemical systems favored perennial weeds, particularly dandelion (*Taraxacum officinale* L.), indicating long-term management challenges. Integrated systems revealed up to threefold higher treatment frequency and labour use relative to the chemical benchmark. The system combining mowing with limited chemical intervention effectively controlled dandelion, suggesting that a smart combination of mechanical tactics and well-targeted herbicide applications can manage perennial weeds while reducing herbicide use. These findings highlight future opportunities and challenges of implementing non-chemical weed control tactics in conventional pome fruit orchards.

Acknowledgement / funding: Flanders Innovation and Entrepreneurship (VLAIO) HBC.2020.3190.

S10-O6. Organic mulches suppress annual weeds but *Cynodon dactylon* thrives under them in Mediterranean vineyards

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Vineyard growth and grape yield can be hindered by weeds, particularly those located in the under-vine zone. Traditional weed management in this area typically involves tillage. Plant-based materials used as organic mulches can offer an alternative to manage weed populations.The objective of this study is to test the effectiveness of several agricultural by-products for weed management when used as mulch in Mediterranean vineyards (*Vitis vinifera* L.).

To achieve the proposed objective, two field experiments were conducted in organic vineyards located in Raimat (Lleida, Spain), during the 2022-2023 and 2023-2024 growing seasons. The study includes five treatments, four mulching materials (almond shells, almond peel, walnut shells and wine pomace) and a control (in-row tiller). The mulching materials were applied to the under-vine zone in early October 2022. The percentage of soil covered by weeds in each treatment was monitored monthly. Additionally, an *in vitro* bioassay was conducted to evaluate the allelopathic effect of aqueous extracts from the different mulches on the germination and early growth of *Bassia scoparia*(L.) Voss., a particularly aggressive weed in our area. Results indicate that almond shell, nut shell and almond peel successfully limited annual weed coverage, that did not exceed 15% while grape pomace and the in-row tiller had the highest annual weed coverage, with up to 65%. In contrast, *Cynodon dactylon* L., a perennial weed, thrived under all the mulch treatments in the absence of soil disturbance. *C. dactylon* covered up to 90% of the mulched plots and 30% of the cultivated in-row treatment. These findings highlight the strong inhibitory effect of the mulches on annual weed emergence but also emphasize their inability to control perennial weeds.

In vitro germination of *B. scoparia* was slightly reduced by almond peel aqueous extracts, with germination rates decreasing to 24% compared to the control. However, the extracts inhibited root elongation, reducing radicle growth by more than 85%. This suggests that almond peel may exert a potent allelopathic effects, contributing to their effectiveness as a mulching material for annual weed control. Further studies should evaluate the long-term impact of mulches on weed population dynamics and vineyard productivity.

Project TED2021-130138A-I00 funded by MICIU/AEI/10.13039/ 501100011033, by the European Union NextGenerationEU/PRTR and by the travel grant EWRS/bi-lateral2024/03. The authors thank Raimat SL for providing the experimental vineyard and Maria Casmitjana for her technical assistance.

PS2-33. Cultural and thermal methods for weed management in vegetables

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Chemical weed control in vegetables is widely used. However, for several crops there are very few registered herbicides left with some being rather ineffective. Therefore, the integration of various and alternative methods is very important. The objective of this study was to evaluate false seedbed combined with hot foam applications in vegetable crops.

The field trials were conducted during 2023 and 2024 arranged in a Randomized Complete Block Design (RCBD) with four treatments repeated three times. Treatments involved four seedbed manipulations: normal seedbed preparation and direct sowing (control), false seedbed controlling weeds by hot foam (13.33 L m^{-2}) at 1, 2, and 3 weeks, after the seedbed preparation.

In spinach, all applied treatments significantly decreased the density of the major weed species *Sinapis arvensis*, *Papaver rhoeas*, and *Lolium rigidum*. For instance, the lowest density of weeds was observed in plots treated with hot foam application three weeks after seedbed preparation, resulting in reduction up to 90% compared to the control. In onion and squash, density and biomass of the troublesome weeds *Amaranthus retroflexus* and *Malva sylvestris* were also reduced, with the effect being the highest and the lowest in the three- and one-week periods until hot foam, respectively. Our results highlight that the delayed hot foam application effectively controlled more weeds (including the later-emerging species) and gave an important competitive advantage to the crops.

Hot foam technology introduces an innovative and intelligent approach to thermal weed control. Our study revealed that depending on the time of application it can be combined with agronomic practices like false seedbed and be efficient against a wide range of weeds.

This study was part of the project “Innovations in Plant Protection for sustainable and environmentally friendly pest control, InnoPP - TAEDR-0535675 that is ¨Funded by the European Union-Next Generation EU, Greece 2.0 National Recovery and Resilience plan, National Flagship Initi-ative “Agriculture and Food Industry”.

PS2-34. Assessing the impact of fertilization and non-chemical weed control strategies in organic farming using a life cycle assessment approach

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Climatic changes and the need to reduce the environmental impact of food systems highlight the importance of analyzing the direct and indirect effects of agricultural production systems. Weed management plays a critical role in organic farming, influencing both crop yield and environmental outcomes as global warming potential. This study used a Life Cycle Assessment (LCA) approach to analyze the individual and combined effect of weed control and fertilization tactics on crops' yield and environment in organic production. Data on environmental impacts and agronomic performance were collected over a four-seasons cropping system applied on a one-hectare organic field in Newe Ya'ar, Israel, divided to 0.05-hectare plots in a split-plot design experiment. Each season five different non-chemical weed control methods were examined, namely finger weeder intra-row cultivation, inter-row cultivation, flaming, hand weeding, and non-treated control under varying fertilization regimes: 10, 30 and 60 m^3 ha^{-1} of compost and NPK chemical fertilizers as a control (n=5). Each year, a different crop was cultivated: silage corn (*Zea mays*), sweet corn, broccoli (*Brassica oleracea Italica*), and cauliflower (*Brassica oleracea*). Results showed that weed control methods significantly influenced global warming potential, energy use, eutrophication potential and human toxicity, with emission differences reaching up to 100% between treatments. The combination between the finger weeder and the highest fertilizer treatments produced the lowest environmental impact results, while combinations of flaming or untreated plots with different fertilizer amounts reached the highest results. Cauliflower exhibited the greatest variation among treatments. Weed control effectiveness also impacted yield variability, highlighting the importance of matching methods to crop and field conditions. This study emphasizes the role of weed management practices in shaping both environmental and agronomic outcomes in organic farming. By focusing on the interaction between fertilization and weed control strategies, it provides critical insights for optimizing sustainable practices. The findings lay a foundation for further research into targeted weed management approaches and their broader implications for policy and farm-level decision-making in organic systems.

PS2-35. Laser weeding: dose-response experiments with common weeds

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The massive use of herbicides has resulted in increasing problems with herbicide-resistant weeds and pollution of the environment, including food, feed, and water. These side effects have resulted in political pressures to reduce herbicide application. The European Commission aims to reduce the use and risk of chemicals and more hazardous pesticides in the EU by 50% before 2030. Therefore, new weed control methods are in demand. Laser weeding might be an alternative to replace or supplement herbicides and other weed control methods in integrated weed management strategies. This work aimed to investigate how increasing laser energy affected common annual and two perennial weeds when the apical meristem was exposed to irradiation at the early stages of development. A 50 W thulium-doped fibre laser with a diameter of 2 mm and a wavelength of 2 µm was used.

The highest efficacy of laser irradiation was achieved when the grass weed (*Alopecurus myosuroides*) had one leaf, and the dicot species were at the cotyledon stage. There was a significant difference between the species' susceptibility to irradiation, probably caused by morphological differences and growth habits. At the 4-leaf stage, some plants regrew after irradiation.

When the laser destroys the aerial shoots, perennial weeds regrow from the below-ground parts. Depleting the below-ground parts for resources might be possible if the laser continuously kills new shoots, but it may require many laser treatments. We studied how lasers could be used to destroy plants after the below-ground parts were cut into small fragments. Plants were killed with even small dosages of laser energy and stopped regrowing.

This work was funded by the EU-project WeLASER "Sustainable Weed Management in Agriculture with Laser-Based Autonomous Tools," Grant agreement ID: 101000256, funded under H2020-EU.

PS2-36. Investigating the use of dsRNA as innovative strategy for weed control in Italian rice system

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One of the purposes of the European Green Deal is to reduce reliance on herbicides and encourage integrated weed management strategies promoting solutions more environmentally sustainable and less dangerous for animal and human health. The unique way to pursue a sustainable agriculture is to invest in technical and scientific innovation and the integration with non-chemical methods has become the rule in many cropping systems. Gene-technology tools, and in particular RNA interference (RNAi) that is a dsRNA-mediated gene silencing mechanism, are innovative techniques that are in their early stages and need a more in-depth study to play a role as a potential alternative to GMO technology in gene functional studies, crop protection and weed control.

In this study, which is part of the RiWeCIS* (Rice Weeds Control with Innovation Systems) project, the focus is on the alternative control of two of the most troublesome weed species of the Italian rice cropping system, *Echinochloa* spp. (i.e. *crus-galli* and *oryzicola*) and *Oryza sativa* (weedy rice). dsRNA targeting two genes, *PDS* (phytoene desaturase) and *ALS* (acetolactate synthase), of about 200bp and 400bp, respectively, were designed based on MEGA X alignment andsynthesized on a large scale by Genolution Inc. (Seoul, Korea). The study of the effectiveness in silencing of the dsRNA designed was performed using the VIGS (Virus Induced Gene Silencing) tool both in the model species *N. bethamiana* and in the target weed species (see the abstract Milani et al., “Can we control weeds with RNAi?rdquo;). Different delivery techniques are being evaluated: mechanical inoculation applying different concentrations of dsRNA, high-pressure spraying delivery (HPSD) using a conventional compressor and an air brush pistol, as well as the nanoencapsulation into clay-based nanocarriers will be tested (in collaboration with University and Politecnico of Torino) to favor the penetration of the RNA molecules into plant cells.

Preliminary results are available, but the undoubted potential of this technology has already been widely discussed - and validated in other fields of crop protection - and it is worth studying it further.

This research was funded by the European Union - Next Generation EU, Mission 4 Component 1, CUP B53D23017800006.

PS2-37. Effect of leaf dried residues of dates palm on inhibiting the growth of bermuda grass (*Cynodon dactylon*) in date palm orchards (*Phoenix dactylifera*) south of Kerman

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Date palm one of the economic and very important products in the tropical and subtropical regions of the world. Every year, farmersresidues of dates tons several of dried leaf of dates leaves or store them and set them on fire.The perennial weed,bermuda grass, causes severe damage to date orchards in the south of Kerman every year.This plant has been introduced in 57 countries of the world as a serious, problematic and difficult to control weed.So that some weed control methods, including mechanical control and chemical control, do not have an effective effect on the control of this noxius plant due to the structure and depth of the rhizomes.In the conducted research, no research has been conducted on the allelopathic effects of date leaves on preventing the growth of weeds in date orchards. For this purpose, an experimental in the 2022-2023 crop year in date palm orchards assosiated to Astan Quds Razavi in the south of Kerman in the form of a randomized complete block design with 5 treatments and 4 replications was conducted.The tested treatments includedresidues leafs ofpalmdates at the rate of 1500 kg.ha, 2500 kg.ha, 3500 kg.ha, 4500 kg.ha and control treatment infested with weeds (without residues). At the end of the experiment, quadrarts measuring 1*1 $m^2$was conducted,The traits tested including density, freh and dry weight of above and below ground organs (rhizome) and weed height were counted and weighed. The results of showed thatresiduespalmdate have a very strong effect on suppressing and prevention the growth of the weed.Application date palm residues at the rate of 4500 kg.ha reduced the density and dry weight of the above and below ground parts of the weed by 100%.Whereas the highest density and dry weight of above and below ground organs were observed in weed-infested control treatment. Aplicationleaf date palm residues atdate orchardswhile maintaining soil moisture and reducing theconsumption of herbicides, it is a natural and very compatible method to preserve the environment. Undoubtedly, palm growers can use the allelopathic properties of date leaf in their palm gardenswith the aim of achieving non-chemical control ofbermuda grass weed.

PS2-38. False and stale seedbeds for weed management in winter cereals

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False seedbed is a promising agroecological practice for effective weed management in field crops. The main objective of the present study was to evaluate the potential of false seedbed to reduce weed pressure in durum wheat (*Triticum durum* Desf.) crop under real field conditions.

A field trial was conducted according to the Randomized Complete Block Design (RCBD) with four treatments and four replications during the 2023–2024 growing season in Central Greece. Treatment list included: normal seedbed preparation without any weed control treatment (CON), false seedbed with shallow tillage for weed control one week after seedbed preparation (FS1), false seedbed with shallow tillage two weeks after seedbed preparation (FS2) and a stale seedbed treatment where glyphosate was applied for weed control at the reduced rate of 540 g a.e. ha^{-1} two weeks after seedbed preparation (SS). Weed biomass was estimated 8 weeks after crop sowing by means of two quadrats placed in the center of each plot. The weeds were harvested and oven-dried. Grain yield parameters were also recorded at harvest.

Treatments significantly affected total weed biomass (*P <0.05) with FS1 and FS2 reducing total weed biomass by 33% and 45%, respectively, compared to the (CON) treatment. At the same time, total weed biomass was 60% lower in the stale seedbed (SS) plots compared to the control (CON). SS increased grain yield by 43% compared to CON. The efficacy of false and stale seedbeds can be attributed to the control of early weed cohorts that lets the crop grow in a less competitive environment.

These findings underline the role of false and stale seedbeds as Integrated Weed Management (IWM) tools in modern agriculture.

The research work was supported by the Hellenic Foundation of Research and Innovation (HFRI) under the action of “Funding for Basic Research (Horizontal support for all Sciences)” of the National Recovery and Resilience Plan “Greece 2.0” with funding from the European Union—NextGenerationEU in the framework of the ONE GREEN project.

PS2-39. Boosting weed seed losses: the role of predation in regenerative agriculture

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Regenerative agriculture seeks to enhance ecosystem services, including weed management, through sustainable practices. Weed seed predation, a natural process contributing to weed suppression in agroecosystems, can lead to lower weed seedbanks, facilitating more manageable and efficient weed control and reducing the risk of herbicide resistance. The objectives of our study were: (1) to quantify and compare weed seed predation rates across different tillage systems, seasons, and weed species, with a focus on *Alopecurus myosuroides* (black-grass) and other problematic grass weeds (*Avena fatua* and *Bromus secalinus*) in the United Kingdom, (2) to evaluate the potential of no-till practices in enhancing weed seed predation as a sustainable weed management strategy within regenerative agriculture. Predation rates were compared in three long-term conventionally tilled fields and three long-term no-till fields using a seed card method.

The seasonal predation profile revealed higher predation rates in no-till systems, ranging from 30.9% to 49.5%, compared to 15.1% to 37.2% in conventionally tilled fields. Predation was lowest in autumn and highest in spring. Substantial differences among weed species were observed, with black-grass having considerably higher predation levels in summer than other species ($p < 0.001$). These results suggest that no-till practices enhance weed seed predation by supporting a high-predator population, contributing to sustainable weed management by lowering weed seedbanks. Incorporating a no-till system may thus offer cost-effective and environmentally friendly weed control options for regenerative agriculture.

This research is supported by Syngenta UK.

PS2-40. Study of different mechanical strategies of weed management at the intercropping period in field cropping systems in France

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Weed management strategies without glyphosate in field crops are based on agronomic preventive levers and on soil tillage during the intercropping period. However, soil tillage is not always fully effective or easy to realise. The objective of this study was to test different ways to practice soil tillage to manage weeds mechanically before sowing.

A panel of 190 different sequences of technical operations implemented in 47 trials in autumn or spring intercropping were evaluated. The weed flora (mainly high densities of grass species and cereal volunteers) was observed at crop sowing (end of the intercropping period) and later during the crop. The absence of herbicides during intercropping was compensated by more superficial soil tillage operations.

The results showed that in most cases it is difficult to obtain clean soil at sowing without glyphosate and without ploughing, if spring crops like pea or spring barley were sown fairly early, between February and April, with operations carried out in slightly dry conditions. The data from the different situations of the trials showed that it is difficult to destroy grass species mechanically when they have reached the tillering stage and when superficial soil tillage operations are conducted in wet conditions (weather and soil). When spring crops were sown later, in April or May, and when the weed destruction was often realised in dryer conditions, it was easier to obtain a soil free of viable weeds at sowing. In certain cases, the increased use of tillage before sowing the crop may induced new emergence of ryegrass, especially in wet soil conditions.

In conclusion, the efficiency of superficial soil tillage is variable and depends on weed species, weed stages, soil moisture conditions… Weed management strategies without chemicals during the intercropping period increase the use of soil tillage and this causes some disadvantages, like the variability of the quality of weed destruction, especially if they do not use ploughing, the increased use of fuel, the increased time of work… Therefore, these strategies need sometimes to be combined with others agronomical levers like the delay of the date of sowing, the choice of the previous crop, etc.

PS2-41a. Interrow mowing as a supplemental weed management tool in organic soybean

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No-till planting organic soybean (*Glycine max*(L.) Merr.) into rolled-crimped cereal rye (*Secale cereale* L.) can have several advantages over traditional tillage-based production. However, suboptimal cereal rye growth in fields with large populations of weeds may result in weed-crop competition. As a result, weed control is a constraint for adopting organic no-till. The R-Tech Interrow Mower, a front mounted interrow mower with five independent, hydraulically-powered rotary mower units offers potential for supplemental weed management in organic field crop systems. Previous research examining multi-tactic weed management in organic no-till planted soybean demonstrated that interrow mowing reduced weed biomass by at least 60% and increased soybean yield by 14% compared with the nontreated control. In 2023 and 2024, field experiments were conducted to evaluate interrow mowing in organic tilled and no-till soybean production to address weed-crop competition. Interrow cultivation treatments were: 1) rolled cereal rye, no additional weed control, 2) rolled cereal rye, interrow mowing, 3) rolled cereal rye, high-residue cultivation, 4) tilled cereal rye, interrow mowing and, 5) tilled cereal rye, interrow cultivation. We hypothesized that: 1) weed biomass would be lower and soybean yield higher in the tilled cereal rye, interrow cultivation treatment compared to the tilled cereal rye, interrow mowing treatment, and 2) weed biomass would be lower and soybean yield higher in rolled cereal rye, high-residue cultivation and rolled cereal rye, interrow mowing treatments than in rolled cereal rye with no additional weed control. Weed biomass was lower in the tilled interrow cultivation treatment compared to the tilled interrow mowing treatment ($P < 0.05$). Conversely, weed biomass was lower in the rolled interrow mowing treatment when compared to the rolled, no additional weed control treatment ($P < 0.05$). Soybean yield did not differ between treatments, and overall, weed biomass was low across site-years. Interrow mowing can potentially replace standard cultivation in organic no-till and cultivated soybeans for effective weed control without impacting yields.

PS2-41b. Weed between the lines: Interrow mowing for weed control in organic reduced-tillage corn

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Organic farmers often rely on soil tillage for weed management. Mulch from rolled-crimped cover crops is an alternative that can effectively suppress weeds, especially annual dicotyledon species with small seed sizes. However, mulch from terminated cover crops may not provide adequate weed suppression in fields with large populations of weeds (e.g., high soil weed seed banks), fields infested with perennials or monocot species, or in fields with poor cover crop growth and insufficient mulch. Mechanical control with a high-residue cultivator (i.e., a single shank cultivator with a wide undercutting sweep) is one approach to controlling weeds that break through mulch, but this practice disturbs mulch that is present on the soil surface. Interrow mowing is compatible to reduced-tillage production and can provide supplemental weed control and reduce weed-crop competition. In 2020, we worked with a custom equipment manufacturer and used a collaborative approach to design an interrow mower for controlling weeds between 76-cm crop rows. Results from field experiments over the past four years show that interrow mowing can effectively reduce weed biomass and increase yield in organic corn that is no-till planted into rolled-crimped cover crops. However, additional research is needed to quantify efficacy across different weed species and cropping environments.

PS2-42. Characterisation of the weed communities in sole cropped and intercropped chickpea

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Chickpea is a valuable diversification crop but has limited weed-suppressive capacity. Intercropping legumes with cereals may be an effective agroecological practice for weed control. This study assesses whether intercropping chickpea with bread wheat reduces weed pressure, compared to hoed sole crop chickpea, and how intercropping affects the weed community composition and its functional traits.

The study was conducted in 2023 and 2024 in two locations in Italy with contrasting agro-pedoclimatic conditions: Pisa (centre) and Udine (north-east). Six commercial chickpea cultivars (four Kabuli, two Desi) were tested as sole and intercropped system in a randomized complete block design with four replicates. Chickpea and bread wheat in intercropping were sown and harvested simultaneously in February-March and July, respectively. Sole-cropped chickpea was mechanically hoed once , to simulate farmers' standard weed management; no herbicides were used. The experiment was conducted in a different field, but with similar characteristics, each year.

In Udine, intercropping controlled weed biomass as effectively as hoeing, whereas in Pisa, intercropping was significantly more effective than the hoed sole crop, reducing weed biomass by 57% in the first year and 71% in the second. This result was always independent of chickpea cultivar. Across two years, 39 species were detected in Pisa (>60% belonged to Chenopodium album), while in Udine, 48 species were recorded, with Artemisia vulgaris, Chenopodium album, and Medicago lupulina being the most abundant ones.

Intercropping increased species richness in both locations only in the first year. Intercropping increased the exponent of Shannon and Pielou indices in Pisa but decreased them in Udine in the second year. Regarding the functional structure of the weed communities, intercropping increased the CWM of hemicryptophytes and geophytes while reducing the abundance of forb species, compared to grasses and legumes, in both years and locations. In Pisa, intercropping also favoured communities composed of species with higher Specific Leaf Area and lower height. Intercropping had no effect on the duration or onset of weed community flowering.

Overall, it can be concluded that intercropping chickpea with wheat improves weed control and fosters a more balanced weed community composition, while it increases the LER in most cases.

PS2-43. Pre-harvest control of *Alopecurus myosuroides* Huds. and *Lolium multiflorum* to reduce seed inputs in winter cereals

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The control of *Alopecurus myosuroides* Huds. (ALOMY) and *Lolium multiflorum* (LOLMU) is becoming increasingly challenging due to rising herbicide resistance in winter cereals. A potential non-chemical way to reduce the weed seed input is the 'Top-Cut-Collect' method, which involves cutting and collecting weed seed spikes above the crop canopy. The goal of this study was to determine the optimal timing for the cutting, and the necessity of repeated use. Earlier applications may necessitate repeated interventions, while later applications, particularly after weed flowering, have a higher risk of seeds shedding. In 2024, one field trial was conducted for each species (ALOMY and LOLMU, first-year results) in winter wheat in Germany, using a completely randomized block design with four replicates. Starting from the flowering stage of the weeds, the plant heights of wheat and weeds were measured weekly. The Top-Cut-Collect method was simulated by manually cutting weeds heads. Weed heads were counted weekly, before and after cutting, starting in May until harvest in July. Additionally weed seeds were collected to assess seed viability using a tetrazolium test. Maximal height difference of around 20 cm was reached in the middle of May for ALOMY (BBCH 49-65). Cutting ALOMY spikes above the wheat canopy at this stage reduced the number of ALOMY heads/m^2 by 80 %. Due to regrowth of ALOMY, this reduction decreased to 55 % by harvest. At the time of cutting, seeds were not viable, but viability reached 23 % one week later in mid-May. The maximum height difference between LOLMU (BBCH 55-61) and wheat (BBCH 69) was approximately 55 cm. Cutting LOLMU spikes above the wheat canopy reduced the number of LOLMU heads/m^2 by 94 %. Due to regrowth of LOLMU, this reduction decreased to 57 % by harvest. Viable LOLMU seeds have been observed since mid-June, necessitating the removal of cut material from the field. All in all, cutting weed heads might be an additional tool to reduce weed seed input. Due to the observed regrowth of the weeds it seems to be necessary to cut at least twice.

The project is supported by funds of the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany via the Fe- deral Office for Agriculture and Food (BLE) under the innovation support programm.

PS2-44. Allelopathic potential of wheat, rice and barley: a sustainable approach to managing herbicide-resistant weeds *Lolium rigidum* and *Portulaca oleracea*.

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The rapid expansion of herbicide-resistant weed populations, such as annual ryegrass (*Lolium rigidum*) and common purslane (*Portulaca oleracea*), poses a major challenge for weed management in cereal cropping systems. Over-reliance on synthetic herbicides has exacerbated resistance evolution, while alternative methods like manual removal are labor-intensive and impractical at a large scale. In response, this study investigates the allelopathic potential of wheat (*Triticum aestivum*), rice (*Oryza sativa*), and barley (*Hordeum vulgare*) as a sustainable approach to suppress *L. rigidum* and *P. oleracea*. By analyzing their inhibitory effects on weed germination and growth, as well as their allelochemical profiles, we aim to provide insights into the role of benzoxazinoids in natural weed suppression.

To evaluate this, *L. rigidum* and *P. oleracea* were co-cultivated with wheat, rice, and barley without physical contact, separated by a porous plastic barrier. Germination and growth parameters of the weeds were recorded, and the chemical profile of the crops was analyzed using HPLC-MS. The results showed that all three crops inhibited the germination and growth of both weed species. Significant concentrations of benzoxazinoids were detected in plant tissues and/or root exudates when grown in the presence of weeds, compared to controls. Specifically, DIMBOA and MBOA were predominant in wheat, DIBOA and BOA in rice, and HBOA in barley. These compounds, known for their phytotoxic properties, likely contributed to the observed inhibitory effects.

This study demonstrates that wheat, rice, and barley can suppress *L. rigidum* and *P. oleracea*, potentially through the production and exudation of benzoxazinoids. These findings highlight the role of allelopathic crops as a promising tool for integrated weed management, offering an environmentally friendly alternative to synthetic herbicides.

PS2-45. The impact of cover crops on soil biodiversity in almond orchards: effects on soil microarthropods, community composition and nematode density

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Conventional weed management in Mediterranean almond orchards often relies on chemical herbicides, which can degrade soil quality over time. As an alternative, cover crops (CC) have emerged as a sustainable practice to improve soil fertility, suppress weeds, and enhance soil biodiversity. The interactions between cover crops, soil biota, and soil health remain underexplored, particularly in Mediterranean agroecosystems, where soil functioning is vital and dependent on irrigation and fertilization.

This study investigated the effects of CC on soil biodiversity fauna, focusing on microarthropod diversity and nematode density in an almond orchard in Israel. CC treatment combined a mix of legumes, brassicas, and grasses along tree lines, while no-cover crop plots were treated with a pre-emergence herbicide (glyphosate, indaziflam, and oxyfluorfen). Soil samples were collected during the CC growing season and after its termination. Microarthropods and nematodes were extracted from soil, processed, and analyzed for an index of Soil Biological Quality (QBS-ar), nematode density, total organic carbon (TOC), active carbon (AC), and total nitrogen (TN).

Results showed that CC significantly improved soil biodiversity and quality, with higher microarthropod abundance and diversity in CC plots than in herbicide plots during both sampling periods. Acari, Formicidae, and Collembola were the dominant taxa, with Acari demonstrating 45% and 56% higher relative abundance in CC during and after the CC season, respectively. Microarthropod richness and QBS-ar scores were consistently higher in CC treatments. Non-metric multidimensional scaling (NMDS) analysis revealed distinct community compositions between treatments, with PERMANOVA confirming significant differences ($p < 0.05$). Indicator taxa analysis (IndVal) identified Acari, Coleoptera, and Diplura as key indicators of CC during the active season, while Collembola and Hymenoptera were indicators post-termination. No indicator taxa were identified in Herbicide-treated plots. Nematode abundance was significantly higher in CC plots, with populations 37.5% greater during the CC season and 58.5% greater post-termination compared to herbicide-treated plots. Furthermore, CC plots exhibited significantly higher levels of TOC, AC, and TN.

These findings highlight the ecological benefits of cover crops in enhancing soil biodiversity, biological quality, and ecosystem functioning in almond orchards, supporting sustainable agriculture and resilient soils while mitigating the adverse impacts of chemical herbicides.

PS2-46. Climate change effects on the weed suppressive ability of several cover crop mixtures

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Climate change effects, such as rising temperature and extreme weather events, will impact agriculture in the near future directly by reduction of crop yields and indirectly by increasing damage of crop pests. Therefore, preventive methods of plant protection, like cover cropping, gain in importance. This study examined the effects of elevated temperature (+5°C) and increasing drought levels (no, mild and severe drought) on four commercial (TerraLife-BetaMaxx, -N-Fixx, -AquaPro and Vitalis Aqua Safe) and two self-composed cover crop mixtures (HOH-4, HOH-10) and their weed suppression performance. The experiment was laid out in a split-plot design with four repetitions in pots in the greenhouse and in addition repeated in whole four times from 2020-2022. Cover crop mixtures (CC) were sown in pots at their recommended seeding rate along with 15 seeds each of *Alopecurus myosuroides*and *Stellaria media.* CC and weed biomass were assessed, along with weed control efficacy (WCE) and soil coverage. A canonical correspondence analysis (CCA) was performed afterwards to identify drought and temperature tolerant species. Both, elevated temperature and increasing drought level, reduced CC biomass and soil cover by 50%, in combination even by more than 80%. Weed biomass was affected similarly, only severe drought reduced it by more than 90%. Nevertheless, CC mixtures, and the self-composed mixtures in particular, reduced weed biomass further and showed consistently WCE of more than 80% and up to 98%. The CCA revealed that the presence of *Sorghum bicolor*, *Brassica carinata* and *Camelina sativa* is associated with higher temperatures, making these promising species for temperature and drought resilient CC mixtures. Even though their biomass and soil coverage was reduced drastically by the examined climate change effects, CC mixtures still showed a high weed control ability. This resilience might even be improved by further measures such as adjusted sowing date and establishment method and in turn improve CC performance under adverse climate change conditions.

PS2-47. Roller-crimped cover crops in organic soybean: weed suppression and yield effects

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Rolled cover crops using a roller crimper can be an alternative to conventional tillage for weed control in organic field crops. The use of rye (*Secale cereale* L.) as a cover crop has been tested in previous studies, but there is a lack of knowledge regarding the use of other species in our region (Lleida, northeastern Spain). In this study, in addition to evaluating rye as a cover crop, three other types of cover crops were assessed in organic soybean (*Glycine max* (L.) Merr.) production: hairy vetch (*Vicia villosa* Roth), triticale (×*Triticosecale* Wittm.), and a mixture of vetch (*V. villosa*) and black oat (*Avena strigosa* Schreb). To this end, a completely randomized block experimental design was established during the 2023/2024 season in three locations in Lleida province. The cover crops were sown in mid-November 2023 and terminated with a roller crimper before soybean planting in May 2024 and a non-cover crop tilled control was also established. In all three fields, the weed suppression effect of each cover crop was studied and compared to traditional tillage management. For this purpose, the establishment and development parameters of the cover crops were evaluated, weed and soybean biomass were quantified when the soybean growth stage was R6, and soybean yield was estimated for each treatment.

Triticale and rye cover crops produced a greater amount of biomass and exerted higher suppression of winter weed flora than vetch and the mixture. Additionally, they allowed similar soybean development and achieved yields between 15% and 74% higher than tilled management probably because insufficient tillage operations were performed. Weed pressure was very high and yields were very low in all treatments. In contrast, the vetch cover crop did not establish satisfactorily and did not provide effective weed control. The mixture developed very high amounts of biomass, but once rolled, it was distributed unevenly, making sowing difficult and hindering proper soybean establishment. The cover crops were unable to effectively control weeds in the three fields studied, and in some cases, they even hindered crop establishment.

Project TED2021-130138A-I00 funded by MICIU/AEI/10.13039/ 501100011033 and by the European Union NextGenerationEU/PRTR. The authors thank all the involved farmers for providing the experimental fields and Maria Casmitjana for her technical assistance.

PS2-48a. Evaluation of traits related to weed suppression and tolerance in *Triticum aestivum* (winter wheat).

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With stricter regulations on the use of plant protection products and the growing evolution of weed resistance, there is an increasing interest in non-chemical weed control options in conventional farming systems. Among others strategies, the use of crop cultivars with strong competitive abilities becomes a more relevant tool. Currently, conventional winter wheat cultivars are not assessed for their ability to tolerate or supress weeds in Germany and therefore only limited information on differences in related traits between cultivars is available.

The objectives of the study were 1) to re-evaluate plant traits associated with weed suppression and tolerance in winter wheat cultivars, 2) identify traits with a high impact on cultivar performance and the growth stage at which these traits should be scored, 3) determine whether cultivar competitiveness can be assessed in weed free trials, 4) evaluate the possibility of using digital scoring techniques to make the screening more efficient, and 5) develop a manual for scoring the competitiveness of winter wheat cultivars.

For evaluating the competitiveness traits, a field trial with artificial weed pressure was set up in 2023/24 in Braunschweig, Germany. Ten winter wheat cultivars were tested under weed-free and weedy conditions, with perennial ryegrass (*Lolium perenne*) as a model weed. Multiple plant traits, such as plant cover, number of tillers, plant height, biomass, PAR, and leaf angle were recorded over the growing season.

The tolerance of winter wheat cultivars towards weed competition was measured via the yield loss (difference in yield between weed-free and weedy conditions). No significant effect of cultivar on yield loss was found, with only one of the ten cultivars being significantly different from the others. The choice of cultivar did exhibit a significant effect on weed suppression (*L. perenne*biomass). Out of the traits measured, early plant height, ground cover and low PAR contributed to both suppression and tolerance, while final plant height had little effect.

The development of an efficient scoring manual for traits of winter wheat related to weed suppression and tolerance could both support the breeding process and help farmers in selecting competitive cultivars as part of integrated weed management systems.

PS2-48b. Effect of delayed sowing time and crop cultivar on weed infestation in Triticum aestivum (winter wheat).

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Reduced herbicide inputs require an adoption of non-chemical management strategies in order to maintain sustainable winter wheat (WW) yields. Two strategies with a high potential to reduce weed infestation in winter wheat are delayed sowing time and the use of cultivars with strong competitive properties.

The advantages of late sowing time include reduced germination of important grass weeds such as *Alopecurus myosuroides*, and the opportunity to implement additional weed management measures before sowing, such as the stale seedbed technique. Competitive cultivars can outcompete weeds for light, water and nutrients, and thereby reduce the need for herbicides.

Field trial comparing two sowing dates (three weeks apart), and six WW cultivars, under two plant protection strategies (with and without herbicides (and fungicides)), were repeated over two years (2022 and 2023) at three locations in the first year and over two locations in the second year in Germany.

The aim of the study was to: 1) assess how delayed sowing dates reduce weed infestation, 2) determine the impact of late sowing dates on WW yield, 3) analyze if there are differences among WW cultivars regarding crop competitiveness, and their effectiveness in reducing weed infestation, and 4) estimate the impact of the two strategies on weed community composition.

Weed infestation varied between experimental sites and years. Late sowing consistently reduced the number of weed individuals and weed ground cover, across sites and years. Some combinations of late sowing and cultivar showed greater weed suppression than others. In the early sown WW, more pronounced differences in weed suppression could be observed between cultivars. WW yield differences between early and late sowing were minimal, and there was no clear negative impact on WW yield from late sowing.

The results indicate that delayed sowing, enhanced by the use of competitive cultivars, could be a valuable strategy in integrated weed management, without compromising yield.

PS2-49. Management of weed seeds of *Alopecurus myosuroides* (Huds.) and *Lolium multiflorum* (L.) before and after harvest

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Managing the weed seed input prior and after harvest was tested by cutting and collecting weed heads above the cereal canopy due to the “Top Cut Collect” machine. At two locations, one with ALOMY and one with LOLMU infestation, the Top Cut Collect application was simulated by manually cutting the heads with four different cutting strategies with varriing first cutting dates, counting the number of weed heads before and after cutting. Removed weed heads were used for germination- and viability tests. Additionally, the Top Cut Collect machine was tested once under field conditions.

Another field experiment was conducted to investigate weed seed germination according to different stubble cultivation techniques after harvest, comparing five stubble cultivation techniques (ploughing + catch crop, disc harrowing, stubble cultivator + catch crop, direct sowing + catch crop, untreated control). Number of weeds per sqare metre and the number of weed seeds in soil (4 cm diameter x 30 cm depth, 15 times per plot) were determined.

Findings in 2024 showed high regeneration rates of the weeds after cutting, leading to a weed head reduction between 20 and 50 % (ALOMY) and between 57 and 86 % (LOLMU), depending on the cutting dates. Late cutting was more effective compard to early cutting. Viable and germinable seeds were found from middle May (ALOMY) and from middle June (LOLMU) with rising amounts up to < 90 % (ALOMY) and < 50 % (LOLMU) at harvest.

Stubble cultivation management influenced the number of weeds per square metre. Ploughing + catch crop resulted in the lowest number of weed emergence, followed by untreated plots, stubble cultivator + catch crop, disc harrowing and direct sowing + catch crop. Plant numbers ranged form 100 to 400 ALOMY and from two to 27 LOLMU plants per square metre. Highest number of seeds in the soil was found after ploughing + catch crop, followed by stubble cultivator. Seed viability range from 34 to 50 % (LOLMU) and from 24 to 51 % (ALOMY).

The project is supported by funds of the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany via the Federal Office for Agriculture and Food (BLE) under the innovation support program.

PS2-50. Potential of cover crops and minimal tillage to control creeping perennial weeds

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The creeping perennial weed species *Cirsium arvense*, *Sonchus arvensis* and *Elymus repens* are common in temperate climate and pose a threat to crop production. These weed species are traditionally controlled by herbicides or intensive tillage. Both methods have undesirable side effects, and there is a need for more environmental-friendly control strategies. Effective mechanical weed control methods play a key role in organic cropping. The following weed control measures, repeated in two consecutive years, were compared in spring cereals in Finland and Norway: 1) "untreated" treatment, involving no weed control measures, 2) "preventive" treatment, using clover/ryegrass mixtures as cover crops combined with non-inversion tillage by operating with a new root cutting implement in autumn and spring, 3) "mechanical" treatment, using shallow tillage with KvickFinn harrow in autumn and spring, 4) "combined" preventive and mechanical treatment, using cover crops, root cutting in autumn, and KvickFinn in spring, and 5) "glyphosate" treatment (only in Norway). The field experiments were started with the first treatments in autumn 2019 and the final assessments were made in autumn 2021. All five treatments were performed with and without spring ploughing in a split-block design. Ploughing reduced the aboveground biomass of creeping perennial weed species at crop harvest substantially in Norway (-73% compared to "untreated"), but not in Finland where the organically grown oat field was heavily infested with *E. repens*. In Finland, independent of ploughing, best control of *E. repens* and reduction total biomass of all creeping perennials were achieved with the "combined" (-49%) and "mechanical" treatments (-62%). In Norway, ploughing was overshadowing most effects of the other studied measures. For unploughed plots in Norway, the "preventive" treatment resulted in equal weed control total creeping perennials as the "mechanical", "combined" and "glyphosate" treatments. Concerning individual weed species, control efficacy of the "preventive" differed from other treatments; less effect against *E. repens*, not either different to other treatments against *S. arvensis* but very promising against *C. arvense*(-89%). We conclude that the "preventive" treatment, especially when combined with KvickFinn harrowing, controlled creeping perennial weeds equal to more aggressive tillage strategies.

This study was part of the project "AC/DC-weeds- Applying and Combining Disturbance and Competition for an agro-ecological management of creeping perennial weeds" funded by ERA-Net Cofund SusCrop/EU Horizon 2020 (Grant no. 771134) and national funding bodies in Finland and Norway.

PS2-51. Opportunities and limits of integrated weed control in oilseed rape, using planting green, nurse crops or mechanical control

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Oilseed rape is a major crop in Germany but faces significant herbicide use, especially in pre-emergence stages, conflicting with integrated pest management principles. The “RaBe” project (integrated weed control in winter oilseed rape by hoeing or nurse crops) explores various integrated approaches. The research, carried out in 2-year field trials from 2022 to 2024 in the fertile “Soester Börde” region in Northwestern Germany, examines techniques such as the*planting green*method (living mulch), nurse or companion crops, mulch seeding in cereal straw and mechanical weed control with or without herbicide application. In addition, the oilseed rape was sown in single grain. The following experience has been gained:

1. Planting Green: This method involves establishing a companion crop (e.g. 20 kg/ha “Brassica Pro”) directly after a cereal crop and then seeding rapeseed into it. While it shows potential for effective weed suppression, its success depends on the establishment of the cover crop. It works better following winter wheat than winter barley and is cost-effective since no additional herbicide or mechanical measures are necessary.

2. Nurse Crops: same mixture as in 1., but sown simultaneously with rapeseed. The efficacy of this method was minimal, with final weed suppression nearly zero in both trial years. This approach resulted in "hidden weed growth," where weeds re-emerged in spring after the companion crop had died back. When herbicides were used, compatibility with the companion crop was a concern.

3. Mulch Seeding: Directly sowing rapeseed into cereal straw posed a challenge, especially when combined with mechanical weeding (due to blockage). While the mulch worked well for weed suppression between rows, higher weed growth occurred in loosened areas, suggesting for further trials direct seeding instead of strip till.

4. Mechanical Weed Control (Hoeing): Single-seed sowing and camera-guided hoeing showed good results, though weather conditions played a role. The technique was most effective with two hoeing passes, though it was ineffective for broad-leaved weeds like the mainly occurring *Stellaria media*

5. Hoeing Band Technique: Herbicide application in the row and hoeing between the rows. This method reduced herbicide use by 60% by treating only 40% of the field. Depending on weed infestation, it showed good effectiveness.

Across the trials, no significant yield differences had been observed.

This study was funded by the German Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein Westfalen (LANUF)

PS2-52. Influence of rice sowing system on weed composition

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The impact of weeds in rice fields has become an increasingly significant problem in recent years, primarily due to restrictions on phytosanitary products and the emergence of resistance in certain species. The area of dry-seeded rice in the Ebro Delta has expanded in recent years as a strategy to mitigate the damage caused by the apple snail pest and prevent damage from birds during the initial stages of plant development.

This study aims to evaluate the weed populations present in rice fields using two different techniques: water seeding and dry seeding. The research was conducted in organic rice fields in the Ebro Delta, Catalonia, Spain.

Significant differences in weed composition were observed between the two sowing systems. The main findings indicated that, under water seeding conditions, the dominant weeds were sedges, whereas in dry-seeded rice, grasses were the predominant weeds. Consequently, specific weed management strategies can be developed based on these differences. Thus, the choice of sowing system can serve as an effective and sustainable component of an improved weed management program. This study was supported by the European Agricultural Fund for Rural Development.

This study was supported by the European Agricultural Fund for Rural Development.

PS2-53. Possibilities and limitations of hydromulch for weed control in perennial crops: field trial results

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Weed control in the first years of perennial crop establishment such as fruit orchards, vineyards, almonds, etc. is crucial for crop implantation. Few herbicides are available in that period and mechanical control can harm the saplings. Hydromulch could contribute to weed control in the first years, provided the mixtures are capable to withstand weeds during the most susceptible period (around 1-3 years). This mulch consists of a mixture of crop residues that are chopped or milled if needed and mixed with recycled paper, water and gypsum, being thus biodegradable. The blend is applied with a pasty consistence and hardens in the following days when drying out.

After collecting preliminary data of the potential weed control capacity of several hydromulch blends and their durability in greenhouse and open-air trials, several mixtures were selected and 5 field trials carried out between years 2018 and 2019 in 4 Spanish locations; a second group of trials with other mixtures are ongoing.

The same blends were used in all trials containing: a) weed straw (WS), b) rice husk (RH), c) used mushroom substrate (UMS) and compared with d) untreated control and with e) manually controlled plots by hoeing. The locations were Zaragoza (north-eastern Spain, peach and vineyard), Ciudad Real (central Spain, almond orchard) and Murcia (south-eastern Spain, artichoque). Mulch was applied after planting under the trunks between December 2018 and August 2019, depending on the trial, with 0.8 or 1 m width and each elementary plot measured 5, 6 or 10 m length. The thickness of the layer was around 1.5-2 cm. Weed frequency and richness were determined in each of the plots 9-10 times until finishing the trials (195 days after application, DAA, in the earliest case of artichoque, 435-509 DAA in the rest of trials).

The results of this first group of field trials show that annual species were satisfactorily controlled, in some cases with mean efficacy compared to the untreated control exceeding 90% (e.g. for *Diplotaxis virgata* and *Lamium amplexicaule*). Globally, WS was the mulch most capable of reducing the percentage of soil covered by weeds, RH was intermediate and USM had generally the worst control. The highest mean efficacy on the perennial species *Cyperus rotundus* and *Convolvulus arvensis*was 75 and 69% compared to the untreated control for the mulches containing RH. A possible drawback is the increase of wind-dispersed species that occurred over time, the mulches probably serving as landing strip for the seeds. Future work should envisage developing mulches with a less hospitable surface.

Acknowledgement(s) / funding: INIA RTA2015-00047; PROVESOS A11-23R, Gobierno de Aragón.

6. Weed ecology

S06.O1. Can weed-regulating service plants also regulate other pests?

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Keynote session

Introduction: Service plants can be used in agroecosystems, for example in intercropping and/or in rotation with cash crops (i.e. during the fallow period) and/or in field edges, in order to provide ecosystem services that are not directly marketable. Past studies analysed the effects of service plants for regulating a single pest category: i.e. either weeds, arthropod pests, parasites or pathogens. However, meeting the challenge of agroecological transition requires considering how service plants affect multiple pests. In addition, the potential disservices (negative impacts) that service plants may generate also need to be considered. Our aim was to determine to what extent service plants that are favourable to weed regulation can also promote the regulation of other pests. We also analysed the compatibility between multi-pest regulation and disservice mitigation.

Material and Methods: Given the diversity of pests (plants, arthropods, fungi, nematodes, etc) and regulation mechanisms involved (competition, predation, parasitism, etc), and the diversity of the disciplines involved, we developed a trait-based framework. For that purpose, we first laid the foundation of a conceptual framework by synthesizing (from the literature) the mechanisms and service plant traits involved in the regulation of each pest category. The second step used the conceptual framework and crossed the information in order to analyse the compatibility between (1) the service plant traits involved in weed regulation vs. those involved in the regulation of other pests; and (2) multi-pest regulation vs. disservice mitigation.

Results: For most of the service plant traits, we identified compatibility. For example, tall service plants with a rapid growth rate are known to be favourable to weed regulation (by competition for light). They are also favourable to the regulation of aerial pathogens and phytophagous insects (by providing a physical barrier or increasing emission of volatile organic compounds affecting these pests). However, compatibility needs to be studied in more details for traits related to emission of chemical compounds. As a last step, we identified potential sources of incompatibility between promoting multi-pest regulation vs. mitigating disservices. The level of incompatibility varied with the mode of insertion of service plants, according to the intensity of interaction between service and crop plants (edges < rotation < intercropping).

Conclusion: Despite knowledge gaps, there is good potential of service plants for multi-pest regulation. The difficulty is at least as much to mitigate disservices as to promote multi-pest regulation. This work provides foundations for the (re)design of service-plant based agroecosystems.

Reference. Moreau D, Ballini E, Djian-Caporalino C, Chave M, Cordeau S, Lavoir A-V, Suffert F, Cortesero A-M (in revision) Potential of service plants for regulating multi-pests while limiting disservices in agroecosystems. A review. Agronomy for Sustainable Development.

Funding. SuMCrop Metaprogramme of INRAE.

S06.O2. Distinguishing characteristics of off-crop plant communities – the importance of habitat, region and precipitation

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As a result of global biodiversity loss and climate change, it is now more important than ever to understand how to effectively monitor, manage and protect natural and semi-natural plant communities in agricultural landscapes. Off-crop weed species and plant communities on arable field edges support biodiversity and a range of ecosystem services such as pollination, and promote herbivory and soil health. With increasing awareness of the ecological and ecosystem benefits of these communities, knowledge gaps exist as to the management and environmental factors that explain variation in their composition and function. This study addresses some of these knowledge gaps by delineating different groups of off-crop weed species based on various factors.

Two different datasets were used for analysis: a vegetation dataset from the Farm Scale Evaluation Trials, from the early 2000s of conventional and GMHT (Genetically Modified Herbicide Tolerant) fields; and a vegetation dataset from Farm4Bio from the late 2000s, including conventional and organic fields.

Various analyses were carried out in R and RShiny to delineate different communities and/or different characteristics of communities, including in relation to specific variables. Canonical correspondence analyses were carried out in R and RMAVIS analyses were carried out in RShiny.

Canonical correspondence analyses carried out demonstrated that there is a statistically significant association between different off-crop field habitats and plant species presence; specifically, Boundaries, Verges and Margins are all floristically distinct, although they do have overlaps in species. The Boundary is defined in this study as the outermost edge of the field, often featuring hedgerows, shrubs or trees as well as understorey plants. Elder *Sambucus nigra*and Hawthorn *Crataegus monogyna*are examples of key Boundary species as demonstrated through the relevant canonical correspondence analysis. The Verge is spontaneously colonised and can include a mixture of different species, including Rough Chervil *Chaerophyllum temulum*. The Margin is the most managed part of the off-crop field edge, often specifically planted by the farmer. Key Margin species identified through the relevant canonical correspondence analysis include Common Field-speedwell *Veronica persica*and Common Orache *Atriplex patula*. Understanding the different components of the off-crop field edge is key to understanding how different plants in field edges respond to different types of management and how these habitats interact with the local plant species pool and environment. Other variables in the analyses included tillage, region, crop type and precipitation, providing further insights into the influence of field management on plants in the Boundary, Verge and Margin.

This new information will be used to identify non-target plant communities that make an important contribution to ecosystem function and should be protected from herbicide drift.

Acknowledgement(s) / funding: Crop Life Europe.

S06.O3. Conceptualizing a High-Nature-Value indicator scheme for arable land in the North Aegean (Lemnos, Greece)

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High Nature Value (HNV) farming emerged in the early 1990s as a response to the urgent need to conserve European biodiversity, specifically by preserving traditional low-intensity farming systems. This concept highlights the crucial link between extensive farming practices, the utilization of semi-natural land, and the conservation of high biodiversity within agricultural landscapes.

In Greece almost 50% of the plant species classified as specialized segetal plants have been categorized as threatened according to IUCN Criteria. Their conservation is of significant importance, necessitating targeted management measures and policies. The island of Lemnos in the North Aegean is biogeographically, historically, and ecologically significant. Despite changes in cultivation practices across Greece, Lemnos has remarkably preserved its traditional farming methods, making it a hotspot of arable plant diversity within the Aegean Archipelago.

A total of 113 phytosociological relevés on arable land were recorded on Lemnos between spring 2018 and spring 2021. We collected plant specimens and completed floristic and vegetation sampling, using the method of BRAUN-BLANQUET on plots with a size of 100 m². The plots were placed at least five meters from the edge in a representative part of the field. In addition, the spatial distribution of the plots was based on stratified random sampling to cover the different soil types found on the island (sandy texture, loamy, silty texture and loamy, stony soil).

Based on the recorded material, potential key species/groups were identified in the next step. The most important criterion here was that the species/groups should be easily recognizable for non-botanists such as farmers or officials from agricultural authorities. If a species/group is present in the relevé it is scored with one point. In addition, extra points according to the cover-abundance of key species/groups (based on 100 m² relevés) were awarded: Furthermore, one extra point for the rarity of species/groups was awarded based on the country-wide evaluation by Bergmeier & Strid (2014) as well as own observations. This approach, which is being applied for the first time in the eastern Mediterranean, serves as the basis for an agri-environmental scheme to be developed for species-rich fields.

S06.O4. Weed diversity decrease in vineyards of NE Spain from ‘50s to the twenty-first century.

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Intensified agricultural practices have significantly reduced weed biodiversity with notable declines of their ecosystem services in the last decades. This study aims to evaluate changes in weed frequency, richness and abundance in vineyards of Catalonia by comparing weed flora from traditionally managed fields (1950–1999, with no or low inputs of herbicides and non-intensive tillage) with modern vineyards (2000–2023) from both organic (no herbicides, no tillage or reduced tillage) and conventional (intensive tillage) vineyards.

We analyzed 200 relevés: 44 old (1950-1999) and 156 modern (2000-2023), from 36 published (1950–1995) and 164 own relevés (1997-2023). Modern ones include resampled areas in Penedès, Priorat and Empordà regions, and spanned information from organic or conventional practices. We recorded weed richness and cover in 100 m² plots along two non-adjacent vine inter-line transects of 20m x 2.5m. We assessed total weed diversity, focusing on species with functional importance for birds, pollinators, and other invertebrates, and also rare and invasive weeds.

We detected a 37% decrease in species richness and a 59% reduction in weed cover when comparing data from old to modern vineyards. Functional weed species experienced declines in richness and abundance by 32% (invertebrate-associated), 22% (bird-associated), and 30% (pollinator-associated). In modern organic vineyards weed richness and abundance significantly enhanced compared to conventional ones. However, weed biodiversity of traditional pre-intensification vineyards has not been restored by organic farming in the present (24.2 to 19.8 species/relevé). Overall rare species richness exhibited a 56% loss (from 3 to 1.4 species/relevé) and a weed cover decline of 75.2%, from traditional to modern vineyards. In contrast, the total number of alien species has increased by 50% in the last decades.

The findings underline the need to promote organic management in vineyards and minimize intensive soil management practices to restore plant biodiversity in vineyard agroecosystems.

We agree farmers, technicians and wineries who have provided information on vineyards management. We also agree S. Fernández, A. Ferraiuolo and M. Muray for field data support. This study has been partially funded by the Redbio project (www.redbio.eu) and by the Agroecology Group of the University of Barcelona-IRBio.

S06.O5. Long-term changes in Belgium's winter wheat (*Triticum aestivum* L.) arable flora: A functional and taxonomic analysis from the 1940s to 2024.

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In Northwestern Europe, arable farming is a dominant land use. Since World War II, agricultural intensification has drastically altered agroecosystems, becoming a key driver of biodiversity loss among plants, insects, and birds. Although common weedy species remain persistent, many arable plant species are sensitive to modern agricultural practices and land-use changes, leading to significant declines in many species in recent decades. However, despite a high proportion of rare or threatened species, long-term data on arable plant communities remain scarce.

This study examines taxonomic and functional changes in arable plant communities in Wallonia, Belgium, from the early intensification of agriculture to today.

Phytosociological surveys conducted from 1941 to 1951 in winter wheat (*Triticum aestivum* L.) fields were repeated in 2024 in 77 of the same or nearby fields using comparable methods. All species present within a 100 m² area were recorded, and their abundance was estimated using the Braun-Blanquet cover scale. Species richness, diversity, composition, and frequency shifts were compared between the two periods. Communities were also characterized based on species' functional traits to identify those shaped by agricultural intensification and global change.

In total, 140 species from 19 families were recorded in the 1940s surveys, compared to 105 species from 21 families in 2024. Species richness, as well as Shannon (respectively 3.1 and 2.5 in 1940s and current surveys) and Simpson (respectively 0.94 and 0.85 in 1940s and current surveys) diversity indices, were significantly lower in the current surveys compared to the 1940s surveys ($p < 0.001$***). Some of the most frequent species recorded in the 1940s surveys, such as *Polygonum aviculare* L., *Poa annua* L., *Alopecurus myosuroides* Huds., and *Matricaria chamomilla* L. were also among the most common species in the current surveys. Nevertheless, some species once common in the 1940s surveys, such as *Centaurea cyanus* L. (locally endangered) and *Scandix pecten-veneris* L. (locally threatened), were present in respectively 42% and 17% of the 1940s surveys, but are no longer found in current surveys. Some species that were not recorded in the 1940s surveys, such as *Anthemis cotula* L., were observed in the recent surveys, although at very low frequencies. Finally, current communities showed higher community-weighted mean heights.

Although some weedy species remain well-represented in winter wheat fields, these trends highlight the loss of taxonomic and functional biodiversity within the fields and the need for targeted conservation efforts in agricultural landscapes.

S06.O6. Temporal dynamics of weed seedbanks in organic and conventional farms: biodiversity and management implications

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Understanding changes in the species richness and size of weed seedbanks is vital for effective weed management and biodiversity conservation in agricultural systems. The seedbank acts as both a reservoir for future weed populations and a key component of agroecosystem diversity. Examining these dynamics under different farming systems over time reveals how management practices influence biodiversity and agricultural sustainability.

This study analyzed changes in the weed seedbank over 15 years (2008–2023) across 12 localities in central Catalonia, Spain. In each locality, one organic and one conventional winter cereal field were sampled at four georeferenced points—both at the edge and center. Samples were monitored in greenhouse trays for 13 months to assess germinable seeds.

Total species richness (gamma diversity) was estimated using the Chao 1 index. In 2008, organic fields recorded 141 species (expected: 181 ± 15 SE), significantly more than the 123 species (expected: 187 ± 24 SE) in conventional fields. By 2023, organic fields increased to 150 species (expected: 208 ± 20 SE), while conventional fields declined to 116 species (expected: 177 ± 25 SE). Statistical analyses confirmed consistently higher species richness in organic fields and a significant increase over time, contrasting with a decline in conventional fields. Mean species richness per field (alpha diversity) and seed abundance were analyzed using linear mixed-effects models. In 2008, organic fields hosted more species (20.5 ± 2.6 SE) and higher seed abundance (1125 seedling m-2 ± 194 SE) than conventional fields (14.7 species ± 1.8 SE, 384 seedling m-2 ± 115 SE). Despite a significant general increase in seed abundance by 2023, organic fields showed a lower magnitude of increase, while mean species richness per field remained unchanged. Species richness was consistently higher at field edges compared to centers.

These findings underscore the role of organic farming in enhancing weed species richness over time, contrasting with the decline observed in conventional agricultural systems. Although conventional fields-maintained seed abundance, the reduction in species richness highlights the adverse effects of conventional practices on weed seedbank diversity. Organic farming systems demonstrate their capacity to support biodiversity while maintaining sustainable weed management.

PS2-54. Integrating flower-visiting insects into sustainable agricultural practices with AI

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The sustainable promotion of biodiversity in agricultural landscapes, particularly through the tolerance of 'weeds' or segetal flora (segetalis = belonging to the seed), and the reduction of pesticide use, are central goals of European agricultural policy. These objectives, which are increasingly demanded by society, seek to enhance ecosystem diversity while maintaining agricultural productivity. Segetal flora is essential for agroecosystem biodiversity, but if not managed, it can hinder crop yields and, in severe cases, result in total harvest losses. As a result, balancing biodiversity conservation with the need to maintain agricultural productivity and global market competitiveness is a complex challenge.

A promising approach involves leveraging digital technologies, such as unmanned aerial vehicles (UAVs) and artificial intelligence (AI), to monitor and manage segetal flora in agricultural fields. The development of an AI-based weed identification algorithm trained with drone imagery could enable the efficient assessment of biodiversity and inform targeted weed management strategies. By combining this technology with an index that evaluates services and disservices of segetal species, it would be possible to provide differentiated recommendations for either controlling or tolerating specific weeds, based on their potential ecological value. This approach could help maintain or even enhance ecosystem services, such as pollination, without significantly impacting crop yields.

Therefore, a field trial will be established with 80 segetal species, and flower-visiting insects will be quantified and identified using a metabarcoding approach. The pollen preferences of different bee species will be examined, alongside the assessment of nectar and pollen quantity and quality. Simultaneously, the field trial will serve as a training ground for developing an algorithm capable of multi-species recognition.

The methodological approach will include the collection of biodiversity-relevant data, such as plant parameters, nectar and pollen quantity and quality, and pollen preferences of key pollinator species. These data will be complemented by molecular analyses of flower-visiting insect species using metabarcoding techniques. The resulting index-based approach is designed to pave the way for reconciling productive agriculture and the protection of agroecosystems.

Acknowledgement(s) / funding: BLE (Bundesanstalt für Landwirtschaft und Ernährung), Project ID: 281D205A22.

PS2-55. Dynamics of trait diversity among arable plants

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Arable plants have the potential of being both beneficial and detrimental components of the agroecosystems. They provide ecosystem services such as protecting the soil from erosion, and are a food source for beneficial species, but these benefits are offset by their potential detriment to the crop through competition. These effects are often mediated through plant traits, meaning that optimal management of agroecosystems must walk the line of facilitating biodiversity by increasing the presence of beneficial traits, while minimizing resource competition. To do that effectively, there must be an understanding of the traits that exist within the system, and how they respond to management and climate. While much research focuses on the plant community in the centre of the field, those at the field margin can also act as refuges and preserves for biodiversity. In the field margin, within-field weed species mingle with species from the habitats that lie outside the field, effectively representing the "potential" plant community. The traits found within this community are of interest due to their mediating of ecosystem functions, and hence the services and disservices the field margin community may bring.

We will in this study characterise the field margin community and its traits. To do this, we use data from the first nationwide inventory of arable plants in Sweden. This citizen science project, engaging hobby botanists, contains survey data from 290 field margins and over 300 non-crop plant species. This data is then combined with management and crop rotation data from the Swedish Board of Agriculture, large scale soil survey data, and trait data from databases like TRY. Using multivariate models, we will test associations between plant traits and environmental and agronomic variables. We will also use regression analyses to evaluate how taxonomic and functional diversity depend on specific conditions in the field. The results will lead to better understanding of the driving forces behind trait dynamics in agroecosystems, and what beneficial or detrimental effects field margin communities may have.

PS2-56. Strip cropping with oilseed rape and wheat – Effects on arable weed diversity at field and regional scale

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Diversified farming systems can be a valuable strategy for sustaining biodiversity while maintaining high yields. These systems vary in spatial scale, from large-scale approaches like agroforestry to fine-scale methods such as mixed or row intercropping. Strip cropping is a diversified farming system at field scale, in which two or more crops are grown in alternating strips of machinery width. It increases crop diversity while allowing for crop-specific management. Increased crop diversity at the field scale can promote biodiversity, particularly in arable weed communities, which are adapted to specific crop management practices. This may lead to greater species turnover and overall species diversity within a diversified field. However, the ecological effects of strip cropping may be different at larger, regional scales.

We studied 24 triplets, each consisting of a strip-cropping field with oilseed rape and wheat, along with separate sole-cropped reference fields of each crop. Herbaceous arable weeds were surveyed twice - once in April/May and again in June - in 6 to 8 plots (15 m^2 each) within the oilseed rape and wheat strips, and their respective oilseed rape and wheat reference fields. Species accumulation curves were used to compare species numbers at both field and regional scales, i.e. alpha and gamma diversity.

At both scales, species numbers in strip-cropping fields were comparable to reference fields when no distinction was made between crop types. However, strip cropping supported higher species numbers than wheat reference fields, but had similar species numbers to oilseed rape reference fields at the field scale and lower numbers at the regional scale. When analysing crop types separately, oilseed rape strips contributed more to species diversity within strip cropping, while ecotone effects along strip boundaries appeared to increase species richness in wheat strips compared to wheat reference fields.

Hence, strip cropping enhances arable weed diversity at the local field scale (alpha diversity) but not at the regional scale (gamma diversity). Oilseed rape is the key driver of these biodiversity benefits, though this effect may vary for other biodiversity indicator groups.

Acknowledgement(s) / funding: Landwirtschaftliche Rentenbank.

PS2-57. DNA metabarcoding as a tool for weed soil seedbank assessment: proof of concept

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Soil seedbank characterization is a fundamental step in sustainable weed management; however, conventional methods are time-consuming and labor intensive. Alternatively, DNA metabarcoding (MB) has emerged as a novel tool for species detection and the characterisation of plant communities. Compared to the germinable seedbank (GSB) technique, MB could potentially reduce the time required for species detection and eliminate the need to occupy space for long periods of time. This study provides a conceptual proof of the usability of DNA metabarcoding for the detection of weed species in soil samples and its potential as an alternative to the GSB technique.

Soil samples collected from one maize field (study A) and six paddy fields (study B) were respectively air-dried and lyophilised, and later characterized using both the GSB and MB techniques. The MB protocol consisted of DNA extraction from soil samples, DNA amplification, and high-throughput sequencing. In an initial test, soil samples from both studies, along with a positive control (dummy sample with known added seeds), were tested using an ITS2 primer for DNA amplification.

Despite the primer not being specific to plants, MB detected 80% of the expected species in the positive control and 23% of the species found via GSB from study B, although no plant species were detected in study A. When a plant-specific primer was used (ITS2-S2F), up to90% of GSB-recorded species were detected. Moreover, the range of species detected via MB was tenfold larger than the GSB results, demonstrating greater sensitivity with a challenge in the interpretability of results. By reducing the time required for weed species detection from 12 months to about 2 months, MB demonstrated significant potential for advancing soil seedbank assessment. However, the disparity with GSB results highlights the need for further refinement to ensure the technique’s applicability in practical weed management.

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

PS2-58. Modelling the impact of cropping system on the dynamics and impact of perennial weeds

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Agroecological management strategies must combine numerous agronomic levers maximizing biological weed regulation to reduce herbicide use. Perennial weeds are particularly difficult to control, as they propagate rapidly and regenerate by vegetative propagation. They are often controlled by frequent tillage, which can have negative impacts. The aim of this study was to develop a mechanistic model of crop–weed dynamics and use it to design cropping systems focusing on perennial-weed management.

The starting point was the FLORSYS model which simulates daily seed bank dynamics and 3D individual-based crop–weed canopies over the years from management operations, weather and soil characteristics for annual crops and weeds, as well as the consequences for crop production and biodiversity. Here, FLORSYS was used as a conceptual framework to organize data from literature and to plan experiments to fill in knowledge gaps, e.g., on the fragmentation of belowground storage organs by tillage (field trial) or the regrowth of shoots from such fragments (greenhouse experiment). The new submodel on perennials was designed to (1) fit into the existing FLORSYS representation of plants and biophysical processes, (2) recycle formalisms from existing models whenever possible, (3) be generic for the major perennial weeds found in arable cropping systems.

The new submodel simulates processes specific to perennials: biomass allocation to belowground storage organs, remobilization from these organs after plant damage by management operations (e.g., mowing) or frost, fragmentation of these organs by tillage and mechanical weeding, shoots regrowing from storage organs and fragments. The submodel was connected to the sexual life-cycle already included in FLORSYS, and parameterized for *Elymus repens* (L.) Gould (AGRRE) and *Cirsium arvense*L. (CIRAR). Simulations are currently running with the amended FlorSysto analyze the sensitivity to species parameters and management operations, and to evaluate cropping systems in terms of perennial-weed management.

The amended FLORSYS is the first model that simulates the dynamics and impacts of perennial weeds (as well as annual weeds) on crop production and biodiversity, from cropping system, weather and soil characteristics. It will contribute to designing herbicide-free sustainable cropping systems to manage perennial weeds.

Acknowledgement(s) / funding: INRAE, the French Ministry of Research (PhD grant of S. Skorupinski), the French projects COPRAA supported by the Office Français de la Biodiversité (OFB) and Be-Creative (ANR-20-PCPA-0001) funded by the Agence Nationale de la Recherche.

PS2-59. Intra- and inter-specific phenotypic variability of *Vulpia myuros* and *V. bromoides* populations

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Vulpia myuros and *V. bromoides* are annual grass species with an almost worldwide presence. In Australia, both species are widespread weeds of pastures. In Europe, *V. myuros* is an emerging arable weed, while *V. bromoides* is not considered a weed. Currently, we do not know why *V. myuros* is invading arable fields and *V. bromoides*is not. In addition, it is not clear if the arable populations of *V. myuros* come from opportunistic invasion from semi-natural populations, or if a particular arable weed ecotype is spreading independently. The objective of this study was to assess the phenotypic differentiation of populations of *V. myuros* and *V. bromoides*, coming from different habitats.

In summer 2023, we collected seeds from semi-natural and arable populations of *V. myuros* in the United Kingdom, spanning from the south of England to Scotland. From those, we selected 20 populations (11 arable, 8 from urban habitats and 1 population of *V. bromoides* found in a field margin) to run a set of five experiments: E1: seed germination, E2. plant development, E3. vernalisation requirements, E4. herbicide response, E5. competitiveness. The data were analysed to assess the phenotypic variability of the different populations, and to determine if the habitats (arable vs non-arable) played a role in shaping the characteristics of the individuals.

We observed significant differences between the urban and arable populations of *V. myuros*. Urban populations had lower seed weight and biomass at the end of the vegetative stage. The total seed biomass was similar between urban and arable populations, but with smaller seeds for urban populations it meant these produced more seeds than arable ones. When competing with *V. myuros*, wheat biomass was more reduced by arable populations than by urban populations. *Vulpia bromoides* showed heavier seeds than *V. myuros* and a faster initial growth, but produced fewer seeds.

These results demonstrate that even when growing in similar conditions, the origin of the populations has an impact on the phenotype of the individuals of these grass species. However, further investigations are necessary to understand if those effects are linked to the maternal environment or to genetic differences.

This work was funded by a Royal Society grant to LB (RGS\R1\231310). We wish to thank the BSBI for helping identifying populations in the UK, and all the farmers who sent us some seeds.

PS2-60. Sprouting ability of *Sonchus arvensis* at different growth stages

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Sonchus arvensis L. (perennial sow-thistle) is a perennial weed in the *Asteraceae* family. It can propagate via vegetative roots, thereby forming clones. In arable fields, soil tillage can fragment the vegetative roots of *S. arvensis* into root pieces called ramets. This process further affects its distribution within the field. Knowledge on the ability of the plant to sprout from the ramets is important to optimise management strategies for the species. Environmental conditions, e.g. light and temperature, also affect the sprouting capacity, development and growth of *S. arvensis*. The aim of this study was to analyse the impact of the temperature and the photoperiod on the sprouting ability of *S. arvensis* ramets collected at different growth stages over the year.

The experiment was conducted in Braunschweig, Germany in 2024. At different growth stages of *S. arvensis*, ramets were collected from three field populations in northern Germany. Roots were collected on five plant development stages: rosettes, flowers, seed heads, wilting, and during winter after frost. The samplings are divided into those including roots developed in the previous year (old roots) and those including roots that developed in the current year (young roots). All roots were cut into 5 cm ramets, potted at a depth of 2.5cm and pots kept in growth chambers. The sprouting ability of the ramets was tested under three different temperatures (6°C, 15°C, and 24°C) and two photoperiod (16h light/8h dark and 8h light/16 dark) regimes. In addition, pots with ramets were also placed outdoors to assess the impact of local temperature and photoperiod conditions. The time of sprouting (shoot emergence) was recorded, followed by weekly assessments of the plant development stage and the number of formed leaves. A final destructive assessment was conducted of the treatments when 720 degree-days accumulated. Fresh and dry weight of the aboveground biomass of planted ramets and newly formed roots were measured.

Preliminary results for the experiment will be presented, providing information on the sprouting ability of *S. arvensis* throughout the growing season and the impact of temperature and photoperiod on the sprouting capacity over the year. It can be shown that the developmental stage must be considered when modelling the sprouting capacity of *S. arvensis*, as the base temperature also changes throughout the year.

PS2-61. Text mining methods for automated data extraction to create a tropical weed traits database

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Weeds are among the most significant biotic reducing factors to crop production, causing major yield losses, particularly in tropical agroecosystems where they benefit from favorable climate conditions. However, the high diversity of tropical weeds (more than 1,700 species observed) is still poorly known, especially from a trait-based perspective. Beyond impeding their identification, this knowledge gap strongly limits our understanding of how they respond to the environment and agricultural practices, which significantly compromises the development of appropriate agroecological management. Currently, quantitative data on tropical weed traits are scarce and often difficult to extract. Moreover, qualitative data are heterogeneous from a semantic, syntactic and structural point of view and come from various sources (e.g., databases or herbarium websites such as TRY, GBIF, Kew Garden, WIKTROP, Seed Information Database) in various formats (e.g., numeric, textual, graphical) making them difficult to access, integrate, analyze and model. Though, there is a need to gather, consolidate and standardize the existing knowledge on tropical weed traits to better understand how biotic and abiotic filters influence their growth, development, and effects on cropping systems performances.

Our work aims to create a global trait database dedicated to tropical weeds based on existing online sources. Based on an extensive list of tropical weed species, we use and compare different web scraping and text mining algorithms to collect, sort out, clean and organize relevant qualitative and quantitative data on plant traits in a large sense (i.e. information on plants and organs morphology, growth, physiology, phenology, ecology) from various pre-identified data sources. Using these methods provides access to non-numerical data (e.g. plant reproduction habits) and allows us to explore “grey literature” to enrich our database. Then, the information gathered is filtered and standardized into a database to enable comparative analyses of species traits. We then address the benefits of our approach in the context of weed science.

Drawing on recent data science methods, this work represents a crucial step towards filling in the knowledge gaps concerning these numerous tropical weed species and should help the development of sustainable weed management practices in tropical cropping systems.

Acknowledgement(s) / funding: DigitAg Msc Grant, Conseil Regional de La Reunion, the French Ministry of Agriculture and Food, the European Union (Feader program, grant n◦ AG/974/DAAF/2016-00096 and Feder program, grant n◦ GURTDI20151501-0000735) for funding.

PS2-62. Seed predation of *Sorghum halepense* in maize cultivation: the role of weed management practices

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Seed predation is a key ecological process that regulates weed seed bank and influences the population dynamics of problematic weed species in agricultural ecosystems. Understanding the factors driving seed predation is essential for integrating this natural mechanism into sustainable weed management strategies. This study quantified the rate of seed predation and examined its seasonal variation following the dispersal of *Sorghum halepense* (Johnsongrass) seeds in a maize field over the growing season.

A split-split-plot experiment was conducted using a randomised complete block design with four replications. The study investigated the effects of tillage practices (conventional tillage, reduced tillage, and no-tillage), the herbicide nicosulfuron (0% and 100% of the recommended dose), and maize density (7 and 13 plants per square metre). Seeds were placed in Petri dishes containing sieved field soil and randomly distributed across the plots. To account for seed loss unrelated to predation, control Petri dishes enclosed in 1-mm mesh wire cages were placed alongside the experimental dishes at each sampling date. Seed predation was significantly influenced by both tillage practices and herbicide application, which accounted for 70% and 13% of the observed variation, respectively. The seasonal pattern of predation varied considerably, with a distinct peak from late May to late August, coinciding with rising temperatures and reaching an average predation rate of 53.9%. Thereafter, as temperatures declined, predation rates fell to their lowest level in early September, averaging 21.3%.

These results demonstrate that seed predation is a dynamic process, fluctuating in response to environmental conditions and management practices. Given the clear seasonal trend in predation, ecologically informed management strategies could be developed to sustain or enhance predation rates during peak periods. By fostering conditions that support seed predators, such approaches could contribute to the long-term suppression of *S. halepense* seed banks, thereby reducing future weed infestations. Integrating seed predation into weed management frameworks and aligning other control measures accordingly could promote more sustainable and environmentally responsible agricultural practices.

We would like to thank the whole team from the Department of Agronomy and Plant Breeding at the University of Tehran for their support.

PS2-63. Applying CSR theory to weed classification: Insights from a large-scale plant trait dataset

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Under the European Green Deal, innovative weed management strategies are needed to control undesirable species while preserving beneficial ones. Trait-based approaches are crucial, as the provision of ecosystem services is highly dependent on plant traits. Grime's CSR (Competitor, Stress-tolerator, Ruderal) theory provides a valuable framework for understanding weed functional responses to agricultural management, yet its relevance in agroecosystems remains underexplored at broad scales. This study examines CSR strategies in plant species and their functional patterns related to weed frequency and relevance.

Functional trait data—including vegetative height (PHV) and leaf traits (LA, SLA, LDMC)—were compiled for all herbaceous and subshrub species from the Iberian Peninsula and Balearic Islands with available records in the TRY database. The dataset was extended with additional sources and field measurements, and CSR coordinates were calculated using a standardized methodology. A weediness index classified species from non-weeds (weediness = 0) to those frequently associated species with crops (weediness = 3). Additionally, a text-mining approach was applied to 9,702 articles from major weed science journal to identify the most frequently cited weeds (major weeds), using citation frequency as an indicator of relevance. Trait data were compiled for 3,742 species, enabling CSR coordinates for 1,593, including 787 with documented crop presence.

CSR analysis revealed that: (1) stress tolerance (S) decreased, while ruderality (R) increased in more frequent weeds; (2) competitiveness (C) showed no consistent pattern but was significantly higher in species rarely found in crops; (3) major weeds were, on average, more competitive and less ruderal than other species; and (4) major weeds had significantly higher LA and PHV than non-major weeds. This study provides the most comprehensive CSR-based weed classification to date, uncovering distinct patterns based on weed frequency and relevance. Ruderality, linked to recurrent disturbances, is the key dimension explaining weed frequency in crops. The lower ruderality and higher competitiveness of major weeds suggest that species with a stronger competitive dimension—characterized by greater leaf area and plant height—are a major concern in agroecosystems. These findings highlight the utility of CSR strategies in characterizing and managing weed communities.

PS2-64. Weed occurrence and tropane alkaloids potential presence in Serbian cereal crops: a two-year study

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Tropane alkaloids (TAs) are secondary biomolecules produced by the weeds, predominantly from the Solanaceae family, with which the general public is not sufficiently familiar. They can contaminate agricultural products mostly due to accidental contamination during the harvest, posing a hazard for human health, especially infants and young children. During the 2-year study, the weed prevalence in organic vs. conventional cereals was monitored across 30 locations in the Republic of Serbia. This study aimed to assess the presence of TAs in cereals and cereal-based products. Weed samples were collected from the cereal fields prior to harvest, dried, ground, and aggregated by the species for the analysis by the LC-MS/MS. The most frequent weeds were *Chenopodium album*, *Amaranthus retroflexus* and *Ambrosia artemisiifolia*. *Sorghum halepense* dominated in conventional (15.91%), while *C. album* prevailed in organic maize (12.82%). In barley, *A. retroflexus* and *A. artemisiifolia* were the most common (12.5% each), with *C. album* leading in organic barley (15.38%). In wheat, *A. retroflexus* (9.09%) prevailed in conventional, while *C. album* (19.05%) dominated in organic systems. Among 54 identified weed species, 40.74% of the samples tested positive for both atropine and scopolamine, while the same percentage showed no detectable levels of TAs. Additionally, 16.67% of the samples contained only atropine, and 1.85% contained scopolamine alone. This study highlights the risk of TAs contamination in cereals, particularly due to *Datura stramonium*, a known TA-producer, which was the most prevalent in organic barley (15.38%), conventional maize (11.36%), and organic wheat (9.52%), indicating that both systems are vulnerable to TAs contamination. Many weeds tested positive for TAs despite not being traditional TA-producers, indicating indirect contamination routes. TAs may transfer via mechanical abrasion, adherence to plant surfaces through dust, or uptake from contaminated soil, where residual alkaloids from TA-producing weeds persist. These findings emphasize the potential for TAs contamination to extend to cereal-based products during processing, posing food safety risks, underscoring the need for stricter monitoring, targeted weed control, as well as contaminated soil and dust management to reduce contamination risks and ensure food safety. Further research should investigate these pathways to refine risk assessments and management strategies.

The authors acknowledge The Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia for the financial support (Contract No. 000425527 2023 14842 007 000 000 001).

PS2-65. Arable weed diversity in two German regions: pilot for a national weed monitoring

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To mitigate the loss of biodiversity in the agricultural landscape, detailed knowledge on the status and trend of diversity is required for different taxa. So far, the largest habitat type in Germany – arable fields – is rarely covered by biodiversity monitoring efforts and no coherent national monitoring exists for the arable weed diversity. Within the national MonViA project, monitoring approaches for the agricultural landscape in Germany have been developed. Within the project, we developed a monitoring concept to assess the current and future status of arable weed diversity in Germany. The monitoring focuses on the major crop types in Germany. On the field level, two to three transects (1m * 100m) in the center and the field edge, each with five subplots ($1m^2$), are surveyed. All weeds are addressed to the species level and their abundance is estimated using the Londo scale. In 2022 and 2023, the monitoring concept was tested in two German regions: Braunschweiger Land (Lower Saxony) and Eastern Brandenburg.

The pilot implementation of the monitoring concept showed that Brandenburg exhibited a higher weed species diversity and a greater number of weed species per field compared to the Braunschweiger Land. On average, 20 weed species per field were observed, with a considerable variation between fields. Within the fields, species richness differed notably, as the center of the fields harbored an average of five weed species, whereas the edges showed approximately three times as many species. Furthermore, winter crops displayed a greater species richness than summer crops. Among the crop types, cereal fields showed the highest overall diversity. Certain species also exhibited regional differences: *Alopecurus myosuroides* Huds. was highly abundant in Lower Saxony but absent in Brandenburg, while some species like *Polygonum aviculare* L. and *Elymus repens* (L.) Gould were frequently found in both regions.

The pilot monitoring highlights significant regional and crop-specific differences in arable weed diversity. The results emphasize the need for a systematic national monitoring program to understand and conserve arable weed diversity as an essential component of agricultural biodiversity in Germany.

PS2-66. Pharmaceutical potential of arable weeds: a case study from the Czech Republic

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One of the positive roles of weeds may be their potential use as medicinal plants. The aim of this study was to evaluate the occurrence and distribution of weeds with pharmaceutically important active substances on arable land in the Czech Republic in organic farming.

In 2006-2018, a phytocoenological survey was performed on selected organic farms in different production areas representing various climate and soil conditions and in different crops. The selection of weed taxa of pharmaceutical importance was based on a literature.

A total of 223 species were found throughout the survey and of those, 56 species were identified to have a pharmaceutical significance. The effect of different production area and crops on the occurrence of these species was found statistically significant; however, most of the plants were not strongly associated with a particular region or crop supporting the idea that the listed medicinal plants are somewhat ubiquitous throughout the landscape, resilient in the face of pressures or disturbances on the agroecosystems, and complimentary of the food crops intentionally grown. Among the species that were both frequent and with high mean cover are *Cirsium arvense, Polygonum aviculare, Capsella bursa-pastoris, Stellaria media, Galium aparine, Elytrigia repens, Convolvulus arvensis, Fumaria officinalis, Centaurea cyanus, Descurainia sophia*and *Equisetum arvense.* An example of medicinal use is *Polygonum aviculare* used in the treatment of renal diseases, urinary bladder inflammations, as well as an expectorant and secretolitic agent for coughs and bronchial catarrh, *Capsella bursa-pastoris* used as a haemostatic or *Elytrigia repens* used for its diuretic, urinary and antiseptic properties.

Recognizing possible benefits of ecosystem services provided by arable weeds and finding opportunities for organic farmers to have new seasonal markets may help improve sustainability of small farming operations.

PS2-67. Assessment of the spontaneous flora of Mediterranean olive groves: ecosystem services and disservices

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Spontaneous vegetation in Mediterranean olive groves (*Olea europaea* subsp. *europaea*) has garnered attention due to its positive impacts on agroecosystems, soil health, and ecosystem services (ES). However, managing this flora poses challenges as many species are weedy and serve as hosts for one important vector of *Xylella fastidiosa* (*Xf*), the bacterium causing Olive Quick Decline Syndrome. This disease leads to severe symptoms, including leaf scorching and desiccation of twigs and branches, often culminating in the death of infected olive trees. An important vector of this disease is the meadow spittlebug (*Philaenus spumarius*), a xylem sap-feeder that inhabits weeds, spontaneous plant species and olives. This study evaluated the ES provided by spontaneous flora in olive groves and their disservices, focusing on their potential as weeds and *P. spumarius*hosts. We conducted 13 surveys, each using 30 quadrats of 0.25m2 randomly distributed across the olive grove (Tapada da Ajuda, Lisbon) on tree rows with 10-15 days intervals, from March to August 2024. The most frequent and abundant weedy species were identified and those with insect nymph presence were documented. For each species, we calculated VIFLORES (0-1), an indicator that quantifies the value of spontaneous flora in providing ES and analyzed species abundance during four key olive phenological phases. A total of 43 species were recorded, primarily from the families Asteraceae, Fabaceae, and Poaceae. Of these, 44% were *P. spumarius* hosts, 67% were major weeds, and 12 species had both disservices. Notably, species with high VIFLORES scores, such as *Malva sylvestris (0.73)*, *Sonchus oleraceus (0.71)*, and *Avena barbata (0.76)* were often *P. spumarius* hosts or major weeds. In addition, important *P. spumarius*hosts with low VIFLORES scores (<0.2), including *Picris echioides*, *Galactites tomentosa*, and *Urospermum picroides*, increased in abundance from olive bud development to fruit maturity. To mitigate *Xf* threat, these species should be controlled from late winter to early spring (at least), despite the ES benefits of some species. Effective weed management should integrate weed phenology and abundance with olive phenological phases to balance ES provision and minimize *Xf* contamination risks.

This study was funded under EFSA Grant (GP/EFSA/ALPHA/2021/07 - LOT 2). CEF and GREENIT are funded by FCT (FCT/UIDP/00239 - DOI 10.54499/UIDB/00239/2020 e UIDB/AGR/04129/2020).

PS2-68. Assessing the current status of *Vulpia myuros* as an arable weed in the United Kingdom, France and Switzerland

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The increasing presence of the annual grass weed *Vulpia myuros* (rat's tail fescue) in arable crops is expected to become a problem to crop productivity. The objective of the present study was to investigate the distribution of *V. myuros* across farms in some European countries and to find the farm practices that are associated with its presence. In 2021, an online survey was conducted among farmers across France, Switzerland and the United Kingdom with questions on weed occurrence, farming systems, field management practices, and the expected yield loss caused by *V. myuros*.

The total number of respondents was 433, with 314 from France, 61 from the United Kingdom and 58 from Switzerland. Most of the respondents (>75%) noticed *V. myuros* to be problematic in fields with reduced or no-till practices. However, 17% of respondents reported that this weed is widespread even in fields where ploughing was practised. Farmers were asked to provide information about the predominant crops grown in their fields with *V. myuros* presence. Most of the farmers observed *V. myuros* mainly in winter-sown crops, including winter wheat (282 occurrences), winter barley (188 occurrences), and winter oilseed rape (199 occurrences). It was also recorded in winter oat (42 occurrences) and winter legumes (75 occurrences). The weed was also reported in spring-sown crops, particularly spring barley (113 occurrences), maize (145 occurrences), linseed (57 occurrences), sunflower (118 occurrences), sugar beet (52 occurrences), and soybean (44 occurrences), though less frequently than in winter crops. Farmers from France (44%), the United Kingdom (55%) and Switzerland (64%) also reported that the weed had become more problematic over the past three years. The source of the infestation by *V. myuros* was largely unknown, though some respondents cited field margins and machinery as likely sources of spread. Farmer estimations of expected crop yield losses due to *V. myuros* ranged from 23% (in the UK) to 45% (Switzerland). The current study demonstrates that *V. myuros* is indeed an increasingly important weed in European winter crops, justifying investments in research and development of potential, sustainable management strategies.

PS2-69. Use of eDNA for weed identification: a preliminary data from weeds in Malaysia rice agroecosystem

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Integrated weed management, a system aimed at achieving sustainable weed control, relies on predictive models that help stakeholders adopt long-term strategies. Understanding the weed seed bank in the soil is crucial for developing these models. Nevertheless, integrating eco-physiological data requireshighly complex and time-consuming studies. Since the 1980s, environmental DNA (eDNA) has been widely used in environmental protection strategies. However, its application in weed science remains unexplored, despite its potential for enhancing weed models. This study was conducted in rice fields in Malaysia. Soil cores were collected from depth exceeding 20 cm and seeds were extracted at 5 cm intervals. The eDNA from the soil cores was subsequently extracted using DNeasy PowerSoil® Pro Kit and sent for next generation sequencing (NGS) using *rbc*L marker for plant identification. The sequences were aligned against the nucleotide database at the National Center for Biotechnology Information (NCBI) using BLAST for identification. The exhumed seeds were mainly identified as *Oryza*spp. and *Echinochloa* spp. based on their morphological characteristics. Sequence data showed that *Oryza* was the predominant genus detected at 5 cm depth. Other highly sequenced plant genera included *Fimbristylis* and *Nephrolepis,* followed by *Cyperus*. Although *Echinochloa* seeds was frequently exhumed in various core sections, it was sequenced at lower levels. No clear overall relationship was observed between the number of exhumed seeds and the DNA sequences obtained from the soil cores. The conventional method is labor-intensive and requires specialised expertise, whereas eDNA is more efficient in detecting weed biodiversity from soil on a broader scale. These findings are promising and contribute towardthe application of eDNA in weed management.

PS2-70. Weed survey projects using the citizen science app iNaturalist

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The Italian weed research society (SIRFI) initiated a series of projects to map the presence of weeds in Italy through the iNaturalist application. One project, "Weeds of Italy", started in 2020, involved the analysis of observations on a selected number of weed species already included in the database. A list of 90 weed species considered to be the most important in Italian agricultural and non-agricultural areas was selected by the society members and included in the project. Two other projects were launched in 2024, one on *Cyperus esculentus* reported in cultivated fields and another on the presence of *Ambrosia artemisiifolia*. For both projects, people were asked to join the project and upload geolocated weed images to create a distribution map. The project on *C. esculentus* was started because this species is rapidly expanding its distribution area, becoming a very important weed in summer crops. The target group for uploading observations in this project were field technicians who regularly surveyed arable fields. The project on *A. artemisiifolia* aimed to collect observations on this invasive species in different environments in Italy following the accidental introduction of the beetle *Ophraella communa*, a biological control agent of the weed. All people who visit agricultural and non-agricultural areas were the target group for uploading observations. By January 2024, the project "Weeds of Italy" recorded almost 68,000 observations of 87 weed species documented by about 11,000 observers. The most recorded species were *Malva sylvestris*, with about 4,000 records, followed by *Veronica persica*, *Papaver rhoeas* and *Phytolacca americana*. The *C. esculentus* project recorded about 50 observations, more than 90% of which located in northern Italy, and observed in winter crop stubbles, maize, rice, vegetable crops, and orchards. The *A. artemisiifolia* project included 110 observations, all recorded in northern Italy, except for one southernmost site in Florence. It was recorded from sea level up to about 1,200 meters of altitude. Roadsides, natural areas, and winter crop stubble accounted for most of the records. The application proved to be a useful method for producing weed distribution maps, while raising the awareness of weed science among citizens and technicians.

PS2-71. Do pesticide seed coatings influence weed communities?

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Pesticide seed coatings (often mixtures of neonicotinoid insecticide and fungicides) are widely used in maize, soybean, and other row crops and are intended to protect crop seeds and seedlings from soilborne insect pests and fungal pathogens. Many of the same pest organisms targeted by pesticides in seed coatings also damage weeds. Additionally, ground beetles and other beneficial natural enemies of weeds can be negatively impacted by the pesticides in seed coatings, suggesting that this practice may undermine the biological control of weeds. We conducted a three-year field experiment (2016 to 2019) with a maize-soybean rotation grown with and without pesticide seed coatings under three tillage systems (no-till, strip-till, and full-till). While the specific pesticide seed coating varied each year and by crop, it always contained a neonicotinoid insecticide and several contact and systemic fungicides. Weed seed banks and emergent weed communities were sampled each spring and fall, respectively. Seedbanks were enumerated by direct germination in a heated glasshouse. Temporal change in weed seedbank community composition and diversity from the beginning of the study (spring 2016) to the final sampling period (spring 2019) was assessed by examining differences in Bray-Curtis coefficients and percent change in Shannon diversity, respectively. The effects of pesticide seed coatings on weed abundance and community metrics varied by tillage system. Generally, pesticide seed coatings reduced the temporal variability of weed seedbank communities, the nature and extent of which depended on tillage system. Bray-Curtis distances were lower in the pesticide treatment compared to the no-pesticide control in no-till but did not differ between treatments in the other two tillage systems. In contrast, percent change in seedbank diversity in the pesticide treatment was consistent across the three tillage systems (+5%), while in the no-pesticide treatment the change in diversity ranged from -9% (less diverse) in the full-till treatment to +14% and +27% in the no-till and strip-till treatments, respectively. Together, these results add to the growing list of unanticipated effects associated with this nearly ubiquitous practice.

Funding for this research was provided by the USDA National Institute of Food and Agriculture (NIFA) Agriculture and Food Research Initiative (AFRI) Grant No. 2017-67013-26594, USDA NIFA Hatch Project 1016232, and the New Hampshire Agriculture Experiment

PS2-72. Development of species-specific DNA primers for detecting *Apera spica-venti* (Poaceae) in soil seed banks

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Apera spica-venti is a grass species that has become a widespread weed in winter crops across Northern, Central, and Eastern Europe, as well as the Northeastern USA and Canada. *A. spica-venti* significantly reduces crop yields and is prone to developing herbicide resistance. Although its seeds are considered short-lived, the accumulation of a persistent soil seed bank remains a major concern for local growers. Thus, the development of reliable methods for detecting this weed in soil is crucial. In this study, two nuclear primer pairs were designed using the Angiosperms353 probe set and tested for species specificity. *In silico* analyses suggested that these primers would not be expected to amplify loci found in transcriptomes from the 1000 Plants (1KP) initiative, thus minimizing the risk of amplifying non-target species' DNA. Seed and organic matter extraction was achieved using a flotation method with a potassium carbonate solution. Mock soil samples were prepared using seed-free sieved soil spiked with a known quantity of *A. spica-venti* seeds. Tests were conducted to determine the minimal number of *A. spica-venti* seeds required for specific DNA amplification. The amplicon lengths were 100 bp for both primer pairs. DNA amplification was empirically tested using DNA isolated from *A. spica-venti* samples and 20 other typical arable weed species occurring in Latvia. Sanger sequencing was used to confirm correspondence of the expected sequences derived from the Angiosperms353 dataset. We found that the primers effectively amplified DNA extracted from seed-spiked soil samples. In samples containing a single seed per 100 g of soil, *A. spica-venti* was detected in 33.3% (1/3) of biological replicates using the first primer pair and in 66.7% (2/3) using the second primer pair, indicating that the presence of a single seed may be sufficient for detection but with varying amplification efficiency depending on the primer pair used. Future research will focus on assessing the genotype specificity of the primers to ensure reliable detection across different genotypes of *A. spica-venti*.

This research was funded by the Latvian Council of Science, project “Development of DNA markers for detection of loose silky bent (*Apera spica-venti*) seeds in soil seed banks”, lzp-2023/1-0265.

PS2-73. Morpho-anatomical features and distribution patterns of underground organs in *Reynoutria japonica* and *Reynoutria* × *bohemica* (Polygonaceae)

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The rhizomatous taxa of the *Reynoutria japonica* complex (Polygonaceae) are characterised by highly efficient vegetative growth, making them one of the most invasive and problematic plants worldwide. Precise knowledge of the distribution of the underground organs, and in particular of the resprouting rhizomes, is a key prerequisite for targeted eradication measures.

In the present study, we aimed at (1) clarifying existing differences in the morpho-anatomical characteristics of rhizomes and roots, (2) assessing their respective distribution patterns along the soil profile and (3) developing an approach for estimating the rhizome resprouting potential in knotweed populations. During digging activities in November 2023, we described the underground organs of three wild populations for both *Reynoutria japonica* and *Reynoutria* ×*bohemica* in Canton Ticino (southern Switzerland). In addition, rhizome resprouting tests were carried out in greenhouse experiments allowing to assess key rhizome morphological characteristics.

The obtained results show that rhizomes are characterised by pith tissue in the section centre and display nodes with peripheral dormant buds that enable them to resprout. Rhizome biomass is mainly concentrated in the first 40 cm of soil, although some outlying rhizomes may be found in deeper soil layers depending on soil compaction and related penetrability. Roots, on the contrary, dominate and are more abundant in deeper soil layers, constituting more than 75% of total biomass situated below 40 cm. Rhizome resprouting rates are significantly correlated with ontogenetic pith brightness, rhizome diameter and taxon. To estimate the overall rhizome resprouting potential, the amount of expected resprouting nodes was theoretically calculated for both taxa by combining data on the distribution of rhizome nodes and their respective pith brightness category as a proxy for the resprouting capacity. Such amount of expected resprouting nodes may equivalent to 1958 n/m^2 with standard error limits ranging from 1783 to 2179 n/m^2 and 1630 to 2240 n/m^2 for *R. japonica* and *R.* ×*bohemica*, respectively.

Finally, we provide practical advice on how these outcomes can be used to optimise investment in machinery and human resources for the management of these rhizomatous taxa, and more specifically to determine the optimum depth of intervention during soil improvement operations.

For financial support, we would like to thank the Section of the Territorial Development (Office of Nature and Landscape), the Section for the Protection of Air, Water and Soil (Office of Waste and Contaminated Sites) of Canton Ticino and the Gruppo di Lavoro Organismi Alloctoni Invasivi in Canton Ticino (GLOAI).

PS2-74. Small scale versus large scale diversification of cropping systems – effects on weed flora diversity, abundance and species composition in conventional agriculture

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Heterogeneity at different scales is claimed to be a key factor for promoting biodiversity on agricultural land while minimizing risks for production and providing important ecological feedback loops in farming systems. The social pressure towards reductions in chemical crop protection, the narrowing of the available herbicide spectrum, and opportunities created by new technologies (robotics) require modern solutions for more heterogeneous cropping. The objective of our studies was to analyze the potential of small-scale diversification, as created by clustering patches of 5 different crops in a single field („PatchCropping"), for bridging ecological and farming goals for the weed flora.

The PatchCrop experiment was carried out as an on-farm experiment on a typical agricultural farm in NE-Germany. The field with the patch crop design (70 ha) consisted of 30 patches (6x5 field units, of 5.184 m² each) under nine different crops organized in 2 different crop rotations and 2 weed control intensities with 3 replications. The weed flora at the PatchCrop field was compared to the weed floras at 6 sole cropped fields in the surrounding the field with the PatchCrop experiment. The 6 reference sole cropping fields had a size between 10 and 46 ha and included 2 weed control intensities analogous to those at the PatchCrop field. The following research questions were analyzed comparing the PatchCrop field with the surrounding sole crop references: (1) the effects on annual weed species richness, (2) relating the effects of crop diversification to the 2 weed control intensity levels and (3) analyzing the contribution of single crop kinds to the crop diversification effects. The results were framed with yield data.

The data from 2021-2023 was analyzed with generalized linear models by using either Poisson distribution models for species number data or gamma-distribution models for coverage data. The results for the analysis of species numbers showed that the individual crop clusters in the "PatchCrop" experiment showed an average of 10,7 weed species per year (30% higher) compared to single, individual reference fields (annual average = 7,1 species). However, the results were reversed when viewed over several years and from a landscape perspective. The sum of all 6 reference fields together showed with 57 species a higher species richness over the three years than the clusters of crops in the patch crop experiment (47 species in total) due to huge complementary species occurrences among the reference fields. The reduction in plant protection intensity, which provided for the replacement of chemical measures by mechanical weed control, especially in summer crops, resulted in increasing the annual total species number at the PatchCrop from 22 to 31 species (33%) and at the references from 38 to 58 species (39%) and doubling the annual averaged weed species coverage from 8,9% (conventional) to 19% coverage (reduced). The crop kinds studied showed significantly different contributions to both weed diversity and weed severity. This indicates that diversification requires a targeted selection of participating crops to achieve synergy effects.

The patchCROP experimental infrastructure is maintained by the Leibniz Centre for Agricultural Landscape Research (ZALF). It is financed in equal parts by the Federal Ministry of Food and Agriculture (BMEL) and the Ministry for Science, Research and Culture.

PS2-75. Untangling the genomics of *Galium*

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In 1991 Holm listed eighteen species of *Galium* (Rubiaceae) as problematic agricultural weeds in numerous countries around the world. These species can cause significant losses in cereals, canola, and sugar beet and three of the most aggressive species: *G. spurium, G. aparine,* and *G. tricornutum* have evolved herbicide resistance. Identification of these and other *Galium* species is frequently challenging, likely because of the role of hybridization and polyploidization within the polyphyletic genus. We assembled the genome of *G. spurium* to clarify its evolutionary relationship to other *Galium* species, understand its genome composition, and provide a foundation genetic resource. We then used the genome sequence to support an investigation of the population genetics of nineteen populations on the Canadian Prairies and an investigation into the genetic basis of herbicide resistance. *Galium spurium's* chromosome level genome assembly covers approximately 85% of the expected 360Mbp genome and has 94% of BUSCO genes complete with majority represented in single copies (89%). Approximately 37% of the genome is repetitive elements and we used RNA-Seq data to annotate the genome with 35,540 genes, including one hundred homologs for genes potentially involved in herbicide resistance. The genome shows strong macrosynteny with other members of the Rubiaceae published by other groups including *Cruciata laevipes* and *Coffea canephora* and a strong similarity to the genome of *G. aparine*. This similarity confirms that *G. spurium* either represents an extant relative of one the parental genomes for *G. aparine* or it is a close relative of that parent. Double digested RADseq population data indicated that *G. spurium* has highly structured populations on the Canadian Prairies (F_{ST} = 0.54) with evidence of inbreeding (F_{IS} =0.86) and low levels of both heterozygosity (H_O = 0.02) and nucleotide diversity (π = 0.0003). This could explain why herbicide resistance has been slow to spread across Canada. Several homologs of genes involved in the assembly of the Skp1-Culliun-F-Box IR1/AFB E3 ubiquitin ligase complex (e.g., CAND1, ECR1) are in areas of the genome with evidence of selection and are candidates for further investigations into the genetic basis of resistance to auxinic herbicides.

Acknowledgement(s) / funding: AAFC.

PS2-77. Weed diversity in a long-term trial of tillage management in rainfed crops

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Abundance and diversity of weeds vary significantly among crops and land management strategies, such as tillage and crop rotations. The objective of this work was to compare the evolution of weed diversity in a long-term trial of different tillage systems.

The study was performed on a long-term experiment initiated in 2004 and located at the research station of the ITACyL (Valladolid, Spain). The site is characterized by a Mediterranean climate, with a mean annual temperature of 12.7°C, and annual rainfall of 433.5 mm. The soil is classified as Typic Xerofluvent, with loam soil texture. The experimental design was a split-plot with four replicates with a plot size of 18 x 9 m, where the main factor of the study was the tillage system (conventional tillage (CT), minimum tillage (MT) and no-tillage (NT)), and the second factor was the crop rotation (62 plots). Different crops rotations were studied over the years, all of them based on combination of cereals and grain legumes. The trial was conducted under rainfed conditions. Glyphosate (2 L ha^{-1}) was applied prior to planting to zero-till plots, and herbicides and pesticides were used as convenience equal in any tillage system. Samples of 0.25 m^2 of weeds were collected in spring (1 to 6 samples per plot) in two periods (2007, 2008, 2009 and 2010, and 2019, 2020, 2021 and 2022), to assess the number of plants by species.

Forty species of weeds were identified along the study.A three-way ANOVA (period, tillage system and its interaction) was performed, showing that the period of years was the most important factor explaining the variability (twenty-two species), followed by tillage system (nine) and the interaction (nine).A NMDS (Non-metric MultiDimensional Scaling) analysis were performed to compare samples collected from 2007 to 2010, and those collected from 2019 to 2022.Significant differences were found mainly based on *Polygonum aviculare*, *Bromus sp*. and *Fumaria sp.*, but also in *Chenopodium album* and *Polygonum convolvulus*. Differences among crops (cereal vs. grain-legumes) along both periods of years were found for several weeds, bring to light dissimilarities in biology and management of crops.

This work was carried out within the framework of projects RTA2017-00006-C03-02 and PID2022-138060OR-I00, funded by AEI.

7. Economic and societal aspects of weed management

S07-O1. Redefining economic thresholds: valuing biodiversity and ecosystem services of weeds

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Keynote session

Economic thresholds for weeds represent an agronomic concept used to evaluate the necessity of weed control measures. These thresholds are reached when the costs caused by weeds—such as yield losses, increased cleaning and drying expenses, or harvest difficulties—exceed the costs of weed control measures. So far, this concept has focused on the economic losses caused by weeds without accounting for their potential positive effects. However, the positive effects of weeds, known as ecosystem services—such as providing food for insects and birds, supporting pollination, sustaining herbivores and seed eaters, and contributing to natural pest control—are increasingly recognized and investigated by agricultural and ecological research.

These positive effects serve the ecosystem and can be attributed to the functional traits of weeds. For example, weed flower characteristics such as flowering duration and flower shape influence the attraction of weeds for pollinators. For insect herbivores, leaf traits like hairiness or thickness are significant, while for seed eaters, the timing and properties of seeds are decisive. Morphological traits, such as the leaf, flower, or seed structure that attract predatory insects, in turn, enhance natural pest control.

In addition, the pure existence of weeds independent of their provision of ecosystem services or harmful impacts is known as "existence value". To account for this existence, the value in economic thresholds is required to be allocated to it. We set this value as equal for each species but density-dependent, being highest for the first individuals and converges to an asymptote as the species density rises since additional individuals add no more existence value for this species. Assigning an economic value to these weeds raises the weeds economic thresholds.

An extended concept of economic thresholds that incorporates both the economic losses and the ecosystem services and the existence value of weeds could represent an important step toward more sustainable weed management. This approach should integrate natural pest control mechanisms and prioritize biodiversity conservation. The functional traits of weeds enable a more precise assessment of their ecosystem services, allowing these to be quantitatively represented in the threshold calculations.

The work is funded by the German Federal Agency for Nature Conservation with a grant from the Federal Ministry for the Environment, Nature Conservation Nuclear Safety and Consumer Protection (FKZ 351984070).

S07-O2. Weed perception and management decision criteria of farmers reducing reliance on herbicides

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Economic weed thresholds refer to the density of a specific weed species in a particular crop, beyond which the cost of yield loss caused by the weed exceeds the cost of herbicide application. It is the main indicator to trigger a herbicide treatment. Economic thresholds are commonly used to assess the harmfulness of weed species since the 1970s. However, with the national and international objectives of reducing reliance on herbicides and the promote of integrated weed management, new research approaches focusing on weeds' functionality have emerged. Weeds are no longer viewed solely as pests but are also evaluated for their potential to provide ecosystem services. They are no longer measured on a species-by-species approach, but described as plot-specific communities filtered through the cropping system and landscape. Farmers who reduce the reliance on herbicides face new challenges in assessing the potential harmfulness of weeds and deciding to act with a wide range of tactics. We therefore aimed to study farmers' perception of the negative and positive effects of weeds and their management decision criteria when implementing integrated weed management (IWM). We conducted a survey of Swiss arable farmers in winter 2023. In total, 562 farmers responded, with a representative distribution across Switzerland's agricultural regions. 13% of the respondents were organic farmers, 70% subscribed to a federal contribution for pesticide reduction and 35% subscribed to a federal contribution for herbicide reduction. The median number of crops per farm was six, with a predominance of wheat, maize, temporary meadow, rapeseed and barley. The most problematic weeds cited were perennial species (e.g.*Cirsium arvense*) and grass species (e.g.*Echinochloa crus-galli*). The indirect effects of weeds (e.g. increased soil seed bank) are perceived as more important than the direct effects (e.g. yield loss). Weed observation remains a predominant criterion for decision-making (93% of farmers) but the decision criteria are not based on weed density but the presence of specific weed species and their growth stage in relation to crop development. Indicators, such as the number of weed species or evenness between species, are rarely taken into account by farmers. This suggests new avenues of research to provide farmers with relevant indicators to help them implement IWM.

S07-O3. Love the neighbour? Even if they don't manage their weeds?

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Herbicide resistance is a critical challenge to sustainable agriculture at an individual, landscape and global scale. A key question arises: should a grower invest additional resources to prevent the evolution of herbicide resistance, even if neighbouring farms do not? The objective of this study was to use a spatial simulation model to explore how the adoption of best-practice weed management impacts resistance evolution across a larger landscape and how outcomes for individual growers are affected by the practices of their nearby neighbours.

The findings reveal that widespread adoption of best weed management practices reduces herbicide resistance across the landscape. This is achieved by lowering weed populations, leading to localized eradication of resistance alleles, fewer clusters of farms with resistant weeds, and reduced gene flow. For individual growers, adopting best practices always decreases the risk of weeds developing resistance, but does not guarantee a better outcome. The risk of resistance increases when neighbouring farms do not follow best management practices. The proximity of neighbours also plays a critical role, along with factors such as the initial frequency of resistance alleles, efficacy of weed control, the number of seeds that weeds produce, and dispersal of pollen and seed.

This study highlights the danger of a downward spiral, where poor adoption of the best available weed management practices leads to increased resistance risks, which further reduces the incentive for adoption by others. It also highlights the possibility of reversing this spiral through education, awareness building and community involvement.

This research was funded and conducted in collaboration with Bayer.

S07-O4. Mapping crop weeds using online grower survey

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The importance of weed species and their assemblages in crops can be derived from survey data. Traditionally, botanists, ecologists and/or agronomists undertake large scale weed surveys and collect extensive data to quantify weed species diversity and abundance as well as environmental and management factors related to their occurrence in crop. Field surveys are costly as they usually include recording weed species data in square sample units placed randomly or arranged along transects in at least several hundred arable fields across a landscape.

An online weed survey with mapping capacities was deployed to record weed data in the Australian Sugarcane cropping system for a reduced cost. The survey was developed in R language using the open-source package Shiny and deployed on shinyapp.io. The survey tool included intuitive mapping facilities where users can draw a polygon around locations of their main weed issues (using a satellite view layer), specify the weed species (dropdown list with images of weeds), and specify additional weed density and management data. With the objective to obtain data from ~1000 growers, the survey was heavily promoted via email, social media, newsletters, industry magazines, field days and workshops. A raffle to win drums of a novel herbicide was also used as an incentive. A reporting platform developed using Shiny in R and deployed on shinyapp.io. allowed researchers to visualise and summarise data.

Eight months after its deployment, only 59 growers had completed the survey including 30 who had received assistance from research staff. Only 2.8% of the sugarcane area was successfully mapped. Two explanations for this low participation rate were identified: 1) the low priority of a weed distribution survey from a grower's perspective outweighed the incentive, and 2) the mapping features in the survey deterred less technology savvy growers.

Nonetheless, growers showed no concern sharing their weed data with the research institution and they responded positively to assistance in completing the survey indicating that other mechanisms to assist growers in completing the survey across all the districts are required to meet the objective of ~1000 farms mapped.

The survey can be found at https://sugarresearch.com.au/research-development/sra-weed-survey/.

Acknowledgement(s) / funding: Sugar Research Australia Ltd.

S07-O5. Vines, weeds, and good solutions: exploring sustainable weed management in European vineyards

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According to the European Commission, Europe is the world's largest producer, consumer, and exporter of wine, accounting for approximately half of global production. In 2023, grape production reached 22.4 million tons, with Italy, France, and Spain leading the way. The significant socioeconomic importance of viticulture within the European Union, combined with recent policies such as the Green Deal and the Farm to Fork Strategy, which aim to reduce pesticide use by 50% by 2030, underscores the urgent need to develop innovative strategies that ensure both high-quality and sustainable production in European vineyards.

In this context, the AGrOecOlogy for weeDs (GOOD) project, funded by the EU, seeks to advance and promote agroecological weed management practices across Europe, with a particular focus on various crops, including grapes. This study evaluates stakeholders' perceptions of different weed management practices, based on data collected through questionnaires administered in Spain, Italy, and Greece as part of the project.

The research assesses the most relevant weed management strategies in grape production, as evaluated by a diverse group of stakeholders, including advisors, consumers, farmers, policymakers, industry representatives, and researchers. Respondents were presented with a set of assumptions regarding the disadvantages, needs, opportunities, and barriers associated with each known weed management technique, and evaluated their relevance.

A total of 98 unique stakeholders responded to the questionnaire, providing 185 responses to the evaluation of 15 weed management practices. Chemical (42.16%) and physical (37.84%) solutions were the most commonly cited approaches, while biodiversity-based strategies—both temporal (7.07%) and spatial (11.35%)—were also recognized as significant. The transition to more sustainable practices should focus on improving the practical application of nature-based solutions, while addressing the need for better training, extension services, and the development of appropriate policies and regulations.

Funded by the European Union under Grant Agreement No. 101083589. Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

S07-O6. Evaluating and identifying the drivers of sustainability of Integrated Weed Management systems in three European case studies with in silico tools

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Background and objectives. Integrated Weed Management (IWM) aims to control weeds by combining many cropping techniques and using synthetic herbicides only as a last resort. Identifying and evaluating such IWM strategies is difficult in fields because of the many candidate systems to be tested and long-term effects. The present study was aimed to develop a simulation-based methodology for evaluating IWM systems by farmers and other experts, to identify the technical and biological determinants of the performance of IWM systems.

Material and methods. Three European case studies were chosen (Denmark, France, Italy) in which local experts identified conventional arable, cereal-based cropping systems (local reference system) and designed IWM alternatives. Weed dynamics and impacts on crop yield and weed-related biodiversity (wild plant biodviersity, trophic ressources for pollinators etc.) were simulated with FLORSYS, which is to date the most complete model in terms of cropping-system effects, realism of biophysical processes and weed impacts. Economic and environmental sustainability was evaluated with the Business Economics Analysis tool, the Pesticide Load Indicator and Synops-Web. The IWM systems were compared to their local reference system.

Results and discussion. This comparison showed that reduced herbicide use did not come with a cost in terms of crop production, workload, fuel use or profitability but often improved biodiversity and generally reduced environmental and health impacts. The best IWM systems (which were in France and Italy) increased their crop diversity by including either more cover crops, spring crops and/or multiannual crops, resulting in increased diversity in cropping techniques. On average over the rotation, these crop-diverse strategies led to better crop production (+27% energy yield per ha in France, +105% in Italy), a similar weed harmfulness (e.g., –4% yield loss) and more biodiversity (e.g. +20% and +78% trophic resources for pollinators). Generic rules for redesigning IWM systems were summarised, together with the underlying causes and consequences for economic and environmental sustainability. The present proof of concept needs to be applied to a larger diversity of cropping systems and include other processes of biological regulation (e.g., weed seed predation) to move on from IWM towards agroecological weed management.

Conclusions. The present simulation study demonstrated that innovative cropping systems with reduced or no herbicide use can be sustainable in terms of environmental, social and economic aspects, if they diversify crops and are adapted to the local production context.

Acknowledgement(s) / funding: INRAE, the European Union’s Horizon 2020 Research and innovation programme under grant agreements N 727321 (IWMPRAISE project), the French projet COPRAA supported by the Office Français de la Biodiversité (OFB).

S07-O7. Framing decisions in weed management to balance rationalities

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Management decisions are necessarily taken “ex-ante” – hence, always involve a prognostic element. In science, the ex-post perspective is common – analysing data from experiments or surveys after those were performed. Decision rules, ranging from rule-of-thumbs to KI-supported decision systems, connect the information generated in science for applications and adds knowledge from experience.
Farmers take on-field weed management decisions. However, more actors affect decisions about weed management, not only on the field scale but on a broader scale: advisors, authorities, scientists, conservationists, and citizens. These decisions are reflected in, e.g., recommendations, trend monitoring, legislation, demand and public opinions.

From a scientific point of view, evidence is the basis of decisions. For arable weeds, evidence on, e.g., losses through competition, species adaptations, resistance to control, species losses, changing communities, and contributions to ecosystem services, is provided through experimental studies. However, the pictures of the proven effects of weeds that are important in management are multifaceted and complex. The impression is that the narrower the study, the clearer the evidence is confirmed.

Rationality goes beyond. It includes documented evidence in weed management stretching from detailed micro to system analyses and combines all these with experience, knowledge and logical thoughts to serve a broader perspective. In weed management, rationalities manifest themselves in concepts such as integrated, site-specific, anti-resistant, agroecological or conservational weed management. All claim a holistic view, but obviously assess what is rational in weed management differently.

Evidence and rationality are mental concepts. However, the weed management carried out impacts the field and landscape level or the food chain. When making decisions, the various effects of weeds are assessed ex-ante, either positively or negatively. The decisive factor here is whether only the impairment of agricultural objectives by arable weeds or their benefits are seen. The side effects of control can also be assessed differently.

A theoretical framework is presented on how these assessments can be integrated into farmers' field decisions. It is discussed how the approach can be scaled up and applied at the landscape level, in food chains and in agricultural policies.

PS3-01. Innovation in weed science. When research and knowledgetransfer walk together

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At the European level, research and extension in the agricultural sector (weed science included) have undergone significant changes in recent years, marked by the guidelines of the current CAP, which have been transposed in all EU countries. These guidelines particularly highlight the concept of "innovation" used specifically by the European Partnership for Innovation in Agricultural Productivity and Sustainability (EIP-Agri), whose objective is to stimulate innovation and improve the exchange of knowledge in the agro-food sector. In this sense, in the period 2023-2027, innovation is one of the CAP's cross-cutting objectives and includes support for the Agricultural Knowledge Innovation System (AKIS) by three means: a) creating added value through a closer relationship between research and agricultural practices; b) establishing a connection between innovation agents and projects; c) promoting a faster and broader practical application of innovative solutions and informing the scientific community of the research needs in agriculture. A fundamental pillar of the EIP-Agri is the exchange of knowledge and the dissemination of project results so that they reach the end users. As an example, in Spain, these grants are programmed through the so-called "Operational Groups" (OG). OG are a set of stakeholders with different profiles linked to the rural environment who come together to develop and execute an innovative project aimed at finding a solution to a shared problem or to test and put into practice an innovative idea related to a sector specific to the rural environment. This type of projects, are planned and developed by farmers, agro-food industries, research, development and innovation (R&D&I) centres, training and advisory centres and non-profit institutions.

According to the objectives of the EIP-Agri, and from the point of view of the research groups dedicated to agricultural issues (which include weed science groups), a new approach is needed to modify the traditional linear model of science, where the farmer is just the recipient of knowledge by a participatory approach where innovation is co-generated thanks to the interaction among the aforementioned agents. In other words, it is about moving from a Top-Down approach to a Bottom-Up approach. In this need for a paradigm shift, the innovation model followed by the weed science and plant ecology research group of the University of Lleida in the last 30 years is described. Its successful research and extension activity carried out with growers, advisors, stakeholders, companies and public administration in different projects, courses and through the creation of a Spin Off is analysed.

PS3-02. Determination of weed species in spinach fields of Ankara province and assessment of the contamination risk of toxic weeds in the product at harvest

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One of the primary challenges in spinach production is weed infestation. *Datura stramonium* L. (jimsonweed), a toxic weed species found in spinach fields, poses a contamination risk during harvest. The toxicity of *D. stramonium* arises from the presence of atropine and scopolamine, compounds that can cause poisoning if consumed. This study aimed to evaluate the contamination risks toxic weeds in spinach production areas of Ankara Province, to raise awareness among farmers, and to assess their weed control practices through field surveys and questionnaires. Surveys were conducted on 14 hectares in Beypazarı (2% of the total 700-hectare spinach cultivation area) and 3,6 hectares in Kahramankazan. Observations occurred at irregular intervals following the emergence of spinach and weed species. In Beypazarı, 22 weed species from 12 families were identified, with *Chenopodium album* L. (common lambsquarters) showing the highest frequency (51%). In Kahramankazan, 12 species from 8 families were recorded, with *C. album* again being the most prevalent (69%). No weed contamination was detected in spinach samples collected at harvest in Beypazarı. However, a *D. stramonium* plant at the flowering and early fruiting stage was found in Kahramankazan. The plant was sent for analysis to the Istanbul Food and Control Laboratory Directorate, which revealed atropine (510.464 µg/kg) and scopolamine (212.007 µg/kg) at toxic levels. A questionnaire conducted with 22 spinach farmers revealed that most participants were high school graduates (54%), middle-aged (40-50 years old), and had over 20 years of farming experience (55%). Agricultural information was predominantly obtained from Provincial/District Agricultural Directorates (68%). Key challenges reported included pest control (59%) and economic difficulties (32%). Chemical weed control was the most commonly used method (77%), and awareness toxic weeds was notably high (95%). To ensure agricultural sustainability, the study highlights the need to engage younger farmers and provide educational programs focusing on weed management and food safety.

This project was supported by the General Directorate of Agricultural Research and Policies (TAGEM) with the project number 'TAGEM/BSAD/G/22/A2/P4/5982.

PS3-03. Role of the advising systems in the implementation of integrated weed management in Catalonia (IWM)

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Crop production is facing major changes. On the one hand, society demands sustainable production, with increased environmental and human health requirements. On the other hand, the productive sector has to deal with declining profitability as well as an increase in overwhelming bureaucracy that entails the concentration of crop production in larger companies. Moreover, there is an increasing process of digitalisation together with an advanced age of producers that makes it difficult for producers to adapt novel digital technologies and management options.

Integrated weed management is an aspect that is challenging for farmers to implement and effective agronomic advice is seen as essential for its implementation. Several questions then arise: Should the advice be provided by private or public institutions? Should the same advisor provide information on various issues such as plant health, fertilisation, irrigation, occupational safety, etc.? Should the advisor receive ongoing training and how should these training options be designed? How important should be the work and opinion of the advisors in the coordination of different stakeholders such as governmental and administrative centers, universities, research centers, plant protection product companies, farmers, etc?

This poster reflects the importance of the advisors for the adoption of integrated weed management. As an example of their influence on uptake of IWM, their performance in the management of invasive weeds in Catalonia is described: *Sicyos angulatus*, *Leptochloa* sp, *Amaranthus palmeri*. The network of advisors of the Plant Protections Groups (ADV) has conducted early detection and monitoring for their location and control. Likewise, the work carried out in Catalonia by the ADVs, network of advisors active for 40 years, is intended to be described. This capacity to influence the farmer is also important when implementing integrated weed control programs. Thus, we aim to find the answer to a recurring question within the EWRS: How do we get from proof-of-concept to adoption? Why are farmers reluctant to adopt non-chemical alternatives to herbicides?

PS3-04. Herbicide regulatory framework; from science to market

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Herbicide authorization process in the European Union is based on the Regulation (EC) 1107/2009 that regulates the placing of plant protection products (PPPs) on the market. Data requirements needed for active substance and PPPs in European Member States are described in the EC Reg. 283/ 2013 and 284/2013, respectively.

Efficacy data is required to accomplish with abovementioned EC regulations. The herbicide efficacy of an active substance/PPP needs to be demonstrated per each use compared to positive (other herbicide already authorized) and negative control (no herbicide application). The number of trials depend on the crop, conditions of use, climatic conditions affecting efficacy, target weed species, mode of application, etc. and the herbicide should be applied according to the Good Agricultural Practice (GAP) to be registered, at lower dosages (to know the minimum effective dose) and higher dosages (to test crop selectivity). At this point, preliminary tests conducted by universities/research centers could help to define the GAP and set conditions to carry out the trials according to EU requirements. It should be note that trials can fail due to low weed pressure, not favorable climatic conditions, etc increasing the number of trials to be done, so increasing cost for PPPs registration.

The EPPO (European and Mediterranean Plant Protection Organization) is publishing standards for the assessment taking into account special characteristics of the crop, the pest/organism and/or type/way of application of the PPP. Research groups can help setting the characteristics of these trials and can give information to be used as preliminary data in the PPP evaluation, as well as recommendations on resistance management. It is important that when assessing new herbicide products the minimum requirements to accomplish for its implementation in the market were taken into account. Researches also have information on areas to carry out the GEP (Good Experimental Practice) trials /trials done by Officially Recognized Entity considering where the organism is causing greater damages according to monitoring data of each zone. This is a way to focus trials in the places/areas where organism to control is present, to ensure the exit of these trials. By other side can also advice in the evaluation in special cases were guidelines not fully described how to proceed.

A shared understanding among research teams and regulatory framework will improve the data production, as well as evaluation, leading to more efficient and timely evaluation of the data reported to European Member States for placing on the market of herbicides.

PS3-05. Project GoodWeedBadWeed: using AI and ecological value to identify sustainable weed thresholds

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Economic thresholds for weed management have been developed since the 1970s and well into the 1990s, but have never been fully implemented in agricultural practice. Recent advances in weed control technology now enable farmers to apply plant protection products or alternative control measures selectively to specific areas of the field by using global navigation satellite systems and real time kinematic positioning. The potential spatial resolution of herbicide application has become finer through the use of field sprayers with more individually regulated nozzles and techniques like pulse width modulation. To make use of these novelties, site-specific knowledge of weed occurrence in the field is crucial. The project 'GoodWeedBadWeed' aims not only to update existant weed economicthresholds, but also to re-conceptualize them regarding new opportunities for site-specific weed control as well as changes in weed flora composition, herbicide resistance, prices for agricultural products and other factor prices. While existing thresholds are primarily economically orientated, the newly developed concepts also take ecological aspects like nectar quantity and pollen quality into consideration. The aim is to develop an index to estimate, on the one hand, the ecological value of weeds and, on the other hand, the economic effects tolerating weeds

To gather the necessary data basis, existing data will be integrated with data derived from a trial field with approximately 40 different weeds in different spring and winter crops. The weed density will be manually adjusted to ten weed plants per square meter for comparability. The impact of weeds on crop yield will be assessed separately, while the presence of pathogens and insect pests on the weeds will be evaluated using visual assessments and molecular techniques. In parallel, convolutional neural networks are used for the identification of individual weed species in drone imagery within the framework of the joint project. Strategies for spot and patch spraying applications will be derived under the consideration of the availability of soil and leaf active herbicides.

The project is supported by funds of the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany via the Federal Office for Agriculture and Food (BLE) under the innovation support program.

PS3-06. Fundamentals of Weed Science

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The sixth edition of *Fundamentals of Weed Science* maintains its core ecological framework in this new edition, with updated research and science-based information throughout the text. The goal of the text is to explore and provide students with information on the history of weed science, the uses of weeds, and types of mechanical, biological, cultural, and chemical management. The text challenges students to think holistically about approaches to weed management as well as provides students with a background on how weeds have adapted to these types of management including genetics driving resistance. *Fundamentals of Weed Science*, in its sixth edition, includes new weed management methods such as harvest weed seed control, robotic weed management, and precision agriculture's role in managing weeds in agriculture. More focus on integrated weed management has been emphasized to students, given the rising need for multi-pronged approaches to combat rising herbicide resistance. *Fundamentals of Weed Science* is a text that is applicable to introductory and advanced weed science courses and serves to provide students with a reflective look at the history of weed management and prospects for future weed management challenges.

PS3-07. Palmer amaranth pathway of introduction in Catalonia (Spain)

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Since 2007, there is evidence of the presence of *Amaranthus palmeri* S. Watts. in Catalonia (Spain). The detection of corn fields infested by *A. palmeri* in 2018 without any relation to the original site where the weed was first detected raised fears that a continued entry of the weed into the territory was taking place.

A survey of the possible entry points was carried out during the summers of 2019 and 2020. In that moment, Tarragona's port was identified as the main point of introduction of *A. palmeri* in Catalonia in Spain probably as a contaminant of grain commodities.

To identify which commodities were contaminated and their origin is important in order to regulate the spread of *A. palmeri* seeds via this pathway and to establish some requirements that mitigate the risk of introducing new resistant biotypes of *A. palmeri*. Nowadays, grain commodities are not subject to Plant Health control in Europe.

Imported commodities were sampled from 2020 to 2023 in the Tarragona port and their final destination in feed factories. Corn grains, soybean meal, soy hull and DDG (Dried distillers grains) were sampled and analysed in order to detect *A. palmeri* seeds as a contaminant. Main commodity origins were Argentina, Brazil, United States, Canada, Rumania and Ukraine.

Samples were cleaned and sieved in order to detect *A. palmeri* seeds. The detected seeds were subjected to a viability test and a PCR test to verify that seeds originated from *A. palmeri*.

Between 2020 and 2021, 320 samples were analysed. Soybean meal of Argentina was the most contaminated commodity. 23 of the 53 analysed samples of soybean meal analysed from Argentina contained *A. palmeri* seeds which were found to not be viable. Of the 105 maize samples analyzed from Brasil, only one sample had presence of viable *A. palmeri* seeds. Three contaminated samples from Romania and Ukraine maize were detected with viable seeds. This study highlights the importance of consider grain commodities as a pathway of introduction of weeds in a territory and the necessity to control and regulate their introduction.

PS3-08. Factors Influencing Cover Crop Adoption in Chilean Orchards and Vineyards: A Socioeconomic and Management Perspective

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As environmental and economic challenges intensify, mixed cover crops in perennial systems intersects sustainability and resilience. Cover crops enhance biodiversity and soil health, yet adoption in perennial systems remains complex. This study unravels factors shaping cover crop adoption in Chilean orchards and vineyards, aiming to: (1) Analyze the impact of farm-level characteristics—including size, income diversification, and management structures—on growers' propensity to adopt mixed cover crops; (2) Determine how factors such as education, experience, and risk perception influence adoption patterns among orchard and vineyard managers; and (3) Identify principal barriers (e.g., economic constraints, agronomic concerns) and facilitators (e.g., technical support) that affect decision-making processes. Utilizing a multilevel binomial probit model, we analyzed responses from over 170 Chilean orchard and vineyard managers, collected via the LivinGro™ survey encompassing 99 variables, including correlation analyses and multilevel model specifications to effectively capture variability in adoption patterns. Data analyzed reveals that cover crop adoption is shaped by socioeconomic and institutional factors, consistent with established agricultural technology adoption frameworks. Our model confirms that perceived simplicity of adoption significantly influences decision-making, with a straightforward perception of cover crop implementation increases the likelihood of adoption. Farmer preparation—encompassing prior experience and technical readiness—also proved to be a strong predictor, reinforcing the importance of knowledge accumulation and adaptive capacity in technology uptake (Knowler & Bradshaw, 2007). Unexpectedly, perceived importance of sustainable practices exhibited a negative relationship with adoption. This suggests that although farmers may acknowledge the environmental and agronomic advantages of cover crops, this perception does not necessarily lead to implementation. Additionally, diversified income sources were positively associated with adoption, highlighting financial stability's role in facilitating risk-taking behavior in farm management decisions. Conversely, the absence of modern irrigation systems acted as barrier, possibly reflecting resource limitations or competing priorities. Demographic factors also played a role, with farmers aged 18 to 60 years being more inclined to adopt, aligning with literature suggesting middle-aged farmers exhibit greater openness to innovation than older cohorts. Our findings suggest that enhancing technical support, reducing economic barriers, and fostering localized knowledge-sharing networks could accelerate the integration of cover crops into future regenerative Chilean perennial production systems.

PS3-09. Integrated Weed Management: its influence on herbicide fate in soil

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Weed management poses a significant challenge in agriculture, with profound implications for crop yield and soil quality. While pre-emergence herbicides are effective in controlling a wide range of weeds, their prolonged use can lead to the development of herbicide-resistant weed species, deteriorating in soil health and cause shifts in weed community composition. Integrated Weed Management (IWM) practices, such as the use of cover crops, are known to enhance soil health by improving organic matter content, microbial activity, and soil structure. However, their impact on herbicide degradation remains insufficiently studied. Understanding these relationships is critical for optimizing the integration of IWM practices with herbicide applications.

This research investigates how cover crops, as part of IWM practices, influence herbicide persistence, focusing on microbial activity and organic matter content as drivers of these processes. Soil samples were collected from an almond orchard from two treatments:plots with cover crops and no pre-emergence herbicides, and plots where a pre-emergence herbicide was applied annually. These soils were tested periodically in the laboratory using maize (Zea mays) root elongation as a bioassay. Each soil sample was spiked with Indaziflam at 1 µg/g dry soil (1 ppm), and root elongation in this spiked soil was then compared to the same soil without Indaziflam. Root inhibition data at 35 days after Indaziflam application showed no significant difference between the conventional herbicide treatment and the cover crop treatment, with inhibition levels of 76.8% and 74.0%, respectively. However, by 260 days after application, significant differences emerged: root inhibition was 72.5% in the conventional herbicide plots compared to 60.3% in the cover crop plots. Additionally, CO_2 respiration measured over one week indicated emissions of 0.175 mg CO_2 /day /g dry soil in the conventional herbicide plots versus 0.372 mg CO_2/day/g in the cover crop plots, reflecting higher microbial activity in soils with the history of cover crops.

These findings suggest that soils with prolonged vegetation cover demonstrate elevated microbial activity, potentially enhancing herbicide degradation rates. Such considerations should be integrated into decision-making processes to enable more judicious herbicide use alongside alternative weed control methods, promoting sustainable and effective management practices.

PS3-11. Biopesticides in agricultural production: consumers' awareness and willingness to pay in three Mediterranean countries

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Biopesticides are natural or biologically derived substances used to control pests, including insects, weeds, fungi, and other organisms that can harm plants and crops. The prospects for biopesticides are quite promising, especially under the Green Deal policy of the European Union and they are expected to play an increasingly important role in sustainable agriculture and pest control in the future. However, it is important also to investigate if consumers are willing to buy food and agricultural products treated with biopesticides. Consumers who are concerned about the potential risks of residues of synthetic chemicals in food, as well as those interested in sustainable farming practices, tend to be more willing to support products treated with biopesticides. Having this in mind, the consumers' attitudes towards biopesticide-treated food products could affect the biopesticides perspectives to be adopted by farmers and thus acquire a significant market share in the pesticides market.

The objective of this study is to illustrate consumers' awareness and their willingness to pay for agricultural and food products treated with biopesticide products. For this reason, a survey was conducted in three Mediterranean countries (Greece, Tunisia, Algeria) during the autumn of 2024. One hundred thirty-six questionnaires were collected for the survey following a convenient sampling procedure capable of providing a preliminary illustration of consumers' attitudes towards biopesticide treated food products.

Respondents were asked directly how much more they would be willing to pay for a product treated with bio-pesticides compared to one treated with conventional pesticides or left untreated.The results defined that different levels of awareness of climate change and the consequences of pesticides on the environment affect their willingness to pay for biopesticide treated products. At the same time, the differences are statistically important between the respondents in the three participating countries. These results shed some light on the general perception that consumers' food choices are shaped by their attitudes towards environment protection and at the same time, their choices affect farmers' practices in fond of a more environmental responsible farming.

The project entitled "Development of Bio-Pesticides and -Herbicides for Sustainable Agricultural Crop Production", Acronym "BIOPESTICIDES" is funded by the Federal Ministry of Education and Re-search, Germany (No. 01DH21010A), General Direction of Scientific Research and Technological Development (DGRSDT-Algeria), the General Secretariat for Research and Innovation of the Ministry of Development and Investments of Greece (GGPRM-0357185 and GGPRM-0357186), the Scientific and Techno-logical Research Council of Turkey (TÜB˙ITAK) (121N251 and 121N259) under the PRIMA Programme. PRIMA is an Art.185 initiative supported and co-funded under Horizon 2020, the European Union's Pro-gramme for Research, and Innovation.

8. Herbicides and application technology

S08-O1. Innovations in herbicide discovery

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Keynote session

During the past several decades, an impasse has developed in the discovery and commercialization of synthetic herbicides with novel modes of action (MOA). Traditional approaches used by the main agrochemical industry companies repeatedly identify molecules with already known MOAs. Concomitantly, there has been little success with bioherbicides, both microbial and biologicals. In response to this substantial and growing opportunity, numerous startup companies have emerged to provide new tools for weed management using innovative and disruptive technologies. Ten of these companies were invited to introduce their platforms during a symposium entitled 'New Approaches to Herbicide and Bioherbicide Discovery' during the 64th Annual Conference of the Weed Science Society of America (WSSA).

A brief review of the history and status of the agrochemical industry will describe why the discovery and commercialization of new herbicides with novel mechanisms of action has decreased dramatically over the last several years. Then, innovative approaches developed by selected startup companies will be discussed. These diverse new tools encompassing new microbial and biologicals, advanced computational, bioinformatic, and imaging platforms, plant genome-editing and targeted protein degradation technologies, as well as machine learning and artificial intelligence (AI)-based strategies broaden the scope of discovery. These new technologies are needed to fulfill the need for more environmentally and toxicologically safe herbicides and to combat fast-growing herbicide resistance.

Acknowledgement(s) / funding: USDA National Institute of Food and Agriculture, Hatch Project 7005022/ COL00785A.

S08-O2. Long term field trial for sustainable control of multiple herbicides resistant *Alopecurus myosuroides* by integration of agronomic tools and cinmethylin

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Alopecurus myosuroides (ALOMY) is a troublesome weed in Europe. In cereals it is difficult to control and herbicide resistance is widespread. Consequently, weed control today strongly depends on pre-emergence products and agronomic strategies must be implemented as well to achieve a level of control that is needed. Resistance of ALOMY to pre-em compounds is also increasing in recent years. However, with cinmethylin a "new" mode of action is or will be available as a pre-em compound. Nevertheless, in many cases the use of a pre-em herbicide only will be insufficient to stabilize ALOMY populations in cereals to an acceptable level.
The objectives of our studies were: (1) to determine the different levels of adaption of agronomic tools to reduce ALOMY densities in crop rotation that is necessary to control the weed populations with the pre-emergence herbicide cinmethylin, (2) susceptibility of ALOMY is investigated after six years of continuously use of cinmethylin under field conditions.

Field trials started in Germany on two different sites in 2017. Trial on one site ended in 2023, while trial on second site is still ongoing. Crop rotation was oilseed rape, winter wheat and winter barley (maize). Three different adaption levels of agronomic tools were implemented including stale seedbed, late drilling, tillage and spring cropping. In the crops the direct ALOMY control was done by pre-emergence herbicides only, with a focus on use of cinmethylin. ALOMY plants and head counts, crops yield as well as soil seed bank were determined. Furthermore, seed samples from surviving plants were collected.

Field trial results showed that the initial high density of ALOMY was reduced with all strategies. However, a constant low level was only achieved by combination of different agronomic tools in combination with use of cinmethylin. Most successful strategy was additional integration of spring cropping (maize instead of winter barley). Yields evolved corresponding to ALOMY control level. Best strategy reduced ALOMY soil seed bank from ~20.000 seeds/m² to near zero after six years. Results from the whole-plant dose-response experiments conducted with seeds from surviving plants in the field defined that continuous use of cinmethylin over a period of six years did not change susceptibility significantly.

S08-O3. Development of a nano-chitosan product with encapsulated gibberellic acid (GA3): from bench to field

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Nanoformulation of Plant Protection Products (PPPs) is a cutting-edge technology aiming to improve pesticide performance and minimize the negative impacts of conventional agro-chemicals on the ecosystem. Chitosan is a well-known natural polymer with several beneficial biological characteristics, such as: non-toxicity and biodegradability; thus it has been extensively utilized as a nanocarrier. This presentation reports results from laboratory, controlled conditions and field experiments of nano-chitosan with encapsulated GA3 (nanoCS-GA3) product. The nanoCS is based on hydrochloride chitosan (i.e. industrial scale; specifications of European Pharmacopoeia standards). Gibberellic acid (GA3) was encapsulated in the nanoCS and a series of water-soluble nanochitosan (nanoCS; size: 100-400nm) products were developed based on NanoshieldTM technology. The ecotoxicity of xenobiotics was assessed in a standardized protocol (Lemna minor protocol). Efficacy of the nanoCS-GA3 product was assessed in-planta (i.e. seed priming in tomato and bean seeds and whole plant applications). From the above experiments, a specific nanoCS-GA3 product was selected for further field trial experimentation. A field trial (2024 season) was conducted in sultana (Vitis vinifera L.) grapes that requires several sequential gibberellic acid (GA3) treatments to achieve high-yield and quality raisins. Several concentrations of the nanoCS GA3 product were assessed: 12, 1.5, 0.12, 0.0012%. Morphological effects (cluster and berries traits, and total yield per plant), and the kinetics of the GA3 (in all treatments) were measured. For the kinetics of the nanoCS-GA3 product, the determination of the analytes (GA and isoGA) was conducted using liquid chromatography in combination with mass spectrometry (LC–ESI (-)-MS/MS) operating at multiple transition mode. Results have shown that the lowest 0.0012% of the nanoCS GA3 product resulted in the highest values of cluster weight and doubled the compactness of the clusters compared to untreated control. Outcome of these studies could provide knowledge for developing nanoformulated PPPs, address safety concerns and support more environmentally sustainable solutions.

Acknowledgement(s) / funding: Nanoshield, InnoPPP.

S08-O4. Does climate change require adjustment of glyphosate dose?

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The major cause of climate change and global warming is elevated CO_2 concentration- e(CO_2)- which affects plant growth and reproductivity. In Scandinavia, the changing climate may extend the growing season and the latitude at which some crops can be grown, but it may also benefit some noxious weeds. In dose-response experiments the effect of increasing glyphosate dosages on *Echinochloa crus-galli* (barnyard grass- C4 plant), *Avena fatua* (wild oat- C3 plant), and *Brassica napus* (oilseed rape- C3 plant) was evaluated under e(CO_2) and elevated temperature- e(T)- conditions. Oilseed rape is a crop that often occurs as a volunteer in the following crop. Plants were grown at ambient CO_2 concentration (400 ppm) and temperature (18°C day/12°C night) in one greenhouse compartment and at elevated CO_2 (800 ppm) and temperature (20.5°C day/14.5°C night) in another compartment. Plants were sprayed with Roundup Flex 480 (a.i. 480 g L^{-1} glyphosate) at 3–4 leaf stage. For each species, four pots with four plants were sprayed with 0, 8.75, 17.5, 35, 70, 140, 420, and 1260 g a.i. ha^{-1}, respectively. The above-ground portion of one plant per pot was sampled for transcriptomic analysis 72 hours after spraying. Three plants per pot were also harvested two weeks after spraying to measure above-ground dry weight. The experiment was repeated once, adding one more dose of 2520 g a.i. ha^{-1}. Dose-response relations were estimated using non-linear regression and the efficient doses to reduce the dry weight by 50 and 90% (ED50 and ED90) were estimated. For *A. fatua* and *E. crus galli*, there was no significant difference between the ED50 and ED90 values in the two different environments. However, the ED50 and ED90 were significantly lower for *B. napus* plants grown in e(CO_2) and e(T) than in ambient climate conditions. Transcriptome analysis indicated that *A. fatua* gene expression was most affected by e(CO_2) and e(T) while *E. crus galli* gene expression was most affected by high glyphosate doses in ambient climate conditions. The experiments showed that climate changes may require adjustment of glyphosate dose for some plant species but not for others.

This work has been done as a part of the project “Weeds vs. Crops: the winner of climate change” financed by the Norwegian Institute of Bioeconomy Research (NIBIO) base funds from the Research Council of Norway (Cotract number 342631/L10).

S08-O5. Rational herbicide use as a weed management in edamame soybean production

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Edamame soybean is a vegetable crop whose immature beans are harvested at the R6 stage. Weeds are considered a major limiting factor in soybean cultivation and their effective management is crucial for optimal produciton. This study compares the impact of different herbicide treatments on weed control and edamame yield. During the 2022-2024 growing seasons, Chiba Green (V1) and Midori Giant (V2) edamame varieties were sown. Applied herbicide combinations were: H1: pre-emergence herbicides (a.i. metribuzin 350 g ha^{-1} and s-metolachlor 1334 g ha^{-1}), H2: pre-emergence (a.i. metribuzin 350 g ha^{-1} and 1334 g ha^{-1}s-metolachlor) + post-emergence herbicides (a.i. imazamox 44 g $ha^{-1}$and cycloxydim 200 g ha^{-1}), and H0: control-without herbicides. Treatments were applied using a CO_2 backpack sprayer with TeeJet TTI 11102 nozzles, calibrated to 140 L ha^{-1} at 275.8 kPa

The significant differences in weed fresh biomass were presented between H0 (2105.02 g m^2) and herbicide treatments (H1: 712.94 g m^{-2} and H2: 12.58 g m^{-2}). Similar trend was observed in weed dry biomass, with 341.9 g m^2 in H0 and insignificant differences between H1 (126.0 g m^{-2}) and H2 (3.3 g m^{-2}). The year, variety and their interaction did not have significant impact on weed biomass parameters, while herbicide and its interaction with year and variety influenced significant variations. Dominant weed species were *Chenopodium album*, *Chenopodium hibridum*, *Solanum nigrum* and *Sorghum halepense*. The lowest pod yield was in average achieved by V1 variety (6.1 t ha^{-1}), while V2 had greater yield of 10.6 t ha^{-1}. The lowest pod yield was under V1H0 in 2024 (2.6 t ha^{-1}), while the highest value was obtained by V2H2 in 2022 (16.3 t ha^{-1}). While the herbicide did not express significant impact on pod yield, its interaction with variety induced significant increase in average pod yield of V1H2 (7.5 t ha^{-1}), as well as V2H1 and H2 (10.6 t $ha^{-1}$and 11.9 t ha^{-1}, respectively). Thus, it could be assumed that edamame production requires herbicide use for successful weed management, while insignificant differences between pod yield under H1 and H2 treatment, particularly when used with V2 could indicate sufficiency of only pre-emergence herbicide use.

S08-O6. Controlling perennial and annual weeds in grassland whilst maintaining white clover in the sward

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Controlling weeds in established grasslands and newly sown leys (less than one year old) is essential to ensure the highest quality and quantity of nutritional forage production for livestock. Established grasslands can get infested with perennial weeds, such as *Rumex obtusifolius*(broad-leaved dock), *Ranunculus repens* (creeping buttercups), and *Taraxacum officinale*(dandelions). In newly sown leys annual weeds such as *Stellaria media*(chickweed), *Polygonum persicaria*(redshank), *and Capsella bursa-pastoris*(Shepherd's purse) are all very competitive, along with seedling *R. obtusifolius*.

White clover, part of the *Fabaceae* family, is a perennial plant that can fix atmospheric nitrogen. White clover in a grass sward increases the value and quality of the forage and is therefore favoured by livestock farmers. Depending on management and ground cover, white clover can fix 0-280 kg/N/ha/yr (Cowling 1982). To ensure the maximum quality of the forage weed control is required to prevent competition for nutrients. However, many herbicides for the control of weeds in grassland are not clover-safe, so only suitable for a grass sward. Corteva Agriscience have developed a new herbicide product ProClova® XL, containing two actives Rinskor™ (Epp *et al*., 2016) 75.5 g/kg and amidosulfuron 360g/kg that can achieve the important function of controlling key broad-leaved weed species whilst preserving the white clover population already present.

The objective of a series of field trials was to validate the range of weed species controlled by the new product compared to existing products, with a particular emphasis on the clover-safe aspect of the product, that was demonstrated to farmers.

Results from a range of field efficacy trials in both established grass and new sown leys will be presented including the new product in comparison to key market products. The main weed focus will be *R. obtusifolius,*however a range of key weeds will be presented.

The key outcome of this study is to highlight the benefit of a new clover-safe herbicide in retaining a high-quality grass sward whilst controlling competitive perennial and annual weeds. This new product provides farmers with a value tool to ensure competitive weeds are controlled and a quality grass and white clover forage mix can be produced.

acknowledgement(s) / funding : Corteva Agrosciences.

PS3-12. The effect of different temperatures on the efficacy of herbicides for managing the invasive weed *Solanum rostratum*

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Solanum rostratum is an invasive, thorny annual weed native to Central America. It was first recorded in Israel in the 1950s, and its distribution has significantly expanded in recent years, with new populations reported across the country. This weed presents a major challenge due to its resistance to control measures and its detrimental impact on various crops, including *Citrullus lanatus*, *Allium cepa*, *Zea mays*, and *Solanum lycopersicum*. Germination occurs in multiple flushes from spring through summer, meaning both high and low temperatures can influence the effectiveness of chemical control. However, the number of registered herbicides available for managing *S. rostratum* is limited, with only a few modes of action. Additionally, there is a lack of updated information on the efficacy of existing herbicides against this invasive species. The plant's leaves, stems, and fruits are covered in small, sharp thorns, making manual removal particularly difficult. To address these challenges, we conducted a greenhouse experiment at the Newe Ya'ar Research Center to evaluate the herbicide response of different *S. rostratum* populations. Plants were sprayed at a height of 4–5 cm with four herbicides—Fluroxypyr, Tembotrione, Oxyfluorfen, and Metribuzin—at three doses: ½×, ×, and 2× the recommended rate. The plants were grown under two temperature conditions:High temperatures (34.43°C ± 5.77, 25.82°C ± 1.72 day /night) and low temperatures (19.27°C ± 5.27, 16.02°C ± 2.79 day/night). The results showed that *Fluroxypyr* and *Tembotrione* were effective under both temperature conditions, while *Oxyfluorfen* performed best at high temperatures, with variations among different plant populations. In contrast, *Metribuzin* exhibited the highest effectiveness under colder conditions. These findings underscore the importance of adapting herbicide applications to local temperature conditions to improve efficacy and prevent further spread.In conclusions, *Solanum rostratum* exhibits rapid adaptability to new environments, making temperature-based herbicide application crucial for effective control. This strategy may help mitigate herbicide resistance and reduce environmental impacts. Future research should focus on understanding the physiological and genetic mechanisms behind temperature-dependent herbicide responses to enhance weed management, particularly in the face of climate change challenges.

PS3-13. Dissipation kinetics of diflufenican and metamitron herbicides applied in protection of different lupin varietes

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Dissipation kinetics of pesticide residues is an important tool to confirm safe and proper use of candidate herbicides having potential to be applied on selected lupine species to control pests, weeds and diseases affecting the production of these crops. In this work, we focused on study of dissipation rates of herbicides diflufenican and metamitron after application to lupines. These studies were a combination of field trials, in which the pesticides were applied in the ways we proposed to use them on lupines (on-soil or foliar spraying), followed by laboratory analysis for the presence of pesticide residues.

Three species of lupine were included in the studies, *Lupinus albus*, *Lupinus luteus* and *Lupinus angustifolius*. Samples from the field experiments were taken at regular intervals from the first day after foliar spraying and from the tenth day after soil spraying, and then every seven days until lupine harvest maturity.

The dissipation of selected herbicides approximately fitted to a first-order kinetic model, with half-life values ranging from 2.86 to 4.88 days for metamitron and from 4.10 to 9,62 days for diflufenican, depending on the lupine species. One day after foliar application of selected herbicides, concentrations of diflufenican ranged from 1.24 to 3.03 mg/kg and from 7.01 to 14.60 mg/kg for metamitron residues. In a case of on-soil application, ten days after spraying, concentrations ranged from 0.05 to 0.12 mg/kg and from 0.09 to 0.36 mg/kg for diflufenican and metamitron, respectively. The dynamics of the disappearance of pesticide residues in green lupine plants reached a level below 0.01 mg/kg after about 27 days from the treatments (foliar or on-soil), for both herbicides. This is important information due to the use of green plant material in safe animal feeding. The observed dissipation patterns of the applied herbicides were different owing to different chemical structures, applied doses, species of lupine, growing and harvest time but the final residues in the samples collected in the last sampling time were always below the limit of quantification indicating that the proposed plant protection products could be used on the studied crops without the risk of leaving residues.

PS3-14. OPTiSPRAY: Performance of drift-reducing nozzles for controlling small weeds with foliar herbicides

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The spray droplet spectrum generated by agricultural nozzles is an important and easily controllable factor affecting spray drift, spray coverage, and pesticide performance. Dose-response experiments were carried out during the summer of 2023 using an automated spray cabinet with one nozzle to evaluate the performance of different flat-fan nozzles. Young plant stages (cotyledon, 2-, 4-leaf stage) of major weeds (*Solanum nigrum*, *Chenopodium album*, *Echinochloa crus-galli*) were treated with increasing dosages of contact herbicides bentazon (Basagran SG + Actirob) and phenmedipham (Astrix) and systemic herbicides tembotrione (Laudis), nicosulfuron (Samson 60OD), and cycloxydim (Focus Plus) using a set of ISO 025 (4.5 bar) and ISO 03 (3 bar) flat-fan nozzles at 240 $L.ha^{-1}$. The nozzles (varying in drift reduction) consisted of a standard flat-fan nozzle (TeeJet XR 11003), a drift-reducing pre-orifice nozzle (Albuz ADI 11003), three drift-reducing air induction nozzles (Lechler ID3 12003, Albuz AVI 11003, AVI 110025), two drift-reducing dual-fan air induction nozzles (TeeJet TTI60 11003, TTI60 110025), and a drift-reducing non air induction dual-fan nozzle (TeeJet APTJ 11003). Dose-response curves were made for each combination of weed species, weed stage, and herbicide based on the aboveground live dry biomass, 21 DAT. Spray droplet size and velocity characteristics were determined using an Oxford VisiSize N60 laser. Spray coverage was quantified on water-sensitive papers and on leaves sprayed with a kaolinite solution. In 11 out of 12 herbicide–species–stage combinations, several coarser droplet drift-reducing nozzles showed similar performance in controlling small weeds with foliar herbicides compared to the XR standard flat-fan nozzle with a finer droplet spectrum. However, the effect of nozzle choice on herbicide efficiency was more important for difficult-to-wet weeds and herbicide spray solutions with high surface tension. Nozzle-pressure combinations producing a finer droplet spectrum showed superior herbicide performance and spray coverage on weeds with highly lipophilic leaf surfaces and large contact angles between spray droplets and leaf surface. Overall, sprays with low droplet velocity and/or low volume median diameter but few driftable fines (2% by volume <150 µm) allow substantial spray drift reduction without compromising herbicide performance of foliar herbicides against small weed targets, irrespective of herbicide and weed species.

This project has received funding from VLAIO under grant agreement No HBC.2021.1070 (OPTiSPRAY-project). Contact angle and surface tension measurements were executed at the Particle and Interfacial Technology lab (PaInT) of Prof. Paul Van der Meeren.

PS3-15. Plant Inositolphosphorylceramide Synthase (IPCS) as a novel herbicidal target.

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Herbicides play an essential role in contemporary agricultural production, enabling farmers to achieve assured and enhanced crop yields. Due to stricter environmental legislation, market requirements, considerations for sustainability and the emergence of weed herbicide resistance, it is necessary to develop new herbicidal active compounds, ideally with greater selectivity and minimum environmental impact.

This work focuses on plant Inositol Phosphoryl Ceramide Synthase (IPCS), a key enzyme in the sphingolipid biosynthetic pathway and a potential, non-mammalian herbicide target. IPCS converts phosphatidylinositols (PI) and phytoceramide to inositolphosphorylceramides (IPC) and diacylglycerol (DG). A knockout of AtIPCS2 in the model plant *Arabidopsis thaliana* results in a dwarf phenotype and symptomology related to plant cell death. High-throughput screening of 10,000 compounds identified a promising candidate inhibitory for AtIPCS2 activity.

A focus of the work is to assess the *in vivo* activity of this compound on Arabidopsis plants which overall appears to inhibit lateral and primary root growth.

To validate the compound mode of action and the suitability of AtIPCS as a target, compound inhibition and creation of knock-out combinations of all three IPCS homologues in Arabidopsis IPCS genes via CRISPR/Cas9 genome editing is performed.

Lipidomic analysis of compound related inhibition of IPCS is expected to decrease the levels of IPC. Arabidopsis seedlings were submerged in water, treated with the hit compound and sampled over a period of time. Analysis of the lipid extract profile using LCMS post-extraction, revealed an increase in the levels of IPC and DG. A possible explanation is that the hit compound only inhibits AtIPCS2 expression but not AtIPCS1 and 3, possibly leading to an overexpression of these two isoforms to compensate for the inhibition of AtIPCS2, increasing IPC levels. We will test this in first instance by determining gene expression levels using semi-quantitative RT-PCR on all IPCS isoforms in treated vs non-treated plants. The generation and characterisation of all combinations of AtIPCS1,2 and 3 KO mutants will allow to further test the impact of the component and the role of IPCS in the plants response.

Acknowledgement(s) / funding: Biotechnology and Biological Sciences Research Council and Bayer Crop Science.

PS3-16. Efficacy of foramsulfuron and mesotrione applied at reduced rates with adjuvants

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Currently, there is a growing movement in Europe towards more sustainable and environmentally friendly farming practices. The European Commission has required the reduction of the use of herbicides by 50% by 2030, in order to reduce the negative impacts of their use on biodiversity, soil and human health. As herbicides are still powerful tool for weed control, there are many possibilities to apply lower rates or add adjuvants into the tank. Adjuvants are agrochemicals or natural substances, commonly mixed with pesticides to increase their efficacy or reduce off-target movement by modifying the physical properties of the spray solution, such as surface tension, droplet size, and spreadability, which ultimately improve pesticide adhesion and coverage on target surfaces.

A two-year field study was done at the Maize Research Institute Zemun Polje, Belgrade, Serbia in order to evaluate the effects of adding adjuvants on foramsulfuron and mesotrione weed control in maize. Two adjuvant types were tested: nonionic surfactant (NIS) and methylated seed oil (MSO). Herbicides were applied following maize development – 15-16 BBCH. *Chenopodium album* and *Ch. hybridum* were the most present species at the field in the first year, while *Ch. album* and *Sorghum halepense* in the second year. Herbicides were applied in the following rates: 1x, 0.5x, and 0.25x allone and mixed with each adjuvants. Sprayings were done using a CO_2 backpack sprayer with a four nozzle boom equipped with TTI nozzles, calibrated to deliver a spray volume of 140 L ha^{-1} of solution at 275.8 kPa.

Mesotrione applied at the recommended rate influenced about 90% of biomass reduction of both *Ch. album* and *Ch. hybridum*, while adding either NIS or MSO at the ½ of the rate influenced 85% of the biomass reduction. Foramsulfuron applied at the full rate resulted in 79 and 95% of biomass reduction of both species, respectively, while adding both adjuvants resulted in 95% of biomass reduction. In the second year, lower efficacy on *S. halepense* was achieved using mesotrione, while increased efficacy on *Ch. album* when adjuvants were added. *S. halepense* was controlled more than 95% when adjuvants were added to ½ rate of foramsulfuron.

PS3-17. The characterisation of bleaching inhibitors

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In order to sustain a predicted global population of 9.0 billion by 2050, it is estimated that a 70% increase in food production is required. These increases must be achieved with less land, water, energy input, fertilisers and chemicals. Herbicides will remain part of the food security solution despite stricter regulations on the use of chemicals and more prevalent resistance or tolerance to herbicides. Herbicide discovery and determination of their mode of action (MOA) is often very expensive and labour-intensive, with phenotypes from whole organism screening not always revealing the target site. Very few new herbicides have been discovered over the last thirty years. Bleaching herbicides enable the light activation of reactive oxygen species in leaf material upon application. However, diverse chemistries can be responsible for this bleaching. The present objectives for this project will be to (1) use metabolite profiling to differentiate between the chemically diverse classes of bleaching herbicides. (2) Identify potential secondary targets of inhibition from adaptive mechanisms. (3) Concurrently, to establish an *in vitro* enzyme assay for the desaturation of phytoene to validate phytoene desaturase as the target site.

The results from investigations into *N. benthamiana* PDS activity by *in vivo assays* generated an active recombinant plant-type PDS in *E. coli*, yielding expected desaturation products phytofluene and zeta-carotene when co-transformed with a phytoene producer. The establishment of an *in vitro*enzyme assay enabled characterisation in a cell-free system, with optimal conditions for enzymes determined. Notably, increasing lipid concentration to 25mg/ml increases product formation by 10 to 100 fold. Additionally, a designed mutant PDS exhibited increased desaturated product accumulation compared to the wild-type enzyme at 100 µM norflurazon providing evidence of resistance.

To conclude, this work culminated in generating a robust *in vitro* enzyme assay for *N. benthamiana* phytoene desaturase. This assay enabled accurate determination of inhibition by target molecules and validated the suspected MOA proposed by in vivo treated plant metabolic profiling data. Thus, it provides a selection of valuable tools for determining PDS inhibition and carotenoid biosynthesis.

Acknowledgement(s) / funding: Fraser Lab group Royal Holloway University of London, BBSRC, Syngenta global.

PS3-18. Sequential and combined spray of herbicides in tomato field on weed reduction, fruit parameters and terminal residues

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Tomato is a globally significant fruit crop, valued for its nutritional and sensory attributes. However, weed infestation remains a major challenge in its cultivation, particularly in semi-arid regions. This study evaluated the effects of sequential and combined applications of glyphosate, pendimethalin, and metribuzin on weed control, tomato growth, fruit quality, and residue levels, particularly in semi-arid conditions in India. The predominant weed species identified in the experimental area included Parthenium Euphorbia hirta, Cyperus rotundus, Alternanthera bettzickiana, and Cynodon dactylon. The results demonstrated that sequential and combined herbicide treatments, with a focus on a tank mix of pendimethalin and metribuzin following glyphosate application. The experiment was conducted in a split-plot design, with the main plot assigned to Soil Test based NPK with FYM @ 25 t/ha and the subplot allocated to herbicide treatments. The herbicide treatments included glyphosate at 7.5 L/ha, pendimethalin at 1000 g (ai)/ha, and metribuzin at 500 g ai/ha, applied in various combinations. Results indicated that sequential and combined herbicide applications, particularly the glyphosate followed by pendimethalin and metribuzin tank mix, significantly reduced weed density and biomass, achieving superior weed control efficiency compared to glyphosate alone or untreated controls. Tomato growth parameters such as plant height and cluster density improved, and fruit yield increased significantly. Importantly, fruit quality parameters, including titratable acidity, total soluble solids, ascorbic acid, lycopene, and shelf life, were not adversely affected, confirming the safety of these herbicides. Residue levels in tomato fruits were below regulatory maximum residue limits (MRLs) of 0.1 mg/kg for glyphosate and 0.01 mg/kg for pendimethalin and metribuzin, meeting standards set by USEPA, FSSAI, and CODEX. No residue toxicity was detected in soil, as validated by plant bioassay and instrumental methods. While these findings underscore the effectiveness and safety of the tested herbicide strategies, long-term monitoring is essential to assess the development of weed resistance, residue persistence in soil, and potential environmental impacts associated with repeated and combined herbicide applications.

The authors recognize the Professor & Head, Nammazhvar Organic Farming Research Centre for consent to utilize LC-MS-MS facilities and the Vice-Chancellor, Dean (SPGS), Professor & Head (SS&AC), TNAU, Coimbatore, India for motivating the Ph.D. scholar (aut

PS3-19. Comparative efficacy of different herbicides for weed control in chamomile

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Chamomile (*Matricaria chamomilla* L.) is annual medicinal and aromatic plant, which is most widely used for a variety of healing applications. However, weeds cause the yield losses of these crops up to 45%, affecting yield of essential oil and its composition. In order to obtain the correct raw material that is of good quality, weed control is necessary. The aim of the present study was to investigate the efficacy of selected herbicides for weed management in chamomile crop.

Experiments were conducted to assess the control of weeds with two PRE (pendimethalin and ethofumesate) and two POST (fluroxypyr-meptyl and linuron) herbicides used in chamomile. Pendimethalin (990 g a.i. ha-1) and ethofumesate (1000 g a.i. ha-1) were applied after crop sowing, but before crop and weed emergence, while fluroxypyr-meptyl (258.48 g a.i. ha-1) and linuron (1125 g a.i. ha-1) were applied when weeds achieved 2-4 developed leaves and chamomile was at early stage of development. Visual estimates of percent weed control were recorded 20 and 40 days after treatment (DAT) for PRE and 15 and 30 DAT for POST herbicides. A scale of 0 to 100% (0 = no weed control and 100 = complete control) was used. Better control of the most species was observed with POST than with PRE herbicides. Pendimethalin showed good efficacy (>90%) for *Abutilon theophrasti*, *Anagallis arvensis*, *Chenopodium album*, *Chenopodium hybridum*, *Chenopodium polyspermum*, *Rumex crispus* and *Veronica persica*, while the efficacy of ethofumesate was less than 90% for all weed species. Both POST herbicides showed good efficacy for many species with completely control (100%) achieved for *A. theophrasti*, *Amaranthus blitoides*, *R. crispus*, and *Solanum nigrum*. Except that, fluroxypyr-meptyl showed efficacy of 100% for *Bilderdykia convolvulus*, *Polygonum aviculare*, and *Veronica hederifolia*, while linuron showed the same effect on *A. arvensis*, *Ch. hybridum*, *Ch. polyspermum* and B. *convolvulus*.

This study was conducted with financial support of Ministry of Education and Science of the Republic of Serbia (Grants numbers: 451–03–66/2024–03/200003 and 451–03–65/2024–03/200116).

PS3-20. Effectiveness of a new Imazamox-based nano-herbicide formulation for weed control

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Herbicides are essential tools for reducing yield losses due to weed competition, but in certain circumstances they can be responsible for environmental and human health impacts. One solution to reduce the environmental impact of herbicides could be to formulate them using nanotechnology. In this study, which is part of the RiWeCIS (Rice Weeds Control with Innovation Systems) project, two clay-based imazamox nanoformulations (one using zeolite and one montmorillonite) have been synthetized according to a patented protocol that foresee the loading of the herbicide active ingredient on the mineral carrier at room temperature and atmospheric pressure. The efficacy of the nanoformulations was compared with that of technical grade imazamox and a commercial product containing imazamox (Beyond plus). The herbicides were applied either as a single treatment or as two consecutive treatments. The study was conducted in greenhouse on two weed species: *Echinochloa crus-galli* and *Oryza sativa* (weedy rice). The products were applied when seedlings reached two-leaf stage (and 14 days after in the case of two consecutive treatments) at a rate of 36.6 g a.i. ha^{-1} using a cabinet track sprayer equipped with a single air induction nozzle (Teejeet AI11002-VS), calibrated to deliver 300 L ha^{-1} at a pressure of 203 kPa. Visual efficacy against an untreated control was assessed both 14 days after the first herbicide application and 14 days after the second herbicide application. Fresh aboveground plant biomass was assessed for all treatments at 14 days after the second herbicide application. In weedy rice, montmonrillonite-based nanoformulation showed good efficacy, with an average biomass reduction of about 87% compared to the control, with no differences between single and double applications. The zeolite-based nanoformulation showed a similar efficacy, with 85% and 87% of biomass reduction in the case of single or double applications, respectively. In *E. crus-galli*, biomass reduction averaged 87% for the montmorillonite and 80% for the zeolite-based nanoformulation, with no differences between single and double applications. The nanoformulation demonstrated comparable efficacy to that of the commercial herbicides but further studies are needed to assess whether the efficacy can be increased and to determine the environmental behavior of the nanoformulation.

This research has funded by the European Union - Next Generation EU, Mission 4 Component 1, CUP B53D23017800006.

PS3-21. Physiological response of tree Duo System maize hybrids to increasing rates of Stratos Ultra (100g/l cycloxydim)

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Grass weed control in maize is of consequence because they can significantly reduce the yield. Due to the strong lack of selective herbicides, growing cycloxydim-tolerant maize is an alternative especially when there is a high monocotyledonous weed infestation. Known as Duo System technology, it offers both grass and broadleaf weeds control. A field trial for evaluating the selectivity of Stratos Ultra (100 g/L cycloxydim) with three maize hybrids from the Duo System technology was conducted. The study was carried on the experimental field of the department of "Agriculture and Herbology" of the Agricultural University of Plovdiv, Bulgaria. The grown hybrids were Zanetixx DUO, Hexxagone DUO and Elaraxx DUO. There were six treatments for each hybrid: 1. Untreated control; 2. Stratos Ultra – 1.00 L ha^{-1}; 3. Stratos Ultra – 2.00 L ha^{-1}; 4. Stratos Ultra – 3.00 L ha^{-1}; 5. Stratos Ultra – 4.00 L ha^{-1}; 6. Stratos Ultra – 5.00 L ha^{-1}. The herbicide was applied in growth stage 3rd - 5th true leaf of maize. On the 3rd, 7th, 14th, and 21st day after treatment, the selectivity of the herbicide was evaluated using the 9-score scale of European Weed Research Society. Measurements of the leaf gas exchange and chlorophyll content index were taken on 7th, 14th and 21^{st}day after treatment trough portable infrared gas analyzer and portable chlorophyll meter. Weak but discernable symptoms of chlorosis were observed on the 3rd day in variants 5th and 6th of the hybrid Zanetixx DUO. A strong chlorosis was noticed on the 7th day of the herbicide application in treatments №5, №6 of the hybrid Hexxagone DUO but those symptoms disappear afterwards. The high rates applied in the above treatments were found to seriously affect the Elaraxx DUO hybrid by causing strong chlorosis and bleaching. The same above treatments with Stratos Ultra were found to cause significant decrease in the photosynthesis and chlorophyll content of plants. The transpiration rates and stomatal conductance measured do not vary significantly among the variants of all the maize hybrids. Increasing the rates of Stratos Ultra resulted in significant yield decrease in treatments №5 and №6.

Acknowledgement(s) / funding: PhD thesis.

PS3-22. Effect of herbicides on weed management and vermicompost application in maize (*Zea mays* l.)

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A field experiment investigation was carried out during the Kharif season of 2024 at the Agronomy farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India. The effect of different herbicide treatment on weed control and vermicompost application in Maize (Zea mays L.) was studied. The experimental design was a factorial Randomized Block Design with three replications. The herbicide treatments were as follows: T1: atrazine 750g ha-1 (PRE), T2: pyroxasulfone 127.5 g ha-1 (PRE), T3: atrazine + tembotrione (Tank mix) (750 +120) g ha-1 as EPOST (15 DAS), T4: atrazine + topramezone (Tank mix) (750 + 25.2) g ha-1 as EPOST (15 DAS), T5: atrazine + mesotrione (RM) 875 g ha-1 as POST (20 DAS), T6: pyroxasulfone 127.5 g ha-1 (2 DAS) fb tembotrione 120 g ha-1 (20 DAS), T7: pyroxasulfone 127.5 g ha-1 (PRE) fb mechanical weeding at 40 days, T8: Two hand weeding at 20 and 40 DAS, and T9: Weedy check and another facter vermicompost application B1: Control, B2: 5 t ha-1 vermicompost. The predominant weed flora in the experimental site are a) broadleaved weeds such as: *Digera arvensis*, *Commelina benghalensis*, *Physalis minima*, b) narrowleaved weeds such as: *Setaria glauca*, *Dactyloctenium aegyptium*, *Echinochloa colonum*, *Dinebra retroflexa*, and c) sedges such as: *Cyperus rotundus* and *Cyperus irria*. Application of T7pyroxasulfone 127.5 g ha-1 (PE) fb mechanical weeding at 40 days with combination of B_2 vermicompost application 5 t ha-1 recorded higher grain yield, high weed control efficiency and lowest weed population.

Acknowledgement(s) / funding: EWRS.

PS3-23. Chalcones as new herbicides and their impact on cell division

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Chalcones are multifunctional natural products that can be extracted or synthesized by green processes. These molecules interact with various molecular targets, exhibiting diverse biological effects. The herbicidal activity and mode of action of 4'-hydroxy-3'-methoxychalcone (CH1), 3,4-dimethoxychalcone (CH2) and cinnamaldehyde (P1) were evaluated in this study. Dose-response experiments were performed with each substance.*Arabidopsis thaliana* seeds were grown on agar containing these compounds under a 16-hour light cycle at 25°C for 21 days. Root lengths were measured, and IC_{50}values were calculated to assess the effectiveness of each compound. Phenylalanine ammonia-lyase activity was determined spectrophotometrically by measuring cinnamic acid production at 290 nm. For the mitotic index, onion seeds were germinated in the presence of the chalcones and P1 for 7 days. Root tips were fixed, hydrolyzed, stained, and mounted on slides to evaluate the mitotic phases. The number of cells in each stage of mitosis was counted, with abnormal configurations recorded separately. Dose-response curves were analyzed using non-linear regression, while the other data were subjected to one-way ANOVA followed by Tukey's post-hoc test. Among the compounds, CH1 had the strongest inhibitory effect on root growth (IC_{50} = 17.3 μM), followed by CH2 (IC_{50} = 31.4 μM) and P1 (IC_{50} = 72.3 μM). Chalcone treatments also significantly increased enzyme activity, with CH1 and P1 having greater efficacy than CH2. Additionally, chalcones and P1 induced abnormal cell elongation, leading to a higher proportion of abnormal cells. Treatment with CH2 caused the strongest effect, with 26% abnormal cells. Both CH1 and CH2 reduced the number of interphase cells compared to the control and decreased the number of cells in prophase and metaphase. CH1 uniquely reduced the number of telophase cells. The findings suggest that chalcones disrupt cell division, causing abnormal plant growth and development by interfering with the cell cycle. By interfering with the cell cycle, chalcones can inhibit the development of new tissues and restrict plant growth. Additionally, these molecules may excessively stimulate lignin production by the increase of phenylalanine ammonia-lyase activity, resulting in the formation of abnormal cells. Further research needed to understand mode of action and applications.

Acknowledgement(s) / funding : São Paulo State University - UNESP and Colorado State University.

PS3-24. Living lab to promote integrated weed management in Italian agricultural crops

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The use of a collaborative approach among all stakeholders to encourage technological innovation within farms is the basis of the so-called Agroecosystem Living Labs (ALLs). In the frame of the Agritech project*, Task 4.2.1 aims to create networks of researchers, farmers and stakeholders working together to develop and disseminate innovative practices for enhancing farms' resilience in the climate change scenario. The CNR research unit focuses on weed control aiming to combine sustainability and effectiveness, decreasing the use of chemicals, preserving water, and keeping the carbon cycle balanced.

The first step was the setup of the network, which currently includes 14 farms distributed in North-eastern Italy, the Italian Herbicide Resistance Working Group (GIRE), an agricultural consultancy and research company (Agrin) and other stakeholders. Then, some OFEs (On-Farm Experiments) were initiated in pilot farms with different aims: 1) comparison between broadcast and band herbicide application to reduce herbicide use; 2) comparison between different cover crop mixtures and managements to evaluate the benefit on weed control and improvement of soil quality; 3) management of *Amaranthus* spp. in soybean through a comprehensive approach (from in-field ALS inhibitors resistance detection to the implementation of site-specific management strategies).

After the first year of experimentations, in OFE1 the treatment with herbicide band application gave the same maize yield of broadcast application despite a 50% reduction of herbicide use. In OFE2, three field trials are ongoing and the different cover crops proved to be differently effective at controlling weed emergences with a 30-50% reduction of weed density after the cover crops establishment. OFE3 will start in spring 2025 and first data on the herbicide resistance status of *Amaranthus* spp. will be available.

The implementation of alternative management strategies through a collaborative,and constantly evolving, approach will allow to increase sustainability and environmental protection. Dissemination and organization of open days and working groups will be a fundamental part of stakeholders involvement.

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

PS3-25. Nanotechnology contributions to weed management: is this an alternative for sustainable use of herbicides?

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Herbicides harm the environment but are still necessary to maintain crop productivity and ensure efficient weed control in agricultural areas. Nanotechnology has become an essential tool to improve the efficacy of herbicides by increasing toxicity to target species, leading to effective management with reduced active ingredient (a.i.) rates due to changes in herbicide delivery. In this work, we highlight the contributions of nanoherbicides to the safe and sustainable use of herbicides in weed management. Several tests were carried out with atrazine, glyphosate and metribuzin encapsulated in nanoparticles (NPs) based on biodegradable polymers, with toxicity tests on target weed species (*Amaranthus hybridus, A. viridis, Bidens pilosa, Eleusine indica,*and *Ipomoea grandifolia*) and non-target organisms (crops such as maize, soybean and cotton, soil microorganisms) under controlled environmental conditions. All herbicides were compared with commercial formulations. The results were subjected to ANOVA assumptions tests, then ANOVA, and means were compared using post-hoc comparisons ($p<0.05$). Atrazine systems based on zein NPs showed increased toxicity to weeds (>85% weed control), reducing the dose from 2,000 to 25 g a.i. ha^{-1} without reducing herbicidal efficacy. The same was observed for the metribuzin-loaded polycaprolactone pattern (dose reduction from 480 to 48 g a.i. ha^{-1}) against *I. grandifolia*, A. viridis and *B. pilosa*. For glyphosate nanosystems, only in *A. hybridus* did the nanosystem show the possibility of a dose reduction from 720 to 360 g acid equivalent ha^{-1} without compromising weed control. For *E. indica*and *I. grandifolia*, nanoglyphosate was not effective (weed control < 40%). Regarding the effect on non-target organisms, none of the developed nanoherbicides showed toxic effects on crops (atrazine in maize, metribuzin in soybean, glyphosate in resistant soybean and cotton) or soil microorganisms compared to commercial formulations. Combining herbicides with nanomaterials offers greater weed control efficacy at lower herbicide doses without increasing toxicity to non-target organisms or target crops. This confirms this as a promising technology to contribute to weed control with herbicides while at the same time contributing to more sustainable agriculture without compromising crop production.

Acknowledgement(s) / funding: São Paulo Research Foundation (FAPESP #2024/00869-1, #2022/00718-8 and #2021/10639-5) and CNPq – INCTNanoAgro (#405924/2022-4).

PS3-26. Herbicide strategies for the control of natural populations of Echinochloa species in rice fields of the Ebro Delta

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Echinochloa is a difficult to manage genus in rice fields. The lack of active ingredients and proliferation of herbicide resistant biotypes to most common herbicides, mainly those of Groups 1 and 2, has worsened their problematic in the last years. Integrated weed management strategies have become mandatory to maintain these populations under threshold levels. The present work was performed within the integrated management program established by the Plant Health Service of the Catalan Government since season 2023 for *Echionchloa* species. This study aims to evaluate the efficacy of different herbicides other than those of Groups 1 and 2 on the control of *Echinochloa* species in flooded rice fields of the Ebro Delta.

Echinochloa was successfully controlled by imazamox (> 99 % of control) and cycloxydim (88 %). In general, treatments which included the application of preemergence herbicides followed by a postemergence application showed the excellent results. For example, benzobicyclone applied in preemergence followed by florpyrauxifen-benzil applied in postemergence achieved control efficacies over 95 %. In contrast, results of this kind of treatment, but with clomazone instead of benzobicyclone, were not successful enough (39 %). It is necessary to improve the positioning of this last herbicide to achieve successful control levels for *Echinochloa* species.

PS3-27. Evaluation of integrated weed control methods to reduce herbicides input in processing tomato

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Herbicides are frequently used in the chemical control of weeds in processing tomato due to their high efficacy, selectivity and lower cost than other non-chemical methods, allowing to improve crop yield and quality. However, herbicides are frequently detected outside their application areas, contributing to the risk of environmental contamination. The aim of this study was to test integrated chemical and non-chemical weed control methods in processing tomato, evaluating their efficacy against weeds and the effects to the crop, in order to reduce herbicides inputs, minimizing or avoiding their impact in the water and soil pollution. Two field experiments in processing tomato (*Solanum lycopersicum* L.) were carried out in 2023 and 2024 (May-September) at the Experimental Station of the Dept. of Agricultural, Food and Environmental Sciences (42°57'N, 12°22'E, 165 m a.s.l.) on a clay-loam soil (25% sand, 30% clay and 45% silt, pH 8.2, 0.9% organic matter).The experimental design was a randomized block with three replicates and plot size of 32 m² (4 m width). Processing tomato was transplanted at 3,3 plants m^{-2} and inter row distance of 1 m. Different weed control methods were applied: a) chemical (herbicide broadcast application) (HE); b) mechanical (inter row hoeing) + chemical (herbicide in row) (HOE+HE); c) chemical (herbicide inter-row) + physical (plastic mulching in row) (HE+PM); d) mechanical (inter row hoeing + in row finger-weeder) (HOE+FW); e) physical (plastic mulching in row) (PM). Untreated plots (untreated control, UC) and weed-free plots by hand weeding (weed free control, WFC) were added as controls.All in the row and inter-row treatments were applied in band on a width of 0.5 m. Metribuzin was applied as pre-emergence herbicide (one application at 280 g a.i. ha^{-1}). Four suction cup lysimeters per plot were applied in herbicide treatments at two different soil depths (0.3 m and 0.6 m) to collect water samples. The herbicide phytotoxicity to the tomato, weed ground cover, weed density, weed biomass, tomato biomass and tomato yield were evaluated during crop cycle and at harvest. The data obtained from the experiments were subjected to ANOVA and the means were separated according to Fisher's protected LSD at p = 0.05 level.The weed control efficacy (WCE) was the highest with the HE treatment or HE+PM and HOE+HE treatments, with the WCE always higher than 95%. The integrated weed control methods (i.e. HE+PM and HOE+HE) allowed to obtain a 50% of herbicide reduction with respect to HE, maintaining the same efficacy.The WCE was statically lower without chemical control, although OE+FW was able to obtain a WCE of 90%, allowing a 100% of herbicide reduction. PMshowed the lowest WCE.Tomato yield was related to the weed efficacy of treatments, with the highest yield obtained by the most effective treatments.The preliminary results on the mobility of metribuzin in soil showed that, at 0.3 m depth, metribuzin concentration in water decreased under the limit of quantitation at 15 days after herbicide treatment, whereas, at 0.6 m depth, metribuzin concentration was always under the limit of quantitation. This research was supported by PRIMA Project - Acronym "Safe-H2O-Farm".

This research was supported by PRIMA Project - Title: "Innovative farm strategies that integrate sustainable N fertilization, water management and pest control to reduce water and soil pollution and salinization in the Mediterranean".

PS3-28. Time of residual herbicide application in cabbage: efficacy, benefits and risks

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The goal of this study was to evaluate herbicides for weed control in cabbage, pushed with the fact that pendimethalin is on EFSA's candidate for substitution list (CfS). The field experiment was conducted during 2024 at the experimental station of the Institute for Vegetable crops Smederevska Palanka. The study was established as a full randomized complete block design. All herbicides were applied with abattery powered backpack sprayer "Farm® KF-16C-47" which delivers a constant pressure. For this study a four nozzle boom with Lechler IDK12002 nozzles have been used to deliver 200 L of water ha^{-1} by 200 kPa pressure and the speed of 3.84 km h^{-1} (±10%). Herbicides were applied without adjuvants on three ways: 1) incorporation (PPI) a) napropamide 1800 g a.i. ha^{-1} and b) napropamide 900 g a.i. ha^{-1} + clomazone 96 g a.i. ha^{-1} and 2) preemergence (PRE-EM) c)pendimethalin 1650 g a.i. ha^{-1} and 3) postemergence (POST-EM)d)flumioxazin 40.8 g a.i. ha^{-1}, e) dimethenamid-P 500 g a.i. ha^{-1} and f)metazachlor 500 g a.i. ha^{-1} + clomazone 96 g a.i. ha^{-1}.Herbicides were applied without adjuvants.The most dominant weed species were:*Ambrosia artemisiifolia* L, *Galinsoga parviflora* (Cav.), *Hibiscus trionum* L, *Polygonum lapathifolium* L. and *Portulaca oleracea* L. Herbicide efficacy and crop injury were estimated every 7 days after treatment (DAT). The field was cultivated on 29th of April, whereby cabbage variety Ditmar was transplanted on 7th of May for POST-EM treatments and 17th of May for PPI and PRE-EM treatments whereby the herbicide application followed 10 days after and 7 days before transplanting respectively..

The results varied among treatments, whereby treatments a), b) and c) provided excellent weed control 28 DAT without crop injury. Treatments d) and f) provided excellent weed control 14 DAT but not 21 DAT. Treatment e) provided poor weed control 14 DAT. Treatments which included clomazone or flumioxazin caused slight crop injury.

All mentioned herbicides can be used for weed control in Ditmar cabbage variety with some minor crop injuries. A lower herbicide efficacy of POST-EM herbicides could be because of the long period between field cultivation and transplanting. Further research needs to be conducted.

The research presented in this article is part of the research project number 451-03-66/2024-03/200216 and 451-03-65/2024-03/200383 funded by the Ministry of Education and Science, Republic of Serbia.

PS3-29. Validating molecular targets of thiocarbamate herbicides

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Herbicides are widely used in agriculture to control weeds, ensuring crop yields and profitability. Herbicides are classified into groups based on their mode of actions (MoAs) by the Herbicide Resistance Action Committee (HRAC) to support resistance management strategies. In 2020, the MoAs of herbicides previously assigned to classes N and K3 were consolidated into group 15, characterized by the inhibition of very-long-chain fatty acid (VLCFA) biosynthesis. While the MoAs of former class K3 herbicides has been well-established (Trenkamp et al., 2004), the molecular targets of former class N herbicides, including thiocarbamates, have not yet been validated. In this study, we hypothesize that sulfoxidated thiocarbamates inhibit 3-oxoacyl-CoA synthases (also referred to as keto-acyl-CoA synthases, KCSs), the condensing enzymes in the VLCFA elongation complex. For the validation, expression patterns of KCS isoforms in seedlings of several weed species are analyzed using RNA-Seq data. We select highly expressed candidates and heterologously expressed in *Saccharomyces cerevisiae*. These yeast strains are subsequently incubated with sulfoxidated thiocarbamates, and VLCFA profiles are analyzed through gas chromatography-mass spectrometry (GC-MS). Improved understanding and classification of herbicides based on their MoAs will enhance resistance management strategies, offering farmers better options for integrating herbicides while mitigating resistance evolution.

Acknowledgement(s) / funding: HRAC.

PS3-31. Weeds and weed management in nursery production of spruce seedlings

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Spruce is beside black pine, the most abundant and most frequently used coniferous species for afforestation in Serbia. The basis of every successful afforestation is the quality of planting stock used. The spruce seeds are sown in April-May in the seedbeds, and the seedlings are growing and staying in the seedbeds for two years. After two years, young seedlings are transplanted to nursery beds, where they are grown for a few more growing seasons until they are used for afforestation.

During the growth period in the nursery, due to wide inter-row distances and an open development framework during the early stages of seedling development, the weed communities are very rich of species. The most important and frequent weeds are *Portulaca oleracea* L., *Chenopodium album* L., *Amaranthus retroflexus* L., *Ambrosia artemisiifolia* L., *Rorippa sylvestris* (L.) Besser, *Plantago lanceolata* L., *Cirsium arvense* (L) Scop., *Convolvulus arvensis* L., *Sorghum halepense* L., *Echinochloa crus-galli* (L.) Beauv., *Cynodon dactylon* (L.) Pers., *Polygonum* spp. and *Setaria* spp.

Conventional weed control is based on mechanical hoeing, but due to labour shortages and high manpower prices, producers are more often turning to herbicide application. In spring, prior to weed emergence, S-metolachlor and pendimethalin provide good control of annual grasses, whereas flurochloridone controls broadleaved weeds. The herbicide clopyralid is a selective herbicide that is used for the post-emergence control of many broadleaf weeds and does not affect grasses. Herbicides clethodim and fluazifop-p are selective herbicides that work on grass weeds and are safe to use in all periods of spruce growth. Glyphosate controls a wide range of weeds, including herbaceous and woody ones. It is important to know that in the growing season, application of glyphosate should be avoided. Spruce will tolerate glyphosate provided leader growth has hardened. Hardening can occur as early as the end of July or may be delayed until October in some locations.

However, herbicide weed resistance is becoming an increasingly important question in all areas of plant production, and so in spruce seedling production. Therefore, although chemical weed control is highly effective, in the future, successful weed management in spruce seedling production needs to focus on an integrated approach, which is the combination of chemical and non-chemical methods.

9. Invasive weeds

S09-O1. Invasive plant species effects on the communities of seed-predator insects: an ecological network approach

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Keynote session

Invasive alien species are a major driver of biodiversity loss and ecosystem disruption, significantly impacting ecosystem processes and structure across trophic levels. Co-responsible for 60% of global extinctions and escalating economic costs, these species necessitate innovative management strategies. Biological control is a sustainable method to manage invasive alien species and requires rigorous protocols and risk assessments to prevent unintended ecological effects. Ecological networks are valuable tools for understanding community interactions and may be used to assess invasive species impacts and predict non-target effects of biological control agents. In Portugal, *Acacia dealbata* is one of the most widespread invasive plant species and is targeted for biological control using a seed-borer weevil.

This study employs a dataset encompassing three trophic levels and replicated interaction networks to: (1) define ecological network structures among plants, seed predators, and parasitoids across different *A. dealbata* invasion levels; (2) establish a baseline of the tri-trophic ecological network for future comparisons; and (3) evaluate *A. dealbata*'s cascading effects on ecological networks in different invasion levels.

A space-for-time substitution approach evaluated the effects of *A. dealbata* invasion on plant, seed predator, and parasitoid communities. Around 150 20-meter-long transects in the center of Portugal, representing varying *A. dealbata* invasion levels, were surveyed monthly over a year to identify plant species and quantify their cover. Seeds and fruits were collected, quantified, and monitored for insect emergence over at least three months. Insects were identified, classified as seed predators or parasitoids, and their abundance and richness recorded. The effects of *A. dealbata* on plants and seed predator communities were analyzed through classical diversity measures (species richness, abundance, and biomass) and through ecological networks, using a replicated approach to capture community-level dynamics.

Preliminary results show that invasion by *A. dealbata* causes a simplification of plant communities, with cascading effects to higher trophic levels. We hypothesize that higher *A. dealbata* invasion levels will correlate with reduced species richness and simplified community interactions. This work highlights the potential of ecological networks to provide comprehensive insights into community-level impacts and inform sustainable biological control strategies.

Acknowledgement(s) / funding : Elizabete Marchante; Hélia Marchante; Francisco A. López Núñez.

S09-O2. Seed biology and germination response of weedy *Gazania* species in Australia

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Two species of genus *Gazania*, *Gazania linearis* L. and *Gazania rigens* L. were introduced in Australia from South Africa as ornamental flowering plants. Both species coexist and potentially hybridise, are very difficult to distinguish in the field and therefore, commonly known as gazania. Over time, gazania have escaped from the gardens into roadsides, native vegetation, fallow fields and agricultural lands. Now they have become highly invasive and are recognised as emerging, difficult-to-control weed in grain production systems across southern Australia. Our objectives were to: (1)investigate the germination response of gazania to different environmental factors, including temperature, photoperiod, osmotic potential, salt and pH, and (2) explore whether gazania populations collected from different geographic locations and land-use scenarios differed in their seed morphology and germination ability. Seeds of four populations of gazania were collected from contrasting geographic locations (South Australia and Victoria) and land-use scenarios [roadside (Pop-1), fence line (Pop-2), grain crop production field (Pop-3) and pasture field (Pop-4)] and compared for their seed morphology and germination response to different temperatures and photoperiods. The remaining germination experiments (osmotic potential, salinity and pH) were then conducted using two contrasting populations (Pop-1 and Pop-3) out of the original four. The results indicated that seeds of a population collected from a pasture field (Pop-4) were 75% heavier than the fence line population (Pop-2). Seed length did not vary across populations but seed width of a roadside population (Pop-1) was significantly lower (37%) than a population from a cropping field (Pop-3). Germination response was same in alternating light/dark (14/10 h) or complete dark (24 h) conditions. All populations had >78% germination across a wide range of alternating day/night temperatures (15/5, 25/15, and 35/25°C). Populations did not differ in their germination response to moisture stress. Seeds did not germinate beyond -1.2 MPa water potential, while 50% germination inhibition occurred at -0.67 MPa. Both populations could germinate up to a high salinity level of 300 mM of sodium chloride. The pH did not affect germination irrespective of the population. Despite some population variation, gazania have very flexible germination requirements potentially enabling their robust invasion.

Muhammad Adnan is thankful to La Trobe University for the provision of PhD scholarship.

S09-O3. Rapid adaptation in invasive Amaranthus albus seed germination: better understanding climate change responses

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Background and objectives Understanding the effects of abiotic and biotic on weed germination is vital for optimizing weed control in agricultural fields. This study explores the intra-specific variability in seed germination of invasive *Amaranthus albus* populations.

Methods Twenty populations of *A. albus* were collected across climate gradients within their invaded range, representing diverse climatic conditions from semi-arid to Mediterranean. Seed traits, germination patterns, and growth rates of both maternal and progeny populations were characterized and compared. Progeny seeds produced in a common garden experiment were subjected to germination experiments under gradual temperature regimes. Cardinal temperatures and germination niches for each population were estimated and analyzed in relation to the climatic conditions representing each population.

Results and discussion Significant seed weight differences were found among the F1 populations, with eastern populations having the highest mean weights (28.6–38.5 mg per 50 seeds). Two distinct germination patterns were observed in F1 populations: rapid and uniform germination with higher percentages at lower temperatures in early-season planting areas, and delayed and variable germination with higher percentages under more favorable conditions (30 °C) in late-planting areas, suggesting plasticity in the germination response to temperature. Intra-specific variation in cardinal temperatures and germination niche for *A. albus* exhibited clinal variation, with populations from cooler climates having lower base temperatures. The model predicted a ~1°C increase in base temperature for each 1°C rise in mean annual temperature. These insights into short-term evolutionary responses to novel environments are crucial for predicting and managing plant invasions considering climate change.

Conclusions The study emphasizes the importance of incorporating location-specific factors into weed management strategies, considering both natural processes and anthropogenic influences shaping weed populations.

Our thanks extend to Ran N Lati and Maor Matzrafi from Newe Ya'ar Research Center for sharing their knowledge and facilities. This research was funded by the BSF (US-Israel Binational Science Foundation) grant 132-2101 and the Chief Scientist, Israel.

S09-O4. Recent updates of alien plant taxa of Türkiye

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Since the publication of the first inventory of the alien flora of Türkiye in 2017 (https://doi.org/10.3897/neobiota.35.12460) (2017), 33 new alien plant taxa have been recorded, i.e. approximately four new taxa per year, which were mostly herbaceous species. Therefore, to date, the total number of alien plant taxa in the flora of Türkiye has reached 374 plant species. Most of the newly recorded alien species are present in agricultural areas, urban ecosystems, riparian habitats, and park gardens. These new alien species are mostly native to Americas, Africa, Asia, Europe, and subtropics. Escape is the most common introduction pathways of these new taxa, as they have been introduced by international trade as plants and seeds for ornamental purposes. Owing to the increased tourism in the Mediterranean and Black Sea regions, the use of alien plant species as ornamentals has rapidly increased. Every national checklist of non-native flora needs to be periodically updated, taking into account the habitat types most prone to be invaded.

S09-O5. Viability of *Cyperus esculentus* seeds and tubers after ensiling, digestion by cattle and manure storage

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Cyperus esculentus is a pernicious invasive sedge causing high yield penalties in many arable crops in NW Europe. Despite obligatory weed control in Belgium, the number of infestations is steadily increasing. Given its low sensitivity to control measures and high reproduction rate, prevention is key in minimizing further spread of *C. esculentus.* Dispersal of seeds and tubers may occur through water, animals, agricultural machinery or manure. These propagules may end up in manure after being ingested by ruminants eating contaminated feed (e.g. silage maize, grass, potato, fodder beet). This study examined the effect of ensiling, digestion by cattle and storage in slurry and farmyard manure on the viability of *C. esculentus* seeds and tubers. Hereto, seeds and tubers were subjected to five ensiling durations (0-16 weeks) in mini-silos with chopped whole plant maize, seven durations (0-48 h) of ruminal digestion in fistulated Holstein–Friesian cows (seeds) or in vitro (tubers) using a Daisy incubator, and five durations of storage (0-16 weeks) in a slurry cellar or a farmyard manure heap, or combinations of previous processes. After each treatment, seed and tuber viability was determined by a germination test followed by a tetrazolium test. After 6 weeks in a maize silo, viability of tuber and seeds was reduced by 100 and 96%, respectively. Incubation for 36 and 48 h in the rumen followed by a post-ruminal digestion in-vitro reduced seed viability by 30% and 45%, respectively. However, in vitro rumen incubation followed by post-ruminal digestion did not significantly reduce tuber vitality. Vitality of seeds and tubers was reduced by 90% after 11.5 and 13.7 weeks of incubation in a slurry cellar, and by 99% after 31.5 and 44 weeks, respectively. Storage in a farmyard manure heap for 4-16 weeks did not affect seed and tuber vitality. Compared with seeds, tubers were less tolerant to 12-24 h animal digestion followed by 8 week storage in a slurry cellar. Keeping a fresh maize silo closed for at least 6 weeks and slurry storage for at least 16 weeks are excellent preventive measures to limit the spread of *C. esculentus* propagules between fields.

This study was financially supported by Flanders Innovation and Entrepreneurship (VLAIO), grant number AIO.LAN.2021.0003.01.

S09-O6. Perceptions and practices of sustainable valorization and management of water hyacinth in Portugal

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Water hyacinth (*Pontederia crassipes*) is one of the most widespread invasive aquatic plants (IAP) globally, known for its rapid growth, prolific reproduction and negative impacts. The search for sustainable solutions to manage it has driven research into its potential uses. From 2021 to 2023, the project BioComp_2.0, in Portugal, tested the production of organic compounds from water hyacinth and agro-industrial by-products to use in agriculture. Results have demonstrated that composting this IAP with organic wastes (e.g., olive pomace, potato peel and forest wood chips) is a sustainable solution that supports the circular economy and enhances agricultural soils. Since 2023, composting at industrial scale, financial viability of the process and field trials with different crop species are underway at BioComp_3.0. Yet, focusing on responsible valorisation to avoid additional spread of this IAP is key. To achieve this, training and awareness-raising sessions have been held across the country, and a survey was conducted aiming to: 1) analyse perceptions and knowledge about water hyacinth among management entities in Portugal, focusing on the invasive behaviour, its use as compost and biological control; and 2) assess the willingness of the target entities to collaborate in the creation of a Responsible Network to promote more effective management of the species. The survey results show that, although most entities recognise the presence this IAP in their areas, many are unable to quantify its impacts. Composting is recognized as a promising solution for the valorisation of the IAP biomass, though concerns remain about the potential spread of the species. Perceptions of biological control were mixed with over 60% considering it a safe and sustainable option, but gaps in knowledge and practical experience being identified. Over 40% of the entities expressed an interest in joining the Responsible Network, while 43% were undecided, which highlights the need for greater efforts to raise awareness, strengthen dialogue with entities, overcome objections and develop a clear and sustainable structure. Despite the field trials and other tasks are ongoing, preliminary results already support that BioComp_3.0 plays a crucial role in advancing sustainable control strategies, promoting collaborative networks, and delivering ecological, social and economic benefits.

This work was developed within the scope of the BioComp_3.0 project, which aims at the production of organic biological compounds from water hyacinth, enabling its valorisation alongside agro-livestock, forestry, and agro-industrial by-products.

PS3-32. PalmerNET: a research network to joint efforts against the demon weed

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PalmerNET is a research network from Spain (RED2022-134285-T), financed by the Ministry of Science and Innovation to fight against *Amaranthus palmeri*, an invasive weed species established in north-eastern Spain (Cataluña and Aragón) and Extremadura, with great capacity to evolve herbicide resistance. PalmerNET started in June 2023, under the coordination of the Agrotecnio Centre and the University of Lleida (UdL). Other universities and research entities are participating, with eight research groups overall: Public University of Navarra, University of Vigo, Polytechnic University of Valencia, Centre for Agricultural Research and Technology of Aragon (CITA), National Institute of Agricultural Research (INIA-CSIC) and the Scientific and Technological Research Centre of Extremadura (CICYTEX). 25 people, among researchers, professor and PhD students, conform PalmerNET.

PalmerNET has promoted research collaboration efforts between the participating research groups to understand and contain the spread of this invasive weed in Spain.Our network also aims to disseminatethe available knowledge about this significant threat to the summer crops in Europe.So far, PalmerNET initiative was presented in two congresses, the XIX Congress of the Spanish Weed Science Society (Beja, Portugal) in September 2024, and the XXV Congress of the Weed Science Society of Latin America (Campinas, Brasil) in August 2024; in addition, it supported an oral communication at the 9th Resistance Conference (Rothamsted, UK) in September 2024. Some PalmerNET members authored two articles for the Spanish agricultural journal Vida Rural. The network has also supported three articles published in international peer-reviewed journals: a review published in Agronomy, an editorial accepted in Weed Research and, another research article under revision. Our initiative has participated in several technical meetings with farmers and stakeholders, in July, September and November 2024. Moreover, it organized an online Technical Meeting to raise awareness of the problem in October 2024. Another objective of the network is to organize regular meetings among the research groups, which were held in July 2023 (online), November 2023, and May 2024 (online). For more information about this research network and project, the website https://redpalmer.net/ is available (in Spanish).

Acknowledgement(s) / funding: RED2022-134285-T, financed by the Ministry of Science and Innovation from Spain.

PS3-33. Seed germination and root-sprout requirements of *Ailanthus altissima* (Mill.) Swingle.

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Tree of heaven (*Ailanthus altissima*) is a worldwide invasive species characterised by its high capacity of both seed production and root sprouting. Knowledge of the environmental requirements for its germination and sprouting is essential to stop its spread and develop successful management programs. Seeds and roots of different diameters of *A. altissima* were collected from natural populations in autumn and stored at environmental conditions. In spring, different treatments were applied to a portion of seeds in order to determine the best technique to break dormancy. Once the best technique was found, different temperatures (10, 14, 17, 22, 25 and 28 °C) and water potentials (0, -0.1, - 0.2, -0.4 and -0.6 mPa) were applied to the rest of the seeds to estimate base temperature and base water potential. Germination rate of seeds from trees treated with glyphosate prior seed collection was also tested. Simultaneously, roots were collected and cut at different lengths and their sprouting rate together with base temperature were estimated. The results showed that cold pre-treatment at 10°C for 21 days provided the best results to break dormancy of seeds. Base temperature and water potential of seeds was 9.6 ºC and -0.73 mPa respectively. Seeds from trees treated with glyphosate did not show any reduction in their germination rate. The minimum fragment of root able to sprout was estimated in 4 cm long and 3-4 mm diameter. Base temperature of roots was 9 °C. This data can help stop its spread and better manage this important weed found in natural ecosystems.

We are grateful to Joan Vilamú (Head of the Department of Natural Environment and Territory of the Conservation Park of Serra de Collserola) for facilitating the access and get the seeds and roots from the park.

PS3-34. Habitat preference study of the tree of heaven (*Ailanthus altissima* (MILL.) Swingle) in the Nagy-Eged hill (Hungary)

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The tree of heaven (*Ailanthus altissima* (MILL.) SWINGLE), one of the most dangerous invasive species in Europe. The problems caused by the species are mainly manifested in its explosive expansion, shading, and effects on soil chemistry and water balance. Its decomposing avary causes a nitrogen surplus favorable to weeds, and the allelopathic compounds produced by the species cause biotic inhibition of the surrounding soil. Among its natural habitats, it colonizes mainly open canopy dry forests and dry grasslands. Early and accurate detection of stands and rapid identification of management actions are essential to control the spread of the species.

The aim of our research was to accurately assess the quantitative and qualitative characteristics of the *Ailanthus altissima* populations in the area of the Nagy-Eged hill (Hungary), and to search for correlations between habitus and habitat quality of the given tree of heaven populations based on a detailed habitat map.

During our field studies covering two growing seasons, we assessed the localities of the stands, classified the individuals into 4 developmental categories (age groups), and examined the extent.

The 139 populations recorded showed great diversity in both size and habitus. Unfortunately, the survey results show that the largest patches of tree of heaven are located in the area between the Kis-Eged and the Nagy-Eged, touching protected (Natura 2000) areas. Tree of heaven is also located in natural habitats (open and closed steppes, termophilous oak woodlands), but is more associated with low naturalness uncharacteristic dry grasslands, industrial and agricultural yards or wastelands. Large, stable, multileveled populations are most favored by habitats dominated by spontaneously occurring or introduced alien species (S6, RDb) and roads/railroads (U11), while the habitat preference of juveniles are intensive vineyards (T7).

The important conclusion of the research is that the conservation objective of interventions aimed at reducing the number of tree of heavens can only be achieved effectively with the support of other sectors of agriculture and with the appropriate attitude of the owners of vineyards.

Acknowledgement(s) / funding: EPR 149341 MEC_R_24.

PS3-35. The invasion of common milkweed (*Asclepias syriaca* L.) in the Kesznyéten Landscape Reserve

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Asclepias syriaca L. (Apocynaceae, hereinafter called milkweed), is an invasive species that has colonized extensive areas in Europe, forming novel ecosystems. Because of its invasiveness and negative impact on native habitats and its threat to agricultural lands, the plant is listed on the EU's List of Invasive Alien Species of Union Concern. This species was brought to Hungary for beekeeping purposes in the 18th century.

Our research was performed in 2019 and 2020, in the Kesznyéten Landscape Reserve, which is under the authority of the Bükk National Park Directorate in Hungary. We have investigated three areas (Horgoló, Vitéz-telek, Nagy-legelő) infected with milkweed. In this present study, we aimed 1) to monitor the spread of milkweed, 2) to explore the effectiveness of the treatment in controlling milkweed in the short term (Glyphosate, Colombus). Two different survey methodologies have been used. Massive stands were recorded in patches, while stands smaller than 5 m were recorded as points with QField. The following data were provided: geographic coordinates, phenological stage, number of individuals, cover (%) and area (m^2). The stands of milkweed were plotted on maps. Samples of *A. syriaca* collected during this research were deposited at the Herbarium of University of Debrecen. Temperature and precipitation data have also been collected.

The milkweed population increased in all three areas. In total we have detected 130 972 milkweed in 2019 and 150 650 milkweed in 2020, which is an increase of nearly 15 %. The largest increase (67%) has been observed in the Nagy-legelő. During the survey, the average temperature increased and precipitation was very low. This has resulted in increasingly favourable conditions for the drought-tolerant milkweed. It can be assumed that the drying process of the area may be related to the increase in the milkweed population. During the survey, the Glyphosate has proved to be the most effective approach. Early detection and eradication are important in preventing the spread of invasive species. Controlling the species is extremely difficult and can only be successful with continued management. Further research is needed to find the most appropriate method to control the continued spread of *Asclepias*.

PS3-36. Potential and actual vegetative regeneration of Oxalis pes-caprae as affected by different treatments

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Oxalis pes-caprae (Bermuda buttercup) is an invasive, perennial geophyte weed native to South Africa that has spread to many regions of the world, including Sardinia (Italy). *O. pes-caprae* significantly impacted both ecological processes and agricultural productivity, and basic information is needed to establish integrated methods for a sustainable management of the this weed in a Mediterranean cereal-farming system. Within the Horizon Europe GOOD project, our research aimed at investigating *O. pes-caprae*, particularly the effectiveness of different control interventions on its regenerative capacity by quantifying bulb and seedling density. The study was started in 2023 in a Mediterranean rainfed cereal farming systems highly infested with *O. pes-caprae* where triticale was the main crop.In a complete randomized block design, the following treatments were compared to an untreated control: soil tillage, mowing, application of sulfonylurea and phenoxy herbicides and intercropping of triticale with self-reseeding annual legumes. Viable bulb density was estimated in September 2024 by taking soil cores to a depth of 30 cm during the plant's dormant phase. Seedling density was determined in January 2025 during the plant's full vegetative activity by counting their number in three sampling areas per plot. Soil core sampling (September 2024) revealed that the level of Oxalis infestation varied significantly across the applied treatments. The untreated control exhibited a bulb density of slightly more than 1400 bulbs m^{-2}, whereas tillage and sulfonylurea herbicide significantly reduced bulb density by 80–90%. In contrast, phenoxy herbicide, mowing, and cover cropping did not result in statistically significant differences compared to the untreated plot. These trends were also observed in the plant density assessment conducted in January 2025. This second survey, however, revealed lower density values than bulbs for all treatments, varying from about 650 seedlings m^{-2} in the untreated control to 80 - 60 seedlings m^{-2} in the tillage and sulfonylurea herbicide treatment, respectively. As contrasting invasive alien species can prove difficult when biological information and propagation dynamics within new habitats are little investigated, our experimental results constitute a basic starting point in the setting up of combined methods for sustainable management of this invasive weed.

The authors thank Daniele Dettori, Daniele Nieddu and Maddalena Sassu for technical assistance in field and laboratory at CNR ISPAAM. Funded by the European Union under Grant Agreement No. 101083589.

PS3-37. Impact of invasive alien plants on vegetation diversity in Korea

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Invasive alien plants such as *Humulus japonicus* (Japanese hop), *Ambrosia trifida* (Giant ragweed), and *Sicyos angulatus* (Bur-cucumber) are weeds that are problematic in agroecosystem and mainly distributed in uncultivated areas including field margin, roadside, parkside in Korea. Due to their early seedling emergence and vigorous growth, they have caused vegetation disturbance and then soil erosion. However, little information is available on how much they affect vegetation. Therefore, vegetation analysis was conducted to investigate the impact of invasive alien plants on vegetation diversity. Two neighboring sites, one with invasive alien plant infested and the other without invasive alien plant were selected in each location and their vegetation parameters such as plant density and plant ground cover of each plant species were assessed in 1 m x 1 m quadrat. The infested sites were selected based on single-species infestations of the aforementioned invasive alien plants. Based on vegetation parameters assessed in each location, vegetation indices including importance value and Simpson's diversity index were calculated. As a result, the site with invasive alien plant invested showed much lower vegetation diversity than the site without invasive alien plant. Interestingly, the site with invasive alien plant infested showed much lower proportion of perennial plants, while the site without invasive alien plant maintained relatively higher proportion of perennial plants. Our finding thus suggests that the interference of invasive alien plant reduces vegetation diversity with a particular decrease in perennial plants. The decreased perennial plants in the site may eventually cause soil erosion, so invasive alien plants management should also consider how to restore vegetation with perennial plants.

PS3-38. Effective long-term strategies for reducing *Cyperus esculentus* infestations

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Cyperus esculentus is a perennial invasive sedge which causes huge losses in many crops. It reproduces and spreads very fast via the production of large numbers of daughter tubers. For successful control, the depletion of the soil tuber bank is key. Nowadays, farmers apply different combinations of different control measures (chemical, mechanical, cultural, or thermal), depending on their farm-specific situations and opportunities. However, there is a lack of knowledge whether these strategies really provide sufficient and consistent *C. esculentus* control, and under which conditions. Thus, there is a need to identify promising strategies for future robust *C. esculentus* control. Present study has analysed the effectiveness of various farmers' control strategies undertaken in 54 *C. esculentus* infested fields (Belgium) during three consecutive years (2022, 2023, 2024). Hereto, on each field, an infested patch of 100 m^2 was demarcated using RTK-GPS. Every autumn (2021, 2022, 2023, 2024) these permanent sample plots were sampled to estimate their soil tuber bank. The sampling protocol consisted of taking 20 soil core samples 30 cm deep and 8 cm in diameter. After sampling, tubers were immediately extracted by wet sieving and subjected to a germination and a tetrazolium test to determine their viability. Data on control measures were yearly collected through farmer interviews. To identify the most promising control strategies, temporal variation in tuber bank density in each permanent plot was linked with historical data on control measures undertaken in these plots. During the experimental years, significant reductions in soil tuber bank were observed. For example, in 2022, a mean reduction of 54% was observed when maize was treated with preplant incorporated dimethenamid-P or S-metolachlor, followed by a post-emergence application with mesotrione plus pyridate. Season-long black fallows resulted in annual reductions in soil tuber bank up to 78%. However, their effectiveness varied widely over fields and years. Overall, results highlighted that efficacy of *C. esculentus* control strategies highly depended on climatic conditions and *C. esculentus* genetic background and that the more consistent and robust strategies were based on herbicide sequencies in maize and intensive black fallows leaning on combinations of thermal, mechanical and/or chemical methods.

This study was financially supported by Flanders Innovation and Entrepreneurship (VLAIO), grant number AIO.LAN.2021.0003.01.

PS3-39. Floristic analysis of anthropogenically modified and semi-natural riparian areas in Serbia (SE Europe)

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Riparian areas represent dynamic and fragile zones connecting rivers and the adjacent land, which host a mosaic of different vegetation types. These high biodiversity zones, which provide a wide array of ecosystem services have long been subjected to numerous anthropogenic pressures, leading to their degradation and changes in vegetation structure. Bearing this in mind, our aim was to analyze the floristic characteristics of the riparian vegetation of these anthropogenically affected areas across Serbia. A total of 203 riparian field sites situated along 38 rivers belonging to 9 catchment areas were studied for four years. Vegetation data was collected on 100 m long longitudinal transects, set up on the riverbank parallel to the river. Cover and abundance values were recorded, and field data were georeferenced. Plants were determined and their life form and areal types designated following the relevant literature, with their nomenclature following the Euro+Med PlantBase database. As a result of field research, a total of 299 taxa, belonging to 63 families were recorded. The most abundant families, based on the number of taxa were: Asteraceae (44 taxa), Poaceae (32), Fabaceae (19) and Lamiaceae (18). Plant species with the highest number of records across the analyzed field sites was *Xanthium strumarium* subsp. *italicum*, found at 138 field sites (68%). Regarding the biological spectrum of the analyzed vegetation, hemicryptophytes were the dominant life form (33,78%), followed by therophytes (26,09%) and phanerophytes (18,39%). Floristic elements were grouped into ten areal types, dominated by species of Eurasian origin (41,47%). The presence of 43 alien species is of special concern, with 26 of them being categorized as invasive in Serbia. Their number was negatively correlated with the altitude of the field site ($p<0.01$). While habitat type did not show any statistically significant effects on their number, catchment area was shown to be a strong predictor ($p<0.01$) of the number of alien species per field site. Further analysis should reveal the relations between the land use/land cover characteristics of the analyzed field sites and the overall plant diversity and floristic characteristics of the riparian vegetation.

The authors acknowledge the financial support of the Ministry of Science, Technological Development and Innovations of the Republic of Serbia (Contracts No. 451-03-66/2024-03/200010, 451-03-66/2024-03/200125 and 451-03-65/2024-03/200125).

10. Weed biology and physiology

S11-O1. Innovative modelling approaches for effective weed control in rice-wheat cropping system

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Weed management in Southeast Asia's critical rice-wheat cropping systems, where *Phalaris minor* and *Leptochloa chinensis* can sternly impact yields, poses a significant ecological challenge. Both weeds are non-native species to the Faisalabad region, with *P. minor* being indigenous to the Mediterranean, while *L. chinensis* originates from tropical Asia. A promising approach uses population-based threshold (PBT) models to predict weed seed germination timing and location, enhancing control methods. This study intended to predict the germination and emergence patterns of these weeds under several environmental conditions using PBT models. The trials involved exposing seeds of both weeds to a range of temperatures, water potentials, and light regimes under controlled environments with CRD design and three replications. PBT models were fitted to the data using R packages available at (https://pbtmodels.shinyapps.io/pbtm-app/). For *L. chinensis*, the highest germination percentage was observed at temperatures between 30 and 35°C, with optimal water potential ranging from 0 to -0.3 MPa. The base and ceiling temperatures were determined to be 12.7°C and 43.6°C, whereas the base water potential was found to be -0.41 MPa. Light was found to be critical for germination, as continuous darkness inhibited the process, resulting in a decline in germination compared to those getting 12 hours of light. In contrast, *P. minor* preferred germination and quick emergence at temperatures between 20 and 25°C, with optimal water potential 0 to -0.4 MPa. The PBT model for *P. minor* identified a base temperature of 3.3°C, and a ceiling temperature of 34.4°C, with a base water potential of -0.72 MPa. The developed model equations efficiently predicted germination behavior across fluctuating temperatures, showing a strong association between simulated and observed values. This research underscores the significance of PBT models in safeguarding future food security by predicting shifts in weed populations due to climate change. Understanding the relationship between seed germination and environmental factors allows for identifying optimal germination regions, and proposing critical insights for sustainable weed management.

S11-O2. Environmental regulation of dormancy release in *Echinochloa crus-galli* (L.) P. Beauv. seeds

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Echinochloa crus-galli is a problematic weed of summer crops. Understanding how *E. crus-galli* seed dormancy and germination is regulated by environmental factors is critical for effective management. This study investigated the effect of (i) post-maturation conditions (stratification and after-ripening), (ii) light and alternating temperatures (AT), (iii) wide variations in soil temperature, and (iv) seed water content (SWC) on dormancy release in *E. crus-galli* seeds. To achieve these objectives: (a) seeds were stored under two regimes: moist stratification at 5°C and 10°C, and dry after-ripening at 15°C and 25°C, for 80 days, (b) seeds were exposed to wide soil thermal fluctuations (10 → 5 → 15 → 20°C, 7 days per temperature) after 40 and 80 days of stratification at 10ºC, and (c) seeds were stored at 10ºC under a range of SWC (5.5 - 36.8%). During storage under the different experimental condition's germination was periodically assessed across a thermal range (10–35°C) and under different light (red, far-red and darkness) and AT conditions (10/24°C and 20/30°C). Our results showed that stratification provoked *E. crus-galli* seeds dormancy release and that 10ºC is more effective than 5ºC. The effect of light and AT on seed germination were dependent on dormancy level: highly dormant seeds required both light and AT to achieve higher germination values, whereas seeds with low dormancy bypassed the light requirement and germinated under any light condition with AT. Wide variations in soil temperature have opposite effects on *E. crus-galli* seeds, breaking dormancy if seeds are dormant or inducing dormancy if seeds are non-dormant, with optimal germination occurring at higher constant temperatures and under AT. Finally, SWC was found to modulate the rate of dormancy release during stratification above 16%, while below this value the dormancy release rate is almost constant. These findings advance our understanding of the environmental regulation of *E. crus-galli* seeds on dormancy and germination, offering insights for developing adaptive weed management strategies.

S11-O3. Seed base temperature and emergence of selected *Echinochloa crus-galli* populations

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This research aims to estimate the base temperature (T_b) and field emergence of eight *Echinochloa crus-galli* populations. Seeds from *E. crus-galli* populations were collected from maize fields from Denmark, Latvia, Germany, Czech Republic, France, Italy, Greece and Spain during summer 2023, and sent to Lleida (Spain). For each population, 50 seeds were placed in Petri dish and incubated on filter paper with distilled water at constant temperatures of 5, 8, 11, 14, 17, 20, 23, and 26 ºC, with 12h:12h photoperiod; four replicates were used. The germination of the seeds was followed daily, and germinated seeds were removed. The cumulative germination was plotted against time, and a sigmoid logistic model was applied to estimate time to 50 % emergence (T_{50}) at each constant temperature. The inverse of T_{50} was plotted against temperature and a linear regression was applied. The point where the regression line intercepts the *x* axis will be the T_b for each respective population. Additionally, 100 seeds per population were sown in November 2023 in the experimental fields of the University of Lleida with four replicates. A manual soil disturbance was done in late March, following the typical seedbed preparation for maize in the area; however, *E. crus-galli* emergence was first observed in February. Seedling emergence was monitored every three to four days from February to May 2024. The cumulative emergence was plotted against hydrothermal time (HTT), using the estimated T_b for each population, and considering -2.0 MPa as base water potential. The estimated T_b was within the range estimated in previous research, being lowest in France (7.5 ºC), followed by Italy and Greece (9.6 ºC), Germany (10.1 ºC), Czech Republic (10.5 ºC), Denmark (10.6 ºC) and Latvia (11.5 ºC). The estimated T_b for the Spanish population was unexpectedly high (15.9 ºC), likely due to low germination percentages, and requires further confirmation. Regarding field emergence, two population groups could be distinguished: those that emerged mainly during winter, before soil disturbance (Central and North European populations from Latvia, Czech Republic, Denmark and Germany), and those that emerged after soil disturbance (Italy, Spain and France). Regarding the Greek population, only 1% of emergence was observed before soil disturbance. The emergence of all populations could be described with Gompertz or Weibull sigmoid functions. The results show that most European populations have similar T_b values, around 10 ºC, but also highlighted the existence of at least two main groups according to their emergence behaviour.

S11-O4. Burial depth and temperature effects on seed germination of *Ambrosia trifida*: implication for weed management

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Ambrosia trifida is a problematic weed species in arable rotations dominated by summer annuals and its allergenic pollen can be harmful to human health. Accurately predicting seed germination timing is crucial for planning management strategies after soil tillage operations. Ploughing places *A. trifida* seeds deep into the soil where they may remain dormant until subsequent ploughing. When viable seeds are returned to the soil surface, they are exposed to light before reburial and elevated and varying temperatures, promoting germination. A no-till or shallow-till strategy may retain most of the *A. trifida* seeds at a shallow soil depth, which is favorable for germination, and where intensive weed control can effectively deplete the soil seed bank. Mixing seeds from different soil depths may stagger germination if they are at different levels of dormancy, causing difficulties in weed management. We aimed to increase understanding of how the burial depth of seeds prior to soil tillage impacts *A. trifida* seeds after tillage, by investigating the germination of seeds from different burial depths at different temperatures.

Three *A. trifida* populations from Serbia and Nebraska were buried in November 2018 at 5, 10, 15, 25, and 40 cm depths. During the experiments in 2019 and 2021, seeds were removed every month between April and July and tested for germination at 5, 10, 15, 20, 25, and 30 °C.

The results show that as the seeds' age increased, it took more time for them to germinate, i.e., they became more dormant. All populations germinated rapidly after shallow burial, but the rate of germination decreased with burial depth. The rate of germination increased, and latency decreased with increasing temperature. Therefore, mixing seeds from different depths could cause uneven seed germination and difficulties in weed management. This implies that tillage systems that do not mix soils from different soil layers result in more predictable germination and that shallow cultivation has the potential to empty the soil seed bank if maintained over time.

Acknowledgements: Ministarstvo nauke, tehnoloskog razvoja inovacija, Grant/Award Number: 451-03-136/2025-03/200010; COST (European Cooperation in Science and Technology) Action, CA21134 - Towardszer0Pesticide AGRIculture: European Network for sustainability (T0P-AGRI-Network)

Funding was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (451-03-66/2024-03/200010), COST Action CA21134 - Towards zer0 Pesticide AGRIculture: European Network for sustainability (T0P-AGRI-Network).

PS3-40. Effect of seed water content and storage temperature on the dormancy release rate of *Amaranthus hybridus* seeds

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There is evidence that low winter temperatures trigger dormancy release in *Amaranthus hybridus* L. (smooth pigweed) seeds. However, the role of seed water content in modulating this effect remains poorly understood. This study aimed to investigate how seed water content influences dormancy release rate in *A. hybridus* seeds stored at low temperatures. Two experiments were conducted to modify seed water content during storage. In the first experiment, freshly dispersed seeds were stored at 10°C in sealed tubes containing: (a) silica gel, (b) saturated salts, or (c) water, creating different controlled relative humidity conditions inside the tubes. These conditions resulted in seven seed water content values: 7.7%, 8.5%, 17.6%, 19.8%, 24.5%, 27.3%, and 33.6%. In the second experiment, freshly dispersed seeds were placed on trays with moist paper for increasing times (0, 3, 6, 8, 24, and 48 hours), resulting in a gradient of seed water content (15.6%, 20.7%, 21.2%, 24.9%, 26.6%, 29.8%, and 36.9%). These seeds were then stored at 10°C, with additional storage at 5°C and 15°C for seed water contents of 26.6% and 36.9%. For both experiments, germination was quantified at 20, 40, 60, and 90 days of storage by incubating seeds in water at 15°C, 20°C, 25°C, and 30°C. The results revealed a threshold seed water content of 15.9%, below which no significant changes in dormancy were observed. Above this threshold, dormancy release rate slightly increased up to a seed water content of 25.3%. Beyond this point, the dormancy release rate sharply increased, reaching its maximum at a seed water content of 33.6%. At 36.9%, the dormancy release rate decreased. Regarding storage temperatures, the highest dormancy release rate occurred at 10°C, with a decline at 5°C and 15°C. Based on obtained data we developed a model to predict dormancy release rate in this species based on seed water content and soil temperature.

Acknowledgement(s) / funding: UBAINT 2025 Doctoral Grant; CONICET 2024 Doctoral Completion Grant; UBACYT-20020130100653BA; ANPCyT PICT 2018-03546; ANPCyT PICT-2021-00563.

PS3-41. Modelling the emergence of *Kochia scoparia* in the NE of Spain

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Kochia scoparia, also known as *Bassia scoparia*, is a troublesome weed species in the Great Plains of the USA and Canada where it has developed herbicide resistance to several Modes of Action. The presence of this weed has increased the last decades in the Ebro Basin, in the NE of Spain, where it affects winter and summer cereals, fruit orchards, olives and almond trees, and where populations resistant to glyphosate, ALS inhibitors and synthetic auxins have been confirmed.

Initially, the lack of control of this weed during summer was attributed to its late germination but research in the USA and Canada showed that germination begins between late winter and early spring. To confirm this, the objective of this work was to develop an emergence model for NE Spain conditions, based on hydrothermal time. A two-year field experiment was performed in three different locations. Precipitation and temperature data was obtained from a weather station belonging to the regional Government of Catalonia and was used to study the historical emergence dates of *Kochia*. Base temperature for emergence was established at 7.5 ºC, first emergences were already recorded in February, and ended by May. A log-logistic model was successfully applied to the cumulated emergence of the weed (RMSE < 12) for all locations and years. In 2023, the lack of rains delayed the beginning of the emergence, which ended the last week of May. Based on these data, first emergence in the reference location (Verdú), was historically on 10th January and the last emergence on 27th May.

The emergence behavior of *Kochia* is similar to that observed in North America. A hydrothermal time-based emergence model was successfully developed for NE Spain. This model can be used to predict future *Kochia* emergences based on weather forecast and design management strategies for its control.

PS3-42. A renewed typology of perennial weeds according to their clonal traits and growth forms in arable crops to enhance research in sustainable weed management

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Context. Perennial-weed management is one of the most critical issues for sustainable agriculture. These clonal-weed species spread rapidly and regenerate through vegetative propagation, making them particularly difficult to control without systemic herbicides or intensive tillage. Until now, research on the ecology and biology of weeds has focused mainly on annual weeds, overlooking perennial weeds, whose growth forms are nonetheless very diverse and complex. To identify sustainable, non-chemical perennial-weed-management strategies, it is crucial to increase our knowledge of the biological properties of these weeds that are linked to their ability to spread and regenerate, which condition their effects and responses to management techniques. To date, few studies have been carried out to characterize and classify perennial weeds according to key functional traits and behavior in cultivated fields, and these are imprecise and sometimes inconsistent with each other.

Methods. An in-depth bibliographical study was carried out, combining knowledge from contrasted disciplines. Especially, we combined knowledge from 1) work in weed science on life cycle, anatomy and ecophysiology in the field for frequent perennial weeds in arable crops in European countries and 2) work in functional ecology analyzing clonal-plant growth forms, storage organs and bud bank traits for species of various habitats.

Results. We proposed a renewed and enlightening categorization of the most common and problematic perennial weeds in arable crops of temperate regions, based on a description of their growth forms and known functional traits (e.g., organ type, form and positioning, reserve compound, vegetative-bud growth). We emphasized the lack of terminology and knowledge on clonal traits to characterize the contrasted behavior of very harmful species (e.g., *Elymus repens* vs. *Tussilago farfara*; *Cirsium arvense* vs. *Convolvulus arvensis*) and to better describe their storage organs.

Conclusion. This synthesis will allow 1) to provide food for thought on the differential responses of perennial-weed species to management techniques and 2) serve as a foundation for future research into comparative biology and ecology of perennial-weed species, identifying key biological traits that need to be better described. Especially, this new knowledge could feed cropping system models, tools that are increasingly used to design and fine-tune sustainable weed management strategies.

Acknowledgement(s) / funding: INRAE, the French Ministry of Research (PhD grant of S. Skorupinski), the French project COPRAA supported by the Office Français de la Biodiversité (OFB) and Be-Creative (ANR-20-PCPA-0001) funded by the Agence Nationale de la Recherche.

PS3-44. Waterhemp emergence dynamics across U.S. latitudes: influence of tillage and cereal rye cover crop

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Understanding weed seedling emergence dynamics is key to understanding weed demographics and direct suitable management tactics. Common waterhemp (*Amaranthus tuberculatus*) is a challenging weed in row-crop production in the US. However, there is a knowledge gap regarding its seedling emergence dynamics, particularly under different management regimes. This study examined the influence of tillage practices and cover crop integration on waterhemp seedling emergence across a latitudinal gradient (Wisconsin, Illinois, Arkansas, and Texas). We hypothesized that manipulation of tillage practices and inclusion of a cereal rye (*Secale cereale*) cover can help alter seedling emergence patterns. Conducted from fall 2022 to late fall 2023 and fall 2023 to late fall 2024, the study used a split-plot design with three primary tillage treatments: 1) fall tillage followed by spring tillage, 2) fall tillage only, and 3) no-tillage, combined with subplot treatments of cereal rye versus fallow. Waterhemp seedlings were counted weekly from the first emergence until emergence ceased. Cumulative emergence was modeled using a three-parameter Weibull function based on thermal time (Growing Degree Days, GDD). A two-way ANOVA with a Generalized Linear Model (GLM) assessed the impact of tillage and cereal rye on total seedling emergence count. Results indicated that fall tillage followed by spring tillage led to earlier and more rapid emergence, while cereal rye extended the emergence periodicity. Regional variations were observed: in northern regions (Wisconsin and Illinois), fall tillage resulted in gradual and consistent emergence, whereas in southern regions (Arkansas and Texas), it delayed emergence, concentrating it into a shorter period, particularly in the absence of rye. No-tillage combined with rye significantly delayed emergence and expanded the emergence window, especially in southern locations. Cereal rye suppressed waterhemp emergence in most locations, except Wisconsin. These findings suggest that while rye is effective in both altering suppressing waterhemp emergence, tillage practices play a significant role in modulating emergence timing. This study offers novel insights into how tillage, cover crops, and regional environmental factors influence waterhemp emergence. Further research should explore the long-term effects of these strategies on emergence dynamics.

PS3-45. Maternal environment regulates seed dormancy and longevity to maximise reproductive fitness of *Lolium multiflorum* offspring

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Seed dormancy and longevity are crucial factors that influence the dynamics of soil seed banks and the field emergence patterns of weedy species. Both processes are influenced by environmental conditions during seed development and maturation on the mother plant, often referred to as the maternal environment. However, the impact of the maternal environment on seed dormancy, longevity, and field emergence patterns has been scarcely explored, particularly in autumn-winter species. This study aimed to investigate how variations in the maternal environment experienced by *Lolium multiflorum* L. (annual ryegrass) seeds, resulting from different emergence dates (*i.e.*, different cohorts) influence seed bank dormancy, longevity, and post-dispersal emergence patterns.

Plants were sown in pots within their emergence window (early autumn to late winter) on three dates in 2021 and 2022 and on two dates in 2023 and 2024. In 2022, additional sowings were made in field plots on four dates. For each sowing date, data were collected on time of flowering and dispersal, seed production, primary dormancy, dormancy release and seed longevity. Seed dormancy was assessed at dispersal by incubating seeds at temperatures ranging from 5 to 30°C. Seed longevity was assessed by an accelerated ageing test at 40°C and 75% relative humidity. Seeds from each sowing date were also buried in the field and seedling emergence was monitored weekly. Viability of seeds from the ageing tests and non-emerged seeds was tested by germination at 10°C followed by a tetrazolium test for non-germinated seeds.

The results indicated that seed production was reduced in late emergence cohorts. Those seeds also had lower dormancy and increased longevity than seeds from early emergence cohorts, which was associated with higher temperatures during seed maturation. The proportion of emerged seedlings was higher for seeds from late emergence cohorts, but the moment of emergence occurred simultaneously for seeds from all cohorts. These findings suggest that the maternal environment regulates seed dormancy and longevity, increasing emergence of seeds from late cohorts and synchronizing it with the emergence of seeds from early cohorts. This mechanism maximises the reproductive fitness of late emergence cohorts by increasing seed production in the following generation.

Acknowledgement(s) / funding: UBAINT 2025 Doctoral Grant; CONICET 2024 Doctoral Completion Grant; UBACYT-20020130100653BA; ANPCyT PICT 2018-03546; ANPCyT PICT-2021-00563.

PS3-46. Base water potential of selected *Echinochloa crus-galli* populations

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This study examines the base water potential (Ψ_b) required for germination in several European populations of *Echinochloa crus-galli*, a significant agricultural weed, from Spain, Greece, Norway, and the Czech Republic. Seeds were collected in summer/autumn 2023 and sent to the University of Padova (Italy). Initial germination tests revealed varying dormancy levels among populations. To uniformly break seed dormancy, seeds were scarified with 96% sulphuric acid for 8 minutes, thoroughly washed with distilled water, and air-dried for 48 hours. Germination trials were conducted at constant 24 °C to estimate Ψ_b using polyethylene glycol (PEG) 6000 to simulate eight water potentials (-0.05, -0.10, -0.25, -0.38, -0.50, -0.80, -1.00, -1.25 MPa); additionally, distilled water was used as control. For each population and water potential, four replicates of 50 seeds were tested. Germination was monitored every 2-3 days germinated seeds were recorded and removed. Besides, physical seed traits, including total area, perimeter, and circularity, were analysed by scanning 100 randomly selected seeds per population and processing images in ImageJ software. Statistical analyses in R were used to estimate Ψ_b with drc and drcSeeds packages, differences between Ψ_b were examined using Student's t-test. Differences in seed dimensions among populations were assessed via one-way ANOVA and Tukey's HSD post hoc test ($p < 0.05$). Results revealed significant variation in Ψ_b and seed traits. The Norwegian population had the lowest Ψ_b (-1.81 ± 0.04 MPa), indicating greater drought tolerance, followed by the Greek population (-1.11 ± 0.01 MPa). The Spanish and Czech populations showed the highest Ψ_b (-0.93 ± 0.01 MPa and -0.92 ± 0.01 MPa, respectively), with no significant difference between them. Seed dimensions also differed significantly, the Spanish population had the smallest seeds (1.61 ± 0.02 mm²) and the most spherical shapes, while the Greek population had the largest seeds (2.79 ± 0.08 mm²), and Norwegian seeds were the most elongated. These findings provide valuable insights into the germination patterns of *E. crus-galli* and seed traits across different populations. Furthermore, these results are crucial for the development of predictive models for weed emergence, offering practical applications for improving management strategies for this globally problematic species.

PS3-47. Estimation of seed persistence in soil seed bank in *Echinochloa crus-galli* and *Avena fatua* in Latvia

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Wild oat (*Avena fatua*) and barnyard grass (*Echinochloa crus-galli*) are troublesome, economically important weeds distributed worldwide. In Latvia, both species often occur in cereal fields and *E. crus-galli* is also common in vegetable and maize fields. Information on seed persistence in soil seed bank that is available in the literature varies and may depend on the region where the research was conducted. Therefore, to plan the soil seedbank management and model population dynamics of these species, it is necessary to test persistence in different regions and at different soil conditions. We conducted a seed burial experiment using seeds collected in different plant populations in different years. Seeds were buried in two different sites and recovered at intervals to estimate the proportion of remaining viable seeds. Burial site and depth were crucial factors for persistence of *E. crus-galli* seeds, irrespective of seed origin and morphological properties. More seeds survived at greater depth and in soil with high organic matter content in the site located in a meadow. In *A. fatua*, seed persistence varied more depending on the place and year of seed collection, rather than burial depth. Seed persistence may be positively related to seed mass and hull thickness. This research was funded by the Latvian Council of Science, project Characterization and dynamics of seed-associated microbiome in weed soilseed-bank, project No. lzp-2020/1-0163.

Acknowledgement(s) / funding: Latvian Council of Science, project No. lzp-2020/1-0163.

PS3-48. Weed management in rice: modelling *Oryza sativa* (weedy rice) emergence dynamics

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The proper management of weeds is crucial in rice cultivation, significantly impacting crop yield. The success of chemical and non-chemical weed control methods depends on their precise application timing. To address this, predictive models have been developed to understand weed emergence patterns, enabling more accurate treatment scheduling, optimizing chemical and mechanical methods, and reducing herbicide use. In this study, which is part of the RiWeCIS* (Rice Weeds Control with Innovation Systems) project, the main objective is to develop a predictive model for the main rice weed, *Oryza sativa* (weedy rice), adapted to the complexities of rice fields. The methodology involved 9 populations of *O. sativa* from different fields located in the Lombardy region. Base temperatures and emergence dynamics data from the populations were evaluated and used to develop predictive models based on the thermal time concept. Petri dish tests were set up for each ecotype to establish the base temperature, with four replicates for each temperature ranging from 9° to 36°C, with 3°C intervals. 25 seeds of *O. sativa* were sown in each dish. The emergence dynamics of the populations were tested through an outdoor trial under semi-controlled conditions with 3 replicates of 500 seeds per population. The base temperature ranged from 7.51 ± 0.47 °C to 10.26 ± 0.34 °C. The emergence model development produced promising results even if the model still has not been validated in the field. This project's results encourage further experimentation with predictive models for *O. sativa*. Additional years of study in different weather conditions and field settings will be necessary to build a more robust model. This work contributes to the development of decision support systems, providing rice farmers with adaptable, data-driven tools for sustainable weed management in diverse agricultural settings.

This research has funded by the European Union - Next Generation EU, Mission 4 Component 1, CUP B53D23017800006.

PS3-49. Survival of *Echinochloa crus-galli* and *Avena fatua* seeds in anaerobic digestion

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Anaerobic digestion of animal and plant residuals provides a dual advantage by generating both bioenergy and fertilizers. One significant benefit of utilizing digestate (biogas residue) as a fertilizer is its ability to minimize nutrient loss by reintegrating organic matter into the agricultural nutrient cycle. However, applying digestates as fertilizers poses potential risks, such as the spread of weed seeds, plant and human pathogens, or other pollutants. Weed seeds may enter the biogas production chain through plant biomass or manure. If these seeds survive the anaerobic digestion process, their dispersal with the digestate could lead to future weed infestations. We used continuous lab-scale biogas reactors fed with livestock manure, dead-fish silage, fish sludge from land-based smolt plants, and glycol (10 L; 38–40°C; 10 rpm) to assess the survival of *Echinochloa crus-galli* (barnyard grass) and *Avena fatua* (wild oat) seeds during anaerobic digestion. For each species, 18 replicates of 50 seeds were placed in heat-tolerant permeable polypropylene fleece bags. Half of these bags underwent dry heat treatment at 70°C for two hours before the experiment, while the other half remained untreated. The seed bags were wrapped around a metal bar and immersed in the liquid of the biogas reactor. One bar was used for each weed species. Seed samples- three replicates of each heat-treated and untreated seeds- were collected after 10, 24, and 43 days of digestion, respectively. Un-treated and heat-treated seeds were used as controls. The experiment was repeated in a second reactor with identical conditions. Seed survival was then assessed through germination tests in a greenhouse (20/16°C and 16/8 h day/night; 65% RH). Results indicated that although untreated and heat-treated seeds of *E. crus-galli* and *A. fatua* exhibited germination rates of 80–90%, no seeds from either species survived the anaerobic digestion process, regardless of prior heat treatment.

PS3-50. Effect of seed priming on germination and emergence rate in five species as cover crops against weed flora.

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The lack of sufficient soil moisture or the prevalence of low temperatures at sowing stage are considered important obstacles to rapid and uniform germination, as well as to plant growth, during the early stages of cultivation. Cover crops have been widely adopted as an integrated pest management component in agriculture. The aim of this study was to evaluate the effect of hydro priming, of bio priming and the combination of them, on emergence rate and improved agronomic traits for selection as cover crops. A specific protocol was applied with *Bacilus subtilis* seed suspension (strain NCBI 3610; ATTC 6051), standardized by the collaborators from the University of Pavia, Italy. Five species were selected, *Lathyrus sativus*, *Pisum sativum*, *Trifolium subterraneum*, *Vicia* sativa and *Hordeum vulgare*. Two experiments were arranged as a completely randomized block design with three replications and four treatments per species, control (T1), hydro priming (T2), bio priming (T3) and a combination of hydro + bio priming (T4). The first experiment was conducted in a growth chamber with 20 seeds per petri dish. The effect of the seed priming on germination rate (GR), was investigated. The results indicate that (T4) increased (GR) in all species compared to the control with ($p \leq 0.05$). On average, (GR) increased for lathyrus by 5%, for clover by 9%, for common vetch by 7.4%, for forage pea by 7.3% and for barley by 3%. Additionally, the radicle fresh weight, radicle length, plumule fresh weight and plumule length were measured. The results showed that (T4) compared to the control, had significantly higher effects on radicle fresh weight and radicle length with ($p \leq 0.05$). Also, 20 seeds were sowed on a mixture of loam soil and perlite in a 1:3 (w/w) ratio, and germination rate (GR), root fresh weight (RFW), root length (RL) and shoot length (SL) were measured. The results indicate that (GR) increased in the (T4) compared to control in all species. Increased by 8% in Lathyrus, by 11% in clover, 14% in common vetch, by 7% in forage pea and by 24% in barley. For (T4), (RFW) and (RL) were increased compared to the control with ($p \leq 0.05$). Also, for (T4) compared to the control, (SL) increased for grass pea by 1.2%, and for forage pea by 2.5%, while no significant differences observed for clover, common vetch and barley. The data from this study indicate that hydro-bio priming can increase the germination and emergence rate in seeds of cover crops and enhance the weed competition.

PS3-51. *Sonchus arvensis* in a common garden experiment

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Sonchus arvensis L. (perennial sow-thistle) is a perennial weed native in Europe. Common in arable fields, the species causes problems to crop production, especially in Northern Europe and Northern America. In recent years, in Europe a southern move of *S. arvensis* towards has been observed by farmers. With a common garden experiment, we want to analyse the adaptation and spreading potential of different *S. arvensis* populations under the climatic conditions of Braunschweig, Germany. *Sonchus arvensis* populations from Belgium, United Kingdom, France, Norway, Finland, Denmark, Sweden and Germany were included in this experiment.

The common garden experiment is conducted outdoors using 10x1m trays, each divided into eight sections. *Sonchus arvensis* populations from all countries are represented in each tray, ensuring that each tray serves as a single replication. Populations were planted as fragmented roots (ramets) and/or seeds. All roots were cut in 5cm ramets before planting. The experiment started in November 2024 with planting of the ramets. As germination from seeds requires higher temperatures, seedlings from germinated seeds will be planted in spring 2025. The germination rate of the seeds will also be tested in outdoor pots.

The development of *S. arvensis* plants emerging from ramets vs. seeds will be assessed for the different populations. Assessments include time of sprouting from ramets, the below-ground root biomass at the end of the experiment and weekly measurements of the number of leaves, plant height and diameter, number of (bud-, flower-, seed-) heads and number of seeds per head. The first results of the experiment ongoing in 2025 will be presented.

We thank Benny de Cauwer, Richard Hull, Guillaume Adeux, Kirsten Tørresen, Jukka Salonen, Christoph von Redwitz, Daniel Körbächer and Aleksandra Savic for providing *S. arvensis* roots and seeds for the experiments.

PS3-52. Weed seed reference collection for important Norwegian weeds

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Seed collections and databases are established worldwide and tailored to meet different needs and preferences including preserving genetic resources and availability of the research material. In the case of weeds, as the primary contributor to economic loss in crop production, a seed collection may help to unravel their adaptive evolutions likely due to the selective pressures (e.g., herbicide) and contribute to their control. In 2023 a reference seed collection for weeds was established at the Norwegian Institute of Bioeconomy Research (NIBIO) including weed seeds for selected weed species.

Initially, seeds were collected for 59 species where several populations were collected for some species. The selection was based on the most economically important weeds in Norway. Collected material was dried at room temperature in paper bags, cleaned and moved to labelled plastic containers for permanent storage. Germination tests were carried out in growth chambers. A database for collected species was created in 2024 using Microsoft Access databases. The database contains information about the collection date and location, collector name, storage conditions, seed number and weight, biological status of each accession, and the germination percentage. For more comprehensive data registration of collected weed seeds a literature review was conducted, and similar databases were studied.

The collection is going to be renewed every year for the present populations of weeds while adding new weed species is a long-term plan. Further development of the collection is important for the maintenance of existing services related to biology and weed control, as well as creating possible international collaborations.

This work has been funded through 1) the Norwegian Institute of Bioeconomy Research (NIBIO) base funds from the Ministry of Agriculture and Food and 2) the project “Weeds vs. Crops: the winner of climate change” financed by the Norwegian Institute of Bioeconomy Research (NIBIO) base funds from the Research Council of Norway (Contract number 342631/L10).

PS3-53. Activities of the Soil Seed Bank, Germination and Early Growth working group of the EWRS

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The Soil Seed Bank, Germination and Early Growth Working Group (WG) is a joint group of EWRS members. The main objective of this WG is to promote collaboration between participants to achieve common goals within the scope of initial growth stages of weeds, either annual or perennial, from seed dispersal to early growth stages of the seedlings. This includes addressing the challenges associated with controlling weeds during these critical stages of their development. The primary collaborative activities are joint experiments that could produce publications in scientific journals, preferably in Weed Research. Currently, a joint experiment, initiated in 2023, is underway to estimate the base temperature and base water potential of 32 populations of *Echinochloa crus-galli* collected from maize fields throughout Europe and the Middle East. This research was designed upon the knowledge generated by the WG's previous common experiment on *E. crus-galli* (2015-2017), that were published in three articles in 2022. Additionally, the WG organizes workshops, the last one held in Perugia in June 2023, to facilitate the exchange of knowledge and foster collaboration, present and discuss research finding with other fellow members. In recent years, the WG has also organized various courses for its participants. In this context, an R course for modelling seed germination and seedling emergence was organized in Perugia in 2023, with Andrea Onofri serving as lecturer. In 2024, a course on weed seedling identification was organized in Lleida, with Aritz Royo-Esnal and Joel Torra as lecturers. These courses aim to enhance the participants' skills and knowledge, contributing to the group's overall research and weed management efforts. The group is open to collaborations and new ideas are welcome.

PS3-54. Emergence of natural rice field populations of *Echinochloa* in Catalonia

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Echinochloa is a worst weed genus in rice worldwide. Its management is difficult, and the situation in Catalonia has worsened over time, mainly in the last years, because of lack of effective control tools and of the presence of herbicide resistant biotypes, mainly to Groups 1 and 2. The scarce authorized active ingredients different to these groups reduces the range of control strategies for this genus species. Within this scenario, integrated weed management is mandatory, which include alternative management methods. The coexistence of different *Echinochloa* species in different proportions in rice fields require the study of the behaviour of these populations, so that adequate weed control methods are applied. To accomplish this objective, the Plant Health Service of the Catalan Government established in 2023 an integrated weed management program that includes the implementation of different tools and strategies to successfully control these species in the Catalonian rice fields. In the present work, the main objective was to model the emergence of these populations, so that the best cropping strategies regarding sowing dates and control treatments could be established. For this, the emergence behaviour of four commercial rice field populations of the Ebro Delta, with different proportions of *Echinochloa* species, including *E. crus-galli*, *E. oryzoides* and *E. oryzicola*. In the first field, *E. oryzoides* was the most abundant species, in the second one, it was *E. oryzicola*, and in the last two fields no species prevailed. In three of the fields, rice was flooded, and the fourth one was dry seeded. The emergence of *Echinochloa* species was followed every two-three day from beginning of April to late June, after which no more emergences were observed. The first-year results show an exponential increase of *Echinochloa* emergence after the first flooding date but, interestingly, in the dry seeded field, several emergence fluxes where observed, the first one being before flooding. This result might be explained by the presence of *E. crus-galli*, which does not need the field to be flooded to begin its emergence, which happens at about 180 growing degree days (GDD). The second flux in this field coincided with that occurred in the field where *E. oryzicola* prevailed, at about 485 GDD, while the field population where *E. oryzoides* was the prevailing species, the emergence flux occurred at about 585 GDD. This work underlines some of the different casuistries that can be found in the Catalan rice fields, and the need of applying specific strategies for the management of these populations. The study was carried out with the collaboration of the University of Lleida.

PS3-55. The complete genome sequence of *Eragrostis plana*: an important invasive plant on South America rangelands

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The problem of biological invasions is considered one of the major global concerns threatening biodiversity. *Eragrostis plana* is a C4, perennial, clump-forming grass which has been invaded the Pampa region across Argentina, Brazil, Paraguay, and Uruguay in South America. This region is characterised by its uniquely fertile grasslands and exceptional flora and fauna making it a region that needs to be protected for both biodiversity and economic reasons. The management strategies adopted to contain the invasion of *E. plana* mitigate it, but do not prevent it. Therefore, new technologies are urgently required to control the spread and persistence of *E. plana* in the Pampa region. Access to genomes and genomic resources for invasive/weed species provides insights into the traits that underpin their success across myriad conditions and environments. Here, we present the complete genome assembly for *E. plana*. Using short and long reads from Illumina and Nanopore sequencing technologies, polished with a high-throughput/resolution chromosome conformation captured-based (Hi-C), we have generated a genome assembly that has a total size of 426 Mb into 6,943 scaffolds with a N50 of 35.6 Mb. BUSCO analysis indicated a completeness of 96% of Poales genes. RNA-Seq was also performed on *E. plana* plants from leaf material at 5-6 tiller stage which identifies 56,192 protein-coding genes. This understanding of the global transcript profile during the early developmental stages of *E. plana* was possible due to our high-quality genome and offers valuable insights for developing strategies to control its invasion. This novel, high-quality genome adds to the genomic resources available for the *Eragrostis* genus but more importantly represents an important first step toward new management tools based on biotechnology.

PS3-56. The effect of hydrosols on the germination of ryegrass (*Lolium* spp.) seeds

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Excessive use of chemical herbicides is causing numerous environmental changes. Therefore, finding effective alternatives to chemical agents is increasingly urgent. Bioherbicides have great potential for successfully controlling weeds in an environmentally friendly way. Plant extracts, essential oils, and hydrosols are particularly highlighted in this context. Due to their specific properties, hydrosols—byproducts of essential oil production—have attracted the attention of many scientists who are exploring their potential as bioherbicides. Hydrosols are relatively harmless to the environment and human health, and they are inexpensive to produce. This study investigated the effects of peppermint (*Mentha × piperita* L.), lavender (*Lavandula × intermedia*), and mastic tree (*Pistacia lentiscus* L.) hydrosols on the germination of ryegrass (*Lolium* spp.) seeds. The experiment was conducted under laboratory conditions in Petri dishes with filter paper soaked in undiluted and diluted (50:50) hydrosol, with distilled water used as a control. Each dish contained 30 seeds, and 3 mL of hydrosol was added. The experiment consisted of six treatments and five replications. The effect of the hydrosols on seed germination was assessed by calculating the percentage of germinated seeds on the fifth and seventh days after the experiment was initiated. Both undiluted and diluted hydrosols showed complete (100%) inhibition of ryegrass seed germination, while the control group's germination rate averaged 75%.

PS3-57. The role of fire in the germination of invasive plants in Mediterranean environments: A meta-analysis

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Fire is a key trigger for the germination of serotinous plants in Mediterranean environments. Despite the availability of ample investigations into how fire contributes to plant fitness and germination patterns in pyriscent plants, there is no published content on how fire and associated heat and smoke factors influence germination of the group of plants successfully invading a particular biome. In this meta-analytic study, 29 studies were collated regarding the effects on germination of the temperature range corresponding to Mediterranean subsoil fire temperatures (50–99 ◦C), and a further 29 experiments were used to reveal the effects on germination of soil surface temperatures (100–120 ◦C) during Mediterranean fires. 24 studies were selected to investigate the effects of smoke during a shorter and longer exposure duration to reveal the boundaries of imbibition and toxicity associated with fire smoke. The chosen experiments performed heat shocks or smoke treatments on the invasive species found in the Mediterranean biome- a part of the globe that experiences periodic, extensive fire regimes. These experiments were then subsequently categorized into herbaceous or ligneous plants to study whether type of serotiny is associated with morphology life history. The results showed that generally, soil fire temperatures have a positive effect on the germination rate of invasive plants but only significantly in the case of invasive ligneous plants. Additionally, subsoil fire temperatures trigger invasive plant germination significantly, whereas soil surface fire temperatures do not. Only short exposure periods (c.a. 5 min) to smoke produced a positive effect in the germination of invasive plants. Longer exposures can be toxic and prevent germination. Herbaceous invasive plants responded positively to smoke treatments and ligneous invasive plants responded positively to heat shock. Our results highlight the importance of fire components (high tem- perature and smoke) in the success of many invasive plant species in Mediterranean environments.

11. Weed management on non-agricultural land

S12-O1. The impact of plant and patch-level characteristics on False Codling Moth infestations in Castor plant patches across northern Israel

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Keynote session

The False Codling Moth (FCM), *Thaumatotibia leucotreta*, is a significant quarantine pest. FCM is a highly polyphagous fruit borer that affects over 70 host-plant species, including economically important crops like citrus and avocado. In Israel, FCM has become a major threat, impacting yields and the ability to access export markets. The Castor plant (*Ricinus communis*), an invasive perennial weed, serves as a key host of FCM in Israel. The extensive presence of Castor plants in disturbed habitats near orchards contributes to the persistence and spread of FCM populations, and consequently increases the risk of crop reinfestations. To mitigate and suppress FCM spread, an area-wide Integrated Pest Management (IPM) approach is needed, taking into account the ecological interactions between the two species.

The aim of our research is to provide essential insights in to the ecological factors influencing the presence and abundance of FCM in Castor plant patches, that may be further manipulated to control the pest via Castor plant management in an area-wide scale.

We conducted a field survey at different sites across Israel, seeking for individual-plant and patch-level characteristics that correlate with FCM abundances. Based on population ecology hypotheses, we designed a causal inference framework to estimate the causal relation between the pest and its host. Each hypothesis was statistically analyzed by Generalized linear mixed model.

The results indicate that Castor plants adjacent to surface water, particularly vigorous plants, have greater FCM infestation. However, larger patches were less infested. This may be due to greater distances between host-plants within larger patches, which could negatively affect within-patch migration and subsequently reduce FCM abundance.

Since patch characteristics may be manageable through treatment of Castor plants, improving our understanding of FCM population ecology in relation to its weedy host is crucial for designing effective, area-wide management strategies to mitigate FCM infestation and minimize crop risks on a landscape scale. By distinguishing Castor patches within the agricultural landscape based on their characteristics, an IPM approach can aid in prioritizing the management of patches with higher infestation risks and target individual Castor plant characteristics to enhance the success of control efforts.

S12-O2. Invasive turned weed – ecology and management of *Gazania* species in Australia

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Australia is home to numerous introduced invasive species. Some of them have been introduced as ornamental, garden plants. The introduction of gazania species is one such example. Two species, *Gazania linearis* and *G. rigens* have been introduced to Australia from South Africa and are widespread across southern and western Australia in a variety of habitats, including coastal sand dunes, pasture/grassland systems, roadsides, and natural ecosystems. These species outcross extensively and the whole complex of species is generally referred to as the *Gazania* spp. The plants are highly invasive, drought-hardy, and are massive seed producers. Due to their established status as environmental weed and significant negative ecological impacts, they are declared weed species in South Australia. In recent years, there have been reports of *Gazania* spp. infestations in grain production fields in the Victorian and South Australian Mallee, Riverland, and Wimmera regions. To deal with this rapidly establishing weed in cropping systems, research is underway to map their incidence in the southern grain producing region and develop effective management strategies. The surveys to date have revealed that *Gazania* spp. are getting hold into the cropping fields in the Riverland region with expedited incursions from horticultural crops in which they have existed for long time. Recent wet years and high seed load with easy dispersal may have contributed to these incursions. Our studies so far have also revealed significant flexibility and variation in seed germination ability of various populations, which might be a contributing factor toward their variable invasion and might limit their effective management. Research is underway to further understand the dispersal pathways, seed ecology and to develop chemical control strategies for grain production systems. The outcomes of this work will help manage these problematic weeds in their relatively early invasion stage in the broadacre agriculture in the Southern region.

Acknowledgement(s) / funding: Grains Research & Development Corporation, Australia.

S12-O3. Do wider field margins really host more diversity and less weeds? An example in north-eastern spain

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In the conservation of field margins in productive areas, it is essential to define the width that functions as a refuge for biodiversity. The aim was to characterize and compare the vegetation composition of field margins of different width in cereal systems in several regions of Aragon. During spring of 2024 the abundance of plants present in 200 meters of field margins, classified as wide or narrow (wider or less than 2 meters, respectively), was determined in five locations. Statistical analysis was using R software analyzing data with ANOVA, the Tukey mean separation test ($P<0.05$) and performing linear regressions. Total plant cover exceeding 75% in all cases, although the abundance of entomophily dicotyledonous species was higher ($P<0.001$) in the wide margins (52.4 vs 19%), mainly due to the presence of shrub species such as *Retama sphaerocarpa*, *Rubus idaeus* and *Genista pumila*. Wide margins also presented a higher ($P<0.001$) Shannon diversity index (3.2 vs 1.9) and richness of botanical families (16.9 vs 11.4). Likewise, differences were found between sites for diversity and abundance of entomophily plants. Species richness was higher in three sites, while no significant differences were found in the remaining ones. Diversity ($P<0.01$, $R^2=0.25$), species richness ($P<0.01$, $R^2=0.48$) and botanical families ($P<0.01$, $R^2=0.60$), and abundance of entomophily species were positively correlated to width ($P<0.01$, $R^2=0.42$). In narrow margins there was a predominant abundance (≥45%) of some perennial species, mostly monocotyledonous like *Agropyron spp*. In fact, there was a negative relationship ($P=0.04$, $R^2=0.13$) between the abundance of anemophily monocotyledonous species and the width of the margin. In most of the cases, no significant differences were found in the weed number between both types of margins, although this value was negatively correlated to the width ($P=0.02$, $R^2=0.16$) and the cover of perennial species of the margin ($P=0.02$, $R^2=0.15$). The results would indicate for different environments in the region an influence of the width of the margin on the quality of the crop margins as a refuge for diversity. Width greater than 2 meters increases plant diversity, richness, abundance of flowering plants attractive to entomofauna and reduces the presence of weeds.

This study has been financed thanks to the project “Biodiverse and Resilient Agrarian Systems” (BIODIVERSA), being part of the Complementary I+D+i Plan in the Agri-food Area (AGROALNEXT) and by the Consolidated Team PROVESOS A11- 23R.

S12-O4. Evaluating root fragmentation as a control strategy for *Ambrosia psilostachya* DC.

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Ambrosia psilostachya DC. (perennial ragweed) is an invasive alien weed in Catalonia, primarily affecting non-agricultural areas. As an environmental weed, it disrupts the structure and function of vulnerable habitats, including dune ecosystems in the Llobregat River delta. Environmentally sustainable management strategies are essential to conserve and restore these fragile environments. While seed production plays a minor role in its propagation, the spread of *A. psilostachya* is driven by its roots, which enable it to colonize new areas and access widespread resources. Thus, understanding root management's impact on plant development is key to controlling its spread.

This study examines how root fragmentation influences the root expansion of *A. psilostachya* to develop targeted control strategies. Two greenhouse experiments were conducted: (1) assessing growth responses to different sizes of original root (OR) fragments, which produce new shoots and spreading roots (SR), and (2) evaluating the effects of varying intensities of root fragmentation. A field experiment on a naturally invaded beach also tested root fragmentation's impact under natural conditions. Using GLMs, we analyzed how OR fragment length and weight-to-length ratio affect: (1) the likelihood of forming new roots or shoots, (2) the number of new SR and shoots, and (3) SR dry weight. We also examined how three levels of root fragmentation (C: no cuts, F2: one cut into two fragments, F4: three cuts into four fragments) and weight-to-length ratios influence SR production. For the field experiment, we studied how root fragmentation by simulated tillage (C: control, PF: parallel fragmentation, CX: crisscross fragmentation) and soil depth affect shoot biomass. All analyses were performed using R software.

Our results show that longer OR fragments significantly boost production of new SR and shoots, and promotes new SR dry weight accumulation. Intense root fragmentation under controlled conditions increases SR production, but it has little impact on shoot production. Notwithstanding, severe fragmentation in the field reduces biomass and stem height, though its effectiveness declines with soil depth. These findings suggest that complete root system removal may not always be necessary to reduce significantly *A. psilostachya* density, but that its effectiveness is low.

This study was conducted as part of an agreement of the Facultat de Biologia (Universitat de Barcelona) with Viladecans City Council, and under the auspices of the Consortium for the Protection and Management of the Natural Areas of the Llobregat Delta.

PS4-01. Exploring the distribution of plant composition of field margins and crops in northeastern spain

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Understanding the factors that determine plant composition of field margins and their environment in agroecosystems is complex because there are multiple variables that influence it (Ernoult & Alard, 2011). The aim of this study was to describe and to analyze the spatial distribution of the vegetation present in crop margins and fields in cereal systems in several areas of Aragon (northeastern Spain). During spring 2024 the abundance of the vegetation was determined in 5 locations in wide (WM exceeding 2 meters as required by the eco-scheme) and narrow (NM) field margins (< 2 meters), fields adjacent to WM (FWM) and nearby fields with the same crop, but without margins (F). Multivariate analysis were performed with Canoco 5.0. Canonical correspondence analysis (CCA) determined that the main factors that affected the distribution of the species were altitude, the presence of irrigation and locality, which were more relevant than the environment (WM, NM, FWM and F), explaining 51% of the total variation. Consequently, it was decided to analyze each locality separately. At all sites the environment was a significant factor in the distribution of the species (CCA, explaining 57.2%, 54.1%, 62.6%, 67.8% and redundancy analysis (RDA) explaining 58.2% of the total variation). In most of these the vegetation present in the fields was different from that found on the WM and NM exhibiting at each site a characteristic different plant composition. In over half of the sites, the WM had a higher abundance of shrub and tree strata compared to the NM (RDA, 79.5%), which were mainly composed of herbaceous strata. Typical weed species were observed in each location associated with all environments, such as: *Convolvulus arvensis*, *Diplotaxis erucoides*and *Papaver rhoeas. Lolium rigidum* was more associated with the fields than with the margins in most of the sites. The results suggest that the vegetation composition of crop margins is mainly determined by landscape characteristics (such as altitude, climate, soil) and, within the same locality, by margin width, supporting the requirement of the eco-scheme. Furthermore, this composition differs from that of agricultural fields, although both share typical weed species.

PS4-02. Evaluating the efficacy of direct drilling to reduce weed pressure following intercropping in *Taraxacum kok-saghyz*

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In the context of developing an effective weed management strategy for a new rubber crop *Taraxacum kok-saghyz* L. Rodin (Tks), which is undergoing agronomic testing, challenges emerge particularly during early stages of growth. At this particular stage, the majority of herbicide products tested are only safe for the crop at low doses, thereby limiting their effectiveness in controlling weeds. However, this challenge presents an opportunity to develop agronomic practices that rely less on herbicide use by adapting integrated weed management practices. Integrated practices, such as intercropping and direct drilling, are known to reduce weed pressure; however, their combined effectiveness in managing weeds in the new crop is not well defined.

To address this issue, we tested a cropping system of intercropping followed by direct drilling Tks, grown as a spring and row crop, at two different sites in Germany with different weed spectra. Two different intercrops (*Secale cereale*L., *Lolium perenne*L.) were sown and established in the autumn prior to the spring crop establishment. The intercrops were terminated by cutting prior to glyphosate application. After four weeks, Tksseeds were sawn using direct drill methods between the two remaining intercrop rows using a slit technique with minimum soil disturbance.

To assess the potential reduction in herbicide treatments, the combined system was compared with a conventional herbicide-based system for spring-sown Tks cultivated fields after seedbed preparation, which included pre-emergence and three post-emergence herbicide applications as standard. In addition, the combined system was compared with conventionally sown plots that were either hand-weeded or left unweeded. Weed density and species composition were assessed before the end of the intercrop period and four weeks after the crop was sown.

Initial observations showed that the growth of intercrops reduced weed density. Additionally, direct sowing delayed weed emergence, resulting in lower weed pressure during the early growth stages of Tks. Results on weed pressure and number of herbicide applications will be presented to assess the effectiveness of this integrated approach in reducing both weed pressure and herbicide use.

PS4-03. The weed management in Mediterranean cropping system working group: where are we going from here?

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Recently, the European Weed Research Society (EWRS) restructured its working groups (WGs), resulting in the establishment of the "Weed Management in Mediterranean Cropping Systems" group. In September 2023, this new WG initiated a questionnaire to identify the interests of potential participants, focusing on thematic priorities, preferred activities, and opportunities for collaboration with other WGs. The survey received 54 responses from EWRS members, categorized into three geographic regions: Southwestern Europe, Southeastern Europe, and others. This paper analyses the results, incorporating additional insights and suggestions from respondents. The findings reveal a broad spectrum of interests, with certain topics emerging as particularly significant. The most frequently selected topics of Medium or High interest included "Weed management in minimum tillage and direct drill" and "Long-term experiments in Mediterranean cropping systems." Additional suggestions covered themes related to plant ecology, specific crops, and unique growing conditions. Regarding activities, the top priority was "Building a network related to Mediterranean weed management," bolstered by specific recommendations from respondents. There was also strong support for collaboration with other WGs, especially those focused on "Physical and cultural weed control" and "Sustainable use of herbicides." Based on these findings, the WG proposes future actions to address identified gaps and advance research topics within its scope. Key objectives include organizing activities to benefit the scientific and technical community in Mediterranean weed management, expanding collaboration with other WGs, and increasing the availability of webinars for EWRS members.

The authors thank the respondents of the questionnaires for their time and support. Authors would also like to thank S. Gennai-Schott and C. Moonen for the technical support with the distribution and results obtain of the questionnaire.

PS4-04. Competitive and establishment success of native species facing an invasive competitor: testing ecological principles for vegetation buffer zone creation in mediterranean regions

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Soil erosion is one of the most pressing global environmental challenges, particularly in Mediterranean regions. In Israel, natural areas along rivers are extremely limited due to intensive agriculture. As a result, soil erosion is often addressed through engineering solutions that fail to mitigate the broader ecological consequences ofsoil loss.Native Vegetation Buffer (VBS) zones offer a preferred nature-based solution designed to prevent soil erosionwhile addressing relatedecosystem needs.However, the successful establishment of native species in these VBS is frequently hinderedby invasive weed species. To assess these challenges, we performed a controlled pot experimentevaluating the impact of native plant cover on the establishment success of *Conyza canadensis*, a common invasive weed species in Israel. To this end, we planted individuals of *C. canadensis* alongside a native forb (*Plantago lanceolata*) and a native grass (*Hyparrhenia hirta*) species, at both low and high densities, either alone or in combination. We also tested the effect of early and late introduction of the invasive weed into the experimental system.For each treatment, we have used 10 replicates, a total of 210 pots (75 L each) were used. This study aims to identify the most suitable native species for establishing effective VBS, which are often threatened by invasive species. We found that the timing of planting (early vs. late) and whether the invasive weed (*C. canadensis*) grew alone or with competitors had the greatest influence on its growth. Among competition treatments, high-density forb competition had the strongest negative impact on *C. canadensis* growth, significantly surpassing the effects of both low-density forb and grass competition. By expanding scientific and practical knowledge on stream restoration in Mediterranean ecosystems, these findings could support evidence-based restoration efforts. Ideally, this research will help guide drainage and stream authorities, river restoration offices, and private companies in implementing sustainable, ecologically sound restoration strategies.

PS4-05. Can weed management help pests and diseases regulation in cropping systems? A case study in Madagascar

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In cropping systems of Malagasy highlands, weeds constrain crop growth and reduce yields in addition to a wide range of pest *e.g*. aphids, fall armyworms or white grubs, and diseases *e.g*. Bacterial Leaf Blight (*Xanthomonas oryzae* pv. *oryzae*, Xoo) or Bacterial Wilt (*Ralstonia solanacearum* species complex, Rssc). Some studies showed that weeds could host plant pathogens and provide food and habitats to pests but also to natural enemies underscoring their importance in agroecological crop protection. Focusing on some main crops grown in Madagascar, *i.e.* rice, maize and potatoes, the objectives of this study were: (i) to inventory weed, pest and natural enemies' communities to determine if and which weeds could be host to both of them, and (ii) to assess the ability of weeds to act as alternative host for Xoo and Rssc.

We conducted field and laboratory experiments during the 2023/24 cropping season. Floristic, pest and natural enemies' surveys were conducted on two sites and two fields per site (1 grown in rainfed rice, 1 in maize) every 15 days over crop growth cycle. Palatability of white grubs was tested on 4 weed species while collected weeds in potatoes and rice fields were tested for detection of Rssc or Xoo at the laboratory.

Among the 113 weed species observed in rainfed rice and maize fields, 34 and 38 species hosted pests and/or natural enemies in rice and maize fields respectively. *Stigmatrachelus nubifer, Spodoptera frugiperda* and *Nymphalis* spp., and *Cheilomenes sulphurea* and *Syrphus* spp. were the most observed pests and natural enemies respectively. No clear trend emerged from the results on white grubs. 25 weed species were detected positive for Rssc and could be considered as potential hosts for Rssc among 59 weed species collected in potato fields.12 weed species were tested positive for Xoo and 8 Xoo strains were isolated on only 2 species over the 16 species observed.

These preliminary results will contribute to identify target weeds whether they promote the regulation of pests and diseases or, on the contrary, their development, thus contributing to the definition of agroecological crop protection practices.

Acknowledgement(s) / funding: EU fundings - Dinaamicc project (GCCA & DeSIRA initiatives).

12. Site-specific weed control

S13-O1. Integrating advanced ai-driven vision system for precision weed management in orchard ecosystems

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Keynote session

Adopting mechanical and automation technologies in orchard production is primarily driven by labour productivity, labour cost, availability, cultivar improvements, fruit quality and safety, disease and pest pressures, environmental regulations, and global market demands. With this in mind, we are developing a cutting-edge computer vision system integrated with robotic navigation at the University of Seville to enable precise weed detection and targeted herbicide application. While the robotic platform facilitates autonomous navigation and spraying, the key innovation lies in the advanced vision system powered by convolutional neural networks (CNNs).

The selected weed species—*Lolium rigidum*, *Erigeron canadensis*, *Cynodon dactylon*, *Malva sylvestris*, *Convolvulus tricolor*, and *Erodium malacoides*—were chosen for their prevalence in orchards such as olive groves, almond orchards, and citrus. These weeds were cultivated under controlled nursery conditions to ensure a robust and diverse dataset, confirm their authenticity, and guarantee accurate identification. Once germinated, a total of 2,000 weeds, approximately 500 per species, were transplanted into the soil during their juvenile stages, when herbicides are most effective. High-resolution images were collected to build a dataset capable of addressing the variability inherent in real-world scenarios, forming the foundation for training object detection models to achieve precise weed detection and classification in complex field environments.

The vision system leverages a pre-trained YOLO architecture, fine-tuning top layers to optimize performance for specific weed detection tasks. This approach allows for efficient adaptation to the unique characteristics of the dataset while maintaining an accuracy in real-time of 92% for weed detection, with a detection speed of approximately 30 frames per second (FPS) and an average precision (mAP) of 89.5% across the selected weed species.

This work detailed the development of the vision system, dataset generation, and the integration of AI technologies to address practical challenges in weed management. Ultimately, our findings underscored the potential of AI-driven solutions to enhance sustainability in orchards by reducing environmental impact and improving efficiency.

The GREENBOT project, “Deployment of an Autonomous and Precise Vehicle for the Protection of Woody Crops” (Project ID: GOPG-SE-23-0027), is funded under Measure 16 of the Rural Development Program of Andalusia 2014–2022. It falls within the operational framework of the Operational Groups of the European Innovation Partnership (EIP) for agricultural productivity and sustainability (Operation 16.1.2), and is co-funded by the European Union through the EAFRD (90%) and the Regional Government of Andalusia (10%).

S13-O2. The best parameters for herbicide applications by Unmanned Aerial Vehicles (UAVs) in rice

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The increased adoption of precision agriculture has influenced the development of unmanned aerial vehicles (UAVs) due to their ability to conduct low-altitude operations in many fields. The most significant area of focus is herbicide application, particularly in rice cultivation, where managing weed issues poses considerable challenges and alternative control methods are limited. Using unmanned aerial vehicles (UAVs) for herbicide application has increased substantially. However, there is a lack of technical information regarding the optimal operational parameters. This study aimed to evaluate the quality of herbicide application efficacy on rice using a UAV employing different heights, application volume rates, and flight speeds to ensure herbicide effectiveness under ideal conditions.

The experiments were conducted in the Thrace and Black Sea regions (Turkey) using a split-plot design with four replications in flooded rice cropping systems. The field was infested with natural populations of Echinochloa oryzoides, *E. crus-galli*, *E. oryzicola* (syn: *E. phyllopogon*), and *C. difformis*. The application volume rates in the study were 15, 20, 30, and 40 L ha^{-1} and applied at flight heights 1.5, 3, 4, and 5 meters. Furthermore, three different flight speeds at 4.4, 5.5, and 6.6 ms^{-1} were included in the experiments. The tank mix 2 lt/ha Quinclorac, 2 lt/ha Florpyrauxifen-benzyl, and 3 lt/ha Cyhalofop-butyl were applied as post-emergence. A DJI AGRAS T40 (DJI, Shenzhen, China) was used with four air-induction flat-spray nozzles for applications in all treatments. The efficacy and phytotoxicity of each tere were measured visually at 7, 14, 28, and 56 DAT. During the experiments, wettable papers (Syngenta water-sensitive paper) were placed on the weeds and rice plants just before spraying. The coverage of droplets on rice and weeds was counted immediately after the application.

The relationship between coverage and application volume rate was significant. The 40L ha^{-1} volume rate had the highest coverage on rice and weeds across heights and flight speeds. The coverage was 16.2%, and with every 10-litre water decrease, the area decreased by approximately 3.5%. A positive correlation was found between the phytotoxicity in rice among application volume rate, heights, and flight speeds. It was observed that the injury rate increased with the decrease in volüme rate and heights. UAV applications caused 17% injury in rice while applied at 15 L ha^{-1}, flight heights at 1.5 m, and ms^{-1} at flight speeds at 14 and 28 DAT. Regarding the weed control efficacy evaluation, the interaction between the factors volume rates, flight heights, and speeds was significant, indicating that the water volume affects the control of *Echinochloa oryzoides*, *E. crus-galli*, *E. oryzicol*a (syn: *E. phyll*opogon), and *C. difformis*. The weed control efficacy was above 91.25% for all those weed species when applied at heights 4 m, 30 L ha^{-1} volume rates, and 5.5 ms^{-1} at 28 DAT. A positive correlation was found between the coverage area of herbicides and visual effectiveness by counting the droplets on wettable papers placed on weeds. Results from the present study indicate integrating UAVs for weed control in rice fields can create an efficient alternative to conventional broadcast weed management practices.

This project has been funded by TUBITAK with number TOVAG-123O060.

S13-O3. A comparative applied analysis of six site-specific robotic assisted weeding approaches in sugar beet including the evaluation of contemporary weed assessment methods

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Effective weed management is crucial in sugar beet production, but lacking sustainability and environmental protection. The rising prevalence of herbicide-resistant weed species and the prohibition of certain herbicides has intensified the necessity for development in weed management. Recent advancements in sensor-based weed control systems have rendered a realistic prospect against these problems, though demanding for detailed analyses. This study evaluated six advanced site-specific robotic assisted weeding approaches, including sensor-based mechanical and chemical methods in comparison to a standard broadcast herbicide treatment and an untreated control. The treatments were tested in three independent experiments in sugar beet in 2024. Assessments in the field focused on (I) comparing the intra-row and inter-row weed control efficacies (WCE) of six site-specific robotic assisted weeding systems with each other and to broadcast herbicide application and untreated control, (II) investigating the impact of the different weeding systems on weed composition and crop performance, (III) analysing potential discrepancies between several sampling teams in the recorded density of weeds, and (IV) comparing unmanned aerial vehicle (UAV)-based digital weed coverage estimation and WCE with manual counts. Hoeing robots equipped with selective intra-row blades yielded a maximum of 80% WCE in the intra-row area. In comparison the broadcast herbicide control gave 67% and the spot-sprayer 60% WCE. Total WCE of herbicide treatments ranged between 81 – 92%. Hoeing-systems equipped with finger-weeder, band application or without intra-row elements resulted in 25% lower total WCE than the broadcast herbicide application. Robots equipped with real-time weed identification detection systems (ARA® and Farming GT®) could provide the highest total, intra- and inter-row WCE equal to the broadcast herbicide application. Crop plants were affected by all hoeing treatments, with maximum burial rates of 33% (finger-weeder), even though lethal uprooting of plants was less than 5.5%. Sampling groups had no significant effect on count data. Manual weed density counting was more suitable to evaluate the performance of the robots than weed coverage data derived from UAV-images. Site-specific robotic assisted weeding holds considerable promise as a new component of integrated weed management (IWM) strategies.

We thank all students and researchers participating in the combined event “Robotic Weeding in Sugar Beet” of the Euroleague of Life Sciences and the European Weed Research Society. We furthermore thank the technicians of the research station Ihinger Hof, as well as the agricultural technicians of the Weed Science department. Parts of the work was carried out as part of the ENABLE research project, which is funded by the Baden-Württemberg Foundation in the “Innovative Technologies for Climate Resilience in Agriculture and Forestry” program.

S13-O4. Comparative analysis of autonomous robots and traditional tractors for mechanical weed control in maize and wheat

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Mechanical weed control, as an alternative to herbicide use, offers significant environmental and economic benefits. However, conventional methods require high labour and resource input, challenges that innovative technologies such as agricultural robots can mitigate. This study evaluates the performance of the agricultural robot Robotti 150 D (Agrointelli, Aarhus, Denmark) compared to a traditional tractor for mechanical weed control in maize and wheat fields at the University of Padova's experimental farm in northeastern Italy. A Rotosark hoening weeder (OliverAgro s.r.l., Verona, Italy) was used in maize, while a tine harrow was employed in wheat. Each field was divided into robot- and tractor-managed plots. Weed species presence and density in 24 randomly positioned 1 x 1 m quadrats were assessed using ArcGIS Pro (v3.3.2, ESRI). Weed control efficiency was calculated by comparing weed density before and after operations, while long-term effects were evaluated by analyzing weed biomass before harvest and comparing yield differences. In maize, both methods achieved approximately 95% weed control efficiency. Weed density decreased from 88.8 ± 13.96 to 3.33 ± 0.93 plants/m² in robot-managed plots and from 99.2 ± 13.94 to 4.25 ± 1.36 plants/m² in tractor plots. Final weed biomass was 145.24 ± 22.71 g (robot) versus 137.1 ± 32.25 g (tractor), with no significant yield differences (15.14 ± 2.08 t/ha robot vs. 14.90 ± 2.80 t/ha tractor). In wheat, both methods showed lower control efficiency, reducing density from 7.5 ± 1.41 to 3.75 ± 0.95 plants/m² (robot) and from 8.83 ± 1.09 to 4.5 ± 0.65 plants/m² (tractor), with no significant differences in final biomass (9.42 ± 4.68 g robot vs. 10.3 ± 2.87 g tractor). However, robot-managed plots produced significantly higher wheat yields (6.42 ± 0.09 t/ha) compared to tractor-managed plots (5.36 ± 0.40 t/ha). These findings suggest that autonomous robots provide comparable weeding efficacy to traditional tractors while offering potential advantages such as reduced soil compaction and improved labour efficiency. Further trials are needed under diverse conditions to optimize their performance and address user requirements.

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

S13-O5. In-field classification of weeds and crop plants for advanced ISOBUS spot-spray applications using high-speed remote sensing and edge-AI

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Drone-based spot-spray maps have moved beyond scientific trials and are now commonly used in commercial farming. Typically, moderate-resolution aerial imagery is sufficient for patchy weed infestations (e.g. localized Cirsium arvense clusters), suitable for basic “patch spraying”. However, newer sprayer systems equipped with single nozzle control in 50 cm or even 25 cm increments require higher-resolution spot-spray prescriptions at the individual plant level of weed seedlings. This poses a challenge for large-scale operations, since improving ground sampling distance (GSD) by half multiplies the total image data fourfold, and additional overlap is required for standard structure-from-motion (SfM) georeferencing. To address these constraints, a multi-camera rig has been introduced, wherein several cameras operate in parallel to maintain high area coverage even at 1,64 mm GSD. Still, managing the massive data volumes in mm-resolution mapping demands novel processing solutions. In this study, a GPU-based AI accelerator was integrated into the mapping system, enabling real-time in-flight image processing using a pre-trained CNN. The CNN classified weeds into dicots or monocot grasses and could output separate or combined Spot-Spray Maps as needed.

Following the mapping flight, the Spot-Spray Maps were exported to ISOBUS-field sprayers, allowing targeted herbicide applications within three hours after the mapping flight was conducted. Field trials were conducted in sugar beet (Beta vulgaris) and Maize (Zea mays) across 5 field sites in Germany during the 2023 and 2024 vegetation seasons. Weed seedlings at sizes above 5 mm were detected with 97% accuracy. Simulations based on these maps showed herbicide savings compared to broadcast spraying ranging from 47% at 50 cm and 93% at 25 cm nozzle distance. Rapid data processing further facilitated tight scheduling between mapping and application, which is critical for controlling weeds before they become less susceptible. Simulations based on these maps showed herbicide savings compared to broadcast spraying ranging from 47% at 50 cm to 93% at 25 cm nozzle spacing. Rapid data processing further facilitated tight scheduling between mapping and application, which is critical for controlling weeds before they become less susceptible. Field applications were carried out with a Fendt Rogator sprayer (50 cm nozzle no PWM, operated via the Amatron4 Terminal) and a Horsch Leeb 6 LT sprayer (25 cm PWM nozzle distance using a John Deere Generation 4 terminal), both with a total boom width of 36 m and at a constant driving speed of 10 km/h. The weed control efficacy was at 95% for the 50 cm sprayer and 97% for the 25 cm sprayer. These results demonstrate that combining multi-camera high-resolution imaging with in-flight AI processing can enable precise, large-scale spot-spray solutions that meet the requirements of advanced single-nozzle sprayer systems in professional crop production in large-scale farming operations.

S13-O6. Using LiDAR technology to verify weed control effect of roller-crimped cover crops in vineyards

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In organic viticulture when cover crops are terminated with a roller crimper, they have a great weed control effect. However, its efficacy depends on the biomass generated by the cover and its ability to create a stable mulch on the soil. During seasons 2023 and 2024, a field trial was established in a vineyard in Raimat (Lleida, Spain) to estimate the weed control effect of two cover crops (Triticale - x *Triticosecale* Wittm. - and *Lolium multiflorum* Lam.) terminated with a roller crimper. In parallel, a mobile terrestrial laser scanner (MTLS) based on light detection and ranging (LiDAR) was used to define the vegetation structure (height) present in the vineyard inter-rows, in order to relate these data with the values of cover crop and weed coverage obtained across the season.

In 2023, before the roller pass, the *L. multiflorum* showed a lower soil coverage, a higher percentage of weeds and lower biomass than the triticale. In 2024, the values were similar in both cover crops except for the crop biomass that was lower in *L. multiflorum*. In 2023, the roller pass was not successful in creating a mulch of *L. multiflorum*, but it was successful with triticale. However, the percentage of weed coverage was similar in both cover crops and significantly lower than the control. In 2024, for both cover crops, the roller was very effective creating a mulch. In both seasons, at the end of summer, weed biomass was significantly lower in both cover crops than in the control.

Before the roller pass (April) and in both seasons, the MTLS detected the greater height of triticale compared to *L. multiflorum*, and in June, after the roller pass, it detected higher cover height in *L. multiflorum*. In August heights of both cover crops were very low (< 20 cm). The LiDAR-derived results are consistent with the manual measurements of the cover crops, and confirm the accuracy of this technique to describe the structure of cover crops at high resolution. In turn, it is confirmed that the pressure caused by the cover crop on weeds does not depend exclusively on the cover crop biomass or the effectiveness of the roller pass, but also on the type of cover crop. *L. multiflorum*, even if it had a lower height and lower biomass than triticale, exerted a similar and effective weed control effect.

This research was funded by the project PID2020-113229RB from the Agencia Estatal de Investigación (AEI) from Spain.

PS4-07. Harnessing ecological insight and technological advances for smarter blackgrass (*Alopecurus myosuroides*) management

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Black-grass (*Alopecurus myosuroides*) is the UK's most pernicious weed, causing considerable yield losses each year and threatening the sustainability of UK cereal production. Herbicides remain a key tactic to control this species, yet evolution of resistance threatens their efficacy, their widespread usage has negative environmental consequences, and their cost to growers is significant. 'Smarter' or more precise weed management approaches have the potential to mitigate some of these issues – enabling reductions in herbicide usage as well as more targeted non-chemical control. However, effective precision management requires a comprehensive understanding of the ecological dynamics of the targeted species, alongside technological advancements for implementation of precision strategies. Here we present the results of a recent three-year project in the UK, to examine the ecological and technological considerations for precision Blackgrass management.

Using a decade-long survey of Blackgrass abundance over >150 locations, we demonstrate the spatial and temporal dynamics of blackgrass patch stability. For a subset of 11 fields, we examine the role of environmental drivers (soil properties) in determining the within-field localization of these patches, and their persistence over time. Data are combined within a simulation model, to highlight in-field variation in Blackgrass habitat suitability, and determine zones for more targeted management. Farm-machinery-mounted camera technology coupled with computer-vision approaches are then evaluated in their potential for more high-throughput mapping of this species, and for further facilitating targeted herbicide application.

Key findings will be discussed in relation to the role of ecological weed surveillance and knowledge of spatio-temporal dynamics in facilitating targeted weed management, and how technological innovation can complement this through more rapid and high-throughput weed detection. Results will highlight the principal opportunities and challenges for development of future precision management approaches in UK cereal cropping.

Acknowledgement(s) / funding: InnovateUK.

PS4-08. Detection and analysis of the infestation and spatial distribution of *Datura stramonium* in soybean fields in Austria

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Datura stramonium L. (Solanaceae) is an annual weed species, which commonly occurs in summer crops including soybean. It is a competitive weed and a source toxic tropane alkaloids (TAs). Late-season escapes are responsible for the cross-contamination of crops during harvesting. The origin of such contamination is generally twofold: (1) seeds enter the harvested crop (seed contamination) and (2) the sap that gets onto the harvested crop (sap contamination). In Austria, reports of TA contamination of soyabeans have already been documented; thus, measures to control late-season infestations of *D. stramonium* are required.

Therefore, the StopDatura project (https://dafne.at/projekte/stopdatura) was initiated with the overall aim of identifying options for minimizing undesirable levels of TAs in harvested soybean crops. We analyzed the spatiotemporal spread patterns of *D. stramonium* in Austria to identify severely impacted regions (risk areas). We also applied a customized image recognition method (based on a semantic segmentation model) using drone images to produce late-season weed infestation maps of *D. stramonium* in soybean fields. Results show that this species is increasingly spreading in Austria, especially in the lowlands where the largest soybean growing areas are located. Weed maps provided insights regarding the infestation and spatial distribution of *D. stramonium* in soybean fields. Late-season infestation of *D. stramonium* is already a common problem in soybean and infestation varies significantly between fields, while populations are particularly concentrated at the field edges. This information can be used to develop precise weed control management strategies for *D. stramonium* in soybean fields.

This project is funded by the Federal Ministry of Agriculture, Forestry, Regions and Water Management via dafne.at. The BML supports applied, problem-oriented research in its area of expertise.

PS4-09. Spatial-biological models to forecast weed infestation dynamics

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Weeds significantly impact crop profitability by reducing yield and quality while increasing management costs. Weed sensing technologies primarily focus on identifying weeds for immediate herbicide treatment but often overlook weed biology and non-herbicidal management strategies. The objective of this ongoing study is to develop predictive weed models that integrate remote/proximal sensing, weed biology, and field management data to anticipate future weed infestations and allow the development of more sustainable, long-term weed control strategies. The five-year study includes approximately 30 fields ×time points across Australian cropping farms. The data includes remote sensing images from satellites, associated field surveys of weed patch locations (i.e., ground truth data) and field management data, which will be combined to predict weed emergence and weed patch dynamics. Ground truth data is collected by first identifying an area of a field with suspected weed patches (~1–2 ha), then geolocating the patch boundaries, followed by sampling, using a grid layout of 30cm² quadrats, to quantify weed density, germinable soil seedbank, and species distribution.

Preliminary results demonstrate that combining spatio-temporal remote sensing imagery with ground truth data effectively identifies vegetation variation associated with weed infestations. The spatio-temporal analysis will be employed by the predictive model, together with weed species biology, density, soil seedbank dynamics, and field management history, providing a rich context of the environment leading to weed emergence. The predictive model will highlight areas of likely weed emergence, enabling growers to implement targeted, preemptive management actions. By identifying future infestation scenarios, growers can adopt diverse, targeted, control tactics, such as optimising pre-emergent herbicide use, increasing crop seeding rates to enhance competition, amending fertiliser inputs, and adjusting harvest cutting heights to maximize harvest weed seed control efficiency. This study aims to demonstrate that integrating remote sensing, weed biology, and management data into a predictive model enables more sustainable and cost-effective weed management strategies. The approach allows growers to combine immediate weed control measures with foresight-driven, preemptive actions to reduce the underlying seedbank and long-term infestation risks.

We would like to acknowledge the support from the Grains Research and Development Corporation (UWA2307-005RTX). Roberto L. Rocha was supported by the Research Training Program scholarship and the Western Australia Agricultural Research Collaboration.

PS4-10. Investigating weed and companion plant ecosystem services and disservices distribution maps using machine learning

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Weeds and companion plants play a complex dual role in agroecosystems, contributing significantly to agricultural biodiversity while also posing challenges to crop production by causing substantial yield losses. The ongoing decline in European biodiversity underscores the urgent need to adopt agricultural management strategies that balance biodiversity conservation with sustainable agricultural production. In agricultural regions like Denmark, where farming dominates the landscape and natural habitats are highly fragmented, agricultural fields must contribute significantly to biodiversity. To elaborate possible weed management practices that could increase plant and insect diversity while maintaining crop productivity, it is critical to identify weed species that heavily impact crop yields and should be prioritized for removal, as well as those that have minimal competitive effects but contribute positively to biodiversity. This research, conducted within the agriphotovoltaic (AgriPV) project 'Agrivolt', investigates the spatial distribution of ecosystem services and disservices provided by weed species within agroecosystems, utilizing machine learning techniques to map their functional roles. An agricultural robot equipped with RGB cameras was used to capture high-resolution images that were subsequently processed to map the spatial distribution of weed species and companion plants across fields. Key functional traits associated with ecosystem services and disservices were extracted from the literature. By weighting the weed community by functional traits, we generated spatially detailed maps depicting the distribution of ecosystem services and disservices provided by the weed communities at 1 m^2 resolution. The analysis of the spatial maps enabled the identification of the key functional traits with the greatest influence on the provision of ecosystem services and disservices, thereby informing targeted management approaches. Our result support weed control strategies that account for the contributions of weeds and companion plants to support biodiversity. By understanding the relative weight of these traits, management strategies can be prioritized to target weed species most detrimental to crop productivity while conserving those that provide ecological benefits. Leveraging precision farming technologies, such as targeted spraying, could allow for the selective management of weed species based on their functional traits. This method could therefore be used to enhance biodiversity, promote more sustainable agricultural practices and to minimize herbicide usage.

PS4-11. Mapping soil moisture variability in wheat fields: high-resolution satellite spectral indices as an alternative to field sampling

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Prediction of weed patch location early in the agricultural season is key when developing precision application maps for pre-emergence herbicide regimes. Within field patches of black grass (*Alopecurus myosuroides*) have been shown to be highly correlated with soil moisture. High-resolution (3m) satellite imagery from Sentinel-2 and PlanetScope SuperDove offers an innovative alternative to traditional field sampling for soil moisture mapping. Using Sentinel-2 and PlanetScope data, we calculated more than 12 vegetation indices (VIs) to evaluate their correlation with soil moisture and blackgrass abundance. Feature extraction techniques were applied to identify the indices most strongly associated with soil moisture variability and blackgrass abundance variability throughout each field. Field-collected soil moisture data were used to train and validate machine learning models—including random forest, support vector machines, and gradient boosting—to estimate soil moisture distribution at the field scale. Preliminary results indicate that spectral indices derived from high-resolution satellite imagery show promise in capturing overall soil moisture variability, which could potentially reduce the number of soil samples required per field. This approach aims to provide insights into field-level water dynamics, offering a pathway toward precision blackgrass control, sustainable land management, and efficient precision agriculture practices.

PS4-12. Decision-making for site- and plant-specific weed management: Comparing novel approaches

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Site-specific weed management (SSWM) can significantly reduce the amount of herbicide used in arable fields. In the future, recent innovative approaches such as the use of images taken with unmanned aerial vehicles or ground-based sensors combined with deep learning techniques for weed classification could facilitate automatic weed detection at species level. Automatic species-specific weed classification allows incorporating information on species' traits into SSWM approaches, allowing to consider weed functional traits for weed control decision-making. In the projects 'Cognitive Weeding' and 'Better-Weeds', two approaches to reduce the abundance of weeds with a high harm potential (disservice) while preserving weeds that provide beneficial ecosystem services (service) were developed for SSWM.

To compare these two approaches, a manual weed sampling on four winter wheat study fields close to Braunschweig (Germany) was conducted using a 5 m x 3 m grid. In addition, two artificial scenarios were simulated: an arable field with a high infestation of weeds with high service and low disservice potential and a second one with opposite conditions. For the 'Better-Weeds' approach, weed distribution maps were generated using inverse distance interpolation to estimate weed distribution between sampling points. Species-specific functional traits relevant to the provision of services (e.g. importance for insect species, birds, or duration of flowering) and disservice (e.g. leaf dry matter content, competition index, or plant height at the vegetative stage) were extracted. Afterward, a PCA was performed for each pixel of the weed distribution maps using the species-specific service and disservice traits. As a result, two maps were generated: one showing the areas in the field that provide biodiversity benefits and the other showing the areas where there is high disservice potential. After plotting the service against the disservice potential in a scatterplot, the area to be treated can be defined.

The weed density from the distribution maps is transformed into individual plant number by filling the square meter pixel values with randomly distributed points representing weed plants for the 'Cognitive Weeding' approach. Each weed species gets a specific density threshold based on the ratio between the species-specific service and disservice potential. If the individual plant count of a species for a specific field area exceeds this threshold, the weeds exceeding the threshold should be treated. Based on both approaches, SSWM maps for the study fields were created and compared based on the area to be treated. Both approaches aim to reduce herbicide use, while simultaneously taking the ecosystem service provided by the weed flora into account.

The project 'Better-Weeds' is supported by funds of the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany under the innovation support programme.

PS4-13. How difficult is weed management in sugarbeet with reduced herbicide inputs and alternative methods?

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This study addresses the need of reducing herbicide use, while maintaining a successful weed control in sugarbeet. The objectives were to determine weed control and sugar yield effects when reducing herbicide-sprayed area and increasing mechanical weeding intensity. Five strategies were field-tested between 2022-2024, full-herbicide application (*Herbicide*), band-herbicide with interrow hoeing (*bandHerb-Hoe*), reduced-band-herbicide with interrow hoeing (*redbandHerb-Hoe*), pre-emergence harrowing with camera-guided hoeing (*preHarr-camhoe*) and camera-guided interrow hoeing (*camhoe*). The latter three used also a weed-pulling machine, when weed control was insufficient. A fully *weedy* and a manual weed-free until canopy closure (*manual*) references were included in 2023 and 2024. Weed pressure assessed before weeding was higher in 2022, particularly on *bandHerb-Hoe* and *redbandHerb-Hoe* (> 60 plants m-2). In 2023, weed pressure was more homogeneous across all plots (< 15 plants m-2), being slightly higher in 2024 (< 20 plants m-2). The final weed density after the last weeding operation was <30 weeds m-2. Weed control was lower in the crop row region (*R*) than in the inter-row area (*IR*). In 2022 and 2023, *Herbicide* plots showed a lower weed control than all other plots within the *IR* because soil moisture was too low for root herbicides to be effective. Weed control in *IR* was more effective during 2023 and 2024 on all treatments and no lower than for *manual*. The *weedy* plots depicted the huge white sugar yield reduction potential (*i.e.*, at least 50%). All weeding strategies yielded similar white sugar production (~11 t ha-1 in 2022 and 2023, and ~14 t ha-1 in 2024), being similar to *manual* results. The weed-puller only achieved 20% weed control in average because it broke weed stems instead of uprooting them, in most cases. Sugar yields of *bandHerb-Hoe* and *redbandHerb-Hoe* slightly advantaged those of *Herbicide* and *manual*. These results demonstrate that weed management in sugarbeet can be successful with alternative methods, especially reducing the area sprayed and combining with interrow hoeing. However, site and climatic conditions are crucial for implementation of such weeding alternatives. Future research should refine traditional mechanical tools and compare them with advanced alternatives, such as spot sprayers and robotic weeders.

PS4-14. Spectral analysis and mapping of the weedy rice *Oryza latifolia* in rice plantations

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Oryza latifolia Desv. is a weedy rice species of difficult control in rice plantations in various parts of the world. Areas infested with *O. latifolia* are controlled with low selectivity herbicides or mechanical methods that could damage the crop or be expensive. Considering that site-specific management tactics would increase the control efficiency and reduce costs; the objective of this study was to generate the spectral signature of the weed and the crop for its differentiation and mapping using airborne sensors. In 2021, a field spectroradiometer (ASD FieldSpec 4) was used to measure the reflectance of *O. latifolia* in three development stages: seedling, vegetative, and reproductive, in three locations in Costa Rica: Parrita (soil with a clay texture), Jicote and Garita (soil with a loamy texture). In addition, the reflectance of three rice varieties was measured in both vegetative and reproductive stages. Multispectral images were taken with a Altum (Micasense) sensor carried by an unmanned aerial vehicle (UAV, DJI Matrice 2) in one location. The data obtained with the spectroradiometer were subjected to an analysis of variance and a Tukey test. Principal component analysis was performed on the multispectral images. The reflectance in the near infrared band (NIR) of *O. latifolia* and commercial rice varieties was significantly different ($P<0,05$) in each development stage and location. In the green wavelength band, some significant differences ($P<0,05$) were also obtained in the reflectance of the evaluated species. The spectral signature of *O. latifolia* in the locations with sandy and clayey soil textures was different ($P<0,05$). The distribution map of *O. latifolia*, generated from the first principal component, showed a clear spatial delimitation of the weed within the evaluated perimeter. The analysis also identified other areas not evaluated where the reflectance of the present vegetation was also different from that of the crop, probably due to the poor control of other grasses in the rice plantation. In conclusion, *O. latifolia* and rice varieties spectral signature differed in the green and NIR bands. The magnitude of this difference made it possible to map the distribution of *O. latifolia* in a rice plantation with acceptable accuracy.

PS4-15. Unraveling the influence of soil properties on *Sorghum halepense* density

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Sorghum halepense L. is one of the most widespread and problematic weeds globally. However, research on the spatial relationships between its density and soil properties remains limited. This study aimed to identify the key soil characteristics influencing the spatial distribution and density of this weed.

The study was conducted in a 3-ha maize field at the CSIC experimental farm La Poveda (Madrid, Spain), previously used for winter cereal research. The area has a Mediterranean Continental climate, sandy loam soils (1.4–1.6% organic matter), and receives ~400 mm annual rainfall. Maize was conventionally tilled and planted at 85,000 plants ha^{-1} (0.75 m row spacing). Pre-emergence herbicides applied were pethoxamid (1.20 kg a.i. ha^{-1}) and mesotrione (0.30 kg a.i. ha^{-1}). *S. halepense* density was assessed at BBCH17 using drone imagery, with weed polygons mapped and analyzed using point pattern analysis. A Kernel Density Estimation heatmap (30-m radius) was generated. Soil was sampled systematically (17 samples ha^{-1}, 0–30 cm depth), analyzing texture, pH, EC, and nutrients. Additionally, gamma radiation (total count) and plant available water were assessed using SoilOptix® technology. Data were interpolated onto a 3 × 3 m grid using kriging. Parametric (Ordinary Least Squares, OLS) and non-parametric (Random Forest, RF) regression models were developed to explain *S. halepense* density based on soil properties.

The results indicated that soil properties had varying levels of influence on the density of *S. halepense*. The RF model identified the most important variables as DTPA-extractable Zn > elevation > total carbon (TC) > extractable P > NO_3-N > DTPA-extractable Fe > exchangeable Na > soil organic carbon > exchangeable Mg. In summary, *S. halepense* was more abundant in soils with lower fertility, characterized by lower levels of Zn, TC, P, and NO_3-N, but higher concentrations of Fe, Na and Mg. In addition, total count, which inversely reflects plant available water, showed a negative correlation with weed density.

Although variable rankings differed between regression models, the RF model significantly outperformed the OLS model, achieving a higher R^2 (0.998 vs. 0.754). This highlights the RF model's superior ability to capture nonlinear relationships and complex variable interactions.

This research was funded by project PID2023-150108OB-C31 from the Spanish MCIU/AEI/10.13039/501100011033 and co-financed by FEDER, EU.

PS4-17. An online digital tool to assess the costs and profits of drone-based weed mapping

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Despite the potential of drones for weed mapping in order to implement site-specific weed management (SSWM) strategies, their widespread adoption remains limited mainly due to uncertain costs and benefits of applying this technology. This article introduces an online digital tool (ODT) aimed to determine the cost-effectiveness of using drones for weed mapping prior to conduct a map-based precision weed control (map-based SSWM option), in comparison to treating the entire field uniformly (conventional option), or not treating the weeds (no-treatment option). The ODT considers a range of variables associated to the crop type, field size, weed coverage, crop-weed competitiveness, herbicide pricing and its potential residual damage, and drone operating costs, and assesses the economic balance of costs and profits of the three management options, reporting which one is most profitable following a sensitivity analysis. To illustrate the ODT´s outputs, two 30-ha fields, one for winter wheat (rainfed) and one for maize (irrigated) with potential yields of 4,000 and 12,000 Kg/ha, respectively, were evaluated. The results indicated that the decision to implement the map-based SSWM option is highly depend on the field area infested with weeds, the price and residual damage of the herbicides and the cost of the drone service. In the wheat and maize scenarios considered, sensitive analysis showed the following thresholds to recommend the SSWM option instead of the conventional or the no-treatment ones: 1) a minimum herbicide prize of 52 and 34 €/ha, respectively, for a weed area of 40%; 2) a maximum weed-infested area of 58 and 68%, respectively, for a herbicide prize of 50 €/ha; and 3) a maximum cost of the drone service of 30 and 45 €/ha, respectively. These simulations assumed a residual herbicide damage of only 1%, so higher values would further support the selection of the SSWM option. The ODT is versatile and customizable, and can help to make informed decisions on whether or not to use drones for weed mapping based on economic values and the specific conditions of each agricultural scenario, which will also boost a broader adoption of precision weed control to optimize the use of resources and reduce environmental impact.

Research funded by the projects PID2023-150108OB-C31 and PID2023-150108OB-C32 from the Spanish MCIU/AEI/10.13039/501100011033 and FEDER, EU.

PS4-18. Time-series model of weeds' spatial distribution in organic paddy fields based on UAV imagery

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Modeling of weed populations' spatial dynamics is useful to evaluate weeds' growth and the effect of control quantitively. In this study, we tried to model weeds' growth to evaluate them based on unmanned aerial vehicle (UAV) imagery.

We obtained the UAV images of the organic paddy fields (cultivar: Koshihikari) dominated by monochoria (*Monochoria vaginalis* (Burm. f.) Kunth) in Fukui, Japan at intervals of 2 weeks from June to July. The weeds were extracted manually and the coverages were calculated in each grid (1m × 1m) on GIS.

The time-series spatial data of coverage were fitted to the model by year. In the model, the temporal transition of the weeds' coverage was expressed as follows:

$$c_{i,t+1} = c_{i,t} + r_{i,t}\, c_{i,t}\, (1 - c_{i,t}) + \varepsilon$$

where $c_{i,t}$ is the weeds' coverage in grid i at time t and ε is the residual error.

The weeds emerged in late June and spread gradually. The weeds seemed to distribute along the direction of cultivation. The places in which the weeds started to emerge earlier did not stay in a same location for years, whose ground surface level tended to be higher. The growth rate r_t varied by year. r_1 (growth rate from late June to early July) in 2023 and 2024 was lower than that in 2022. This difference seems to be derived from the temperature and the timing of intertillage weeding (2022: late July; 2023, 2024: early July). In contrast, r_2 (growth rate in mid-July) in 2024 was higher than that in 2022 and 2023. For preventing weeds from growing in high density in a specific place in a paddy field, adequate leveling of ground surface through puddling and early weeding of early-emerged seedlings seems to be effective.

These results implied that a spatio-temporal model enables us to evaluate weeds' growth and the effect of farming operation in each period quantitively.

PS4-19. Weed detection using deep learning of multispectral images from unmanned aerial vehicle

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Although rice cultivation is an important agricultural activity worldwide, weeds cause serious problems in this production. As a result, growers often spray pesticides. Chemical spraying to control weeds often covers non-target areas, causing both economic losses and environmental damage. Today, as technology evolves, the use of artificial intelligence to process images from sensors attached to unmanned aerial vehicles (UAV) is becoming more common in agriculture. Recent advances in agricultural technologies offer innovative solutions to this problem. In particular, the sensors and advanced imaging technologies integrated into UAV allow for detailed mapping of vegetation cover in agricultural areas. These innovations are an important step towards a more sustainable production model in rice farming, providing both economic and environmental benefits.

The aim of this study is to detect weeds that pose a problem in rice cultivation by processing the images captured by a multispectral camera of two different UAV systems in real time with deep learning algorithms by an artificial intelligence supported computer on the UAV.

The study used a UAV with DJI Matrice 350 RTK-Micasense RedEdge-NVDIA Jetson AGX Orin artificial intelligence computer integrated system and features. For this purpose, flights were made over the fields and images were taken from twenty different paddy producers. The images were taken in 6 different bands from the multispectral sensor from an altitude of 30 meters with the UAV and an autonomous flight was made using internet based RTK (Real Time Kinematic) for precise determination of the coordinates of the weeds. The YOLO (You Only Look Once) Roboflow 3.0 object detection model was used for these images. The same platform was used for labeling and only one class named "weed" was created. Synthetic data was also created by increasing the data to increase the accuracy of the model. In the dataset, the model was built with a total of 1838 data, including 1617 training, 148 validation and 73 test data. The accuracy rates of 69% MAP, 69.7% Precision, 67.8% Recall were achieved in the model. The alien weed species *Echinochloa* spp. and *Abutilon theophrasti* Medik. were detected by the model. Among the images used for detection, band 3 (red) and band 5 (NIR) provided the highest accuracy rate. This model was used as a test model. It may be possible to increase the accuracy rate by using more images and labels.

This study was funded by The Scientific and Technological Research Council of Türkiye (Project Number: 123O500).

PS4-20. Leveraging geospatial intelligence for *Amaranthus palmeri m*anagement in Spain

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The invasive weed *Amaranthus palmeri* has become a critical threat to Spanish agroecosystems, demanding advanced monitoring tools for timely intervention. However, current efforts are hindered by fragmented data collection, delayed reporting, and inconsistent formats. This study introduces DIGINVASIVE, a semi-automated web platform designed to centralize and visualize invasive species alerts. The objective is to monitor the emergence and spatio-temporal distribution of *A. palmeri* from data gathered by regional Plant Health Services throughout the infested areas in Spain, leveraging Spain's Agricultural Plot Geographic Information System (SIGPAC).

The platform employs an Extract, Transform, and Load (ETL) pipeline that ingests georeferenced data (CSV, Shapefile, GeoPackage), normalizing metadata on administrative divisions, infestation status, and reporting years. Automated workflows correct errors, remove duplicates, and align historical entries with 2024 SIGPAC parcel boundaries. Geospatial data, stored in a PostgreSQL/PostGIS database, enables efficient queries, while encrypting coordinates and aggregating results to SIGPAC polygons for privacy. A role-based web visualizer provides advanced filters, maps, and statistics for plant health authorities, and simplified dashboards with regional filters for public users.

Between 2018 and 2023 (with available records in Spain), DIGINVASIVE documented 2,526 infested parcels (6,339.34 ha), with Cataluña (49.14%), Aragón (43.14%), and Extremadura (7.71%) as the affected regions. Provincial hotspots included Lleida, Huesca, and Badajoz, with peak infestations in 2019–2020. DIGINVASIVE fosters collaboration among farmers, plant health services, and researchers, thereby enabling proactive prevention measures. This study highlights the critical role of standardized geospatial protocols and collaborative data governance in weed management.

This work has been funded by DigitalWeeds project (ref. MMT24-INIA-01) of the MOMENTUM CSIC program and TED2021-132401A-I00 (PRTR and European Union-NextGenerationEU), and PID2023-150108OB-C32 from the Spanish MCIU/AEI/10.13039/501100011033 and FEDER, EU.

PS4-21. Spectral analysis as a tool for weed and crop identification

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The possibility to recognize weeds and crops through the analysis of hyperspectral data was investigated in field conditions. Two studies were carried out in the Piedmont region (Italy), each on a distinct crop/weed system. The first study (A) was carried out at the University of Turin's experimental field in Grugliasco and included three crop species, namely barley, wheat, and oat along with four weed species*: Papaver rhoeas*, *Polygonum aviculare*, *Veronica hederifolia*, and *Avena fatua*. The second study (B) included, in addition to the university field, two maize fields in Villafranca and Carmagnola (Piedmont) and targeted maize as a crop, as well as five weed species: *Chenopodium album*, *Cyperus esculentus*, *Echinochloa crus-galli*, *Galinsoga quadriradiata*, and *Sorghum halepense*. The spectral analysis covered 21 vegetation indices including but not limited to Normalized Difference Vegetation Index (NDVI), Pigment Specific Simple Ratio (PSSR), Carotenoid Index (CARI), and Normalized Difference Water Index (NDWI). The statistical analysis of the indices resulted in the classification of species into homogeneous groups; moreover, the principal components analysis identified 5 significant indices that account for 94% of the variance between species. The PCA scores of the first component produced a new index that distinguishes monocotyledonous and dicotyledonous species with negative and positive average values of the index for each category respectively. When paired with more powerful statistical tools, such as machine learning, the five significant indices could serve as the foundation for more exact weed/crop distinction at the species level.

PS4-22. Monitoring and managing weeds in rice cultivation using digital tools

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This study presents an innovative approach to weed monitoring and management in rice cultivation, leveraging advanced digital tools for weed detection and mapping. The research focuses on three major weed species affecting rice productivity: *Oryza sativa* (ORYZA), *Echinochloa spp.* (ECHCG), *and Cyperus difformis* (CYPDI). These species significantly impact rice growth due to their highly competitive ability, leading to substantial yield reductions. The study was conducted in Greece's most prominent rice-growing region (wider Chalastra area, Thessaloniki) during the 2023-2024 growing season across three experimental fields (~2 ha each). Ground sampling was performed using a 0.5×0.5m grid, visually classifying weed density into low, medium, and high zones. A total of 48 samples were collected to validate remote sensing data and improve digital weed detection models. Yield measurements revealed significant yield losses due to weed competition: 18t/ha in weed-free control plots, 16t/ha in low-density zones, 13t/ha in medium-density zones, and 7t/ha in high-density zones. To monitor weed distribution, UAV flights were conducted at 60 m altitude during critical growth stages using a MicaSense RedEdge-MX™ multispectral camera. The drone images were processed in Pix4D Fields to generate NDVI and NDRE vegetation indices and high-resolution orthomosaics (3.5cm/px). Sentinel-2 satellite imagery (10m resolution) was acquired on dates close to the UAV flights, providing broader spatial coverage. Image fusion was performed in ArcMap by georeferencing Sentinel-2 images to align with UAV-derived orthomosaics. Ground-truthing data collected with RTK-GPS were overlaid on these maps to validate weed classification accuracy. The integration of UAV and satellite imagery enabled the creation of precise geospatial weed distribution maps. From the pilot area, weed biomass percentages were recorded as follows: low (5%), medium (18%), and high (31%), showing strong correlations between ground truth measurements, digital weed detection models, and geospatial maps. Fields with high weed density showed a drastic yield reduction (7t/ha) compared to weed-free areas (18t/ha), emphasizing the need for accurate weed control measures. This study highlights the potential of precision agriculture in weed management by integrating UAV multispectral imaging, satellite data, and geospatial analysis. The results demonstrate the feasibility of incorporating advanced technologies into routine agricultural practices to maximize crop productivity and efficiency.

This research was funded by ELIDEK as project: Agro-Rice -Tools: Novel digital tools for weed mapping and sustainable views of herbicides in rice and project #16845

PS4-23. Geostatistical analysis of the spatial dynamic of *Amaranthus palmeri* in Aragón-Spain

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Invasive alien plant species pose one of the most significant threats to biodiversity, agriculture, sustainable economic development and human and animal health. In that context, *Amaranthus palmeri* S. Watson, an invasive weed native to the USA and northern Mexico, is currently recognized as one of the most serious invasive species in Mediterranean basin countries (includig Spain) due to its high competitiveness, high fertility rate, and ability to develop resistance to herbicides. Considering the high adaptation capabilities and the difficulty of controlling *A. palmeri*, the Plant Health Services foresee its rapid spread across Spain, highlighting the importance of effective control measures to prevent such spread and mitigate the negative impacts of *A. palmeri* on agricultural systems. Therefore, it is essential to identify and understand the factors affecting the dynamics of this invasive weed in order to develop effective control strategies.

This research focuses on the analysis of the environmental variables affecting the habitat suitability of *A. palmeri* in Aragón (Spain), geographical area with the highest infestation in Spain, using advanced data analysis tools and Geographic Information Systems (GIS). In this regard, *climatic* (temperature and precipitation) and *geomorphometry* (topographical, morphometric, hydrological and topo-climatic) covariates were calculated as continuous data surfaces in raster format for the entire study area. Then, multivariate, entropy and risk analyses were carried out to identify the most significant factors and develop the potential distribution maps. Semi-automated analysis techniques were applied to optimize the processing of large datasets.

This approach has led to correlate *A. palmeri* spread with climatic covariates, with the lowest maximum temperature in spring and the lowest minimum temperature in winter, both during the previous ten years, being the most significant covariates, with 44% and 25.6% of explained variance, respectively. In contrast, the morphometric variables LS factor (9.2%) and topographic moisture index (2.5%) were the least informative. The MaxEnt model enabled the prediction of the potential distribution areas in 18.1% of the surface, providing a better understanding of its dynamics and spread. These results are crucial to establish prevention and eradication measures, thereby contributing to reduce the use of herbicide use and to preserve the biodiversity.

This work has been funded by DigitalWeeds project (ref. MMT24-INIA-01) of the MOMENTUM CSIC program and TED2021-132401A-I00 (PRTR and European Union-NextGenerationEU), PID2023-150108OB-C31, and PID2023-150108OB-C32 from the Spanish MCIU/AEI/10.13039/50110

PS4-24. Closing the digital gap through precision weed control in maize and grain crops

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There is a wide range of technology available to the agricultural sector to optimize the use of plant protection products. However, the integration of these technologies and their use by advisors and farmers is very limited in Europe.

The main objective of this demonstration project is to optimize and therefore reduce the use of herbicides in arable crops. For this reason, it is integrated into the line to promote sustainable development and the efficient management of natural resources such as water, soil and air, including the reduction of chemical dependency.

Currently, on the one hand, there is the Expert Decision Support System (DSS) IPMWise, developed by Agrotecnio and the University of Lleida and commercialized by the spin-off IPM Advice, and on the other hand, sensors and drones that allow for zoning of plots. IPMWise, since the beginning of its development in 2009, has demonstrated that, working at the plot level, it allows a reduction of between 20 and 60% of the chemical dependency of crops for weed control compared to traditional practices. On the other hand, sensors such as Veris3100 and Smart Firmer have begun to be commercialized in Europe, which are capable of determining the amount of clay and organic matter in the soil. This is key to being able to apply root-absorbed herbicides appropriately, as their effectiveness depends on these soil parameters. In addition, within the framework of the PID2020-113229RB-C42 project of the State Research Program, Development and Innovation Oriented to Societal Challenges. State Research Agency, work has been done to detect and identify weeds adequately in extensive crops. Therefore, in this demonstration project, it is intended to bring to the field the integration between all systems: Generation of variable rate application maps depending on soil parameters using the IPMWise DSS and subsequently, the use of drones to identify, locate and design specific treatments for each specific point of the plot. With this, it is expected to achieve reductions in the use of phytosanitary products of more than 60%.

Advisors play a decisive role in this demonstration activity. They locate suitable fields, machinery adapted to precision agriculture and are the direct transmission belt between the university and its advised farmers.

These works are funded by ”the activitats de demostració de transferència de coneixements (intervenció 7201), en el marc del pla estratègic de la PAC 2023-2027, corresponents a la convocatòria 2023”.

PS4-25. Precise robotic weed spot-spraying for reduced herbicide usage and improved environmental outcomes in Australian sugarcane cropping system

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The widespread use of herbicides to control weeds in sugarcane crops presents a significant environmental threat due to their runoff into waterways of the Great Barrier Reef (GBR) catchment, prompting public concern and regulatory scrutiny. One promising solution to mitigate runoff of herbicides is the adoption of precise robotic spot-spraying techniques. We developed AutoWeed, a ground-based spot-spraying automated system. This involved designing computer vision and deep learning AI algorithms for weed detection within sugarcane crop and creating a spraying system that can be retrofitted to existing farm equipment.

Over 5 million images of weed species were collected across three main sugarcane regions of the GBR catchment and used to develop deep learning models to accurately detect several priority weeds within sugarcane fields. Field trials took place in major sugarcane cultivation area of Queensland, spanning four years to assess the efficacy of the AutoWeed technology by measuring its effect on herbicide reduction, weed control, and water quality improvement. Specific herbicides registered to control the weed targets in each cane field trial were used.

Results from eleven trials across a total of 86 hectares indicated the AutoWeed spot spraying system was on average 96% as effective to control the targeted weeds compared to traditional broadcast spraying, which was on average 99% effective to control the targeted weeds in the trials. Notably, AutoWeed led to a significant 44% reduction in herbicide usage, with up to 78% reductions in areas with lower weed pressure.

The AutoWeed technology was particularly effective at discriminating broadleaves and nutgrass (*Cyperus rotundus*) from sugarcane plants and has showed promising results in the detection of grasses, even for Guinea grass (*Megathyrsus maximus*), a perennial grass with very similar visual features to sugarcane. An automated spot spray system to control Guinea grass would be particularly attractive to growers, as they typically spot spray it by hand.

Additionally, runoff water quality assessments after spraying showed reductions of 46% in mean herbicide concentration compared to broadcast spraying.

These findings underscore spot spraying's potential for sustainable weed management in sugarcane cultivation, emphasizing its efficacy in reducing herbicide application and improving environmental outcomes.

Acknowledgement(s) / funding: Great Barrier Reef Foundation.

PS4-26. Analysis of restrictions due to infrastructure on the UAV use in the open category over agricultural areas for weed detection

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UAVs are playing an increasingly important role in modern precision agriculture by providing high-resolution aerial images of agricultural land, enabling optimized management. By using various sensors, UAVs can collect precise data on plant health, soil moisture and stress factors such as pest infestation or nutrient deficiency. In addition, the detection and mapping of weeds enables the site-specific application of herbicides. The present study analyses the extent to which agricultural land is affected by this restriction.

The geographical analysis is based on OSM data and data on farmland from the Lower Saxony Digital Agricultural Application (ANDI). OSM data was extracted using the QuickOSM plugin in QGIS for a model region (Hildesheim) in southern Lower Saxony to identify relevant infrastructure elements. ANDI data contain information on field geometry and use in the 2024 study period. Combining both data sets allows for a precise spatial assessment of area restrictions for UAV use in agriculture.

The study examines agricultural land use and its overlap with infrastructure elements, taking into account a 100-meter safety buffer. In total, the agricultural area in the study region covers 68,833.71 hectares, which are divided into 20,657 land parcels with an average size of 3.33 hectares.

Taking into account a given 100-meter buffer saftyzone around infrastructure, the results show a considerable overlap of agricultural areas with infrastructure safety zones in some cases. Areas along power lines (4,719.87ha, 6.9% of agricultural land) are particularly affected, followed by federal highways (2,060.38ha, 2.9%) and railway networks (1,695.37ha, 2.4%). The average size of the affected area per land-use unit is between 1.17 and 1.64 hectares, which corresponds to an average overlap rate of 43.9% to 48.5%. Smaller, but still relevant overlaps occur for waterways (99.12ha, 0.2%) and wind turbines (238.06ha, 0.3%).

The infrastructure elements examined here only include the main components in rural areas and must be expanded for further investigations. However, it is clear that large areas of the study region are subject to extended regulations and thus may not be flown over or only with special extended rules, which complicates the widespread use of UAVs for weed detection in the open category.

13. Weed detection using Artificial Inteligence

S15-O1. Evaluating precision sprayers for targeted weed management in corn and soybean production in the USA

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Keynote session

Precision sprayer uses a combination of hardware and deep machine learning to enable intelligent, real-time weed management decisions in the field. The speaker will share his experience evaluating a precision sprayer for weed management in corn and soybean in the USA. A targeted application of herbicides in commercial crop fields is desirable for reducing chemical inputs and promoting environmental sustainability. Precision sprayers, equipped with cameras and sensors, detect weeds in real-time and apply herbicides only where needed. The objective of this study was to evaluate spot spray (SS) technology compared to the traditional broadcast application for early post-emergence (E-POST) and late-POST (L-POST) herbicides for broadleaf and grass weed control in corn and soybean fields in the USA. Two precision sprayers were evaluated separately, Greeneye Technology's sprayer in a corn field near Clay Center, NE, in 2022 and John Deere's sprayer in a soybean field near Mead, NE, in 2023. In 2022, Palmer amaranth (*Amaranthus palmeri*S. Watson) and giant foxtail (*Setaria faberi* Herrm.) control was similar between SS (94%-99%) and broadcast (99%) application 21 d after L-POST. In 2023, common lambsquarters (*Chenopodium album* L.), kochia [*Bassia scoparia* (L.) A.J. Scott], and waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer] control was similar between spot spray and broadcast 21 d after L-POST. Herbicide savings varied by site years, ranging from 87% to 94% in 2022 and 0% to 5% in 2023. Weed infestation during herbicide applications was low in 2022 and high in 2023, influencing the year-to-year variation in herbicide savings. Corn and soybean yield did not differ among broadcast and SS. The results suggest that precision sprayers can provide comparable control to broadcast herbicide applications and would be more rewarding in fields with low weed infestation and where pre-emergence herbicide is applied. The results of the study on how dual tank system of a precision sprayer can help overcome herbicide antagonism and better weed management will be shared. The pros and cons and future of this new technology in the USA and Europe will be discussed.

S15-O2. Weed detection in cabbage using multispectral images and YOLO models

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Automated weed recognition in agricultural fields can be considered one of the most important tools to minimize herbicide use and thus decrease environmental pollution and improve food safety, especially in vegetable production. Despite recent advances, higher precision is still needed for the recognition of weeds at early growth stages to be implemented in reliable weed management technologies. This research uses the YOLO deep learning model family to investigate the potential of combining near-infrared (NIR) data with RGB imaging to advance real-time weed detection and classification in dynamic field environments. Field data, capturing diverse plant phenotypes under varying conditions, were collected from sown weed and cabbage plots and multiple sites across Bohemia using a multispectral RGB+NIR camera system paired with LED lighting. Images were segmented and plant objects were annotated using a semi-automated procedure followed by careful manual corrections.

Eleven sown weed species along with cabbage crops and two non-target plant groups were classified using various YOLO models, with YOLOv10l delivering the best performance. Incorporating RGB+NIR data improved mean average precision (mAP@0.5) to 94.9%, compared to 94.5% with RGB alone, while achieving a remarkable 97.8% mAP@0.5 for sown species. Misclassifications occurred mainly in non-target weed species which occurred randomly in image data. Beyond enhancing classification accuracy, NIR data streamlined annotation processes, accelerating dataset preparation. These results highlight the promise of NIR-enhanced YOLOv10l in precision agriculture, enabling precise weed management and reduced herbicide dependency. Future work will focus on expanding model adaptability and accessibility, paving the way for broader agricultural applications and sustainable farming practices.

This work was supported by the National Agency for Agricultural Research (NAZV) [grant number QK22010348].

S15-O3. Application of digital technologies for understanding weed ecology and weed-crop interactions

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Weed management is a major crop production challenge worldwide. A better understanding of weed ecology and weed-crop interactions is valuable for developing effective management strategies. In this regard, recent advancements in digital technologies offer tremendous opportunities in agricultural systems. Sensor-based weed recognition and mapping can assist with the characterization of weed-crop interactions, spatial distribution, and population dynamics. Deep learning frameworks such as convolutional neural networks are particularly valuable. Further, different 3-D approaches are being evaluated to improve the estimation of plant biomass, with applications in crop-weed competition and cover crop suppression of weeds, among others. A large-scale, open-source 2-D weed image repository is being developed as a collaborative effort to facilitate the application of digital tools in agricultural weed management

S15-O4. Leveraging fake weeds from stable diffusion to improve CNN training

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The annotation of weed datasets is a labor-intensive and time-consuming process that limits the application of data-driven models for site-specific weed management (SSWM). This study explores the use of Stable Diffusion, an artificial photorealistic image generation technique, to enhance the quantity and diversity of training data for convolutional neural networks (CNNs). The primary objective was to improve the generalization capabilities and accuracy of CNN-based weed detection models while reducing reliance on extensive manual annotations. Additional goals included increasing training efficiency and adaptability to diverse environments. The proposed approach leveraged Stable Diffusion to generate artificial images based on learned weed concepts. A dataset comprising annotated tomato crop images with weeds was used as a case study. By combining 30 real images with high-quality artificial images, CNN models (Yolov8l and RetinaNet) were trained for weed classification and detection. Model performance was evaluated using mean Average Precision (mAP) and generalization across unstructured agricultural data. Results showed that integrating artificial images into the training set improved model performance, with a 9% increase in mAP, achieving a peak of 93% for multi-species detection with overlaps. Artificial datasets reduced manual labeling requirements and enhanced resilience to noise and variability. Additionally, models demonstrated rapid feature extraction (10.2 ms per frame), supporting real-time applications for automated weed management. Future improvements include refining the Stable Diffusion pipeline to layer artificial weeds on diverse backgrounds, further enhancing model adaptability.

This study highlights the potential of Stable Diffusion to revolutionize dataset preparation for weed detection, enabling CNN models to achieve superior accuracy and generalizability while minimizing manual annotation efforts. These findings underscore the transformative role of artificial image generation in developing robust, machine vision-based systems capable of rapid training and adaptation to new environmental conditions.

This research was funded by the grant PID2023-150108OB-C33 funded by the MCIU / AEI / 10.13039/501100011033 and FEDER, EU and by the grant TED2021-130031B-I00 funded by MICIU/AEI/ 10.13039/501100011033, as appropriate, by the “European Union NextGenerationEU/PRTR.

S15-O6. Crop row identification in lettuce for precision mechanical weeding using Yolov8n and Yolov11n

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The increased demand for organic produce, along with the European regulations restricting the use of chemical formulations, and the reduced efficacy of some herbicides due to weed resistance are driving the increased adoption of mechanical weed control. To enhance the effectiveness of this method, various intra-row weeding tools are employed. However, the implementation of these tools, whether via autonomous robotic vehicles or tractor-mounted implements, requires high precision in their placement along the crop row. To support this process, an image-processing model based on machine learning was developed to detect the lettuce (*Lactuca sativa*) crop row using optical methods. The identification method focused on distinguishing between crops and weeds within the row rather than relying on the conventional approach of separating the crop from the background. This strategy is particularly advantageous in environments characterised by high weed densities. Multispectral images were captured from a height of 1m above the ground using a 1.6MP multispectral camera. YOLOv8n and YOLOv11n, as convolutional neural networks ideal for object detection, were trained using 70% of the dataset (200 images of 640x640 pixels and 100 epochs), validated on 15% during training, and tested on the remaining 15%. The weed composition included *Galium spurium* L., *Papaver rhoeas* L., *Veronica persica* L., *Stellaria media* (L.) Vill., *Sinapis arvensis* L., *Sonchus oleraceus* L., *Fumaria officinalis* L., *Lamium amplexicaule* L., *Chenopodium album* L., *Malva sylvestris* L., *Convolvulus arvensis* L., *Lamium amplexicaule*, and *Urtica* sp. all at a relatively low growth stage (BBCH 10-14). The evaluation of both models shows a crop detection accuracy of 96.6%, a recall of 97.6% and an average inference time of 7.24±2.92 ms on the NVIDIA GeForce RTX4080 GPU, while the increase of the training data using image augmentation technics didn't lead to significant performance improvement. Further research and field trials using camera-guided hows are required to demonstrate the weed control efficacy that can be achieved with this approach. However, the results demonstrate successful row identification even in conditions of extensive weed presence (~300 weeds m^{-1}). This facilitates their integration into robotic systems for row alignment using optical sensors, thereby enhancing the precision and efficiency of mechanical weeding.

This research was funded by ELIDEK as project: "Precision Weed Management in Cotton", Project # 15563.

S15-O7. On-the-go herbicide patch spraying in winter wheat

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Weeds often grow in patches. Herbicides are saved if the patches are sprayed (PS). Bottlenecks for PS are automatic weed detection and decision rules, i.e. machine-vision based thresholds. Market-ready equipment for on-the-go PS in small-grain cereals was tested in six field trials in winter wheat in Norway during 2022-2024. Equipment applies deep learning (DL) to estimate proportions of weed and crop in RGB images (< 1m^2) captured by cameras on the field sprayer boom. Cameras control boom sections on/off whether above/below threshold. Two machine-vision based threshold criteria were tested: *Relative weed cover=total weed cover/total vegetation cover* and *Relative dicot cover=dicot weeds/total vegetation cover* except *monocots*. Broadcast spraying (BS) and PS were conducted in parallel swaths in spring. Herbicides and doses were identical across spray method per trial. Grain yield and hectoliter weight were higher after PS than BS in two (+7-8%) and one (+0.2 kg) trial, respectively. Otherwise, no differences in these measures. PS gave slightly more screening (weed seeds and leaves etc.) in harvested grains than BS in the two trials with highest weediness 3-4 weeks after treatment. These and another trial had nevertheless same grain water content (at harvest) across method. PS gave slightly higher water content than BS in the remaining trials. Protein content was higher after PS than BS in one trial. In two others, the opposite occurred. Nonetheless, protein content after PS qualified to the best price in five trials. The same was the case after BS. Falling number were equal across method and above limit for food quality in the food cultivar trials. Tested thresholds were adequate in terms of crop yield and quality (except protein in one trial). Weed control, however, was ambiguous. In four trials PS gave higher weed density than BS. In two trials, weed densities were equal across method. In these two a relatively liberal and restrictive threshold, respectively, were used. Hitherto, restrictive thresholds is recommended since the two criteria were relatively ‘coarse’, i.e. total and dicot weed cover. Refined DL algorithms are underway. Compared to BS, PS would reduce sprayed area by 30-86% per trial (using most restrictive threshold).

‘PresiHoestkorn' was financed by 'Action plan for sustainable use of pesticides' (Landbruksdirektoratet) and in-kind (Dimensions Agri Technologies AS). ‘GreenPatch' was financed by NRC.

PS4-27. Farmland weed recognition in complex environments based on the improved Yolov7 model

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Background: Weeds in farmland are a significant factor affecting the yield of crops. Accurate weed identification is an effective means of scientific weeding. However, the complex field environment, such as varying backgrounds, plants at various growth stages, and lighting conditions, significantly complicate the weed identification process. Existing datasets have limited regional coverage, particularly for weed datasets in southwestern China, which remain scarce. Additionally, the detection accuracy and real-time performance of some models in complex backgrounds have not yet reached the ideal level.

Objectives: (1) This study collected images of common weeds in the southwest of China, sorted them out and constructed a large-scale weed dataset - Weed29; (2) To enhance the accuracy of weed detection and localization, this study proposes an improved deep learning algorithm, YOLOv7_ACE, based on the YOLOv7.

Methods: This study integrates three attention modules into the YOLOv7 model and conducts ablation experiments to compare their performance. This study conducted ablation tests by integrating three attention modules into the YOLOv7 model. It also introduced Distribution Shifting Convolution and Efficient Channel Attention, achieving a dual improvement in detection speed and accuracy. The final optimization of YOLOv7_ACE is as follows: First, the Convolutional Block Attention Module (CBAM) is incorporated into the backbone network of YOLOv7 to enhance the feature extraction across both channel and spatial dimensions; next, the Distribution Shifting Convolution (DSConv) is employed to replace certain 3×3 convolutions (Conv) in the head network; finally, a lightweight attention module, Efficient Channel Attention (ECA), is integrated to reduce computational complexity.

Results: The experimental results demonstrate that YOLOv7_ACE effectively detects weeds in farmland, with mAP@0.5 of 96.0%. Compared with Faster R-CNN, YOLOv3, YOLOv5 and YOLOv7, it has improved by 6.6, 11.0, 8.9 and 5.3 percentage points, respectively. This model has achieved improvements of 5.1, 7.0, and 6.0 percentage points in precision, recall, and F1 score, respectively, compared with YOLOv7.Meanwhile, YOLOv7_ACE reduces the model parameters by 0.49% compared to the YOLOv7 model, while maintaining its accuracy and ensuring real-time detection speed. The proposed method provides effective technical support for the precise detection of weeds in farmland.

This research was funded by the National Natural Science Foundation of China, grant number 32201651 and 32001425

PS4-28. Precision weed detection in onion fields using YOLO neural networks

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Fully automated weed detection is essential for the contemporary goals of reducing herbicide use and promoting sustainable agriculture, particularly in vegetable crop production. This analysis investigates the application of the YOLOv10 deep learning model for real-time weed detection in onion fields using multispectral imagery. Images of the crop and weeds were taken using an RGB+NIR camera under a controlled flashlight. A dataset comprising 13 specific weed species and three broader weed groups was collected under field conditions and on experimental plots, capturing diverse plant phenotypes. Weed composition was selected to cover the most important species in onion fields. Images were annotated using a semi-automated pipeline with careful manual oversight and corrections to ensure high-quality labels. The trained neural network model achieved a mean average precision (mAP@0.5) of 94%, demonstrating strong detection performance across varying lighting and plant growth conditions. Misclassifications primarily occurred in broader weed groups, while species-level identification remained highly accurate. Lower precision (mAP@0.5 of 91%) was achieved for onion probably due to the overlapping nature of long and thin plants. These overlaps caused less match in shape and size of predicted and true bounding boxes which may not mean missing onion plants. The results highlight the potential of the state-of-the-art YOLO-based detection systems for precision agriculture, enabling targeted weed management and reducing chemical inputs given their inherent processing speed. Future research will focus on refining the model's early growth-stage weed identification capability and expanding its applicability to other crop systems.

This work was supported by the National Agency for Agricultural Research (NAZV), grant number QK22010348.

PS4-29. Machine learning applications for analyzing herbicide droplet deposition patterns

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Understanding herbicide spray patterns (i.e. droplet size and distribution) is essential for optimizing application parameters to maximize spray coverage on the target plant and minimize herbicide drift. The spray patterns are typically captured using spray cards which are then analyzed to detect spherical droplets. The traditional methods of analysis can be inaccurate. Moreover, wind and other factors can cause droplet smears on spray cards, leading to further inaccuracies in determining spray patterns. In this study, custom machine learning pipelines were developed using YOLOv11, integrating CSPDarknet and PANet architectures to detect and quantify droplet size distribution on spray cards, including error rate estimation caused by smears. The spray cards used for model training, validation, and testing were obtained from a herbicide spray deposition study conducted earlier. Roboflow was used to annotate and augment droplets and smears on spray cards, and the model was created and tested using Python. To overcome the training dataset size limitation and increase the diversity of the data, the images were cropped into nine equal squares per raw image to enlarge the dataset. 411 images were allotted for training the model, 116 for validation, and 57 for testing. The best smear detection model provided a precision of 83% (number of correctly predicted detections) and a recall of 80% (number of actual smears detected), indicating reliable model performance. A complementary model for total droplet detection further enhances accuracy, allowing for precise quantification of smear rates and herbicide deposition efficiency. Here we demonstrate the use of a machine-learning model for effectively detecting droplets and smears in spray cards and estimating associated error rates. This model enables researchers to analyze spray patterns with high accuracy, supporting robust decision-making for optimizing herbicide application.

Acknowledgement(s) / funding: Texas A&M University.

PS4-30. An ISOBUS low-cost approach for intelligent mechanical variable weed control

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Currently, no commercial weed identification systems support ISOBUS communication, despite the growing need for standardized protocols to handle increasing data processing demands. This study aimed to develop an advanced intelligent system for accurate, variable-intensity weed control enabled by ISOBUS communication. An AI-driven decision-support system (DSS) was designed to process data and relay treatment decisions, which were executed by an ISOBUS-enabled tine harrow capable of dynamically adjusting its intensity. By targeting weed-infested areas, the system seeks to enhance efficiency, reduce resource usage, and promote site-specific weed management.

The system includes a tine harrow mounted on a tractor, controlled by a linear actuator for variable mechanical weed management through adjustable tine angles. An integrated RTK-GPS ensures precise geolocation, while the AI-driven DSS facilitates site-specific treatment decisions. A digital twin of the tine harrow and its actuation mechanism was created using CAD software and integrated into Unity, enabling the simulation of various operations. A hybrid simulation environment replicated the hardware and virtual scenarios, preparing the system for field deployment.

Simulation testing in Unity, incorporating physical components and a digital twin, validated the system's real-time activation mechanisms and tractor movements. This approach enhanced reliability and performance under field conditions, significantly reducing dependence on chemical herbicides and improving resource efficiency. Outdoor trials confirmed the system's ability to dynamically adjust the tine harrow's angle for precise mechanical weed control, demonstrating promising results.

The integration of an AI-driven DSS with a digital twin and ISOBUS-enabled tine harrow demonstrated effective control of treatment intensity and enhanced system reliability in real-world agricultural settings. Outdoor experiments validated the system's readiness for practical applications, highlighting its potential to optimize weed management by reducing chemical herbicide use and improving resource efficiency. This technology represents a sustainable, environmentally friendly solution for precise and efficient weed control in modern agriculture.

This research was funded by the grant PID2023-150108OB-C33 funded by the MCIU / AEI / 10.13039/501100011033 and FEDER, EU and by the grant TED2021-130031B-I00 funded by MICIU/AEI/ 10.13039/501100011033, as appropriate, by the "European Union NextGenerationEU/PRTR.

PS4-31. An AI-based annotation tool for measuring crop and weed cover increases novice observer survey precision

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Vegetation surveys are crucial in agro-ecosystems for understanding weed eco-biology and developing integrated weed management solutions. Vegetation cover estimation is the most common, non-destructive quick and reliable measurement but often suffers of subjective evaluation of vegetation cover that leads to inter- and intra-observer variability, since the surveys are often performed by multiple observers.

We used a novel AI-based tool based on two models: shape (SAM) and vegetation (VegAnn) recognition. The tool provides cover estimates of species/categories through image annotation performed manually by an observer, to test:1) measurement reliability of observers with different levels of expertise; 2) precision increase of novels observers after training with the AI-based annotation tool.

Two vegetation surveys were carried out during the initial stages of a lentil-buckwheat intercropping trial and at lentil branching, with more complex and multi-layered vegetation. Vegetation (lentil, buckwheat, weeds) and soil cover were evaluated independently by two observers (expert and novice) on two framed sampling areas per plot. Each sampling area was then photographed (Samsung Galaxy A42 smartphone). Pictures were then cropped to the size of the sampling frame and processed by the novice with the AI-based tool.

The effect of the observer type (expert, novice, AI-tool) on the cover of lentil, buckwheat, weeds and bare soil was tested using generalized least squares (GLS) mixed effect models (MEM). The novice gave an average weed cover value of 8% which was reduced to 3% after using the AI tool, while the expert gave a value of 4%. Lentil cover values calculated with the tool were 36% lower compared to the expert, but this is mainly attributed to the 2D representation of the photos, while the observers unavoidably move in a 3D environment and can ignore stratification. Crop cover estimation seemed to be influenced by the spatial layout of the crops and the amount of bare ground in the frame. The study contributes to clarifying the relevance of expert training in weed field surveys in arable crops scenarios. We also proved that the AI tool is useful for novel observer training since it can reduce inter-observer variability and increase precision in complex vegetation surveys.

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17.

PS4-32. International Weed Recognition Consortium (IWRC): facilitating the development and use of digital imagery for weed research and management applications

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Recent advancements in digital imaging and artificial intelligence/machine learning (AI/ML) have enabled precise recognition of individual weed plants and plant parts within agricultural settings. This capability paves the way for targeted weed management and enhanced weed ecology research by facilitating highly detailed analyses of weed-crop interactions. However, the development of effective weed recognition algorithms is heavily dependent on access to large, high-quality weed image datasets. The complexity of agricultural scenarios further increases dataset requirements, often necessitating millions of annotated images for accurate algorithm training. Despite the transformative potential of these technologies, dataset availability and algorithm development remain major limiting factors. To tackle this challenge, the International Weed Recognition Consortium (IWRC) has been formed. This initiative aims to (i) facilitate the development of image libraries for problematic weed-crop scenarios; (ii) provide research and industry guidance on image collection, classification, and annotation; (iii) offer training and technical support for weed recognition algorithm development; and (iv) promote the application of digital technologies in global weed research and management. By integrating AI-driven weed recognition with accessible datasets, the IWRC will accelerate innovation in weed science, supporting more efficient and sustainable weed control strategies.

PS4-33. Image classification of seedlings of maize weeds using Deep Learning

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Weeds must be in order to minimize their influence in crops. Several approaches have been devised as a form of weed monitoring, the first step towards managing their presence in different crops. Usually weed monitoring is made by visually assessment and record of plant coverage or counting; species identification could be a complex and time-consuming task. New procedures and their implementation are necessary for identifying plant taxa. Content-based image retrieval and computer vision approaches are considered as one of the most promising solutions. To that end, we present an application capable of detecting and assisting the user in the identification of ten maize weed species relevant in Ribatejo and Oeste Portuguese regions, through the use of deep learning based techniques: *Amaranthus retroflexus, Chamaemelum mixtum*, *Chenopodium album, Digitaria sanguinalis, Fallopia convolvulus, Portulaca oleracea, Solanum nigrum, Tribulus terrestris*, and *Urtica membranacea.*Identification of weed seedlings was chosen because many control tactics are most effective against newly germinated or young weeds. It is expected that all kinds of end users are able to use the application to automatically detect and identify different species of relevant weeds in the Ribatejo and Oeste region. Several deep learning model architectures that proved to be efficient in similar problems were tested and compared. A dataset with 12000 images of individual weed seedling was constructed from *circa* 4000 mobile phone camera images labeled by an expert, using data augmentation techniques. It was concluded that the most suitable architecture for the task of identifying the different species of weed seedlings was *ResNet50 with retraining of the classification layers*, since this was the architecture the best results with a F1 test score of 86%. Similarly, it was also determined that the architecture for identify whether the image provided by the user is in fact a seedling was *MobileNetV2, also with retraining, attaining a F1 test score of 99%*. Both models attain F1-scores. In this way, both the *ResNet50* and *MobileNetV2* resulting models were integrated into the mobile application.

PS4-34. Development of deep learning networks for automated detection of selected weeds in tomato cultivation

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Effective weed control is essential for optimizing the tomato yield. Precision agriculture facilitates selective herbicide application through site-specific weed management (SSWM), reducing chemical inputs. Automated weed detection using deep learning has gained increasing interest. In the current study YOLOv8 and YOLO11 models were developed and evaluated for detecting four weed species (*Amaranthus retroflexus, Chenopodium album, Portulaca oleracea,* and *Cyperus esculentus*) in outdoor tomato fields using UAV-acquired RGB imagery. The evaluation of the deep learning models was based on widely used performance metrics, including Precision, Recall, mAP50 and F1-score, both for each weed species individually and overall. Results showed that this type of deep learning model achieves satisfactory accuracy in recognizing and detecting the target weed species under real-world tomato cultivation conditions, despite the relatively high image acquisition altitude, which was over 5 meters above ground level. However, performance varied among species, with *Cyperus esculentus* dominating the dataset and affecting detection rates. Furthermore, utilizing higher image resolutions as network inputs for the training and validation of the aforementioned networks resulted in an increase of the overall precision and recall of the networks. The best model so far achieved an F1 score of 0.496 with an inference time per image of about 4000x3000 pixels in the order of 30ms (using an RTX4090 GPU). Improvement of the model's performance will be attempted by applying image tiling, because of the small size of the target weeds in relation to the large size of the available images. Due to the small size of the weeds relative to the overall image dimensions, this research suggests that model performance decreases as the level of image compression increases. Future research will explore these constraints, considering computational limitations of advanced GPUs during training.

14. Connecting weed ecology with management

S16-O1. NeutraWeed: combining functional ecology with AI and robotics to shift the integrated weed management paradigm

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Weeds represent the base of agricultural trophic networks whose ubiquity requires effective management. Even though herbicides and soil tillage remain the most widely used options to control weeds worldwide, these practices have been associated with drawbacks such as herbicide resistance, soil degradation, and biodiversity loss. Therefore, it is essential to identify innovative weed management strategies based on cutting-edge ecological knowledge of crop-weed interactions while harnessing innovative technologies like artificial intelligence (AI) and robotics. A change in the weed management paradigm is needed to encourage farmers to adopt alternative strategies for weed management. The concept of Neutral Weed Communities (NWCs) is proposed as a solution to reduce herbicide use and intensive soil tillage while increasing biodiversity and ecosystem services. NWCs are weed communities that can coexist with crops without negatively impacting crop yield and quality compared with weed-free conditions. With these goals in mind, we conceived of *NeutraWeed*, a

worldwide European-funded Project (MSCA Staff Exchange), elaborated to better characterize NWCs, provide a greater understanding of the underlying ecological processes, and investigate how novel technologies could allow the selection of them. The Project allowed the creation of an international and inter-sectoral network of 16 organizations from Europe, the Americas, Africa, and Asia with complementary skills. This network will be involved in joint research programs on weed ecology and management, AI, and robotics. *NeutraWeed* participants will focus on 1) identifying NWCs in the most common cropping systems, including interactions with crops and other biotic agents, 2) characterizing the effects of NWCs on the provisioning of ecosystem services, 3) the development of weeder robot prototypes for weed-specific analysis, and 4) the identification of AI algorithms for weed species-specific discrimination to attain NWCs via robots. The multiple interactions between NWCs and crops will be investigated using expertise and approaches in the fields of agroecology, microbiology, plant physiology, molecular biology, computer science, and engineering. Participants come from Italy, France, the Netherlands, Greece, Spain, Argentina, Kenya, the United States of America, and China. The ultimate goal of this multidisciplinary international exchange effort is to develop and deploy novel effective weed management strategies, economically viable, and promote agrobiodiversity.

Acknowledgement(s) / funding: HORIZON-MSCA-2023-Staff Exchange- Grant Agreement N101182891.

S16-O2. From experimental data to actionable knowledge: stochastic matrix population models to inform the design and evaluation of integrated weed management strategies.

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The objective of this study is to propose the utilisation of stage-classified stochastic matrix population models for the analysis of the population dynamics of annual weeds. The model presented here provides a foundation for the evaluation of integrated weed management strategies, with the objective of regulating the population dynamics of agriculturally harmful plants with reduced reliance on chemical weed control tools.

The presented matrix model approach was initially parameterised for *Alopecurus myosuroides* Huds., with the aim of allowing a comparison of the presented stochastic modelling approach with other existing deterministic modelling approaches.

The weed life cycle is modelled in five periods, each of which is characterised by agronomic and/or environmental events that are expected to significantly affect the life cycle. These periods are represented as a seasonal matrix containing the respective state variables for describing the fate of seeds, seedlings or mature plants during the respective period. The model incorporates key state variables, including: i) the proportion of non-dormant seeds in the soil seed bank, ii) the actual germination and emergence rate, influenced by environmental parameters, iii) the seed predation rate, iv) the plant mortality rate, encompassing natural plant death and death attributable to agronomic measures, and v) plant reproduction.

The model parameter estimates were derived from a series of long- and short-term field experiments conducted in Sweden between 2002 and 2018. The full life cycle is simulated with 10^4 iterations, each time with parameter estimates sampled according to their actual distribution. The outputs of the model are utilised to calculate the stochastic population growth rate as well as its sensitivity and elasticity.

The model's capabilities are illustrated through the demonstration of simulations of direct and indirect weed management measures with emphasis on agronomic and mechanical management tools and their interactions. Furthermore, the impact of harvest weed seed destruction and seed predation on population dynamics is demonstrated.

The proposed modelling approach is intended to stimulate open science. To this end, it will be made publicly available under a Creative Commons license, and a web-based version will be available for teaching and advisory purposes.

S16-O3. Tree-based inference of weed community networks: unraveling crop-weed interactions across agroecological treatments

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Modelling plant competition has advanced our understanding of crop-weed dynamics, particularly concerning plant density and interspecific interactions. However, predicting crop responses to weed competition remains challenging due to the complex interplay of biotic and abiotic factors. This study employs a network-based approach to better capture weed community assembly under different management and environmental conditions, using weed occurrence data across various treatment regimes. We aim to address: (1) Which species interact with each other and with crops in each system? (2) What functional traits drive these interactions?

We apply a tree-based inference method—novel in weed ecology—to reconstruct species interaction networks, capturing both weed-weed and crop-weed relationships. This analysis uses weed abundance and biomass datasets from field experiments under organic agriculture on annual crops over multiple years. Treatments include reduced tillage, living mulches, and intercropping systems. Environmental covariates help distinguish direct species interactions from indirect associations. A Poisson log-normal model handles overdispersion, and an expectation-maximization algorithm identifies significant species relationships. We analyze functional trait data from an existing database to assess the role of functional diversity in weed community structure. The network-based approach is compared with traditional ordination techniques.

Preliminary results show that weed communities exhibit distinct interaction structures depending on the treatment applied, with certain weed species emerging as key network nodes. Incorporating environmental covariates reduces spurious associations, providing a more accurate representation of species interactions. Variations in network connectivity suggest that different practices shape competitive and facilitative interactions among weed species. Graph-based visualizations and trait-based analysis further elucidate species relationships and explain observed interactions.

This study highlights the value of network-based approaches in analyzing weed community structure and crop-weed interactions under different management practices. Integrating trait-based analysis and network inference offers a deeper understanding of the ecological processes driving weed community dynamics. These insights can improve predictive models of weed dynamics and support the development of more effective integrated weed management strategies.

S16-O4. Weedy fallow as a strategy to increase soil cover in dry no-till systems of northeastern Spain

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In the last decades, the area devoted to no-till is increasing in Europe, since 2023 encouraged by one eco-scheme of the common agricultural policy. However, in very dry areas the scarce residues of the winter crops after harvest do not favour the generation of a significant soil cover. Mostly, farmers apply herbicides during the summer, but some have reached the conclusion to leave the weeds untreated those months. This work aims to collect data on the soil cover achieved by weeds growing during the crop and in the summer fallow and their possible effect on yield.

Three plots located in Perdiguera (Zaragoza, north-eastern Spain) managed in no-till during 22 years have been periodically visited (15 times) from summer 2021 to autumn 2024. Weed soil cover of each individual species was recorded and frequencies calculated. Each plot followed a different crop rotation: barley-oat-pea-barley, barley-durum wheat-barley-pea and pea-wheat-barley-wheat.

The plots showed differences in richness (93, 47 and 42 species over the sampling period, respectively) that could be due, in part, to differences in crop rotation.

Mean total weed cover in the crop-free periods was 20, 30 and 34% and during the cropping period, 18, 15 and 10%, for the three plots, respectively. *Bassia scoparia* was the only species with a mean abundancy when present exceeding 5% in all plots (7, 20 and 40%, respectively, reaching 80% in some assessments in September). The farmer usually applies 2,4-D+tribenuron in April to hold the first emergence flushes, what seems to be sufficient as the yields obtained are in the range of the region means. Other species such as *Bromus rubens, B. diandrus, Conyza bonariensis, Cynodon dactylon* and *Heliotropium europaeum* reached mean cover between 3 and 4%; the rest of species had lower values.

Concerning frequency, 13, 5 and 6 weed species were present in more than 45% of the sampling moments in plots 1-3, respectively, being most of them biennial or perennial, favoured by no till.

These data show the effect of summer weedy fallow on the weed community and on yield as a successful management strategy for the implementation of no-till in the region.

S16-O5. Study of *Bromus tectorum* cultural management at seeding time in dryland cropping systems

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Bromus tectorum L. is a difficult species to control in the dryland wheat production region of the Pacific Northwest. The widespread herbicide-resistant *B. tectorum* populations in the region have further complicated this species management. The main goal of this research was to study how cultural practices at seeding time might alleviate the problem. The particular objectives were to determine the effect of the seeder type, winter wheat density (regular vs. high), winter wheat variety (more upright vs. more prostrate plant architecture), crop type (wheat vs. peas), and crop rotation (crop vs. fallow) on *B. tectorum* infestation. We also included soil disturbance of the seeders without planting seed (hereafter referred as false seeding). The study was a randomized complete block design with three replications established in 2023 and again in 2024 at the Columbia Basin Agricultural Research Center, Adams, OR. The two drills used were a conventional seeder with chisel type openers and 36 cm of inter-row space and a no-till drill with disc openers and 19 cm of inter-row space. *Bromus tectorum* infestation was evaluated three times during the growing season. In 2024, *B. tectorum* biomass and crop yield were also evaluated. Analyses of variance were used to find differences among treatments. In 2023, *B. tectorum* was suppressed by the winter wheat crop regardless of seeder type or crop density. The *B. tectorum* infestation was similar in the pea crop and fallow, indicating a poor competitive ability of winter peas against this weed. In 2024, there were no differences in *B. tectorum* infestations in any of the eight treatments based on plant density or percentage cover measured before April. However, later in the season, greater *B. tectorum* biomass was found in the plots with false seeding. The plots in fallow and with peas showed greater *B. tectorum* biomass than the winter wheat plots but they were not significantly different. Differences in interrow-spacing, crop variety, or crop density did not affect *B. tectorum* infestations in any of the studied years. The cultural practices studied did not show promising results to suppress *B. tectorum* at seeding. Another year of study is on-going.

Authors thank the Oregon Wheat Commission for funding this study.

S16-O6. Assessment of legume-asbed cropping systems for weed management in VALERECO's Greek Living Lab (LL)

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VALERECO, a Horizon Europe project, aims to identify and assess the environmental and economic value of the Ecosystem Services (ES) of legumes through the establishment of nine Living Labs (LLs) in 11 European countries. An important ES from the introduction of legumes in diversified cropping systems is weed suppression in agricultural fields.

A two-factor field trial (strip-plot arrangement) was established in a Randomized Complete Block Design (RCBD) with three replications in the Greek LL in Central Greece to evaluate the weed suppressive potential of legume-based cultural practices and weed management strategies during the 2024–2025 growing season. Crop rotation was the vertical plot factor with seven levels: lentil (cv. 1)-wheat-sulla, lentil (cv. 2)-wheat-sulla, wheat-wheat-wheat, sulla-lentil (cv. 1)-wheat, sulla-maize-sulla, sulla-wheat-sulla. Weed management was the horizontal plot factor with five treatments: sole crops with mechanical weeding (T1), sole crops untreated (T2), intercropping without weed control (T3), cover cropping (oat + white mustard) without weed control (T4) and cover cropping followed by post-emergence weed control (T5).

As this was the first year of crop rotation, all significant (*P <0.05) differences relate to comparisons between weed management strategies. *Avena sterilis* L. and *Sinapis arvensis* L. were the most frequent species with an occurrence in at least 73 of the 105 plots. Treatment T5 suppressed weed biomass by 60–70% compared to T2. T1, T3 and T4 resulted in weed biomass of 150–180 g m^{-2}, reducing weed pressure compared to T2 (424 g m^{-2}). The performance of T5 is attributed to the weed suppressive potential of oat + white mustard cover crop combined with the post-emergence weed control.

These preliminary results underline the central role of diversified legume-based cropping systems for the development of sustainable farming systems in modern agriculture.

This research was supported by the European Union's Horizon Research and Innovation Action (RIA) project under the grant agreement no. 101135472 (VALERECO project – https://valereco.eu/)

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