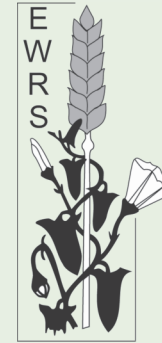


6th Workshop of the EWRS Working Group: Weeds And Biodiversity
September 28–29, 2016 in Riga, Latvia



European Weed Research Society

**Proceedings of 6th workshop of the EWRS working group
Weeds and Biodiversity**

**Riga, Latvia
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Predicting the winners and losers of agricultural change

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The past 60 years have been characterized by major changes to the way crops are grown and farming landscapes. A common feature of these changes is a loss of diversity; fewer crops are grown with simpler management in landscapes with fewer boundary features and less semi-natural habitat. The homogenization of farming has been a major challenge for the non-crop biodiversity that shares the habitats in agro-ecosystems with cultivated crops. Not least, the weed flora and higher trophic groups it supports has undergone significant declines in diversity, both taxonomically and functionally. As opposed to studying these changes using an autecology approach (modelling the response of individual species to change), I present general principles that explain shifts in the weed flora at a national or continental scale. This involves defining environmental and management change in terms of a hierarchy of 'filters' that acts on a regional species pool. These filters act on the functional response traits of the weeds selecting out poorly adapted species. I present evidence for the concept of syndromes of traits that can be used to predict winners and losers in modern intensive cropping systems based on empirical evidence from weed surveys, models and experimental data.

Weed species that have declined across Europe in response to changes in management are characterized by more stress tolerant traits that make them better adapted for below ground competition including a higher root weight ratio and later flowering. Increased use of fertilisers and herbicides have reduced the available realized niche for species with this trait syndrome and selected for more nitrophilous species that are better adapted for competition for light. This functional shift in the weed flora will have implications for the invertebrates and birds that use them as a resource. I will also present data demonstrating how the concept of response and effect traits can be used to model the effects of changing the weed flora on wider biodiversity.

**Session “Arable weed diversity I: environmental and
historical factors”**

Impoverishment of the arable flora of central Germany during the past 50 years: a multiple-scale analysis

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Several studies have examined changes in arable plant vegetation at the species or population level. However, analyses at the community or genetic level are lacking. Here, the results of a survey across several regions in central Germany covering different soil/climate conditions and landscape structures are presented.

At the species and community level, changes in 392 arable fields from the mid-20th century with the current situation were compared. We also assessed differences in structure between structurally uniform and diverse agricultural landscapes, and analysed the genetic structure of remnant arable plant populations in relation to landscape complexity. Furthermore, it was tested whether *ex situ* cultivation affects genetic diversity of rare arable plants.

With respect to the field interior, the local species pool experienced a dramatic reduction of nearly one quarter, and an equally significant decline in biodiversity occurred at the plot-level. Diagnostic species for phytosociological syntaxa have largely vanished, with losses being more pronounced among diagnostic species of lower-ranked syntaxa, such as associations.

Within-population levels of gene diversity did not differ significantly between landscapes. These results suggest that landscape complexity is of limited importance for genetic structures. Under *ex situ* conservation, population sizes of arable plants tended to be lower, and levels of genetic diversity also tended to be lower compared to arable fields. *Ex situ* populations, *i.e.* in botanical gardens, showed incomplete representation of alleles found in the wild.

Our results imply that against common assumptions *ex situ* populations may not represent secure sources for arable plant diversity due to limited sampling and population sizes. Hence, we urge for improved conservation measures at all levels.

Joining weed survey data bases for analyses on a European scale

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Research on weed distributions and distribution changes, for example in the context of climate change, relies on data sets of species occurrence with large geographic extent, but precise coordinates. Repositories, such as the Global Biodiversity Information Facility (www.gbif.org), provide such data. Unlike in natural ecosystems, the occurrence data is often insufficient to analyze vegetation data meaningfully in arable systems. A minimum of information would be required, such as the crop grown, sowing season, or whether the field was treated with herbicides.

Our proposition is to join weed survey data from the various data bases that weed scientists have collected all over Europe. These surveys have usually collected additional agronomic information (Hanzlik & Gerowitt 2016). Besides distribution change analyses, the joint dataset may also facilitate analyses on weed composition and the underlying factors or patterns on a larger spatial scale than has been possible so far. A number of researchers and working groups have indicated interest to contribute to such a project, including, for example, the WeedMap initiative (Hamouz et al. 2011).

Future working steps will be suggested and may be discussed, including:

Who has data? What are on-going data collection activities? - Networking, collecting data on weed surveys, making data sets visible.

Who is willing to share? Who wants to collaborate? On what? - Drafting possible analyses together.

What is needed? - Deducing data requirements.

How can the work be done? – Joining data for certain analyses or building a joint data base, possibly application for funding, preferably using existing data base structures.

Hanzlik & Gerowitt (2016). *Agronomy for Sustainable Development* 36: 11.
Hamouz, Kolářová & Soukup (2011) Presentation at the Workshop of the EWRS Working Group Weed Mapping, Jokioinen, Finland.

Factors influencing weed species composition in Hungarian soybean fields

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The goal of this study was to identify factors determining weed species composition in conventional soybean (*Glycine max* /L./ Merr.) crops in Hungary, where its expanding production faces serious weed problems.

The abundance of the weed flora was measured in 262 fields across the country, along with 38 potentially explanatory variables. Using a minimal adequate model containing 24 terms with significant net effects, 21.6% of the total variation in weed species data could be explained.

Plot location (edge vs. center) was found to be the most important explanatory variable, which was followed by a set of environmental (temperature, precipitation, altitude, soil texture, pH, Ca, K, Na and humus content), cultural (cultivar maturity, organic manure, fertiliser P and N, row spacing), and weed-management (flumioxazin, pendimethalin, dimethenamid, propaquizafop, bentazon, quizalofop-p-ethyl, quizalofop-p-tefural, linuron, thifensulfuron) factors. Variation partitioning revealed that environmental variables accounted for about four times more variance than cultural and about two and half times more than weed-management variables. *Chenopodium album* L., *Ambrosia artemisiifolia* L., *Hibiscus trionum* L., *Echinochloa crus-galli* (L.) P. Beauv and *Convolvulus arvensis* L. were the most dominant and frequent weeds but their abundance was influenced by different factors.

Despite the relatively weak influence of management factors, the responses of the most noxious weed species to the studied cultural and weed-management variables can be used to customize weed management strategies.

This work was supported by Hungarian Scientific Research Fund (OTKAK111921).

Biology and distribution of rare weeds in the Northwestern Waldviertel, Austria

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The Lower Austrian part of the Hercynian region (Waldviertel) near the city of Gmünd is characterised by very nutrient-poor, acidic sandy soils. This specific underground provides a habitat for weeds with a low ability to compete. In the context of investigations for the Austrian agri-environmental program (ÖPUL), four rare annual weeds were mapped in 2013. Moreover, a suitable management for each species was elaborated.

Illecebrum verticillatum L. was only found once in an arable field near Gmünd. Due to its prostrate habitus, this Caryophyllaceae needed large gaps in the canopy to survive in crop land.

Aphanes australis Rydb. (Rosaceae family) was restricted to winter cereals, where the annual species grew in the understory. It occurred in the sandy region north and west of Gmünd.

Teesdalia nudicaulis (L.) R. Br., a small rosette plant of the Brassicaceae family, preferred uncultivated field margins or very nutrient-poor fallows. Its distribution in the study area ranged from Gmünd 7 km to the North.

The ecology and distribution range of *Arnoseris minima* (L.) Schwegg. & Körte, a yellow Asteraceae, was somewhat wider: This rosette plant germinated in autumn or spring and therefore occurred in summer or winter crops. Most populations were located around a circle of 10 km around Gmünd, but there were isolated occurrences in the entire Waldviertel region.

These weeds are not only endangered by intensive farming, but also by management changes, such as the abandonment or transformation of arable land to grassland or fallows. Arable fields with low input of fertilisers and herbicides and a high proportion of winter crops favour the last populations of these species.

Session “Arable weed diversity II: crop diversification and cover crops”

**The occurrence of weed species in arable fields in Latvia,
as a function of crop rotation**

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The overall aim of the research was to work out science-based recommendations for weed management necessary to implement Integrated Pest Management principles. Crop rotation can be used as a tool for weed management. It also affects weed species occurrence. Our hypothesis was that infestation of fields with certain weed species could be controlled by decreasing the proportion of cereals in a crop rotation.

Field data were collected in Latvia from 2011 to 2015. For weed monitoring, six fields were chosen in each of 50 farms and visited in years 2013-2015. Occurrence of weed species in each field was measured in 100 points along a transect. Plant density was calculated using correlation table based on negative binomial distribution.

One hundred and fifty weed taxa, at the species or genus level, were recorded during the three-year period. Most common weed taxa were *Viola* spp., *Equisetum arvense* L., *Fallopia convolvulus* (L.) Á.Löve, *Lamium* spp., *Galium aparine* L., *Elytrigia repens* (L.) Nevski, and *Veronica* spp. The number of weed plants and the number of weed species were significantly ($p < 0.05$) influenced by an increasing proportion of cereals in crop rotation, which reached a maximum of 80–100%. An increase of proportion of cereals in the rotation also favoured the occurrence of volunteer crops and invasive weed species, including *Avena fatua* L.

The usefulness of crop rotations as a weed control method requires additional studies, especially with regard to increasing infestation with noxious annual grass weeds.

Key words: weeds, weed occurrence, proportion of cereals in crop rotation, integrated pest management.

Studying the workings of on-farm crop diversification on weed diversity in Northern European organic cereals

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This study is a part of the CORE Organic PRODIVA project; a collaboration between N-European weed research institutions, which aims to improve the utilization of crop diversification for weed management in organic arable cropping systems. The overall goal is to maintain a diversified and manageable weed flora that can support beneficial organisms. The specific objectives of the research conducted by our group are: to identify practical weed problems, to investigate the role of crop diversification on weed communities and to categorize weed species in accordance with their response to crop diversification strategies (e.g., crop rotations, cover crops, catch crops, intercropping)

In order to reach these objectives a range of methods is proposed. Data collection is taking place in six countries (Denmark, Sweden, Finland, Latvia, Poland and Germany) over the course of two years (2015-2016). Firstly, existing information from the literature on weed occurrences from all regions has been compiled into an Ex-ante database. Next, a two year on-farm weed survey is being carried out in summer cereals on organic arable farms. This is supplemented with the collection of information on the field history, with a focus on the crop diversification strategy used.

Data collected will be processed and analyzed. The data from the weed survey will be compared with the Ex-ante database and analyzed for interactions with the crop diversification strategies. Results will be shared with the international partners to be communicated towards farmers and extension services, in hopes of bridging the science-practice gap.

Tillage and cover crop management as an option to minimize soil compaction and weed infestation

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It is known that low intensity tillage is economically beneficial and minimizes soil erosion, but it is often accompanied by problems, such as soil compaction and higher weed and pest infestation. A cereal-based crop rotation, which is common practice in Lithuania, increases the occurrence of the specific weeds and pest, especially when low intensity tillage technologies are applied.

A number of studies has been performed on the effect of break crops, also known as catch or cover crop, for green manure, on nitrogen leaching. Not many data are available on the impact of break crops on soil physical properties and weed density under various tillage conditions.

The main purpose of our study was to measure the effect of white mustard *Sinapis alba* L., as a cover crop, on soil compaction and weed pressure in different tillage systems. Five tillage practices, namely deep ploughing (20-22 cm), shallow ploughing (14-16 cm), harrowing (8-10 cm), harrowing (12-16 cm) and direct drilling, were investigated in combination with and without white mustard, in a loamy soil in a long-term experiment in Dotnuva. White mustard was established before harvest of the main crop, using a fertilizer spreader, in 2013 and 2014. White mustard had a positive effect on soil bulk density, total porosity and other physical properties. It also clearly reduced the number and mass of weeds in all tillage treatments.

Our results suggest that white mustard as cover crop might be an option not only to prevent nitrogen leaching but also to reduce soil compaction and weed pressure.

Manipulating plant species diversity with cover crops - enhancing both biodiversity and weed management in cereals?

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Summer annual plant species dominate the weed flora if crop rotations primarily consist of spring-sown crops. In addition, some perennial species, such as *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) Gould and *Sonchus arvensis* L. thrive in cereals and impede cropping particularly in organic production systems. In Finland, spring cereals account for more than 50% of the arable land and, although more than 150 weed species have been recorded in Finnish farm fields, only some 10-15 species are prevalent in cereals both in terms of density and biomass production and not many of these provide notable ecosystem services.

In organic production of cereals, the integrated weed management strategies should include cropping measures and crop sequences which create more balanced and manageable weed floras, which consist of less harmful species for crop production. Cover crops and their management are of interest in this respect.

Cover/catch crops were studied in the field experiments that started at Luke Jokioinen in 2015 as a part of PRODIVA project*. Various leguminous species and some grass species (ryegrasses, rye, timothy) were grown in mixtures and sown at high seeding rates with the aim to hamper the growth of weeds as well as to support biodiversity at higher trophic levels. The cover crops were sown in organically grown spring barley in 2015 and, subsequently, in winter wheat in May 2016. Some experimental aspects and first results will be presented and discussed in the EWRS working group meeting.

*The PRODIVA project, funded by the Core Organic Plus ERA-NET action, was started in 2015 with the aim to promote crop diversification and demonstrate its impact on weed infestation. More information at: <http://coreorganicplus.org/research-projects/prodiva/>.

Cover crop roller-crimper increases biodiversity in Swiss vineyards

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Climate and soils in western Switzerland in most cases allow a continuous green cover between rows in vineyards. While most winegrowers mow the weeds or use herbicides, a minority uses a roller-crimper, commonly known as *Rolofaca*™ (Gerber H&M). The latter crushes the plants and crimps their stems. This study measures differences in weed composition and diversity between roller-crimper and other weed management practices (mowing, chemical and mechanical weeding).

We compared the weed flora in 15 vineyard plots managed with roller-crimper with that in 100 plots managed with different practices in western Switzerland (excluding Wallis).

In contrast with chemical and mechanical weeding, the roller-crimper had a similar effect as mowing, namely it promoted the establishment of grassland weed communities. Biodiversity was highest ($p < 0.05$) in plots managed with a roller-crimper, followed by mowing, mechanical weeding and finally chemical weeding. We assume that the reasons for the increased biodiversity in the roller-crimper treatment lie in a lower selection pressure. Interviews with wine producers and measures of grapevine vigour suggested that the roller-crimper allowed avoidance of excessive competition for resources after the establishment of a stable weed community.

In conclusion, roller-crimper seems to have a good potential for managing weeds in vineyards when the objective is to combine high quality wine with enhanced biodiversity. However, the acceptance of this technology may be hindered by issues, such as the increased occurrence of voles or the fact that the vineyard's appearance did not correspond to the "tidy" image perceived with other weeding practices.

Session “Arable weed diversity III: management”

Weed density in winter oilseed rape crop under different weed control methods in organic farming system

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As mechanical weed control options in organic oilseed rape production are limited, other, non-chemical, weed control methods have to be used. Exploiting the competitive ability of a crop (smothering of the weed) is widely used. Steaming can be effective for weed control at the beginning of crop growth. Here, the influence of different weed control methods on weed density in winter oilseed rape (*Brassica napus* L. ssp. *oleifera biennis* Metzg.) in organic farming systems was investigated.

A field experiment was performed in 2013 and 2015 at the Experimental Station of Aleksandras Stulginskis University (54°53' N, 23°50' E). The soil at the experimental site was classified as Calc(ar)i-Endohypogleyic Luvisol (Drainic) according to the WRB 2014. Non-chemical weed control treatments in the experiment were: 1) thermal (steaming); 2) mechanical (inter-row loosening) and 3) crop competition (smothering), by reducing the crop row spacing from 48 cm to 12 cm.

During all periods of examination, annual weeds prevailed in winter rape. The highest number and air-dry biomass of weeds were found in plots where smothering was used. The efficiency of thermal weed control depended on weather conditions: when the soil remained moist, e.g. during prolonged period of cool weather in spring, weed germination can even be enhanced by steaming. The most effective method of weed control in organically grown winter oilseed rape was mechanical; the weed density was significantly lower and the seed yield higher, compared to other methods used. A very strong correlation ($P \leq 0.05$) between winter rape seed yield and weed numbers in winter rape before harvest was found.

Thus, weed control in winter rape in organic farming systems is important. Mechanical weed control is most effective and can be used in rape grown at wider row spacing.

Impact of seeding rate and delayed sowing on winter wheat and weed competition

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Modification of crop sowing date and stand density can change extent of weed emergence and increase crop competitive ability. The impact of crop seeding rate and delayed drilling on crop – weed interactions in winter wheat was investigated in field experiments at the Institute of Agriculture, LRCAF, in 2015 and 2016. Three seeding rates (200, 400 and 800 seeds m⁻²) were sown at three sowing dates, namely at the recommended date (1st decade of September), three weeks later and six weeks later.

Annual dicotyledonous that are common for winter cereals in Lithuania are *Thlaspi arvense*, *Viola arvensis*, *Galium aparine*, and *Lamium purpureum* (Auškalnis *et al.*, 2007).

Crop density had a small effect on weed numbers; in the densest winter wheat stand the weed number was 10 – 30% lower than in the sparsest stand. In winter wheat in which sowing was delayed by six weeks, no weeds appeared until the following spring. In plots in which sowing was delayed by three weeks, the response differed between weeds, namely (1) a 80-100% decrease in the numbers of *T. arvense*, (2) a 60 – 80% decrease in the numbers of *V. arvensis* and *L. purpureum* and (3) a 20-30% decrease in the numbers of *G. aparine*.

Apparently, if the objective is to reduce crop - weed competition, a three weeks sowing delay of winter wheat would be most effective. However, delaying of sowing date could result in a significant decrease in grain yield of winter wheat.

Auškalnis A., Kryževičienė A., Auškalnienė O. Weed occurrence and control in energetic plants in Lithuania // Progress in Plant Protection. – 2007, Vol. 47, Nr. 4, p. 313–320.

Investigations of tillage systems and crop sequence on weed incidence

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A long-term field experiment was established at the Study and Research Farm “Peterlauki” of the Latvia University of Agriculture in 2008 (55 30' 7" N; 23 41' 6" E). The soil at the experimental site is Cambic Calcisol (Endogleyc, Bathyrptic, Episiltic), sandy loam. Two tillage systems were compared, namely 1. conventional mouldboard ploughing (CT) to a depth of 0.22–0.23 m, and 2. reduced tillage with disc harrow (RT) to a depth of 0.10–0.12 m. These were applied in two crop rotations, namely 1) spring wheat – winter wheat – winter wheat – spring wheat – winter wheat, and 2) spring oilseed rape – winter wheat – winter oilseed rape – spring barley - spring oilseed rape. Weeds were counted before the harvest of the crops. Herbicides were used as needed.

Annual weeds were the most important group of weeds in all treatments. During the five years (2011 – 2015) that the RT and CT systems were compared, the average number of weeds in crop rotations 1 and 2 were, for annuals, 1) 56.6 and 21.4, 2) 43 and 16.4, plants m⁻² and for perennials, 1) 9.8 and 3.2, 2) 7.2 and 1.2 respectively. Reduced soil tillage significantly increased the incidence of perennial weeds ($P < 0.05$), but the effect of crop rotation was not significant.

This research was supported by a grant from the Ministry of Agriculture «Influence of minimal soil tillage on its fertility maintenance, development and distribution of pests as well as crops' yield and quality in resowings».

Effects of management intensity on plant biodiversity and related ecosystem services in Austrian, French, Romanian and Spanish vineyards

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Vineyards may be biodiversity-rich habitats, as areas between vine rows could host a diverse flora of local species or cover crops. Vegetation cover within vineyards provides important ecosystem services, such as soil erosion mitigation and the provision of habitat and food resources for pollinating insects and natural enemies of pests. However, dense vegetation cover could also lead to increased water and nutrient competition between vines and weeds. Frequent tilling or the use of herbicides for the eradication of vegetation cover are associated with ecosystem disservices, such as very high rates of erosion, degradation of soil structure and fertility, contamination of groundwater and high levels of agricultural inputs, such as pesticides.

In the BiodivERSA project VineDivers, we analyze the effects of three different management intensities (bare soil, permanent or temporary vegetation cover) on above- and below-ground biodiversity and the associated ecosystem services across Europe. We established four plots within each vineyard of high, medium and low intensity management. In this paper, we present the results of the plant diversity survey. Up to now, we recorded plant biomass and diversity in 81 Austrian, French, Romanian and Spanish vineyards at least two times a year.

Species diversity was significantly higher in vineyards with permanent or temporary vegetation cover compared to vineyards with bare soil. In Austria, diversity in vineyards with permanent vegetation cover was not significantly higher than in vineyards with temporary vegetation cover. We will discuss the results of the vegetation survey in view of related ecosystem services in vineyards.

Session “Arable weed diversity IV: primary productivity”

Relationship between weed diversity and crop yield in Spanish wheat fields

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When exploring the relationship between weed diversity and crop production, a community perspective can be useful to balance weed control and weed diversity in crop fields. Here, we analyzed this relationship using data from 29 wheat fields under a Mediterranean climate in Spain.

In each field, weed cover was assessed in 10 (1 x 1 m) plots at crop stem elongation. Crop grain weight was used as a proxy of crop primary production. Weed cover data and data on functional type, maximum height, life form, growth form, month of flowering onset, flowering duration, specific leaf area and seed mass for each species were used to obtain species richness, the exponent of the Shannon-Wiener index, Pielou evenness (J) as well as community weighted mean (CWM) and functional dispersion (FDis) for each trait. The relationship of each of these indices to crop grain weight was tested, using general linear mixed models, with field as random factor.

We found a positive relationship between J and crop grain weight. Grain weight values were higher when weed communities had low CWM height values and when CWM functional type was forb or legume than when plots were dominated by grasses. Crop grain weight values showed a tendency to increase with higher values of FDis growth form and FDis height.

Our results show that not only weed abundance but also weed diversity determine crop grain weight. In wheat, agricultural practices aimed at reducing dominance, especially of grass species, and at increasing the variability in growth forms and heights would reduce the impact of weeds on crop yield.

**The original law of field crop performance (agrophytocenosis)
productivity for development of the theoretical cognition of
weed control and soil tillage**

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Worldwide practices reveal a unique situation, in which the traditional system of weed control is not based on any theoretical fundamentals, but on primitive empirical experience. From a geobotanic viewpoint, the field crop stand is plant community based (agrophytocenosis). This is why the management of weeds must be based on the natural crop stand law of those communities. This law can be defined as follows: the productivity of the whole typical agricultural plant community, including the overall mass of crop plants and weeds, growing under the same conditions, is relatively constant. It can be described by the equation: $A = Y + Xb$, where A is the productivity of the whole community, Y the yield of crop plants under existing conditions, X is the weed mass, and b is yield depression rate.

Implementation of the above law should change the former discipline of a primitive empirical “science” to a theory-based soil tillage science. It is expected that, in the future, soil tillage will be applied in a more precise way, new possibilities to develop soil tillage will appear, annual deep ploughing could be omitted, the amount of carbon dioxide discharged into environment would decrease, soil degradation mitigated, and non-renewable energy costs reduced.

Therefore, I am seeking to create new theory-grounded technologies of weed control by applying the original crop plant community productivity law.

Session “Ecosystems services by weeds”

**Important weed species for sustainability of Megachilidae
(Hymenoptera: Apoidea) species in Turkey**

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Bee species belonging to Megachilidae have a wide host plant range. The structure of their tongue allows them to collect nectar and pollen from both tubular and non-tubular corolla flowers. Many agriculturally important plants, such as forage plants and fruit trees blossoming in early spring, are among of the plant species pollinated by bees of this family. Like other bee species, Megachilidae are under serious threat by anthropogenic causes, such as habitat destruction, pesticides, invasive species, climate change and crop monocultures. To maintain the pollination services, it is very important to take measurements to maintain the populations of bees and prevent that they become regionally extinct. As a first step, wild plant species that are visited by these pollinators should be determined.

In this study, all published articles that mention an association between plant taxa and the Turkish Megachilidae fauna were evaluated. It showed that 327 plant taxa belonging 36 families were visited by 258 species of the Megachilidae. It was determined that 152 of the bee species visit Fabaceae (66 taxa), 146 of them Asteraceae (68 taxa). It seems that Asteraceae and Fabaceae have got an important role in terms of the sustainability of Megachilidae species. Therefore, the weed species belong to Asteraceae and Fabaceae can be used as pollinator-friendly weeds in created the corridors within or around agricultural areas.

Rimsulfuron and nicosulfuron mitigation potential of some grass species

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Residuals of herbicides applied to maize for weed control can transport to other locations by several routes, including leaching, drift, and runoff. Runoff is of special importance in Turkey as maize is irrigated 4 to 5 times during a growing season. Herbicides can also be transported from the sprayed to unsprayed areas via surface runoff caused by sudden rainfall if there are no protective measures, such as Vegetative Filter Strips (VFS) constructed with grass species. In this study, growth chamber experiments were performed to determine the suitability of various grasses as components of a VFS. For this, the species need to be tolerant to common maize herbicides, such as rimsulfuron and nicosulfuron.

Herbicides were applied to seedlings of various grass species at the 2-4 true leaf stages at different rates (2X, X and X/2). The effects were determined visually and gravimetrically at 28 days after treatment based on the percentage of reduction in aboveground biomass. Both cool season grasses (e.g., *Festuca arundinacea* Schreb., *Lolium multiflorum* Lam., *Lolium perenne* L., *Bromus inermis* Leyss., *Festuca rubra* L., and *Poa pratensis* L., *Agropyron cristatum* (L.) Gaertn.) and warm season grasses (e.g., *Cynodon dactylon* (L.) Pers. and *Sorghum bicolor* x *Sorghum sudanense* Stapf.) were examined.

The grass species *Poa pratensis* L., and *Agropyron cristatum* (L.) Gaertn., were tolerant to nicosulfuron, but sensitive to rimsulfuron. *Bromus inermis* Leyss., *Festuca rubra* L. and *Cynodon dactylon* (L.) Pers. were tolerant to these herbicides while the other tested grasses were very sensitive. Although *Bromus inermis* Leyss., *Festuca rubra* L., *Cynodon dactylon* (L.) Pers., may be used as a VFS plant to reduce these herbicide residues in VFS, *Poa pratensis* L. and *Agropyron cristatum* (L.) Gaertn. can only be preferred for nicosulfuron.

Weeds and Ecosystem services: a systematic review in arable crops

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The negative impacts that weeds can have on crops are well documented. However, much less is known on the benefits of the presence of weeds in agricultural systems. A systematic map approach was adopted to find articles in the literature that contained proof of weeds providing ecosystem services.

In total, 150 articles with evidence of weeds benefiting ecological processes were collected. The most common services regarded pest control (91 papers). In most cases, pest control was explained by weeds providing a suitable habitat for natural enemies. Some papers showed that weeds improved soil nutrient content (23 papers), soil physical properties (7 papers), the overall biodiversity by sustaining higher trophic levels in the food-chain (22) and crop pollinator abundances (5 papers). The effect of weeds on crop yield was quantified in only 28% of the articles that were analysed. Most of these papers found that weeds had a negative impact on yield despite the service provided.

The results suggest that weeds may contribute to the provisioning of some important ecosystem services for agriculture. As they tend to have a negative effect on crop yield, the challenge for future weed scientists is to design and test weed management approaches aimed at reducing weed competition with the crop while improving ecosystem service provisioning. These new approaches to weed management would greatly benefit from basic research identifying and quantifying the services specific weeds can provide in various cropping systems since systematic knowledge is lacking especially regarding their effect on soil properties and crop pollination.

Carabid beetles respond differently to seeds liberated from the seed bank

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Predation of seeds liberated from the soil seedbank is understudied but important as viable seeds from the bank may establish new populations of plants.

We tested how the duration of burial affects the consumption rates and preferences by three model species of carabid seed predators, *Pseudoophonus rufipes* (DeGeer), *Harpalus affinis* (Schränk) and *Amara littorea* (Thomson). Seeds of different species were mixed with fine soil particles and buried in the soil in bags of nylon fabric for 1-8 years (7 species) or 1-6 years (18 species). One batch was exhumed each year consecutively. Seeds frozen at the time of burial served as controls. Seeds were presented to predators on seed trays. We studied the variation among age cohorts of particular seed species, and we tested the change in the order of preferences between control and 6-yr buried seeds.

In most species of seeds, the palatability to carabids decreased with burial, but the trajectory of the decrease varied among seed and carabids species. In some weed species, the consumption increased with time or there was no time effect. We found a correlation in consumption of control and 6-year buried seeds, suggesting that the order of preferences were largely similar, although the overall consumption of 6-yr buried seeds was lower than of control seeds.

The observed variation in seed consumption over time spent in seedbank will be interpreted in relation to traits, such seed mass, visible modification of external structures and viability, and they will be linked to the traits of the carabid beetles, mainly body size.

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Insect attractiveness of five weeds

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The number of pollinators in agro-ecosystems worldwide has declined alarmingly in recent decades due to the mismanagement of the habitat and intensive agricultural practices. Increases in agricultural land area have restricted natural flora to small patches, reducing food sources for most insects. Thus, knowledge of the role that surviving weeds can play in maintaining insect biodiversity in these systems is crucial.

Field studies of cereal margins located in central Catalonia, carried out by Morrison *et al.* in 2015, revealed that several weed species were highly attractive to insects. To further estimate the level of attraction of these weed species, a trial was carried out at the Agropolis experimental farm located near Barcelona. The trial consisted of three repetitions of six, 2.5 x 2.5 m² plots sown with: *Sonchus oleraceus* L., *Papaver rhoeas* L., *Daucus carota* L., *Malva sylvestris* L., *Convolvulus arvensis* L. and a mixture of these species. When flowers were in bloom, visual counts of insects visiting flowers were performed in each plot for 5 minutes, twice a week. Insect sampling was also carried out with pan traps (yellow, blue and white dishes with soapy water), set for 24 h each week. Collected insects were classified to family level.

Visual counts showed that pollinators, such as honeybees and wild bees, were highly attracted to *P. rhoeas*, *D. carota* and the mixture. Sirfidae were highly attracted to *D. carota*. Heteroptera were mainly attracted to *M. sylvestris* and *D. carota*, although the number of individuals was very low. Coleoptera were mainly attracted to *D. carota*. Insects collected in the traps belonged to three orders: Hymenoptera (Apidae, Halictidae, Ichneumonidae, Megachilidae, Sphecidae), Coleoptera (Cantharidae, Cerambycidae, Chrysomelidae, Meloidae, Mordellidae) and Heteroptera (Lygaeidae, Pentatomidae).

According to these results, weeds like *P. rhoeas* and *D. carota* can not only contribute to maintain the ecosystem biodiversity but also they can contribute to increase crop production, because they attract beneficial insects such as different Hymenoptera species (pollinators) and also Syrphidae (predators). This study shows the role that weeds can have also in maintaining the ecosystem services, rather threatened by agricultural intensification.

The role of weeds in supporting bee populations in agroecosystems

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Recent concerns about the global decline in pollinators, as a result of agricultural intensification, have called for more knowledge about the drivers of bee abundance and diversity in agro-ecosystems. Weeds in field margins provide food and refuge for pollinators, and play a significant role in supporting biodiversity and ecosystem services. This study investigates the role of margin weed flora in supporting bee populations in Mediterranean cereal agro-ecosystems, with a landscape perspective.

The experiment was carried out from 2014-2016, at 27 cereal field margins in Catalonia, Spain. Margins represented a gradient in surrounding landscape, from mainly agricultural to mainly forest. Sampling took place during the peak period of bee activity and comprised: plant inventory, bee trapping and observations of pollinator foraging activity. Bees collected in traps were identified to genus level. From 2014-2015, 161 plant species were identified from 44 different families. In bee traps, 3066 wild bees were collected and identified, representing 26 genera and 7 families. The most abundant family was Halictidae, comprising 75% of bees captured. A total of 1720 pollinators, from 5 orders of insect, were observed foraging on flora within margin transects.

Analysis will model multivariate relationships between margin characteristics, surrounding landscape and bee populations. Functional relationships between the morpho-physiological features of bees (e.g., body characteristics, behaviours, etc.) and associated floral traits present in the margin (e.g., size, shape, colour, nectar/pollen qualities, etc.) will be analyzed. Hopefully this research will help with the development of forward-thinking policies and management strategies for efficient and environmentally sustainable farming.

Session “Weed biology and integrated control”

Effect of temperature and storage conditions on seed germination of *Avena strigosa* and *Avena fatua*

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Storage of seeds is crucial for the long-term conservation of plant genetic resources. Maintaining seed viability of rare species of weeds, which sometimes are also crop wild relatives, is very important, because we do not know the value of particular species for agroecosystems functioning in the future. Reliable methods for assessing the viability of stored materials and breaking dormancy are required. Here, the effect of temperature and storage conditions on seed germination of a rare and a common weed species, namely *Avena strigosa* Schreb. and *A. fatua* L., was investigated. Field observations have shown that *A. strigosa* is resistant to rust, powdery mildew and other diseases, and useful in oats breeding.

Seeds were kept in three storage conditions: 1) long-term, cold storage (low constant temperature and humidity, in vacuum), 2) storage at room temperature (from 20 to 30 °C) and humidity (from 40 to 80 %) and 3) storage with variable temperatures (from -10 to 40 °C) and variable humidity.

Germination of *A. strigosa* was high (about 95%) when stored under conditions 1 and 3. *Avena fatua* germinated better under condition 1. To verify the effect of temperature on seed germination of *A. strigosa*, germination was tested in a range of temperatures from 10 to 35 °C. A high level of germination was observed up to 30 °C, however, at 35 °C germination was almost completely inhibited.

The best temperature for germination of *A. strigosa* was 25 °C, while the temperature recommended by ISTA (International Rules for Seed Testing) is 20 °C. This information will facilitate effective seeds storage, for example, in the Polish Gene Bank.

Germination rate of wild oats (*Avena fatua* L.) in relation to seed morphology

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In recent years, the distribution of wild oats (*Avena fatua* L.) in the agricultural lands of Latvia has expanded. The aim of the research was to determine the germination rate for different wild oat populations and to find out relations with seed morphology.

Seed samples of wild oats were collected in 2015 from 20 commercial fields in Latvia. Seeds stored for six months at room temperature (18 °C) were germinated at 22 °C in darkness in four replications; germination was recorded after 3, 7 and 34 days. Evaluated seed morphological traits were: seed coat colour (scores), pubescence of the lemma (scores), seed size determined as weight of 100 seeds (g), seed length (mm), and husk content (%).

The most active seed germination was observed during the first 7 days with variation between wild oat populations: from 3 to 70% in 3rd day and 12 to 98% in 7th day. Seed samples of wild oat populations were phenotypically diverse in seed coat colour and lemma pubescence intensities but these traits did not affect germination behaviour. Seed length ranged from 12.5 to 15.9 mm, weight of 100 seeds from 1.9 to 3.1 g, and husk content from 34.3 to 40.8%. It was found that the germination was significantly ($p < 0.05$) positively correlated with seed size ($r = 0.493$). A negative correlation was observed between seed germination after 3 days ($r = -0.334$) and seed husk content.

These morphological traits could be additional indicators that can influence physical seed dormancy for wild oats and that prevent the penetration of water to the embryo.

Effect of environmental factors on germination of *Lolium rigidum* resistant and susceptible biotypes to ALS-inhibiting herbicides

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Weed biotypes resistant and susceptible to herbicides may differ in their germination and growth response to environmental factors. The aim of this study was to compare the effects of light, temperature, osmotic stress, salt stress, and pH on the germination of resistant and susceptible biotypes of *L. rigidum* to ALS inhibiting herbicides.

Lolium rigidum seeds were collected from wheat fields in August, 2014. Germination tests were conducted in a growth chamber at 25/15 °C, 20/10 °C, and 15/10 °C with a 12/12 h night/day regime and a dark regime. Aqueous solutions were prepared by dissolving 0, 30.3, 48.4, 62.6, 74.6 and 85.4 g polyethylene glycol 6000 in 1 L of distilled water to obtain 0, -0.2, -0.4, -0.6, -0.8 and -1.0 MPa osmotic potential, respectively. To investigate the effect of salt stress on seed germination, 10 ml of 0, 25, 50, 100, 200, 400 and 800 mM sodium chloride solutions were added to Petri dishes. Buffer solutions of pH 4, 5, 6, 7, 8, 9 and 10 were prepared. Petri dishes were placed in sealed polyethylene bags to prevent desiccation. Germinated seeds were counted at 7 and 14 d and removed.

The susceptible biotypes showed a higher germination speed and higher germination rate when compared with the resistant biotypes. As either water stress or NaCl concentration increased, cumulative seed germination decreased in both biotypes. No seeds germinated when NaCl concentration exceeded 400 mM. The germination rate was lower in resistant biotypes.

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Hogweed containment with integrated pest management methods; the EMPHASIS project

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Hogweeds (*Heracleum mantegazzianum*, *H. sosnowskyi*, *H. persicum*) are listed in the EPPO A1/A2 lists as pests recommended for regulation as quarantine pests. They have a wide geographical distribution in the EU in non-agricultural areas. It was chosen as one of pathosystems in the EMPHASIS project (<http://www.emphasisproject.eu/>), with the aim to develop new and effective IPM methods to control harmful alien pests.

EMPHASIS (Effective Management of Pests and Harmful Alien Species: Integrated Solutions) is a four-year project funded by the EU and is conducted by a consortium of 21 partners (research institutes, professional associations, SME) from 10 countries. It focuses on native and alien pest threats (insects, pathogens, weeds) in a range of natural and agro-ecosystems (field crops, protected crops, forestry, orchards and amenity areas). Key plant/pest pathosystems will be studied following a multi-method approach in order to design an IPM methodology. The effectiveness of the solutions will be assessed, validated and transferred through innovative research and demonstrations to ensure that they are in line with end users' needs and capacities.

The purpose of the study on hogweeds is to review all available studies over the last 20 years, and identifying new methods, technologies and products for control of hogweeds that are available, but never used in the EU. This should lead to new sets of IPM methods (biological, chemical and mechanical means), where biodiversity is main part of the crop protection instrument (biological method).

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