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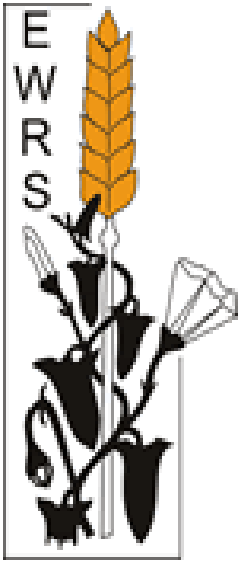

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CONTENTS

OPENING SESSION

Session organizer

Paolo Barberi

Resistance to ACCase and ALS inhibiting herbicides in cereals in Turkey; What have we learned?

H. Mennan[1], E. Kaya-Altop[1], S. Raşa[2], J.C. Streibig[3], D. Yatmaz[2], U. Budak[1], D. Sarıaslan[1] K. Haghnama[1]

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The herbicides are very effective tools for controlling weeds but their extensive use over time has resulted in evaluation of weed resistance to herbicides with different modes of action. ACCase and ALS inhibiting herbicides have been used extensively in winter wheat and rice fields to control grass and broadleaved weeds since last two decades in Turkey. Recently, many growers in various area of Turkey complained for reduced control of *Bifora radians* and *Galium aparine* in winter cereals, and *Echinochloa* spp.*,* and *Cyperus difformis* in water seeding rice after use of ALS and ACCase inhibitor herbicides.

Therefore, the aim of this study are to understand the occurrence and frequency of resistant biotypes of these species to ACCase and ALS inhibiting herbicides; does the mechanism of resistance are target site (TSR) or non-target site resistance (NTSR), risk assessment of herbicides history in evaluation of resistance and how crop rotation reduce selection for resistance?

Forty-three rice fields were sampled randomly in 2005 to confirm the existence of cross and multiple herbicide resistance of *E. oryzoides, E. crus-galli* and *C. difformis* involving ALS (penoxsulam, bispyribac-sodium) and ACCase Inhibitor (cyhalofob-butyl). The same and more fields re-sampled in 2011. In addition to that, greenhouse experiments were conducted from 1995 to 2011 to monitor possible resistance populations of *B. radians* and *G. aparine* to ALS inhibitor (chlorsulfuron and tribenuron-methyl) sampled from 13 winter wheat fields.

A log-logistic dose-response curve was fitted to greenhouse data of *E. oryzoides* to obtain ED_{90}. On the basis of those data, resistance to ALS inhibitors was detected in 2 accessions in 2005. On the other hand, all *E. oryzoides* accessions were susceptible to ACCase Inhibitor in the same year. The effective dose response level of ED_{90} resulted in 36 and 9 resistant accessions to ALS and ACCase, respectively after re-sampling from same fields in 2011.

Most of *E. crus-galli* accessions were effectively controlled with penoxsulam and cyhalofob-butyl in 2005. But, 4 accessions did not controlled with bispyribac-sodium and these accessions were characterized as resistant. The number of resistant accession significantly increased in 2011 and reached almost 75% in both inhibitors.

Of the 43 *C. difformis* populations tested, 11 survived after treatments of penoxsulam and bispyribac-sodium in 2005. But, the application of four times recommended rate of these herbicides resulted only 3-5% fresh weight reduction of 40 *C. difformis* populations in 2011. The remaining 3 population with no evidence of penoxsulam and bispyribac-sodium resistance were controlled with almost double dose of these herbicides.

A significant proportion of the populations in all species were found to be non-target site resistance (NTSR) after molecular assay in 2011. Target site resistance to ALS inhibiting herbicides in 3 populations of *E. oryzoides* was determined by a mutation at codon Trp574 of the ALS gene which induces a leucine for tryptophan substitution. A mutation to resistance at the position Ala122 was identified in *4 E. crus*-galli populations. An additional mutation was found at the position Pro197 in 5 *C. difformis* populations. Two different mutations at 1781-Leu and 2041-Val were detected in the cyhalofob-butyl resistant *E. oryzoides* and *E. crus-galli*.

The dose–response curves of 13 populations on chlorsulfuron and tribenuron-methyl show that recommended field rate were enough to control *B. radians* and *G. aparine* in most cases in 1996. But, after 5 years later the species could not be effectively controlled at the recommended herbicide rates and it show that these species are slowly become more tolerant to the registered herbicides. However, the relative potencies showed that tolerant populations of *B. radians* and *G. aparine* required up to twice the field rate in order to get the same efficacy in 2008. The effective response level of ED_{90} resulted in 2 and 7 ALS resistant populations to *B. radians* and *G. aparine* in 2011, respectively. Molecular assays showed that of all the plants treated with chlorsulfuron and tribenuron-methyl were resistant due to NTSR, probably enhanced metabolism.

In conclusion, the problem of weed biotype resistance to the currently used herbicides is a major issue as resistant weeds exhibit resistance to multiple herbicides and alternative herbicides that provide effective control are not available in rice. Some of the accessions were strongly resistant to both inhibitors and had 100% survival at 6 times the recommended application rate. Most of these resistant accessions were from Marmara region, predominantly in Edirne and Balıkesir, which is the region without any crop rotation. These studies indicate that resistance to both inhibitors in *E. oryzoides, E. crus-galli* and *C. difformis* are likely to continue to increase throughout Mediterranean regions, and this may be prevented by use of mixtures temporarily.

The authors thank The Scientific and Technological Research Council of Turkey (TUBITAK) for supporting the Project (Number TOVAG 1080371 and 1090521). We also thank to Dow AgroSciences for partially supporting rice experiments.

Weed management in Europe at a crossroads – Challenges and opportunities

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On 14 June 2011 the EU Thematic Strategy on Pesticides came into force. The strategy consists of 4 pieces of legislation of which Regulation (EC) No 1107/2009 to regulate plant protection products in Europe and Directive 2009/128/EU to regulate the sustainable use of pesticides in Europe are the most important.

The Regulation No 1107/2009 replaces Directive 91/414/EEC and aims to harmonise the authorisation of pesticides within the EU. Besides harmonising the authorisation procedure the regulation also introduces new and stricter criteria for approval including hazard criteria based on the inherent properties of pesticide. For active substances failing to meet all the hazard criteria the assessment procedure will be stopped and approval cannot be granted. Substances demonstrating a less favourable toxicological profile but still satisfying the hazard criteria may be approved as candidates for substitution and will be subject to a comparative assessment. It is widely expected that several herbicide active ingredients approved under Directive 99/414/EEC will not fulfil the new requirements and therefore not be approved when up for re-registration. The tightening of the approval procedure happens just as the EU had finalised a review of all previous approved active substances (ca. 1000) of which only 26% were re-registered.

Directive 128/2009 relates to the use of pesticides and is the first EU legislation ever dealing with this aspect. All EU Member States are required to develop National Action Plans describing how they intend to implement a number of measures listed in the directive e.g. education of users and distributors of pesticides and testing of application equipment. An important component of the directive is the requirement that all professional users of pesticides should comply with the general principles of Integrated Pest Management (IPM) stipulated in the directive by 1. January 2014. IPM is seen as an important tool in reducing the adverse effects of pesticides on human health and the environment.

The on-going loss of active ingredients, the increase in the number of herbicide resistant weed biotypes and the emergence of new weed species is seriously questioning the sustainability of the existing, and largely herbicide-based, weed management strategies practised by most European farmers. Notwithstanding the directive many European farmers have reached a crossroads where weed management strategies need to be rethinked.

In this presentation the weed management tools available to farmers or under development will be presented and examples will be presented on how weed management strategies can be redesigned incorporating the principles of IPM.

SESSION I

WEED BIOLOGY

Oral presentations

Session organizers

Hansjörg Kraehmer & Henry Darmency

Plant biology revisited to understand invasion success

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Biological invasions still remain an enigma to ecologists and evolutionary biologists. A detailed study of the plant invader's biology under different environmental settings to elucidate genotype by environment interactions may help to unveil the success of some plant species to invade new regions and habitats.
I will illustrate this for the European native and highly invasive *Centaurea stoebe* (Asteraceae), which experienced an exceptionally high shift in cytotype frequency and climatic niche towards drier and warmer habitats during its invasion into North America. Thus, this represents a great opportunity to elucidate potential underlying life history and performance traits.
Both diploid (EU2x) and tetraploid (EU4x) cytotypes occur in Europe, but only tetraploids have been recorded so far in North America (NA4x). In EU, the 4x cytotype expanded its range from SE towards N and W, mainly facilitated by disturbance, but niche limits of both cytotypes remained fairly stable. In NA, we identified two focal introduction points both around 1890, one in the pacific North West (SW Canada) and one at the Atlantic coast (NY). Niche limits changed only little during the invasion in the East, but they largely expanded in the West, being more pronounced in disturbed habitats.
In the talk, main emphasis will be given to disentangle pre-adaptation (through differences in traits and plasticity of EU2x vs. EU4x) from post introduction evolution (EU4x vs. NA4x) to explain differences in the spatio-temporal dynamics of the observed range expansions and invasion routes, using our extensive experimental data. Our results showed that multiple introductions, biotic release, plasticity (for early establishment) and directional selection allowed to conquer the novel environment within less than a century. Invasion into drier habitats in the West - constituting a niche shift - allowed to dominate the less competitive vegetation (*C. stoebe* as a "driver" in the West!). Both pre-adaptation and rapid evolutionary change contributed to the invasion of the tetraploid cytotype, but at the demographic level, it was only post-introduction evolutionary change through positive selection for traits related to increased reproduction in 4xNA vs. 4xEU that promoted the invasion success. I will conclude by outlining the strengths and limitations of this novel multi-forked approach and advocate its broader use for other study systems.

Our relevant publication on this study system can be found at
http://www.unifr.ch/ecology/groupmueller/publications.

Genetic diversity of bittersweet (*Solanum dulcamara* L.) a native weed across Europe

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Bittersweet (*Solanum dulcamara*), a European native weed, is widespread across a variety of habitats and often occurs as a coloniser of open, disturbed, ephemeral environments or wetlands, although it is also found in mountain habitats and on forest edges. This diploid species is also found in North America, where it can be considered as an invasive species that is becoming naturalised. It serves as an alternative host for many agriculturally important diseases including the potato quarantine pathogen *Ralsonia solanacearum* (Smith) Yabuuchi *et al*., causing bacterial wilt, and *Phytophthora infestans* (Mont.) de Bary, a dangerous oomycete that is the causal agent of late blight. We sampled natural populations found in Europe and analyzed them with conserved DNA-derived polymorphism (CDDP) and intron-targeting (IT) markers to assess genetic diversity found within and among the populations. We found that there is limited genetic variability within the collected *S. dulcamara* accessions, with a greater proportion of allelic variation distributed among populations and considerably greater population structure at higher regional levels. Although bittersweet is an outcrossing species, its population structure might be affected by its perennial self-compatible nature, reducing genetic diversity within regional populations and enhancing inbreeding leading to high interpopulation or spatial differentiation. We found that populations have been separated by local selection of alleles, resulting in regional differentiation. This has been accompanied by concurrent loss of genetic diversity within populations, although this process has not affected species-level genetic diversity.

Emergence of several rare arable weeds from winter cereal fields

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Due to agriculture intensification and to natural habitat lost, a lot of arable weed species are currently in clear regression. To preserve them, it is necessary to know their biology and response to the different management techniques used, like the type of soil tillage. This information is necessary at species level for conservation purposes. The objective of this research is to study the emergence of several rare arable weed species at two burial conditions.

Seeds from 29 rare arable weed species were sown on 4th November 2011 at two depth conditions: constant 1 cm depth and homogeneously distributed from 2 to 10 cm depth. The experiment had a complete randomized design with four repetitions per depth. Elementary plots had 0.5 x 0.5 m. For each species 200 to 1000 seeds/plot were seeded. Emergence was weekly monitored through destructive counts from sowing until 18th May 2012.

The emergence ranged from 0 to 71% depending on the species. Two periods of emergence could be identified: autumn-winter and spring. 18 species emerged mainly in autumn-winter, while 11 species showed a second peak of emergence in spring (≥25% of overall emergence). The species showed three patterns: those with equal emergence at both burial depths (13 species), species with higher emergence at 1 cm depth (14 species), and species with more emergence at 2 to 10 cm depth (2 species). Seed traits like size could partly explain these results. This information, at species level, is necessary to understand how tillage affects these rare arable weeds to preserve them in our agro-ecosystems.

Modeling weed emergence of *Polygonum lapathifolium* L. and *Solanum nigrum* L. in maize

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The agronomic importance of knowing weed emergence patterns has been recognized for many years and several studies have been conducted on weed emergence dynamics with various approaches. Predictive weed emergence models can estimate, in a given moment, the percentage of weeds that have already emerged and the successive seedling emergence dynamics. Therefore they may be useful to achieve well-timed and efficient weed control, both chemical and mechanical. There is no universal best approach to create an accurate model, since it depends on many factors, such as climatic characteristics of the area, cultivation practices, etc. A commonly used approach is the hydrothermal time concept, based on the idea that seeds need a certain amount of hydrothermal time to germinate. The aim of the this research was to model weed emergence of Polygonum lapathifolium L. and Solanum nigrum L. to enrich and improve the information provided by the predictive emergence model AlertInf. Base temperature required for the hydrothermal time calculation of these weed species was calculated with an innovative method using alternating temperatures. Base water potential was empirically derived from field data using an iterative process. Emergence dynamics were modelled using data of seedling emergence collected from 2005 to 2012 in maize fields at two sites located in northeastern Italy. Simulating emergence dynamics based on hydrothermal time of species which germinate only with alternating temperature is fundamental to increase number of species predicted by AlertInf and consequently the richness of information provided by the model for more effectively timed weed management.

Do arable and aquatic weeds have anything in common?

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For farmers, weeds are plants which compete with their crop, reduce yields, impede their harvest, or reduce the quality of their products. To modern citizens, the production purpose seems not to exist in aquatic systems. Many scientists even try to avoid the term weed for aquatic plants. Invasive species or too dominating species are, however, not on their wish-list. Species causing turbidity or leading to algal bloom in lakes or rivers are also regarded as undesired. In fact, the interest of man is affected by weeds e.g. in fishing ponds, swimming facilities, boating sites or when the quality of drinking water is in jeopardy. The abundance of aquatic weeds is a result of the evolutionary pressure as caused by man. Rice and irrigated crops are some kind of interface between agricultural weeds and pure aquatics. Despite common non-ornamental aquatics, water primroses can be used for the description of characteristics in non-cultivated areas. Several morphological features of aquatics and arable weeds can be used to demonstrate evolutionary co-developments. Aerenchyma modifications exemplify this aspect. Lysigeny (creation of aerenchyma by cell death) and schizogeny (creation of aerenchyma by cell separation) in roots are common processes of species adapted to temporary water logging on dry arable land or of species on irrigated land. These processes have been described by several authors in detail but have not been discussed as weediness factors yet. Shoot modifications are usually caused by various aerenchyma formation processes also. Some morphological characteristics should even allow conclusions on species with a marshland origin before their career as weeds. Physiological traits such as the tolerance to high nutrient levels and biodiversity issues are additional features both functional groups, aquatics and arable weeds, have in common. New global weed distribution maps proof that most aquatic and dryland habitats of industrialized countries are dominated by a few species with apparently “superior” traits.

SESSION I

WEED BIOLOGY

Poster presentations

Session organizers

Hansjörg Kraehmer & Henry Darmency

Seedling emergence of *Chenopodium album* as a function of thermal time in soil profiles

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Chenopodium album L. (common lambsquarters) is one of the world's worst weeds in many crops. Quantification of factor regulating seedling emergence e.g. temperature is crucial to predict seedling emergence of a weed species in the field. The seedling emergence behavior was studied with seeds of *C. album* buried at soil depths of 0, 2, 4, 6, 8, and 10 cm in outdoor pots. The experiments were conducted in a strip plot design with four replicates. The numbers of emerged seedlings were counted and seedlings were removed regularly until late May when no more seedlings emerged. Soil temperature was recorded at all depths during the experiment. The base temperature of 3.5 C was estimated for the seed germination. The cumulative seedling emergence curves were regressed using a three parameter Weibull model. The thermal time (GDD) requirement to start seedling emergence at soil surface was estimated to be 27.8, 28.4, 28.9, 31.8, 102, and 150 GDD, respectively, for seeds buried at depths of 0, 2, 4, 6, 8, and 10 cm. The model could well explain the cumulative seedling emergence (R2= 0.60 to 0.97) of *C. album* as a function of GDD. Seedlings of *C. album* showed the capacity to emerge, from all depths, over an extended period of time from mid February to mid May, as shown in two years of experiment. This characteristic might be the reason for the seriousness of field infestations with *C. album*.

Seedling emergence of *Vaccaria pyramidata* as a function of temperature and soil depth

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Vaccaria pyramidata Medik. (cowherb) is a common weed in rainfed crops. Quantification of factors regulating seedling emergence e.g. temperature is crucial to predict seedling emergence of a weed species in the field. The seedling emergence behavior was studied with seeds of *V. pyramidata* buried at soil depths of 0, 2, 4, 6, 8, and 10 cm in outdoor pots. The experiments were conducted in a strip plot design with four replicates. The numbers of emerged seedlings were counted and seedlings removed regularly until late May when no emergence was observed any more. Soil temperature was recorded at all depths during the experiment. The base temperature of 2.6 C was estimated for the seed germination. The cumulative seedling emergence curves were regressed using a three parameter Weibull model. The thermal time (GDD) requirement to start seedling emergence was estimated to be 25.0, 38.7, 34.0, 43.9, 50.1, and 60.0 GDD, respectively, for seeds buried at depths of 0, 2, 4, 6, 8, and 10 cm. The model could well explain the cumulative seedling emergence (R2= 0.93 to 0.97) of *V. pyramidata* as a function of GDD. Large numbers of seedlings of *V. pyramidata* appeared to emerge from all depths, over a short period of time in February as shown in two years of experiment. The seedling emergence was low and sporadic after this time. These results demonstrate that it should be possible to control large numbers of seedling early in the season with a single weed control measure.

Seedling emergence of *Carthamus oxyacantha* affected by soil depth and temperature

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Carthamus oxyacantha M. Bieb. (wild safflower) is a troublesome weed especially in rainfed cereals. Information on seedling emergence of this species is necessary to improve the control of this weed in the cultivation. The seedling emergence pattern was studied during two years with seeds of *C. oxyacantha* buried at soil depths of 0, 2, 4, 6, 8, and 10 cm in outdoor pots. The experiments were conducted in a strip plot design with four replicates in 2010 and 2011. The numbers of emerged seedlings were counted and seedlings were removed regularly until late May when no more seedlings emerged. Soil temperature was recorded at all depths during the experiment. Most of the seedlings emerged in February to early March at a depth of 0 to 8 cm with slightly delayed emergence depending on seedling depth. After this period, the seedling emergence was low and sporadic. Seedling emergence was negligible and sporadic at a depth of 10 cm in 2010. The total seedling emergence was 45.5 % for seeds placed at soil surface, it increased when seeds were buried at 2 cm depth (88 %) followed by a decrease at the rest of the depth. It reached its minimum (5.5 %) at the depth of 10 cm. Total seedling emergence did not show a consistent pattern in 2011 and the emergence percentages were between 23.5 to 49.8 % in all depths. Further analysis was done using time and thermal time calculations. According to the regression model, the emergence time lag (delay) increased linearly with depth.

Seedling emergence of *Vaccaria pyramidata* affected by soil depth and temperature

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Vaccaria pyramidata is found as a weed in rainfed grains. The seedling emergence pattern was studied with seeds of *V. pyramidata* buried at soil depths of 0, 2, 4, 6, 8, and 10 cm in pots outdoors during 2010 and 2011. The experiments were conducted in a strip plot design with four replicates. The numbers of emerged seedlings were counted and removed regularly until late May when no more seedlings emerged. Soil temperature was recorded at all depths during the experiment. In 2010, seeds of *V. pyramidata* had the main flush of emergence from mid to end of February at all depths with some delay depending on seedling depth. In 2011, the seedling emergence was low in seeds placed at the soil surface and started sporadically from mid February to early May. Seeds at depths of 2 to 10 cm had the main flush of seedling emergence from mid February to early March. Total seedling emergence was low for seeds placed at the soil surface in both years (22% in 2010 and 18.5% in 2011), it was increased at a depth of 2 cm (% 59.5 in 2010 and 51.3% in 2011). This was followed by a decrease at lower depths and reached its minimum at 10 cm (30%) in 2010. However, there was no significant decrease in total emergence at a depth below 2cm in 2011. According to the regression model the start of seedling emergence after sowing is delayed by soil depth linearly.

Modeling weed emergence in cucumber (*Cucumis sativus* L.)

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Cucumber is among the major vegetables in Turkey. Modeling was carried out for eleven major weeds to develop estimated models for weed emergence time in cucumber. Weed emergence was observed for two years (2010 and 2011). Thermal time was used as the independent variable for predicting cumulative emergence. Different non-linear growth curves (Chapman-Richard, Weibull, logistic, Gompertz and cubic spline) were fitted to the data sets of cumulative percent emergence for the different species and years using genetic algorithms. Based on their emergence patterns, weed species were arranged into three groups: 1) species with early-period emergence (*Amaranthus retroflexus, Chenopodium album, Heliotropium europaeum, Polygonum aviculare* and *Solanum nigrum*); 2) species with whole-period emergence (*Convolvulus arvensis*, *Cyperus rotundus*, *Cynodon dactylon*, *P. oleracea* and *S. halepense*) that started early their emergence processes but the emergence continued throughout the cucumber life-cycle; 3) the only species with late-period emergence was *Tribulus terrestris*. The results obtained in our experiments have shown a good synchrony between the predictions obtained in different years. Also, these results suggest that thermal time allows good predictions for weed emergence and modeling weed emergence, which will help cucumber growers make better crop and weed management decisions.

Pollinators and the pollination efficiency in natural populations of *Monochoria korsakowii*, a paddy weed in Japan

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Monochoria korsakowii Regel et Maack (Pontederiaceae) is an annual paddy weed found in East Asia. It has evolved resistance to ALS-inhibiting herbicides in Japan, China and South Korea. Meanwhile, with the number of individuals in western Japan decreasing rapidly, it has been designated as a near threatened species by the Ministry of the Environment in 2007. Enantiostyly is seen in *M. korsakowii* flowers, which was historically considered to be a mechanism to promote pollination between heterostylous flowers, and it has been shown to possess a function that inhibits geitonogamy. In this research we aimed to demonstrate 1) differences in flower visiting insect fauna and pollination effects between populations, and 2) differences in pollination effects between insect species. We then investigated what environment and what kind of insects visiting the flower resulted in opportunities for seed production and cross-pollination occurring more easily. From the results of this research, it was shown that 1) pollination of *M. korsakowii* certainly occurs through the visit of large bees, 2) large bees assume behavior through which cross-pollination occurs easily, and 3) pollen is removed from the large stamen and small stamens by the visits of large bees. It was also demonstrated that the members of the large bee group are important pollinators for *M. korsakowii*. Meanwhile, it was demonstrated that flower visits by hoverflies were more typical in the currently numerous wild populations of *M. korsakowii* in Japan. From this research, the pollination and pollen removal effects, and also the probability of outcrossing occurring due to hoverflies were all considered to be small. Accordingly, it is possible that if the flower visiting insects are hoverflies alone, the quantity of seeds produced decreases in addition to opportunities for genetic diversity through outcrossing to be produced decreasing.
Also, the family of *Lasioglossum* or *Halictis* bees (small bees) most commonly observed second to hoverflies clearly contributed to seed production as they have a high pollination ability, but from their behavioral patterns, it was conjectured that they do not contribute to cross-pollination.

Weed emergence under simulated arable and no-till conditions: First year results

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No-till management leads to beneficial effects on soil fertility preservation, erosion mitigation and cost reduction. However, weed management strategies should be adapted to no-till field conditions. A field experiment was set up on November 2011 to compare emergence behavior of three weed species (*Abutilon theophrasti* Medik*., Sonchus oleraceus* L. and *Sorghum halepense* L. Pers.) and to evaluate if a single model could be adopted to predict their emergence in arable and no-till managements. Two treatments were performed to simulate conditions of weed seeds in arable (seeds overwinter buried in the soil and are affected by soil disturbance due to spring seedbed preparation) and no-till managements (seeds overwinter on soil surface without any further disturbance). Four 100-seeds replicates were included for each treatment. Seedlings were counted weekly from March 2012. Mean percentages of emerged seedlings were calculated for each species, treatment and their combinations. Emergence dynamics was modeled using a logistic function from which time of 50% relative emergence (t50) was estimated. Factorial ANOVA ($P<0.05$) identified significant effects of species, treatment and their interaction on percentage and t50 of emergence. Regarding emergence percentage, significant differences were found between treatments for *A. theophrasti* and *S. halepense*, but not for *S. oleraceus*. Moreover, the two treatments of each species presented identical emergence dynamics without any significant difference for emergence t50. These findings may suggest that a single model could be adopted to predict seedling emergence for the three species in arable and no-till systems. However, this experiment has to be replicated to confirm these results under different environmental conditions.

Germination dynamism of two *Rumex* species affected by chilling duration, moisture and light

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This study was conducted to evaluate the effect of light, soil water content, and chilling duration on seeds of *Rumex obtusifolius L.* and *R. crispus*. Experimental treatments comprised seven chilling durations of 1, 2, 4, 8, 15, 21 and 42 days, soil water potentials of field capacity (FC), ½ FC and 1/4 FC and four light treatments: Light (1) Darkness (2) Short duration light exposure immediately after exhuming the seeds (3) and Short duration light exposure after 24 hours of water soaking (4). In general, a total decline of germination was observed due to a decrease in soil moisture content in all light treatments except for short duration light exposure after soaking. Also providing short duration light requirement could supersede chilling requirement. Our results indicated that chilling requirement of the seeds can be affected by light and moisture environment. Prolonged chilling duration could also induce secondary dormancy in some light treatments. Based on our observations in both species, environmental factors did not affect the level and process of germination in short duration light exposure aftersoaking. This type of information about seed dormancy and germination of *Rumex spp* could be used in weed management either with chemical or non-chemical methods.

Comparison of germination in two *Rumex* species: Does soil conditions affect seed germination response to light?

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Photocontrol is a preventive method in weed management which aims to reduce germination of photoblastic weed seeds. One of the basic researches in photocontrol is to identify these species and their germination behavior in various environmental circumstances. In this study, germination behavior of two *Rumex* species in response to three different light conditions was investigated after seed burial in the soil under two different soil moisture environments during nine months. Results showed that both species are positively photoblastic but their responses to soil moisture environment were different. Under natural conditions *Rumex crispus* (curly duck) shows a peak of germination in autumn and one in late spring, while *R.obtusifolius* (broad leaved duck) seeds germinated greatly in late autumn, winter and spring, all in presence of light. *R.crispus* seeds became more sensitive to light when buried in dry soil and germination increased in full light condition, while dormancy of *R.obtusifolius* seeds seemed to alleviate more slowly in dry soil. Overall, our results indicate that seasonal dormancy cycle would occur in both species under natural moisture conditions, and also there is a possibility of environmental factors replacing each other to satisfy germination requirements. Information gained in this study would be useful in developing weed control programs for this species.

Ludwigia sedioides: An alien ornamental aquatic with invasive potential in Sri Lanka

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Ludwigia sedioides, an ornamental aquatic is not a naturally occurring plant in Sri Lanka. However, recently concluded studies recorded this plant in many water bodies in the wet zone of Sri Lanka. Therefore, it can become a potential invasive plant in the near future. The knowledge of the mode of propagation of invasive species is vital in the management of biological invasions. Therefore, the present study was conducted to investigate the propagation ability of vegetative parts of *L. sedioides.*

In the first experiment, three different maturity stages of stem cuttings each 15cm long were planted in containers in a Complete Randomized Design. Terminal shoots showed the highest survival rates. The shoot and root numbers as well as root dry weights of terminal shoots were significantly higher ($P<0.05$) compared to middle and basal parts of the stem cuttings. Thus, terminal cuttings have a better ability to spread compared to other stem cuttings. Hence, the propagation ability of fragmented terminal vegetative parts was investigated in the second experiment. Terminal stem cuttings with six different lengths (viz. 2.5, 5, 7.5, 10, 12.5 and 15 cm) were planted in containers in a Complete Randomized Design. All cutting types regenerated into a new plant. However, 5 cm long terminal fragments showed the significantly highest growth performance. Aquatic plants can spread easily through fragmentation and manual removal is considered as effective for small infestations. Therefore, repeated removal of all the plant parts can be suggested as an ecologically sound management approach to prevent further spread of *L. sedioides.*

Triticum boeticum as a new weed in Iranian wheat fields

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In recent decades selective pressures due to weed control caused new weed or invasive plants that required better management. Three experiments (laboratory, greenhouse and field) were conducted in Karaj in 2011 to evaluate the biology and control of *Triticum boeticum* Boiss (Wild einkorn) as a new weed in wheat fields of western provinces of Iran. The experiment was a complete randomized design with four replications in which treatments were arranged as factorial. The first factor was temperatures at six levels (5, 10, 15, 20, 25 and 30 °C), and second factor was osmotic potential at four levels (0,-4,-8,-12 bars). Herbicide treatments (diclofop methyl, fenoxaprop-p-ethyl, clodinafop-propargyl, isoproturon + diflufenican, sulfosulfuron, metribuzin, mezosulfuron + iodosulfuron, pinoxaden, and haloxyfop-r-methyl) were applied at recommended doses at two phenological stages of wheat and *T. boeticum* separately. Results showed a significant decrease in germination parameters at different temperatures by increasing osmotic potential. Among different temperatures, 30 °C caused a decline in the germination of *T. boeticum* to zero percent. Greenhouse study indicated that weed biomass was reduced by all herbicide treatments at both phenological stages two months after herbicide application. Herbicides pinoxaden, sulfosulfuron and clodinafop-propargyl resulted in the highest reduction of 70.4, 75.4 and 77.5%, respectively, compared to the check. Therefore, they can be recommended for controlling this weed in infested areas. Meanwhile reduced biomass is a goal for lower competition, reduced seed production is a goal for lower infestation on further years.

Spread dynamics and agricultural impact of emerging *Iva xanthiifolia* in Central and Eastern Europe

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Iva xanthiifolia Nutt. (burweed marshelder) is a serious allergenic wind-pollinated and competitive weed originating from North America. The species has increased locally in abundance and range in some parts of Central and Eastern Europe (CEE). Its invasion has received much less attention in CEE and has not been investigated systematically so far. Given this current trend, it seems likely that *I. xanthiifolia* may create significant problems for agriculture but also for human health in the medium term.

We provide an analysis of its spread dynamics in ten countries of CEE including Austria, Croatia Czech Republic, Germany, Hungary, northern Italy, Slovakia, Slovenia, Serbia and Switzerland. We extracted distribution records of *I. xanthiifolia* from a wide range of sources (floristic literature, national and international databases, unpublished data) up to the year 2012. Based on >1,000 distribution records, we then reconstructed its spatio-temporal invasion history and analysed its habitat affiliation and concurrent habitat shift. A niche-based predictive modelling was used to assess the invasion risk of the study region and its agricultural area by *I. xanthiifolia* under current climate. Moreover, different management strategies to halt or slow down its future spread will be evaluated.

In CEE, the spread pattern indicates a distinct lag phase for *I. xanthiifolia*, since the cumulative number of all records was scarce until 1950, but has sharply increased since then. Initially occupying mainly ruderal habitats, *I. xanthiifolia* started to invade crop fields since the late 1950s. Approximately 10% of all records of *I. xanthiifolia* for which habitat information was available, have been collected in crop fields and more than three-fourths of it after 2000. It is presently a common agricultural weed in the Slovakian Danubian lowland, Vojvodina and in the Southern Great Plain in Hungary. In the other parts of CEE the species remained restricted to ruderal habitats. Habitat suitability maps show that almost >25% of the area of the study region is prone to be invaded by *I. xanthiifolia* under current climate conditions. Spring-sown crops like maize, sunflower and sugar beet followed by soybean are most at risk of being invaded by the species. Our results suggest that *I. xanthiifolia* may cause further impacts in crop fields most likely in agricultural areas in the warm and continental parts of the study region.

Silverleaf nightshade (*Solanum elaeagnifolium*) in the Jordan Valley: Invasion, biology, phenology and chemical control

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A field survey was conducted to assess the occurrence of S*olanum elaeagnifolium* Cav. in the Jordan valley during 2011. During the survey a field experiment was conducted on the chemical control of this species. Our results revealed the presence of S. *elaeagnifolium* in field crops, on roadsides, fallow lands, ground for livestock feeding, and around water resources. Different crops were found suffering from the effects of this weed including vegetables and fruit trees. The weed density was 10 to 60 plants per m^2 and populations extended along the whole valley while weed individuals exhibited a wide morphological variation. Hot pepper (*Capsicum annuum*) was most heavily infested, while the weed was destructive in citrus (*Citrus* spp.) and olive (*Olea europaea*) orchards on certain sites. Except metribuzin, all post-emergence herbicides reduced weed growth and fruit production compared with the control. The reduction of shoot dry weight ranged between 12 to 78% of the control. 2,4-D isoocotyl ester (0.93 a.i lha^{-1}), trichlopyr (1.38 l a.i ha^{-1}) and glyphosate (2.88 l a.i ha^{-1}) were most effective and reduced the weed shoot dry weight by 78, 67 and 57% of the control, respectively. However, none of the herbicides prevented weed re-vegetation although differences in weed density and stature between herbicides treatments were evident. Additional treatment of the re-vegetated weed severely reduced its density and growth. It is concluded that S. *elaeagnifolium* is an invasive, troublesome noxious weed recently introduced to Jordan while more than a single application of most effective translocated herbicides was necessary to exhaust weed recovery.

Environmental effects on *Digitaria sanguinalis* growth, seed production and dormancy

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The success of *Digitaria sanguinalis* on summer crops in Argentina is due to its capacity to produce large number of seeds and to escape the chemical controls by successive cohorts. Both processes are modulated by the effect of the environment on plant growth, development and seed dormancy. The objective of this work was to study environmental effects on plant growth, seed production and dormancy in *D. sanguinalis*. Three experiments were done during summers of 2011 and 2012. Field experiments were carried out with five replications each. Treatments in Exp. 1 were different levels of shading (0, 50 and 80%) and in Exp. 2 different light qualities around the panicles (low R (red) :FR (far red) ratio, reduced blue light and controls). Exp. 3 was a factorial experiment with three replications combining presence of soybean (with or without) and soil fertility (high, low and medium level). The seeds sown in the experiments were collected from soybean fields in the previous autumn. The experiments were carried out on pots, placed in the experimental field of Facultad de Agronomía (Universidad de Buenos Aires, Argentina). At the end of experiments biomass and tillers per plant were determined and seeds were collected. Germination tests were carried out in a growth chamber at 20/30°C (8/16h) with light. In 2011 shading had no effect on seed dormancy, but in 2012 reducing 50% and 80% of intercepted radiation reduced seed dormancy by 26 and 35%, respectively. No differences were found on seed dormancy among seeds exposed during the reproductive stage to low R : FR ratio, reduced blue light and controls. Plants growing with low soil fertility and without soybean showed lower dormancy than the rest of the treatments during 2011 but not during 2012. In both years plants growing without soybean showed the highest number of tillers, biomass and seeds per plant and increased with the availability of soil resources. Among the studied environmental factors, shading during the reproductive phase of the weed was the only one affecting *D. sanguinalis* seed dormancy. Competition with soybean reduced the growth and seed production of the weed.

Quarantine weed seed determination in Anise (*Pimpinella anisum* L.) seed lots from Turkey to be exported abroad

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This study is the analysis of the quarantine procedure to determine the amount of weed seeds contained in the exported anise (*Pimpinella anisum* L.) to foreign countries during the 2010-2011 period. The total amount of the product to be exported was 150,000 kg. Every 10,000 kg anise product intended to be exported, 1 kg samples were taken on different dates using the method of full-aleatory sampling. With the help of forceps under a stereo microscope, weed seeds were separated from samples taken from anise seeds. As a result, a total of 57 g of quarantine weed seed samples was determined every 15 kg of seeds of anise. This amount of weed seeds corresponds to a 0.38 % seed admixture on a weigh basis. These weed seeds belong to 11 botanical families (Amaranthaceae, Primulaceae, Apiceae, Asteracea, Brassicaceae, Euphorbiaceae, Papeveraceae, Lamiaceae, Rubiaceae, Poaceae, Leguminosae) including 15 major weed species. Among them *Amaranthus albus* L., *Anagallis arvensis* L. , *Bifora radians* Bieb., *Centaurea cyanus* L. , *Caucalis platycarpos* L., *Descurania sophia* (L.), *Erysimum repandum* L., *Euphorbia* spp., *Fumaria parviflora* Lam., *Galeopsis bifida* Boen., *Galium tricornutum* Dandy., *Lolium temulentum* L., *Myagrum perfoliatum* L. , *Neslia apiculata* Fisch., *Sinapis arvensis* L. and *Vicia* spp. had the highest contamination rates. In this study, the rate of weed contamination in Anise seeds can be acceptable. However, the seeds of anise were, contaminated with weed seeds in spite of beeing seed cleaned by selectors. This shows that well-developed technical specifications for the prevention of contamination need to be observed by seed cleaning selectors.

Suicidal germination of some broomrape species under the influence of polymeric particles

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Orobanche and *Phelipanche* spp. (broomrapes) are obligate root parasites, completely devoid of leaves and chlorophyll. Their growth and development fully depends on their hosts. Seed germination of these plants depends on chemical signal molecules released from host plants.*Phelipanche aegyptiaca* (Pers.) Pomel and *Orobanche cumana* Wallr. seeds were used for determining the germination induction capacity of polymeric particles in this study. *P. aegyptiaca* seeds were collected from infested pepper and tomato fields in Çanakkale (Turkey). *O. cumana* seeds were collected from an infested sunflower field in Tekir dağ (Turkey). Nanoparticles prepared from carboxy methyl cellulose (CMC) are usually obtained from cell walls of green plants. In this study, CMC particles were synthesized using DVS as a crosslinker via a water-in-oil microemulsion polymerization technique. The dried CMC particles were used in loading experiments by soaking the particles in Nijmegen-1 solution for 24 h. The broomrape seeds were surface sterilized and the sterile seeds were sown in sterile petri dishes containing wetted paper with sterile water. Every petri dish was stored for seven days in the dark for stratification. After this period, 1 ml germination stimulant (1, 5, 10 mg/L Nijmegen-1 and 1, 5, 10 mg/L loaded Nijmegen-1 polymeric particle) was applied to each petri dish. After the application, the seed germination was checked throughout ten days. The photographs of the seeds were taken under an Olympus BX51 microscope integrated Altra-20. It was observed that the lowest and slowest germination induction with 4.23 % was achieved with a solution of 10 mg/L polymeric particles for *P. aegyptiaca* seeds at the end of the study. For *O. cumana* seeds, this result was 0.88 % with a solution of 1 mg/L polymeric particles. The highest germination induction was 18.92 % with a solution of 1 mg/L polymeric particles for *P. aegyptiaca* seeds. It was 2.89 % with a solution of 10 mg/L polymeric particles for *O. cumana* seeds. The germination reached 0.79 % for *P. aegyptiaca* seeds and 4.66 % for *O. cumana* seeds in the control groups. All data were analyzed by using SPSS 17.0 for Windows and levels of statistical significance of the results were determined as $P < 0.005$.
We have thought that the germination of broomrape seeds under the influence of polymeric particles could provide long-term protection in control method of parasite plants.

Effects of excessive soil moisture on seedling emergence of upland weeds

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In Japan, soil moisture of soybean fields is often excessive as many of these fields are converted paddy fields. In addition, the fields are often submerged as parts of a paddy-upland rotation system. Soil moisture is an important environmental factor affecting seedling emergence. However, its effects on seeds of upland weeds are not well documented. In this study, effects of excessive soil moisture on 12 upland weeds were evaluated. Seeds were buried in plastic boxes (123 × 75 × 55 cm) that were placed in two locations of different water levels: a moist location where the groundwater level reached to 10 cm below the soil surface in the box, and a control location with upland conditions. Experiments were conducted over three years (2010-2012). In 2010, seedling emergence rates were increased in moist soils compared with dry upland soils for 7 species, including *Echinochloa crus-galli* and *Bidens frondosa*. However, this increase was observed only in *B. frondosa* in 2011. In that year, seedling emergence rates were reduced in 5 species including *E. crus-galli* and *Amaranthus hybridus*. We hypothesize that the effects of excessive soil moisture on seedling emergence depend on the degree of seed dormancy, because in general, dormancy was lower in 2010 than in 2011. The effects of seed dormancy were also observed in 2012. Seedling emergence of dormant *E. crus-galli* and *A. hybridus* seeds was reduced but seedling emergence of non-dormant *E. crus-galli* and *A. hybridus* seeds was increased or unaltered in moist soils.

Evaluating the efficacy of mechanical and chemical scarification on dormancy breaking of *Abutilon theophrasti* Medik. seeds

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Most weed species acquire different types of seed dormancy because of some ecological adaptations to environmental conditions. Dormancy results in seed dispersal over time and supports weed seeds survival in disturbed habitats.
To evaluate the effect of different scarification treatments on dormancy breaking of *Abutilon theophrasti* (MED.) (Velvetleaf) seeds, a completely randomized design experiment with three replications was conducted at Research Laboratory of Faculty of Agriculture, Birjand University in 2012. Scarification treatments included acid scarification using sulfuric acid 98% (1, 2, 4, 8, 16 and 32 minutes), soaking seeds in boiling water (5, 10, 20, 40, 80 and 160 seconds) and mechanical scarification using sandpaper (three intensity levels).
Results showed that *A. theophrasti* seeds possessed a deep primary dormancy, so that they could not germinate greater than 8% at the time of collection. There were significant variations amongst different treatments in terms of dormancy breaking of *A. theophrasti* seeds. The highest and lowest germination percentages were caused by soaking in boiling water for 40 seconds (96%) and scarification with sandpaper level 1 (22%), respectively. This study clearly reveals that *A. theophrasti* possesses a physical type of dormancy and seed coat is the major constraint against its germination.

Physiological indices of weed species effects at different density on corn (*Zea mays* L.) growth

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Crop density is one of the usage tools in sustainable agriculture to carry out integrated weed management. This study was conducted in research field of Ferdowsi University of Mashhad, Iran. Four levels of corn densities (5, 6, 7 and 9 plant /m^2) and four levels of species diversity were used including complete control, broad leaved control (corn and grass weeds), grass control (corn and broadleaves) and without control (corn, broadleaves and grass weeds) by weeding. All species sampling were done at five stages from 42 days after planting up to the end of growth period. Crop growth rate (CGR), total dry matter of weed (TDMw), total dry matter of corn (TDMc) and seed yield per ha (SY) of corn were measured. Results showed that TDMc was minimum at 9 and 5 plant /m^2 in the early growth period, while it was highest at 9 plant/m^2 by the end of the growth period. Also, TDMc increased by 46% with increasing density in the weed free control. The same trends were observed for CGR. It was found that broad leaved weeds were more effective than grass weeds (causing 60 and 34% lower CGR reduction, respectively) on corn growth. Also SY in low density was significantly less than that in great density. Furthermore, inter-competition at 9 and 7 plant /m^2 was more effective than intra-competition, but competition had no significant influence on SY at low density (5 and 6 plant /m^2).

Predicting emergence of *Hordeum spontaneum* ecotypes collected from different climates of Iran

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Wild barley (*Hordeum spontaneum L.*) is an annual invasive weed that in recent years has become increasingly problematic in Iranian wheat cropping. Knowledge of patterns of annual emergence of this species should provide helpful information for management decisions.

Therefore, six H. spontaneum populations collected from different climates around Iran were sown in fields in a complete randomized blocks design with 4 replications. Seedlings were counted using the fixed quadrates at 3-day intervals until no emergence occurred any more. Non-linear regression was used to describe cumulative seedling emergence of each ecotypes against thermal time.

Parameter estimates indicated appearance of populations in the field with different patterns. The Kermanshah province population was the first in which seedlings emerged after receiving 67 growth degree days (GDD) followed by the Khorasan province populations which emerged 2-weeks later (76.6 GDD). Tehran and Ghazvin provinces populations showing similar patterns appeared in the field at a GDD of 83.4. Fars and Khozestan provinces were the last populations that emerged in the field after receiving 83 and 88 GDD, respectively. There was a significant clustering in the emergence patterns based on climate conditions from where seed populations collected. For instance, the commencement of emergence was with a significant delay in populations from relatively warm climates.

Determination of essential oils of *Salvia sclarea* (L.) populations collected from Tokat province-TURKEY

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The genus *Salvia* (Lamiaceae) includes nearly 900 species. *Salvia sclarea* L. populations were collected from Tokat province during the 2012 growing period near the cities of Resadiye, Artova, Almus, Turhal. The essential oils from the dry aerial parts of *S. sclarea* were obtained by hydrodistillation and analyzed by gas chromatography-mass spectrometry. A total of 44 compounds were identified in total oil composition. Major components of the essential oil from Resadiye sample were Fenchene (24.09%), β-Pinene (23.59%), Caryophyllene oxide (15.54%), Copaene (8.77%) and α-Terpieol (4.36%) while these of Artova were β-Pinene (23.29%), Fenchene (22.00%), Caryophyllene oxide (19.77%), α-Terpieol (8.10%) and Isocaryophyllene (6.31%). Similarly, major components of plants from Almus were β-Pinene (34.76%), Fenchene (21.15%), Caryophyllene oxide (11.42%), α-Terpieol (9.31%) and β-Bourbonene (5.11%). Major components of Turhal (A) were caryophyllene oxide (16.51%), Fenchene (15.90%), β-Pinene (12.95%), Camphor(5,97%) and Isocaryophyllene (4.96%), while major components of Turhal (B) were Fenchene (25.08%), β-Pinene (16.86%), Caryophyllene oxide (11.35%), Isocaryophyllene (4.00%) and α-Terpieol (3.85%). These results show the wide diversity of major components of essential oils among *S. sclarea* populations.

Determination of cardinal temperatures for germination of *Euphorbia maculata* and *E. heterophylla*, introduced weeds in the soybean fields of Iran

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Euphorbia maculata and *E. heterophylla*, two summer annual weeds, have been introduced in soybean fields in the Golestan province, Iran, in recent years. Due to the presence of these species, the weed flora species have changed. In order to investigate if germination ability contributed to this invasion we aimed to determine their cardinal temperatures of germination. A laboratory experiment was conducted at constant temperatures including, 10, 15 , 20, 30, 35, 40 and 45 °C with a daily alternating photoperiod (14 h light/10 h dark) in a completely randomized design with eight replications in Ferdowsi University of Mashhad. Non-linear regression methods were used, including five-parameter Beta (FPB) and Intersected-lines (ISL). *E. maculata* did not germinate at temperatures below 20°C. The lowest and the highest germination percentage and germination rates were observed at 25 and 35°C, respectively. The highest and the lowest germination rate for *E. heterophylla* were 11.2 and 1.34 seed %/day at 35 and 45°C, respectively. The highest germination percent of this species (76.5-80%) occurred within the range of 25-35°C. Base temperature, optimum temperature and ceiling temperature were 19.7, 40 and 47°C for *E. maculata* and 10, 33 and 47.7°C for *E. heterophylla*, respectively.

Genetic diversity and relationship analysis among accessions of *Aegilops* ssp. in Turkey using amplified fragment length polymorphism (AFLP) markers

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Amplified fragment length polymorphism (AFLP) DNA markers were used to assess the genetic diversity and relationships between 55 accessions of genus *Aegilops*, including the species *Aegilops triuncialis* L. (UUCC), *Aegilops geniculata* Roth (MMUU), *Aegilops cylindrica* Host (CCDD) and *Aegilops umbellulata* Zhuk (UU). The samples were collected from Aegean region and East Anatolia, Turkey. 16 AFLP selective primer combinations generated a total of 3200 polymorphic amplification products. 50 *Aegilops* accessions were analyzed using the data analysis software, unweighted pair-group method arithmetic average (UPGMA) method and numerical taxonomy and multivariate analysis system (NTSYSpc-2.02k). The similarity index coefficients were calculated according to simple matching coefficient. Using 16 AFLP primer combinations, species from Aegean region and East Anatolia were clustered as four major groups. *Aegilops* species having U genome clustered together and *A. cylindrica* host was out grouped.

The effect of anaerobic digestion in experimental and commercial biogas reactors on weed seed survival

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Crop biomass is used in co-fermentation with animal manure to produce biogas, as a durable alternative to fossil fuel. The digestate, the leftover after anaerobic digestion, is usually returned to the field as a crop fertilizer. If weed seeds survive the biogas process, the use of contaminated digestate could contribute to the spread of weeds, which can be particularly troublesome in the case of invasive weeds. Conditions inside biogas plants can be extreme, leading to thermal, biological or chemical inactivation of the seeds. Potentially high-risk species include those with hard seeds (physical dormancy). In this study, the probability that weed seeds survive exposure to the conditions in biogas reactors was investigated. Seed survival chances were estimated for a range of weed species in experimental batch reactors (37°C; 30 d exposure in 60 L reactors; ten species, *Abutilon theophrasti* Medik., *Datura stramonium* L., *Erodium cicutarium* (L.) Aiton, *Geranium pusillum* L., *Malva neglecta* Wallr., *Vicia tetrasperma* (L.) Schreb, *Bromus secalinus* L., *Lycopersicon esculentum* L. (tomato), *Rumex obtusifolius* L., and *Stachus arvensis* L.)) and commercial continuous biogas reactors (CSTR)(40-41°C; 1-9 d exposure; reactor 1, 800 m^3, HRT 35 d; reactor 2, 2000 m^3, HRT 70 d; five species, *A. theophrasti*, *M. neglecta*, *Chenopodium album* L., *Fallopia convolvulus* (L.) A. Löve, and *L. esculentum*). Batches of 100-300 seeds were exposed inside small fine-meshed bags. Prior to and immediately after exposure, seed viability was determined using a combination of germination testing and tetrazolium staining.

Weed species clearly differed in their ability to survive anaerobic digestion. Species with physical dormancy were more likely to survive anaerobic digestion in experimental batch reactors (up to 58%) compared with species whose seeds lack a water-impermeable layer (≤ 1%). Among the best surviving species were *Abutilon theophrasti* (batch reactor), *Malva neglecta* (continuous reactor) and *Chenopodium album* (continuous reactor). Tomato appeared to be a good model species for species without, but not for species with physical dormancy. In large-scale commercial CSTRs, ranking of species differed from that in batch reactors. This suggests that experimental batch reactors are not necessarily a good model system for CSTRs. There were also large differences in seed survival between subsequent runs of a reactor that could not be traced back to changes in important process parameters. Especially seeds of *C. album* were likely to survive the biogas chain, due to the combination of high seed production and survival probability in commercial biogas reactors, although in low numbers.

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Germination physiology of *Cuscuta approximata* Bab. (alfalfa dodder)

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The germination physiology of *Cuscuta approximata* Bab. (alfalfa dodder) was investigated in this study. The seeds of alfalfa dodder were collected from alfalfa fields in Erciş, district of Van in 2010. It was detected that 98 % of the alfalfa dodder seeds were viable. In order to determine the maximum and minimum germination temperature of seeds, they were treated with sulfuric acid for 30 minutes. However, no any germination was observed. In dormancy study, seeds were divided into two groups, either treated with sulfuric acid or kept at room temperature for 18 months. Then they were kept in a constant temperature of 22°C and in the dark for germination. Seeds treated with sulfuric acid did not germinate while the seeds kept at room temperature for 133 days reached 50.3% germination. The highest germination rate (82%) was obtained with 5-minute sulfuric acid treated seeds thereafter stored at 2ºC for 28 days in a cold and wet condition. It was concluded that seeds have very strong dormancy due to seed coat and that holding seeds in cold conditions (stratification) has significant effect on breaking dormancy.

Seasonal pattern in field emergence of some monocot weed species

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Monocot weeds cause a serious problem in root crops and cereals in Hungary. Regarding that nowadays farmers rather preferpost-emergence herbicide treatments as compared to the pre-emergence ones, long term effects of some soil herbicides do not apply any more. Reducing the application of soil herbicides resulted in inreasing weed populations of some lately-emerged monocots, such as *Setaria* and *Panicum* species in Hungary. The good weed control effect of post-emergence treatments greatly depends on the presence of weeds in arable fields as the majority of leaf herbicides has no long term effect via the soil. Therefore late emerging weeds can escape from the herbicide effect.

The aim of our experiments was to compare the seasonal patterns of field emergence of nine monocot weeds [*Digitaria sanguinalis* (large crabgrass), *Echinochloa crus-galli* (barnyardgrass), *Panicum capillare* (witchgrass), *P. dichotomiflorum* (fall panicgrass), *P. mileaceum* (common millet), *P. riparium*, *Setaria pumila* (yellow foxtail), *S. viridis* (green foxtail), *Sorghum halepense* (Johnsongrass)]. At the beginning of October 2011 plastic pots (25 cm in diameter) were digged into the soil under field conditions at an experimental field of Kaposvár University (Hungary). The pots were filled with a soil mixture. 100-100 freshly harvested seeds/caryopses of each weed species were mixed into the top 2 cm soil layer of each pot in four replicates. Seed emergence was evaluated weekly throughout a year (from the beginning of Oct 2011 until the beginning of Oct 2012). Seedlings were removed after counting.

The seasonal pattern of field emergence and the number of total seedlings within a year showed great variations, depending on weed species. Caryopses of weed species failed to emerge at the year of sowing. The first seedlings began to appear at the beginning of April of the next year, with a germination peak of *S. pumila* (26%). The germination peak of *S. viridis* happened one month later (at the beginning of May). Germination peaks of *S. halepense* and *D. sanguinalis* were in the middle of April and middle of May, respectively. The majority of monocot weed species has a germination peak at the beginning of May: (*E. crus-galli,* Panicum species except *P. riparium* whose germination peak was at the end of May). Only very low germination occurred in the case of *P. dichotomiflorum* (2.75%).

Weed germination of all examined species entirely ceased during the hot, dry summer months (from the end of July until the first half of September). From the second half of Sept seeds began to germinate again, but only low percentages were obtained.

The rank of order among species regarding the total seedling emergence within a year is the following: *D. sanguinalis* (77.75%)*>S. pumila>P. capillare > P.mileaceum >S.halepense >E. crus-galli >S.viridis>P.riparium>P.dichotomiflorum* (2.75%).

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Leaf anatomy of invasive and non-invasive climbers: does it correspond with ecophysiological performance?

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An aspect of invasion biology is the identification of common traits of invasive species. A previous study that compared resource-use efficiency and phenotypic plasticity of invasive and non-invasive climbing plants in South-eastern Queensland under different light conditions indicated that invasive species tend to have a more efficient use of light and carbon compared with non-invasive counterparts, while non-invasive species have a greater water-use efficiency. Furthermore, the invasive species were shown to have a lower leaf construction cost and greater plasticity in such structural traits as leaf thickness and density. This set of characteristics may contribute to the fitness of the invasive species.
The present study compares leaf anatomical and morphological traits associated with relevant ecophysiological traits of the same species grown under different light conditions. These anatomical traits were examined primarily by light microscopy of stained leaf sections and impressions of the epidermis. Data was analysed using ANOVA, plasticity index and principal component analysis.
The invasive species showed greater phenotypic plasticity than the non-invasive species for almost all of the measured traits. All invasive species had traits associated with lower leaf construction cost and high carbon gain (e.g. thinner leaves, more intercellular airspace, less lignin, thicker palisade layer). Newly introduced or naturalised plants could be screened for these kinds of traits, but many of these are taxon-specific so broad generalisations cannot be made.

Effect of nitrogen fertilizer and vermicompost on the seed bank of jimson weed (*Datura stramonium*)

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Jimson weed is a common annual weed in tomato and corn production in Iran. Fertilizers are one of the most important inputs in farmlands that may change the seed bank of weeds over time. Thus, a field experiment was conducted to evaluate the effect of three levels of N fertilizer (0, 150 and 300 kg ha^{-1}) and two levels of vermicompost (3 and 6 ton ha^{-1}) on the seed quantity and seed quality of this weed. It was found that when Jimson weeds received 300 kg ha^{-1} N fertilizer they had two- times larger architecture and higher mean seed dispersal distance than the ones in control. In the case of vermicompost, when plants received 6 ton ha^{-1} they produced 30 % more branches than the ones in control. They were also 20% shorter than the plants received N fertilizer. Plants fertilized by 300 kg ha^{-1} N produced 25% more seeds than those fertilized with 6 ton ha^{-1} vermicompost. When plants received 300 $kgha^{-1}$ N or 6 ton ha^{-1} vermicompost they had 25 and 30 % higher seed vigor than the controlled ones, respectively. Results showed that applying vermicompost to tomato production can slightly promote the seed vigor which in long term may increase the competitive ability of this weed over crops. On the other hand, number of seeds decreased in vermicompost treatment which can have negative effect of the seed bank on this weed. This is the preliminary report of our ongoing study. The experiment related to seed dormancy and seed composition is under progress.

Modelling the emergence time of shoots of *Sonchus arvensis* L. as a function of initial root size, soil temperature and burial depth

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The aim of this study was to predict the emergence time of shoots in populations of *Sonchus arvensis* L. (perennial sow-thistle) in relation to initial root size, soil temperature and burial depth. We also aimed to describe shoot emergence in terms of the relative depletion rate of the roots and accounted for temperature dependent respiration. In temperature controlled dark rooms (4, 8 and 18°C), differently sized roots of *S. arvensis* were planted in pots at different depths. During sequential harvests, shoot length was measured prior to or at emergence and the weights of the shoots and remaining root were assessed. The relative root depletion rates were estimated analytically as a function of the different combinations of factors and related to shoot length development over time. The relative root depletion rate was highly temperature dependent. Below-ground shoot length development over time was dependent on initial root size and temperature, but not on planting depth. The developed model allows for a prediction of changes in emergence time of *S. arvensis* under elevated temperature scenarios and can be used, together with crop information, to develop future weed control strategies.

Determination of morphology and genetic diversity of *Cyperus difformis* L. populations in rice fields in Turkey

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The study was conducted to detect morphology and genetic diversity of 50 smallflower umbrella sedge accessions from different rice fields in the Marmara and Black Sea region in Turkey. Morphological variations were scored for 11 different parameters on five individuals of each population growing in pots in greenhouse in a randomized block design. Morphological parameters such as plant height (cm), cotyledon leaf area (cm^2), leaf number (unit), the number of rays per spike (units), spike length (cm), spikelet length (cm), number of rays on spike (unit), number of flowers on nod (unit), total number of flowers (unit) and above-ground were measured. Morphological parameters were tested for group differences and compared using an analysis of variance (ANOVA). Univariate statistical analyses were conducted using SPSS package version 20 (for Windows). In addition, two ordination methods were used, principal component analysis (PCA) and hierarchical clustering. PCA was performed using SPSS including the 11 quantitative characters. The hierarchical cluster analysis based on quantitative characters clearly separated *C. difformis* populations. The principal component analysis for eleven quantitative morphological parameters that showed significant variation indicated that the first three PCs with eigen values ≥1 accounted for 80.07% of the total variations. Morphological similarity among populations ranged from 75% to 100%. Genetic variations among populations were investigated by using 17 RAPD primers on 1 individual for each 50 populations. The characters were subjected to hierarchical cluster analysis (a statistical method used in the construction of a dendrogram) in SPSS. The dendrogram was constructed based on the average linkage between groups, using the Euclidean distance as a similarity index. Genetic distance and similarity were calculated using Jaccard's coefficient. The seventeen RAPD primers amplified 210 bands whose molecular weight varied between 100 and 1400 bp. The percentage of polymorphic bands was 92%. Results showed slight morphology and genetic variability among individual genotypes within geographic locations. The data were analyzed by hierarchical cluster analysis and showed distinct differences between populations. Genetic and morphological relationships among populations were not correlated with geographical distance. The influence of agricultural practices, crop characteristics, geographic location and herbicide on low differentiation of *C. difformis* populations is discussed.

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Genetic variation of some Northern Europe populations of *Impatiens glandulifera*

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Himalayan balsam (*Impaties glandulifera*) is an annual ornamental plant introduced to Europe in the 19th century. Nowadays it is regarded as a highly invasive species in almost all European countries. This species is considered being a riparian plant but more often it appears not only in riparian zones but also in abandoned homesteads and gardens. In Lithuania it is distributed throughout all the country. Population genetic analysis is very useful to evaluate distributions of biological invasions. The objective of our research was to evaluate the genetic diversity of populations different in geography and habitats. This is why we selected populations of *I. glandulifera* from various places of Lithuania for our investigations. Genetic diversity of *I. glandulifera* populations was evaluated using two molecular methods: simple sequence repeats (SSR) and randomly amplified polymorphic DNA (RAPD). A total of 300 *I. glandulifera* individuals were examined. Six SSR markers were represented by two different alleles, fragment size ranged from 100 to 156 bp. For Lithuanian *I. glandulifera* populations observed heterozygosity (H_o) ranged from 0 to 1, mean being 0.5, expected heterozygosity (H_e) ranged from 0.2 to 0.5, mean being 0.4. Eight RAPD markers were represented by 18 and 30 DNA bands each, in total 188 bands were recorded as polymorphic. Percentage of polymorphic DNA bands in *I. glandulifera* populations were between 40 and 56 %, Nei's gene diversity interval was 0.115–0.165 and Shannon's information index ranged between 0.179–0.255, pairwise genetic distances between populations were 0.088–0.259. In conclusion, our study indicates various ways of introduction of *I. glandulifera* to Lithuania.

Comparation of phenology and germination of different white mustard (*Sinapis alba* L.) populations

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White mustard (*Sinapis alba*) is one of the most important weeds in cereals in the Turkish Republic of Northern Cyprus (TRNC). *S.alba* is often found as winter weed beside of field in Turkey. The aim of this study is to compare germination and phenology of white mustard populations originating from Turkey (İzmir-Bornova) and from Cyprus (Türkmenköy). The germinated seeds at different temperatures (5°C**,** 10°C**,** 15°C**,** 20°C**,** 25°C**,** 30°C**,** 35°C) were counted and germination rate was calculated. Those experiments were conducted in petri dishes. One of the Cyprus population (Türkmenköy) had highest rate of germination at 5-15°C, while the Turkhish population (İzmir-Bornova) had the highest germination rate at 15-30°C. The development and phenology of Türkmenköy and Bornova populations were observed in pot experiments in green house. Cotyledons and rosette stage, stem elongation, flowering time, fruiting time were observed and compared. The flowering time of the Cyprus population was five weeks before that from Turkey (İzmir-Bornova). The first fruiting time in the Cyprus population was also four weeks before the Turkish population. There are probably two different ecotypes of Turkish and Cyprus *S. alba*. Further investigations are needed to clearify the *S. alba* ecotype diversity and its implication.

Investigations on the germination biology of *Salsola kali* subsp. *ruthenica* (Iljin) Soo. seeds

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With this research the germination biology and dormancy conditions of *Salsola kali* subsp. *ruthenica* (Iljin) Soo. (Russian thistle) that is widespread in the Middle Anatolian agricultural area was examined. Mostly, our research concentrated on dormancy-breaking treatments. We researched at 2, 5, 10, 15, 20, 25, 30, 35 and 40 ^{o}C for germination experiments. According to the research results, minimum, optimum and maximum germination temperatures were <2 ^{o}C, 20 ^{o}C and 40 ^{o}C for Russian thistle respectively. Soil humidity had a considerable influence on the germination of *Salsola kali* subsp. *ruthenica*. 25, 50, 75 and 100% soil field capacity were tested. The germination maximum was achieved at a soil field capacity of approximately 75 %. The following treatments were applied to break seed dormancy: pre-soaking, pre-washing, pre-chilling, pre-heating, mechanical scarification of the seed coat and complete removal of the seed coat. The process of mechanical scarification resulted in the highest germination rates in our experiments. The statistical analyses were performed by Minitab 15 packet programs (MSTAT C 15.1.30).

Results from the HALT AMBROSIA Project: New insights into seed biology

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The European Commission is currently funding the project "HALT AMBROSIA" executed by a multi-national consortium. The project aims at improving the knowledge about the invasive alien common ragweed (*Ambrosia artemisiifolia*, Asteraceae) in order to develop measures for the prevention of further spread, eradication, containment and control of the species. As a prerequisite for the planning of eradication and control measures one part of the project is dedicated to the study of life history characters, in particular the dormancy and germination behaviour of the plant. We used germination tests and TTC tests (triphenyl tetrazolium chloride) to determine the following features:
proportion of living, dormant and dead seeds in fresh and stored seed lots,
seeds' ability to survive heat in different conditions,
the development of seed viability in the soil,
suitability of the soil seed bank monitoring to evaluate the efficacy of control measures.
In addition we studied the production of seeds (quantity and quality) and pollen of plants with different germination dates and after different treatments, e.g. cutting and herbicide treatment. The results allow first recommendations on the choice of control measures.

Three years of *Ambrosia* pollen soil dust flux in the Eastern Lyon (France)

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Municipalities need an easy control system for assessing the effectiveness of their fight against common ragweed (*Ambrosia artemisiifolia* L.*)*. The aims of the study are: to evaluate the local - Saint-Priest town (about 3000 hectares) - common ragweed fight during the last three years (2010-2012), to compare the *Ambrosia* (*A*) soil pollen percentages (%) with the *A* airborne pollen % of a pollen trap, set between 5-7 km from the sampling sites at the Lyon-Bron meteorological center.

The pollen soil dust flux method is used (Déchamp and Méon 2011, 2012). These studies were carried out with the same material, each year on the same date in day near, *i.e.* during the 30th week at the start of the *A* pollen release and about at the end, during the 38th week. Control of *A* pollen at the start of the season is necessary to know what is remaining from the last season. Pollen were collected on the same dirt tracks: a technologic park, an agricultural area and a town centre garden. No precipitation for 3 days. Pollen identification and pollen count were analysed by the same team. The Cour's pollen trap is used at the same site since 30 years. Filters are the same.

Studied criteria are *A* % *versus* total pollen, *A* pollen numbers/dust gram and /kilometer. At the start of the pollination seasons, *A* pollen % are less than 2% of the total flora, so the identified pollen at the end, are essentially those fallen during the season. From 2010 to 2011: *A* pollen % always decreased, *A* pollen/dust gram decreased once, *A* pollen/km decreased everywhere. From 2011 to 2012: *A* pollen %, *A* pollen/dust gram *A* pollen/km increased in two sites and decreased in the town center. *A* pollen % in dust flux and on atmospheric filters are always close the same week (15 data).

An important point: in the literature, it seems that it is the first time that pollen of a plant are counted on the soil at the start and the end of their pollination period. Distribution of vegetation pollen is different at any time and varies each year, it depends on the meteorological conditions of the year. The high rates of *Cedrus* pollen in 2011 (24% in front of 2-3% in 2010-2012) are partly responsible for reduction of *A* pollen %. So the more reliable criterion is pollen number/km.

From 2010-2011 soil *A* pollen have decreased everywhere, from 2011-2012, they have increased in the technologic park and the agricultural area but they have decreased in the town where the most of the population lives. The pollen trap gives results always close the same week. However, between 2010 and 2011, airborne *A* pollen have increased by 30%, whereas between 2011 and 2012 they have decreased by 25%.

Comparison of the emergence of three *Brassicaceae* species of different origins grown in Spain and USA

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Thlaspi arvense, *Camelina sativa*, *C. microcarpa* and *Neslia paniculata* are four *Brassicaceae* family species that are becoming rare in North-Eastern Spain. Conversely, both *T. arvense* and *C. sativa* are being investigated as oilseed crops in North America for industrial/biofuel purposes. *C. microcarpa* could have similar productivity characteristics as *C. sativa*, while the potential benefits of *N. paniculata* are largely unknown. Knowledge about the timing of emergence of these species could be helpful for either conservational or production purposes. Therefore, for these species, we compared the emergence of populations from Spain and USA, both under Mediterranean (Lleida) and Continental (Morris) field conditions. Seeds harvested in summer 2011, and stored at laboratory conditions, were sown in 1 m^2 plots in September (Morris, USA) and November (Lleida, Spain) 2011 at a rate of 1000 seeds/plot, with four replications. Emergence of seedlings was followed weekly until May. The emergence of the two populations of *T. arvense* was similar in Lleida and in Morris; the Spanish population presented a higher peak in spring than in autumn-winter, while the USA population presented similar emergence peaks. *C. microcarpa* also presented similar emergence behavior in both sites, but *C. sativa* did not have any spring emergence in Lleida, while in Morris, it did present some additional emergence. Finally, *N. paniculata* presented similar emergence in both seasons in Lleida, but the spring peak was much higher in Morris. The results suggest that, despite low emergence in some species, the two emergence peaks would allow their establishment as crops in either autumn or spring.

Sprouting ability of different parts of the taproot of *Anthriscus sylvestris*

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Anthriscus sylvestris is an abundant weed species in grasslands, road verges and less managed areas in Northern Europe and is increasing in North America. It can dominate the landscape which is covered in white during flowering. *A. sylvestris* is a monocarpic perennial species that propagates by seeds and formation of side taproots. The aim of this study was to investigate the sprouting ability of taproots cut at various positions.
In Experiment 1, taproots were collected in autumn 2010 at van Etten, NY, USA and stored at 4°C in moist conditions, were cut into 1, 2, 4 or 8 cm lengths from the upper (excluding the upper 1 cm), middle and lower parts of the root in spring 2011 and tested in a greenhouse in Ithaca, NY, USA. In Experiment 2, taproots collected in Tromsø, Norway in June, July and August 2011, were divided into the upper 4 cm (including the upper 1 cm) and the lower parts. These parts, as well as intact roots, were tested outdoors. The root fragments were buried at 2, 8 and 17 cm soil depth in large pots in both trials. Another experiment (Experiment 3) was set up in Ås, Norway where 4 cm root fragments from the upper root part with or without the upper 1 cm were planted at 2 cm soil depth in pots in a greenhouse in April, May and August 2012. In all trials 10-12 root fragments per treatment were planted. Sprouting (emerged) of root fragments was assessed 1-3 months after planting. Sprouted or not sprouted was analysed as a binary response variable with 'proc glimmix' (SAS) with root parts, burial depth and time (Experiment 2 and 3) as factors.
In Experiment 1 and 2, shoots emerged from the upper part of the roots, whereas no sprouting occurred from the lower part of the roots. Deeper burial resulted in less emergence. More root fragments sprouted in Experiment 2 than in Experiment 1. The results from Experiment 3 showed that root fragments only sprouted when the upper 1 cm was included, and more sprouting with August plantings than with spring plantings. Therefore the reason for less sprouting in Experiment 1 compared with Experiment 2, may be that in Experiment 1 the upper 1 cm of the taproot was excluded from the trial and that it was conducted in spring, whereas in Experiment 2 the upper 1 cm was included and the trial was performed later in the growing season. Another reason may be location or population differences in sprouting ability.
Because shoots only sprouted from the upper 4-5 cm of the root and deep burial greatly inhibited emergence, mouldboard ploughing may effectively control this species. These results also indicate that handweeding by removing the above-ground shoot and the upper 4-5 cm of the root could control the species in smaller areas.

Reduced sprouting from perennial weeds in autumn

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The rhizomatous species *Elytrigia repens, Equisetum arvense* and *Tussilago farfara*, and *Cirsium arvense* and *Sonchus arvense*, with plagiotropic roots, are the most troublesome perennial weeds in Nordic agriculture. Non-chemical control is mainly based on depletion of storage reserves using fragmentation, which stimulates sprouting, followed by destructive cultivation. However, the effect is reduced if conducted during a period of low sprouting capacity from roots and rhizomes.
Our main questions were i) if a seasonal variation could be observed in the studied species, ii) if the variation could be shown in both intact root/rhizome systems and fragments, iii) if the latitudinal origin affected the variation, and iv) which environmental trigger(s) induce the sprouting reduction.
Questions i, ii and iii were investigated in outdoor pot experiments, including five species with two or three populations each from northern and southern Sweden. Pots were exhumed at 12 to 14 dates, and re-sprouting tested from intact root/rhizome systems and fragments. Question iv was mainly investigated in a climate chamber experiment with *C. arvense* and *S. arvense*. Re-sprouting was tested in root fragments from plants subjected to different photoperiod and temperature conditions.
Intact root/rhizome systems showed reduced sprouting capacity in all species during autumn, which could not be explained by poor growth conditions. For *E. repens* the reduction was mainly shown as reduced shoot:rhizome ratio. Re-sprouting from fragments varied with season in all species except *C. arvense*. The climate chamber experiment indicated that short photoperiod in combination with high temperature induced sprouting reduction in *S. arvense*.

Ambrosia spp. (ragweed) in Israel - an allergenic invasive plant

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The genus *Ambrosia* spp. is an invasive plant in Europe, Asia and Australia. In recent years *Ambrosia* spp. invaded vast areas in Israel. The species widespread in Israel are *A. confertiflora* and *A. tenuifolia*, which are perennial plants. *A. confertiflora* is much more spread; perhaps it is due to its achene hooked prickles that get caught on any material in the environment. It seems that the achene of both species germinates poorly, but when seed germinated, it reproduces mainly by rhizome. The rapid spread of both species in Israel is attributed to their efficient vegetative reproduction by rhizome. Our experiments showed that in a single 10 L pot of dry soil taken from an infested field with *A. confertiflora* more than 670 shoots were sprouted during five months, and a single plant of *A. tenuifolia* developed 210 shoots after three months. It appears that ragweed invaded Israel via contaminated shipments of imported grains for food and feed, spread along roads, streams and railway tracks, farming vehicles and by the movement of contaminated soil.

The *Ambrosia* spp. pollen grains are well known for their high allergenic effect. Allergy skin tests experiments examining the responses of volunteers to pollen extracts are conducted in two hospitals in Israel. Preliminary results of allergy tests show that 30% of the atopic participants are sensitive. Various species sensitivity seems different, with *A. confertiflora* pollen more allergenic than *A. tenuifolia* pollen.

Ragweed is a noxious weed in agriculture, especially in orchards and in row crops such as cotton, sunflower, maize, and chickpeas. *Ambrosia* control experiments with various herbicides were carried out in the greenhouse and results show that although there is a response to most of the herbicides used, the treated plants recover and resume growth. Speices respond similarly and plant size determines the response - larger plants recover faster. Our data indicate the need of more research in order to develop a cost-effective ragweed management program.

Will photoperiod requirements serve as a barrier to establishment of A*mbrosia artemisiifolia* in Sweden?

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Ambrosia artemisiifolia (common ragweed) has been recognized as the most serious weed in Central and Eastern Europe (COST Action "SMARTER" for "Sustainable management of *Ambrosia artemisiifolia* in Europe", 2012). This plant coming from North America constitutes a great threat to public health due to its abundant production of highly allergenic pollen, also known to cause asthma. Moreover, direct skin contact might cause dermatitis or urticaria. In addition, this annual species is known as a highly competitive weed in organic farming and has already infested nearly 80% of the agricultural area in Hungary. Climate change, characterized by higher temperature and prolonged vegetation period, would increase the risk of this southerly species establishing viable populations in Northern Europe. However, as the species is a short-day plant, with a strong requirement for long nights to induce floral production, it might fail to produce seeds. Genetic diversity in traits related to flowering may, probably, enhance adaptation to Scandinavian environmental conditions. Our main hypothesis is that diversity among and within populations regarding the requirement of a specific photoperiod for induction of flowering enables an adaptation of *Ambrosia artemisiifolia* to northern latitudes. To test this hypothesis, a parallel common garden experiment including twelve populations is presently being conducted, at the same time, in Uppsala (Sweden) and in Osijek (Croatia). These populations originating from five European and two North American countries will be the base of one larger population genetic study using AFLP and microsatellites to trace-back the Swedish and European ragweed invasion.

Germination biology of *Phytolacca esculenta* – a new urban weed in the Czech Republic

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Phytolacca esculenta (*Phytolaccaceae*) is a perennial herb native to South-east Asia. In the Czech Republic it is grown as an ornamental plant. It easily escapes from cultivation and establishes feral populations. It can be found more often as a weed in home gardens, parks, along roads, rivers, on waste places; especially on places with sufficient soil moisture, often partially shaded. The species is spread by frugivorous birds, which consume its fruits and disseminate seeds. We collected seeds from wild plants in 2009 and 2010. Laboratory and field experiments were conducted in 2010 and 2011. We tested the germination of fresh seeds using different pre-treatments: scarification by concentrated (96%) sulphuric acid (1-10 minutes), germination under different temperatures (5, 10, 15, 20, 25, 30°C, seeds scarified by sulphuric acid were used) and primary dormant seeds stored dry in the laboratory, in wet sand in climatic boxes (5°C) and in soil under field conditions from September 2010 to March 2011. Freshly harvested seeds did not germinate at all. The optimum scarification time in sulphuric acid was 1 minute (68 % seeds germinated); longer times decreased the rate of germination (5 min. – 55 %; 10 min. – 15 %). Scarified seeds germinated best at 25°C. In seeds stored in soil (Chernozem, experimental field of CULS in Prague – Suchdol) the primary dormancy disappeared within one month (80 % seeds germinated). Wet storage in climatic boxes gave sufficient rates of germination (75 %) during fourth month, dry stored seeds germinated at rates 0 – 3 % during all terms.

Seasonal variation in storage reserves and effect of cutting on regrowth ability of Rush species (*Juncus* spp.)

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Soft rush (*Juncus effusus* L.) and compact rush (*J. conglomeratus* L.) are two perennial weed species which are common on a wide range of wetlands. During the last decades they have showed an increasing success in coastal parts of Norway, especially in the western coastal regions and next 50 -100 km from the coast. The species have occurred mainly in extensive grassland systems and pastures, but recently they have become also to some extent problematic in more intensively managed leys. Rush infestation causes a serious reduction in forage quality and consequently hamper the meat and milk production both in organic and conventional farming.

The majority of scientific work related to biology of soft and compact rush is from the 1940s and1950s, mainly from UK which is not always relevant to Norwegian growing conditions. Although this information is still of great value, the needs for basic knowledge on biological traits is crucial for rational control of these weed species.

The aim of this study was to obtain new knowledge on seasonal variation of storage compounds in above- and belowground fractions as well as regrowth activity after treatments to simulate cutting with different stubble heights during the growing season.

The studies of regrowth ability after mowing were performed in two separate pot experiments (in 2009 and 2010) under growth chambers conditions at Ås (59°40'N, 10°46'E, 90 m ASL). The factors were (i) *Juncus* spp. (soft rush and compact rush), (ii) Populations from West and East Norway, (iii) Stubble heights (1 cm and 5 cm), (iv) Temperatures (7.5 °C, 12.5 °C and 17.5 °C for six weeks) and (v) Dates of harvesting and initiating the experiment (5 dates from spring to autumn).The variation of carbohydrates through the growing season was studied using plant material (stems, rhizomes, roots) collected from a three years field experiment at Fureneset, Fjaler (61°18'N, 5°4'E, 10 m ASL). The material was dried, finely ground and three times extracted with 80% ethanol and then with water before analysis. HPLC and TLC methods were used for determination of individual carbohydrates where mono- and disaccharides were separated and quantified independently using sucrose, fructose and glucose as standards. Preliminary results showed a distinct regrowth pattern of rush species, the highest values in spring, lowest in July-August and an increase again in autumn. The carbohydrate analysis correlated well with the results of the pot experiment. Sucrose was the principal reserve carbohydrate with maximum concentration in spring and minimum in mid-summer. Regrowth ability of both species depended also on temperature level and stubble height. The lowest biomass yield was obtained in 7.5 °C and when plants were cut at 1 cm stubble height. The finding of a reduced regrowth ability in mid-summer which indicate a distinct weak point in the

rush life cycle may be useful for performance of treatments at right time and consequently for developing cost effective control measures of rush.

Biomass, seed and pollen production decreasing effect of mechanical control on common ragweed (*Ambrosia artemisiifolia*)

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Common ragweed (*Ambrosia artemisiifolia* L.) is an invasive weed. It was introduced to Europe from North America from the end on 19th century. Up to now with its excellent ecological adaptability it invaded the whole Europe. It is not only a noxious weed causing yield losses in agricultural crops; its highly allergenic pollen induces allergic rhinitis to sensitive people. In urban areas mowing is the most widely used means of ragweed control.

At mean plant density of 91 plant/m^2 mean number of female flowers was 150 that of male inflorescences were 1676 and the mean number of released pollen grains was 59 million at none mowed intact plants. Mowing treatments significantly decreased above ground fresh biomass and plant height compared to none mowed control. Early mowing (12 June) did not decrease significantly the number of female flowers and that of the pollen grains. Mowing twice (12 June and 25 July) and late mowing (25 July) significantly decreased number of female flowers; percent reduction was 49.45 and 56.88 %, respectively. Number of male inflorescences and number of released pollen grains were also significantly decreased; percent reduction of male inflorescences was 86.38 and 90.38 %, respectively and that of pollen grains was 85.42 and 51.10 %, respectively. However, it is remarkable the length of pollen releasing period decreased from 6 to 4 weeks compared to control due to mowing treatments.

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SESSION II

WEED ECOLOGY I

Oral presentations

Session organizers

Maurizio Vurro & Lammert Bastiaans

16th EWRS Symposium 2013, Samsun

The advantages of a process based approach to modelling the impact of climate change on weeds

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Bio-climatic envelope approaches have proved to be a powerful tool for predicting the future distribution of weeds under climate change at the continental scale. However, as scale decreases, an increasing number of other factors need to be included to capture local changes in the impact of weeds or prevalence of individual species, including local soil conditions, biotic interactions and crop management. That is, the 'realised niche' determined by local environmental and management conditions may differ from the 'fundamental niche' predicted on the basis of physiological thresholds. Weather driven, process based models of weed growth, development and competition are one way of meeting the challenge of how to model this realised niche as they integrate the impacts of the environment and management at the scale of the individual plant.

Simulation models of crop growth were combined with functions that simulate weed competition for resources, derived from the INTERCOM model, to develop a new model of weed growth and population dynamics, Sirius2010. The model was used to study the potential impact of climate change in the UK on the distribution and damage niche of *Alopecurus myosuroides*. The model used local-scale climatic scenarios generated by the LARS-WG weather generator and based on the HadCM3 projections for the periods 2046 - 2065 and 2080 – 2099 to predict yield loss and future weed distribution.

Although a slight northward shift in the UK range of *A.myosuroides* was predicted, its distribution is expected to remain broadly the same. However, the impact of the weed in terms of crop yield loss was predicted to decrease because of the increased frequency of early summer drought, particularly on light soils. The process based approach is an essential modelling tool in the study of the impact of climate change on weed dynamics and will become particularly important for integrating the direct effects of climate with indirect effects of changes in management. The model is currently being used to predict the impact of climate change on the European distribution of the invasive weed *Ambrosia artemisiifolia.*

Ecophysiological analysis of the nitrophily of weed species

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The evolution of agriculture towards more intensive practices has resulted in a dramatic loss of weed biodiversity. In response to the use of nitrogen fertilizers, oligotrophic species regressed whereas nitrophilic species were maintained. This indicates that nitrophilic species are more competitive than oligotrophic species in nitrogen-rich environments. Nitrophily (vs. oligotrophy) commonly refers to species flourishing in nitrogen-rich (vs. poor) environments. Oligotrophic are commonly described as species growing much more slowly than nitrophilic species whatever soil nitrogen supply. However, it is not determined whether this differentiation between these two types of species is progressive from the most oligotrophic to the most nitrophilic weed species. Moreover, little is known about the main physiological processes related to carbon and nitrogen nutrition on which nitrophilic and oligotrophic weed species differentiate. Our objective was to determine (1) whether, beyond a dichotomous approach, the differences of plant growth in response to soil-nitrogen supply is progressive from the most oligotrophic to the most nitrophilic weed species and (2) on which processes related to carbon and nitrogen uptake and use nitrophilic and oligotrophic weed species differentiate.

Twelve weed species contrasted for their Ellenberg index of nitrophily were studied at two levels of soil nitrogen (low vs. high) in a glasshouse experiment. Plant leaf area, shoot and root biomass and plant nitrogen were measured for each species × nitrogen treatment combination at two dates during plant vegetative cycle. In order to answer to question 1, the ratio of leaf area at high nitrogen to leaf area at low nitrogen was calculated to account for the response of leaf area to increasing nitrogen. In order to answer to question 2, physiological traits representing the capacity of the plants to extract and use carbon and nitrogen resources were calculated.

Firstly, the response of plant leaf area to soil-nitrogen supply was strongly, positively and linearly correlated to the Ellenberg index of nitrophily (R^2=0.73; P= 0.0035). So, the more nitrophilic a weed species, the more plant growth responded to increasing nitrogen supply according to a unique relationship including all monocot and dicot weed species. Secondly, the more nitrophilic a species, a better adaptation to increased soil-nitrogen via an increase of the efficiency of nitrogen uptake. Besides, the more oligotrophic a species, a better adaptation to decreased soil-nitrogen via an increase in allocation of biomass to root (vs. shoot). However, these two trends explained only one part of the variability of the nitrophily index (adjusted R^2=0.55; P=0.0116). The existence of a residual variability shows that, beyond these general concerns, different strategies of carbon and nitrogen nutrition are possible for a plant to be considered as nitrophilic.

This study is the first one quantifying the impact of the nitrophily on weed growth and nutritional strategies. From our results, concrete applications can be proposed for instance

for selecting catch crops species in cropping systems. Selecting preferentially very nitrophilic species will contribute to select species with strong capacities to take up nitrogen in the soil, thereby reducing leaching losses of nitrogen. Moreover, it is expected that very nitrophilic catch species are also competitive towards weeds, thereby contributing to reduce the bank of weed seeds in the soil via biological regulations.

Studying the resistance mechanism of chickpea (*Cicer arietinum*) and tomato (*Solanum lycopersicum*) to field dodder (*Cuscuta campestris*)

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Field dodder (*Cuscuta campestris*) is a troublesome obligate above-ground holoparasite that sustains on plants worldwide and substantially reduces their yields. In previous studies we detected two chickpea genotypes and one tomato genotype exhibiting consistent resistance to dodder. The aim of this research was to elucidate the resistance mechanisms of these chickpea and tomato genotypes by utilizing anatomic sectioning and microscopic examination. We studied the influence of temperature regime, day length and radiation level on the response of the resistant genotypes to field dodder in the phytotron. An integrated control approach was tested combining the resistant genotypes with PRE and POST application of reduced rates of selective herbicides. The results show that in the tomato resistant genotypes, cortical and epidermal cells surrounding the parasite haustoria were damaged and in both crops, the haustoria failed to reach the host vascular tissues. Extreme temperature regime negatively influenced the interaction between host and parasite, especially when the conditions were not optimal for the host growth. Cell division inhibitors affected field dodder shoot growth and damaged its development on chickpea genotypes. ALS herbicides did not inhibit field dodder shoot growth when applied directly to the young unattached dodder seedling as opposed to most of ALS herbicides applied by spray and drench applications to dodder- parasitized chickpea and tomato genotypes. Combination of the resistant tomato genotype with herbicides from the ALS group reduced field dodder growth compared to susceptible tomato genotype. Future work will be aimed at isolation of compounds that might be involved in the observed impeding of the invading parasite.

The response of an invasive weed and its biological control agent under a changing climate of CO_2 enrichment: management challenges for the future

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The invasiveness of certain weeds and the impact of their biological control agents will be influenced by changing climate. In particular, an elevated CO_2 concentration is predicted to alter the rate of assimilation of carbon by some invasive weeds and the performance of their specialist insect herbivores. Here we used *Parthenium hysterophorus* L., an alien invasive weed of global significance and *Epiblema strenuana* Walker (a stem galling moth), one of its biological control agents, as a model system to suggest how invasive species and their biological control agents will respond to climate change. When grown under an elevated CO_2 concentration (550 µmol mol^{-1}), *P. hysterophorus* produced significantly greater biomass, grew taller, produced more branches and 37% more seeds per plant, and photosynthesized at a greater rate, when compared to plants grown at an ambient CO_2 concentration (380 µmol mol^{-1}). The better water use efficiency of parthenium weed under an elevated CO_2 concentration suggest the weed has a greater ability to withstand prolonged periods of drought in the future. *E. strenuana* significantly reduced the height, biomass and seed production of *P. hysterophorus* when grown under both the ambient and the elevated CO_2 concentration. In the presence of *E. strenuana*, the total seed produced was 30 or 60% less at elevated and ambient CO_2 concentrations, respectively. Moreover, the moth had a negative effect upon seed quality and 45% of seeds produced were not filled. *E. strenuana* had the ability to reduce *P. hysterophorus* seed quantity and quality, under both the current and a possible future CO_2 concentration. However under an elevated CO_2 condition *P. hysterophorus* did produce more seeds even in the presence of *E. strenuana*. Managers should be prepared for future increments in invasive potential of weeds and challenges for biological control strategies which are a key component to integrated weed management programs.

Impacts of wheat row spacing, seeding rate and herbicide performance on grain yield and weed suppression

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Conservation cropping systems with no-till and stubble retention benefit soil condition, soil carbon and water availability. In the medium to high rainfall zones of southern Australia and under irrigation, stubble burning is still widely practiced for weed control and to remove stubble, but this practice reduces air quality and creates greenhouse gas emissions. Wide row spacing is also used to enable seeding into heavy stubble loads. Limited evidence suggests that wider row spacing leads to reduced crop yields and also competitive ability with weeds and its associated costs. We examined the impact of two wheat row spacings and five seeding rates on control of *Lolium rigidum* with four rates of diclofop-methyl below those recommended, to test the hypothesis that increasing seeding rate compensated for reduced competitive ability at wider rows especially when herbicide performance was sub-optimal. In the presence of *L. rigidum*, grain yield was unaffected by row spacing but was significantly reduced at low seeding rates, especially at lower herbicide rates. Grain yield of wheat was maximised when post-emergence herbicide was applied at 60-100% of the recommended dose at wheat densities above 300 plants/m^2. Nevertheless, significant levels of the weed still remained in the crop at anthesis in all treatments. Suppression of *L. rigidum* was unaffected by row spacing. However, weed DM at anthesis ranged from around 600 g/m^2 at low crop densities and with no herbicide to around 145 g/m^2 with the recommended rate of herbicide and high wheat densities. The implications of manipulating crop competitive ability to improve weed control are discussed. Situations where herbicide performance is unreliable are increasing, especially with the continuing spread of herbicide resistance, and climate change leading to more adverse hotter and drier conditions.

SESSION II

WEED ECOLOGY I

Poster presentations

Session organizers

Maurizio Vurro & Lammert Bastiaans

Allelopathic interactions between wheat (*Triticum aestivum* L.) and some of main weeds

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Plants can influence each other by allelopathy, which is usually harmful and sometimes is beneficial. Wheat and their weeds can interfere together during germination and seedling growth. In order to determine the effects of interaction seed to seed between wheat (*Triticum aestivum* L.) and some of its main weeds on seed and seedling growth factors, an experiment was carried out as complete randomized block design with four replications in the agronomy laboratory of the University of Tabriz.Seeds of the following weeds were used: *Rumex crispus* L. (curly dock), *Datura stramonium* L. (datura), *Sisiymbrium irio* L. (London rocket), *Daucus Carota* L. (Carrot), *Peganum harmala* L. (harmel), *Cardaria Draba* (L.) Desv. (horay cress), *Hordeum spontaneum* C. Koch. (wild barley), and *Avena ludoviciana* Durieu (oat). Germination percentage of carrot and curly dock seeds was reduced by the presence of wheat seeds. Conversely, seeds of wheat had stimulatory effects on germination percentage of London rocket, harmel, and oat seeds, which increased from 45, 92, and 96 respectively in control increased to 64, 98, and 98 %, respectively, in presence of wheat seeds. Germination rate of wheat seeds was increased by beside of carrot, London rocket and curly dock seeds. However, proximity seeds of horay cress, oat, harmel and datura had inhibitory effect on germination rate of wheat seeds. Number of roots in wheat was significantly increased by the presence of harmel and curly dock, but proximity of wheat with datura and London rocket had inhibitory effect on radical genesis in these weeds. Length of root in wheat seedling wa s reduced by adjacency of wild barley, horay cress, harmel and curly dock seedling. Length of shoot in wheat seedling was also reduced by adjacency of carrot, horay cress, oat, harmel and curly dock seedling. Fresh weight of root and shoot in wheat seedling were significantly reduced by the presence of carrot, horay cress, oat and curly dock seedling. Release of inhibitory substances from seeds of wheat and weeds would be the responsible for the observed effects. Since the early growth stage is very important in plant establishment, so should be acted for control and management of these harmful weeds.

Effect of temperature, CO_2 and water conditions on the growth of some important weeds

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The increases in air temperature, atmospheric carbon dioxide (CO_2) concentration and water shortage are thought to be important consequences of global climate change affecting agricultural production. Therefore, implications of these factors on the agricultural production have been a popular research topic recently. The present study aims to investigate the interactive effects of temperature, CO_2 and water conditions on the growth of some important weeds occurring in Turkey.

Chenopodium album L. (CHEAL), *Datura stramonium* L. (DATST), *Xanthium strumarium* L. (XANST), *Amaranthus retroflexus* L. (AMARE), *Portulaca oleracea* L. (POROL) and *Cyperus rotundus* L. (CYPRO) seeds (CYPRO rhizomes) were sown to the pots (3.8 L) filled with soil, sand, turf and perlite (at 1/1/1/1). After emergence, single plants were grown for 6 weeks under different temperature and CO_2 conditions. Temperature regimes were 16/30 ^{o}C as well as 22/36 ^{o}C (night/daytime), each with two CO_2 levels (ambient ca. 450 ppm or elevated ca. 750 ppm). Plants grown under each temperature-CO_2 regime received either full or half dose of water. Response of weeds to these conditions were evaluated by means of dry weight.

Dry weight of all weed species were significantly lower (between 27-47 %) under half water conditions, regardless of temperature and CO_2 conditions. Although most weeds grown under high temperature regime produced more biomass, this was only significant in the case of AMARE and DATST (41 and 46 % increases, respectively). Similarly, elevated CO_2 increased dry weight of all species as compared to ambient conditions, but the increase was only significant with DATST (by 48 %). Temperature-water interaction was significant for CYPRO. Weeds grown at 16/30 ^{o}C produced more dry weight with the half dose of water, but opposite plants at 22/36 ^{o}C produced more dry weights with full dose of water. The temperature-CO_2 interaction was significant so that weed responses to increased CO_2 were negative in the case of POROL, CYPRO, CHEAL and XANST at 16/30 ^{o}C. Dry weights of POROL, CYPRO and CHEAL were reduced by around 25 % by elevated CO_2 at low temperature regime, while this reduction was about 44 % for XANST. In contrast, elevated CO_2 increased the biomass of all weed species significantly at 22/36 ^{o}C. Dry weights of C4 weeds, such as AMARE, CYPRO and POROL were increased by 38, 39 and 57 %, respectively, while C3 species CHEAL, DATST and XANST increased their dry weights by 74, 89 and 147 %, respectively.

These results show that investigated factors affect the growth of weeds markedly. Water is an important factor affecting weed growth regardless of temperature and CO_2. However, temperature and CO_2 played a joint role on weed growth. Results here showed that weed

growth would be enhanced by higher temperature and CO_2 levels. Therefore it can be concluded that weed control will remain an important issue under future climate scenarios. However, results given here are based on weed responses when grown alone, studying these effects under competitive growing conditions would be an interesting next step.

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Influence of elevated CO_2 on the growth of some important weed species grown alone or in competition with maize

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Impact of increasing atmospheric carbon dioxide (CO_2) concentration on agricultural crops as well as weeds has been an important research topic recently. In general it is assumed that increasing CO_2 would improve the growth of some crops as well as weeds under future climate scenarios. Therefore the aim of the present study is to investigate the growth of some important weeds alone and in competition with maize under different CO_2 conditions.

Rhizomes of *Sorghum halepense* L. Pers., SORHA and the seeds of *Echinochloa cruss-galli* L., ECHCG, *Amaranthus blitoides* L., AMABL and *Solanum nigrum* L., SOLNI were sown to the pots (3.8 L) filled with soil, sand, turf and perlite (at 1/1/1/1). After emergence weeds were grown either alone or together with a maize plant under two different CO_2 conditions for about one month. Experiments were replicated at two different dates with average temperatures of 12/25 ^{o}C and 20/31 ^{o}C (night/day). The CO_2 values were 535-823 and 521-798 ppm (ambient/elevated) for the first and for the second experiment, respectively. The response of the weed species was evaluated by means of dry weight.

In both experiments, when grown alone, SORHA dry weight was higher under elevated CO_2, but only in the first experiment this was significant (2.7 fold higher as compared to ambient CO_2). Under competitive conditions however, no significant differences were obtained in both experiments. ECHCG dry weight was higher under elevated CO_2 regardless of competition. When grown alone, weeds produced 4-5 fold more dry weight while under competition dry weight increase was only 1.8 fold in the first (non-significant) and 3.3 fold in the second experiment (significant). Dry weight of AMABL was also increased via elevated CO_2 by 5.1 fold (significant) in the first experiment and 2.1 fold in the second experiment (non-significant), when grown alone. Under competitive conditions dry weight of this weed was significantly increased in both experiments by about 7 fold in both experiments. The growth of SOLNI was also significantly improved by elevated CO_2 in both experiments under both competitive conditions. In the first experiment dry weight of SOLNI was increased 1.9 fold under both competitive conditions. In the second experiment weed dry weight was increased 2.4 fold when grown alone and 4.4 fold under competition.

Results from both experiments showed that all these weeds would be more vigorous under elevated CO_2 conditions. Although this is true for weeds on non-crop areas, the same conclusion cannot be made for weeds under competitive conditions. Since crops also benefit from elevated CO_2 and improve their competitive ability, they can have advantage in competition. This was clearly observed in our studies. Competition of some weeds caused important dry weight reductions of maize under ambient CO_2 conditions while, with

the same species, no reduction was achieved under elevated CO_2 conditions. This was observed with SOLNI in both experiments and with other weed species only in the second experiment.

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Critical period of weed interference in soybean variety of indeterminate growth habit in two different row spacing

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Recently, two important factors appeared in soybean, the main agricultural crop in Brazil: the GMO varieties with herbicide resistance and the soybean rust. In this situation it would be interesting to increase the row spacing of the soybean crop and cultivate varieties with smaller leaf area. This will enhance the penetration of sunlight into the crop canopy and also facilitate the fungicide application, without harming the weed control that will be done by applying glyphosate. Actually, some farmers already increased the row spacing from 0.45 m to 0.60 m and started using varieties with an indeterminate growth habit. However, it is necessary to know the critical period of weed interference for these new conditions to optimize weed control. Determining the critical period was the objective of this study.

For this, a field experiment was carried out at Embrapa Soybean, Brazil. The experiment was laid out as a randomized block design, in plots of 30 m^2, in two row spacing (0.45 m and 0.60 m) with and without weed competition for periods of 0, 7, 14, 21, 28, 35, and 42 days after emergence (DAE). The variety used was BRS 294RR, of indeterminate growth and resistant to glyphosate. Twelve different weed species were observed and the total weed density ranged from 31.4 to 89.7 plants/m^2. The weeds were removed through application of glyphosate.

The results obtained showed that the critical period of weed interference was between 13 and 24 DAE for the row spacing of 0.45 m, increasing to the period between 6 and 37 DAE for the row spacing of 0.60 m. In the absence of any weed control, The weed competition resulted in the maximum yield losses of 57.2% and 62.6% were observed for row spacing of 0.45 m and 0.60 m, respectively.

Interference of common cocklebur (*Xanthium strumarium* L.) and spiny cocklebur (*Xanthium spinosum* L.) with tobacco (*Nicotiana tabacum*)

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Tobacco (*Nicotiana tabacum*) is one of the most important industrial crops for many countries. Especially Eastern type tobacco with its Greek varieties is of high quality, while it is a crop of further potential especially for marginal or declining areas. Lately, because of the reduction of the cultivation of tobacco due to the abolition of the EU support, there is an increasing demand for Eastern type tobacco of Greek origin. However, farmers face several problems, with weeds being among the most serious ones. The main objective of the present study was to evaluate the interferences between tobacco and two serious weeds (*Xanthium* spp.) under organic conditions.

In our study, field experiments were conducted in two sites, Agrinio and Athens, during 2011, in order to evaluate the competitive effects of common cocklebur (*Xanthium strumarium* L.) and spiny cocklebur (*Xanthium spinosum* L.) on the growth and yield of Basmas, a fine Greek tobacco variety. For each experiment, the experimental design was a split-plot in a randomized complete block with three replicates. Weed species was the main plot factor and the time that weeds were transplanted in the field was the subplot factor. *Xanthium* spp. transplanting was conducted 1, 2 and 4 weeks after tobacco's transplanting (WAT). There were also control subplots, which were kept weed free during the growing season by several cultivation or hand-hoeing treatments.

Our results showed that maximum tobacco yield loss was up to 32 and 41% for early emerging spiny and common cocklebur, respectively. However, even in the case of late weed emergence (4 WAT), there was a noticeable yield loss especially for the harvests after the first one (up to 8 and 23%). *X. strumarium* was significantly more competitive than *X. spinosum* due to its higher growth. Moreover, the higher yield reduction was observed in the experiment of Agrinio region and it is probably correlated with the significantly higher precipitation compared to Athens. Growth and seed production of both weeds decreased with increasing duration of the weed-free period. However, there were still many seeds produced by the later emerging cocklebur plants, which could easily contaminate the field and preserve the seed bank for the next growing seasons.

In conclusion, the results of this study highlight the differences between the two weed species (with *X. strumarium* being more competitive against tobacco than *X. spinosum*), confirm that the avoidance of early cocklebur emergence is of major importance for crop productivity and reveal the need of an integrated weed management strategy for tobacco in semi-arid environments.

Functional variation of weeds within winter wheat fields partly explained by variable disturbance and competition for resources

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Weed density in space and time varies greatly across fields. Arable fields are highly disturbed environments in which weed species abundance could be, at least partly, driven by their functional attributes. The analysis of weed functional variation may thus give insights into the species assembly processes acting at a fine scale within a crop field and in the field edge. Here, we measured functional response traits on seven abundant species in three field elements: the field edge (i.e. a tilled but uncultivated zone), the field margin (i.e. within the first crop rows) and the field core area. Our hypothesis was that environmental conditions (crop competition and intensity of disturbance) differ between these three elements. We aimed at (1) detecting if environmental filters associated with agricultural practices and biotic interactions (i.e. weed-crop or weed-weed competition for resources) varied from the field edge to the field core area and, (2) comparing how different species responded to these environmental filters.

Up to 10 individuals from each species were collected in the edge, the margin and the core of four winter wheat fields with similar crop sequence and management practices. Functional traits (specific leaf area (SLA), plant height and above-ground biomass) were measured following standardized protocols. These traits are known to respond to competition and disturbances.

A linear mixed model showed that functional trait values significantly differed between species and with field elements. Besides, a highly significant 'field elements x species' interaction affected the values of the three functional traits. The SLA decreased from the field core to the field edge, suggesting that competition for light decreased from the inside to the outside of the field. Plant height and above-ground biomass showed the opposite pattern, although less marked (differences between the field margin and the field core were often non-significant). This suggests that the intensity of disturbances induced by agricultural practices and the crop-competition decreases from the inside to the outside of the field, allowing for a more extended vegetative growth phase in the latter area.

The multidimensional functional spaces occupied by individuals for each species were significantly different between field elements. Moreover, the values of functional traits varied between species for some, but not all, field elements. In the field edge, species showed either a shade tolerance or a shade avoidance strategy, while in the field margin and field core, most species were functionally similar.

Our study demonstrates the high adaptive potential of weeds which are characterized by an important intraspecific variability allowing their development in contrasted environment al conditions.

Accumulation of nutrients by weeds and winter wheat plants

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The absorption of nutrients by a range of weed species (*Galium aparine* L., *Matricaria perforata* Merat., *Centanrea cyanus* L., *Cirsium arvense* L., *Apera spica-venti* L.) and winter wheat plants (*Triticum aestivum* L., variety Smuglyanka) under field conditions was investigated by the methods of ICP-EOS and Kjeldahl. Determination of elemental composition in samples of plant material carried by ICP-EOS (iCAP 6300 Duo MFC, USA). Plant samples were dried at 105 ^{o}C and digested in nitric acid at 240-250 ºC and a pressure of 60 bar for 90 min in a microwave digestion system Multiwave 3000 from Anton Paar, Austria. Determination of nitrogen with the Kjeldahl method was carried out on Behr S4 system, Germany.

High absorption levels of a number of macro- and microelements was found in harmful weed species *Galium aparine* L., *Matricaria perforata* Merat., *Centanrea cyanus* L., *Cirsium arvense* L., *Apera spica-venti* L. Dicotyledonous weed species absorb from the soil, not only large amounts of nitrogen, phosphorus, potassium, sulfur but also magnesium, calcium and boron. So, herbicide application at a later date significantly reduces the availability of nutrients for winter wheat plants. Under conditions of growing wheat on light-textured or acidic soils, established in experiments elements absorption by weed plants, especially calcium and magnesium, will increase soil local acidity in the area of the wheat root system that will reduce the efficiency of phosphorus, sulfur, nitrogen, potassium sorption by plants. Assumed that the lack of *Cirsium arvense* L. control can enhances in the next season wheat field infestation by *Apera spica-venti* L. with corresponding increase in the cost for pinoxaden, fenoxaprop or other graminicides.

These results may determine the structure of agrophytocenoses and that should be considered when implementing complex nutrition and protection systems of winter wheat.

Self-thinning and colonization success in ephemeral plant populations under varying resource availability

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Ephemeral plants usually are pioneers occupying open gaps after disturbances. Clear examples are many annual weeds and invasive plants in frequently disturbed environments. Colonization success of ephemeral plants commonly results from the balance between initial seed density and resource availability in recently open patches. Thus, understanding self-thinning in short-lived plants may contribute to understand early stages of plant invasions in highly disturbed habitats. Here, we evaluate the impact of density-dependent mortality on the colonization success of ephemeral plant populations in response to varying initial density and resource supply. We used an individual based model that simulates individual plant growth at a one week time step for a short growth cycle (10 weeks) in a 1 m^2 plot (100 by 100 cm grid=10,000 cells). Plant growth depended on resource supply and was a function of specific maximum growth rate and efficiency. Resource supply for a plant was influenced by its size, resources used by neighbor plants within a specified neighborhood radius, size and distance to neighbors, and two specific resource use rate parameters for the neighbors. Seeds were randomly distributed in the plot. We used two generic species differing in their potential growth rate. We explored a wide range of scenarios obtained by combining nine initial densities (between 4 and 800 seeds m^2) and four resource levels. Weekly, total biomass per plot, mean individual mass, and survivor density were recorded, and mortality rates then calculated. At the tenth week, seed output per plot was obtained by multiplying total biomass of survivors by fecundity (20 seeds per gram for both species). In all instances, total biomass increased as initial density and resource availability increased. Maximum total biomass was lower and achieved earlier when resources were limiting. Self-thinning became important at high densities and was modified by resource availability. Mortality was lower and started later as resource availability increased. Mortality started earlier and was greater for the species with higher growth rate. In both species, all individuals died at high densities and lower resource supply. Mean individual mass was higher in the species with greater growth potential, albeit growth rate highly decreased at increasing densities due to size-asymmetric competition. When log mean individual mass was related to log survivor density, the thinning slope b was close to -0.5; the expected slope assuming a -3/2 rule. The highest seed output was observed at the highest resource supply. However, seed produced per plot was slightly higher in the species with the lower growth potential. There was an optimum initial density maximizing seed production, which was always higher in

the species with the lower growth rate. Interestingly, for a given level of resource supply, a species with lower growth rate may produce more seeds than other with higher growth rate. Our results suggest that pre-emption of a greater share of resources early in the growing cycle may constraint seed production in ephemeral plants, which would reduce colonization success and impede self-perpetuation in highly disturbed environments.

Resource effective control of *Elytrigia repens*

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Couch grass (*Elytrigia repens L.*) is a problematic weed on northern latitudes. Once established in a field it spreads quickly through underground rhizomes. It is controlled either with glyphosate, or extensive stubble cultivations to fragment and starve the rhizomes. The aim of the project is to develop methods where couch grass is controlled without using chemicals and with insignificant nitrogen leaching. More specifically we test the hypotheses that perennial ryegrass and red clover cover crops under-sown in spring barley/oat reduce couch grass growth during autumn (1), reduce nitrogen leaching (2) and that mowing in autumn will further reduce couch grass growth (3). Moreover we tested if two stubble cultivations during autumn were significantly better for couch grass control than one time-optimized stubble cultivation (4) and if nitrogen leaching is smaller after cultivation with a goose foot cultivator (5 cm depth) than with a disc cultivator (10 cm depth), with similar effect on couch grass (5). Three experiments, each lasting two years, started in 2011 (results presented here) and repeated with start 2012. Exp. 1 and 2 were conducted at three different locations in Sweden and Exp. 3 at one site, all with four replicates in randomized complete blocks. In Exp. 1 the effect of mowing was investigated in main-plots and cover crops in sub-plots. In Exp. 2 stubble cultivation was conducted at different times in relation to harvest of spring barley/oat as the single factor. In Exp. 3, using separately tile-drained plots, the effect of different combinations of tillage and cover crops on N-leaching and couch grass was investigated. Measurements taken were e.g. abundance of couch grass shoots, aboveground biomass (cover crops and couch grass), rhizome biomass, soil mineral nitrogen (Exp. 1 and 3) and N-leaching (Exp. 3).

Preliminary results from the first experiments showed no significant reduction of couch grass shoots or rhizomes for any of the cover crop treatments, but cover crops reduced nitrogen leaching by almost a third compared to traditional disc cultivations after harvest. In one instance where mowing was applied, there was a reduction (approximately 27%) for shoot abundance at the harvest of the subsequent crop, without cover crop interaction. The difference in control of couch between two stubble cultivation during autumn and one time-optimized stubble cultivation was insignificant. Treatments with goose foot cultivator significantly reduced rhizome and shoot biomass compared to control and nitrogen leaching was less than after disc cultivation.

Results so far indicate that the combination of goose foot cultivator and cover crop, or using only one stubble cultivation after harvest, may combine reduction of couch grass

with reduced risk of N leaching. Results during 2013 will be important to further evaluate these effects, especially since the cover crop in 2012 established itself better than in 2011.

Effect of high temperature and seed moisture on germination of *Euphorbia heterophylla*

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Thermal heating methods provide rapid weed control without leaving chemical residues in the soil and water. In order to investigate the effect of high temperature on germination of seeds of *Euphorbia heterophylla* in soybean fields of Golestan province, Iran, a factorial experiment was conducted in a completely randomized design. Treatments included 4 thermal levels of 80, 100, 120 and 140 ˚C; two exposure times (1 and 5 min), two seed types (dry and wet).Seeds without treatment were used as control. The results indicated that by increasing temperature and exposure time, germination percentage was significantly reduced. There was no difference between the two exposure times at a temperature of 80˚C. No germination was observed with temperatures of 120 and 140˚C in combination with an exposure time of 5 minutes. Germination percentage of wet seeds was less than dry seeds, although both dry and wet seeds were destroyed completely with temperatures of 120 and 140˚C in combination with an exposure time of 5 min.

Examination of allelopathic effect and allelochemicals of velvetleaf (*Abutilon theophrasti* Medik.)

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Velvetleaf (*Abutilon theophrasti* Medik.) is one of the most important, hazardous, invasive weed species in Hungary.
We examined the allelopathic effect of velvetleaf plants in a laboratory bioassay and in the greenhouse on the germination and growth of cereal crops. We used air-dried shoots and roots of velvetleaf in a concentration of 2.5 and 5g $\cdot 100ml^{-1}$ tap-water solvent to prepare the extracts. We used solutions after 24 hours extraction and filtration. In the greenhouse experiment we measured 1 kg air-dried Ramann's brown forest soil in pots of 2-litres capacity. Dried shoots: 50g (5%) or 100g (10%), and roots: 25g (2.5%) or 50g (5%) were mixed into the soil.
Furthermore we analyzed the phenoloides and phenol-acid components of seeds of velvetleaf with thin layer chromatography (TLC). We defined the total amount of tannin in the seeds. We analyzed also the volatile components of velvetleaf's roots and shoots with SPME-GC/MS method.
The 5% extract obtained by dry velvetleaf shoots decreased germination (25, 13 and 10%), and the growth of the shoots (80, 42 and 76%) and roots (85, 46 and 46%) of winter wheat (Mv Magdaléna), corn (PR35F38) and spring oats (Mv Pehely), respectively. The alteration of germination percentage did not influence the length of shoots and roots (R^2 = 0.0013 – 0.27).
$100g \cdot kg^{-1}$ dried shoots of velvetleaf mixed into the soil hindered the shoots and roots progression of the test plants, but mixed roots had a stimulating effect on the growth of test plants.
By SPME-GC/MS analysis, we identified 23 volatile components from the shoots of velvetleaf. Hexanal, benzaldehyde, benzil-acetaldehyde, limonene, trimethyl-cyslopentanone, ß-cubebene and safranal occured. In TLC tests we couldn't identify flavonoid from the seeds. The tannin content was low (0.14%). Phenol-carbonyl acids weren't specific in the shoots. Rutoside was identified in the shoots, mainly at 6-8 leafy stage (0.142%).

Changes in antioxidative enzyme activities caused by *Phelipanche ramosa* (L.) Pomel and salt stress in *Arabidopsis thaliana* (L.) Heynh.

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Phelipanche ramosa (syn. *Orobanche ramosa*) is an obligate root parasite which causes high yield losses on crops such as tomato, eggplant, potato and tobacco. Salinity, which is an important abiotic stress factor, affects 20 % of land area and approximately 50 % of irrigated area in the world. In this study, *Arabidopsis thaliana* ecotype Wassilewskija (Ws2) was used as a host for *P. ramosa,* whose seeds were collected from an infested tomato field in Çanakkale, Turkey. For the study, *P. ramosa* and *A. thaliana* Ws2 seeds were sown within the same Petri dishes, filled with Gamborg B5 medium, for eighteen days with 16 h photoperiod at 22 $^{\circ}$C.

To understand how salt affects the antioxidative defence system during the interaction between these plants, three treatments were set up, i.e.: salt (S), broomrape infection (BI), broomrape infection and salt (BIS). When broomrape penetration in Arabidopsis roots was observed, 100 mM NaCl was applied to Arabidopsis seedlings in treatment S and treatment BIS by soaking their roots into the solution for 3 and 6 h. After this period, fresh plant samples for each group were harvested and frozen in liquid nitrogen.

We determined that alteration in MDA content and the activities of SOD, POX, CAT, APX and GR enzymes under these conditions. Our results showed that the activities of these enzymes increased and MDA content decreased by these increased activities as compared to control plants depend on time. However, although APX activity increased by 130 % in 3 h and 76 % in 6 h in BI treatment, MDA content also increased 5 folds in 3 h and 7 folds in 6 h. In BIS treatment, the activities of POX, GR, CAT and SOD increased 10, 6, 3 and 3 folds in 6 h, respectively. These results were significant at $P < 0.05$.

These results indicated that selection of salt tolerant crop varieties which have antioxidant capacity can be used as a control strategy in saline fields or in fields infected by broomrape seeds, for preventing crop losses.

Competitive effects of *Abutilon theophrasti* (Medik.) on yield and yield components of *Lathyrus sativus* (L.) under drought stress

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Grass pea, a member of Fabaceae, has a long history in Iranian agriculture, and has long been cultivated as food for humans and fodder for livestock. Iran is located in a dry region, and in many areas of the country, crops are facing water deficits during their lifetime. These drought events can, in turn, affect the competitive ability of crops, especially when they are growing along with vigorous weeds, such as *Abutilon theophrasti* (MED.) **(**velvetleaf), which also is one of the important weeds in Southern Iran.
In order to investigate the effect of drought stress and *A. theophrasti* competition on yield and yield components of grass pea, a factorial experiment was conducted based on RCBD with three replication in the Research Greenhouse of University of Birjand, Iran, during 2012. Treatments were drought stress (irrigation at 25, 50 and 75% of field capacity, FC), and different plant densities of grass pea (3 and 6 plants.pot^{-1}) and *A. theophrasti* (0, 3 and 6 plants.pot^{-1}). All irrigation treatments were imposed when plants were established.
The results showed that crop yield and seed weight of grass pea were decreased in response to an increase in the severity of drought stress and/or higher *A. theophrasti* densities. There was a higher crop harvest index under increased drought stress and lower grass pea densities. The lowest grass pea biomass was achieved in a combination of irrigation at 25% FC and the mixed planting of 6 plants of each crop and weed, whereas the highest biomass was observed when 6 grass pea plants.pot^{-1}, grown as weed-free, were irrigated at 75% FC.

Effect of high temperatures on tuber sprouting and shoot growth of purple nutsedge (*Cyperus rotundus*) populations

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Purple nutsedge is the most troublesome weed species of vegetable crops in the East of Iran. Understanding of environmental factors that impact tuber sprouting of this noxious weed may assist in improved purple nutsedge management. Laboratory and greenhouse studies were conducted to assess the effect of high temperatures on tuber sprouting, accumulation of plant biomass and new tuber formation of this weed species.
A factorial experiment with three replications was carried out at Birjand University. Treatments included different temperatures from 40 to 60°C with increments of 5° and exposure times including 1, 2, 4, 8, 16, 32 and 64 hours as well as two nutsedge populations originating from Birjand and Jiroft. After exposing tubers to high temperatures for the indicated exposure times, they were planted in 15 cm- diameter pots in a greenhouse (25/15°C 12h/12h) for 50 days. Tuber and pre-tuber number, tuber and pre-tuber weight as well as aboveground biomass were recorded at the termination of the experiment.
Results showed that increased temperatures significantly reduced tuber and shoot growth of both purple nutsedge populations. At a temperature of 60°C, there was even no tuber sprouting observed. There was a significant population x temperature x exposure time interaction effect fort all measured traits. Overall, Jiroft population showed greater susceptibility to high temperatures. This study showed that implementing high temperatures could be used as an effective non-chemical management tool for the control of purple nutsedge.

Translocation of molecules and macromolecules from host plants to the parasitic weed *Phelipanche aegyptiaca*

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Broomrapes (*Phelipanche* spp. and *Orobanche* spp.) are holoparasitic plants that subsist on the roots of a variety of agricultural crops, establishing a direct connection with the host vascular system. After the establishment of the first direct connection, exchange of molecules and macromolecules occurs. The aim of this study is to summarize our results on translocation of the molecules and macromolecules (peptides, siRNA, viruses, and proteins) from host plants to the parasites and the potential significance of such molecules to the parasite.

To test for peptide movement between host and parasite we have generated transgenic tobacco plants expressing a cecropin peptide (*sarcotoxin IA*), under the control of the inducible *HMG2* promoter. In this study it was demonstrated that *sarcotoxin IA* translocated from transgenic tobacco plants to the attached *Phelipanche* tubercles. Mannitol content in the parasite is regulated by Mannose 6-Phosphate Reductase (*M6PR*) gene, an essential process to *Phelipanche* for water and nutrient uptake from the host. We transformed tomato plants with the M6PR as a target gene for silencing, using the inverted repeat technique. It was shown that the M6PR mRNA target gene was silenced (60 – 80%) in *P. aegyptiaca* tubercles or shoots grown on the roots of transgenic tomato.

To test for protein movement between the host and the parasite, we used transgenic tomato and tobacco lines targeting a Green Fluorescent Protein (*GFP*) to the companion cells or to the endoplasmic reticulum (ER) respectively. In this study it was demonstrated that *GFP* was transferred from the companion cells of a transgenic tomato to the attached *Phelipanche* tubercles or shoots through phloem connections. In addition, it was shown that *CMV* can move also from virus infested tomato plants to the parasite tubercles and shoots attached to the infested tomato plants. An improved understanding of molecule and macromolecule exchange between hosts plant and their parasites could facilitate optimization of new and effective genomic approaches to parasitic weed management.

The effect of water stress on competitive interactions between weeds and willow plants during establishment of short-rotation coppice

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Long-term productivity of willow short-rotation coppice systems for energy purposes is known to be highly dependent on survival and growth of willow plants in the establishment year. Cutting quality, abiotic factors such as water and nutrients, and weed pressure are likely to interact and are assumed to underlie the variability in establishment success of willow stands in commercial practice, but little is known about the interactions of such factors. By means of a controlled bucket experiment, we studied the effects of weeds, water stress, cutting size and their interactions on the early growth of willow plants of two different willow clones. We used spring barley (*Hordeum distichon* L.) and *Sinapis alba* L. as model weeds. In general, early biomass production was decreased by competition of weeds or by the use of shorter cuttings. The applied reduction in water supply did not reduce willow growth in the absence of weeds. However, when willows were grown with weeds under reduced water supply, a significant reduction in growth of willow was observed. This result stresses the importance of weed control in willows on sites which are prone to droughts.

Effect of weed removal time on weed population dynamics in oil pumpkin crop

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Oil pumpkin is traditionally grown in some central and eastern European countries (Austria, Slovenia, Croatia, Hungary). Due to limited distribution and acreage, there are only a few investigations related to oil pumpkin production systems and even less related to weed problems in oil pumpkin crop. Oil pumpkins are very sensitive to weed competition, especially in early crop stage. As a general principle, weeds which emerge with the crop will be more competitive than those emerging once the crop is established. Late emerging weeds which remain below the canopy are unlikely to reduce crop yields.
Hence, there is a need to evaluate weed population dynamics in oil pumpkin crop in order to develop efficient weed management strategies.
A three-year field study was conducted at Krizevci College of Agriculture (north-western Croatia) to determine the weed population dynamics in oil pumpkin crop. Weed species composition, weed density (number m^{-2}), above-ground dry weed biomass (g m^{-2}) were determined two, three, four, five and six weeks after crop emergence. The same parameters were determined six weeks after emergence (fully closed crop canopy) on plots where weeds were removed for the first two, three, four, and five weeks after the crop emerged. The experiment was set up in a randomized complete block design in four replications. The total number of weed species in all three years was similar, ranging from ten to twelve, but only three to four species were dominant. The predominant species in all three years was *Echinochloa crus galli*, but its share in total number of weed plants and dry weight of weeds were different with each year. Although the number and dry weed biomass, as well as the share of species in total number and weight of dry weed biomass varied in relation to year and weed removal time, changes in weed plant number and weight showed similar trends in all three years. The highest total number of weeds was found two weeks after the emergence of oil pumpkin (in average 66 m^{-2}, 100 m^{-2}, 254 m^{-2} in 20.., 20.. and 20.., respectively) and the lowest number was determined six weeks after the crop emerged (33 m^{-2}, 46 m^{-2}, 117 m^{-2}). Contrary to the number of weeds, dry weed biomass weight was increasing, and the highest weight was determined six weeks after oil pumpkin emergence (156 g m^{-2}, 221 g m^{-2}, 304 g m^{-2}). The largest increase in dry weed biomass weight occurred in the fourth week (44, 96 and 122 g m^{-2} in a week) and in the fifth week (89, 86 and 96 g m^{-2} in a week) after pumpkin emergence in all three years. Number of weed species, number and dry weight of weed plants that emerged after weeding never achieved the number of weed species, weed plant number and dry weight on weedy control plots, regardless of the length of previous weeding.
The research provides relevant data for efficient weed management strategy, particularly with respect to timing of weed control.

Effect of *Fusarium oxysporum f. sp. melongenae* and its interactions with *Orobanche ramosa* on the disease development and growth parameters of eggplant

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Fusarium oxysporum f. sp. melongenae is a highly virulent pathogen that causes serious losses in crop production on eggplant (*Solanum melongena*) plants in field and greenhouse conditions. In this study, the interactions between *Fusarium oxysporum f. sp. melongenae* (Fomg) and *Phelipanche ramosa* on the disease development and growth parameters of eggplant (cvs. Anamur Karası and Karnaz F1) were investigated in pot conditions. For this, Fusarium-inoculated eggplants were evaluated under P. ramosa threat or not for the possible interactions and biochemical resistance mechanisms. Our findings showed that the height and relative growth rate (RGR) and the number of fruits were lower in Fusarium-inoculated eggplants than that of control plants ($P<0.001$). The progress of the disease through the symptom index values showed that the cv Anamur Karası was more sensitive than cv. Karnaz F1, as a result of that severe loss of crop production occurred in cv. Anamur Karası. Chlorophyll and carotenoids were also degraded in both cultivars. The chlorophyll a/b ratio, expressing the degree of stress, showed that both cultivars were severely stressed.

However, when *P. ramosa* interacted with the roots of Fusarium-wilted eggplant plants, the growth parameters such as height and RGR were almost 50 % of the control (non-inoculated) and 70% of the Fusarium-inoculated plants. The disease progression was faster and took half of the time for colonization when compared to Fusarium-inoculated plants alone. Chlorophyll and carotenoid contents as well as chlorophyll a/b were also found lower that those of the control and Fusarium-inoculated plants alone.

On the other hand*, P. ramosa*-colonized eggplant plants without Fusarium inoculation also showed significant differences from the control plants suggesting that this holoparasite is a serious threat alone in eggplant crop production. In this study, we showed that the combined effects of *P. ramosa* and Fomg severely reduced the crop production. We, therefore, suggest that the studies focusing on development for the Fusarium-resistant eggplant varieties should also involve the resistance studies against P. ramosa. This study is the first step of a series of studies between *P. ramosa* and *Fomg* dealing with biochemical, physiological and molecular pathology studies.

Element concentrations of two alien *Impatiens* species growing in various locations of Lithuania

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The spread of invasive alien species is a matter of great concern that mostly impacts on biodiversity and as a consequence on total ecosystems. Two *Impatiens* species, Small Balsam (*Impatiens parviflora*) and Himalayan Balsam (*Impatiens glandulifera*) are particularly outspread invaders in many parts of Europe. In order to assess adaptation and resistance to environmental pollution of above–mentioned plant species, estimation of their elemental composition was made.

Himalayan Balsam and Small Balsam plants were collected from twenty locations in Lithuania. Dried and milled plant leaves were digested using HNO_3 + H_2O_2 mixture in the closed vessel microwave system. The determinations of metals (Ca, Mg, P, K, Na, Al, Fe, Zn, Cu, Mn, Pb, Cd, Cr, Ni) were performed by flame and graphite furnace atomic absorption spectrometry. The concentrations of phosphorous were determined colorimetrically.

The obtained results revealed that *Impatiens* species differed significantly in the contents of calcium (ANOVA, F = 126.84, $P < 0.001$), potassium (F = 69.90, $P < 0.001$), magnesium (F = 95.63, $P < 0.001$), phosphorous (F = 14.90, $P < 0.001$), sodium (F = 8.75, $P < 0.005$), chromium (F = 32.81, $P < 0.001$), nickel (F = 40.77, $P < 0.001$) and lead (F = 26.58, $P < 0.001$). Additionally, the levels of elements in *I. parviflora* leaves varied significantly depending on sampling site: calcium (F = 24.06, $P < 0.001$), potassium (F = 70.28, $P < 0.001$), magnesium (F = 169.70, $P < 0.001$), phosphorous (F = 821.80, $P < 0.001$), iron (F = 152.16, $P < 0.001$), aluminum (F = 311.48, $P < 0.001$), manganese (F = 1374.1, $P < 0.001$), sodium (F = 128.32, $P < 0.001$), zinc (F = 169.39, $P < 0.001$), copper (F = 171.89, $P < 0.001$), chromium (F = 55.50, $P < 0.001$), nickel (F = 89.41, $P < 0.001$), lead (F = 83.02, $P < 0.001$) and cadmium (F = 457.53, $P < 0.001$).

The same tendency was observed in *I. glandulifera* leaves: calcium (F = 9.80, $P < 0.001$), potassium (F = 222.95, $P < 0.001$), magnesium (F = 935.80, $P < 0.001$), phosphorous (F = 1317.2, $P < 0.001$), iron (F = 896.90, $P < 0.001$), aluminum (F = 299.63, $P < 0.001$), manganese (F = 1564.7, $P < 0.001$), sodium (F = 198.47, $P < 0.001$), zinc (F = 77.48, $P < 0.001$), copper (F = 441.1, $P < 0.001$), chromium (F = 7.90, $P < 0.001$), nickel (F = 2.31, $P < 0.05$), lead (F = 307.83, $P < 0.001$) and cadmium (F = 580.57, $P < 0.001$). The amounts of Mg, K and P were about 1.5 times higher in Small Balsam leaves. Moreover, *I. parviflora* contained slightly higher concentrations of Na, Zn, Pb and Cd. Also slightly higher amounts of Cr, Al, Mn, Fe and Ni and 1.5 times higher amount of Ca was found in Himalayan Balsam leaves. The levels of heavy metals were below their toxic levels. A high supply of essential elements may clarify the high growth rates and rapid spread of particular plant species. It shows that habitat and environmental factors greatly affected accumulation of some trace metals in alien Impatiens species in Lithuania.

The search for resistance to branched broomrape *Phelipanche ramosa* L. Pomel among different tomato cultivars

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Due to global climate changes the area where branched broomrape *Phelipanche ramosa* L. Pomel occurs is constantly increasing. Although branched broomrape is a species present in warm countries, in the near future it could also become a threat to vegetable crops in Poland. Confirmation can be the fact that *P. ramosa* already threatens crops in Polish border countries, such as Slovakia and Germany.

For several years in the Research Institute of Horticulture studies on branched broomrape with tomato as host plant were conducted. In the greenhouse experiments relations between the parasite and several tomato cultivars were analyzed. Investigations were carried out with cultivars Corindo F_1 (2003- 2005), Remiz F_1 (2006 i 2008), Admiro F_1, Bigdena F_1, Eufaria F_1, Flexion F_1, Grace F_1, Growdena F_1, Zouk F_1, Julia F_1, Starbuk F_1 (2010-2012). At the beginning of March tomato seeds were sown to multipots in the glasshouse and in April seedlings were transplanted to the bigger multipots. Selected seedlings were planted to pots filled with substrate mixed with about 2 mg of branched broomrape seeds. Tomato plants without *P. ramosa* in pots were used as a control in the test. To obtain material for microscopic analysis additional experiments were conducted in special rhizoboxes. This enabled the continuous monitoring of the branched broomrape development without damaging the host and parasite material. To obtain material for microscopic analysis, laboratory experiments on the anatomy and morphology of parasite were conducted with the use of stereo-, light and scanning electron microscope. Underground tubercles of *P. ramosa* with fragments of tomato plants were collected for the anatomical study. Aboveground part of plants in various stages of development were also collected. The effect of *P.ramosa* on growth, development and yield of tomato showed adverse impact on host plants. Both yield and the height of tomato plants were lower in the pots with parasite than in the control. In the experiment it was observed that aboveground parts of branched broomrape growing with different tomato cultivars was characterized by a similar habit and color. However in the same conditions in pots with different tomato cultivars the parasite appeared at a different time and with a different number of parasite shoots during the whole experiment. Microscopic experiments revealed information about inner and external plant structures.

Results confirm that branched broomrape causes reduction of yield and plant height by competing with host for water and nutrients. However results suggest also that, among the tested tomato plants, genotypes with tolerance/resistance traits to *P. ramosa* can be found. Laboratory experiments revealed interesting information about structures that could be involved in the parasitic mechanism of *P. ramosa*.

Allelopathic potential of some European flax varieties against burclover (*Medicago polymorpha* L.) weed

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Allelopathic crops may play an important and useful role in minimizing problems in agriculture production, such as pollution of agriculture environment, unsafeagricultural products to human and animals, depletion of crop diversity, soil sickness and unavailability of mineral nutrition. To evaluate the allelopathic potential of a plant, germinating seeds of a test plant are often exposed to whole plants, seeds, plant extracts, or isolated allelochemicals of the aggressive species. In this study, sixteen varieties of flax (7 local, i.e., Sakha-1, Sakha-2, Sakha-3, Sakha-4, Giza-8, Giza-9, Giza-10 and nine imported from Europe i.e., Mayak, Tekka, Alba, Ariana, Letoania-5, Letoania-7, Letoania-9, Fyking and Blanka) were selected to evaluate their allelopathic potential against bur clover (*Medicago polymorpha* L.) that causes great damage to flax production in Egypt. Of each variety, fifty seeds were placed in a Petri dish of 12 cm diameter, whereas in a second Petri dish 25 seeds of that variety were combined with 25 seeds of bur clover.. The germination percentage varied from 36-100% in the Petri dishes with flax only, and from 4.44-100% in the Petri dishes where flax was combined with bur clover . According to germination %, the flax varieties can be divided into resistant varieties, in which their percentage of germination varied from 83-100 with bur clover (Sakha-1, Giza-8, Giza -9, Giza-10, Alba and Ariana) and moderately resistant varieties for which germination percentage varied from 61-71% (Sakha-4, Mayak and Tekka) and sensitive varieties with percentages of germination less than 50%. Also, it was noted that some varieties (as Giza-10, Mayak, Lituania-5, Lituania-7, Tekka and Sakha-2) had negative effects on bur clover germination. It could be concluded that flax varieties can be cultivated to adversely affect the germination of the bur clover weed without affect on germination of it. We need extensive studies to make an allelopathic map for different crop varieties. Such a map may be used as a practical indicator for precision crop protection.

Effect of cotton seed vigor on the early competition with weeds

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Cotton is an important crop in the Mediterranean region and frequently faces severe competition from narrow and broadleaf weeds resulting in yield losses. The main objective of this study was to determine how the seed vigor components related the seedling emergence affect competition with *Sinapis arvensis* and *Echinochloa crus-galli*. Three different seed vigor levels: high vigor (HV), medium vigor (MV) and low vigor (LV) seeds of a commercial cv. (Atlanta) were used. Final germination percentages and the patterns of emergence [timings (E_{90}), Mean Emergence Time (MTE), and uniformity (U)] were determined for all cases. Competition with , and plants derived from LV seeds were less competitive . Competition with the two weed species, as measured by the plant growth characteristics (height and dry weights of leaves, stems and roots) was weed species dependant. Early competition of the crop with the weeds was due to negative effect of seed vigour on the above emergence patterns. Seed vigour plays an important role to improve crop competitive ability against weeds and therefore could be part of an integrated approach to weed management systems.

Problem and Management of Broomrape (*Phelipanche ramosa* (L.) Pomel/ *P.aegyptiaca* (Pers.) Pomel) in Tomatoes Greenhouses of Turkey

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Climatic advantages in some parts of Turkey have made protected crop production common system. The Antalya Province with 60 % of greenhouses, which are total 56381 ha., allover Turkey is main covered crop producing area. Tomato is the most produced crop. Broomrapes [*Phelipanche ramosa* (L.) Pomel and *P.aegyptiaca* (Pers.) Pomel (Syn.Orobanche ramosa L./O.aegyptiaca Pers.)] significantly reduces yield of tomatoes in greenhouses as well as open fields. Especialy, bannig methyl bromide which was extensively used in greenhouses, has caused exploiting broomrape problem. It has been observed that up to 50 shoots of broomrape emerged from roots of a tomato plant.

So far, there has not been a method to control broomrapes in tomato efficiently and safely. However, some fumigants and solarization can be a solution to control broomrapes. Earlier studies showed that combining methods can give better control. In this study, the effect of some fumigants alone and combined with solarisation on broomrapes in tomato greenhouses were researched.

Experiments were conducted in two distinct locations in 2010 and 2011. One is Bozhoyuk village (Elmalı, Antalya) with 1100 m altitude from sea level, which grows early crop. The other one is Yeşilköy (Kaş, Antalya) at the sea level and produces tomato in winter. Iodomethane at 30, 40 and 50 l ha^{-1} and methamsodium at 1250 l ha^{-1} were applied alone or with solarisation in Kaş. Due to high elevation, solarisation was not applied in Elmalı. Iodemethane at 40 and 50 l ha^{-1} and methamsodium at 1250 l ha^{-1} were applied alone.The number of emerged broomrape shoots was counted and broomrape dry weight were measured to assess the effect of treatments on broomrape.

At Elmalı experiment, iodomethane 40, 50 l ha^{-1} and methamsodium 1250 l ha^{-1} reduced the number of broomrape shoots respectively 94.7%, 98% and 95%. The effect on dry weight of broomrape emerged was the similar to the number of shoot of broomrapes emerged.

At Kaş experiment, iodomethane 30, 40, 50 l ha^{-1} and methamsodium 1250 l ha^{-1} reduced the number of emerged broomrape shoots 86.58%, 91.69% , 99.08% and 75.76%, respectively. Combining solarisation slightly increased the control level: iodomethane (30 l ha^{-1}) +solarisation 96.59%, iodomethane (40 l ha^{-1})+solarisation reduced broomrape shoots 99.86%, Iodomethane (50 l ha^{-1})+solarisation reduced broomrape shoots 99.94% and methamsodium+solarisation 87.07%. Solarization alone reduced the number of broomrape shoots 77.85%. Further studies have been conducted to reach a precise conclusion.

PARASITE: An integrated research programme on parasitic weeds of rice in sub-Saharan Africa

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Parasitic weeds are progressively spreading in rain-fed rice production systems in sub-Saharan Africa (SSA). This is particularly worrisome as rice is gaining in importance as a strategic crop for attaining food security in SSA. The most important parasitic weeds in rice are *Striga hermonthica*, *S. asiatica* and *Rhamphicarpa fistulosa*. Stakeholder analyses in three affected areas in West and East Africa showed that the problem is mainly affecting resource-poor farmers, which generally lack the knowledge and means to effectively control parasitic weed infestations. Extension services are not always aware of the actual extent of the problem and are often unable to backstop farmers with adequate solutions. This proved particularly true for *R. fistulosa*, which is a relatively new parasitic weed. The stakeholder analyses further showed the existence of a large time gap between the emergence of a parasitic weed problem and the start of any targeted action to control the problem. Clearly, improved communication between stakeholders and a better preparedness at farm, community and government level would help to reduce the extent and impact of any future outbreak.

The parasitic weed problem is inherently complex as it covers different dimensions and disciplines (e.g. biology, ecology, agronomy, economy, sociology) and a variety of integration levels (e.g. plant, crop, farm, national, regional). The implication is that for real impact the involvement of different groups of stakeholders is essential. This notion was used as a starting point for a collaborative programme of Wageningen University, Africa Rice Center and NARS of Benin, Côte d'Ivoire and Tanzania, funded through the Integrated Programme scheme of The Netherlands Organisation for Scientific Research (NWO-WOTRO). The research programme consists of four sub-projects that cover (1) biology and ecology, (2) agronomy, (3) economy and (4) sociology and institutional analysis. The programme expects to deliver locally adapted management strategies, and to stimulate institutional innovations and farmer experimentation to reduce the expansion and negative impacts of parasitic weeds in rain-fed rice systems in SSA. An example of the

added value of the integrated approach is that control strategies are evaluated at pot (subproject 1), field (subproject 2) and farmers (subproject 3) level. Subsequently, subproject 4 provides insight in what type of institutional innovations can enable or constrain the broader dissemination of such management strategies.

SESSION III

WEED ECOLOGY II

Oral presentations

Session organizers

Garifalia Economou-Antonaka & Euro Pannacci

16th EWRS Symposium 2013, Samsun

Long-term changes in the weed communities of intensively managed cropland: effects on species diversity and functional composition

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Weed communities shift in response to changes in cropping systems, such as the adoption of no-tillage. In addition, different weed assemblages may occur in different crop types. Interestingly, weed shifts are rarely studied in the long-term. Here, we study the changes in the arable flora of the Rolling Pampa, the corn-belt of Argentina, since the early 20th century. We focus on maize and soybean, the most important warm-season crops in region. Maize expanded at the 1900s. Soybean was introduced during the 1970s, and considerably expanded since the inception of glyphosate tolerant GM-soybean sowing in 1996. Weeds were surveyed during the summer seasons between 2004 and 2011. Previous research on weeds of warm-season crops was also included. Historical data on crop management was compiled. Regional species richness (γ-diversity) was accumulated for particular periods associated with key technological changes. γ-diversity was additively partitioned into local (α-diversity) and turnover (β-diversity) components (β-diversity = γ-diversity − α-diversity). Species were classified according to origin and functional traits. Weed flora of maize crops was enriched in *c.* 7 species per decade between 1920s and 1995. Subsequently, weed flora of warm-season crops lose nearly 3 species per year (γ = 99 to 49). β-diversity decline (85 to 41) mainly reflected regional richness loss. Mean α-diversity similarly decreased in soybean (13.8 to 6.9) and maize (14.0 to 7.3) since 1995. Land-use changes explain β-diversity decrease. No-tillage, adopted in the late 1980s, almost completely replaced ploughing and is the usual practice nowadays. Maize sown area considerably decreased due to the widespread sown of soybean. Weed control now remains on a narrow spectrum of active ingredients. Glyphosate, which was mostly applied during fallows and pre-sowing before GM-soybean adoption, has now become the most common post-emergent herbicide. Pasture ploughing and fencerow removal to increase cropland changed the proportions of source and sink habitats consequently altering dispersal relationships between cropped and non-cropped habitats. Frequency of common weed species from Asteraceae and Poaceae decayed during the 2000s, whereas few species occurred as new weeds of warm-season crops in the region (*Parietaria debilis*, *Urochloa platyphylla*). No-tillage hindered weed species requiring regular ploughing to perpetuate within fields (*Datura ferox*, *Sorghum halepense*), whereas promoted small-seed weeds (*Digitaria sanguinalis*, *Euphorbia maculata*), wind-dispersed species (*Conyza bonariensis*), and woody species (*Sida rhombifolia*, *Gleditsia triacanthos*). Crop productivity increase since the 1990s would have restricted the occurrence of most C_4 species. Our results highlight that long-term changes in weed communities, in terms of species diversity

and functional composition, are driven by both transformation in cropping systems due to the adoption of new technologies at wider spatial scales, and by both management and ecophysiological attributes of particular crop types at field scale.

Changes in patterns in weed species and communities across the south west of Western Australia and their relationships with climate and soil

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Successful weed management depends on a sound understanding of how environmental and management factors affect the distributions of weed species and communities and how these distributions change over time. Similarly to many regions in the world, broad scale farming systems within the south-western Australian wheat belt have changed dramatically over recent decades with a general reduction in diversity due to a decrease in grazed pasture and grain legume cropping, an increase in cereal production, and extensive adoption of low tillage systems. The resulting increased dependence on herbicides for weed control has led to widespread evolution of herbicide resistance. The regional climate has also undergone substantial change over this period with greater climatic variability and reduced rainfall particularly in the winter growing season. All these factors are likely to affect weed distribution and incidence.

To investigate these issues, the prevalence of weeds in fields in the south west of Western Australia was surveyed in 1997 and again in 2008 across a total of 956 sites from both surveys. Altogether 194 weed species (or groups of species within a genus) were identified. The majority of survey sites were used for cropping, and 152 weed species were identified within these cropped fields. A univariate analysis was conducted to determine which species had changed in abundance and distribution. A multivariate community analysis approach was then used to investigate potential environmental drivers of changes in community composition and diversity, including annual and seasonal temperature and rainfall over both the survey years and the preceding decades, as well as soil characteristics such as thickness, water-holding-capacity, organic carbon, bulk density and pH.

Between 1997 and 2008, noticeable decreases in incidence (in cropped fields) were observed for *Vulpia* spp. (-25.3%), *Aira caryophyllea* (-20.5%), *Bromus diandrus* (-19.9%), *Avena fatua* (-17.6%) and *Austrostipa* spp. (-12.8%), with only *Raphanus raphanistrum* (11.3%) and *Arctotheca calendula* (7.1%) significantly increasing in frequency. A wide range of edaphic, climatic and meteorological factors were found to be significantly related to differences in weed community composition and diversity across time and space.

Our results lead to the conclusion that any future research should focus on developing and improving management strategies for *R. raphanistrum, Hordeum spp.* and *Conyza spp.* Although these are not the most common weeds, they are an emerging threat. Many of the very common weed species had stable or reduced incidence, suggesting that the

current management practices are adequate. Multivariate analyses, such as those conducted in this study, can help us understand the drivers of weed community composition and diversity and thus predict how weed communities will evolve as climate and farming systems continue to change.

Impact of environmental and management factors on weed species composition in sunflower fields in Greece, Turkey and Croatia: a comparative approach

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Sunflower (*Helianthus annuus* L.) is one of the most important oil crops in the world. Continuous demand for oil consumption and biofuel production has led to sunflower expansion in Balkan Peninsula. Evros region in Greece, Trakya territory in Turkey and eastern part of Kroatia constitute the main cultivated zones of sunflower at national level. *Orobanche cumana* Wallr. and some broadleaf and grass weed species have been serious hindrances in sunflower production throughout these regions. Resistant hybrids together with post-emergence (IMI group) or pre-emergence herbicides (trifluralin) have been extensively used by farmers to control both *O. cumana* and weeds. During the period July-August 2012 extensive surveys were conducted in the aforementioned regions in order to examine the integrated impact of herbicides, sunflower hybrids, crop rotation, tillage and fertilization on weed communities composition. Particularly, 27, 34 and 24 fields corresponding to 243, 470 and 368 acres were surveyed in Evros, Trakya and eastern Kroatia, respectively. The surveyed fields were located in different ecoregions encompassing the cultivated land of Evros, Trakya and eastern Kroatia respectively. The surveyed fields were chosen to fit the desired management systems after personal interviews on a farmer-friendly questionnaire. In each field we sampled five quadrats of 4 m^2 following the W pattern. In addition, climatic features of each region such as temperature and precipitation were taken to develop the bioclimatic indices such as degreedays and humidity index. Furthermore, soil parameters such as pH, soil texture and organic matter were examined at each sampling site. Descriptive statistics, Spearman's rank correlation coefficient and multivariate analyses were used in order to examine the relationship between abiotic factors and weed occurrence.

All three countries differentiated in weeds composition and abundance. *O. cumana* was successfully controlled with the use of CLEARFIELD® SYSTEM in all three regions. However, weeds such as *Xanthium strumarium* L., *Chenopodium album* L. and *Echinochloa crus-galli* (L.) P. Beauv. showed to escape weed control treatments especially when susceptible target-growth stage has evaded. Special attention should be drawn to the fact that *Ambrosia artemisifolia* L. has invaded sunflower fields in Kroatia to such an extent that is difficult to control. Tillage systems and crop rotation are common in all three countries. Deep plowing during fall and basic fertilization are the practices adopted by the farmers. However, differentiations exist when irrigation is applied. 100%, 90% and 40% of sunflower fields were rainfed in Kroatia, Turkey and Greece respectively. Climatic conditions and soil parameters also had a strong impact on spatial differentiation among weed species and ecoregions.

The influence of landscape simplification on weed traits in Mediterranean cereal boundaries

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Crop boundaries are important areas supporting weed diversity in agro-ecosystems, although the progressive landscape simplification during the last century has eroded weed richness of these habitats. The ecological processes involved in the diversity loss in response to landscape simplification may be clarified focusing on response traits. The aim of this work was to assess the influence of landscape simplification on weed traits in Mediterranean (Andalusia and Catalonia regions) winter cereal field boundaries. Weed species were recorded in 101 boundaries of conventional cereal fields along a landscape complexity gradient. Weed species were characterized by five traits: life form, growth form, seed mass, seed dispersal type and pollen vector. The relationship between species traits and landscape complexity was assessed by RLQ analysis. The first RLQ axis showed a significant association between plant traits and landscape complexity. The different plant traits explored, with the only exception of growth form, explained 62% of the variation found. Traits associated to simple landscape were annual, non-zoochorous, anemogamous and light seeded species. The functional approach of this study can help understand general patterns of response of weed diversity to landscape simplification and to develop agri-environmental policy for weed diversity conservation in Mediterranean areas.

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Poaceae weed host range of *Luteoviridae* viruses in the Trakya region of Turkey

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Trakya Region of Turkey is located in between $26^0\ 1^1$ -- $29^0\ 1^1$ East longitude and $40^0\ 5^1$ -- $42^0\ 2^1$ North latitude. The elevation of region is being 50 – 500 m with hilly and low plain in topography. The region has 61% arable land, 16 % forest and 16 % pasture and meadow. Trakya Region is considered important cereal production area in Turkey. Previously systemic yellow dwarf diseases caused by viruses and their vectors were reported by Bremer and Raatikainen (1975) as sporadic infections in some parts of Turkey. Merely yellow dwarf diseases on cereals have been prevailed in the Trakya region of Turkey since 1999. Those yellow dwarf diseases on winter wheat (*Triticium aestivum* L.), barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.), triticale, rye (*Secale cereale* L.), bird seed (*Phalaris canariensis* L.) and maize (*Zea mays* L.) caused yellowing, dwarfing, reddening and reduction of yield and quality. As a result of several investigations, viruses of yellow dwarf diseases in the area have been identified by İlbağı *et al.* (2003) and Pocsai *et al*. (2003). All those studies revealed that *Barley yellow dwarf virus*-PAV (BYDV-PAV) was determined as the dominant species. The other virus species however were BYDV-MAV, BYDV-SGV, BYDV-RMV and *Cereal yellow dwarf virus*- RPV (CYDV-RPV). In order the control of yellow dwarf virus diseases on cereals, studies have been extended to search over summering and over wintering weed hosts after the identification of common reed *Phragmites communis* as the weed host of BYDV-PAV by İlbağı (2006). D'Arcy (1995) compiled the studies and listed the names of 75 annual, 1 biannual and 74 perennial weed species belongs to 9 genera of Poaceae family from all over the World as host of BYDV'es. So, Poaceae weed species have been investigated as the sources of those viruses in The Trakya Region since 2009. For this purpose 327 symptomatic weed leaf samples from 28 species were collected randomly from 12 districts of 3 provinces in 2010. By employing DAS-ELISA test method of Lister and Rochow (1979) and RNA extraction methods of Falke *et al*. (2000) RT-PCR tests were implemented to leaf samples. As a result of both tests 162 out of 327 leaf samples had BYDV-PAV. Beside 21 samples infected with CYDV-RPV, 14 samples had BYDV-MAV, 5 samples BYDV-SGV and 5 samples had BYDV-RMV. These viruses were present as individually and mixed infections. In second year 370 weed leaf samples were obtained from 35 species in the area. As a result of RT-PCR test 255 samples revealed the presence of viruses. 25 of them had BYDV-PAV, 68 of them had BYDV-MAV, 35 of them were found to be infected with CYDV-RPV and 5 of them had BYDV-SGV. All of those results revealed that Poaceae weed hosts having virus species of yellow dwarf virus diseases and cause the sustainable epidemic infection in Trakya region of Turkey.

SESSION III

WEED ECOLOGY II

Poster presentations

Session organizers

Garifalia Economou-Antonaka & Euro Pannacci

16th EWRS Symposium 2013, Samsun

Tremendous changes of Central Europe's arable plant communities since the 1950s/60s - a resampling study

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Various studies examined changes in arable plant vegetation on species or population level but a synoptic analysis of the impoverishment on the community level is lacking. Here we present the results of a survey across ten sub-regions throughout Central Germany with a range of different soil/climate conditions and therefore a wide range of arable plant communities. We compare changes in community composition and diversity of phytosociological syntaxa in the 1950s/early 1960s before the onset of agricultural industrialisation with the current situation in 392 arable fields. All historical records had been sampled in the field interior. In 2009 in every field, an additional plot was recorded at the field margin. At every locality, recent samples were taken at increasing sizes of 25, 50 and 100 m² (nested); comparisons over time were, however, based on the size used in the given historical sample (mean plot size: 65m²). The presence/absence of recognisable arable plant communities was determined in both periods based on diagnostic species.
We applied a Detrended Correspondence Analysis (DCA), as suggested by a relatively high β-diversity (gradient length on first DCA axis: 5.2 multivariate s.d. units). Arable plant species diversity at the plot-level (α-diversity) was assessed with respect to species richness (qualitative) and arable plant cover (quantitative, median cover abundance value). We tested differences in species richness over time separately for each community. Changes in the occurrence of the diagnostic species over time were tested with separate Indicator Species Analyses. Our study proves for the field interiors a dramatic reduction in the species pool of nearly one fourth (from 301 to 233 taxa), and an equally significant diversity decline at plot-level in most arable plant communities. Diagnostic species for phytosociological syntaxa have largely vanished, with losses being more pronounced among character species lower-ranked syntaxa such as associations. They are more threatened than diagnostic species for higher-ranked syntaxa like alliances, orders and classes. The present-day arable plant communities in Central Germany are species-poor, consisting of mostly widespread, often herbicide-tolerant generalist species, with no clear preference neither to cereal and root crops nor autumn- and spring-sown crops. For the majority of recent samples, strong impoverishment renders assignment to phytosociological associations impossible. The resulting community fragments may be classified on the levels of higher-rank syntaxa. Some relevés could not even be classified at class level. To our knowledge, this is the first study which shows the decline of an entire vegetation class for a large area. As a consequence of these dramatic diversity losses the existing phytosociological system of arable plant vegetation in Central Europe which is based mostly on historical relevés is no longer suitable and needs to be amended to accommodate for present-day species combinations.

Relative Dominance index in weed flora surveys

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Weed flora studies were surveyed in alfalfa fields of Tabriz county (located between 35º 7′ latitude and 46 º 26 longitude) right before the first cutting during 2010- 2012. Sixty five weed species of 25 families were recorded. *Bromus tectorum* (roof broom grass), *Crepis sancta* (bastard hawkweed), and *Tragopogon graminifolius* (Goat′s beard) with 30.25, 25.56, and 22.16 RD (Relative Dominance), respectively were classified as the dominance and the most important weed species in Tabriz alfalfa fields. Different indices have been used for weed species ranking in weed studies. Indices such as relative abundance (RA) and abundance index (AI) for weed species are more effective in weed surveys, but both of them have some shortcomings. The objective of this study was to improve the RA and AI indices and introducing of Relative Dominance (RD) for weed species ranking in weed communities. In RD method, we used four quantitative measures including relative frequency, relative uniformity, relative density, and relative coverage. The frequency value was the percentage of fields infested by a species k, at least in one quadrate per field. The field Uniformity value indicates the percentage of quadrates infested by one species. The density value was calculated as the mean number of plant per square meter for each weed species, expressed over all fields surveyed. The cover percentage value indicates the vertical projection on the ground, based on visual estimates. In RA, the mean density had a significant role and in AI, the frequency and uniformity had a higher value than the mean field density. In both of them, the role of vegetation cover percentage has been taken in to consideration. In weed flora surveys, in case of some parasitic weeds like Cuscuta sp. (dodder), perennial rhizomatous weeds like *Convolvulus arvensis* (bindweed), *Cynodon dactylon* (bermudagrass), *Sorghum halepense* (johnsongrass) and etc, winter weeds compare with summer weeds, and Grasse weeds compare with broadleaf weeds, only the density calculation could not be sufficient. By adding vegetation coverage to RA we suggested RD for weed species ranking in weed flora surveys.

Spontaneous vegetation (weed) management as an alternative to tillage in ornamental cherry orchards: effects on soil compaction

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Frequent mechanical tillage is a common practice in some orchards of the Mediterranean area. It is particularly effective for two reasons: it reduces soil compaction and it prevents weed competition. But it has also been demonstrated that leaving spontaneous cover in the interrows can provide multiple benefits. In this communication we compare the effects of mechanical tillage and spontaneous vegetation cover on soil compaction in a cherry orchard. Our work was done in an ornamental cherry orchard located at Torre Marimon (Caldes de Montbui, Barcelona, Spain; 31T 430962 m E and 4606707 m N 159 m asl) on an alluvial terrace with an Inceptisol (probably *Xerochrept*) that contains many rock fragments. Trees were planted in a 4x4m frame. Before 2011 regular mechanical tillage was done in the interrows, but as of February 2011 two treatments were considered at random: mechanical tillage (T) and no tillage (NT). T was done four times per year using a mouldboard plough (30 cm depth). In NT plots the only operation performed was mowing when weeds were 30 cm tall. To evaluate the soil compaction a lightweight dynamic penetrometer (PANDA2) fitted with a 2 cm^2 cone area was used in two campaigns with different soil water content: July 2011 – dry soil conditions (13-14% daily soil water in NT at 25 cm depth), May 2012 – wet soil conditions (18-20% daily soil water in NT at 25 cm depth). Values of CID (mean Cone Index value at inverse depth) were obtained by testing the first 40 cm of soil profile in the middle of the interrows. A total of 24 penetration tests were performed, giving 6 replicates for each combination of effects. Analysis of variance and mean separation of the parameter CID previously transformed (natural logarithm+1) was performed considering the tillage effect, soil water condition and the interaction between these two effects. The species composition and total cover of spontaneous vegetation were evaluated using six permanent quadrats (0.25 m^2) in 2011 (April to November). In the interrows of the orchard there were no significant differences in mean CID in the 40 cm topsoil between T (1.45 MPa mm^{-1} SEM 0.07) and NT (1.45 MPa mm^{-1} SEM 0.08). Soil water content was a significant factor (1.86 MPa mm^{-1} SEM 0.06 in dry conditions and 0.26 MPa mm^{-1} SEM 0.02 in wet conditions). The interaction between these two factors was not significant ($p>0.05$). During the period April-November 2011, we identified 35 species (19 botanical families). The mean cover percentage reached a maximum of 70.00% (July) and fluctuated throughout 2011 from 23.75% in April to 18.42%

in November. Preliminary results obtained for a period of a little more than a year show that tillage did not improve significantly the mechanical soil conditions in the first 40 cm of stony soil with respect to the no tillage management. Weeds can be useful to maintain a herbaceous cover that did not increase the topsoil compaction comparatively. Particularly in irrigated ornamental orchards, this situation could allow a major reduction in economic and environmental costs.

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Mapping of invasive weed species on the territory of the urban areas

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Systematic monitoring and control of invasive weeds is of high significance for agricultural production, as well as for protection of endangered biodiversity and environment in whole. During several last decades, some sporadically occurring, or entirely new weed species took increasingly more important role in the region; more than a half century ago in such a manner, *Ambrosia artemisiifolia* L. also occurred for the first time on the territory of the Former Republic of Yugoslavia, and nowadays it is frequently occurring species that has become serious ecological threat also for Novi Sad. Studies performed in the period 2008-2012, on over 400 ha of non-agricultural and ruderal sites of the City of Novi Sad, revealed presence of *A.artemisiifolia* on over 200 locations in 21 city zones. The highest determined abundance was 50 plants per m^2. On the territory of Autonomous Province of Vojvodina, northern region of the Republic of Serbia, among invasive weeds were found several ruderal weed species, threatening agricultural production, human and animal health and the environment in general. Mapping of invasive species in urban environments was performed by GPS, and data were inserted into software program Ambrosia Spot Marker for the region of the municipality of Novi Sad, while mapping data for the territory of AP Vojvodina were inserted into program Google Earth. The greatest economic significance have ruderal weed species *Sorghum halepense* (L.) Pers, *Rumex crispus* L., *Carduus acanthoides* L., *Conyza canadensis* L., *Urtica dioica* L., *Chenopodium album* L., *Rubus caesius* L., *Arctium lappa* L., and established invasive weed species *Ambrosia artemisiifolia* L., *Asclepias syriaca* L., *Iva xanthofolia* L., *Artemisia vulgaris* L., *Amaranthus retroflexus* L. and *Cuscuta campestris* Yunkers Abundance and coverage were determined by the method of Braun-Blanquet (1951). Established coverage of invasive weed species was within a range of 30-95%. Presence level marked 5 was established for *A. artemisiifolia* L. in municipalities Sombor, Odžaci and Novi Sad, and *A. vulgaris* L. in Sombor, Odžaci and Šid. Presence level marked 4 was found in 7 municipalities for weed species *A. vulgaris* L. and *R. crispus* L. Data processing revealed presence level marked 1 was found for species *A. artemisiifolia* L. in municipality Zrenjanin, *A. retroflexus* L. in municipalities Kula, Sombor,

Ruma, and Šid, *A. syriaca* L. in municipalities Kikinda, Vrbas, Kula, Sremska Mitrovica, and Novi Sad, while *C. campestris* Yunkers was established in even 7 municipalities, i.e. Kikinda, Sombor, Odžaci, Sremska Mitrovica, Šid, Bačka Palanka, and Novi Sad was marked with the presence level 1.

Identifying the traits in cereals that confer greater suppressive ability against *Alopecurus myosuroides* (Huds.)

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Herbicide resistance is increasing, no new modes of action are available and there is political and public pressure to reduce pesticide use. Many cultural control methods may be utilised to manage weeds. Cereal cultivars have been demonstrated to differ in their ability to compete with weeds, but this has seen limited application in commercial agriculture. Understanding how plant traits contribute to suppressive ability will allow predictions to be made for new cultivars, before they are commercialised, so that farmers may include them in their weed management strategies. The aim of this project is to establish which cereal traits contribute to the suppression of *Alopecurus myosuroides*, and if there is a yield penalty imposed by these traits in weed free situations. These traits can be used to devise a screening protocol, to rank cultivars for competitive ability and make this information available to farmers.

Fifteen cultivars of wheat, two barley cultivars and one oat cultivar were assessed for their ability to suppress *A. myosuroides*. These cultivars were grown in containers in competition with *A. myosuroides* (density 281 m^{-1} and 78 m^{-1} respectively) at Rothamsted Research, UK. *A. myosuroides* seed return and biomass were measured in June and July 2012 respectively. Ecophysiological traits (including specific leaf area, leaf area ratio and relative growth rate) of the crop during the first six weeks of growth were quantified through destructive sampling. Height, tiller number and height/width ratio were measured throughout the growing season, and flag leaf measurements taken during flowering. Thousand grain weight was also measured. Two-sided correlations were used to search for relationships between cultivar traits and *A. myosuroides* seed return and biomass.

The trait with the most statistically significant impact on *A. myosuroides* final biomass and seed return was cereal seedling height a month after emergence ($P=0.0016$; $P<0.001$). Longer flag leaves at GS65 ($P=0.0016$; $P=0.0055$), higher rate of tillering ($P=0.001$; $P=0.0019$), and green area a month after emergence ($P=0.0051$; $P=0.0364$) all relate to decreased *A. myosuroides* biomass and seed production, respectively. Final cultivar height was important for suppressing seed production ($P=0.0379$), but not in suppressing biomass production. Higher SLA in the first month following emergence corresponded to increased suppression when wheat cultivars were analysed separately ($P=0.0196$).

The study has revealed traits that may be used to develop a protocol to quickly and easily rank cultivars on their suppressive ability. Further work is required to establish if the relationships observed in this experiment exist in the field, and are consistent across seasons. Wheat will be the focus of this continuing work.

Factors determining the species composition of summer arable weed vegetation in Hungary, with particular focus on sunflower fields

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Weed vegetation in arable land is governed by several management and environmental factors, and assessing the importance of these variables could help to understand the assembly rules of weed communities and might be useful in planning weed management strategies.
The abundance of late-summer weed flora and 25 environmental, management and site context factors were measured in 243 maize, sunflower and stubble fields representing the whole territory of Hungary. Data were analysed by redundancy analysis (RDA) after backward variable selection.
The net effects of 24 variables on species composition were significant. Most variation in species composition was explained by plot location, which was followed by temperature, crop type, precipitation, soil texture, neighbouring habitat, altitude, soil pH, Na and K content of the soil. Variation partitioning revealed that environmental variables accounted for twice more variance than management variables, but the relative impact of management variables was larger in field cores than in field edges. Our results suggest that even for intensified agriculture the effects of environmental factors are of greater importance than management factors on summer arable weed composition in a country-wide context.
In order to determine the importance of specific management factors related to sunflower cultivation, a complementary analysis only addressing sunflower fields was also conducted. This analysis resulted in five significant variables: soil Mg and Ca content, preceding crop, temperature, and field size. The remarkable share of environmental factors on the variation on species composition suggests that the success of agro-technical treatments in sunflower fields is highly dependent on a complex of edaphic and climatic constraints.

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Weed survey of poppy (*Papaver somniferum*) fields in Hungary

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In Hungary, poppy is either used as a pharmaceutical crop or a food crop and the production target strongly determines every aspect of the cultivation and accordingly it influences the weed species composition as well.
Two Hungarian poppy trading companies and several contract providers were asked to identify poppy growing farmers. Each farmer was mailed and telephoned to ask whether they would permit access into their fields and consent to being interviewed about management factors. We generally surveyed only one poppy field from each farmer willing to co-operate. Two fields from the same farmer were investigated only if they differed in major management factors. This resulted in a set of 102 arable fields across the poppy-growing districts of Hungary. Weed vegetation was sampled in the fields in four randomly selected 50-m^2 plots between 30 May and 14 June 2010. Percentage ground cover of plant species in the plots was estimated visually. Weed species were ranked according to their mean cover values. Altogether, 173 weed species were recorded. In spring-sown alkaloid poppy the most abundant species and their mean cover values were: *Papaver rhoeas* (3.2%), *Fallopia convolvulus* (2.43%), *Chenopodium album* (2.25%), *Polygonum aviculare* (2.12%), *Echinochloa crus-galli* (1.58%), *Ambrosia artemisiifolia* (1.36%) and *Sonchus asper* (0.8%). In autumn-sown food poppy fields the most abundant species and their mean cover values were: *Papaver rhoeas* (5.82%), *Descurainia sophia* (1.56%), *Fallopia convolvulus* (1.26%), *Convolvulus arvensis* (1.03%), *Consolida regalis* (0.93%), *Galium aparine* (0.9%), *Polygonum aviculare* (0.89%) and *Tripleurospermum inodorum* (0.89%). The most important plant families were: Papaveraceae, Polygonaceae, Poaceae and Asteraceae. The largest proportion of the total weed cover was due to spring-germinating summer annuals in alkaloid, while autumn-germinating winter annuals in food poppy fields.
According to both published literature data and the results of this study, the most abundant weed species is *Papaver rhoeas*, both in food and alkaloid poppy. The fact that weed and crop species belong to the same plant family, result in a very low efficiency of chemical control.

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The presence of weed species in the regeneration of common oak (*Quercus robur* L.) forests

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The presence of weeds and a large number of shrubby species per area unit is a basic limiting factor for survival and rejuvenation of common oak. Weeds can compete with trees, especially young ones, for sunlight and ground water and nutrients required for the growth and development of the common oak. However, in terms of competition all weeds are not of equal importance in regard to cultivated plants. From the aspect of control, the perennial weeds, which are difficult to control mechanically present much bigger problem. Thus it was necessary to study the weed flora composition aimed at applying appropriate control measures. The study was carried out during the period 2007-2009 at three localities: Vinichna (44^0 55' 39,85''N, 19^0 6' 30,39''E), Naklo (44^0 57' 34,40''N, 19^0 20' 48,74''E) and Varadin (44^0 56' 43,74''N, 19^0 15' 48,97''E) which are located in the areas of Ravni Srem. Four trial plots 10 x 10 m^2 in size were set at each locality. Within them, five subplots of 1x1m^2 randomly chosen were set, and used for the study of weed flora. Data on the presence and abundance of weed species were obtained by sampling the plant material during spring and summer. Based on the studies, which included collection, herbarisation and determination of plant material, the plant species of the most common families and the plant life forms were identified in the localities mentioned above. The greatest number of plant species was determined in Varadin (the total of 24), and Vinichna (23 species). The locality of Naklo revealed the presence of 17 weed species. A total of 38 plant species was classified into 20 families. The greatest number of species belonged to family *Asteraceae*. In the first year of investigation the most abundant species found in Naklo were: *Sonchus arvensis* L., *Ambrosia artemisiifolia* L. and *Chenopodium polyspermum* L., whereas in the second and the third year the species *Sonchus arvensis* L. *Ambrosia artemisiifolia* L., *Erigeron canadensis* L. and *Stenactis annua* (L.) Nees were similarly abundant. Dominant species found in Varadin in the first year of investigation were *Ranunculus ficaria* L.*, Ambrosia artemisiifolia* L. and *Solanum nigrum* L., whereas in the second and the third year the species *Ambrosia artemisiifolia* L., *Stenactis annua* (L.) Nees. and *Erigeron canadensis* L. were similarly dominant. The following species were abundant in Vinična in the first year of investigation: *Polygonum lapathifolium* L.*, Solanum nigrum* L., *Sonchus arvensis* L. and *Sorghum halepense* (L.) Per. In the second year the species *Stenactis annua* (L.) Nees.*, Sorghum halepense* (L.) Pers. and *Ambrosia artemisiifolia* L. stood out in terms of abundance, and in the third year this was true for *Stenactis annua* (L.) Nees. and *Sorghum halepense* (L.) Pers., and abundance of *Symphitum officinale* L. and *Setaria viridis* (L.) P.B was also observed. The analysis of the life-forms confirmed the

dominant presence of therophytes in Naklo and Varadin localities, whereas in Vinichna the most abundant were hemicryptophyte. Abundance of weed species during the first years of oak development could significantly limit the development of young trees. Since the initial stages of development of young oak trees were crucial for the process of area regeneration, the mechanical and chemical control measures were applied for weed control.

Weed species composition in maize fields of Northern Germany

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Over the last decade, the acreage sown to maize increased rapidly in in Germany. Breeding created more cold tolerant varieties, which allowed cultivation to expand northward. In recent years, the German policy for biomass based renewable energy strongly reinforced this trend.
We monitored and analyzed the response of the concomitant weed population, in terms of species composition, in maize fields to this ongoing development. In northern Germany four regions were defined on a gradient from West to East, creating a climatic gradient ranging from more maritime to more continental. We expected to find a response of weed assembly to this gradient.
In 2011 and 2012, data were collected from unsprayed plots within approximately 40 maize fields per region. Per plot, weeds were counted and identified in ten randomly assigned quadrats (0.1 m²). A distinction was made between "old" and "new" maize fields depending on how long ago maize had been included in the crop rotation.
The multidimensional scaling (MDS) with Bray-Curtis distance was used to analyse the weed assembly. Differences of weed density and number of species between regions were described by generalized linear models. All statistical analyses are done with R.
Results of MDS and GLM are presented.

Anthriscus sylvestris – biology, control and people's perception of cultural landscapes

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Anthriscus sylvestris is a monocarpic perennial herb, and has in recent years increased in abundance on nutrient rich road verges, less intensively managed areas and grassland. It dominates the landscape, especially visible during flowering. *A. sylvestris* propagates by a balance between vegetative and generative reproduction, which makes it difficult to control. In a four-year (2010-2013) multidisciplinary project we study biology and control measures of *A. sylvestris* and peoples' perception of their cultural landscape. Here some preliminary results are presented.

Two pot experiments were conducted in 2011 in spring (greenhouse, Ithaca, NY, USA) and outdoors in June, July and August (Tromsø, Norway). The taproot was cut into 1, 2, 4 or 8 cm lengths from upper, medium and lower parts of the root (Ithaca) or the root was divided into upper 4 cm and the lower part, and including also intact roots (Tromsø). Root fragments were buried at 2, 8 and 17 cm soil depth. Sprouting/no sprouting was noted and analysed as binary response variable with 'proc glimmix' (SAS) with root parts, burial depth and time (Tromsø) as factors. Only root fragments including the upper 4-5 cm sprouted, but less so with increasing burial depth.

A demonstration trial with randomised complete block design and 2 replicates on an area infested with *A. sylvestris* was established in 2010 in Sandstrand, Northern Norway. Treatments with cutting (early+late summer 5 cm height, at full bloom 5 or 70 cm or at seed set in late summer 5 cm height), mecoprop-P (2.7 kg a.i. ha^{-1}, applied with a backpack sprayer, spray volume 250-300 L ha^{-1}, nozzle pressure 2-3 bar, in early or late summer (+cut in early summer)), and untreated control in 2010 and 2011. Percentage biomass of *A. sylvestris* and other species were visually estimated, and seedlings, small and large rosettes of *A. sylvestris* were counted in 4 x 1.0 m^2 squares in each plot in June 2012. The results were analysed with analysis of variance and Tukey test, $P<0.05$.The results showed that 1-2 cuts did not reduce biomass of *A. sylvestris*. Mecoprop-P effectively controlled the species and especially the number of small and large rosettes was reduced. Treatment with cutting of flowers (70 cm height) greatly reduced the number of seedlings (not significant), but not small or large rosettes.

In Vadsø and Herøy qualitative interviews were conducted on how actors such as farmers, tourist entrepreneurs and agents of public management, make use of, under-stand and perceive the landscape. The cultural landscape is a crucial element of people's perception of place. People and landscapes are closely interwoven through practices, and landscape is

part of the dynamic processes of rural transformations. The valued landscape is the traditional, open grazed land, which is disconnected from today's farming practices.
To conclude, these results indicate that removal of the upper 4-5 cm of the root or the herbicide mecoprop-P could effectively control *A. sylvestris*. For people, *A. sylvestris* seems to symbolize a degradation of the cultural landscape.

Occurrence of weeds in crop rotation experiments combining annual energy crops at two sites in Germany

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In Germany classical annual field crops like cereals, oilseed rape and maize increased in the cropped acreages due to their possibility to use them for energy production. However, these crops are mainly grown by specialised farms and thus are in practice usually not combined in rotations. This counts especially for oilseed rape and maize.
A crop rotation experiment was established 2008 resp. 2009 on two sites in Germany. One site is in the North close to the Baltic Sea (Rostock) in a coastal climate on a sandy soil, while the other is close to the centre of Germany (Göttingen) on a very fertile soil and in a more continental climate. Four different crop rotations of maize, winter oilseed rape (OSR) and winter wheat (WW) are investigated. Rotations include three ranks of percentage of OSR and maize in the rotation. Each crop is cultivated each year at both sides. Four treatments of crop protection run over all rotations. In two treatments seeds of selected weed species (*Amaranthus retroflexus* (L.), *Anchusa arvensis* (L.) M.Bieb., *Echinochloa crus-galli* (L.), *Galium aparine* (L.), *Geranium pusillum* (L.), *Sisymbrium officinale* (L.), *Solanum nigrum* (L.), *Stellaria media* (L.) Vill., *Viola arvensis* Murray) were sown in the starting years of the experiments. Design is a split-plot with four replications. Weed species and weed densities were determined in spring and autumn in ten repeated measurements per plot. Observations were carried out before any herbicide application. Data about the first 3 resp. 4 years are analyzed for weed species and densities concerning the crops and their rotations. Special emphasis is given to the establishment of the sown weed species. Weed densities among crop rotations as well as densities of sown weed species were evaluated statistically with non-parametric Kruskal-Wallis test by using R software (package agricolae) separately for each study site.
The examination indicated a significant disparity between weed infestation in crop rotation composing of OSR - WW and such with different ranks of maize for the site Rostock. Moreover, three of nine sown weed species (*Geranium pusillum, Stellaria media, Viola arvensis*) have been established. High weed densities occurred in rotations containing OSR and WW. Regarding the second study site, analyses revealed a significant difference between weed infestation in monoculture maize and all other crop rotations. Furthermore, *Geranium pusillum, Solanum nigrum* and *Stellaria media* have been established locally. Thereby occurrence of high weed densities of *Geranium pusillum* and *Stellaria media* were restricted to crop rotations containing OSR whereas high weed infestation of *Solanum nigrum* occurred in all crop rotations comprising maize.

Evaluating of irrigation levels on species richness on corn (*Zea mays* L.) field

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In order to study the different levels of irrigation on diversity, density and compound of weed species in corn field, experiment was conducted at Ferdowsi University of Mashhad Research Field (36° 15′latitude, 59° 28′ longitude and 985 m elevation). The experiment was based on interval mapping with four levels of irrigation (6130, 7290, 8800 and 12330 $.m^{-3}$) and four levels of weed control (complete control, broad-leaves control, grasses control and without control). Weed sampling was done at 4 stages including first, meddle and end of critical period weed control and harvest then all species counted species separate. The results showed that in different levels of irrigation the weed species were different. At the first time of critical period, the most diversity was in 8800 and 7290 m^{-3} and the minimum diversity was in 12330 and 6130 m^{-3} irrigation levels. At the harvest time, the most diversity was in 12330 and 6130 and 8800 m^{-3} irrigation levels respectively and least diversity within different indexes were in 7290, 8800 and 6130 m^{-3} irrigation levels respectively. Stability index changed at different levels of irrigation. In addition, Maximum when the irrigation level was in minimum level, however, highest level of irrigation caused the maximum Unstability of species but levels of irrigation had no significant on dominance Index.

Abundance development of four *Senecio* species on low-input grassland in Germany

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Recently there have been many reports on the increasing incidence and spread of common ragwort (*Senecio jaobaea*) and other ragwort species in Germany. Hypothetically, some types of ragwort have a high potential as pioneer plants to establish themselves and propagate on spotty grassland canopies or grassland canopies which are not under plant cover. The competitive abilities in conventional grassland are considered low. To test this hypothesis a field trial at each of two grassland areas of the Julius Kühn-Institut in Braunschweig was initiated. Both areas were extensively farmed and mowed once or at the most twice a year. The two areas, both loamy sand, showed different site characteristics. Trial site one in an exposed position can be regarded as a dry location. Trial site two in the shade of trees had a more humid microclimate. Four Senecio species were planted in 5m^2 plots. The Senecio species were *Senecio aquaticus*, *Senecio erucifolius*, *Senecio inaequidens* und *Senecio jacobaea.* The experimental design was a randomized complete block design with four replicates. A second parameter of the experiment was the frequency of mowing (once or twice). At regular intervals the number and the development of the *Senecio*-plants was determined. After two years, there was a significant difference in the decline of plant numbers between the species. On both trial sites the number of *Senecio jacobeae* plants had decreased by about 50%. *Sencecio aquaticus* with a volume of 10%, *Senecio erucifolius* with 40% and *Senecio inaeaquidens* with 1% of the originally planted plants could be found only on one trial site. At both trial sites, no new emergence of *Senecio* plants was observed despite copious seed shedding by *Senecio* plants which reached seed maturity and many remaining seeds at the trial sites. Until now, all four tested *Senecio* species have been weakly competitive, and even in low-input farming with no fertilizer and mowing only once, these did not exhibit a capacity for spreading.

The effects of row width and plant population on weed control in oilseed rape

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Control of weeds in oilseed rape in the UK has always been challenging. The crop is often established following minimal or no cultivation and seedbeds can be rough with high levels of trash. Many of the available herbicides need to be applied pre-emergence when the seedbed is often dry. Two frequently used herbicides, propyzamide and carbetamide are key for the control of *Alopecurus myosuroides* Huds. in a rotation as there is no known resistance to these herbicides in the UK, but these, and metazachlor, are found regularly in watercourses. If these herbicides are withdrawn due to changes in European legislation this challenge will become greater.

Establishment of oilseed rape in wide rows (greater than 30 cm) is becoming increasingly common. The introduction of wide rows can reduce the level of crop competition leading to a greater number of weeds between the rows but conversely reducing the degree of soil movement on a greater proportion of the seedbed can lead to fewer weeds.

Two trials were done in each of 2 years (2009-2012), there were two herbicide treatments, a full herbicide programme and no herbicide, with four plant populations (15, 30, 60 and 120 plants/m²) and four row widths (12, 24, 48 and 72 cm). The experiment was done as a split plot design with the herbicide treatments as main plots and the row width and seed rate as sub plots in a two way factorial. Assessments of plant population, grass and broad-leaved weed populations, light interception by the canopy, lodging and yield were made. Data was analysed by ANOVA.

Alopecurus myosuroides, *papaver rhoeas*, *stellaria media*, *veronica*, *hederifolia* and volunteer winter wheat were recorded in the trials. These weeds are commonly found in UK oilseed rape crops. Consistently grass and broad-leaved weed populations were higher where oilseed rape populations were low. Increasing the seed rate from 30 seeds sown/m² to 120 seeds sown/m² reduced A. myosuroides populations by 41% and S. media by 28% at a single site. Increasing row width from 12cm to 72cm generally had no effect on weed populations.

Determination of important weed species, their distributions and densities in grasslands of Trabzon province, Turkey

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This study was carried out to determination important weed species, the available frequency, common covering and density of weeds in grasslands of Trabzon province in 2008-2009. Surveys were conducted in 214 sampling areas belong to 80 grasslands of Trabzon province (central district, Akçaabat, Araklı, Çaykara, Dernekpazarı, Hayrat, Köprübaşı, Maçka, Sürmene, Tonya, Vakfıkebir and Yomra). The random sampling was made according to representing at least 1% of the areas of grassland. 1/4 m^2 were taken in a sampling area at least 20 times. The weeds within the frame were counted, the frequency, common covering and density of weeds were determinated.
Sixty weed species and forty eight genus belong to Twenty four families (1 Pteridophyta, 4 Monocotyledonae, 19 Dicotyledonae) were identifield in the grasslands surveyed. The most commonly found families were Asteraceae (10 species), Apiaceae (6 species), Lamiaceae (6 species), Scrophulariaceae (5 species), Liliaceae (4 species) ve Polygonaceae (3 species). The most common weed species were *Alchemilla pseudocartalinica* Juz., *Pteridium aquilinum* (L.) Kuhn, *Euphorbia oblongifolia* C. Koch, *Veratrum album* L., *Silene vulgaris* (Moench) Garcke, *Digitalis ferruginea* L., *Hypericum perforatum* L., *Conium maculatum* L. and *Alchemilla orduensis* B . Pawl. in pasture areas surveyed.

Changes in arable weed communities in Switzerland

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Arable weeds are among the species richest and most threatened ecological plant groups in Switzerland. This can be ascribed to agricultural intensification. Due to their adaptation to crops and farming practices arable weeds need very specific concepts for promotion; classical nature protection areas cannot be effective.
The vegetation database of the research station Agroscope Reckenholz-Tänikon (ART) offers a unique opportunity to study changes in the arable weed population over the last 90 years and it will be the base for identifying criteria and proposing of arable weed promotion areas and farms
In the years 2011 and 2012 we revisited 520 of these arable-land locations. On the 232 fields where the current crop type corresponded with the historical one, we recorded all plant species and estimated their abundance according to Braun-Blanquet. Relevés were made on 100m^2 in the field centre. Additionally species in the field border were recorded.
In the historic sampling period 297 species were found. The total species number of recent fields is 214. Overall species richness had not changed considerably but the mean number of species per field had declined by 65 % from 22.6 to 7.9 species. But the decline in the average number of species differs between the biogeographic regions. today the percentage of grassy weeds on the total number of species is higher than 90 years ago.

Temporary grasslands as an agroecological way to regulate weed abundance and diversity

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The aim of this work is to analyze how the insertion of temporary grasslands into cereal-based rotations may affect weed abundance and diversity. Three levels of statistical analyses (α diversity, β diversity and functional diversity) are carried out in order to understand the weed community composition changes in crops and temporary grasslands.
Weed flora observations are realized in the long-term experiment SOERE–ACBB (Observatory and Experimental System for Environmental Research - Agroecosystems, Biogeochemical Cycles, and Biodiversity) at the INRA research centre of Lusignan in western France. Five treatments are differentiated by duration (0, 3, 6 and 20 years) and nitrogen fertilization (low or high) of grasslands in cereal-based rotations (maize/wheat/barley). Weed flora is observed at least once a year. Species richness (S), abundance (A), and diversity indexes, namely Shannon (H) and Piélou (J) indexes, were computed from weed flora data in crops and grasslands.
Crops have low weed abundance (because of weeding) but quite high α diversity (especially in spring crops). A, S and H decrease with grassland age in high N grasslands whereas they remain stable in low N grasslands. Weed community composition greatly differs between groups, in particular between low and high N grasslands. Indicator species analysis (ISA) allows identifying species and functional groups specific to each group. Perennial species benefit from the particular growth conditions in temporary grasslands. On the other hand, the conditions in annual crops favor annual broad-leaved species with an upright morphology. The legumes increase in grasslands with low nitrogen fertilization
These results highlight two main effects of temporary grasslands on weed community. Firstly, temporary grasslands allow reducing weed abundance to values similar to those in crops in which chemical weeding is applied. Secondly, low N grasslands present higher species richness and functional diversity that may be interesting to support biodiversity in crop fields. Hence, this study demonstrates that inserting temporary grasslands is a promising agroecological way to regulate weeds in cropping systems.

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Spatial distribution of weed communities in maize crops in Central Spain

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This study describes the spatial distribution patterns of seven species considered among the major weeds in maize crops in Central Spain. In addition, spatial association among weed species was also analysed. Visual assessments of the density of *Abutilon theophrasti*, *Amaranthus* spp., *Cyperus rotundus*, *Datura ferox*, *Solanum nigrum*, *Sorghum halepense* and *Xanthium strumarium* were conducted on photographic images. The images were taken on the inter-row area when maize was at the 4- to 6-leaves stage, each image covering 0.375 m^2 (0.75 m × 0.50 m). A total of 1,148 digital images were acquired contiguously so that the entire surface was sampled.
The results showed aggregated patterns with varying intensity in all weed species. Furthermore, we found populations spatially dissociated, such as *X. strumarium* with both *Amaranthus* spp. and *S. halepense*. Similarly, *A. theophrasti* was negatively correlated with both *Datura* spp. and *C. rotundus*. In contrast, other populations as *X. strumarium* and *A. theophrasti* were positively associated, *i.e.* sharing the same locations. This information is useful to compare the reduction of herbicide spraying with different strategies in the context of site-specific weed treatments. For example, we can calculate the savings of herbicides when applied separately at the patches of grasses and dicots with respect to when applying a mixture of herbicides in all patches without distinction.

Weed seed predation in cereals as influenced by density and farming system

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Seed predation can influence weed population dynamics. It can reduce future seedling emergence substantially. Little is known about how seed predation rates are influenced by size and food quality of weed patches. Seed predation will be most effective if seed predation rate increases with weed seed density.
In 2008 and 2009, experiments were conducted on four conventionally managed cereal fields in both North Germany (Mecklenburg-Vorpommern; MV) (54˚ N, 12˚ E) and Northeast Spain (NES) (42˚ N, 1˚ E). In MV the average temperature is 8.4˚C and annual precipitation 591 mm and in NES 14.7°C and 369 mm. In NES, farmers irrigated at 3-weekly interval in the experimental area. *Lolium multiflorum* Lam. seeds (4.22 ±0.03 mg seed^{-1}; mean ± SE) were exposed to seed predators either on seed cards or scattered on the soil surface in metal frames. Exclosure cages were used to distinguish between vertebrate and invertebrate predation.
In MV, the level of seed predation was low (32.7%). Granivorous rodents and carabids both responded directly density-dependent, although for carabids the relationship was not statistically significant. In NES, seed predation by carabids was negligible, but rodent seed predation rates were high (91.9%). Rates decreased slightly with increasing seed density, probably due to saturation. However, the level of predation was so high that, irrespective of the type of response, hardly any seeds will enter the seed bank, resulting in exhaustion of the seed bank and reduced seedling densities in subsequent seasons.
In an attempt to explain the low level of seed predation in MV, the effect of crop management type and location within the field on seed predation rates was investigated on three conventional and three organic fields in 2011. We hypothesized that organic crop management and close proximity to field edge vegetation would favour seed predation. Predation rates were low (33.9%) again. However, organic management and a close proximity to the field edge did not enhance predation rates. Other factors, such as landscape complexity, tillage intensity or quality and quantity of field edge vegetation, could possibly explain the difference in predation level between MV and NES. This needs to be further investigated.

Determination of weed seed contamination of wheat grain

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Weeds are the most important yield constraint causing an approximately 30-50% reduction in wheat yield. The weed seeds mixed in wheat seeds makes the wheat grains poisonous and also contaminate the other fields. We aimed to identify the weeds seeds that mix with wheat plants harvested from the wheat areas of Aydın Province of Turkey.
In this study, 65 samples in 2005 and 78 samples in 2006 (a total of 143 samples) of wheat grain were collected from different grain stores located all over the Province to record the wheat grains contamination with weed seeds in Aydın, Turkey. Samples collected from the different grain stores were used to identify and quantify the contaminating weed seeds. *Secale cereale* was not consider a weed in 2005 and vice versa in 2006. Identified weed seeds were quantified as number and weight (g) per 1000 g of wheat grain.
The results indicated that 28 weed species belonging to 11 different families were identified. The identified families were Poaceae (7 species), Brassicaceae (5), Asteraceae (4), Fabaceae and Apiaceae (3 each) and Convolvulaceae, Rubiaceae, Malvaceae, Papaveraceae, Ranunculaceae and Polygonaceae (1 each). The *Melilotus officinalis* was the most contaminating weed species in both the years. In 2005, the number of weed seeds for *M. officinalis, Lolium* spp., *Vicia* spp., *Galium tricornutum, Ranunculus arvensis, Phalaris minor, Convolvulus arvensis* and *Sinapis arvensis* were 191.3, 62.0, 47.6, 34.7, 23.5, 18.1, 17.8 and 15.8 respectively, per 1000 g of wheat grains. In 2006, the number of weed seeds for *M. officinalis*, *Secale cereale, P. minor, S. arvensis, R. arvensis, G. tricornutum* and *Vicia* spp. were 690, 78.7, 78.1, 47.6, 32.3, 13.2 and 10.5 respectively, per 1000 g of wheat grains. In 2005, the seeds weights of the *Vicia* spp., *G. tricornutum* and *M. officinalis* were 1.72 g, 0.46 g, and 0.40 g respectively, per 1000 g wheat grains. Likewise, in 2006, *S. cereale*, *M. officinalis* and *Vicia* spp. were 3.66 g, 1.08 g and 0.36 respectively, per 1000 g of wheat grains. Comparison of the weed species present in the wheat field and the weeds species contaminating the wheat seeds indicated that the all of the prevailing weed species do not contaminate the wheat seeds. Out of the total 90 weed species under the field conditions, seeds of 28 weed species were contaminating wheat grains. Several phenomena can explain this observation. For example, the *Alopecurus myosuroides* weed grows to maturity well before wheat and drops its seeds before the wheat harvest and hence does not contaminate the wheat grains. Similarly, the *Avena* spp. and some other weeds also drop their seeds before the wheat harvest.
The results suggest that the wheat seeds contamination with numerous weed species (e.g. 28 weed species contaminating wheat grains in our studies) can accelarate the weed dispersal process especially at the farms where farmers do not use a certified seed or selector.

Changing agricultural practices modifies the species and trait composition of the weed flora: A simulation study using a cropping system model

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Cropping systems change over time to adapt to socio-economical and environmental constraints and to profit from technological innovations. These changes can result in unexpected side-effects which are difficult to determine in fields. The objective of the present study was to use a cropping system model to evaluate the impacts of modified agricultural practices *ex ante* on weeds.

The FLORSYS model quantifies the effect of crop succession, management techniques and climate on multi-specific weed dynamics over the years; it was parameterized with functional relationships predicting model parameters (e.g. pre-emergent seedling mortality) from species traits (e.g. seed mass). Cropping systems typical of three French regions were determined from farm surveys and the Biovigilance data base. These control scenarios as well as various management modifications were simulated in each region, using a weed flora consisting of sixteen major weed species. Each scenario was simulated over 27 years and repeated 10 times, by randomly choosing each year annual climate series measured in the tested region.

The control and prospective scenarios were analysed for their total weed density and their species compositions, showing for instance that the weed flora was more diverse in the longer Burgundy (oilseed rape / winter wheat / winter barley, with mouldboard ploughing every three years) and Poitou-Charentes rotations (OSR / winter wheat / sunflower / winter wheat, with ploughing three years out of four) than in the Aquitaine maize monoculture. Modifying management practices modified both weed density and composition. For instance, simplifying or abandoning tillage greatly increased weed infestation. If it was moreover accompanied by earlier sowing, infestations increased even more, but only when autumnal weed species dominated. Introducing temporary crops before spring crops (as required by recent French regulations) reduced densities, particularly in autumnal weeds. Simplifying the three-year Burgundy rotation to a two-year oilseed rape/wheat increased weed densities, particularly when mouldboard ploughing was also abandoned. Conversely, diversifying rotations decreased densities in Burgundy (addition of a spring pea) and, particularly, in Aquitaine (maize monoculture changed to a four-year rotation). Abandoning ploughing though still increased densities.

Some cultural changes (e.g. no-till) greatly changed weed flora composition. To understand these changes, the relationships between management practices and weed species traits were studied with RLQ and fourth-corner analyses. Longer rotations were thus shown to select weed species with elongated/flattened seeds (which present little dormancy) and long emergence periods. These species are able to emergence in crops irrespective of their

sowing date. Conversely, rotations with late-sown crops (i.e. spring crops or late-sown autumn crops) favoured species with round seeds which are more dormant, thus reducing germination prior to crop sowing. Frequent mouldboard ploughing selected species with thick-coated seeds which are also those least prone to mortality. Ploughing also favoured species with low-lipidic seeds which germinate later and more slowly. Both consequences, low mortality and reduced germination, improve seed survival after burial by ploughing until a further ploughing moves seeds again closer to soil surface where emergence is possible. More generally, frequent tillage favoured monocotyledonous species and species with a late and short emergence period, thus limiting fatal germination triggered by early tillage. Glyphosate before sowing in direct-drilled fields selected seeds with low area/mass ratios which germinate later and can thus avoid the glyphosate application.

Tomato spotted wilt virus (TSWV) first isolated from birthwort (*Aristolochia clematitis* L.) in Hungary

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Tomato spotted wild virus (TSWV) became to an important plant pathogen in the past 15 years. This pathogen belongs to the family *Bunyaviridae* and genus *Tospovirus*. It can spread through trips and mechanical transmission. According to the latest studies, this virus has about 1090 host plants including crops and weeds.

In the autumn of 2009, some *Aristolochia clematitis* plants were detected showing yellow mosaic symptoms probably of the TSWV infection. The presence of TSWV was proved by TEM electron microscope and RT-PCR. To the molecular test primers were designed and used TSWV-S1983 5' CCCTCGAGGCTTTCAAGCAAGT-TCTGC G-3' and TSWV-S2767 5'-GCTCTAGAGCC-ATCATGTCTAAGGTTAAGCTCAC-3'.

On bases of electron microscopic and molecular studies leaf samples of *Aristolochia clematitis* L. found, which proved to be infected with *Tomato spotted wilt virus* (TSWV).

This is the first report on the occurrence of TSWV on *Aristolochia* in Hungary.

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Interactions between summer weed communities and pedo-climatic characteristics in Italian maize fields

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The aim of the present study was to examine the relationships between weed communities and some pedological and climatic traits in several Italian areas of maize cultivation. Weed data were obtained by gathering the results of several independent studies carried out in the period 1998-2012 by different research organisms and collecting them into a large dataset. The considered studies included herbicide efficacy field trials and weed surveys conducted on a total of about 600 sites, represented by maize fields spread on 175 localities of north and centre Italy. Only data from untreated plots (with size ranging from 10 to more than 100 m^2) were considered. Weed data were collected at least once in June or July of each year. In the case of multiple weed surveys per season on a single site, only the observation with the highest number of recorded weed species was considered. Some indices describing the weed community structure were calculated: total number of weed species, number of monocotyledonous species, number of dicotyledonous species, total weed density. In the surveyed sites, additional data on soil (pH reaction, texture, organic matter content, total nitrogen, Mg/K ratio, assimilable phosphorus, cation exchange capacity (CEC), and C/N ratio) and climate (annual total precipitation, annual mean temperature and the climate classification devised by Thornthwaite) were collected or obtained from regional databases. The relationships between pedo-climatic traits and weed indices in the various sites were investigated by using linear correlation analysis (CA), discriminant analysis (DA), and principal component analysis (PCA). In the case of CA, the significance of correlation and the Pearson's r correlation coefficient were calculated. With DA, pedo-climatic traits were tested as predictors of weed indices for the different sites. PCA was mainly aimed at finding hidden relationships between pedo-climatic traits and weed indices.

The total number of encountered species was equal approximately to 120. Despite the high number of species found, only *Chenopodium album*, *Echinochloa crus-galli*, *Amaranthus retroflexus*, *Solanum nigrum* and *Polygonum persicaria* (ordered in term of occurrence frequency) were present on more than 50% of the sites.

CA and PCA analyses highlighted a weak tendency for a higher number and density of monocotyledonous species in sandy and alkaline soils. Dicotyledonous species were favoured by clayey soil and high pH values. With DA, a good classification of the surveyed sites on the basis of weed indices was obtained by using soil parameters as predictor variables (>60% of sites correctly classified), in particular in a subset of data referred to Piemonte region only (north-west Italy). Soil texture, CEC, as well as pH and the content of some nutrients, resulted significant in predicting some weed indices.

This study pointed out that the weed communities of Italian maize fields are partly influenced by pedo-climatic traits. The weakness of some relationships could be the result of a mitigation effect resulting from the overall influence of the crop practices on weed dynamics.

Weed species diversity in the Czech Republic under different farming and site conditions

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The aim of this study was to explore the composition of weed vegetation on arable land in selected areas of the Czech Republic and to determine the level of γ-diversity which is represented by total species richness within an ecological landscape. Our survey was conducted at 27 conventional and 35 organic farms in 2006-2008. Fields with winter cereals, spring cereals and wide-row spring crops were selected for sampling. In each sampled field, one phytocoenological relevé of standard size of 100 m^2 was recorded in the central part of the field. The species coverage was estimated using nine-degree Braun-Blanquet cover-abundance scale. Total γ-diversity was expressed as total number of weed species recorded, and then the species diversity and constancies for different farming systems, altitudes and crops were stated. Subsequently, the species were divided on the basis of their perenniality. Totally, 172 weed species have been found - 123 in conventional and 162 in organic farming. The highest number of species was found in winter cereals and at medium altitudes. *Chenopodium album* was recorded as the species with the highest constancy in both types of farming. Totally 89 annuals, 17 biennials and 15 perennials have been found in conventional farming. In organic farming, totally 109 annuals, 23 biennials, 28 perennials and 2 semiparasite annuals have been found. The results confirmed positive impact of organic farming on γ-diversity of weed communities.

Site specific weed appearance in barley crop

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Barley (*Hordeum vulgare* L.) is the 4th most cultivated cereal crop in the world. Weeds as a strong competitor for the crop may lead to reduced yield and particularly malt quality in the case of barley for brewery. It is well known that weed populations have a patchy distribution with aggregated weed patches of a varying size and density. Thus, the spatial and temporal dynamics of weed populations is increasingly important as approach for the site-specific weed management in the frame of "low herbicides inputs". The aim of the study was to investigate the weeds continuous appearance or patchiness in the barley.
An experiment set up in the experimental station of AUA in Spata (Athens- latitude of 37.979953 and longitude of 23.915155) in a field site (1000 m^2) with 48 sampling plots of 1m^2. A complete randomized design was selected as the experimental layout using 8 barley varieties with 6 replications. Intensive surveys of weeds were conducted during the growing period in order to assess the weeds growth in terms of their spatial distribution. The abundance of weeds was evaluated based on weeds density, occurrence and frequency in each of experimental plots. Furthermore, the spatial distribution of weeds in the field was estimated using exploratory spatial data analysis in a GIS environment.
The abundance and spatial distribution of the weeds varied widely within the field. *Malva sylvestris* L., *Silybum marianum* L., *Sinapis arvensis* L., *Chrysanthemum coronarium* L., *Cardaria draba* L., and *Calendula arvensis* L., were the most abundant weeds in a diminished rank with values 79.16, 64.58, 47.92, 31.25, 27.08, 25.00, respectively. Data concerning the spatial distribution of the most abundant weeds showed that the weeds occurred in high densities at the northeast sampling sites while across the rest of the field the weeds showed a patched emergence with lower densities. In the northern plots a total density of 182 weeds/m^2 was observed, with *M. sylvestris* and *S.arvensis* presenting the greatest densities (46 and 40 weeds/m^2 respectively). However, in the southern plots a total density of 81 weeds/ m^2 was observed with *C. coronarium* and *M. sylvestris* presenting the greatest densities (19 and 14 weeds/m^2 respectively). Actually, the varieties showed no significant effect on the spatial weeds distribution and the observed occurrence may be related with the pressure of the neighboring field margins, with a heavy weed population load, at the north east side of the crop. Additionally, during the early growing stages for the barley the weeds *M.sylvestris*, *C. coronarium,* and *S.marianum* occurred in densities of 104, 53 and 10 weeds/m^2, respectively, while in the late stages the weeds densities were differentiated to 182, 117 and 37 weeds/m^2 , respectively. The weeds density maps determined weed patchiness, providing the necessary data for a potential site-specific weed management.

Weed vegetation of Slovakia: floristic composition and syntaxonomy

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The beginning of the weed vegetation research in Slovakia dates only to the period after World War II. More authors dealt with the segetal (weed) flora and vegetation. But the research was not systematic and the interest in this topic has declined in the last 30 years. The objectives of this study are to find out the actual distribution of the segetal communities and to analyse their floristic composition in Slovakia.
Phytosociological relevés were made according to the Zürich-Montpellier school and the 9-degree scale of abundance and dominance was used. The cluster analysis was performed by the programs JUICE 7.0 and SYN-TAX 2000.
Flora and vegetation of the arable fields in Slovakia was studied and classified between the years 2002-2008. In total, 507 phytosociological relevés were made in cereals, root crops, cereal stubbles, perennial fodder crops and in abandoned fields as well. The average number of species per relevé was 23,5. By numerical analyses 13 plant communities from the class *Stellarietea mediae* were distinguished, 11 from the subclass *Violenea arvensis* and 2 from *Sisymbrienea*. The vegetation was represented by 407 plant taxa, 26 taxa of them were bryophytes and 381 taxa vascular plants. Agricultural plants were represented by 19 species. The vegetation was dominated by therophytes (57%). They were followed by hemicryptophytes (36%), geophytes (4%), phanerophytes (2%), and chamaephytes (1%). Native species prevailed over aliens and archaeophytes over neophytes. The most species of alien flora were naturalised species (82%), followed by invasive (9%), and casual species (9%). In the weed vegetation there were found 32 threatened vascular plant species included in the Red List of Slovakia (2 CR, 7 EN, 13 VU, 8 LR, and 2 DD) and 4 species of bryophytes (1 VU and 3 LR). The most frequent weeds in all relevés were: *Tripleurospermum perforatum*, *Cirsium arvense*, and *Viola arvensis*.

The use of allometric relations for biomass estimation in above-ground *Cirsium arvense* (L.) Scop.

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Assessment of biomass dynamics by destructive measurements requires a multiplication of the treatment x replicate matrix with the number of sampling occasions. This usually leads to either a compromise with regard to the number of treatments, replicates and sampling occasions, or to the use of methods which may limit result interpretation. In forest mensuration, this problem is remedied by the use of allometric relations between linear stem dimensions and weight of plants and their components. We exploited the suitability of this approach for assessing the above-ground dynamics of *C. arvense* (creeping thistle). Sixteen datasets were analysed with regard to allometric relations between leaf area, shoot height, diameter and weight. Biomass and leaf area dynamics of *C. arvense* could be captured by estimates obtained from allometric relations. Shoot height and diameter can be used as predictors for biomass and leaf area in growing shoots of *C. arvense*. Allometric relations in *C. arvense* are time specific and site dependent, and applicable for the evaluation of management methods such as mowing. The approach can be used to assess vertical resource partitioning profiles and to obtain insights in the effects of environmental factors on above-ground resource partitioning in *C. arvense*. The use of allometric methods may greatly decrease time and costs of field sampling.

Population dynamics and nitrogen allocation of *Sonchus arvensis* L. in relation to initial root size

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The aim of the study was to relate shoot size-and weight variation development in populations of *Sonchus arvensis* L. (perennial sow-thistle) to characteristics of the roots constituting the initial populations, which differed in degree of root fragmentation. We also aimed to assess nitrogen allocation patterns, and quantify the relative amounts of nitrogen allocated to generative and vegetative reproduction, respectively, in the different populations. In a controlled outdoor experiment, three artificial populations of *S. arvensis* of different initial root size frequency distributions were planted. Individual roots were tagged and a continuous census of shoot emergence and above ground growth was performed during the growing season. At harvest, dry weight and nitrogen content of leaves, stem, buds, and roots were measured. The height frequency distribution of the populations in the late of the season was bimodal, indicating the existence of two generations distinctly different in height growth pattern. Biomass production per unit area did not differ between the populations with different degrees of fragmentation. Nitrogen allocation to vegetative reproduction was larger than nitrogen allocation to generative reproduction. Knowledge about pre-emergence variation in *S. arvensis* enables farmers to develop control regimes to fragment roots of perennial weeds in such a way that resulting root populations are less viable than before fragmentation.

Weed emergence and survival in spring barley

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Weed infestation is one of the main factors limiting crop yield. A better understanding of the emergence behaviour of weed presents opportunity to maximize the efficacy of weed control strategies. The aim of the present research was to evaluate the quantify of germination longevity and periodicity of annual dicotyledonous weed seeds in spring barley stands. Weed emergence and survival in spring barley was investigated in field trials at Institute of Agriculture LRCAF in Central part of Lithuania ($55^0$23`50``N and $23^0$51`40``E) in years 2003-2005 and 2008 – 2010. The soil of the experimental site - *Endocalcary-Endohypogleyic Cambisol*, loam. Conventional soil tillage was used. Spring barley was sown in the second half of April, at a rate of 4.0 million seed ha^{-1}. Weed emergence was observed in not sprayed nine plots of barley, in 4 places of each plot. Sites of 50x50 cm in size were marked, where all present weeds were counted weekly from sowing to end of heading. All data were analyzed using ANOVA from package SELEKCIJA (Tarakanovas, Raudonius, 2003). The number of weed species at the begining of spring barley vegetation differed between years: the highest abundance was obtained in year 2003, there was detected 20 weed species and the lowest in year 2008 – 11. The weather conditions, especially the amount of rainfall during the growing season affected weed incidence and conditions for crop – weed competition. During all experimental years, the most frequent were following annual weed species: *Chenopodium album* L.*, Lamium purpureum* L.*, Viola arvensis* Murray, *Stellaria media* (L.) Vill. The begining of weed emergence depended on the meteorological conditions and occured two – three weeks after the sowing of barley, in the second decade of May. According to average data of four years there was found 36% from all in growing period emerged weeds during the first assesment performed at the second decade of May. The part of emerged weed depended on weed species. At the begining of June there were found significant (P>0.05) increase in number of *Lamium purpureum*, whereas *Ch. album* germinated during all growing period of spring barley.
The highest total number of weeds was found in the third decade of June. Later, in the first decade of July total weed number decreased and number of different weed species decreased significantly. This confirms results of earlier investigations. Nevertheless, our data showed, that 1/3 of all emerged weeds was determined to die until the end of spring barley growing period. Weeds predominated until cereal harvesting were from earlier emergence. Later emerged weeds in our case were not able to compete with barley and other earlier-emerged weeds. There was found 11 - 20 weed species in spring barley stands. Occured weed species number depended on meteorological conditions especially moisture content in spring. Weed survival depend on general weed number in the field. In quite low level of weedness later emerged weeds were not able to compete with barley and earlier-emerged weeds.

Consequences of the establishment of grass margin strips for weed species

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The intensification of the management of weed populations, led by a potential decrease in the yield and quality of crop harvest, has largely induced their decline in arable zones across the last decades. This floristic decline in arable landscape, has induced a loss of a larger biodiversity because the presence of others organisms (birds, insects, mammals) are strongly linked with the abundance of trophic resources as weed are. To counter with this loss of biodiversity and to limit the negative impacts of farming practices on environment, numerous agri environmental schemes were launched through Europe. In France, sown grass strips were established by farmers along streams and rivers to limit the pesticide drifts and the hydric soil erosion. The field margin strips are mainly sown with grass mixtures and do not receive neither pesticides nor fertilizers. Consequently, their establishment in the arable landscape for many years, without compensation payments for farmers, spark many fears concerning the weed risk that they could represent for adjacent field. At the opposite, these non-cropped areas adjacent to cultivated fields could be an opportunity to maintain weed populations providing ecosystem services for agriculture which were more and more highlighted.

This work shows that sown grass strips harbour large flora diversity. The weed communities are mainly structured by the type of adjacent boundary (hedge, river, ditch, etc.). The succession of disturbance and competition phase caused by mowing and competition of sown species respectively, do not allow annual species to maintain their populations in this habitat where they rarely reach fructification stages. The frequently observed species are perennials but rarely dominated over the sown cover. Even if the sown grass strips show high level of species richness, mainly composed by arable species, these strips do not enhance the spread of species from the boundary to the field core. Indeed, at least at short term, the sown grass strips decrease the edge effect because they were established where the flora transition between the boundary and the field previously occurred. Moreover, the establishment and management practices cost for farmers, reasonably at the farm scale.

Although some fears on the decline of annual species, the sown grass strips represent an opportunity for the weed management at the field scale as well as at the landscape scale. Joint study linking the flora with other organisms (soil microflora, grasshoppers) have been initiated and could allow to put the environmental sown grass strips to good use for biodiversity.

Lolium multiflorum and *L. rigidum*: a sensitivity analysis to glyphosate

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The literature indicates that glyphosate resistance builds up quite slowly and resistance levels are medium to low. Therefore, the availability of a reliable and realistic baseline sensitivity is critical to discriminate between susceptible and resistant populations and to identify early shifts of susceptibility.

This study documents the susceptibility of 30 Italian populations of *Lolium* spp., most of them recently collected in agricultural environments, towards glyphosate. Our standard susceptible population S-204L collected more than 10 years ago was also tested. Sampling sites included field margins, organic farms (winter cereals), conventional farms (winter cereals, sunflower and perennial crops) and roadsides. Sampling sites cover all major Italian agricultural areas and have been chosen according to the absence or scarce application of glyphosate during the last decade. The areas where glyphosate resistant *Lolium* spp. has been already reported have been avoided. Therefore, the data do not show the status of truly unexposed populations, but they rather represent the "real" susceptibility status of Italian *Lolium* spp. to glyphosate in agricultural environments.

Although morphological traits showed a high variability among and within populations, all of them were classified as *L. rigidum* or *L. multiflorum* or intermediates between the two.

A first outdoor dose-response pot experiment was conducted during spring 2012 and a second one was conducted in autumn to assess the variability of ED_{50}, GR_{50}, ED_{90}, GR_{90} and slopes of the fitted non-linear curves. Inter-population differences are being analysed in relation to the field history or environmental characteristics of the sampling sites.

The lack-of-fit test on both plant survival and fresh weight on preliminary data indicate that it is not possible to simplify the regressions to a model with a common slope for all populations. Spring dose-response experiment outlined that glyphosate GR_{50} range from 31±8.8 to 98±14.7 and GR_{90} from 144±15.7 to 272±26.3 g a.e. ha^{-1}; concerning mortality, ED_{50} vary from 155±5.9 to 260±6.7 while ED_{90} from 243±20.8 to 506±79.1 g a.e. ha^{-1}; . GR_{50} based on the autumn dose-response experiment range from 37±4.8 to 148±8.4 and GR_{90} from 136±10.3 to 348±36.8 g a.e. ha^{-1}; concerning mortality, ED_{50} vary from 107±10.1to 308±8.9 while ED_{90} from 269±49.5 to 410±23.4 g a.e. ha^{-1}. The box plot did not identify any outliers among population.

The range of glyphosate susceptibility of *L. multiflorum* and *rigidum* sampled in agricultural environment was established. Survival results indicate that the vast majority of the plants were controlled at 450 g a.e. ha^{-1} of glyphosate. The information provided is useful for devising herbicide resistance prevention strategies aiming to avoid the selection of glyphosate resistance traits and establishing a threshold for identifying future shifts of susceptibility.

Determination of Weed Species in Sugar Beet Fields (*Beta vulgaris* L.) in Kayseri Province in Turkey

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In Turkey, sugarbeet agriculture has become an important income generating agricultural activity for hundreds of thousands of farmers and is intertwined with agricultural activities and animal husbandry, such as the pharmaceuticals, fodder, medical, meat, dairy industries, as well as the shipping and service sectors. Due to climatic conditions, sugar cane is not grown in Turkey and sugar is produced from sugar beets. Sugar beets are grown mostly around Central Anatolia and the beets are planted in rotations with cereals, pulses, fodder crops and sunflowers. Sugar beets are planted in the spring, around April, and are mostly harvested in October. Turkey with approximately 17 million tons of sugar beet production is the world's fifth largest beet sugar producer, ranking behind France, Germany, the United States, and Russia. Sugar beet is cultivated about 20,000 hectares in Kayseri which is considered important sugar beet producer province. Purpose to determine the weed species in sugar beet fields in Kayseri province 45 surveys were done at 2012 and the coordinates of the surveys fields were collected for making weed map. The first 12 species determined in terms of frequency were *Chenopodium album* L. (% 93.33), *Amaranthus retroflexus* L. (% 88.88), *Convolvulus arvensis* L. (% 75.55), *Xanthium strumarium* L. (% 68.88), *Amaranthus blitoides* L. (% 60.00), *Echinophora sibthorpiana* L. (% 57.77), *Amaranthus albus* L. (% 55.55), *Echinochloa crus-galli* L. (% 53.33), *Tribulus terrestris* L. (% 53.33), *Lactuca serriola* L. (% 51.11), *Salsola ruthenica* L. (% 46.66), *Cuscuta* sp.. (% 42.22)

Determination of Weed Species in Apple (*Malus domestica*) Orchards in Kayseri Province in Turkey

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Apple is one of the most common crops in the World with 58 billion tons production and has very important role in human nutrition. Turkey has 2,680,075 tons apple production in a year which is 4.2 % of the world production. Apple production is an important fruit production has the potential to provide a major contribution to the economy is a large part of the territory of Turkey fruit fields. Apple growing areas are mainly concentrated in the regions of Bursa-Yalova-Çanakkale, Amasya-Tokat, Isparta–Burdur, Niğde-Nevşehir-Kayseri and Antalya in Turkey. In the province of Kayseri, approximately 127.282 tons of apple are produced 5694,4 ha in each year, accounting for 4 % of Turkey's total apple production. Purpose to determine the weed species in apple orchards in Kayseri province 75 surveys were done at 2012 and the coordinates of the surveys fields were collected for making weed map. The first 10 species determined in terms of frequency were *Convolvulus arvensis L.* (%67.3) , *Amaranthus retroflexus* L.(%64) , *Agropyron repens* (L.) P.B. %(61.3), *Chenopodium album* L.(%60), *Lactuca serriola* L %(58.3), *Circium arvense* (%56), *Setaria viridis* (L.) P.B. %(54.6) , *Cichorium intybus* L. %(54.6) , *Plantago lanceolata* L.% (53.3), *Xanthium strumarium* L. %(46.4).

A checklist of the weed flora of Qassim region, Saudi Arabia

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An inventory survey of agricultural district was conducted in the period from October 2010 to July 2011, covering winter and summer seasons to document the weed flora of Qassim region, Saudi Arabia. Qassim region lies between longitudes 41˚ 30' and 44˚ 45' E, and latitudes 24˚ 25' and 27˚ 15' N, and is situated in the central part of the Saharo-Arabian floristic region (Al-Nafie 2008). In each collection site, 2-3 farms were investigated. The collected material was pressed, dried using blotting papers at room temperature, and identified with the help of available literature, monograph, and compared with authenticated specimens in regional herbaria.

The first step towards weed control and management approaches of these weeds is their proper identification to recognize their diversity in the study area. The present work is mainly a taxonomic study pertained to identify, enumerate the weeds of agricultural areas, and highlight the extent of their diversity

A total number of 105 weed species belonging to 78 genera and 25 angiospermic families were recorded from 22 different collection sites in the region, representing various ecological habitats in winter and summer. Poaceae (21 %) was found the most dominant family in the area, followed by Asteraceae (13 %) and Brassicaceae (12%). The study revealed the presence of five succulent and two parasitic species within the weed flora of the region. The most common weed species in the region are *Cynodon dactylon* (L.) Per., *Malva parviflora* L., and *Portulaca oleraceae* L.

Environmental perturbations explain the co-existence of functionally equivalent species on the Broadbalk long term fertiliser experiment

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One explanation for the co-existence of competing species is that they have contrasting responses to variable growing conditions between years. Under this hypothesis, climate change may shift the balance of weed competition favouring some weeds more than others. The Broadbalk long term experiment (begun in 1843) presents a unique opportunity to test this hypothesis and assess how long trends in environmental change may impact weed community composition.
The presence / absence of 17 weeds species in 25 quadrats (0.1 m^2) were recorded annually for 21 years in 10 plots across a gradient of Nitrogen fertilization, where wheat monoculture is grown and herbicides have never been sprayed. Redundancy Analysis was used to (1) identify functionally equivalent groups of species responding to the gradient of Nitrogen fertilization, sowing date and time since fallowing (2) identify contrasting responses between species in these groups to winter and spring temperature and precipitation that may explain their co-existence on the same plots.
Functional groups that were adapted to competing for nutrients (e.g. *Aphanes arvensis, Medicago lupulina*, and *Ranunculus arvensis*) and light (e.g. *Stellaria media*) dominated in low and high fertile plots, respectively. Species with a high seedling relative growth rate (e.g. *Tripleurospermum inodorum* and *Papaver rhoeas*) were favoured by a delay in sowing date. Wet winters favoured *Veronica persica*, *R. arvensis,* and *T. inodorum* and worked against their functionally equivalent competitors (*S. media, Scandix pecten-veneris*, and *Papaver rhoeas,* respectively). Mild spring favoured *P. rhoeas* and *R. arvensis* and worked against *T. inodorum* and *S. pecten-veneris*. Cold winters favoured *M. lupulina* and worked against its functionally equivalent competitor (*Vicia sativa*). The results support the hypothesis that environmental fluctuations promote the co-existence of these species on individual plots on the experiment. Climate change may potentially result in long term shifts in environmental variables that perturb the equilibrium between these species on the experiment.

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A new natural weed host for *Beet necrotic yellow vein virus* and its vector *Polymyxa betae* Keskin from Turkey: *Raphanus raphanistrum* L. (Crucifera)

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Rhizomania is an important virus disease of sugar beet (*Beta vulgaris*) and caused by *Beet necrotic yellow vein virus* (BNYVV). The virus is transmitted to the roots of host plants by the plasmodiophorid *Polymyxa betae.* During the survey studies in September-October 2009, yellow vein banding symptom was observed on wild radish (*Raphanus raphanistrum*) plants growing in spinach (*Spinacia oleracea)* fields, which all have a history of rhizomania, in Samsun province in the Black Sea Region of Turkey For this reason, to verify possible alternative host for BNYVV and *P. betae*, *R. raphanistrum* and spinach plants and also soil samples were collected. Initially, BNYVV was detected in the leaf samples of field-grown *R. raphanistrum* using DAS-ELISA test. Then, this result was confirmed by RT-PCR and the *Raphanus* isolate was assigned to type A strain based on RFLP analysis. However, the presence of *P. betae* was not detected in the roots of *R. raphanistrum* plants using light microscopy technique. In order to confirm this result, total RNAs were extracted from the roots of these samples and tested by RT-PCR using *P. betae*-specific primers. In contrary, all of the tested samples were positive for *P. betae* in this assay. Also, healthy seeds of *R. raphanistrum* were planted in plastic pots containing soil infested with BNYVV and taken from the same fields, and the seedlings also showed similar symptoms to those growing in natural conditions. To best of our knowledge, this is the first report of BNYVV infection not only on *R. raphanistrum* but also in the family of Crucifera under natural conditions.

Identification of weed species and densities on railway platform

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This study was carried out in order to determine the weed species and densities in the railway platform between Sivas-Samsun in September in 2012. The Forth Region Administer of State Railways Roads (DDY) in Sivas contributed the study by providing the mobile vehicle. The results of study showed that the weed density was lower in Sivas-Tokat line than in Tokat-Samsun line. 19 different weed species was determined Sivas-Tokat line and 47 different species in Tokat-Samsun line. As a result, a total of 47 different weed species belonging to 22 different families have been identified in this study. These weed species are following: *Allium* sp., *Amaranthus blitoides* S. Watson., *A. retroflexus* **L.,** *Anchusa azurea* Miller., *Artemisia* sp., *A. vulgaris* L., *Carduus pycnocephalus* L., *Chenopodium album* L., *Chrozophora tinctoria* (L.) Rafin, *Cirsium arvense* (L.) Scop., *Clematis vitalba* L., *Convolvulus arvensis* L., *Conyza canadensis* (L.) Cronquist, *Cynodon dactylon* (L.) Pers., *Dipsacus* sp., *Ecbalium elaterium* (L.) A. Rich., *Echinocloa crus-galli* (L.) P. B., *Echium italicum* L., *Epilobium* sp., *Equisetum* sp., *Eryngium campestre* L., *Euphorbia* sp., *Geranium dissectum* L., *Heliotopium europaeum* L., *Kochia scoparia* (L.) Schrad, *Lactuca serriola* L., *Mentha* sp., *Mercuralis annua* L., *Onopordum* sp., *Onosma* sp., *Pastinaca glandulosa* Boıss. et hausskn., *Phragmites australis* (Cav) Trin. Ex. Steudel, *Plantago major* L., *Rosa canina* L., *Rubus* sp., *Rumex crispus* L., *Sambucus ebulus* L., *Sanguisorba minör* Scop., *Senecio vernalis* Waldst. And Kit., *Seteria viridis* (L.) P.B., *Silene* sp., *Sonchus asper* (L.) Hill., *Tribulus terrestris* L., *Verbascum* sp., *Vicia sativa* L., *Xanthium spinosum* L., *X. strumarium* L.,

Relationship between weed presence and lentil chalking caused by insects

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Study was performed to determine whether reletion between weed species and their densities to *Piezodorus lituratus* (F.) and *Dolycorus baccarum* L. (Hemiptera: Pentatomidae) which causes Lentil chalking or not. Experiments were as a cage and field in Şanlıurfa and Diyarbakır between 2009 and 2011. Based on three years results there were no significant differences between weed-free and weedy cages in terms of pest density and ratio of spot, statistically. There were no significant correlation between weed presence and these harmfull pests. Results were in agreement of cage studies. Weed species present in the surveyed area were *Sinapis arvensis* L., *Anagallis arvensis* L., *Anthemis* sp., *Aristolochia maurorum* L., *Avena sterilis* L., *Campanula* sp., *Caucalis platycarpos* L., *Centaura depressa* Bieb, *Cephalaria syriaca* (L.) Schrader,*Cichorium intybus* L., *Convolvulus arvensis* L., *Euphorbia* sp., *Galium aparine* L., *Galium tricornutum* Dandy., *Hordeum spontaneum* C. Koch., *Lallemanthia iberica* (Bieb.) Fisch. Et Mey., *Lathyrus aphaca* L., *Myagrum perfolatium* L., *Orabanche aegptiaca* Pers., *Papaver macrostomum* Boiss. and Huet. Ex Boiss., *Phalaris* spp., *Polygonum aviculare* L., *Scandix pecten-veneris* L., *Silene conica* L., *Sinapis arvensis* L., *Vaccaria pyramidata* Medik., *Vicia narbonensis* L. and *Anthemis* sp., *A. sterilis* L., *Boreva orientalis* Jaub and Spach., *Bupleurum rotundifolium L., Carduus pycnocephalus* L., *C. depressa* Bieb, *C. syriaca* (L.) Schrader, *G. tricornutum* Dandy. *H. spontaneum* C. Koch., *L. iberica* (Bieb.) Fisch. Et Mey., *Neslia apiculata* Fisch., *P. macrostomum* Boiss. and Huet. Ex Boiss., *S. arvensis* L., *Turgenia latifolia* (L.) Hoffm., *V. pyramidata* Medik., *V. narbonensis* L. weed species were in the cages.

The study has been supported by the Republic of Turkey Food, Agriculture and Livestock Ministry General Directorate of Agricultural Research and Policies (TAGEM)

Ground cover management in olive grove and vineyard orchards to support pollinating and beneficial arthropods

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Monoculture and intensive farming have been linked with a decline in flowering plant species in agroecosystems, with a consequent negative impact on populations of beneficial arthropod fauna. Creation of habitats with selected plants sown in or around fields could provide the food and shelter needed for maintaining a balanced multitrophic system, between sown plants, pollinating insects and natural enemies of crop pests. In order to study this relationship, mixtures of flowering plants were sown in an olive grove (S. Greece, Crete during 2011 and 2012) and a grapevine orchard (N. Greece, Florina during 2011), and their effect was compared to the natural vegetation of each field. The plants selected were sown in two mixtures and consisted of annual broadleaf species belonging to the families Fabaceae, Brassicaceae, Asteraceae, Boraginaceae, Apiaceae, Ranunculaceae and Caryophyllaceae. In the olive grove, plant mixtures were sown as an intercrop in patches of $3m^2$ between the trees, along the tree lines measuring a total of $72m^2$ for each mixture. In the grapevine, the mixtures were sown in the edge of the field in a total area of $180m^2$ per mixture. The experimental design in both fields included also an equivalent surface area of natural vegetation (control). Measurements were carried out during the flowering period and included the percentage of flowering per plant family, the number of Hymenoptera pollinators attracted (counts of insect visits per flower) and suction sampling for beneficial insects. *Sinapis alba* was the predominant species in both experimental sites. In the olive grove a native biotype also emerged with an earlier flowering onset, which prolonged the flowering period for this species. During the flowering period of *S. alba* in the patches of the olive grove, large numbers of Hymenoptera pollinators were attracted, mainly mining bees (Andrenidae) and honey bees (*Apis mellifera*), in both sown mixtures and the control. Later flowering species present only in the sown mixtures included *Pisum sativum*, *Vicia sativa*, *Borago officinalis* and *Coriandrum sativum*, which were also attractive to Hymenoptera pollinators such as mining bees, honey bees and bumble bees (*Bombus* sp.). In addition, beneficial insects (Hymenoptera parasitoids in both experimental years and the predators *Chrysoperla* sp. and *Orius* sp. in the first year) were also identified in the samples collected with suction sampling. In the vineyard the margin with the sown species attracted a significantly higher number of pollinating and beneficial insects, compared to

the control. The natural vegetation in the control area of the vineyard margin had a low ground cover, and contained species that were not attractive to pollinators, such as *Plantago arenaria*, *Chenopodium album* and *Xanthium strumarium*. Overall, the findings support that the management of the ground cover in olive groves (intercropping) and vineyards (margins) can be used as a practice for attracting beneficial insects and Hymenoptera pollinators. This is possible either by utilizing the existing natural vegetation when suitable plant species are present or through the sowing of selected flowering plants.

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Weed occurrence in GM maize tolerant to glyphosate

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Field trial with HT maize NK603 tolerant to glyphosate was established in 2010 in central part of the Czech Republic (Odrepsy, 50°9'17.183"N, 15°12'28.657"E, 205 m a.s.l.) in 3 replicates, each of them consisting of 3 block with following types of tillage: ploughing, conservation tillage, mulch tillage. Each block was divided into 5 plots of 600 m^2 (30 x 20m) that were treated as follows: 1. Conventional standard PRE: Guardian Extra 3,5 l/ha (acetochlor 1350 g/ha; terbuthylazine 749 g/ha); 2. Conventional standard POST: MaisTer 150 g/ha (iodosulfuron-methyl-Na 1.5 g/ha; foramsulfuron 45 g/ha; isoxadifen-ethyl 45 g/ha); 3. Pre Guardian Safe Max 1,4 l/ha (acetochlor 1176 g; furilazole 39.2 g/ha) + post Roundup Rapid 2,4 l/ha (glyphosate 1080 g/ha); 4. Split dose of Roundup Rapid (2,4 l/ha) crop BBCH13 + Roundup Rapid (2,4 l/ha) crop BBCH 16-18; 5. Tank-mix Guardian Safe Max (1,4 l/ha) + Roundup Rapid (2,4 l/ha) - crop BBCH 13-14. Sprayer PZS 200 ST, 10 m (Prodag, CZ) was used with nozzles 110-SF-04, water volume 200 l/ha. During crop vegetation, weed occurrence was recorded in two week interval at the beginning (June) and later once in month (July – October). Data were analysed by ANOVA. In 2011, 58 weed species were recorded in total, the highest number of species (24) was recorded in plot of var. 2 (2.9.), ploughing, the lowest number (2) in plot of var. 5, conservation tillage. In 2011 the weediness was serious in many plots from the beginning of vegetation. Especially in conventionally treated plots the weediness was higher compared to previous year. In average, the lowest weediness (expressed as total weed coverage) in each evaluation term was observed in plots of var. 4, high weed coverage was observed in var. 1 and 2, where weeds were covering 80 % of the plot (26.7.), later in the season the coverage of the weeds decreased.

First results of weed evolution in no-tillage systems in winter wheat in France

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The adoption of no-tillage is presently a strong trend in Europe. If this cropping system is to be widely adopted in the 1980s in the North and South America, in Australia, no tillage is used by few farmers in France where agriculture and tillage are considered synonymous by farmers and agronomists. Weed infestation is generally described as to increase when the selection pressure due to soil tillage is reduced. The European strengthened regulations on herbicide used and the ban of transgenic crop in France does not facilitate the development of non-tillage. This communication presents the first results on the evolution of weed communities on farmer's fields in East of France.

The device included 52 fields (50m x 40 m plots) that are in no tillage for periods of 1 to 13 years. The area is dominated by shallow calcareous soils and the major local crop rotation is winter rapeseed, winter wheat, spring barley. Weed surveys were carried out across winter wheat fields in 2011 and weed data was collected at three periods i.e. the cropping period in late-March before foliar herbicide treatment, before harvest in mid-June (potential seed production) and during the cover cropping period in mid-September. Seven environmental variables were collected that were related to cultivation practices and to soil properties. Thirteen speceis traits were selected as potentially affected by the adoption of no tillage. A RLQ analysis was performed to investigate the relathionship between traits of species and environmental fields characteristics. A total of 121 weed taxa were identified but analyses were carried out with a total of 93 weed species (62% of annual species; 94 of eudicot species). Results indicated that grassweeds and perennials weed species were promoted with time since field conversion to no tillage contrary to annuals and broadleaf species. Data indicated that time since conversion to no-tillage led to a shift in weed community that favored weeds invested more in maintaining their "underground system than in aerial seed production. Furhermore, the duration since conversion was linked to changes in soil parameters. We observed an accumulation of stones on the soil surface and a trend towards a soil acidification in fields converted for several years. The expansion of monocots in no-till systems may be explained by the end of mechanical weed control and the use of foliar-applied- herbicides generally less efficient on monocot species. If geophyte weed species seems to be favoured, we did not observe a clear gradient reflecting ecological community succession and annual species remained present in the fields. One explanation could be that the gradient of time since conversion was too low. We could also hypothesize that weed communities, which may exhibit long-lived seedbank, may respond with a delay to the changes of soil tillage regime.

This study provides empirical evidence of weed trait shifts in conservation agriculture and calls for a move in management practices towards a regime avoiding selection of problematic perennial weeds.

Plant species composition, richness and diversity in selected vineyards under organic management in the area of South Moravia, Czech Republic

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The aim of the study was to describe species composition, richness, diversity and its changes during the growing season in selected vineyards under organic management in the warm and dry area of South Moravia in the Pannonian region (SE Czech Republic). We compared the vegetation between the two vineyards with tilled and grassed-over rows and lanes. The data was collected on 60 permanent plots in tilled rows and lanes and on 60 permanent plots in grassed-over rows and lanes within one vineyard. In those permanent plots 720 phytosociological relevés were recorded during 2012. The abundance of vascular plants was described by means of the nine-degree Braun-Blanquet scale of abundance and dominance.
A total of 130 vascular plant species were recorded. The average percentage of neophytes was 14 % and the average percentage of archaeophytes was 47 % for both study sites. Species richness was significantly lower in grassed-over rows in both sites, whereas the highest species number was found both in tilled and grassed-over plots. There was no significant difference recorded between the groups regarding the number of biennials. The highest number of annuals was found in the tilled plots while perennials were more frequent in the grassed-over lanes. Species associated with different management regimes were determined as well as the most frequent species. The majority of 11 endangered species of vascular plants was found in the tilled plots. According to the field observations the management regime during the growing season is an important factor for the resulting plant community structure.

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Strategic tillage reduces emergence of key sub-tropical weeds in Australia

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The increased incidence of herbicide-resistant and difficult-to-control weeds in the sub-tropical grain region of Australia has led the agricultural industry to consider applying tillage in long-term zero till systems for strategic weed control. The majority of farmers in the region removed tillage as a regular control tactic to conserve soil moisture, prevent soil erosion and ultimately to increase crop production. Weed control is now heavily reliant on herbicides. This paper examines the effect of strategic tillage on weed emergence and seed burial.

The impacts of five types of tillage (zero, harrow, tynes, offset discs and one-way discs) on subsequent weed emergence were examined in a field experiment, sown with *Sonchus oleraceus* L., *Echinochloa colona* (L.)Link, *Urochloa panicoides* P.Beauv., *Conyza bonariensis* (L.)Cronquist, *Chloris virgata* Sw. and *C. truncata* R.Br. Prior to the single pass tillage treatments being applied, viable seed of each species was sown by hand onto the soil surface. In addition, small glass beads, simulating weed seeds, were also sown onto the soil surface. Following treatment imposition, soil cores to 20cm depth were collected, washed, and beads recovered from different depths to measure extent of 'seed' burial.

Recovery of beads showed the greatest amount of burial was in the one-way disc treatment, with 20% of beads buried below 10cm. Harrows caused minimal soil burial with 77% of beads remaining in the top 2cm of soil.

Emergence was counted over four months with seedlings sprayed following each counting. Accumulative emergence density in zero till was 227 (*C. bonariensis*), 142 (*C. virgata*), 412 (*C. truncata*), 103 (*E. colona*), 303 (*S. oleraceus*) and 43 (*U. panicoides*) plants/m^2. Averaged across tillage treatments, emergence of the small-seeded species *C. bonariensis* was reduced the most (>90%). Across all species, emergence generally decreased more as soil intensity increased. The greatest reduction in emergence was generally after a one-way disc, which caused large amounts of soil inversion. However, even after the harrow treatment, which caused minimal soil disturbance, emergence was reduced by an average of 60% across species.

Our research clearly shows there is a potential role for strategic tillage to reduce emergence of key weed species in sub-tropical Australia. It is likely tillage that causes less soil disturbance, such as harrows, will be less likely to undo the soil conservation benefits gained from >30 years of zero till. Further work is needed to assess the impact of multiple tillage events on weed emergence, and to examine if and where strategic tillage fits within long-term zero till systems of the sub-tropical grain region of Australia.

SESSION IV

NON-CHEMICAL WEED MANAGEMENT

Oral presentations

Session organizers

Bo Melander & Paul Hatcher

16th EWRS Symposium 2013, Samsun

Prospects for reduced tillage without herbicides – a Canadian view

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Grain growers in Canada rely mostly on tillage and herbicide use for weed control. However, frequent tillage may lead to soil degradation and environmental pollution, and it requires large amount of fossil fuel energy. Moreover, increased areas infected by herbicide-resistant weeds are observed in all regions of the country and have become an economical problem for Canadian farmers. In an effort to address these issues, efforts have been invested in developing ways to reduce tillage and herbicide use on grain farms while maintaining good weed control. A variety of minimum tillage equipments have been tested to terminate green manures in reduced tillage grain systems: roller-crimper, min till rotary hoe, wide blade cultivator (Noble blade), and flail mower. The wide blade cultivator was found to be a viable alternative to terminate a spring-seeded field pea (*Pisum sativum*)-barley (*Hordeum vulgare*) green manure. In a study conducted between 2010 and 2012, the use of the wide blade cultivator resulted in crops yields not significantly different than a standard tilled treatment, at 3 site-years out of 4.

There has also been a growing interest in trying to adapt the mulch production systems developed in the late 1980s by Brazilian no-till farmers to Canadian conditions. Experiments across Canada have been conducted to examine the feasibility of implementing no-till practices using the roller-crimper in herbicide-free grain production systems. Results from field experiments in Manitoba suggest that thick rolled green manure mulches (especially those with hairy vetch (*Vicia villosa*)) have the ability to suppress weeds, thereby reducing the need for tillage, whereas similar trials in Alberta did not result in the same success: mulches did not provide sufficient weed control to the crops. Promising studies on fall-seeded cover crops are also been conducted across Canada, inspired by work done in United States of America. Grazing has also been investigated as a method for weed control in reduced tillage systems. A 3-year experiment conducted in Western Canada concluded that grazing green manures by sheep does not affect subsequent spring wheat (*Triticum spp.*) and fall rye (*Secale cereale*) crop yields, when compared to a treatment with green manures incorporated using a tandem disk treatment. Grazing by sheep even increased nitrogen availability of green manures. In conclusion, researchers as well as farmers have shown interest in reducing tillage and herbicide use on Canadian farms. The next step of organic research on reduced tillage systems in Canada will be to fine tune agronomic recommendations for Canadian growers. Challenges that refrain farmers to adopt these systems include: 1) Insufficient production of mulch biomass for weed suppression with spring seeded annual green manures other than hairy vetch; 2) Failure to terminate the green manure with the equipment available; 3) Weed population switch from summer annuals to perennials; 4) Possibility that reduced nitrogen mineralization of green manures may lead to reduced yields.

The effects of cover crops on weed suppression and pollen provisioning for predator mites in citrus orchards

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Cover crops are grown for various purposes around the world. Cover crops reduce weeds by competition, shading and allelopathy. Growing cover crops before and during the main crop in orchards and field crops can reduce soil erosion and add organic matter and nutrients to the soil. Cover crops grown in an orchard may also be a pollen source feed for predatory mites (*Phytoseiidae*) that feed on the citrus rust mite (*Phyllocoptruta oleivora*), a major pest in citrus production. The aim of the study was to use cover crops in a citrus orchard for suppressing weeds, adding organic matter to the soil and improving the control of the citrus rust mite. A cover crop experiment was conducted in a sandy soil experimental citrus orchard in Rehovot. We seeded a common oat (*Avena sativa)* and vetch *(Vicia atropurpurea*) mixture in the autumn of 2011, and in the spring of 2012 we seeded Rhodes grass (C*hloris gayana*), Tall fescue (*Festuca arundinacea*), sorghum (*Sorghum bicolor*) and annual ryegrass (*Lolium multiflorum*), all cereal cover crops that potentially provide in the summer air-borne pollen for predator mites. The autumn-sown oat and vetch mixture reduced weeds dramatically by 82% compared to the no cover crop control, but the summer cover crops did not establish well in the dry climate of the Israeli summer, excluding sorghum, the pollen of which was collected and is presently being tested in predatory mite feeding experiments. The effect of cover crops on the soil nutrient availability and soil organic matter will be tested in future studies.

Mentha suaveolens incorporated as green manure for weed control in maize-based cropping systems

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The use of *Mentha suaveolens* Ehrh. (apple mint) for weed control in maize-based cropping systems is proposed. Based on experimental evidence of phytotoxicity by *Mentha* species on weeds, we conducted two greenhouse pot experiments testing incorporated apple mint aerial parts as green manure. The phytotoxic effects were tested on the germination, establishment and growth of *Zea* mays (maize) and some representative accompanying weeds, in comparison to the pre-emergence herbicide metolachlor.

Fresh apple mint incorporated into the soil as green manure at 1 and 2 % w/w in a dry weight basis significantly controlled the emergence of the dicotyledonous weed species *Amaranthus retroflexus* and *Solanum nigrum*. After one month of incorporation, both doses reduced more than 90 % the aerial biomass of two monocotyledonous weed species (*Echinochloa crus-galli* + *Digitaria sanguinalis*) with respect to the mint-free pots, and around 99 % for the dicotyledonous weed species. Although the aerial biomass of maize suffered a 21 % reduction, the final relative yield of maize biomass with respect to the untreated control was significantly increased by 43 %. On the assessment of the temporal phytotoxic effects, the reduction of aerial biomass in maize could be overcome by adopting a relay-planting of maize after 15 to 18 days from mint incorporation.

Our results constitute evidence that the incorporation of *M. suaveolens* to soil could be a feasible practice to reduce the reliance on synthetic herbicides in maize-based cropping systems.

The potential for electrical weed control in a range of horticultural crops

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Perennial weeds are becoming increasingly difficult to control in conventional bush and cane fruit crops in the UK due to limited herbicide availability. Annual weeds and volunteer potatoes in vegetable crops in the UK are also an increasing challenge again due to very limited herbicide choice. Alternative methods of control are often required. The highly competitive and persistent nature of perennial weeds make them extremely challenging for non-chemical control options and often require repeated cultural methods which are both costly and time consuming.

A set of experiments over a two-year period have been investigating the efficacy of electrical weed control in bush and cane fruit using a shielded high powered electrode applied to the weeds in the field. The target perennial species were *Cirsium arvense* (creeping thistle), *Urtica dioica* (common nettle) and *Rumex obtusifolius* (broad-leaved dock). Target weed plants were tagged and assessed 1, 4 and 10 weeks post-treatment.

Data were analysed using a Freidman's non-parametric ANOVA. Results show that control of *C. arvense* is more consistent with the electrical weeding than that of *U. dioica* and *R. obtusifolius,* where re-growth occurred more readily.

Experiments on annual broad-leaved weeds in vegetable crops have begun this season and show promising results on *Senecio vulgaris* (groundsel) and volunteer potatoes.

Effects of flaming and cultivation on weed control and yield of maize in Nebraska and Serbia

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Propane flaming and mechanical cultivation are common tools for weed control in agronomic crops. Therefore, independent studies were conducted in Nebraska (USA) and Serbia with the objective to evaluate the effectiveness of inter-row cultivation, flex-tine harrow and flaming conducted alone, and various combinations of cultivation and flaming combined in a single operation for weed control in corn.

Field experiments in Nebraska were conducted in 2010, 2011 and 2012 at the Haskell Agricultural Laboratory of the University of Nebraska-Lincoln (UNL), Concord, NE utilizing flaming equipment developed at the UNL. The treatments included: weed-free control, weedy season-long, and combinations of broadcast flaming, banded flaming (intra-row), and cultivation (inter-row), applied at the V3 and/or V6 growth stages in maize. Propane doses were 20 and 45 kg/ha for the banded and broadcast flaming, respectively. The operating speed for all treatments was 5 km/h. Weed control and crop response was evaluated visually at 14 and 28 days after treatment (DAT), while yield and its components were collected at crop maturity.

Field experiments in Serbia were conducted in 2011 and 2012 at the Institute of Field and Vegetable Crops, Rimski Sancevi, Serbia, utilizing propane doses ranging from 20 and 80 kg/ha, in order to test which dose give the best results on weeds but the lowest possible injury of maize. Treatments were conducted at V3 and V7 leaf stages of maize and included flaming alone, inter-row cultivation and flex-tine harrowing. In addition, flaming alone was also conducted at V5 stage of maize. Efficiency of weed control was evaluated at 7, 14 and 28 DAT including the number of weed species and their dry weight.

Results from Nebraska suggested that maize exhibited excellent tolerance to heat from flaming conducted at the above selected growth stages. Level of weed control varied with application time and treatment type. A single application of any of the weed control treatments did not provide satisfactory weed control regardless of the application stage. At least two applications of weed control treatments were needed for acceptable level of weed control. Maize cultivated once at the V3 stage had the lowest weed control level (20%) at 28 DAT and the lowest yield (9.7 t/ha). Plots treated twice (eg. V3 and V6 stages) with the combination of cultivation and banded flaming had 27% higher yield compared to the plots cultivated twice (12.6 t/ha vs. 9.9 t/ha). Cultivation and banded flaming applied in

a single operation at the V3 and V6 stages of corn exhibited the greatest level of weed control (> 95%) in both years. Flaming, with or without inter-row cultivation, can provide acceptable level of weed control in corn when conducted at least twice (V3 and V6 stages in corn).

Results from Serbia suggested that two applications of flaming was more efficient for later emerging weeds, with excellent control (>90%) for *Datura stramonium*, *Abutilon theophrasti*, *Amaranthus retroflexus*, *Chenopodium album*, *Ambrosia artemisifolia* and under 90% on *Sorghum halepense*. There was no statisticaly significant difference in crop height and yield between flamed and non-flamed control plots by the season end. Flex-tine harrow has shown lower efficiency than flaming. Inter-row cultivation controled weeds only in intrarow space leaving weeds within crop row, which negatively impacted yields of maize.

Overall, the results from both locations suggested that integration of flaming and mechanical tools can provide acceptable and sustainable level of weed control in maize.

SESSION IV

NON-CHEMICAL WEED MANAGEMENT

Poster presentations

Session organizers

Bo Melander & Paul Hatcher

16th EWRS Symposium 2013, Samsun

The use of living mulches for weed suppression in horticultural crops

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Options for weed control in UK horticultural crops are very limited. The number of available herbicides is rapidly declining, the pipeline of new products is very limited and recent legislation places emphasis on non-chemical means of control. As such, there is a growing demand and need for effective methods of non-chemical weed control.
Living mulches are slow-growing species that are established into a crop. They can provide many benefits to a crop (e.g. improved soil structure, nutritional, pest protection) and have been shown to suppress weeds. There are several risks to using living mulches (e.g. crop competition) so careful selection of the mulch species is crucial.
A series of experiments are examining the potential of several species for use as living mulches in fruit and vegetable crops. Living mulch species included in these experiments were *Trifolium repens* (white clover), *Medicago lupulina* (black medic), *Festuca rubra* (creeping red fescue) and *Lotus corniculatus* (birdsfoot trefoil). Experimental parameters for each potential living mulch species include: growth rate, height, moisture demand, nutrient demand and weed suppressive ability. Weed suppressive ability is being measured on a variety of annual and perennial broad-leaved weeds and grasses. Weeds such as *Stellaria media* (common chickweed), *Chenopodium album* (fat hen) and *Senecio vulgaris* (groundsel), *Elytrigia repens* (common couch), *Cirsium arvense* (creeping thistle), *Urtica dioica* (common nettle) and *Rumex obtusifolius* (broad-leaved dock) have been included.

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Effect of wheat residue and nitrogen management on soil seed bank and growth of weeds in corn (*Zea mays*) at three tillage systems

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Tillage systems and crop residues are among the many agronomic factors that interact with weed management to affect the size and composition of the weed seed bank. Field experiments were conducted to estimate the effect of wheat residue management on soil seed bank and growth of weeds in a corn field at Koshkak experimental station of Shiraz University in 2007 and 2008. Experimental design was split plot with three factors. Main factor was three tillage systems; conventional tillage (CT = once moldboard plowing), moderate tillage (MT= 2 times chisel plowing) and reduced tillage (RT = once chisel plowing), and sub factors were four wheat residues levels (0, 25, 50 and 75%) and three nitrogen rates (common rate, ¾ and ½ common rate). There were significant effects of tillage and depth, and a tillage-by-depth interaction for total weed seeds density in soil. The number of seeds was highest in RT and generally declined as tillage intensity increased. Total seed density was higher in RT in the 0-15 cm layer while both MT and CT were higher in the 15-30 cm soil layer. Nitrogen rates and residue levels did not influence weed seed bank size and distribution significantly. However with increase in residue levels and decrease in nitrogen rates, seed density was declined slightly in soil surface layer. With increase in residue levels and decreases in tillage intensity and nitrogen rates, seedling emergence and growth rate were decreased significantly. The lowest weed seedling emergence and growth rate was observed in RT with 75% residue levels and ½ common nitrogen rate treatments. These results confirm that tillage systems and crop residues can regulate soil seed banks and weed growth rate. Weed management programs most take this information into account.

Evaluation of cowpea (*Vigna unguiculata* L.) living mulch for weed suppression and yield response of maize (*Zea mays* L.)

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In order to evaluate the effects of cowpea (*Vigna unguiculata* L.) living mulch on weed dry matter and corn grain yield, a study was conducted in 2009 and 2010 at agricultural college of Shiraz University at Bajgah. This experiment was arranged in a factorial split plot design with four blocks. Cowpea densities were considered as main factors at four levels and suppression periods of cowpea with 2,4-D herbicide were sub factors at five levels. Two control treatments, weed free and weedy check, were also included. The results showed that the lowest weed dry matter and the highest grain yield of corn were obtained from 30 and 22 plants m^{-2} of cowpea living mulch density, respectively. The lowest weed dry matter and the highest grain yield of corn, in comparison to the weedy check, were obtained when cowpea growth was terminated 90 and 75 days after corn planting, respectively. It is concluded that the highest grain yield of corn and the highest suppression of weeds are achieved with the application of cowpea living mulch at 22 plants m^{-2} using a suppression period of cowpea for 65 days after corn planting.

Possibility of *Phelipanche aegyptiaca* control in tomato by strains of *Pseudomonas fluorescens*

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Phelipanche aegyptiaca (Egyptian broomrape) is one of the most important parasitic weeds imposing severe damage on crops especially in Middle East countries such as Iran.

In order to study the biological control of broomrape in tomato, outdoor pot experiments were conducted to evaluate the efficacy of bacterial and hormonal treatments in randomized complete block design with five replications in the Agronomy & Plant Breeding Department of University of Tehran, Karaj in 2009 and 2010. The treatments were *Pseudomonas* strains (UTPF5, UTPF18, UTPF68, and UTPF124), Benzothiadiazole (30 and 60 ppm), salicylic acid, and controls with and without broomrape infestation.

The results indicated that *Pseudomonas* isolate UTPF5 caused an increase (14-fold) in tomato shoot dry weight compared to the infested control. Furthermore, UTPF5 reduced the shoot dry weight, nodules and numbers of broomrape stems, 77, 71 and 50%, respectively. Among *Pseudomonas* strains, UTPF5 amplified the activity of catalase enzyme and ascrobat peroxidase 1.81- and 9.71-fold, respectively. Benzothiadiazole and salicylic acid, the hormonal treatments, had no effect on broomrape control and damage reduction. The bacterial strain UTPF5 which had a significant effect on increasing the tomato yield and reducing the parasite traits, could be useful for developing biological control approaches in combination with other methods against broomrape.

Cultivar effects on weeds and yield for different control methods in wheat

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Field trials with 16 different wheat cultivars were conducted between 2004 and 2011 near Braunschweig, Germany. The investigations were aimed to evaluate cultivar effects in terms of (i) weed suppressive ability, (ii) tolerance to weed and (iii) selectivity for mechanical control treatments. We assessed the effect of harrowing and reduced herbicide dosages on weed infestation and wheat yield in two different experimental series each with 8 cultivars. As expected we found clear cultivar effects on weed biomass and a strong correlation between cultivar-specific growth characteristics, light penetration (PAR) and weed suppression. In contrast to one of our hypotheses there were no significant interactions between harrowing and cultivar regarding weed biomass and grain yield for winter wheat. Compared to the overall average, none of the tested cultivars showed a higher tolerance in terms of mechanical weeding. Also, the yield reduction caused by the natural weed infestation and by the model weed *Sinapis alba* were similar in all tested cultivars. However, looking at the herbicide effects, the experiments demonstrated that a reduction of the dosage by up to 50% in competitive cultivars achieved the same control level as the full dosage in cultivars with weak weed suppression. As a consequence the competitiveness of cultivars should be estimated and published regularly in order to provide an additional tool for integrated weed control.

Improving the competitiveness of sunflower and maize against common ragweed (*Ambrosia artemisiifolia)*

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Common ragweed (*Ambrosia artemisiifolia)* is a tall erect annual species of the daisy family (Asteraceae) native to North America. It has been inadvertently imported to many countries in Europe, Asia and Australia. It has an impact on public health, agriculture and biodiversity, which cannot be denied. Therefore the European Commission, DG Environment, is funding a 3-year project on common ragweed. Six institutions in five European countries representing high infested countries like Hungary, Slovenia and Austria, beginning infestation in Germany and the not yet infested country Denmark are involved. The overall aim of the project is to contribute to the reduction of the prevalence of ragweed in European countries. The presented trial was carried out in Germany.

Ragweed can be a strong competitor to open row crops like sunflowers, maize, potatoes, pumpkins and legumes and can lead to high yield losses. But it also reacts very sensitively to competition. Therefore small plot (3x3 m) field trials were conducted in 2011 with sunflower and in 2012 with maize. The treatments were the same in both years: two-row spacing with 35 and 70 cm widths (8 plants m^{-2} in each case) in combination with or without undersown white clover (10 kg ha^{-1}). 2 g of common ragweed was sown along one metre between two rows in the middle of each plot and were thinned out at the four-leafe stage to five plants per metre (one plant every 20 cm). The common ragweed was harvested at a growth stage from beginning of budding until beginning of flowering at the end of August in both years. At the same time the sunflower and maize plants directly neighbouring the ragweed row were harvested too. Fresh sunflower and maize matter and dry common ragweed matter was determined in order to detect the impact of row spacing and undersown clover on common ragweed, sunflower and maize.

Significantly lower (*$P<0.05$) dry matter of common ragweed was found in narrowly spaced sunflower and maize plots with undersown white clover compared to the other treatments. Fresh matter of sunflower and maize therefore was not affected by wide or narrow spacing or by undersown clover.

The results show that there is an impact of competition on dry matter of common ragweed and it can be assumed that seed production would be reduced as well. To verify this assumption further investigations have to be carried out.

Effect of coloured plastic mulches on weed suppression and yield of sweet corn in organic production systems

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Organic agriculture employs a combination of the best methods of traditional agriculture and modern technology. Present-day organic growers use safe-and-true practices such as crop rotation, growing a diversity of crops, planting cover crops, and adding organic matter to the soil. At the same time, most organic production systems include use of modern equipment, improved cultivars, and new technologies such as drip-irrigation and plastic mulch. Therefore, organic sweet corn growers prefer the use of non-chemical methods such as coloured mulches for weed control. Black plastic is most effective in reducing weeds; but warms the soil in summer too. In order to evaluate effects of colored plastic mulches on weed control, a field experiment was conducted to,study the effects of growth and fresh ear of sweet corn at Islamic Azad University Varamin Branch, Iran, during summer 2010. Four plastic mulches including clear, black, blue, white on black and no mulched, weed free and weedy check were arranged within a randomized complete block design with four replicates. Weed control was satisfactorily provided by all mulches except clear plastic. Clear and blue mulches provided the greatest soil warming. The white on black plastic mulch had the highest plant height, leaf area and stem diameter. The highest fresh ear was recorded in black plastic mulch fallowed in white/black (23617 and 23396 kg ha^{-1}, respectively), although statistically there was no significant difference between mulch treatments. The greatest fresh seed yield was obtained in white/black plastic mulch. The white on black plastic mulch could be a good alternative to traditional plastic films for organic production in arid and semi-arid zones, because light reflection from the white surface leads to reduced soil temperature while the black surface prevents light transmission resulting in weed suppression.

Effect of peas and cereals intercropping on weed suppression

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Weeds are one of the major threats of crop production in organic farming. One of the options to manage weeds can be the use of intercrops. Intercrops can be combinations of annuals, perennials or a mixture of the two (or more) species (breed, type). When two or more crops are growing together, each must have adequate space to maximize cooperation and minimize competition between them. One of the most commonly used intercropping mixtures is the legume/nonlegume (usually cereal) combination. Grain legumes are weak suppressors of weeds, but mixing species in cropping system becomes a way to improve the ability of the crop itself to suppress weeds. The objective of the present study was to evaluate the effect of pea and spring cereals intercrop on weeds in organic farming conditions.

The field experiments were carried out in 2007–2010 at the Institute of Agriculture in Dotnuva and at the Joniskelis Experimental Station, Lithuanian Research Centre for Agriculture and Forestry. Spring wheat (*Triticum aestivum* L. emend. Fiori et Paol.), spring barley (*Hordeum vulgare* L.), spring oat (*Avena sativa* L.) and spring triticale (*x Triticosecale* Wittm.) were grown as intercrops and sole crops with field pea (*Pisum sativum* L. Partim). Intercrop design was based on proportional replacement principle, with mixed pea and spring cereals grains, sown at the same depth in the same rows at relative frequencies of 50:50. Weeds were assessed twice: at stem elongation growth stage (BBCH 32-36) and at development of grain filling growth stage (BBCH 73). Mass of weeds and botanical composition was determined in 0.25 m^2 at 4 settled places of each treatment. Weed number data were transformed to $\sqrt{x+1}$.

During the study period up to 14-25 weed species were obtained. Prevailing weed species were *Stellaria media* L., *Veronica arvensis* L., *Fallopia convolvulus* (L.) A. Löve, *Chenopodium album* L., *Lamium purpureum* L., *Viola arvensis* Murray, *Thlaspi arvense* L., *Galium aparine* L., *Fumaria officinalis* L., *Cirsium arvense* (L.) Scop., *Sonchus arvensis* L., etc. Both experimental sites were similar in weed species composition and amount of weeds. The ability of pea intercropped with cereal to suppress weed species was revealed at BBCH growth stage. It was revealed that total number of weeds in intercrops and sole cereal crops was significantly reduced as compared to the sole pea crop stand. However, intercrops and sole cereal crops exhibited similar weed suppression. Intercropping well suppressed those weeds: *G. aparine, C. album, T. arvense, F. officinalis.* Sole crops and intercrops showed low competitive ability against *F. convolvulus. C. arvense, S. arvensis* were more competitive against pea/oat intercrop and oat sole crop.

Sole cereals and pea / cereals intercrops provided better weed suppression than sole pea crop stand. The best weed suppression was exhibited by sole oat crop and its intercrop with pea. According to the reduction of weed number and mass, the intercrops were ranked in the following order: pea/oat > pea/wheat; pea/triticale > pea/barley. Sole cereal crops reduced weed mass more appreciably than intercrops. Crops had the lowest suppressive effect on perennial weeds as compared to annual crops.

Integrating preventive and curative non-chemical weed control strategies on concrete block pavements

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Reduction of herbicide use in non-agricultural areas is imposed by a growing number of governments, triggering the development of alternative strategies for weed prevention and control. In Flanders (Northern part of Belgium), the government has imposed a reduction program, with a complete phase out of herbicide use on public pavements by 2015. This study aimed to determine the weed preventive abilities of different paving types, the required treatment frequency of non-chemical weed control scenarios on these pavements and the associated species composition.

A test parking, comprising four paving types (block paving with drainage holes, concrete block paving with enlarged joints, porous concrete block paving and conventional, impermeable block paving), was sown with a mixture of seven dominant weed species. This was used to test curative scenarios: six scenarios with repeated use of one single weed control method (brushing, hot air, selective application of hot water and flaming at different energy doses) and two scenarios with alternating use of brushes and hot air. Treatments were repeated each time a predefined maximum weed coverage was exceeded, during two growing seasons. The energy dose applied by the weed control equipment was regulated by the driving speed and corresponded to the dose required to achieve a 80% reduction in weed coverage. Weed coverage (%) and weed composition were periodically recorded in 6 fixed quadrats per plot by using Image J software.

The paving types differed largely in weed coverage and required treatment frequency. Treatment frequencies were seven-to eleven-fold higher for conventional pavings, pavings with drainage holes and enlarged joints than for porous pavings, irrespective of the weed control scenario. Lowest frequencies were recorded for the hot water technique, irrespective of non-porous paving type. Frequencies of scenarios with hot air technique and flaming were similar. Compared to repeated use of a single weed control technique, the alternating use of brushes and hot air technique reduced treatment frequency by 10%. Shifts in weed composition occurred in plots treated repeatedly with the same technique due to the observed species-specific sensitivity to different modes of action (mechanical, thermal convective, thermal conductive) of the used techniques. Maintaining a more stringent level of tolerated weed growth, increased the treatment frequency only slightly but retained a better picture quality.

Overall, our results show that the combination of preventive (using suitable paving materials) and alternating curative methods with different modes of action allowed to keep weed growth controllable without herbicides for a period of two years with a minimum of treatments.

Determination of herbicidal and antifungal effects of *Salvia aethiops* (L.) and *Foeniculum vulgare* Miller subsp. *vulgare*

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This study was carried out to determine the herbicidal and antifungal effects of *Salvia aethiops* L. and *Foeniculum vulgare* Miller subsp. v*ulgare. F. vulgare* was collected from Kalınkoz village of Denizli and *S. aethiops* was collected from Tokat during the plants' flowering period in 2012. A water abstract of the aerial(shoot+leaves) parts of the plants was applied to the seeds of *Cardaria draba L., Rumex crispus L., Plantago major L., Lepidium sativum L., Triticium vulgare L.* in 0%, 1%, 2%, 4%, 8%, 10% concentrations in 9 cm diameter sterile disposable petri dishes. To evaluate the antifungal effect of *S. aethiops* and *F. vulgare* on the growth of *Alternaria solani, Rhizoctonia solani* and *Fusarium oxysporum* in vitro, potato dextrose agar (PDA) was amended with plant water extracts of 0%, 1%, 2%, 4%, 8% and 10% original concentration. Non amended PDA was used as a control. Mycelial discs of 5 mm diameter of pathogens were transferred to extract amended petri dishes. The experimental design was a randomized block design with four replications. Radial growth of the isolates were measured at the end of 7 days' incubation period at 25 ^{o}C. The percent inhibition rates of the extracts were calculated. Plant extractsreduced seed germination and shoot and root growth of test plants compared to the control. Also, depending on application dose, *S. aethiops* and *F. vulgare* inhibited mycelium growth of *A. solani, R. solani* and *F. oxysporum.*

Effect of P-enriched compost and green manure on maize weed density and composition

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The aim of this study was to explore the influence of hairy vetch (*Vicia villosa* Roth) used as green manure and different composts enriched in phosphorus on weed density and composition in grain maize. A plot trial was started in 2010 at the experimental farm of the University of Pisa (Italy). The experiment was laid out as a two-way randomised complete block design with three replications, in plots of 8x8 m. The first experimental factor was the presence or the absence of a hairy vetch cover crop, seeded in early autumn and ploughed under in April, which did not receive any fertilisation, crop protection or direct weeding interventions. The second factor was the use of compost from food and pruning wastes, which differed in preparation technique (phosphorite added or not). Compost was soil-incorporated at the time of cover crop termination. Weed species density was measured at maize 5-leaf stage in three 50x50 cm sampling areas plot^{-1}. Weed data were used to create a dissimilarity matrix used in Non metric MultiDimensional Scaling (NMDS). Weed diversity indices (Shannon's H', Pielou's J and Inverse Simpson) were calculated. Species density was partitioned into functional groups according to two response traits: (1) Raunkiaer life form, and (2) Grime CRS plant strategy. Weed relative density was used as independent variable in a two-way RCB ANOVA. Total weed density, species richness, and diversity indices were influenced neither by compost application and type nor by green manure. Weed community species composition was significant influenced by green manure application ($P<0.001$). Results showed that compost enhanced competitive (Grime) species emergency, while the use of Hairy Vetch as green manure depleted them. Furthermore the presence of Hairy Vetch as green manure increased the relative density of adventitious cosmopolite (Chorology), ruderal and competitive ruderal (Grime) species. Use of hairy vetch green manure strongly affected weed community composition and reduced abundance of *Cyperus esculentus*, one of the most troublesome weeds in the area.

Alcidodes chaudoiri Chevrolat (Coleoptera : Curculionidae), first record for biological control of *Convolvulus arvensis* L. (field bindweed) in Iran

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Convolvulus arvensis L. (Field bindweed) is an important weed in crop lands and is distributed throughout the world.
In order to evaluate biological control of this weed, during an investigation in summer 2010-2011, a seed weevil species was collected from inside of the seeds of *C. arvensis* L., in the region of Shiraz, Iran and was identified as *Alcidodes chaudoiri* chevrolat (Coleoptera: Curculionidae).
The percentage of seed damage was approximately 85% in 2010 and 94.2% in 2011. *A. chaudoiri* adults and larva feed on the content of the fresh *C. arvensis* seeds. The first larva was observed in the region in early July. This species is newly recorded from Iran.
The results showed that because of its impact on seed production, the field bindweed weevil may be a valuable candidate for biological control of *C. arvensis*.

Can polyethylene mulch improve the control of purple nutsedge (*Cyperus rotundus*) populations?

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Cyperus rotundus is the most troublesome weed species of vegetable crops in East of Iran. Polyethylene mulch is an effective barrier for most weeds; however, purple nutsedge may grow in beds covered with polyethylene mulch. Outdoor research was conducted to test the influence of polyethylene mulch on tuber sprouting and shoot production of different purple nutsedge populations over time.

A factorial experiment carried out with three replications at Birjand University Research Farm. Treatments included different polyethylene mulch including 1- layer clear polyethylene film, 2- layer clear polyethylene film, 1- layer black polyethylene film and 2- layer black polyethylene film as well as a non-mulched control and different populations including Birjand, Kahnooj and Jiroft. Experimental plots consisted of 40 x 40 x 40 cm boxes with one pre-sprouted tuber planted 2.5 cm deep in the center of each box. The study lasted for 60 days after planting and then tuber number, tuber weight, above- mulch shoot number and weight, below- mulch shoot number and weight were recorded.

Results showed that using polyethylene mulches significantly reduced tuber and shoot growth of all purple nutsedge populations. There were no significant differences between different populations in all measured traits. The most effective mulch type was 2- layer black polyethylene film, followed by 2- layer clear polyethylene film. Although employment of polyethylene mulching technique can control purple nutsedge growth through increasing soil temperature under the polyethylene film, it seems that increasing the physical potency of the mulch film would be an effective management tool against this weed species also.

Bioherbicidal activity and chemical composition of *Origanum hypericifolium* O.Schwartz & P.H.Davis essential oil

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The inhibitory effects of *Origanum hypericifolium,* an endemic plant species, essential oil on seed germination and seedling growth of different plant species were investigated. The essential oil was isolated by hydrodistillation of leaves and flowers. The chemical composition were determined by gas chromatography equipped with flame ionisation detector (GC-FID) and gas chromatography coupled to mass spectrometry (GC–MS). Plant materials used were collected from wild grown plants in the Aegon region of Turkey. Bioherbicidal effects of the essential oil were tested in 0-control, 0.5, 1, 2, 4 and 8 µl/petri dish doses against seeds of *Triticum aestium*, *Rumex crispus*, *Abutilon theophrasti, Lepidium sativum* and *Chenopodium album* in petri dishes. The main constituents of the essential oil were carvacrol (65.9%) and p-cymene (10.6%). The essential oil was highly phytotoxic to seed germination and seedling growth of tested plant species. The differences in mean germination time were also significant. The negative impact was progressively increased with higher doses, and seed germination was totally inhibited with the highest dose of essential oil.

Outcompeting ragweed - control of the invasive common ragweed (*Ambrosia artemisiifolia L.*) by vegetation management

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Ambrosia artemisiifolia L. (common ragweed) invades Europe causing health problems and crop yield losses. Spread along roadsides is one of the most efficient vectors throughout Europe. Control measures by vegetation management i.e., optimal cutting regime and enforcing competitive vegetation was tested in the greenhouse as well as at natural sites.

In a pot experiment we tested the competitive efficiency of grass mixtures sawn together with high or low ragweed densities (153 and 728 seeds/m^2, resp.). Two commercial seed mixtures differing in their respective quantities of competitive grasses and dicots like clover were selected to compete with ragweed. Ragweed population size and biometric variables (branching aspects, phenology, fecundity, etc.) were response variables measured before each cutting event and after the last cutting.

The seed mixture with higher proportion of Perennial ryegrass turned out to hamper rather effectively the germination of Ragweed under glasshouse conditions. Both tested mixtures caused 64 or 65 %, resp., ragweed mortality during the experiment. Therefore the effect of the 4 different cutting regimes applied was negligible. The total number of seeds averaged between 20 and 80 per individual, the lower value characteristic of the mixture with higher ryegrass content.

Sowing of competing vegetation on newly constructed roadsides under field conditions gave less impressive results in the first year.

Ragweed is a shading-intolerant plant and thus suffered from competing vegetation in all experimental designs with fostered competition.

Selective mowing of creeping thistle (*Cirsium arvense* (L.) Scop.) in winter wheat

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The control effects of a selective mower (CombCut©), which cuts *Cirsium arvense* (L.) Scop. (creeping thistle) in growing cereals without damaging the crop, are studied in two field experiments and one outdoor pot experiment 2011-2013 in Sweden. The hypotheses are that selective weed mowing decreases the ability of the weeds to compete and reproduce in a crop, decreases long-term development of the weed populations, and increase crop yields. The effects of selective mowing on *C. arvense* and winter wheat were determined by mowing at two different development stages of *C. arvense*. Statistical analyses were done by ANOVA and comparisons were made by Student *t*-test. In the pot experiment, root biomass accumulation of *C. arvense* over the season was significantly reduced after mowing. When competition from winter wheat was added, the root biomass reduction was even higher. The crop yields were, however, not affected by mowing. In the field experiments, above-ground weed biomass was reduced by mowing while no significant effects were obtained on the crop yield. This was probably due to large amounts of *C. arvense*. We conclude that selective mowing combined with crop competition decreases the abundance of *C. arvense*, both above and below ground, without damaging the crop.

Evaluation of some hybrid maize varieties for tolerance to *Striga hermonthica* in the Guinea Savanna Zone, Ghana

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Striga hermonthica is a parasitic weed and endemic in the semi-arid and semi-humid areas of Sub-Saharan Africa. This plant parasite, which attaches itself to the roots of plants and "sucks out" the nourishment, affects maize and sorghum, the major staple food source in the region. Yield losses of between 30% and 100%, worth US$1 billion, and affect the livelihoods of about 100 million people have been reported in endemic regions.

In Ghana, approximately 30% of cereal fields in the Upper East Region and 40% of maize fields in the three regions (Upper East, Upper West and Northern) are infested by *Striga* because of their nature of being soil-borne and their mechanism of parasitism alongside their tremendous genetic viability. *Striga* species are very difficult to control by any single control measure. Research on striga has been conducted at the Savanna Agricultural Research Institute (CSIR-SARI) in collaboration with Crops research institute (CSIR-CRI) and the Ministry of Food And Agriculture (MoFA). Technologies that have been evaluated on-farm for *Striga* control include the use of tolerant varieties, hand pulling, crop rotation with non-host plants and application of organic and inorganic fertilizer.

This research was conducted with the objective of identifying maize hybrids for *Striga* tolerance. The research was done at the experimental field of the CSIR-SARI at Nyankpala in the Northern Region of Ghana. Maize seeds of hybrids, open pollinated varieties and cultivars were obtained from the maize program of CSIR-SARI. Randomised complete block design was used with 37 genotypes with two replications Seeds were planted in two environments (artificially infested and no infestation). The infestation was done using a mixture of striga seed and sand. The ratio of the striga seed – sand mixture was about 1g striga to 99g sand. The sand – striga mixture was applied at approximately 2,500 germinal striga seeds to each maize hole. Data was recorded on the total number of *Striga* seeds that germinated and emerged in each hybrid variety and the number of plants that showed signs of scorching, wilting, yellowing of leaves, etc, as a result of striga influence in each genotype. This was done at eighth (8^{th}) and tenth (10^{th}) weeks after planting.

Out of the thirty seven (37) hybrid maize that were screened, thirteen (13) of them (V351 - 1/6*721 Cmp3, Exp 24*351 - 1/6, 9071 - M131, 9071*T2h Comp3, 9071*V481 – 73, M131*88094*9071, M131*1368*Entrada 29, Exp 24*87036*9071, 9021 - 18*88094*87036, 9021 - 18*88094*M131, 316 - 7*P43 SR C9 F5100 – 7, 9021 - 18*88094*M131, 87036*∫ - 16 - 1) were superior in grain production in spite of *striga* infestation. They were ranked high for agronomic score. This indicated that they were the type of varieties preferred by farmers, the thirteen hybrids are more tolerant to *Striga* than their counterparts. Therefore, they can be recommended for growing by farmers in *Striga* endemics.

Weed significance in archaeological sites

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The study includes the recording of spontaneous flora in seven archaeological sites. Archaeological sites, other than their historic and cultural value, enclose rich plant communities, as they are protected ecosystems. The purpose of the study is to analyze the plant communities that develop in archaeological sites, which will constitute the base for developing the weed management methodology in archaeological sites. The seven archaeological sites are: Early Christian Amfipolis (40°49'13.9''N, 23°50'51.7''E, alt 120 m), Forum of Thessaloniki (40°38'15.9''N, 22°56'45.2''E, alt 26 m), Nekromanteion of Acheron (39°14'10.4''N, 20°32'2.5''E, alt 40 m), Ancient Agora of Athens (37°58'30.1''N, 23°43'19.3''E, alt 57 m), Kolona, Aegina (37°45'0.6''N, 23°25'25.3''E, alt 2 m), Amfiareio, Oropos (38°17'28.4''N, 23°50'46.7''E, alt 145 m) and Ancient Messene (37°10'31.8''N, 21°55'13.7''E, alt 323 m). The Terrestrial Vegetation Monitoring Protocol, of the Ecological Monitoring and Assessment Network of Canada, was used for the recording of the species. The Protocol is based on quadrat sampling for the recordings. In each quadrat (50x50 cm), the coverage and abundance of each species was recorded, using the Braun Banquet scale. The plant species identification was based on Flora Europaea. The recordings took place in April and May of 2012. The data underwent simple descriptive statistical analysis. So far we have gathered 355 plant specimens and have identified 230 different taxa, while 53 more plant specimens are under identification. The species are divided among 38 plant families: who in declining order of participation are *Fabaceae* (23%), *Poaceae* (17%), *Asteraceae* (16%), *Plantaginaceae* (5%) and other families with less than 3% participation. The only species that appears in all six sites is *Avena sterilis* L. (0,4%), whereas 21,7% of the species appears in two to seven sites and 77,9% of the species appears in only one site. The richness of each site in plant species is expressed as the percentage of species that appear only in that site over the whole. By this criterion, in declining order of richness, the sites are: Amfiareio, Oropos 33%, Ancient Messini, 19%, Nekromanteion Acheron, 17%, Kolona Aegina, 10%, Ancient Agora of Athens, 10%, Early Christian Amfipolis, 9% and Forum of Thessaloniki, 5%. The richness in plant species can also be expressed based on the number of species that were recorded in each site. Basen on this the plant species richness classification of each site is similar to the one based on percentage of exclusive species. The number of species recorded in each site in declining order is: Amfiareio, Oropos, 100, Nekromanteio Acheron, 75, Ancient Messini, 72, Ancient Agora of Athens, 62, Kolona Aegina, 47, Early Christian Amfipolis, 43 and Forum of Thessaloniki, 32.

Flame weeding effects on some weed species

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Flame weeding is an important alternative weed control method to herbicides. Because, flaming provides rapid weed control and does not leave residues. In organic farming, flame weeding is also an important alternative when mechanical methods are less effective. In this study, experiments were conducted to determine the influence of weed developmental stage and time of exposure to heat on weed control efficacy in comparison with herbicide (glyphosate). For this purpose, response to flaming was evaluated on six common weed species: common lambsquarters (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), black nightshade (*Solanum nigrum*), common cocklebur (*Xanthium strumarium*), prickly lettuce (*Lactuca serriola*) and swallow wort (*Cynanchum acutum*). Weed species were marked at two different developmental stages (to be different for each species) in fields. The growth stages of each weed species were based on number of leaves. Flame treatments were performed using a hand-held, unshielded 63 mm diameter single burner system. The burner positioned 20 cm above weed surface and angled horizontally at 30º. The application speeds (conducted by walking) were 1,5 and 3,0 km h^{-1}. Flame was applied with two bar pressure (200 kPa) on weed species at two different developmental stages. The fuel consumption of burner with two bar pressure is 8.9 kg/h. In the herbicide group, glyphosate was applied at the recommended dose depending on the weed species (300 ml/da for annual weeds, 600 ml/da for perennial weeds) simultaneously with the application of flaming. Weed species were observed on 1^{st}, 3^{rd}, 7^{th} and 14^{th} days after treatment (DAT) and visually evaluated according to a scale from 0 to 100%, where 0 represented no plant injury and 100 represented plant death. End of the visual observation (at 14 DAT), weeds were harvested from fields and dried for 72 hours in 65 °C to determine dry weight. The experimental design was a completely randomized with ten replications. Weed response to broadcast flaming varied dependent upon weed species, developmental stage and duration of flaming. According to the data of dry weight; flaming of both application speeds controlled by 100% at both growth stages of common lambsquarters (2-4 / 6-8 leaves stage), redroot pigweed (2-4 / 6-8 leaves stage), black nightshade (4-6 / 8-10 leaves stage) and common cocklebur (0-2 / 4-5 leaves stage). Swallow wort was controlled by flaming in both application speeds approximately 80% and 90%, respectively in both developmental stages (4-6 / 8-10 leaves stage). Prickly lettuce at first growth stage (2-4 leaves) was controlled by flaming at 100%, but at second growth stage (6-8 leaves) this proportion reduced by up to 48%. Therefore, it is understood that, growth stage is very important for prickly lettuce control by flaming. There were no differences in terms of efficiency between application speeds of flaming in all weed species. Herbicide gave good result as much as flaming for all species except common cocklebur and swallow wort. These results show that flaming has an excellent potential for weed control, especially for annual weed species.

Investigation of the allelopathic effect of some plant oils on germination of common vetch (*Vicia sativa*) and redroot pigweed (*Amaranthus retroflexus*)

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Common vetch (*Vicia sativa* L.) and redroot pigweed (*Amaranthus retroflexus* L.) are important weed species which are a problem in many crops. In this study the allelopathic effects of plant oils belonging to different plant species on seed germination of common vetch and redroot pigweed were investigated. For this purpose, 12 different plant species (anise (*Illicium verum* Hook.f.), fennel (*Foeniculum vulgare* Mill.), castor oil plant (*Ricinus communis* L.), mustard (*Brassica alba* L.), black seed (*Nigella sativa* L.), clove (*Syzygium aromaticum* (L.) Merrill & Perry), eucalyptus (*Eucalyptus globulus* Labill.), peppermint (*Mentha piperita* L.), basil (*Ocimum basilicum* L.), orange (*Citrus sinensis* (L.) Osbeck.), grapefruit (*Citrus paradisi* Macfad.), lemon (*Citrus limon* (L.) Burm.f.))'s oils obtained by steam distillation and cold pressing methods were applied at various doses on seeds of these two weed species. Twenty-five seeds for common vetch and a hundred seeds for redroot pigweed put into each nine cm diameter sterile petri dishes. Different doses (0, 5µℓ, 10µℓ and 15µℓ) of plant oils were mixed with 10 ml pure water and applied to petri dishes. Seeds of common vetch and redroot pigweed were left to germinate at 20 °C and 30 °C, respectively. The seeds were counted on the 3rd, 5th, 7th, 10th, 14th and 19th days from the beginning of the experiment and when their radicula length reached to 0.5 cm, accepted as germinated. As a result of the experiment, *Amaranthus retroflexus* was determined to be more sensitive to plant oils than *Vicia sativa*. All plant oils (except *Ricinus communis* oil) inhibited germination of *Amaranthus retroflexus* at different concentrations. The most effective plant oil was found to be from *Syzygium aromaticum* against to redroot pigweed and then decreasingly effective were *M. piperita, I. verum, F. vulgare* and *O. basilicum*. *S. aromaticum* oil reduced germination of *Amaranthus retroflexus* by 7%, 99% and 100% at the rate of 5µℓ, 10µℓ and 15µℓ, respectively. *Mentha piperta* was found to be one of the most effective species against redroot pigweed. The oil of peppermint reduced germination by 56%, 64% and 96% at the rate of 5µℓ, 10µℓ and 15µℓ, respectively. *Vicia sativa* was affected by just clove and peppermint oils. Reduction of germination by clove oil at the rate of 5µℓ, 10µℓ and 15µℓ was 96%, 96% and 100% respectively. Peppermint oil caused reduction of germination by 0%, 8% and 56% at the same ratio respectively. The efficacy ratio of the other species on germination of common vetch remained between 0% - 8% level at the highest dose. In conclusion, oil of *Syzygium aromaticum* was found the most effective plant oil among the tested plants for both weed species and it is promising that can be used in practice. Therefore, field experiments should be done.

Bioherbicidal activity and chemical composition of coriander (*Coriandrum sativum* L.) essential oil

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The inhibitory effects of *Coriandrum sativum* essential oil on seed germination and seedling growth of five plant species were investigated. The essential oil was isolated from seeds, collected from the Aegean region of Turkey, by hydrodistillation. The chemical composition were determined by gas chromatography equipped with flame ionisation detector (GC-FID) and gas chromatography coupled to mass spectrometry (GC–MS). Bioherbicidal effects of the essential oil were tested in 0-control, 0.5, 1, 2, 4 and 8 µl/petri dish doses for seeds of *Triticum aestium*, *Rumex crispus*, *Abutilon theophrasti, Lepidium sativum* and *Chenopodium album* in petri dishes. The main compounds of the essential oil were linalol (71.7%), trans-anethole (15.9%) and alpha pinene (1.8%). Although statistically significant differences in bioherbicidial effects were observed among tested plants, the essential oil was highly phytotoxic on seed germination and seedling growth of the tested plant species. Mean germination time was also negatively influenced by the essential oil application. This negative impact was progressively increased with higher essential oil doses. Seed germination was totally inhibited with the highest doses of the essential oil.

Phytotoxic effect of essential oils from temperate climate herbs against selected weed species

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In recent yearsinterest in ecological methods of weed management has increased. Among them an important role is played by chemicals extracted from plants of known or observed allelopathic potential. Essential oils, composed of various groups of chemicals, are the crucial component of medicinal plants. They show mostly antibacterial and antifungal properties, and recently also their insecticidal and phytotoxic potential has been shown i.e. clove oil or lavender oil.

This study aimed at assessing the phytotoxic potential of essential oils extracted from nine herbal species, cultivated and wild ones, from a temperate climate against seeds of six weed species.

Herbal plants were collected from south-eastern Poland in June-August 2011, and their essential oils were extracted using Clavenger apparatus. There were 9 essential oils tested in the experiment: mint, lavender, cumin, lemon balm, thyme, sage, chamomile, calamus and tansy. In a Petri dish bioassay their phytotoxic potential was tested against six common weeds of temperate climate: *Avena fatua*, *Apera spica-venti*, *Bromus secalinus*, *Amaranthus retroflexus*, *Chenopodium album* and *Centaurea cyanus*. There were 6 doses of each of oil used and control (distilled water with 5% acetone): 0.2; 0.4; 0.6; 1.2; 2.4; 7.2 g/L. After 6 days of growth the percentage of germinated seeds, their root and coleoptile length were measured. The experiment was repeated twice. The chemical composition of essential oils was assessed using GC/MS method. The statistical analysis was carried out using a non-linear regression.

The effect of the essential oils depended both on kind of oil and on concentration. The most effective turned to be the cumin and mint oils. Two higher doses totally inhibited the germination of seeds of most of the weed species. *Avena fatua* turned to be sensitive just to the cumin oil.

Bioherbicidal activity and chemical composition of *Laser trilobum* (L.) Borkh essential oil

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The inhibitory effects of *Laser trilobum* essential oil on seed germination and seedling growth of different plant species were investigated. The essential oil was isolated from seeds by hydrodistillation. The chemical compositions of essential oil were determined by gas chromatography equipped with flame ionisation detector (GC-FID) and gas chromatography coupled to mass spectrometry (GC–MS). The seeds were collected from plants found in uncultivated land of Aegean region, Turkey. Bioherbicidal effects of the essential oil were tested in six concentrations (0-control, 0.5, 1, 2, 4 and 8 µl/petri dish) against seeds of *Triticum aestium*, *Rumex crispus*, *Abutilon theophrasti, Lepidium sativum* and *Chenopodium album* in petri dishes. Peril aldehyde (70.5%) and limonene (11.5%) were the main components of the twelve constituents characterized in the essential oil. The essential oil was highly phytotoxic on seed germination and seedling growth of tested plant species. Mean germination time was also negatively affected by the essential oil. However the differences were observed among tested plants. The negative impact was progressively increased with increasing essential oil doses. The seed germination was totally inhibited with the highest dose.

Prevention of weed invasion through small vehicles in Queensland, Australia

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Spread of invasive weeds through small vehicles is an important vector of seed spread in Queensland, Australia. For the prevention of alien weed seed spread > 80 wash down facilities have been built near the alien weed infested areas in Queensland. Experiments were conducted to see the efficiency of fixed and portable wash down facilities. It has been found that washing vehicles coming from weed infested areas at a wash down facility significantly reduces the chance of weed seeds being spread, however the standard times suggested for their use seem to be inadequate to remove weed seed loads. Depending upon the locality, weed infestation, types of vehicle, soil and water availability (i.e. mud available), both kinds of portable wash down facility tested (*i.e.*. high pressure-low volume and low pressure-high volume systems) are effective in cleaning mud and seeds from vehicles, however less water is used to achieve a good result with the high pressure-low volume system but it has to be used over a longer time. With respect to fixed, road-side wash down facilities in Australia, when using such systems the time of washing needs to be at least 15 or 20 minutes. Operated in their present condition, are not so effective in removing dicot seeds as they are in removing monocot weed seeds from vehicles. To overcome this problem and to improve wash down efficacy, vehicles could be pre-washed for a short period of time and left to stand for a few minutes, before the actual washing takes place. In summary, it is clear that the prevention of the spread of weed seeds is far better than to managing the weeds once they have spread to new locations.

Effect of some physical and mechanical weed control methods on some perennial weed species in tomato fields in Turkey

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Weed management is often the most troublesome problem in organic farming, especially in poorly competitive crops like vegetables. Especially perennial weeds are the most problematic in cultivated areas and cause serious yield losses because of their competitive ability. Physical weed control methods are the most commonly recognized methods as alternatives to herbicides for weed management.

This study was conducted to determine the effect of some weed control methods used in organic farming against weeds in field tomato in Adana provinces of Turkey in the years 2008-2009. Applied methods in the study were; mulching (mulch textile, corn stalks mulch and peanut shell mulch), hoeing (hand hoe, push hoe, cultivator, rotary cultivator) and brushing (horizontal rotating brush weeder). *Sorghum halepense* (L.) Pers., *Cyperus rotundus* L. and *Convolvulus arvensis* L. were identified as dominant perennial weeds in the trials. Mechanical methods were applied three times at 2 weeks intervals. Weeds were assessed before the application of the methods. Effects of the applications on these weed species were determined in both the intra-row and inter-row spaces, effectiveness on tomato yield was also recorded.

As a result, mulch textile (geotextile) was been the most effective application against these perennial weeds both intra and inter row areas, besides cultivator and rotary cultivator that were markedly effective against inter row weeds. In addition, the highest values in terms of tomato yield were obtained using hand hoeing, rotary cultivation and mulch textile applications.

Progress in the classical biological control of non-native invasive weeds in Europe

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Riparian systems have long acted as corridors for the spread of non-native plant species throughout Europe. The impacts these species have on inherently sensitive ecosystems can be profound and include reduced biological diversity, increased flood risk, increased bank erosion, reduced access and land devaluation. Due to the large geographical occurrence of some invasive weed species, and the need to control these species on a catchment scale, over the last decade classical biological control has received increased attention in Europe. This approach targets non-native invasive plant species in their exotic ranges through the introduction of natural enemies (arthropods or fungi) from the native range. As a management tool, classical biological control constitutes an environmentally friendly and less labor-intensive approach compared with the more traditional methods of mechanical and chemical control, if indeed the latter is even permissible.

This paper will review the present situation using the programmes against *Fallopia japonica* and *Impatiens glandulifera* in the UK as case studies. In 2010, the host specific psyllid *Aphalara itadori* was released against *Fallopia japonica* in the UK following extensive evaluation and public consultation. The psyllid is now the subject of an intensive monitoring programme designed to assess establishment, efficacy and safety in the field. For *Impatiens glandulifera*, agent prioritisation through field observations and host range testing has prioritised the rust pathogen, *Puccinia komarovii*. This autoecious, macrocyclic pathogen shows great promise, not only due to its impact on the host but also due to its high specificity as observed in the field and under experimental conditions. In this paper, we will contrast the techniques and processes adopted for determining the host specificity of arthropod and pathogen biocontrol agents as well as presenting the latest data. Finally, we will highlight other weed species that are currently targets in weed biocontrol programmes in Europe and review the potential of adopting this method to other widespread problematic weed species, especially those impacting on Water Framework Directive requirements.

The leaf-spot pathogen *Mycosphaerella polygoni-cuspidati* Hara – an additional tool in the box for the integrated management of Japanese knotweed?

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Following its introduction for ornamental purposes in the 19th century Japanese knotweed (*Fallopia japonica* Houtt.) has become a serious invasive species throughout Europe, as well as in many parts of the US and Canada. Today, it ranks amongst the world's top 100 invaders. In Japan *Fallopia japonica* is a pioneering colonizer of disturbed volcanic habitats and riparian ecosystems as part of the native flora. Conversely, characterized by its vigorous growth and rapid rhizomatous spread Japanese knotweed forms dense monocultures in its exotic ranges impacting severely on native biodiversity and causing extensive damages to local infrastructures. The annual cost to the British economy alone is estimated as £166 million. Current control methods, based predominantly on mechanical and chemical means, are both labour intensive and expensive and usually require repeated applications in order to be effective. Classical biological control using coevolved, host-specific natural enemies from the native range of an invasive species can be an economic and self-sustainable method of weed control, and thus lends itself as an ideal additional tool for the integrated management of Japanese knotweed in its introduced ranges.

A classical biocontrol programme against *Fallopia japonica* commenced in the UK in 2003 and identified two promising natural enemies associated with the species in Japan: the psyllid, *Aphalara itadori,* and the leaf-spot pathogen, *Mycosphaerella polygoni-cuspidati.* Prioritized research into the potential and safety of the psyllid led to its approval for release in the UK in 2010. Initial evaluation of the *Mycosphaerella* leaf-spot was undertaken up to 2008, and has recently re-commenced with renewed UK government funding available in 2012.

This poster will give a brief summary of the research undertaken into the taxonomy, infection biology and host specificity of the pathogen during the first project phase and give an update on the current studies into the potential of *Mycosphaerella polygoni-cuspidati* as an additional biological control agent for Japanese knotweed.

Biological control of downy brome (*Bromus tectorum*) using wheat rhizosphere bacteria in Fars province

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Deleterious rhizosphere inhabiting bacteria (DRB) have the potential to suppress plant growth. This study focuses on the isolation of DRB with potential to control downy brome. Bacteria were isolated from the rhizosphere of seedling wheat in Fars. Rapid screening techniques were developed to evaluate the effects of bacteria on downy brome in the laboratory and growth chamber. Four strains were identified using the biology system as *Bacillus* sp., one strain of *Pantoae* sp. and one strain of *Pseudomonas* sp. . All of strains specifically *Pseudomonas* sp. inhibited downy brome roots. This study suggested manipulation of the weed seedling rhizosphere using identified DRB as a potential biocontrol agent for downy brome. This is the first report of *Pseudomonas* sp., *Pantoae* sp. and *Bacillus* sp. associated as biocontrol agent in Iran.

Effect of non-chemical weed control treatments and bioorganic fertilization on weeds, nematode (*Tylenchulus semipenetrans*) and yield of mandarin trees

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Organic crop production, whether for export or local consumption, is increasing to avoid the residual effects of synthetic chemicals in foods, soil and water. Organic farmers consistently ranked weed management as one of their most important production problems. Therefore, combined safety methods of weed control and bio-organic fertilizers were designed to produce healthy fruits free from the biomagnified agrochemical residues.
A field experiment was carried out in sandy soil to study the effect of nonchemical weed control treatments (mechanical and black or white plastic mulch) and different composted plant wastes (rice straw, maize stalk or crop weeds) in the presence or absence of multi-biofertilizers and their interactions on the weeds, citrus nematode and fruits yield of mandarin trees. Chemical analysis of artificial used composts after fermentation was determined. Weed density (%), the dominant weeds and soil and root nematodes were recorded. At harvest, diameter, height, weight and TSS of fruit as well as fruit number and yield/tree were recorded. The data from replicated experiments were combined, and after analysis showed no significant year by treatment interactions and the means were compared by LSD test.
The results indicated that *Cynodon dactylon* (L.) Pers., *Echinochloa colonum* (L.) Link, *Amaranthus retroflexus* (L.), *Portulaca oleracea* (L.), *Panicum repens* (L.) and *Cyperus rotundus* (L.) were the dominant weeds in the citrus orchard. Covering the soil of mandarin grove with black plastic mulch recorded the lowest weed density and reducing number of nematode (*Tylenchulus semipenetrans*) and consequently produced the highest fruit yield/tree, followed by white plastic mulching treatment. Addition of the biofertilizer to the compost had an insignificant effect on the weed density. The use of composted rice straw in the presence of biofertilizer under white plastic mulch attained 6 times superiority for controlling the citrus nematode comparing to without biofertilizer application. Generally, the association action between composted plant wastes and biofertilizer led to increase the number and fruits yield under different weed control treatments. On the other hand, composted weeds recorded the greatest fruits yield under black plastic mulch. The treatments of chicken manure and composted rice straw without biofertilizer addition surpassed the chemical treatment in fruit yield by 34.9 and 14.0%, respectively. While, application of maize straw compost caused a reduction in the fruit yield by 8.1%. The highest TSS in fruits was observed with rice straw compost + biofertilizer under white plastic mulch treatment.

These results demonstrate that the most promising combination treatment was associating of weeds compost or chicken manure plus biofertilizer with covering the soil with black plastic mulch could be used effectively for producing the highest safety fruits production in citrus groves.

Bio-Herbicidal Potentials of Sweet Marjoram (*Origanum majorana* L.) and Thyme (*Origanum syriacum* L.) Essential Oils and Hydrosols

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To develop environmentally friendly control methods to replace synthetic chemicals which may be misused and cause problems to the environment and human health is important for sustainable agriculture. In this study, essential oils with the doses of 0.5, 1, 2, 4, 8, 16 and 32 µl/petri dish (µl/100 ml) and hydrosols with the doses of 0.25, 0.5, 1, 2, 4, 8 and 10 ml/petri dish (ml/100 ml) of thyme (*Origanum syriacum* L.) and sweet marjoram (*O. majorana* L.) were used for germination studies on *Amaranthus retroflexus* L. (redroot pigweed), *Portulaca oleracea* L. (common purslane), *Physalis angulata* L. (cutleaf groundcherry), *Echinochloa colonum* (L.) Link. (barnyard grass) and *Solanum nigrum* L. (black nightshade)' as weeds and *Gossypium hirsutum* L. (cotton), *Zea mays* L. (maize), *Lycopersicon esculentum* Miller (tomato), *Lactuca sativa* L. (lettuce) and *Petroselinum crispum* (Miller) A.W. Hill. (parsley) as crops. On average, essential oils of *Origanum syriacum* and *O. majorana* were found to be highly effective inhibitory (>50%) agents for weed seeds. Especially *S. nigrum* and *P. angulata* were affected in higher doses(>90%), followed by *E. colonum*. *A. retroflexus* and *P. olearecea* were affected in lower ratios. Both of the essential oils show differential phytotoxicity on crop seeds. *Lactuca sativa* and *P. crispum* were very susceptible while *Z. mays* was relatively resistant (<40%). The effects of the hydrosols appeared to be less than that of the essential oils. Hydrosols' effects on both the weed seeds and the crop seeds were similar. *Amaranthus retroflexus* and *P. oleaecea* were observed to be affected in lower ratios. On the other hand, *S. nigrum*, *E. colonum* and *P. angulata* were affected significantly.

Effect of cutting regime on common ragweed (*Ambrosia artemisiifolia* L.) dry matter and seed production

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Common ragweed (*Ambrosia artemisiifolia* L.) is a major weed of agronomic crops, and due to the production of allergenic pollen, it is also considered to be a serious public health problem. Common ragweed is particularly abundant along the roadsides and non-agricultural areas, where mainly mechanical measures are implemented to prevent ragweed flowering and seed production. To determine optimal cutting regime, a pot experiment with randomized treatments in 5 replications was conducted in 2011. Factors tested were ragweed developmental stage at first cut (V10, V20 and V30), cutting height (4 and 8 cm), competition (*Lolium perenne* L.*, Conyza canadensis* L. and *Chenopodium album* L.) and time interval between two consecutive cuts (5 and 10 weeks). Data were analyzed with multifactor ANOVA and means were compared with Tukey HSD test at 0.05 probability level. Ragweed developmental stage at first cut, competition and time interval between two cuts significantly influenced dry matter production ($P < 0.001$). The greatest dry matter reduction after cutting was determined, when ragweed was grown in the mixture with ryegrass. Cutting height (4 and 8 cm) influenced ragweed dry matter and seed production only when ragweed in monoculture was grown in the pots ($P < 0.001$); it increased at lower mowing height. Dry matter and seed production of ragweed significantly decreased with ragweed first cut at later growth stages and increased period between two cuts ($P < 0.001$). For optimal results first mowing of ragweed should be performed at later growth stages. Our results indicate that pollen and seed production can be completely prevented with two optimal cuts at specific growth stages.

Determination of micro fungi species on weeds in Dicle University campus

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This study was performed to detect the micro fungi on the weeds becoming a problem on fields of the University Campus. In total 31 different species of micro fungus were detected on a total of 28 weed species in the Campus fields. Three microfungi species, *Puccinia montana* Fuckel, *Cercospora sorokinii* Sacc. and *Puccinia xanthii* Schwein were detected on respective hosts , *Centaurea balsamita* Lam., *Convolvulus arvensis* L. and *Xanthium strumarium* L. These three fungi have been identified as the most common species. Micro fungi of University campus area *Albugo candida* (Pers.) Roussel, *Alternaria alternata* (Fr.) Keissler, *A. amaranthi* (Peck) J.M. Hook., *Cercospora sorokinii* Sacc., *Erysiphe cichoracearum* DC. var. *cichoracearum, E. convolvuli* DC., *E. cruciferarum* Opiz Ex Junell, *Leveillula taurica* (Lév.) G. Arnaud, *Neoerysiphe galii* (S. Blumer) U. Braun, *Peronospora cephalariae* Vincens, *P. farinosa* (Fr.) Fr., *P. lallemantiae* Kolymb., *P. narbonensis Gäum*., P. parasitica (Pers.) Fr., *Puccinia bromina* Eriks, *P. calcitrapae* DC., *P. cirsii* Lasch., P. isiacae (Thüm) Winter in Kuntze, *P. malvacearum* Mont., *P. montana* Fuckel, *P. phragmitis (Schum) Koern., P. taraxaci* (Reb) Howr., *P. xanthii* Schwein, *Pyrenophora chaetomioides* Speg., *Sphacelotheca reiliana* (J.G. Kühn) G.P. Clinton, *Sporisorium cruentum* (J.G. Kühn) Vánky, *Uromyces gypsophilae* Cooke, *U. haussknechtii* Tranz*., U. polygoni-avicularis* (Pers.) P. Karsten, *Ustilago cynodontis* (Pass.) Henn., *Wilsoniana bliti* (Biv.) Thines were determined on the weeds *Portulaca oleracea* L., *X. strumarium* L., *Amaranthus retroflexus* L., *Convolvulus arvensis* L., *Sonchus* sp., *C. arvensis* L., *Sinapis arvensis* L., *Lactuca serriola* L., *Galium aparine* L., *Cephalaria syriaca* (L.) Schrad., *Chenopodium album* L., *Lallemantia iberica* (Bieb.) Fisch.&Mey., *Vicia narbonensis* L., *Myagrum perfoliatum* L*., Bromus sterilis* L., *Carduus pycnocephalus* L., *Notabasis syriaca* (*L*.) Cass., *Cardaria draba* (L.) Desv., *Alcea* sp.; *Malva* sp., *Centaurea balsamita* Lam., *Phragmites australis (Cav.) Trin, Taraxacum officinale L*., *X. strumarium* L., *Avena sterilis* L., *Sorghum halepense* (L.) Pers.,*S. halepense* (L.) Pers., *Vaccaria pyramidata* Medik., *Euphorbia* sp., *Polygonum aviculare* L., *Cynodon dactylon* (L.) Pers., *A. retroflexus* L.,respectively. In addition, *P. xanthii on X. strumarium* was an important pathogen suppressed to development of host plants in field conditions. Some morphological characters based on light microscopes and photographs were given in the text.

Determination of fungal diseases on cotton weeds in Diyarbakır province

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This study were conducted to determine prevalence and incidence of micro fungi on weeds of cotton fields during 2008 and 2009 years. According to survey results, totally 23 different fungal microorganisms were found on 19 different weed species. Rust, mildew, powdery mildew and other fungal agents were identified during studies. In this study 5 fungal microorganisms, *Passalora ferruginea, Peronospora farinosa, Curvularia inaequalis, Uromyces haussknechtii, Sphacelotheca reiliana* were found on their respective hosts, *Artemisia vulgaris* (mugwort), *Chenopodium album* (goosefoot), *Digitaria sanguinalis* (hairy finger grass), *Euphorbia* sp. (spurge), *Sorghum halepense* (johnson grass) as new records for Turkey. In addition, these three weeds, *Amaranthus retroflexus* (common amaranth), *Solanum nigrum* (black nightshade) *and, Xanthium strumarium* (cocklebur) were new host records for *Alternaria amaranthi, Cochliobolus spicifer, A. alternata,* respectively. Moreover, *Albugo bliti, A. candida, A. alternata, A. amaranthi, C. spicifer, Coleosporium datiscae, C. inaequalis, Deightoniella arundinacea, Erysiphe convolvuli, E. cichoracearum, Fusarium proliferatum, Melampsora gelmii, P. ferruginea, P. farinosa, Puccinia malvacearum*, *P. phragmitis, P. vagans, P. xanthii, Scirrhia rimosa*, *S. reiliana, Sporisorium cruentum, U. haussknechtii, Ustilago cynodontis* were determined on *A. retroflexus, Portulaca oleracea, X. strumarium; Polygonum aviculare, A. retroflexus, S. nigrum; Convolvulus galaticus; Physalis* sp., *Datisca cannabina, D. sanguinalis, Phragmites australis*, *C. arvensis, X. strumarium, S. halepense, Euphorbia helioscopia, A. vulgaris, C. album, Malva* sp., *P. australis*, *Epilobium parviflorum, X. strumarium, P. australis*, *S. halepense, S. halepense, Euphorbia* sp., *Cynodon dactylon* respectively. In addition, *Puccinia xanthii on X. strumarium* was an important pathogen suppressed to development of host plants in field conditions.

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Effect of plastic mulch and planting bed shape on weed growth and maize (*Zea mays* L.) yield

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Basically, three major colours of plastic mulches have been used commercially: black, clear, and white (or white-on-black). Black, white-on-black, and silver-on-black mulches greatly inhibit light penetration to the soil. Therefore, weed seedlings cannot survive under the mulch. Mulching with plastic nsheets (white-on-black plastic, bare soil and weedy check) on three bed shapes (furrow, flat ground and raised bed) were evaluated for their effects on weed growth and yield of maize. Soil temperature raised 3 to 4 ˚C under plastic relative to bare soil. Weed dry weight significantly ($p < 0.01$) decreased 5 weeks after seeding with white-on-black plastic mulch (95.7 and 97.5%, respectively compared with weedy plat). The lowest weed dry weight was although recorded in furrow with mulch, the highest crop seed yield and plant biomass (11031.6 and 28018 kg ha^{-1}, respectively) was obtained in flat ground combined with plastic mulch. The use of white/black plastic mulch and flat bed mulch can be useful for weed control and low tillage systems.

Determination of weeds and control of management on organic sweet cherry production in Konya (Akşehir) province

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This study was carried out during 2003-2004 in Konya (Akşehir) province. Organic agricultural and Integrated pest management in cherry orchards were determined on species and density existing weeds and it was controlled in Akşehir. The studies on integrated pest management orchard was carried out for compare. The density weeds were determined *Veronica hederifolia* (Ivy speedwell), *Lolium multiflorum* (Italian rye grass), *Lamium purpureum* (Red deadnettle), *Lactuca serriola* (Oil lettuce), *Trifolium pratense* (Meadow clover) in organic cherry orchard. Weeds which adduced irregular distribution in Integreated pest management cherry orchard *Malva neglecta* (Dwarf mallow), *Plantago major* (Broadleaf plantain), *Geranium* sp., *Ornithogalum umbellatum* (Onion plant), *Atriplex patula* (Spreading orache) and *Galium* sp. were determined.
Control of the weeds in organic cherry orchard, although weeds were covered high rates the soil, once twice cutting and projection of trees was cleaned and weed bands among of the trees was set to protect natural enemies and soil structure. This applies were enough to control weeds in organic cherry orchard.

Transplanting vegetable plants in crimper-rolled winter rye

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The use of cover crops, a living ground cover, for weed suppression is a method that requires less mechanical intervention than tilling. If managed appropriately, cover crops can provide numerous benefits such as a reduction in soil erosion and nutrient loss, an increase in carbon sequestration and an improvement on soil physical health. A particularly promising cover crop is winter rye (*Secale cereale* L.). Rye is able to produce considerable biomass and is very winter-hardy allowing it to be planted in fall which enables it to provide weed control in early spring. Rye mulch can also suppress weeds chemically by producing several allelopathic organic acids that collectively disrupt physiological processes. The purpose of this project was to determine the effect of crimper-rolled winter rye as a cover crop on weed control and transplanted vegetable crop productivity. This project was established at the Platform for Innovation in Organic Agriculture, in St-Bruno-de-Montarville, Québec, Canada. The field crop production methods followed organic agriculture specifications. The experiment was conducted over 3 years in the field. In the first year, winter rye was seeded in September and the following spring, the rye was crimper-rolled in early June at the anthesis stage using a crimper-roller leaving its residues on the surface as mulch. Afterwards, vegetable crops of different families were directly transplanted in the crimper-rolled rye mulch. The transplanted crops were: a Brassicaceae (broccoli), a Solanaceae (pepper), an Alliaceae (onion), and a Cucurbitaceae crops (melon and squash). Five experiments were carried out, one for each crop. The experimental design was a randomized complete block replicated 4 times. Each vegetable crop received four different weed control treatments: (1) crimper-rolled rye, (2) mechanical weeding, (3) hand weeding, and (4) weedy-check (control). The average dry biomass of rye produced through the different protocol was 8.3 ± 1.3 t/ha. Results indicate that vegetable crop productivity does not increase when transplanted into crimper-rolled winter rye. Marketable yield in crimper-rolled rye treatment was reduced by 65, 93, 100, 99, and 86 % respectively for onion, melon, squash, pepper, and broccoli compared with mechanical weeding treatment. The rye mulch did not provide sufficient weed suppression towards the end of the growing season. It controlled weeds for about a month, after that, hand weeding was required. According to our results, crimper-rolled winter rye is not a recommendable technique for transplanted vegetables.

Root extracts of *Ailanthus altissima* have a strong inhibitory effect on the growth of *Amaranths retroflexus*

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Ailanthus altissima (Tree of the Heaven) is an invasive tree that has been proven to have allelopathic components. We investigated the herbicidal effects of the different parts of this tree (root, bark, fruit and leaf) on the 3-week- old seedlings of *Amaranths retroflexus*, *Echinochloa colonum*, Zea mayz, *Carthamus tinctorius*. The extracts were sprayed post-emergence at different rates. Regardless of the rate, the extracts of the roots were more suppressive on the growth of *A. retroflexus* compared to the other seedlings. It could suppress the growth of *A. retroflexus* up to 80%. This is the first step in our ongoing study. The next step of our study would be how we can incorporate the extracts or residue of this tree in our weed management program in corn or sunflower field.

Field observations in Central Turkey on *Lasiosina deviata* Nartshuk, a clerid stem boring fly potential biocontrol agent of *Lepidium latifolium*.

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Perennial pepperweed (PPW), *Lepidium latifolium* L. (syn.: *Cardaria latifolium*), (Brassicaceae) is a herbaceous, semi-woody perennial weed, native of Central Asia, that typically reaches 0.5–1.5 m in height and reproduces vegetatively and by seed. The weed is often associated with mesic habitats, such as river banks, drainage ditches, and subirrigated pastures and hay meadows. However, it can invade a wide range of habitats including pastures, open fields, roadsides and residential areas. PPW is highly competitive and invasions result in dense monocultures and subsequent loss of biodiversity through the exclusion of native vegetation and eliminating shading for fish and aquatic insects.
Starting from 2007, CABI and BBCA decided to share resources and collaborate closely in their effort towards developing a biological control program for *L. latifolium*. Consequently, field surveys have been conducted in Eastern Europe, Asia Minor and Central Asia. Several potential candidate agents have been detected and screened for their host specificity: among them, four have been selected, two tweevil, an eriophyid mite and a stem boring fly for their potential high specific host range. In particular, the stem boring clerid fly *Lasiosina deviata* Nartshuk was recorded very often in large numbers in Central Turkey, North-Western China and South-Eastern Kazakhstan.
The high fitness of the fly species, and the close cooperation with Turkish Universities, allowed us to perform a research plan with this candidate agent: biological notes, field observations and host range tests have been carried out in Cappadocia, Central Turkey to record biological data and to evaluate the host specificity of *L. deviata*.
Oviposition and host suitability larval survival tests were carried both in no-choice and choice conditions, followed by open field host-range tests, confirming the strict monophagous behavior of the species, associated only to plants belonging to the genus *Lepidium*.

Open field studies in Turkey to evaluate the host range of *Larinus filiformis* Petri, a potential biocontrol agent of *Centaurea solstitialis* L.

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Yellow starthistle (YST, *Centaurea solstitialis*, Asteraceae) is a winter annual forb originating from the Mediterranean Basin that has invaded about 8 million ha of North American rangeland, primarily in California, Oregon, Washington and Idaho. Although YST plants can be killed by a number of herbicides and other agronomic practices, it is difficult to achieve lasting control because seeds in the soil can persist for several years. Classical biological control, introducing phytophagous species that attack only the target weed, has the best prospect of economically reducing YST density over large areas. To date, six species of insects and one fungal pathogen have been introduced, but only two of these have become widespread in California. Additional agents are needed, and *Larinus filiformis* looks like a good candidate that has a high attack rate and that is adapted to sites with cold winters.

A combination of laboratory and field experiments were conducted to evaluate the host plant specificity of *L. filiformis*, a weevil native to eastern Turkey that develops inside flower heads of YST. Host specificity experiments to date indicate that the weevil has a strong preference for YST. Of 12 nontarget species or varieties tested in multiple choice experiments, oviposition occurred almost exclusively on YST; however, eggs were found once on *Centaurea americana* and three times on *Ce. cyanus*. Larvae were not able to develop on either of these nontarget plants, indicating the narrow host range of this weevil.

Field garden experiments were conducted in Turkey near Trabzon in 2011 and at Iğdır in 2012. *Larinus filiformis* was found attacking only YST; however, some immature weevil specimens from nontarget plants remain to be identified by DNA analysis. These are very likely to be other *Larinus* spp. that are associated with some of these other plant species.

The combined results indicate that *L. filiformis* is specific to *C. solstitialis*. Additional testing should be done to complete the host plant test list before submitting a petition to USDA-APHIS to request a release permit for the United States.

Laboratory studies for allelopathic and bioherbicidal potential of Tunisian barley (*Hordeum vulgare* ssp. *vulgare* L.) against the great brome (*Bromus diandrus* Roth.)

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Plants may favorably or adversely affect other plants through the release of allelochemicals, from alive or dead plant material. Due to the increasing number of herbicide-resistant weeds, environmental (and human health) concerns in the use of synthetic herbicides, this allelopathic potential should be exploited in alternative weed management strategies.
In this context, a new laboratory assay, named "seedling after seedling agar method", was conducted to evaluate the allelopathic root exudate effects of five Tunisian barley cultivars and a Saoudian barley landrace on the seedling establishment of great brome (Bromus diandrus Roth., syn. Bromus rigidus Roth. subsp. gussonii Parl.), a troublesome weed of the Tunisian cereal crops.
Root and shoot length and biomass accumulation of the weed seedling were significantly reduced when grown in the agar medium of barley. Root growth was more sensitive to allelopathic inhibition than shoot growth. Moreover, chlorophyll content and chlorophyll fluorescence (Fv/Fm) were decreased in the presence of barley root exudates. We further demonstrate that the barley varieties and landraces exhibited a differential allelopathic activity against the great brome. Indeed, it seems that the barley landraces are more allelopathic than the improved varieties. The addition of activated charcoal, an inert material with high affinity for organic biomolecules, decreased the inhibitory effects of root exudates released in the agar medium. These results suggest the release of putative allelochemicals from barley into the soil which affect growth and physiological activity of great brome and might be used as bio-herbicides. We conclude that a careful selection of suitable barley varieties should be beneficial in a continuous cropping system in order to minimize the negative impacts of weeds.

SESSION V

OPTIMIZATION OF CHEMICAL WEED CONTROL

Oral presentations

Session organizers

Per Kudsk & N. Uygur

16th EWRS Symposium 2013, Samsun

Ex-ante assessment of the potential economic and environmental impacts of the adoption of herbicide tolerant maize varieties in the EU

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Since the banning of atrazine and other active ingredients in the European Union (EU), weed control in Z*ea mays* (maize) is a complex issue for farmers that have to deal with many different herbicides. Herbicide Tolerant (HT) crops, the most widespread GMOs worldwide, represent an alternative weed control solution. Farmers in other regions of the world have adopted this technology very quickly. In the EU, the European Food Safety Authority (EFSA) recently issued a positive opinion on HT maize, paving the way for a possible approval for commercial use of the technology.

Data for this study originate from a survey conducted in 2009 in seven EU countries that together represent more than 70% of the EU maize area. About 550 maize growers were included in the sample, which was stratified by the size of the different maize growing regions. Based on the survey, we used a partial budgeting model associated to a stochastic simulation to simulate the potential adoption of HT maize by European farmers, and to compare the current weed control practices of farmers to the possible herbicide treatments associated with the use of HT maize, depending on weed pressure and farmer willingness to opt for good practices for weed resistance management.

Our simulations show that, under the assumption that farmers would only rely on glyphosate to control weeds in HT maize field, the adoption rate of the HT technology would be higher than 60% in all countries of the survey and the average revenue per hectare would be from EUR 22 in Czech Republic to EUR 70 in Romania. Also, as glyphosate has a relatively low Environmental Impact Quotient (EIQ), the shift to HT maize generates a positive environmental impact in all countries except Hungary. When we assume that farmers that adopt HT maize will progressively use other active ingredients in addition to glyphosate in order to prevent weed resistance, our model predict an adoption level that is, on average, 23% lower than in the previous scenario. However, average revenue wouldn't decrease in the same extent, while the environmental impacts would then be rather negative on 46% of the total maize area. Finally, assuming endogenous technology fees, the adoption of the technology would be even lower, and the environmental impacts of the adoption would be negative for 38% of the total maize area and positive for 12%.

In summary, the study shows that the introduction of HT maize in the EU would be an economic relevant addition to the farmer's toolbox for weed control. The results of the different simulations highlight the fact that its main economic and environmental impacts for the EU will largely depend on decisions made by the innovator and the farmers, notably the pricing of the technology and the herbicide program associated to the use of HT maize. Further work on the dynamic of these decisions through time is needed in order to better understand the impacts of HT crops on EU agriculture.

Herbicide tolerant crops: Performance in the conditions of Central Europe

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Commercialization of herbicide tolerant (HT) crops started in 1992 by development of maize tolerant to imidazolinone herbicides. Recently, the genetically modified (GM) HT crops carrying the tolerance to glyphosate or glufosinate are most popular in the world and their total acreage reached 90 Mio. hectares in 2010. In Europe, where the registration of GM crops is difficult, new or reintroduced non-transgenic traits have been offered especially in crops like sunflower, oil-seed rape and sugar beet in which the weed control by common herbicides is difficult under certain conditions.

This contribution summarizes our experience from 10 years research with GM (glufosinate and glyphosate tolerant) and non-GM (imidazolinone and sulfonylurea tolerant) crops: oil-seed rape, maize and sunflower. In oil-seed rape and maize, the reliability of HT technology was usually comparable or better than conventional herbicide control. Significantly better control effects and crop safety of HT technology were documented in sunflower. If properly used, any negative impacts (e.g. shift in weed communities) have not been noticed.

HT technology can bring farmers many advantages from the point of view of efficacy on hard-to-control weeds, as well as flexibility of use with other agronomic measures. New non-transgenic breeding techniques like oligonecleotide-directed mutagenesis are able to accelerate the development and introduction of high-performance HT varieties also in Europe.

Imidazolinone tolerans development in red lentil by mutation

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Turkey is important lentil growers in the world following Canada and India. Red lentil as main sources of food and it has high export value. Weeds are most important to limit lentil yield by competing for nutritions, water and space. Yield losses may vary depend on weed species and densities average 60% yield losses due to weed competition and may increase even higher percentage. Weeds can suppress lentil during growing period because of their slow grow rate and restrict their growing.

Although several herbicides can be used to control grasses, there is no efficient broadleaf weed control due to lack of registered post emergence herbicides. It is known that broad-leaves have strong competition ability and can cause significant yield losses.

Imidazolinone herbicides, include imazapyr, imazethapyr, imazamox, imazamethabenz and imzaquin, control weeds by inhibiting acetohydroxyacid synthase (AHAS) enzyme or also called acetolactate synthase (ALS). AHAS is critical enzyme for biosynthesis of branched-chain amino acids in plants.

Two different mutagens were used in study in order to make local red lentil variety known as Firat 87 tolerant to imazamox.

ALS enzyme activity was measured for mutagenized and untreated control red lentil individuals and also ALS primers were designed and tested for determination of putative amino acid substitution and ALS gene were sequenced in order to identify any amino acid changes between tolerant and susceptible plants.

Controlled release of auxinic herbicides

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The deployment of conventional herbicides requires excessive amounts of herbicide formulations or multiple replications, because a substantial part of active ingredients is expected to be removed from target sites by evaporation or leaching into soil. An enhanced efficiency may be obtained by applying controlled release formulations (CRF) with the active ingredients mechanically entrapped or chemically bound to a matrix. The active ingredients chemically bound with biodegradable polymers could help to overcome environmental problems of conventional herbicides, because the active ingredients are released to plants at a controlled rate and in quantities required over a specified period of time and plants would more effectively absorb them.
The objective of our research took into account the CRF containing auxinic herbicides chemically bound to (R, S)-3-hydroxybutyric acid oligomers, being synthesized via the ring opening polymerization of β-butyrolactone initiated with potassium carboxylates of 2,4-D, MCPA and Dicamba. These products were characterized by the size exclusion and reverse phase liquid chromatography, proton magnetic resonance and electro-spray mass spectrometry in order to determine their chemical structures and molecular weight distributions. The formulations demonstrated the reduced vapor pressures and water solubilities.
We compared the effectiveness of 2,4-D, Dicamba and MCPA chemically bound to 3-hydroxy-butyric acid oligomers vs. classic formulations containing potassium and/or dimethylammonium salts. The conducted greenhouse and field biotests proved that the oligomeric carriers did not changed the phytotoxicity and the controlled release effect enabled use of lower doses of active ingredients per hectare. Besides the agronomical deployment, applications of biodegradable oligomeric carriers in municipal and industrial infrastructures, e.g., peripheries of roads and railways, aisles, industrial sites and ancient ruins, could be evoked, too.

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Integrated weed management with glyphosate in perennial crops: Evolution over 38 years in Europe

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Commercial introduction of glyphosate in the mid seventies represented a milestone in weed management because the systemic efficacy of this herbicide created the possibility to control some troublesome perennial weeds which were hard to control with existing tools. The initial adoption of glyphosate was combined with a gradual training of distributors and farmers, development of new areas of glyphosate use, and thorough monitoring of results and farmer satisfaction. Weed resistance to glyphosate was not an issue given the integration of its use with other chemical and/or mechanical operations as a last resort treatment. In fact the new herbicide became a tool to control weeds resistant to other mode of action herbicides. Glyphosate use expansion in perennial crops started in 1980 when new branded formulations were developed for control of annual weeds, using applications with low water volumes. The price of glyphosate was relatively high and resulted in usage of marginal rates in some cases. The repeated use of the same herbicide on the same fields selected populations of less susceptible species (e.g. *Portulaca*) and resulted in some markets to the commercialization of glyphosate/MCPA and other ready mixes. The optimization of glyphosate applications facilitated the substitution of tillage to control weeds and permitted leaving the stubble on the soil (conservation agriculture) in pre plant of annual crops or in the alleys of perennial crops. This change has decreased erosion, improved water efficiency, increased biodiversity and mitigated CO_2 emissions. Reduction of tillage practices had an impact on integrated weed management systems. Prices for glyphosate herbicides dropped in the glyphosate post-patent, leading to increased use and decreased technical stewardship from manufacturers to farmers. The review of older herbicides according to the strict European Union regulations has led to a strongly reduced pool of alternative herbicides and the overreliance on glyphosate in perennial crop situation over many years has led to the development of some glyphosate resistant biotypes of *Lolium* and *Conyza* in several Mediterranean countries. For a sustainable use of glyphosate herbicides beyond 2013, we recommend for all branded and generic products the provision of technical information thorough use of labels, literature, Internet and new IT technologies to: a) remind good agricultural practices to achieve and maintain complete control in target areas while respecting the quality of water and the environment in non target areas; b) alerting farmers if and when glyphosate resistant biotypes have been confirmed; c) deliver tested technical recommendations for control of resistant weeds including optimal timing of

applications, integrated with the use of alternative herbicides and/or mechanical or biological tools.

SESSION V

OPTIMIZATION OF CHEMICAL WEED CONTROL

Poster presentations

Session organizers

Per Kudsk & N. Uygur

16th EWRS Symposium 2013, Samsun

Response of *Hordeum spontaneum* to sulfosulfuron in different phenological stages

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In different regions of Iran, *Hordeum spontaneum* Koch. (Wild barley) become a noxious weed in wheat fields. Sulfosulfuron (Apyros 75 WG) is an effective herbicide for control of this weed, but its efficacy may depend on weed phenological stage.
Pot experiments were carried out in natural conditions in Agronomy & Plant Breeding Department of University of Tehran, Karaj, in 2012 to study the best application timing and dose of sulfosulfuron. The experimental was Randomized Complete Block Design with four replications in which treatments were arranged as factorial. The first factor was eight doses of sulfosulfuron including 0 (control), 10.1, 20.2, 30.3, 40.5, 50.6, 60.7, and 70.8 g a.i. ha^{-1}, and the second factor was sulfosulfuron applying doses in three growth stages of *H. spontaneum* (2-3 leaves, tillering and second node).
Results indicated that application of 20.2 g a.i. ha^{-1} of sulfosulfuron in second node stage had the best efficacy in controlling the *H. spontaneum* without any plant recovery.
H. spontaneum was recovered when recommended herbicide doses were applied at two- to three-leaf and tillering stages. Although increasing the sulfosulfuron dose from 50.6 up to 70.8 g a.i. ha^{-1} led to plant death. Overall, it was concluded that application of sulfosulfuron at early stage of 2-3 leaves results in an increase in dose of herbicide or re-spraying. Acceptable result would be achieved by application of sulfosulfuron at 20.2 g a.i. ha^{-1} in second node.

Improved Weed Control with Clearfield-Plus Sunflowers

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The initial Clearfield® sunflower production system is known as *ImiSun* system. Besides the Clearfield tolerance trait of this system, background genotype and environmental conditions could have a significant impact on the required commercial tolerance which is defined as tolerance to the 2x rate of a registered imidazolinone herbicide. Yellowing and stunting of *ImiSun* Clearfield sunflowers are occasionally observed as reaction of the imidazolinone treatment. An optimization process of the herbicidal efficacy for improved weed control either by rate or uptake-increase of the herbicide would be limited by the tolerance of *ImiSun* sunflowers.

The development of the new tolerance trait Clearfield Plus – which is based on the novel mutation *CLHA-Plus* with a much higher imidazolinone tolerance allows a significantly enhanced weed control efficacy through the improvement of herbicide formulation and adjuvant without negative effect on crop tolerance.

With the enhanced tolerance of *CLHA-Plus,* field experiments were carried out in Europe, US and Argentina between 2007 and 2011 to investigate new adjuvants for Pulsar40 improved weed control. All experiments were conducted as randomized complete-block designs with three or four replications and products where applied postemergence broadcast between 2 to 6 leaf of stage of sunflower.

DASH®, a proprietary adjuvant was found to be the most effective combination for improving weed control efficacy; it allowed the reduction of the use rate of imazamox from 50 to 40 g ai/ha while maintaining the same control efficacy on major weed species like *Echinochloa crus-galli*, *Digitaria* spp, *Setaria* spp. and *Chenopodium album.* The higher imidazolinone tolerance of the Clearfield Plus trait allows the use of a stronger adjuvant and a better formulation for imidazolinone herbicides and consequently a more flexible and reliable weed control in sunflower by maximizing the herbicidal efficacy per ai unit without any penalty on tolerance.

Efficacy of control measures for *Cymbopogon afronardus* in the rangelands of Uganda

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Rangelands are important feed resources for ruminant livestock production in Sub-Saharan Africa. In Uganda *Cymbopogon afronardus* is an invasive weed that reduces productivity of rangeland resources. Mechanical removal is costly and unsustainable because the weeds rejuvenate and spread rapidly within three years. Within seven days after burning *Cymbopogon* and herbaceous legumes emerges and rapidly smothers other palatable herbage species. Economically rationalised control measures remain to be identified. Therefore grass selective herbicides provide alternative control method because they do not destroy herbaceous legumes that impove the nutritional values of the herbage regrowth after burning. A study was therefore conducted to evaluate the efficacy of post emergence and grass selective herbicides for the control of *C. afronardus.* The experimental area was burnt to allow regeneration of new tillers that are vigorously growing to enhance the chemical reaction of the herbicides. Three weeks after, the experiment was laid out in a randomized complete block design (RCBD) in six replications. The plot size was 8m x 5m. The treatments included six post-emergence herbicides, these were Select, Satunil, Ametrex, Glycel, Butanil and Weed master, plus hand hoeing and control. The herbicides were sprayed using a knapsack hand sprayer CP15 at dose rates of 200, 450, 300, 150, 300 and 150mls in 15L of water respectively. Spot application method was used to target the *C. afronardus* stool to avoid destruction of other palatable herbage. A quadrant of 1mx1m was used to sample and count weed species in each plot. Data was collected at 0, 14 and 28 days after herbicide application. GENMOD analysis of the effects of different herbicides indicated that all tested herbicides reduced *Cymbopogon* growth vigour ($P<0.01$) by over 50% at 14 days after herbicide application. Regeneration was observed from the Ametrex treatment at 28 days after herbicide application. The indigenous grass pastures significantly ($P<0.05$) increased in the grass selective herbicide treatments especially Select, Butanil and Satunil at 14 days after herbicide application. Also, the growth of the indigenous legumes and from the hand weeding treatment significantly ($P<0.05$) increased at 28 days after herbicide application. Non-selective herbicides reduced the growth of the indigenous grasses and legumes. These results suggest that whereas herbicides are promising options for the control of *C. afronardus* in the South-western Uganda, Butanil and Select are candidate formulations for *Cymbopogon afronardus* weed control in southwest rangelands of Uganda.

Effect of growth stage on the efficacy of glyphosate on some important weed species in Turkey

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Glyphosate is widely used in perennial crops, as well as on non-agricultural areas in Turkey. However, some users report inefficiencies against some weeds which might be due to lack of good agricultural practices. Therefore the influence of water volume, spray water quality and weed growth stage on the glyphosate efficacy was investigated in a joint project with Monsanto International Sarl. Results with spray water quality and volume have already been published. Therefore, it was aimed here to present results on growth stage experiments.

Pot experiments were conducted twice with 5 replications. *Sorghum halepense* L. Pers., *Cyperus rotundus* L. and *Portulaca oleracea* L. were chosen as hard to control model weeds. Seeds/rhizomes were sown to pots with different intervals in order to have weeds at three different growth stages (mentioned below in results section) at the time of application. Weeds were treated with four different glyphosate formulations each at doses corresponding to 2160 g a.i/ha (recommended rate) and 1620 g/ha (75 % of the recommended rate). All herbicide treatments were conducted by using a spray chamber via 11002 nozzle at 4 bar pressure. Herbicide efficacy was evaluated by means of relative fresh weed biomass.

Results were pooled for all formulations. *S. halepense* fresh weight was reduced over 95 % at both doses in both experiments, when average plant heights were 22 (early) and 47 cm (late). However, the efficacy of glyphosate was only 77 and 86 % at 1620 and 2160 g a.i./ha doses, resp., when treatments were done at very late growth stages (≥80 cm heights). In the case of *C. rotundus* results were variable depending on the experiments and dose. In the first experiment highest glyphosate effectiveness was obtained when plants were treated at 6-8 leaf stage (late) as compared to early (3-4 leaves) or very late (9-13 leaves) growth stages. However an acceptable weed control (90 % fresh weight reduction) was provided only at the recommended dose. Although similar results were obtained in the second experiment sensitivities of plants at 3-4 leaves and 6-8 leaves were not different from each other, while plants at very late growth stage (9-13 leaves) were less sensitive. Similar to the first experiment acceptable weed control was achieved just by recommended dose. *P. oleracea* was controlled over 95 % at the youngest growth stage (single branches) at both experiments regardless of the dose. Lower efficacies were obtained with plants with 5-6 and 9-13 branches that were around 75 and 50 % effectiveness, resp.

Results of these studies showed that growth stage is very important factor affecting glyphosate activity. *S. halepense* and *C. rotundus* were best supressed when treatments

were done at early or late growth stages. Very late treatments provided lower/least effect on these weeds. For an acceptable control of *P. oleracea* it is compulsory to apply glyphosate at an early growth stage. These results suggest that glyphosate efficacy can be optimized by considering growth stage of weeds.

Farmers' knowledge on herbicide usage in Upper West Region of Ghana

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Herbicides are integral components of integrated weed management, which is a crucial factor in a worldwide increase in agricultural production. The use of chemicals for the control of weeds offers the greatest possibilities for weed control and research has shown that herbicides produce greater yields at less cost than the typical practice of hand weeding. Aside the numerous benefits derived from herbicide usage in controlling weeds, their excessive, ecological unfriendly and inappropriate use have created side-effects such as resistance to pesticides, outbreak of new or secondary pests, toxicity, poisoning, causing cancers and genetics disorders. Research shows that each year, 3 million workers in agriculture in the developing world experience severe poisoning from pesticides, with about 18, 000 of them losing their lives. Therefore, farmers' knowledge and participation in herbicide usage is very important. The purpose of this study was to assess a farmer's knowledge on herbicide usage and safety measures. The study was conducted in the Sissala District of the Upper West Region of Ghana. Five (5) respondents were selected using Systematic Sampling Technique (SST) to obtain a sample size of 50 respondents of which questionnaires were administered to. Secondary data and other relevant information were obtained from Ministry of Food and Agriculture (MoFA) and the district assembly. Data obtained from the questionnaire was analyzed using SPSS (version 10).

The study revealed that majority (90%) of the respondents was males. Crops grown included maize, vegetables and yam. Herbicides mostly used by farmers included Glyphosate, Paraquat, Atrazine and Pendimenthalin. Farmers use either pre-emergence or post-emergence herbicides to control weeds. About 50% of the farmers had to go quite a long distance (5-8Km) to have access to herbicides and other agro-chemicals. A majority (60%) of the respondents had no formal education. About 96% of farmers did not use any protective clothing during application of herbicides; and their reasons being high cost of such items, lack of education and heat stress. Eighty-six percent (86%) of farmers dispose of herbicide containers by leaving them on the farm or any available space. Left-over herbicides were poured on the farm (61%), stored for reuse (32%) or used for other purposes (7%).

Considering the high illiteracy rate among farmers as well as limited knowledge with regards to herbicide application and safety measures, it is obvious that herbicide rate, time and method of application may not meet the required specifications as most farmers cannot read labels on the herbicide containers that gives recommended dosage and precautions. Thus, farmers need to be educated on integrated weed management, appropriate handling of herbicides and formulation, use of protective clothing and proper disposal of left-over herbicides.

Effect of different weeding regimes on yield and yield components of Soybean (*Glycine max* (L.) Merrill)

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Weeds compete with crops for nutrients, space, light and water; thus reducing crop yields. Numerous studies have documented the negative effects on yield of season-long weed competition in Africa. Keeping the crop free of weeds for the first third of its life cycle usually assures near maximum productivity. Hand weeding is the predominant weed control practice on smallholder farms in Africa. Although a lot of energy is expended in removing weeds by hand, crop yields are generally very low because farmers weed their fields at different times, especially if it is carried out after the critical period of weed competition. The objective of this study was to assess the effect of different weeding regimes on the yield and yield components of soybean. The study was conducted during the 2011 cropping season at the experimental field of the Faculty of Agriculture, University for Development Studies, Tamale. The Randomized Complete Block Design (RCBD) was used with five treatments and four replications. There were twenty experimental plots each measuring 3.0m by 3.0m with inter-block and inter-plot distances of 1.5m and 1.0m, respectively. The total land size for this experiment was 19m by 16.5m. The treatments were five different weeding regimes: No Weeding, Weeding at 3 and 6 weeks after planting (WAP), Weeding at 3, 6 and 9 WAP, Weeding at 3, 6, 9 and 12 WAP and Weed-free (continuous weeding). Data analyzed by ANOVA using SPSS and treatment means compared using the least significant difference (LSD) at 0.05. The means predominant weed floras at the experimental field were broad leaves (58.6%), sedges (26.9%) and grasses (14.5%). No weeding had lower ($P<0.05$) plant height (39cm) than other treatments which were similar.(~47cm). Also, no weeding recorded a longer (49) number of days to 50% flowering while weed-free had the lowest (40) which is almost at pal (41) with 3, 6, 9 and 12 WAP. Weed free recorded the highest (183) number of leaves, followed by 3, 6, 9 and 12 WAP (180) and no weeding recorded the lowest (105) in the tenth week after planting. Crops on weed free plots recorded the least number of days to 50% flowering which was similar to 3, 6, 9 and 12 WAP. No weeding had the highest number of days to 50% flowering due to high weed interference on the growth and development of the soybean. Grain yield gave a significant response to different treatment. Treatment 3, 6, 9 and 12 WAP produced the highest (1350kg/ha) grain yield, followed by weed free (1250kg/ha) which was at par with 3, 6, 9 WAP. No weeding recorded the lowest (380kg/ha). The mean predominant weed flora at the experimental field was broad leaves (58.62%), sedges (26.93%) and grasses (14.44%). Although weed-free regime had the greatest impact on soybean productivity, it would be preferable to use a weeding regime of 3, 6, 9 WAP since the weed-free and 3, 6, 9 and 12 WAP method was very tedious and time consuming.

Pendimenthalin as a pre-emergence herbicide at different levels in controlling weeds in tomato (*Solanum lycopersicum*) and pepper (*Capsicum frutescens*)

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Weeds being the major problem compete with crop for available moisture, nutrients, space, sunlight, etc. They also provide opportunities for harboring insects, pests and diseases which results in yield reduction. Chemical weed control is a preferred alternative to manual weeding because it is cheaper, faster and gives better weed control. Herbicide efficacy varies for each weed species and plant size. The efficiency of herbicides on weeds is influenced by dose. Herbicides are often applied at rates higher than required for weed control under ideal conditions. This is done primarily to compensate losses that occur at the target site in the plant. Generally, high herbicide doses are recommended but these doses may be an overestimation of the amount required to obtain adequate control of weeds. Pendimethalin is an herbicide used in pre-mergence and post-emergence applications to control annual grasses and certain broadleaf weeds.

Two field experiments were conducted at the University for Development Studies at Nyankpala in the Guinea Savanna zone during the 2011 cropping season to investigate the optimum and economical rate of application of herbicide for weed control for higher yields of pepper and tomato under rain-fed conditions. A randomized complete block design with four treatments replicated three times was used for both experiments. The treatments for the pepper experiment were Pendimenthalin at four different application rates (800, 1000, 1200 and 1400ml/ha). In the tomato experiment, the treatments were Pendimenthalin at four application rates (800, 1000, 1200 and 1500ml/ha). These dose rates were applied to the respective treatments using a "C15" Knapsack sprayer equipped with a single stainless steel flat-fan nozzle tip before sowing. Data analyzed by ANOVA using SPSS and treatment means compared using the least significant difference (LSD) at 0.05.

In the tomato experiment, 800ml/ha rate gave the highest ($P<0.05$) plant height (59.0cm), number of leaves per plant (43) and canopy spread (53.8cm) whiles 1200ml/ha recorded the lowest ($p<0.05$) plant height (46.0cm), number of leaves per plant (36), canopy spread (43.38cm). Among the treatment, 800ml/ha recorded the highest ($p<0.05$) fruit yield (1980kg/ha), 1000ml/ha (1648kg/ha), 1200ml/ha (1030kg/ha) and 1500ml/ha recorded the lowest (668kg/ha). The reducing effect in yield with higher rate of herbicide might be due to its phytoloxic effect on plant growth. However, in the pepper experiment, herbicide rate of 1000ml/ha recorded the highest ($P<0.05$) plant height (44.2cm), canopy spread (43.8cm) and fruit yield (5510kg/ha).

The results showed that higher Pendimenthalin application rates had negative effects on the productivity of tomato and pepper; probably due to phototoxic effects on plant growth. Therefore, recommended Pendimenthalin rates should be 800ml/ha (tomato) and 1000ml/ha (pepper) for maximum productivity.

Diminishing of herbicide stress with amino acid foliar fertilizer in maize lines

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The maize lines have smaller habit and slower growth than hybrids, which allows significant weed growth. Therefore, the herbicide application is an integral part of cropping. New herbicides in maize could cause higher susceptibility of some genotypes. The aim of this study was to examine herbicide application in recomended and double dose (mesotrione, topramezone, rimsulfuron and foramsulfuron), together with foliar fertilizer 12N:4P_2O_5:6K_2O+0,2MgO+ME+AA as possible antistress factor on five maize lines.
The reactions of maize genotypes were observed during growing season: 48h and 21 days after treatment and anthesis. Content of soluble proteins, free thiolic groups (PSH), fresh and dry matter were determinated in the observed phases, as well as the grain yield at the end of growing cycle. Obtained data were statistically processed by Weibull´s analysis and ANOVA, differences between means were tested by the least significant difference test ($LSD_{0.05}$).
The content of soluble proteins and PSH varied mostly 48h after treatment and the greatest differences were observed between treatments with the recommended and double dose of herbicide. Variations in soluble protein content 48h after treatment showed the highest values compared to control, especially when double dose of herbicide was applied. PSH content was lower at herbicide than at treatment herbicide+foliar fertilizer treatment, indicating faster overcoming of herbicide stress. In other observed phases smaller variations in PSH and soluble protein content were observed. Greatest differences in fresh and dry matter content were observed 21 days after treatment. Significantly higher values of fresh and dry matter and grain yield at herbicide+foliar fertilizer treatment also indicated faster stress overcoming than in treatments with herbicides only.

Interaction of common and new herbicides and wheat residue on weed control, growth and yield of corn (*Zea mays* L.)

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Field studies were conducted in 2009 & 2010 in college of agriculture, Shiraz University, Shiraz, Iran to evaluate the effects of wheat residues and split and combined applications of herbicides on weed control, vegetative and agronomic characteristics of maize hybrid SC 704. The split plot design of the study comprised of randomized complete block arrangement with three replications. Herbicide treatments included atrazine plus alachlor at 1+5, 1.5+6 lit/ha and foramsulfuron at 2.5 and 3 lit/ha. Wheat residue treatments included 1.5, 3, 4.5, and 6 tons per ha. A weed free and a weedy check were also included. Results indicated that minimum weed dry weight at 6 and 12 weeks after planting was obtained with atrazine plus alachlor at both rates with 3 tons of wheat residues per ha. Maximum corn grain yield was obtained with the same herbicide treatments and 3 tons of wheat residues per ha. With increase in wheat residue, total weed dry weight decreased. However, corn grain yield started to decline when wheat residues increased beyond 3 tons per ha.

Use recommendations and farmer acceptance for glyphosate tolerant crops

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Since the introduction of 2,4-D, the use of selective herbicides which are tolerated by the crop has brought many benefits for efficient crop production over the last 60 years. The discovery of new mode of actions and new active ingredients in the following decades were significant milestones to increase the food production, to deliver raw materials for the industrial consumption. Nowadays it's extremely difficult and expensive (~ 200 million € per new ai) to bring a new product to market. Industry tried to find new pathways to make the crops tolerant to effective doses of herbicides, such as: a) use of antidotes coating the seeds or blended with the herbicide; b) forcing mutations and breeding selected lines with improved tolerance to a herbicide, and c) inserting selected genes that confer tolerance to a herbicide through bypass of target enzymes, overproduction of target enzymes or higher herbicide degradation by the crop (GMHT).

The first two options have been regulated as other new phytosanitary product or breeding technique. The third option, more precise and more intensely investigated compared to most conventional breeding techniques, has been severely regulated in the European Union (EU) and other countries, in such a stringent way that no GMHT plants have been allowed to date to be commercially cultivated in the EU despite of a growing adoption rate in the United States, Canada and emerging countries.

The growth in adoption was high in the first years because of economic benefits for the farmers, operational flexibility, and easier adoption of conservation agriculture (no tillage with stubbles on the soil) practices. One of the advantages for the farmers was that instead of using a range of selective herbicides, they could achieve a high level of weed control by sequential applications of one herbicide. This was the preferred grower option among those recommended by the technology providers. However, the overreliance on glyphosate in combination with reduced tillage, and the occurrence of multiple Roundup Ready crops in the same rotation has led to the development of some biotypes of glyphosate resistant weeds

The adoption of glyphosate tolerant crops remains very high and continues to increase because the majority of weeds are still controlled efficiently with glyphosate. Monsanto has however changed over the last years the recommendations to farmers in the Technology User Guides that are linked to the glyphosate tolerance technology, alerting on the potential weed resistance problems. Emphasis is now placed on integrated weed management programs where glyphosate is used in tank mixtures or in sequential applications with herbicides with

a different mode of action. The weed science community is convinced that these approaches will contribute to the efficient control of the target weeds as well as delaying the development of new cases of weed resistance. In this way glyphosate tolerant varieties will continue to be useful tools by offering economic and environmental attractive alternative sustainable farming options.

Effects of an organic silicon surfactant on the efficacy of herbicidal activity on wild oat control

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This study was conducted to find out the influence of organic silicon surfectant in addition to the efficacy of some herbicides recommend in wheat. The wheat variety called "Gönen" was used for field trial that set up in Kocagöl,village of Manyas District in Balıkesir in 2009. Three different doses of fenexoprop-p-ethyl (60, 80 and 160 ml/da) and mesosulfuron-methyl+iodosulfuron-methyl-sodium (15, 20 and 40 g/da) and doses of addition organic silicon surfactant (40 ml Sylgard309®/ 100 liter water) to these herbicides were applied post emergence. The effectiveness at the dose of 60ml/da (25% reduced dose) fenexoprop was 45%, but it was 58.75% when added the silicone organil to the same dose. The dose of 80ml/da (suggested dose) of fenexoprop, the effectiviness was 32%. While the organic silicon was added to the same dose it was 58.75%. The dose of feneezoprop at 160 ml / ha (double dose) were found effective by 56.25%. However it increased to 76.25% when was added to that dose the organic silicon. By trying these and other herbicides it came out that there established no increse. Mesosulfuron-methyl + iodosulfuron-methyl-sodium at three application doses and additional of organic silicon to those were found effective in 98% to 100%.

Chemical control of *Potamogeton nodosus* in paddy fields of Iran

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Rice production is the most dominant economical, social and agricultural activity in northern part of Iran. Weeds are the main constraint in rice production that could cause up to 90% yield loss in transplanted (TR) rice. *Potamogeton nodosus* (Pondweed) has emerged as an invasive weed in water logging rice fields because of its tolerance to flooding, herbicide and reemergence after hand weeding.

This study was laid out in 2012 in order to investigate the efficacy of some herbicides on chemical control of *P. nodosus*. Treatments included butachlor (Buta), thiobencarb (TB), oxadiargyl (Oxa), bensulfuron-methyl (BSM), applied at 3 day after transplanting (DAT) and the mixture of BUTA, TB and OXA with BSM applied at 3 and 10 DAT. Experimental design was a RCBD with four replications. Full season hand weeded and infested controls were also included. In herbicide treated plots all weeds were hand weeded up to six week after TR but Pondweed.

Results showed that none of the treatments caused significant toxicity to rice based on visual evaluation 3 and 6 week after TR. Buta and TB had no significant effect on *P. nodosus*, Oxa reduced the biomass of pondweed 42%. Application of BSM alone or in mixture with other herbicides applied at 3 DAT reduced *P. nodosus* dry weight around 75%. Application of BSM or mixture treatments at 10 DAT controlled pondweed 95% or more. Based on the study it is recommended to apply herbicides intermittent, first graminicides and then sulfuonyl urea in order to increase their efficacy on delayed germinated weeds like *P. nodosus*.

Clearfield® wheat *vs.* Imazamox: Metabolism study by LC–DAD and LC–TOF/MS

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The Clearfield® Production System for wheat is a novel technology that allows wheat producers to control many problematic grass and broadleaf weeds. It was developed using enhanced, traditional plant breeding techniques and is certainly among the most promising and innovative tools for weed control. This production system allows to control several herbicide resistant weeds which invade a large number of crops, such as annual ryegrass (*Lolium multiflorum Lam*.) diclofop-resistant populations in wheat fields. The herbicide blocks the production of the essential amino acids valine, leucine and isoleucine by inhibiting the enzyme acetolactate synthase (ALS), while in Clearfield® wheat, tolerant to Imazamox, has an altered ALS enzyme. However, there is a lack of understanding on the way that Clearfield® wheat plants metabolize the herbicide at several rates.

A method based on LC–DAD and LC–TOF/MS with a HILIC (20 cm × 4.6 cm) analytical column was used for determination and identification of Imazamox and its metabolites. The mobile phases were 1% acetic acid in water (mobile phase A) and 100% methanol (mobile phase B). Fifty µL of extract from the target treated plant was injected and eluted according to an elution gradient by using initial concentrations of 95% of A and 5% of B.

Our results showed that metabolism of Imazamox in Clearfield wheat begins from medium to high doses. Two metabolites: 3-pyridinecarboxylic acid, 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-(hydroxymethyl)- and 3-pyridinecarboxylic acid, 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-[(β-D-glucopyranosyloxy)methyl]- were found at high concentrations, confirming that this pathway is the major mechanism of resistance to Imazamox in the Clearfield® wheat.

Control of weeds with different herbicides in silage maize

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Silage maize production increases along with increasing indoor livestock activities in Turkey. Weeds reduce yield and quality in silage maize. Field experiments were conducted in the Tokat and Igdir provinces in 2010 and 2011 in order to find out effect of herbicides on weeds in maize for silage. Maize planted in Tokat on 10/05/2010 and in Iğdır on 29/05/2011. Herbicides, which were rimsulfuron (40% g/l a.i.), nicosulfuron (25% g/l a.i.) and foramsulfuron + iodosulfuron-methylsodium + isoxadifenethyl (30%+1%+30% ml a.i.), were applied in Tokat on 16/06/2010 and in Iğdır on 21/07/2011. Three rates of herbicides were applied, which were recommended rate for grain maize, its half and double rates. Main weed species were *Abutilon theophrastii Medik, Amaranthus retroflexus L., Capsicum annuum L., Lepidium sativum L., Lolium perenne L., Sinapis arvensis L., Chenopodium albüm L., Convolvulus arvensis L., Sorghum halepense L., Portulaca oleracea.* Applications were evaluated 7, 14 and 28 days after application. Recommended rate and double rate was effective enough on all weeds given with control of between 90% and 100%. They caused higher maize yield than weedy control half rate application which did not give weed control enough.

Effect of herbicide and burial depth on seed germination and seedling emergence of Redroot Pigweed (*Amaranthus retroflexus*)

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Knowledge of emergence ability of a weed species from different soil depths is important value in weed management strategies. In order to, studies in the field and laboratory were conducted to determine effects of burial depth and soil acting herbicides on seed germination and seedling emergence of Redroot pigweed (*Amaranthus retroflexus*) at the Varamin branch Islamic Azad University in 2011. In the pot experiment, seeds were buried in pots outdoors, at depths of 1, 2,3,4,5 and 6 cm in a factorial experiment within randomized complete design with three replication. Second factor included Atrazine (1 kg ha^{-1}), Acetochlor (3 kg ha^{-1}), mixed Atrazine and Acetochlor (0.5 + 1.5 kg ha^{-1}, respectively), black plastic mulch and weedy check. Under laboratory conditions, only herbicides were treated on seeds in Petri dishes in a randomized complete design with four replication. Results showed that Maximum seedling emergence was observed for seeds at 3 and 4 cm depth. Among herbicides, most germination was observed in the Atrazine alone and lowest seed germination and seedling emergence were obtained in Acetochlor and a mixed of Atrazine and Acetochlor. In fact mixture of herbicides optimized their efficiency and reduced the herbicides usage.

Efficacy of pre-emergent herbicides applied on trash blankets and weedicide properties of trash blankets in sugarcane crops

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In Queensland, most sugarcane ratoons are grown on a green cane trash blanket (GCTB), the residue of cane leaves and tops left on the ground when cane is harvested green without prior burning. A better understanding of the role of pre-emergent herbicides in GCTB systems is crucial to optimise the profitability of sugarcane farmers and to comply with the current Great Barrier Reef legislation, which limits the use of pre-emergent herbicides, including diuron.

This poster describes twelve replicated field trials implemented from 2008 to 2011 in Central Queensland. In six trials, the efficacies of three registered pre-emergent herbicides (diuron 1778 g ai/ha + hexazinone 502 g ai/ha, imazapic 96 g ai/ha and isoxaflutole 150 g ai/ha) and a knockdown treatment, and the resulting impact on yield, were compared when the products were applied on bare soil or on a GCTB. One trial was implemented to assess if incorporating these pre-emergent herbicides either just after application or one month after application had an effect on efficacy. Two trials were designed to test two timings of application (just after harvest and before the out-of-hand stage) of these pre-emergent herbicides. In three other trials we compared weed development and cane yield at three trash levels and on bare soil, with no herbicide applied. The tested pre-emergent herbicides were equally efficient in controlling weeds when trash was present and on bare soil. Yields obtained on a GCTB tended to be higher when pre-emergent herbicides were applied in comparison with untreated controls (no statistical difference). In dry conditions, the pre-emergent herbicides achieved better control of a weed population mainly composed of grasses if incorporated by irrigation one month after application rather than immediately after spraying ($P = 0.047$).

Strategies including a pre-emergent herbicide applied just after harvest were more efficient in controlling the weed population (and resulted in slightly better cane yield) than an application before the out-of-hand stage (interaction treatment by date $P < 0.0001$)

In untreated plots, cane yield was higher when cane was grown on the thickest trash treatment and lower on bare soil ($P < 0.0001$). The management of broadleaf weeds and grasses improved with an increasing level of trash. Growth of vines was only slowed down by the thickest trash level.

All tested pre-emergent strategies applied on trash were efficient in controlling weeds; however in most situations the trash blanket itself maintained a low weed pressure in the first weeks after harvest and a late knockdown herbicide application was sufficient to manage the weeds until canopy closure. Strategies on GCTB including pre-emergent treatments should only target specific situations such as paddocks expecting heavy weed pressure, covered by a thin level of trash or with limited access during the wet season.

Highly efficient control of common ragweed (*Ambrosia artemisiifolia*) in sunflower

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Pollen from ragweed (*Ambrosia*) a genus in the Asteraceae is the main cause of allergy and pollen asthma in North America and Central Europe is. Common ragweed (*Ambrosia artemisiifolia,* L.) is rapidly spreading currently in Central Europe and has the highest weed densities in the Carpathian basin: Croatia, Hungary, and Serbia. Common ragweed is the number one weed in Hungary: it covers ca. 5% of the arable land. The competitive weed causes huge losses in row crops. Infestation by common ragweed is heaviest in sunflower (*Helianthus annuus* L., the third most important crop in Hungary) fields, producing the overwhelming majority of allergenic pollen in the air (in the end of the summer pollen counts reach 1000 grains m^{-3}) even in urban areas.

In the presentation we show the results of a five-year (2007-2011) field study on the control of common ragweed by the acetolactate synthase inhibiting herbicides imazamox and tribenuron methyl in sunflower hybrids (NK Neoma and PR63E82) that carry the resistance gene against such herbicides. Common ragweed control by these herbicides was excellent: they suppressed the growth of the weed plant until the canopy closure of the crop (8-leaf stage). Common ragweed plants germinating after this date were unable to compete with the crop: although they survived, they remained small (ca. 70% reduction in height), produced ca. 90% less male inflorescences (source of the allergenic pollen), and caused no significant reduction in the crop yield. In areas where sunflower germination was poor, however, a second, mechanical common ragweed control measure was necessary to keep the weed density below damaging levels.

Efficacy and surface tension of tritosulfuron modified by adjuvants

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Application of herbicides can be optimize by addition of surfactants or oil adjuvants to spray solution. They reduced surface tension and maximized spread of droplets on the leaf, furthermore modifying adjuvants increased the effectiveness of herbicides in water contains a combination of sodium, calcium, magnesium and iron cations which are generally antagonistic for herbicides.
The aim of this research was to determine the influence of different additives on the efficacy of ALS inhibitor, tritosulfuron herbicide applied with hard water (350 mg/l $CaCO_3$). The greenhouse experiments were conducted using tritosulfuron applied post-emergence at reduced rate (50% of recommended rate e.g. 26 g/ha active ingredient) to oilseed rape as tested plant with, ammonium sulphate 2% w/v, citric acid 2% w/v, EDTA 2 % w/v, oilseed rape adjuvant and organosilicone surfactant. Two additional treatments were also sprayed: recommended rate alone and recommended rate with distillate water as well as control no treated with herbicides. Treatments were sprayed in a 305-L/ha volume and applied with a flat fan nozzles with spray pressure set at 350 kPa. Visual assessment and reduction of bioassay of tested plants was determined as herbicide efficacy.
Results indicated significant efficacy and reduction of oilseed rape biomass when tritosulfuron was applied with ammonium sulphate and oilseed rape adjuvant. In these studies modifying adjuvants (citric acid, EDTA and ammonium sulfate) did not affect the physical properties of the spray liquid (surface tension and contact angle). Analysis of the spray liquid parameters revealed that the reduction of the contact angle of the spray liquid to a level close to zero and the reduction of surface tension to the level approximately 20 mN/m, did not result in the best efficacy of tested herbicide.

Effect of multi-functional adjuvant on activity and dynamic of propoxycarbazone-sodium disappearance in *Avena fatua* and *Alopecurus myosuroides*

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Propoxycarbazone-sodium is highly effective herbicide used for control the main grass weeds in cereals. The product is reported to degrade rapidly in soil following application in the field (DT_{50} 9days). Uptake via the leaf is very limited and active ingredient is taken up mainly via the roots. In dry conditions it is advisable to increase leaf absorption by adding appropriate adjuvants.

The aim of greenhouse study was to assessment the relationship between herbicidal activity and dynamic disappearance of propoxycarbazone-sodium applied with multi-functional adjuvant Torpedo II in two weed species *Avena fatua and Aloepecurus myosuroides*. The impact of herbicide on plants via the soil and leaf and only via leaf was analyzed separately. Treatments with propoxycarbazone sodium (Attribut 70 WG) at dose of 60 g ai./ha with addition of Torpedo II (alkoxylated tallow amine, alcohol alkoxylate, natural fatty acids and polyalkylene glycol) at 0,1% were applied at the 3-4 leaf stage of weed species.

Extraction of the pesticide from plant matrices was performed by using a modified quick, easy, cheap, rugged and safe (QuEChERS) method. The method entailed a single extraction of investigated compounds with acidified acetonitrile followed by a dispersive solid phase extraction (dispersive-SPE) clean-up step using graphitized carbon black (GCB) cleanup tubes prior to the final determination by reverse phase ultra-performance liquid chromatography/tandem quadrupole mass spectrometry (UPLC–MS/MS). Dynamics of propoxycarbazone-sodium disappearance for *Avena fatua and Aloepecurus myosuroides* were determined between 1 to 42 days.

Greenhouse studies using a layer of perlite granules placed on the soil surface immediately before the treatment in order to prevent an effect via soil, shown that herbicidal activity is preserved. In controlled greenhouse conditions an addition of multi-functional adjuvant Torpedo II only slightly increased herbicidal effect. The addition of adjuvant had a significant impact on dynamics of propoxycarbazone-sodium residue disappearance in both weed species. High concentrations of investigated compound in weeds were observed up to 14 day after pesticide application. During two –three weeks after treatment propoxycarbazone sodium residues in combinations containing adjuvant were about two times higher and between weed species varied considerably.

Do differences in herbicide sensitivity among local *Echinochloa* populations reflect morphological and genetic variability?

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Echinochloa crus-galli and *E. muricata* are common troublesome weeds in Belgian maize fields. Both species are morphologically hard to distinguish and exhibit high morphological variability. Their response to herbicides varies from field to field. This study investigated whether considerable polymorphism found among Belgian *Echinochloa* populations is consistently associated with differences in sensitivity to maize herbicides. For this purpose 12 populations of *E. crus-galli* and and 4 populations of *E. muricata* were compared for herbicide sensitivity and, morphological and genetic resemblance.

At three different points in time, dose-response pot experiments were conducted in the greenhouse to assess the effectiveness of an ALS- (nicosulfuron), ACCase- (cycloxydim) and HPPD- (topramezone) inhibiting herbicide. Furthermore, all populations were planted in the field to examine morphological traits such as plant prostrateness, number of tillers, spikelet color. A cluster analysis was conducted in order to group the populations according to these characteristics. DNA of leaf material was used for AFLP analysis and the populations were genetically clustered. The genetic and morphological clusters were compared together with the results of the dose-response bioassays.

There was a differential herbicide sensitivity for the different populations of both *E. crus-galli* and *E. muricata* and sensitivity varied according to the mode of action and environmental conditions (repetition over time). In general, *E. muricata* populations showed significantly lower sensitivity to the HPPD inhibitor topramezone than *E. crus-galli* populations. For nicosulfuron and cycloxydim no clear contrasting sensitivity among species was found. There was an obvious difference in spikelet length and kernel weight with lowest values for *E. muricata* populations and *E. crus-galli* populations 'var. *praticola* Merendree' and 'Bellem 1'. In *E. crus-galli* populations, leaf number and spikelet color were other important discriminating morphological characteristics. Based on AFLP, *E. muricata* populations were clustered separately from *E. crus-galli* populations. Among *E. crus-galli*, the dark red, small-seeded population 'Bellem 1' clearly clustered apart in cluster dendrograms for morphological and genetic variability.

Assessment of pethoxamid and pethoxamid plus terbuthylazine efficacy for weed control in maize

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Pethoxamid is a new herbicide in Serbia for the control of annual grass and some broadleaf weeds infesting maize. Field experiments were carried out to evaluate the efficacy of herbicides pethoxamid alone and in mixtures with terbuthylazine in maize. The experiments were established on two locations: Zemun Polje and Boljevci, according to OEPP/EPPO standard methods. Trade formulations Koban (pethoxamid, 600 g/L) and Koban T (pethoxamid 300 g/L + terbuthylazine 250 g /L) were used. Koban was applied at 2.0 L/ha and Koban T was applied at 4.0 L/ha (pre- emergence and early post- emergence application). The evaluation of herbicide efficacy was made 3 and 6 weeks after the treatment.

The main weeds present in the untreated plots in all trails included *Ambrosia artemisiifolia, Chenopodium album, Datura stramonium, Echinochloa crus-galli, Setaria glauca, Sinapis arvensis, Solanum nigrum*.

In the pre-emergence trails only the weeds *Ambrosia artemisiifolia, Echinochloa crus-galli, Setaria glauca* and *Solanum nigrum* were well controlled (efficacy >90%) by pethoxamid treatment. The ready mix with terbuthylazine significantly improved the control of broadleaf weeds. Results indicated that the weeds *Ambrosia artemisiifolia, Chenopodium album, Datura stramonium, Echinochloa crus-galli, Setaria glauca, Sinapis arvensis* and *Solanum nigrum* were well controlled (efficacy >90%) by ready mix pethoxamid and terbuthylazine treatment. The obtained results also indicate that the time of application (pre-emergence and early post-emergence treatment) does not significantly influence the efficacy. No phytotoxic symptoms were observed in any of the pethoxamid alone or combination treatments.

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Combined effects of spring barley competition and different doses of tribenuron-methyl on biometrical indicators of *Chenopodium album* and *Veronica agrestis*

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Sulfonylurea herbicides are widely used to control broad - leaved weeds in crop production systems, but increasing evolution of resistance in different weeds populations poses a major threat to the sustainability of these systems. *Chenopodium album* and *Veronica agrestis* belong to the "worst" arable land weeds in the world. The competitiveness and persistence of these weed species is attributable to many factors including seed germination under a wide range of environmental conditions, early emergence during the crop growing season, competition to nutrients and more other. To control the development of herbicide-resistant weed populations one of the implement is an increasing competitive ability of crop and adjust weed biomass by herbicide.

The effect of different spring barley densities and different doses of tribenuron-methyl on biometrical indicators of *Chenopodium album* and *Veronica agrestis* was investigated in pot experiments in a greenhouse. The trials were carried out in Aarhus University, Department of Agroecology. The design of the pot trials was two factorial including different stand density of spring barley (0, 50, 100, 200, 400 plants per m^{-2} and different doses of tribenuron-methyl on *Chenopodium album* (0; 0.094; 0.188; 0.375; 0.75; 1.5 g a.i. ha^{-1}) and *Veronica agrestis* (0; 0.02; 0.05; 0.1; 0.19; 0.375 g a.i. ha^{-1}). Biometrical analyses of *Chenopodium album* and *Veronica agrestis* plants were made at harvest. The plants were cut at soil surface, stems and leaves were counted, and plant height, fresh- and dry weights were measured. All data were analyzed using ANOVA from package SELEKCIJA (Tarakanovas, Raudonius, 2003) and statistical software "R" (Crawley, 2007; Ritz, 2009).

Analysis of the results indicated that at all doses of tribenuron-methyl, increasing spring barley density reduced plants weight, height, number of leaves, stems and flowers of *Chenopodium album* and *Veronica agrestis*. *Veronica agrestis* was more resistant to tribenuron-methyl than *Chenopodium album*. Only the highest dose of tribenuron-methyl totally controlled both weed species at all spring barley densities. The results showed a potential of reducing the doses of tribenuron-methyl for weed control at high spring barley densities. *Chenopodium album* dry mass in the highest density of spring barley treated by herbicide tribenuron-metyl at the doses 0.094; 0.188; 0.375; 0.75 and 1.5 g a.i. ha^{-1} was 33.0; 40.2; 98.7; 97.6 and 99.3 % less compare to not treated and *Veronica agrestis* at the doses 0.02; 0.05; 0.1; 0.19; 0.375 – 25.0; 60.0; 85.0; 95,0 and 95.0 % respectively.

The results can be used in an IPM strategy combining crop competition with low herbicide doses for the control *Veronica agrestis* and *Chenopodium album* in spring barley.

Efficiency of metsulfuron methyl+sulfosulfuron and sulfosulfuron for the control of *Hordeum spontaneum* ecotypes

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Wild barley (*Hordeum spontanrm L.*) is an annual invasive weed that in recent years has become increasingly problematic in Iranian wheat cropping. In wheat producer provinces such as Fars, Khorasan, Khouzestan and Kermanshah, despite the high rate of herbicides application, H. spontaneum has survived and become a dominant weed.
A field experiment was conducted to evaluate the efficacy of the time of application of herbicides for the control of *H. spontaneum* ecotypes. The experimental design was a factorial split-plot with four replications. Whole plot factors were: a) herbicides Total (metsulfuron methyl+sulfosulfuron) and Apirus (sulfosulfuron), and b) herbicide application times: at 2-4 leaf stage and second node occurrence on stem of *H. spontaneum*. Sub-plots were six *H. spontaneum* populations collected from different climates around Iran.
Significant interactions indicated varying response of ecotypes to herbicides with application time change. Ecotypes Kermanshah, Ghazvin and Tehran were properly controlled using Apirus at 2-4 leaf stage growth stage, while, Fars population was better controlled by total application at this stage. However, Khouzestan population which showed early damage symptoms re-grew and made competition with wheat. With herbicide applications at second node stage, total become more efficient. Although, Kermanshah population was not killed, became very weak and caused no damage for wheat yield. In comparison, total at two nodes stage not only controlled most populations, but also prevented seed producing by *H. spontanum* plants remained. Thus, this herbicide is recommended to control *H. spontoneum* and deplete weed seed in the soil seed bank.

Germination of *Amaranthus retroflexus* seeds from plants treated by reduced herbicide doses

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When herbicides are used at reduced rates, weed species which were not killed, are expected to leave no damage to crop yield and be suppressed by the crop competitiveness. However, they still may produce seeds and enrich the weed seed bank. The question is whether the germination of these seeds and growth of plants emerged from them is similar to normal grown plants.

Therefore, seeds of *Amaranthus retroflexus* plants treated by the different dose of Imazethapyr (0.7 L ha^{-1}) were used for germination and growth rate tests. Bean was grown in competition with natural infestation of *A. retroflexus* sprayed by *Imazethapyr* at 5 doses (0, 0.25, 0.50, 0.75 and 1 rates of the recommended dose) at 2-4 leaf growth stage. Weed seeds were collected at crop majority and tested for germination rate. Also for growth evaluation, seeds were sown in pots in greenhouse and the biomass of *A. retroflexus* plants was measured.

Relationships between seed germination rates and weed biomass with increasing herbicide dose were well described by the standard dose response function. The seeds obtained from plants survived higher dose of herbicide indicated lower germination rates than those received no herbicide. The germination test indicated the lowest rate of germination for plants received herbicide at full rate (41%). The germination rates of plants form no herbicide plots and with 0.25 rates of the recommended dose were at an average of 91%. Applying herbicide at 0.5 and 0.75 rates of the recommended dose decreased the seed germination rates by 50 percent. Additionally, plants were grown from these seeds were weaker and had lower growth rates and biomass. It seems weed seed bank enriched by seeds of plants treated by reduced dose is not as capable as normal seed bank to make competition with crops. Therefore evaluating the reduced doses effects weed seed germination gives useful information to predict weed populations under weed management system.

Glyphosate availability in soil water as affected by phosphate and temperature, and effect on plant growth

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Glyphosate can reach the soil especially when applied on small weeds at low density. Despite the strong adsorption and microbial degradation, glyphosate in the soil could become available in the soil water and affect non-target plants. This study adresses the role of phosphate fertilisation in relation to temperature on the available glyphosate in the soil, and the possibility for plant injury after glyphosate absorption through the roots. A typical agricultural silt soil was used for the experiments where the recommended rate of phosphate and glyphosate was applied. The soil was kept under two temperature regimes (4°C and 25°C) for one week. Available glyphosate in the soil water was determined using high performance liquid chromatography with post-column derivatization and fluorescence detection. Also, a series of glyphosate concentrations (0-72 mg a.i./ml) were studied in a hydroponic system for their effect on a model plant (*Pisum sativum*) after root absorption. Results showed a positive interaction of phosphate addition and low temperature leading to a significant increase of glyphosate concentration in the soil water (70.7 ng a.e./ml), compared to the other treatments (1.8 – 20 ng a.e./ml). The highest amount of glyphosate absorbed by the roots (260 μg) resulted in a 39% reduction in plant biomass while the lowest (15-33 μg) increased plant biomass by 6-13% indicating an hormesis effect.

Picona® - An effective herbicide for the control of ALS-resistant *Papaver rhoeas* with alternative mode of actions

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Papaver rhoeas L. (corn poppy) is a prevalent broadleaf weed in many cereal growing areas of Europe. It produces a high number of initially dormant seeds, which results in several flushes of emergence during a wider time frame and subsequently in the formation of a persistent seed bank. With its high competitiveness and the potential to significantly reduce yield of the cereal crop, farmers do have a high interest in achieving a complete control of the weed.

Intensive uses of sulfonylurea have led to the development of ALS-resistant biotypes. Areas of resistance in Europe have been reported from United Kingdom, France, Spain, Italy and Greece. The number of incidents and areas already affected is still growing and promotes *Papaver rhoeas* to the most important resistant broadleaf weed in european cereal crops.

Pendimethalin based products, widely used in western european cereal regions, are known for their effective control of corn poppy. However, only limited experiences are available so far on biotypes with characterized ALS-resistance, esp. when applied in post-emergence. Picona®, a ready-mixture consisting of 320 g/l pendimethalin (HRAC: K1) + 16 g/l picolinafen (HRAC: F1) as a Suspension Concentrate (SC) was field tested in a randomized bloc design with a plot size of 10m² and 4 replications. Applications were carried out at different post-emergence timings, using a pressurized backpack sprayer at a water volume of 200 l/ha. A widely used sulfonylurea (tribenuron-methyl) and a non-ALS herbicide (CMPP-P + bromoxynil + ioxynil), used as reference and benchmark products, were applied at their recommended timings and dose rates. Picona®, applied at 2,0 – 2,5 l/ha (640-800 g ai/ha pendimethalin + 32-40 g ai/ha picolinafen) provided excellent control of the ALS-resistant biotypes within an application window of BBCH 12-21 of the crop resp. BBCH 10-31 of the weed with high and very reliable performance under different situations. Activity performance of the non-ALS benchmark product was lower and more variable, resulting in the recovery and seed head development of surviving corn poppy plants. As expected, the ALS-herbicide provided insufficient control on the present biotypes of *Papaver rhoeas*. Further investigations are running to describe the resistance pattern more in detail.

The combination of (1) two alternative Mode of Action and (2) soil residual and leaf activity, as present in Picona®, offers a valuable tool in Herbicide Resistance Management and the control of ALS-resistant *Papaver rhoeas*.

Possible control of *Cirsium arvense* in winter wheat, Czech Republic

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Creeping thistle *Cirsium arvense* (L.) Scop. ranks among 10 most harmful weeds of the world. In the Czech Republic, it is classified as a very dangerous perennial weed. Its competitive ability in wheat is high. Creeping thistle is controlled mainly with herbicidal preparations.

Four various herbicides (Mustang Forte - 2,4-D, aminopyralid, florasulam; Huricane - aminopyralid, florasulam, pyroxsulam; pure active ingredients clopyralid and MCPA) were applied at three growth stages of creeping thistle (T1: BBCH 17, T2: BBCH 35 and T3: BBCH 65). The efficacy of chosen herbicides on creeping thistle and their effects on root system were evaluated visually.

The most considerable efficacy was obtained at application timing T1. As the growth stage of creeping thistle increased, the period of beginning of reliable efficacy on the weed delayed. In spite of that, reliable efficacy was recorded for applications at all timings. Applications performed at later growth stages of creeping thistle led to its earlier regeneration. Roots in all treated variants showed symptoms of damage, colour change, reduction in root hairs and the diameter of primary root.

Types and frequency of herbicide resistance in UK populations of *Alopecurus myosuroides*

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Alopecurus myosuroides (black-grass) is a major agricultural weed in northern Europe. In 2011, seed was collected from 92 black-grass populations across the UK. Two populations were collected from each of 46 farms; one from a field that had been treated with the ALS herbicide mesosulfuron + iodosulfuron in that season (treated) and one from an untreated field. All 92 populations exhibited resistance to an ACCase herbicide. Forty-one of the ALS-treated populations and 20 of the untreated populations also exhibited resistance to an ALS herbicide. Pyrosequencing was performed to identify ACCase (Ile-1781, Trp-2027, Ile-2041, Asp-2078, Gly-2096) and ALS (Pro-197, Trp-574) target-site mutations for each population. Additionally the presence and extent of ALS and ACCase metabolism-based resistance was established. For metabolism studies, leaf samples from between the 2nd leaf and main stem were incubated at 28^{o}c for 16 hours in C_{14} labelled mesosulfuron (ALS) or fenoxaprop-p-ethyl (ACCase). Metabolic resistance was then identified by the presence of C_{14} labelled herbicide metabolites using high-performance liquid chromatography (HPLC). Of the 92 ACCase resistant populations, 13 populations had only enhanced metabolism, while 79 populations exhibited both target site and enhanced metabolism resistance. Amino acid substitutions at the Ile-1781 accounted for 84% of resistance-endowing mutations, followed by Ile-2041 (7%), Asp-2078 (4%), Gly-2096 (3%) and Trp-2027 (2%). There was a difference in the frequency of ALS resistance mechanisms between treated and untreated populations. 21 treated and 8 untreated populations were resistant via both target-site and enhanced metabolism, eight treated and four untreated populations had only target-site resistant and 12 treated and 8 untreated populations had only enhanced metabolism. Pro-197 amino acid substitutions accounted for 59% of all ALS resistance-endowing mutations identified within the 92 populations, with Trp-574 mutations accounting for the remaining 41%. Based on the results from this initial survey, 15 contrasting populations have been selected for re-sampling between 2012 and 2014. Glasshouse assays of the 15 populations re-sampled in 2012 have so far confirmed the ALS and ACCase resistance status of the populations, as well as providing a more accurate estimate of the frequency of ALS and ACCase resistance in each of the populations.

ACCase resistance is more prevalent than resistance to ALS herbicides in UK populations of black-grass. The lower frequency of ALS resistance recorded in populations untreated with ALS herbicides in the year of seed collection, highlights the potential for seed collection

following herbicide treatment to elevate estimates of resistance frequencies. This work will inform how the frequency of resistance and resistance mechanisms change within weed populations under documented management to ultimately validate a model of herbicide resistance evolution.

Effects of long-term irrigation with reclaimed wastewater on the efficacy and fate of the ALS inhibiting herbicide trifloxysulfuron-sodium activity in the soil

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Reclaimed wastewater is the main source of water for irrigation of field crops in Israel. Long-term irrigation with reclaimed wastewater (RWW) is known to affect the physical, chemical and biological properties of the soil. The sulfonylurea herbicide trifloxysulfuron-sodium (TFX) is commonly used for post emergence application in cotton. TFX is an ALS inhibitor who is stable in the soil for several months and can carry over to rotational crops; however, we observed that its residual activity in RWW-irrigated soils is much shorter than that recorded in fresh water (FW)-irrigated soil. In this study we monitored the activity/dissipation of TFX applied on RWW-irrigated soil as compared to FW-irrigated soil. A field study was conducted (randomized plots, n=5), and weed infestation in the treated and control plots was evaluated. Soil samples were collected, and using *S. bicolor* bioassay TFX activity in the soil was determined. Dose response curves (n=4) for TFX were performed in soils with different irrigation history (RWW and FW). TFX was applied in a gamma radiation sterilized soil and its activity was determined using *S. bicolor* bioassay (n=4). TFX break through curves were performed, and leaching was examined using HPLC. For statistical analysis, data was subjected to either JMP (SAS) or Sigma Plot (SAS), Tukey-Kramer test, $p<0.05$. In the field study, high weed infestation (mainly *Amaranthus palmeri*) was observed in the TFX-treated soil along with a sharp decline in its herbicidal activity, suggesting rapid dissipation of TFX in the soil. *Sorghum bicolor* response to TFX in RWW irrigated soil was significantly lower than that grown the FW-irrigated soil. Sterilized RWW irrigated-soil exhibited higher TFX activity versus non-sterilized soil. No difference in TFX movement in the soil was observed in soils with different irrigation history. These data imply that TFX activity in RWW-irrigated soil is probably affected by the soil microbial population(s) and by the dissolved organic matter (DOM) content in the water. Furthermore, degradation experiments of TFX will be conducted in different temperatures and field capacity to evaluate the degradation kinetics of TFX in the soil and to analyze the metabolites formed in the process using HPLC/MS.

Novel weed control system in sugar beet

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A novel weed control system for sugar beet is presented. The system is a result of a joint research and development project between BCS-AG Frankfurt and KWS Saat AG Einbeck.
In close cooperation, a herbicide-tolerant sugar beet mutant line containing a single point mutation in ALS has been selected to make use of the leading BCS ALS inhibitors Foramsulfuron and Thiencarbazone in sugar beet. This approach for nonGM trait selection has been pursued successfully to generate fully tolerant sugar beets.
The nonGM trait is currently introgressed into elite sugar beet germplasm of KWS. In parallel herbicide registration trials have been started all over Europe by BCS.

The sensitivity of sunflowers to sulfosulfuron residue in the growth chamber conditions

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Sulfosulfuron is commonly used in Turkey to control brome grass and several broadleaf weeds found in wheat crops that can cause carryover problems to subsequent crops, such as sunflower. A growth chamber bioassay was conducted to determine the sensitivity of sunflower cultivars to sulfosulfuron residue in the soil. The sensitivity of 16 sunflower cultivars to sulfosulfuron and differences in the sensitivity of the sunflower cultivars to soil residue of sulfosulfuron were determined in the growth chamber (16 h of light [24 ± 1^{o}C and illumination 100 µE m^{-2} s^{-1}], 8 h of darkness [15 ± 1^{o}C]). Logarithmic doses of sulfosulfuron, ranging from 0.0 to 20 µg ai kg-1, were applied to the soil taken from nonagricultural land. One sunflower seedling was then sown in a pot containing artificially contaminated soil and grown for 15 days. The pots were randomly placed in the growth chamber and irrigated with deionized water. The roots were gently washed under tap water and the root lengths were measured. To compute the selectivity index, log-logistic analysis was used to calculate the I_{50} values that reduced the root length by 50% (I_{50} [variety a]/I_{50} [variety b]). NX5009 was the most sensitive sunflower cultivar to sulfosulfuron soil residue with an I_{50} value of 0.50 µg ai kg^{-1}. The selectivity index, calculated with respect to NX5009, ranged from 0.27 to 0.88. SANBRO (0.56 µg ai kg^{-1}), C70165 (0.64 µg ai kg^{-1}), and TUNCA (0.65 µg ai kg^{-1}) exhibited the same sensitivity level as NX5009. The sulfosulfuron sensitivity of OLEKO (1.79 µg ai kg^{-1}) and MH4326 (1.82 µg ai kg^{-1}) were the lowest compared to NX5009.

Multifunctional adjuvants for herbicide and other agrochemical formulations

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Efficacy of herbicides and other agrochemicals is reduced by various environmental, biological and application factors. Thus, usually only a small fraction of active ingredients are biologically utilized and because of this relatively high rates of agrochemicals must be applied to provide adequate efficacy. A single-component adjuvants rarely optimise spray mixture characteristics and provide enhanced droplet retention, spray deposit formation, absorption of active ingredient and finally biological performance. To optimize activity of low rates of various agrochemicals under a wide range of environmental, application and biological conditions, several homogenous, liquid multifunctional adjuvant formulations were invented. These adjuvants, that usually contain carefully selected surfactants, modified oils, fertilizers, pH buffers and/or humectants were investigated with glyphosate herbicide and salicylic acid based plant growth regulator formulation in the laboratory and field experiments. Data on glyphosate absorption, chlorophyll fluorescence and efficacy indicate that the herbicide formulation containing multifunctional adjuvant system was more consistent in various conditions and performed substantially better than the reference traditional glyphosate formulation. Experiments indicated also that the glyphosate rate may be significantly reduced while maintaining herbicide efficacy. Multicomponent adjuvant build-in growth regulator formulation provided excellent salicylic acid solubility. This formulation increased grain yield of wheat and maize in dry growing season and slightly decreased maize phytotoxicity caused by 2,4 D + nicosulfuron and tembotrione + flufenacet + isoxaflutole herbicide mixtures.

Use of high-speed imaging to predict spray retention on barley leaves

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Laboratory studies were conducted to validate the effectiveness of the use of the method of high-speed imaging method to replace chemical analysis by fluoremetrie. Measurements were performed with a high-speed camera coupled with a retro-LED lighting. Size and velocity of the drop were extracted by image analysis.
Drop impact types were determined by the operator. Drops were produced with a flat-fan nozzle mounted on a movable ramp. Two surfactant (Break-Thru® S240 and Li700) were sprayed to highlight the effect of the reduction of the surface tension. Relative volume proportions were computed within of an energy scale divided into 11 classes based on the Weber number.
Results are compared to the result of the chemical analysis by spectroflueremetry.

Effect of two surfactants on spray jets retention by barley leaves

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Surfactants are nowadays very useful additives to improve the effectiveness of phytosanitary treatments. They contribute to change the types of impact and thus the amount of spray retained by the leaves of the treated plant.
We performed tests of retention on whole barley plants on BBCH-scale 12 and small pieces of barley leaves at the same stage of growth. Spraying was done in three ways: water without surfactant, water with Break-Thru S240 and water with Li700.
The three slurries of fluorescein contained in an amount of 0.2 g / l. Fluorescein retained by the leaves in both cases is then measured by a spectrofluoremeter.
The retention tests on whole plants show that it is tripled by the first surfactant and doubled by the second. By cons on small pieces of barley leaves, the amount was increased by the use of surfactants but not to the same scale.
This study concluded that the use of surfactants in spray pesticides may increase the amount of retention as a function of leaf area and the surfactant used.

Chemical weed control in direct seeded fine grain rice

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Fine grain aromatic rice (*Oryza sativa* L.) is the special brand of Pakistan liked all over the world and grown conventionally by transplanting the nursery seedlings in puddled and flooded fields. However, the sever water shortage in Pakistan during the recent times has forced to grow the rice by dry direct seeding (DDS). However, the weeds are major constraint to successfully grow the rice crop as DDS. The main focus of our research work has been the evaluation of herbicides for managing weeds, improving yield, economic returns and water productivity in DDS of rice.

Herbicides were evaluated for controlling weeds, increasing yield and economic returns in three field experiments. In the first experiment, three pre-emergence herbicides [butachlor (1.8 kg a.i. ha^{-1}), pendimethalin (1.65 kg a.i. ha^{-1}) and pretilachlor (1.25 kg a.i. ha^{-1}) were sprayed immediately after the sowing of crop and a weedy check was established for comparison. In the second experiment, three herbicides, pendimethalin (825 g ai ha^{-1}), penoxsulam (15 g ai ha^{-1}) and bispyribac-sodium (25 g ai ha^{-1}) were applied pre-emergence, early post-emergence and post-emergence, respectively. Weedy check and weed free treatments were included in the experiment for comparison. In the third experiment, herbicides including pendimethalin (825 g a.i. ha^{-1}) and penoxsulam (15 g a.i. ha^{-1}) were sprayed as pre-emergence and as early post-emergence, respectively for controlling weeds in DDS of rice while a weedy check was maintained for comparison. All the experiments were conducted in randomized complete block design on a sandy loam soil. Manual knapsack sprayer was used to apply herbicides in all the three experiments. Data on weeds and yield were recorded and analyzed using Fisher's analysis of variance technique and treatments means were separated using LSD test at 5% probability. Economic returns were worked out by calculating the total expenses and income. Water productivity was calculated as the ratio of grain yield to applied water and presented as kg of grains per m^3 of water.

The results from numerous investigations indicates that weeds severely infest the DDS rice fields and reduce the grain yield by >70%. In the first experiment, the herbicides pretilachlor, butachlor and pendimethalin reduced the total weeds density (>80%) and weed dry weigh (74-87%) and also significantly increased the paddy yield (7-19%) and economic returns over control. In the second study, the comparison of weed free and weedy check indicated that the weeds decreased the paddy yield by >75%. Pendimethalin, penoxulam and bispyribac-sodium decreased the weed density (50.5-94.6%), dry weight (61.1-89.8%) and unproductive tillers over control and also increased the number of

productive tillers, paddy yield (50.1-62.2%), economic returns and water productivity in DDS of rice. Similarly, the results of third experiment indicated that the application of penoxulam and pendimethalin reduced the weeds density (79.8% and 73.1%, respectively) and dry weight (82.01% and 75.96%, respectively) as well as increased the yield (88.5 and 76.2%, respectively), economic returns and water productivity over the control treatment.
We conceived from the results of these experiments that herbicides including pendimethalin, penoxulam and bispyribac-sodium can act as potential chemicals for controlling weeds, increasing yield and improving the economic returns as well as water productivity in direct seeded rice.

Distribution and characterization of glyphosate resistance in perennial crops in Portugal

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Weed management practices in perennial crops rely most on herbicide application in line row and intra-row cover cropping. Glyphosate resistance was selected in fields with consecutive applications of more than 2-3 applications per year. In this paper we present the distribution and characterization of glyphosate resistance (GR) in *Conyza* spp. from olivegroves (Alentejo, South) and *Lolium* spp. from vineyards (Douro, North).

Dose-response bioassays for glyphosate and sulfonylurea herbicides and shiquimate test were carried out to confirm resistance in 16 populations of *Conyza* spp. and 4 populations of *Lolium* spp. Fresh weight was assessed 21 DAA of seven doses of glyphosate (180 -5760 a.e.ha^{-1}) to plants of *Conyza* spp. at rosetta stage. For *Lolium* bioassay, six doses of glyphosate (60-2400 a.e ha^{-1}) were applied to plants with 4-6 leaves. A RBD design with 7 to 10 replicates was carried out and the bioassays were repeated. ED_{50} were determined by fitting non-linear log logistic models. Field trials were conducted in 2011 in one vine yard (Douro) and in one olivegrove (Alentejo) to assess the efficacy of post-emergence herbicide programs on R populations. A RBD experiment with 8 treatments in Douro and 13 treatments in Alentejo with 3 replicates was implemented. Treatments included POST-only (2 rates of glyphosate) and 2-pass.-POST (foliar or residual followed by glyphosate). An untreated control was included for comparison.

Resistance in *Lolium perenne* populations was confirmed in Régua vineyards (FR= ED_{50} R/ED_{50}S) = 3 but not in Pinhão (FR= 1). In Alentejo , the survey carried out with eight populations of *C. bonariensis* and eight populations *C. canadensis* revealed that about 50% each were resistant to glyphosate. The resistance factor (RF) ranged from 2 to 8. *Conyza* spp. populations presented a higher factor of resistance than *Lolium perenne*. Different mechanism of resistance could explain these results. Shikimate test results indicate that the mechanism of resistance to glyphosate in *C. bonariensis* did not result from the insensitivity of EPSPS but probably a change in the translocation of the herbicide

Management strategies with herbicide programs combining glyphosate with either cycloxidym, flazasulfuron or quizalofop-ethyl could be effective alternatives for the control of R *Lolium* sp. in vineyards. Trials with sulfonylurea herbicides, synthetic auxins and glufosinate confirmed that these are alternative a.i. to control *Conyza* spp. GR populations that could be included in IWM strategies.

The influence of adjuvants on *Amaranthus retroflexus* L. control with topramezone

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Multi-year research in Croatia showed that *Amaranthus retroflexus* L. (redroot pigweed) occupies fifth place among row crop weed flora, including maize. The new herbicide for broadleaved and grass control in maize is topramezone. Nowadays, mostly due to ecological reasons, herbicides are usually used in post-emergence, often in reduced rates in combination with different adjuvants. This paper reports the results of a study designed to determine the rate of topramezone that reduces the redroot pigweed growth for 90% (GR_{90} values) when applied alone and the rate of topramezone when applied in combination with adjuvants to reduce pigweed growth to the same level. The treatments included topramezone applied at different rates (0; 8,25; 16,5; 33; 66 and 132 g a.i. ha^{-1}). Each topramezone rate was applied alone and in combination with nonionic surfactant (NIS), crop oil concetrate (COC), methylated seed oil (MSO), urea ammonium nitrate (UAN) and ammonium sulphate (AMS). Redroot pigweed plants were grown under controlled conditions at the constant temperature of 25^0C during day and 20^0C at night with photoperiods of 16:8 h (light:dark) with relative humidity of 75% in three replicates. The application of topramezone and the adjuvants was done when redroot pigweed plants were in the growth stage of four to six leaves. Plant shoots were harvested three weeks after the treatments to measure dry weight per pot. At the basis of redroot pigweed dry weight reduction logarithmic curves were calculated and plotted as plant susceptibility to treatments. Dose-response curves were created in R program in dose response curve package and GR_{90} values for each treatment were calculated. The significant difference was detected between topramezone rates, between different adjuvants, as well as a significant interaction adjuvant x topramezone rate. The results indicated that redroot pigweed is not sensitive to topramezone when applied alone. Even a doubled rate (132 g a.i. ha^{-1}) of recommended topramezone rate did not satisfactorily reduce plant dry matter (<70%). Consequently, the rate of topramezone applied without adjuvants needed for 90% reduction of redroot pigweed plants dry matter (GR_{90} values) is 369,86 g a.i. ha^{-1}. The addition of the adjuvants to topramezone strongly reduced plant dry matter. The recommended topramezone rate (66 g a.i. ha^{-1}) with all the investigated adjuvants significantly reduced dry redroot pigweed biomass when compared to topramezone alone. When comparing different adjuvants**,** significantly better plant reduction occured with MSO+UAN, MSO+AMS, NIS+UAN, NIS+AMS, UAN and AMS. All the adjuvants, other than MSO+UAN and NIS, applied at 8,25 g topramezone ha^{-1} reduced dry matter from 75 to 92,4%. The calculated topramezone rates applied in combination with the adjuvants needed for 90% dry matter reduction were lower than the lowest topramezone rate (8,25 a.i. ha^{-1}). GR_{90} values for topramezone forall treatments, except MSO+UAN (8,41 a.i. ha^{-1}),

NIS (10,6 g a.i. ha^{-1}) and UAN (61,84 g a.i. ha^{-1}), ranged from 0,87 g a.i. ha^{-1} (MSO) to 7,00 g a.i. ha^{-1} (COC+UAN).

Roundup Ready® maize makes the weed control easier

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Large field trial with glyphosate tolerant NK 603 maize was established in 2010-2012 in central part of the Czech Republic. Three soil tillage systems (conventional, reduced and conservation with mulch) and five different herbicide treatments were the experimental factors. Two treatments were conventional (1. acetochlor + terbuthylazin pre-emergence, and 2. foramsulfuron + iodosulfuron post-emergence) and three intended for weed control in Roundup Ready® varieties (3. pre-emergence application of acetochlor followed by post-emergence application of glyphosate; 4. split applications of glyphosate at BBCH 13 and BBCH 16-18 of maize; and 5. early post-emergence application of acetochlor + glyphosate). *Echinochloa crus-galli* (ECHCG), *Chenopodium album* (CHEAL) and *Amaranthus retroflexus* (AMARE) were prevalent species. Because of high weed population densities and uneven rainfall distribution, ECHCG escaped often after conventional pre-emergence and CHEAL after both pre- and post-emergence herbicide treatments. Roundup Ready® treatments provided more reliable control in all three experimental years. Most efficient were the treatments 4 and 5 with efficacy about 99 % on all assessed weeds in all soil tillage systems. Wide efficacy spectrum of glyphosate, simple timing and sequence of 2 applications contributed to the control success.

Leaching of different maize herbicides as affected by the time elapsed from spraying and first leaching event

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The study was conducted in 2011 in North-West of Italy, on a battery of 12 lisymeters (8.4m^2 large with a depth of 2m) filled with silty-loam soil.
The aim of the study was to evaluate the leaching behavior of five herbicides (terbuthylazine, S-metolachlor, mesotrione, flufenacet, and isoxaflutole) and two metabolites (desethyl-terbuthylazine and diketonitrile) as affected by time elapsed from spraying and first leaching event. All lisymeters were treated in pre-emergence with the selected herbicides applying a mixture of the commercial products Lumax (2.5 L/ha) and Merlin Gold (1 L/ha). An irrigation able to produce leaching (40mm) was carried out on independent groups of three lysimeters at 1 days after treatment (1DAT), 7 DAT, 14 DAT and 28 DAT and then repeated fourteen days later. At the time of the treatment soil of the lysimeters was at the field capacity. Samples of leachate were collected within few days after the irrigation. The compounds were extracted by SPE, and analyzed by HPLC and GC-MS. For all compounds, the highest concentrations were detected at 1DAT and fourteen days later (1+14 DAT). At these time the concentrations detected were respectively: 2.88 µg/L and 0.95 µg/L (S-metolachlor), and 0.96 µg/L and 0.52 µg/L(terbuthylazine). Flufenacet leached only in case of irrigation interventions close to herbicide spraying, isoxaflutole and mesotrione have never been found (<0.1 µg/L), while diketonitrile has been detected in concentrations above 0.1 µg/L at 1DAT only. Desethyl-terbuthylazine has frequently been found, but at concentrations never above 0.3 µg/L.

Glyphosate sensitivity in Italian weedy rice

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Weedy rice (*Oryza sativa* L.) is one of the most problematic weeds of rice cultivation worldwide. An effective control technique is the application of the stale seedbed which consists of preparing the field early in the season and then flooding it to stimulate weed germination. After the seedlings have emerged, they are destroyed by using herbicides such as glyphosate. The efficacy of this technique could be affected by variability in weedy rice sensitivity to the herbicide applied. The aim of the study was to evaluate the sensitivity to glyphosate of 90 weedy rice populations, collected in fields located in the major Italian rice cultivation area, and selected on the basis of their phenotypic features.The experiment was carried out in 2011 and 2012 in greenhouse by seeding weedy rice in alveolar trays (3 seeds/alveolus) with 3 replications. Weedy rice seedlings (3-leaf stage) were sprayed with glyphosate at the field rate (1400 g a.s./ha). Shoot biomass was assessed 15 days after treatment and data were expressed as percent of weight reduction of untreated plants. Visual rating of weed control was also recorded. The results showed that the tested populations had a variable level of sensitivity towards glyphosate, resulting in a visual weed control always exceeding 69%. Weedy rice biomass reduction ranged between 35% and 86%. In spite of this large variability, the sensitivity to glyphosate did not vary significantly among awnless, awned and mucronate populations and was not correlated with hull coloration.

Assessment of weedy rice sensitivity to imazamox with a fast dose-response bioassay

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The objective of this work was to evaluate a low-cost, quick dose-response assay for the assessment of imazamox sensitivity in Italian weedy rice populations. Seeds of ten weedy rice populations and five cultivars (four of which tolerant to imidazolinones herbicides) were incubated in filter paper saturated with distilled water in the light at 25°C for five days. After this time, the seedlings reached the two- to three- leaf stage. The seminal roots of the seedlings were then cut and the seedlings were placed in 50mL-plastic glasses containing 20mL of vermiculite and 30mL of a solution with a specific dose of imazamox. The tested concentrations were 0.01mM, 0.1mM, 1mM, 10mM, 100mM, 1M and 4M. Assessment of plant response to herbicide treatments was carried out after six days by measuring length of the newly formed roots. Data were fitted to a 4-parameter log-logistic model and comparisons between populations were made using estimated imazamox concentrations able to affect root length by 50% (IC_{50}). On this base, imazamox sensitivity of weedy rice populations varied between about 10^2 and 10^9 times that of the average sensitivity of imazamox-tolerant rice cultivar. The discriminatory concentrations for weedy rice, conventional rice and imazamox-tolerant rice plants were <0.0001M, <0.0001M and >0.01M, respectively. This screening technique was proved to be a fast and low-cost tool for preliminary determination weedy rice sensitivity to imazamox.

Evaluation of weed species for influence on maize yield in Latvia

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The area of maize grown in Latvia has increased gradually during the past 10 years (2002: 1.2 thousand ha; 2011: 10 thousand ha) as the crop has been used for biomass to produce biogas. During these 10 years with different weather conditions the weed species composition was evaluated in two regions of Latvia in field trials after different previous crops. In the maize trials annual dicotyledonous weeds were determined as the most frequent: *Chenopodium album*, *Lamium purpureum*, *Sinapis arvensis*, *Capsella bursa-pastoris*, *Thlaspi arvense*, *Veronica arvensis*, *Galium apar*ine.

The results showed that the previous crop greatly influenced the spectrum of dominant weed species and was one of the factors influencing the infestation level. The numbers of weed species recorded in each trial ranged from 7 to 24, and from 2 to 7 species were dominant. The occurrence of *Galium aparine* decreased during last 5 years, but in contrast *Veronica arvensis* increased. *Chenopodium album* was among the most frequent weed species and caused significant losses of yield. In fields where the previous crop was maize in the untreated populations of dicotyledonous weeds ranged from 95 to 215 plants m^{-2}.

To regain profitability, farmers will have to increase inputs like herbicides, but must use them more effectively. A range of herbicides has been tested at several doses and timings in efficacy trials. These have shown that products are available to control the important and competitive weeds in maize and that good control can be achieved with appropriate doses and application times.

Herbicide efficacy for common ragweed (*Ambrosia artemisiifolia* L.) control after defoliation

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Besides being a weed in various cropping systems, common ragweed is also considered a major allergenic plant due to production of pollen, which causes severe health problems in humans. Herbicide efficacy is strongly correlated with uptake of herbicide from plant's active leaf surface, which is strongly decreased after defoliation. To determine efficacy of herbicides applied to ragweed defoliated by cutting, pot experiment with randomized treatments in 5 replications was conducted in 2011. Common ragweed plants were cut 5 cm above ground at different development stages; V10 (10-leaf), V18, V28 and beginning of flowering. Herbicides with active ingredients glyphosate, dicamba, bentazon and thifensulfuron-methyl were then applied on various total leaf areas (10, 35, 60, 85 and 100 %) of defoliated ragweed plants. Efficacy of herbicides decreased with increasing ragweed development stage and decreasing leaf area exposed to herbicide application. Only treatments with glyphosate and dicamba at two early growth stages V10 and V18 stage resulted in 90 % dry matter reduction, when total (100 %) leaf area of ragweed plants was covered with herbicide after defoliation. When very low leaf areas (20-35 %) were treated, the efficacy was low (20-50 %), however seed production of ragweed decreased by 75-90 %. Treatments based on bentazon showed insufficient reduction of ragweed dry matter production. Only glyphosate, thifensulfuron-methyl and dicamba applied at early stages V10 and V18 displayed sufficient control. However, at least 40 % of leaf area of ragweed remains after cutting have to be covered with herbicides to achieve 50 % dry matter reduction and 90 % decrease of seed production.

Efficacy of selected herbicide treatments on potentially invasive species in Slovenia

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Invasions of non indigenous plant species have been recognized as increasing environmental and economic threat as they spread in the native flora and agricultural crops. Efficiency of herbicide active ingredients on the existing economically relevant weed species is known, however we can not simply predict that the effectiveness of the chemical compound would be similar to related invasive species. To determine efficacy of selected herbicide treatments on invasive species from *Ambrosia*, *Amaranthus*, *Bidens*, *Cenchrus*, *Cyperus*, *Datura*, *Echinochloa*, *Ipomea*, *Iwa*, *Panicum*, *Polygonum*, *Setaria*, *Solanum* and *Xanthium* genus, field trial in maize was conducted in years 2011 and 2012. *Echinochloa* and *Setaria* species can be sufficiently controlled with preemergence application of S-metalochlor and terbutilazin. The best postemergence control was obtained with application of nico-and rimsulfuron treatments. *Cenchrus* species were susceptible only to nico- and rimsulfuron and S-metalochlor and terbutilazin. All tested herbicides displayed poor control of *Cyperus esculentus. Bidens alba*, *Bidens connata* and *Bidens vulgata* can be controlled with S-matalochlor, terbutilazin, dicamba, tembotrion, nico- and rimsulfuron herbicides, but results varied greatly among species. *Ambrosia trifida* L. displayed great competitiveness in maize. Best control was obtained with 2.4 D, dicamba, tembotrion and mesotrion application. Our results indicate that *Ipomea*, *Datura* and *Sida* species are difficult to control with available herbicides, although they were not highly competitive in maize. Majority of the invasive species can be effectivelly controlled with tested herbicides, however efficacy of herbicides on some species in this study was insufficient, allowing survival of small initial populations and their further spread.

Determination of weeds and effective herbicides in rice fields in Karacadag

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In this study carried out to determine the prevalence and intensity of weeds in production areas of Karacadağ rice variety and herbicides to be effective against these weeds, a survey was conducted in 2010 and 2011 years in the provinces of Diyarbakır and Sanlıurfa. At the same time, an experiment was conducted to determine the effectiveness of the registered herbicides [bentazone (200 ml/da), bispyribac-sodium (6 ml/da), cyhalofop butyl (150 ml/da), penoxulam (100 ml/da), propanil (1500 ml/da)] widely used in the rice fields with pan-style irrigation system in production areas of Karacadağ rice variety that surface irrigation methods was used. In the result of surveys, a total of 34 weed species were detected. While *Echinochloa crus-galli* (L.) P. B. (barnyardgrass) and *Cyperus* spp. (nut grass) species were common in the narrow-leaved weeds, *Physalis* spp. (ground cherry), *Xanthium strumarium* L. (cocklebur) and *Amaranthus retroflexus* L. (common amaranth) species were found to be more intense in broad leaves. According to the results of a two-year experiment, when compared the control (non-herbicide plots), the plots that propanil and bentazone herbicides were applied have lower weed density. Weed species present in the surveyed area were *Agrostis capillaris* L., *Amaranthus albus* L., *A. retroflexus* L., *Chenopodium album* L., *Cichorium intybus* L., *Conyza canadensis* (L.) Cron., *Cynodon dactylon* (L.) Pers., *Cyperus glomeratus* L., *C. longus* L., *C. rotundus* L., *C. seriotinus* Rottb., *Digitaria sanguinalis* (L.) Scop., *E. crus-galli* (L.) P.B., *Epilobium hirsutum* L., *Equisetum* sp. , *Mentha spicata* L., *Erogrostis collina* L., *Lactuca aculeata* Boiss., *L. saligna* L., *L. serriole* L., *Lythrum hyssopifolia* L., *Poa nemoralis* L., *Polygonum persicaria* L., *Rumex crispus* L., *Scirpoides holoschoenus* (L.) Sojak, *Solanum nigrum* L., *Trifolium arvense* L., *T. haussknechtii* var. *haussknechtii* Boiss., *T. resupinatum* L., *Physalis* sp., *Veronica anagallis-aquatica* L. subsp. *oxycarpa* (Boiss.) Elenevskyı, *V. lysimachioides* (Boiss.) M. A., *Xanthium spinosum* L., *X. strumarium* L.,

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Effect of spray carrier water salts on foramsulfuron performance

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Spray carrier water cations can affect most postemergence herbicides activity on weeds. Foramsulfuron is newly registered for corn weed in Iran so it is needed to determine the effect of water quality on its performance. Greenhouse and field experiments were carried out in the experimental greenhouse and field of University of Tehran during 2010 and 2011. The effect of different adjuvants on offsetting adverse effects of cations of spray carrier water on foramsulfuron performance in controlling *Chenopodium album L.* (common lambsquarters) and *Sorghum halepense (L.) Pers.* (Johnsongrass) in greenhouse and whole weed species in corn field were evaluated. Treatments were various doses of herbicides in companying with adjuvants urea-ammonium nitrate (UAN), ammonium sulfate (AMS) and mutilated seed oil (MSO) which were used with water fortified with calcium and Fe ions. Experimental design was a completely randomized design with four replications. Treatments were a factorial combination of foramsulfuron rates, adjuvants and spray carrier water. The results of this study revealed that Fe was more efficient than Ca in reducing foramsulfuron toxicity to weed species. All used adjuvants increased herbicide efficacy regardless of spray solution salts. Adding MSO to nitrogen additives further enhanced weed control. The best adjuvant for control of common lambsquarters was UAN while for johnsongrass adding AMS was the best adjuvant. In general AMS was most effective adjuvant in enhancing foramsulfuron performance.

Control of *Acroptilon repens* (L.) DC. in Russia

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Acroptilon repens (L.) DC. (Russian knapweed, creeping knapweed, hardheads) is an extremely harmful perennial weed. In 19th century, it was found in the territory of the former Soviet Union. Now it is spreading rapidly. Currently, it is a quarantine species of plant in the Russian Federation. Agronomic and chemical methods are used to control of the distribution of *Acroptilon repens (L.) DC.* There was a need to have some assortment of herbicides to control this weed. To form this assortment we carried out the trials including several groups of herbicides. Therefore, the herbicide LANCELOT 450 (aminopyralide 300 g/kg + florasulam 150 g/kg) can be used for the protection of barley and wheat. The mixture of herbicides OKTYMET (2,4-D 500 g/l + metsulfuron-methyl 5,5 g/l) + LOSK (clopyralid 750 g/kg) can be used for the protection of spring wheat. However, the most effective control of *Acroptilon repens (L.) DC.* is seen in fallow soil or non-agricultural land. For example, the herbicide GORGON (MCPA 350 g/l + picloram150 g/l) can be used in fallow soil. The herbicide SCHKVAL (imazapyr 250 g/l) can be used in non-agricultural land. The herbicide GORCHAK (dicamba 88,5 g/l + picloram 88,5 g/l + clopyralid 177 g/l) can be used both in fallow soil and non-agricultural land.

Efficiency and losses of herbicides when spraying

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Modern technologies of crop cultivation provide herbicide application by spraying method. But this method leads to significant unproductive losses of expensive preparations and environmental pollution. Researches on the effectiveness of herbicides and unsustainable losses of preparations when spraying are carried out. Records of plants weeds were taken on the fixed areas in accordance with the phases of maize development: coleoptile, 3, 5, 7, 9- leaves. Specific composition of plants, their height, leaf area, projective surface of the field were recorded in accordance with the phases of crop development. In parallel, at the same time on the split plots sprouting crops and weeds were recorded and crops were sprayed with working herbicide liquid Dublon Gold v.d.g. and pigment, distribution of its drops on the surface of the field and plants was estimated. The consumption rate of the preparation is 60g ha^{-1} + SAW Adjue at the rate of 200 mL ha^{-1}, working liquid consumption 200 L ha^{-1} .

The results of research of the method of maize spraying with the working liquid with pigment and herbicide have showed that their distribution depended on the species composition of weeds, leaf area and projective cover and spraying terms. The biggest losses of the working liquid were observed at the early phases of ontogenesis of maize and weed plants. In maize they were up to 86.2% of the total consumption.

Postponing of spraying time for later date reduces preparation waste by 52.1%, but herbicide effectiveness decrease makes up 24.9%.

It is necessary to elaborate more advanced methods of preparation application on the target objects plants.

A database for the herbicide use in France

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In order to provide concrete evidence over the use of herbicides in France, their use since 1944 has been analysed from an historical point of view. A database was built up from available data found in the archives of the French Ministry of Agriculture and from the index annually edited since 1961 by the "Association de Coordination Technique Agricole".
This data base gives the number of active ingredients, active ingredient associations and commercial products registered every year for the main crops cultivated in France. We also gathered the modes of action (classification of Herbicide Resistance Action Committee (HRAC)), the way of absorption sites and botanical group susceptibility. Only ingredient associations used in cultivated areas were retained.
The first organic synthetic herbicides were registered after the Second World War and a total of 225 herbicidal active ingredients have been registered in France since 1944. It appears that the number of active ingredients regularly increased with a maximum of 138 in 2002. Different combinations (maximum of 156 in 2002) were available that combined 2 to 5 active ingredients. A decrease in the number of active ingredients was observed after 2003 due to European and French strengthened regulations; 105 were still authorized in 2012. On average, a given active ingredient has been used for more than twenty years. This evolution induces a risk; the repeated use of fewer active ingredients belonging to a few HRAC groups may favour the selection of herbicide resistant weeds. The communication presents the results of this approach that replaces the use of these active substances against weed populations in the present context in the agriculture.

Efficacy of herbicides on tuber production of *Cyperus esculentus* (L.) after surface application and incorporation

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The objective of this study was to evaluate Yellow Nutsedge (Cyperus esculentus *L.)* tuber production after herbicides applications comparing POST treatment and POST treatment plus incorporation.
In order to study the effect of herbicide incorporation on the development of Yellow Nutsedge after different herbicide treatments (residual herbicides, sulfonylureas, contact herbicides) greenhouse and field experiments were conducted in 2012.
The field experiment was arranged in a split-plot arrangement using randomized complete block design with four replications at two different sites in Switzerland. Soil cultivation (main factor) consisted of 2 levels (no soil cultivation and incorporation with a rotary harrow to 10 cm) and the sub-factor consisted of 11 different herbicide treatments and one control with no herbicide application.
Results will be presented showing the effects of incorporation and herbicide on tuber production.

Weed control in chickpea under conditions of the forest-steppe zone of Ukraine

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Legumes play a key role in solving the problem of plant protein. In recent years, farmers are more interested in growing chickpea in the southern and central regions of the country.

Since chickpeas refers to minor crops, today the question of bacteria herbacratic period and thresholds of weed harmfulness in this crop as well the systems of herbicides for their effective control have not been investigated in Ukraine yet.

Field trials were carried out in 2011-2012. Pre-emergenceherbicides were applied on the day of planting, post-emergence at the phase of 1-3 true leaves in chickpea. Sprayer- PL 2 "System Agrotop". Water wolume 250 L ha^{-1}. Herbicides efficacy was assessed 30 days after treatment (DAT) and at crop harvest by measuring the above-ground weed fresh weight.

As a result of researches it has been established that chickpea plants have low competitive activity against weeds. Significant reduction in yield is observed when there are 10 plants of annual weeds m^{-2}. Herbacratic period begins in 20 days after crop germination.

Pre-emergence herbicides acetochlor 1800 a.i. g ha^{-1} and dimetanamid-P 720 a.i. g ha^{-1} have appeared to be the most selective to crop. Among post-emergence herbicides highest level of control has been provided be the application of imazamox 40 a.i. g ha^{-1} or tank mixture of bentazone 720 a.i. g ha^{-1} and tapraloxidim 54 a.i. g.ha^{-1}. Weed ifestation reduce has been 86-89% under these conditions. The highest yield has been obtained in variant, in which dimetanamid-P and acetochlor have been applied 1,35-1,37 t ha^{-1}.

Thus, the presence of 10 m^{-2} annual weeds is considered to be the threshold of harmfulness in chickpea crops. Weed control must be conducted not later than in 20 days after crop germination. In the system of weed control it is advisable to apply pre-emergence acetochlor or dimetanamid-P or post-emergence use imazamox or tank mixture of bentazone and tapraloxidim.

The sensitivity and histological changes in tomato plants (*Lycopersicon esculentum* Mill.) depending on herbicides

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Tomato plants are characterized by high sensitivity to various herbicides used in field crops. Some of them decrease the growth rate, but in most cases herbicides are highly phytotoxic and cause visible damage to tomato leaves and stems, which causes a reduction or complete loss of fruit yield. The aim of the studies was to assess the sensitivity of tomato plants and determine the morphological and anatomical changes caused in them by herbicides used on other field crops.

The studies were carried out during the growing seasons of 2010-2012 at the Research Institute of Horticulture in Skierniewice. The experiments were conducted under greenhouse and open field conditions. The field trials were set up in a completely randomized block design with 4 replications, on a pseudopodsolic soil. The size of each plot was 9 m^2. Tomato plants cv. Rumba were planted between 21 and 23 of May and were treated with selected herbicides such as: tribenuron-methyl, bromoxynil, fluroxypyr and ethofumesate. All the herbicides were applied 2 weeks after planting at the rate of 100, 10 and 2% of their maximum doses recommended in Poland (18.8, 400, 200 and 500 g/ha, respectively). The morphology and colour of the leaves were examined with a stereomicroscope. Changes in tomato leaf tissues were examined with a stereomicroscope, light microscope and scanning electron microscope.

The studies revealed that the treated tomato plants were very sensitive to fluroxypyr applied at the rate of 200 g/ha (100% of plants damaged) and bromoxynil at the rate of 400 g/ha (90% damaged at 21 DAT and over 70% before harvest). The extent of injuries caused by tribenuron-methyl exceeded 70% and of those caused by ethofumesate 20%. Fluroxypyr at 10% of the maximal rate damaged over 70% of tomato plants, and bromoxynil over 40%. Despite the injuries caused by tribenuron-methyl at the highest application rate and fluroxypyr at 100 and 10% of the maximal rate, the damaged tomato plants managed to recover and their height at harvest did not differ significantly from that of the untreated plants. The herbicide treatments reduced the yield of tomato fruit in all of the cases. However, the use of fluroxypyr caused complete yield loss.

There were significant differences in leaf cell responses to individual herbicides. Extensive changes in the tissues occurred after the application of herbicides at the highest doses, except for ethofumesate. The most destructive changes in the epidermal cells (primary cells, hairs and stomata), fragments of parenchyma and vascular bundles were observed after treatment with bromoxynil and fluroxypyr. Fewer necrotic cells were visible in the leaves after spraying with ethofumesate. The type of damage to tomato plants depended on the herbicide, but the degree of damage depended on the rate of application of the

herbicide. The herbicide application rate and the degree of damage had an impact on the persistence of the phytotoxic effect.
The selected herbicides cause stress response visible in the morphology and anatomical structures of tomato plants. The type of tissue damage depends on the active ingredients of the herbicides, their mode of action and the rate of application.

Evaluating herbicide tolerance of Australian cereal crops: A nationally co-ordinated approach

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Yield loss in some cereal crops in Australia has commonly been caused by applying registered herbicides at label rates to recommended crop stages. Furthermore, differences in tolerance have been noted between the sub-tropical and Mediterranean grain growing regions of Australia where cereal varieties grown and herbicide formulations used commonly differ. For example, very few varieties adapted to the sub-tropical cropping region of Australia would suit the different environment and soils of the Mediterranean regions of Australia. Whilst some of the crop damage may be attributed to environmental factors, varieties were also thought to differ in their tolerance to herbicides. Consequently, investigations into the herbicide tolerance of all *Triticum aestivum* L. (wheat) and *Hordeum vulgare* L. (barley) varieties commenced in 1999 with four regionally-based, stand-alone herbicide tolerance projects established to cover the major cereal growing regions of Australia. In 2009, a national co-ordinated approach to herbicide tolerance screening was implemented. Herbicide tolerance screening now involves a three stage testing regime, Preliminary Evaluation (testing new varieties before commercialisation), Advanced Evaluation (post-commercialisation, more detailed investigation of identified crop damage) and New Chemistry Evaluation (testing new herbicides before registration). In addition, common variety by herbicide treatments are being evaluated across regions to explore genotype x herbicide x environment interactions. Also, a simple rating system has been developed using symbols to categorise sensitivity of varieties to various herbicides. The rating system is based on yield responses across herbicide rates and years of testing and is used in publicising results to industry.

Research has shown many varieties to differ substantially in their sensitivity to some important selective herbicides and tank mixes. In addition, testing has shown different levels of crop sensitivity in the sub-tropical region compared with the Mediterranean region, indicating a strong environmental influence on herbicide tolerance. Fortunately, the majority of varieties (approximately 70%) are very tolerant to most herbicides, even when sprayed at higher than label recommended rates. Cereal breeders now have information on crop tolerance of pre-commercialised varieties, growers have information on herbicides' interaction with new and popular varieties and agricultural chemical companies have information on the interaction of new herbicides with widely grown varieties. This national co-ordination provides industry with information, enabling them to choose safer variety x herbicide combinations suited to their region. This information is readily available via NVT Online (www.nvtonline.com.au)

SESSION VI

EVOLUTION AND MANAGEMENT OF HERBICIDE RESISTANCE

Oral presentations

Session organizers

Paul Neve & Baruch Rubin

16th EWRS Symposium 2013, Samsun

Individual-based simulation as a tool to help understand how ecology, management and genetics affect the evolution of herbicide resistance

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Herbicide resistance is a growing problem threatening world food production. The way weeds evolve resistance to herbicides depends on a complex interaction between the underlying genetics, the weed management used by the farmer, and the biology of the weed species. Evaluating different management options for delaying or avoiding resistance evolution is a challenge because it depends on this complex interaction of multiple factors at different scales, and because it is a long-term large-scale process that is difficult to investigate properly with small-scale short-term experiments. Simulation modelling provides a means of integrating the various factors involved in resistance, including physiological mechanisms, molecular and population genetics, ecology, evolutionary dynamics, and practical management. To help better understand, predict and manage evolution of herbicide resistance, we developed a model, known as PERTH (Polygenic Evolution of Resistance To Herbicides), to predict the rates and patterns of resistance evolution in a wide range of different conditions. PERTH is based on an individual-based simulation methodology, which allows it to represent a wide range of details of the real biological system. PERTH has been used to help evaluate the efficacy of management options such as herbicide rotation, maintaining robust herbicide rates at high efficacy, avoiding or introducing refuges, and using non-chemical methods of control, and how the efficacy of these options depends on the genetics underlying the resistance. For example, modelling results showed that maintaining robust herbicide rates at high efficacy is an important strategy for avoiding polygenic resistance, but has a negligible effect on the evolution of monogenic resistance. PERTH has also been used to show that the evolution of resistance can affect be affected by ecological functional traits of different weed species, such as seed bank longevity and dormancy, fecundity, seed dispersal, and rates of self-fertilisation versus out-crossing. Recently PERTH has been adapted to account for spatial heterogeneity, which has let us predict that factors such as seed and pollen dispersal can strongly affect the evolution of resistance. We conclude that the strength of simulation models, and of individual-based approaches in particular, is that they provide a means of integrating knowledge from multiple scientific disciplines at a wide range of temporal and spatial scales. Thus they provide a valuable tool to help understand how ecology, management and genetics affect the evolution of herbicide resistance, and ultimately help safeguard the sustainability of world food production.

Alopecurus myosuroides transcriptome database (ALOMYBase): Unravelling the genetic bases of non-target-site-based resistance to herbicides

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Herbicides are the most effective weed control tools, but their efficacy is jeopardized by the evolution of resistances in weeds. Non-target-site-based resistance (NTSR) is the most challenging aspect of herbicide resistance. NTSR is complex, widespread and unpredictable. It can confer resistance to a range of herbicides with different modes of action. Thus, understanding the genetic bases and the evolution of NTSR is crucial to sustain herbicide efficacy. Therefore, the objective of this study is to identify genes involved in NTSR.
NTSR is part of the weed response to the herbicide stress. Accordingly, differences in gene expression between resistant and sensitive plants are considered to be at the root of NTSR. Thus, a transcriptomics-based approach is expected to identify NTSR candidate genes. Such an approach is now feasible with the tremendous progresses achieved by the sequencing technologies (next-generation sequencing). This study focuses on blackgrass (Alopecurus myosuroides), a major weed in winter crops in Western Europe that evolved NTSR to the most effective herbicides used to control it (i.e., acetolactate synthase and acetyl-CoAcarboxylase inhibitors).
Using the Illumina sequencing technology, an exhaustive transcriptome database was established for A. myosuroides. This database was used as a reference to compare the transcriptomes of herbicide-sensitive and herbicide-resistant A. myosuroides individuals before and after herbicide treatment along a time-course experiment, using a RNA-Seq approach. Genes showing a constitutive or an herbicide-induced increased expression in resistant plants were sought as candidate NTSR genes. 42 genes fulfilling this criterion were identified. These genes encoded enzymes potentially involved in herbicide degradation or compartmenting, regulator proteins, and putative proteins with unknown functions.
The differences in expression observed were confirmed by quantitative real time PCR, yielding a set of candidate NTSR genes of interest. Further investigation on the role of these genes in NTSR must now be conducted.

Resistance to ALS inhibiting herbicides in black-grass (*Alopecurus myosuroides)*: What can be learnt from the last 10 years?

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Effective control of black-grass (*Alopecurus myosuroides)* is a major problem to cereal growers in Western Europe due to increasing herbicide resistance, by both target site (TSR) and non-target site resistance (NTSR), and a lack of new modes of action (MOA). Mesosulfuron-methyl + iodosulfuron-methyl ('Atlantis') was introduced into the UK in 2003 and is one of the most widely used graminicide throughout Europe. Our research aimed to answer the questions: How quickly can resistance build up to ALS inhibiting herbicides such as 'Atlantis'? Is TSR or NTSR the bigger threat? Do field herbicide histories relate to the risk of resistance? Does the use of mixtures or sequences of 'Atlantis' with other (non-ALS) MOA reduce selection for resistance? Nineteen random fields were sampled in 2002, prior to the introduction of 'Atlantis', and the same fields were re-sampled in 2009/10/11. In a glasshouse pot assay all plants grown from the 2002 samples were fully susceptible to "Atlantis" but, by 2009/10/11, resistance was detected in nine populations (47% of the total). Molecular assays showed that of all the plants treated with 'Atlantis', 7% possessed the P197T ALS TSR mutation, 7% possessed the W574L ALS TSR mutation and 21% were resistant due to NTSR, probably enhanced metabolism. A major finding was that NTSR can confer a level of resistance to 'Atlantis' similar to ALS TSR. Herbicide records for 16 fields (8 susceptible and 8 resistant) showed that ALS herbicides accounted for 44% of all grass-weed AIs applied on resistant fields, but only 20% of AIs on susceptible fields. In an outdoor container experiment, 14 treatments ('Atlantis' alone; 'Atlantis' in mixture/sequence with other (non-ALS) MOA; other MOA only) were applied to black-grass plants of one population (PELD03) and seeds from surviving plants were subsequently tested with 'Atlantis' in a glasshouse pot assay. The % reduction of plants in containers for ALS only, ALS + other MOA and other MOA only treatments were respectively: 83%, 89% and 70% in the containers and 31.6%, 32.4% and 81.7% in the glasshouse assay of seeds from surviving plants. These studies show that resistance to 'Atlantis' by both ALS TSR and NTSR mechanisms has increased considerably since 2002 and is now widespread in England. ALS TSR (conferred by both P197T & W574L mutations) and NTSR mechanisms are important but ALS NTSR may be a longer term threat to sustainable black-grass control due to possible cross-resistance to other MOA. This requires verification. Previous ALS herbicide use can give an indication of the risk of resistance. Use of other MOA in all the sampled fields had not prevented evolution of resistance to 'Atlantis'. This conclusion was supported by the container studies where use of other MOA, in mixture or sequence with "Atlantis", led to improved weed control but no reduction of selection pressure for ALS TSR. These studies indicate that resistance to 'Atlantis' in black-grass, by multiple mechanisms, is likely to continue to increase throughout Europe, and this will not be prevented by use of mixtures or sequences with other MOA.

A novel W1999S mutation and non-target site resistance impact on Acetyl-CoA inhibiting herbicides to varying degrees in a UK *Lolium multiflorum* population

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Acetyl-CoA carboxylase inhibiting herbicides are important products for the post-emergence control of grass weeds in small grain cereal crops. However, extensive use of ACCase herbicides over time has resulted in the appearance of resistance in at least 42 grass weeds including key species such as *Lolium* spp. In order to design sustainable weed management strategies, it is imperative to determine the mechanisms by which species evolve resistance to important herbicide modes of action. In this study, we have used an integrated biological and molecular approach to investigate the mechanisms of resistance to ACCase herbicides in a *Lolium multiflorum* population from the UK (UK21).

The glasshouse based methods included whole plant dose response assays on pre-determined wild and mutant ACCase genotypes, and plant phenotyping at single recommended herbicide rates. Nine herbicides were investigated, namely, four aryloxyphenoxyproprionate (FOP), four cyclohexanedione (DIM) and one phenylpyrazolin herbicides. All tests were carried out in comparison with a standard sensitive population (STD1). The DNA methods consisted mainly of cloning and sequencing of the ACCase target gene and development and application of a derived cleaved amplified sequence (dCAPS) marker for large scale characterisation of UK21 plants.

Analysis of the carboxyltransferase herbicide binding domain revealed a novel tryptophan to serine mutation at ACCase codon position 1999 impacting on ACCase inhibiting herbicides to different levels. The W1999S mutation confers dominant resistance to pinoxaden and partially recessive resistance to cycloxydim and sethoxydim. On the other hand, plants containing the W1999S mutation were sensitive to clethodim and tepraloxydim. Additionally, population UK21 is characterised by non-target site resistance affecting several FOP herbicides but not pinoxaden at practical field rates. Determination of the plant status at ACCase codon position 1999 was achieved with an original dCAPS assay that uses the same PCR product but two different restriction enzymes to positively identify the wild type tryptophan and mutant serine alleles. Overall resistance mutations at ACCase codon position 1999 are relative rare compared to the six other positions revealed to date, and thus implies that it may be characterised by a fitness penalty.

In conclusion, this study identified a novel target site mutation and additional underlying non-target site resistance in a *Lolium multiflorum* population. It also highlights intrinsic differences between ACCase inhibiting herbicides that could be exploited for controlling ryegrass populations such as UK21 characterised by compound-specific target site and non-target site resistance.

Cross resistance of different ALS-inhibitors of hetero- and homozygous imidazolinone tolerant winter oilseed rape

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Winter oilseed rape is the most important oil crop in West-Europe. Imidazolinone tolerant winter oilseed rape varieties are or will be on the market soon. Due to conventional breeding methods two ALS-target-site mutations are integrated into these varieties. Consequently selective use of imazamox for weed control is possible. However, volunteer oilseed rape is a problematic weed in subsequent crops. Often ALS-inhibitors are used for volunteer oilseed rape control. If imidazolinone tolerant varieties are grown, the question arises, if it is still possible to use ALS-inhibitors for volunteer control. Dose-response-experiments with different ALS-inhibiting herbicides (imazamox; mesosulfuron; flurpyrsulfuron; florasulam; tribenuron; imazosulfuron; tritosulfuron; propoxycarboxone; metsulfuron; sulfosulfuron; amidosulfuron; iodosulfuron; chlorsulfuron; thifensulfuron; trisulfuron) in the greenhouse were designed with different oilseed rape genotypes (susceptible, hetero- and homozygous imidazolinone tolerant). Herbicides were applied in one leaf stage in 6 different dosages. A lab sprayer (Schachtner) was used (Teejet 9502E, 250 l ha^{-1}, 250 kPa and 2 km h^{-1}). Plant fresh weight was determined 21 days after treatment and ED_{50}-values were calculated by non linear regression model. Resistance factors (RF) were calculated on basis of ED_{50}-values. Furthermore field experiments in winter wheat with sawn volunteer oilseed rape were conducted to confirm the findings of the greenhouse experiments. Therefore different ALS-inhibitors were applied with a one wheel plot spryer (210 kPa; 200 l/ha water, 4.5 km $h^{-}1$, Airmix 025 nozzle) in autumn (1 to 2 leaf stage) or spring and herbicide efficacy was assessed 28 dat and for autumn treatments assessment were repeated in spring. All ALS-inhibitors tested showed resistance to homozygous imidazolinone tolerant winter oilseed rape (range in resistance factors from 20 for metsulfuron to >1000 for imazosulfuron and chlorsulfuron). The same results were confirmed for heterozygous oilseed rape genotypes, but with lower resistance level (range from 2.5 for tritosulfuron to >1000 for imazosulfuron). In contrast to these findings, in the field trials some of the ALS-treatments (full rate of florasulam in autumn and in some cases full rate of tritosulfuron in spring application) showed good efficacy to imidazolinone tolerant genotypes in winter wheat, while most of the other treatments were not able to control imazolinone tolerant volunteer oilseed rape. As a consequence, volunteer oilseed rape control must be adapted in rotations where imidazolinone tolerant varieties are used and the same might be useful on fields neighbouring both systems. In cereals the ALS inhibitors florasulam applied in autumn and tritosulfuron applied in spring are able to control imidazolinone tolerant volunteer oilseed rape to certain extend. However in most cases imidazolinone tolerant volunteer oilseed rape must be controlled with herbicides from other mode of actions than ALS-inhibitors.

SESSION VI

EVOLUTION AND MANAGEMENT OF HERBICIDE RESISTANCE

Poster presentations

Session organizers

Paul Neve & Baruch Rubin

16th EWRS Symposium 2013, Samsun

Effects of ALS mutations endowing herbicide resistance on ALS activity and herbicide sensitivity in *Alopecurus myosuroides* (black-grass) and *Papaver rhoeas* (poppy)

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Acetolactate synthase (ALS) inhibitors are among the herbicides most widely used worldwide to control weeds because of their low cost and favourable environmental profile. Environmental regulations are leading to an increase in ALS inhibitor use, which in turns increases the risk for selection of resistant plants. Resistance to ALS inhibitors is often caused by mutations in the gene encoding ALS. These mutations are currently well identified in species having evolved resistance. Establishing the cross-resistance pattern conferred by each mutation should make it possible to group herbicides in "resistance risk classes" according to the mutations they are likely to select in the field, which should help preventing and managing resistance.

ALS activity was measured *in vitro* on the wild-type ALS isoform and on nine isoforms each carrying a specific amino-acid substitution at codon 197 or 574. ALS isoforms were produced from a synthetic gene encoding ALS from black-grass (grass) or from poppy (broadleaf). This enabled to specifically identify the effect of each isoform in both weeds. The effect of the mutations on ALS activity sensitivity to nine herbicides representing all five ALS inhibitor chemical families and on ALS affinity for its substrate were assessed and compared among isoforms and between species.

The resistance factors observed at the enzyme level ranged from 1 to >50,000, and were higher in poppy than in black-grass. All mutations conferred the highest resistance levels to sulfonylurea herbicides. Mutations at codon 574 generally conferred the highest resistance levels. Mutation-endowed variation in substrate affinity was generally strongest in poppy.

No obvious relationship could be drawn between the structural change caused by a mutation and its associated cross-resistance pattern. Five mutations at codon 197 in poppy and one at codon 197 in black-grass caused a substantial reduction in the affinity of ALS for its substrate. The possible consequences of these changes on the plant physiology and on its fitness remain to be investigated.

Strategies for the effective management of glyphosate-resistant *Conyza* spp. in Greece and ecological fitness parameters of the resistant populations

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Glyphosate-resistance of *Conyza* ssp. populations is a growing economical problem throughout the perennial crops in Greece and especially in the case of minimum-tillage systems. An extended monitoring in several target areas is in progress, involving all three *Conyza* species found in the country (*C. canadensis*, *C. bonariensis* and *C. albida*). The occurrence of glyphosate resistance in hairy fleabane, horseweed and fleabane populations is currently under evaluation through field and pot experiments. The main objectives of the present study were to evaluate several strategies for the control of glyphosate-resistant (GR) *Conyza* spp. and additionally to study the relative fitness of some GR, compared to glyphosate-susceptible (GS) populations of the three species. Field experiments were conducted in Viotia region (vineyard) and Lakonia region (citrus orchard). Treatments were several herbicides applied either alone or in tank mixes; at single time or sequences. Visual estimation of the control was recorded (at 4 and 8 WAT) and presented as a percentage of the untreated control for each field. Studies on the relative competitiveness of several populations have been also conducted, since herbicide resistance may or may not constitute a fitness penalty in the resistant populations. Both non-competitive and competitive studies were implemented, in order to appraise the relative competitiveness of the GR populations and their further potential to spread. Replacement series experiments for each one of the three *Conyza* species were conducted twice in a randomized complete block design with five replications. Seedlings at the 4- to 6-leaf stage were transplanted into 35-cm diameter pots (six plants per pot) at the following proportions of GR : GS plants: 6 : 0, 5 : 1, 4 : 2, 3 : 3, 2 : 4, 1 : 5, 0 : 6, respectively. Plant height, leaf number and plant dry weights were measured 60 DAT. Replacement series indices were also used to determine the relative fitness of the studied populations.
Results have shown that several herbicides control glyphosate resistant *Conyza* spp. in tank mixes or sequences. Among them a mixture of glyphosate with amitrole applied as POST gave excellent *Conyza* spp. control. In addition, a mixture of terbuthylazine with fluometuron (applied as PRE) followed by glyphosate gave excellent residual control and high efficacy on *Conyza* spp. plants. For farm management and economic reasons it is preferred to include glyphosate in the first treatment (sequences as well as mixtures) allowing to control efficiently all other weeds present in the perennial crops. The pot experiments demonstrated that under competitive conditions, there was no apparent fitness penalty for the studied GR populations and that their potential persistence in the environment has to be taken into consideration when implementing integrated weed management strategies.

Investigations on resistance of wild oat (*Avena fatua* L.) and steril wild oat (*Avena sterilis* L.) to herbicides in wheat fields of the Marmara region in Turkey

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This study was conducted to determine the resistance of wild oat populations to herbicides that have been registered to grass weeds in wheat production areas of the Marmara Region of Turkey between 2008 and 2011. Thirtysix populations out of 45, which were collected from intensive wheat growing areas of the Marmara Region, were identified as *Avena sterilis* L. (Sterile wild oat) and nine as *Avena fatua* L. (Wild oats).

In greenhouse studies, four *A. sterilis* populations and four *A. fatua* populations showed resistance to diclofop-methyl and fenoxaprop-p-ethyl, which have been extensively used in that region. The resistance ratio in *A.sterilis* biotypes ranged from 4,96 to 37,7 and in *A.fatua* biotypes from 5,31 to 13,44.

Eight resistant populations underwent to further tests to determine cross and multiple resistance status against herbicides that are recommended in wheat fields in Turkey. They were found resistant to clodinafop-propargyl except one. The resistance ratio in *A.sterilis* biotypes were between from 3,07 to 11,1 and in *A.fatua* biotypes from 5,87 to 13,26.

Cross-resistance was determined in some populations against tralkoxydim. The resistance ratio for tralkoxydim in *A.sterilis* biotypes were found from 8,11 to 11,74and in *A.fatua* biotypes from 4,29 to 9,69. However, no resistance in populations to pinoxaden has been found. There was no multiple resistance in both oat species against mesosulfuron-methyl + iodosulfuron-methyl-sodium and propoxycarbazone-sodium + mesosulfuron-methyl tested.

Testing of annual weed species *Solanum nigrum* (L.) on resistance to triazine herbicides

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Herbicide resistant weed biotypes usually evolve after repeated application of herbicides with the same mode of action. The triazine herbicide, atrazine, has been widely used in Zemun Polje since 1966 and was forbidden some years ago (in 2006) because of unfavorable environment influence. After that, the terbuthylazine with the same mode of action started to be used for broadleaf annual weed control in maize. *Solanum nigrum* is one of three the most abundant annual weed species in maize fields in Serbia. The aim of the study was testing of resistance occurrence of the species *S. nigrum* L. to PS II inhibitors.
The experiment was done in University of Life Sciences, Czech Republic. Seeds of the tested populations were sampled at Zemun Polje from sites on which atrazine had been continuously used (putative R) and from sites on which herbicides had never been used before (putative S). The PSII herbicide terbuthylazine (500 g l^{-1} a.i.) was applied as a commercial formulation by cabinet sprayer at rates of 0.375, 0.75, 1.5 (recommended dose) and 3.0 l ha^{-1} at the 4 leaves stage. The chlorophyll fluorescence of *S. nigrum* leaves was measured from 5 plants of each biotype one hour (1 HAT), one day (1 DAT) and two days (2 DAT) after treatment, by Imaging PAM (Waltz, Germany). Measurements were done on 15-min dark-adapted leaves. Maximum quantum efficiency of PS II photochemistry (Fv/Fm) was calculated. The PCR analysis was conducted by DNA extraction from 10 plants. Specific primers for psbA gene were designed and amplification was carried out. Sequencing was performed directly on purified PCR products.
The putative R population plants showed reduced response than the putative S population plants to all terbuthylazine rates except the highest one. The differential response between populations was observed as early as 1 DAT and the Fv/Fm values for 0.375, 0.75, 1.5 rates were higher for R (0.635, 0.581, 0.588) than for S population (0.617, 0.546, 0.405), respectively, suggesting that the resistance in this biotype has evolved. Ten days after treatment, biomass per plant was 79.46% higher for R than for S population on treatment with recomended rate of herbicide. Amplification of *S. nigrum* genomic DNA produced a fragment of the size of 203 bp for both biotypes. The sequence analysis did not show the nucleotide exchange in the specific region (at position 264) of the psbA gene responsible for resistance and we did not prove that the resistance is target site based.

Rapid bioassay method for herbicide dose-response study and resistance diagnosis

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This study was conducted to develop a rapid bioassay method for herbicide dose-response of *Echinochloa* species and herbicide resistance diagnosis in *Echinochloa* species. Germinated seeds of *Echinochloa* spp. were placed on the paper wick of 18 cm x 16.5 cm growth pouch containing herbicide solution at a range of concentrations. The herbicides tested in this study include bentazone (PSII inhibitor), cyhalofop-butyl (ACCase inhibitor), penoxsulam (ALS inhibitor), glufosinate (GS inhibitor) and glyphosat (EPSPS inhibitor). Shoot and root lengths of *Echinochloa crus-galli* were then measured after incubation for 6 days. Dose-responses in root length by the growth pouch method were well described by the logistic function and confirmed to be similar to those of whole plant assay, which was conducted by foliar spray of herbicides to *E. crus-galli* at the 5th to 6th leaf stage using a compressor pressurized belt-driven sprayer equipped with an 8002E flat-fan nozzle, regardless of herbicide modes of action. Thus, this result suggests that the growth pouch method can be used for herbicide bioassay.

The growth pouch method was also applied to rapid diagnosis of ACCase or ALS inhibitor resistance in *Echinochloa* spp.. Resistant and susceptible biotypes were discriminated by observing root length at 6 days after treatment. In cyhalofop-butyl dose-response study, the R/S ratios, which were obtained by dividing the GR_{50} value of tested biotype by that of reference susceptible biotype of *E. crus-galli*, were 4.3 and 1.6 by whole plant assay and 5.4 and 1.4 by the growth pouch method for Seosan-5 and Seosan-46, respectively. In penoxsulam dose-response study, the R/S ratios were 7.8 and 2.0 by whole plant assay and 7.4 and 1.7 by the growth pouch method for Seosan-5 and Seosan-46, respectively. The dose range which can discriminate betwen resistant and susceptible biotypes was 180 to 300 mg and 80 to 120 mg ai L^{-1} of cyhalofop-butyl for *E. crus-galli* and *E. oryzicola*, respectively, and 350 to 500 mg and 650 to 1000 mg ai L^{-1} of penoxsulam for *E. crus-galli* and *E. oryzicola*, respectively. This method was further applied to discriminate between resistant and susceptible *E. oryzicola* biotypes to other ALS inhibitors, azimsulfuron and bispyribac-sodium.

Therefore, it can be concluded that the growth pouch method can be used for herbicide dose-response study and diagnosis of herbicide resistance in *Echinochloa* spp. with significant time and cost-savings as compared to the conventional whole plant assay. As the growth pouch method requires very small amount of herbicide and small space, it can also be used in an early screening stage of herbicide discovery.

Transcriptome screening-based identification of candidate genes endowing non-target-site-based resistance to herbicides inhibiting ALS in *Lolium* spp.

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Arable weeds have evolved herbicide resistance as an adaptation to herbicide applications. Non-target-site based resistance (NTSR) to herbicides is the major cause for grass weed resistance to herbicides inhibiting acetolactate synthase (ALS), but no diagnosis tools currently exist. NTSR is part of the weed response pathways to herbicide stress. Differential regulation of herbicide-stress-responsive genes between resistant and sensitive plants is a key in NTSR. Due to inherent intraspecific genetic variation, NTSR pathways can differ among individual resistant plants, which makes NTSR complex to study.

We implemented a deep-sequencing approach (RNA-Seq) to identify genes differentially expressed in the transcriptomes of two pools of *Lolium* spp. plants (3 plants resistant *versus* 3 plants sensitive to one herbicide inhibiting ALS) in a time-course experiment. We identified a set of 50 genes over-expressed in the resistant bulk compared to the sensitive bulk.

Candidate genes could show either a constitutive over-expression or an herbicide-induced up-regulation in resistant plants. Depending on the genes, the over-expression observed in resistant plants could be further increased after herbicide application. Genes over-expressed in resistant weed plants, and/or up-regulated by herbicide application encoded cytochromes P450, glutathione S-transferases, glycosyltransferases, as well as genes with other functions such as putative signalling proteins that could be involved in herbicide sensing and upstream regulation of NTSR. To confirm the role played by the NTSR candidate genes identified, the differences in expression observed were checked by quantitative reverse transcription-polymerase chain reaction (qRT-PCR) in the plants used for RNA-Seq and in a range of additional resistant or sensitive plants from various populations from the field. A dozen genes specifically over-expressed in many resistant plants were identified. After further characterisation (i.e., characterisation of the associated cross-resistance patterns), these genes are interesting potential targets to develop molecular NTSR diagnosis.

Segregation of non-target-site based resistance to herbicides of four different modes of action in multiple resistant *Alopecurus myosuroides* (Huds.)

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Black-grass is a diploid, mostly allogamous, wind-pollinated grass weed and well adapted to wheat. In Germany it is one of the most trouble causing weed associated with herbicide resistance. Non-target-site resistance (NTSR) plays an important role in the distribution of herbicide resistance. Due to enhanced metabolic activities weeds are able to withstand herbicide treatments of different mode of actions (MoA), which can lead to cross-resistance. Mechanisms, control and inheritance of NTSR are poorly understood. It seems to be a quantitative and polygenetic controlled trait. Six multiple resistant black-grass biotypes were selected for parental plants because of their specific cross-resistance pattern and the absence of target-site-resistance. Characterization of the F0-generation was done by dose-response curves. The herbicides studied were fenoxaprop-p-ethyl, pinoxaden (HRAC A), mesosulfuron (HARC B), chorotoluron (HRAC C2), flufenacet and prosulfocarb (HRAC K3), applied with a precision lab sprayer. Inheritance of herbicide resistance was investigated by controlled single plant crossings between the resistant (res) and a susceptible (sen) biotype. F1 (res x sen) plants were selected by herbicide treatment and surviving individuals were taken for second single plant crossings a susceptible biotype). Hundred seeds of each F2-generation [F1 (res x sen) x sen] were sown and grown until 7 to 8 tillers were developed. Every single plant was divided in seven single tillers (clones) and each tiller was treated with one of the herbicides mentioned above one week after transplanting. The application was done with a precision lab sprayer (Schachtner) with a usual lethal dose of the herbicides (registrated dose). After four weeks the efficacy of the treatments as well as cross-resistance patterns of the individual plants were detected. A goodness-of-fit χ^2-test was used to compare the observed plant survival segregation values for each F2 family with predicted values according to the Mendelian rules. Each F2-family showed different segregation ratios for all tested herbicides. Generally up to four loci seems to be involved in NTSR. For example resistance against flufenacet involved one to four dominant loci in different biotypes. One out of four dominant loci explained best the segregation ratio of biotype “601 C”. 83 % of the F2 plants were resistant. Two dominant loci are involved in flufenacet-resistance in biotype “710 A”. F2 plants showed 25 % resistant plants. Biotype “9509 B” showed 56 % resistant F2 plants and one dominant locus leads to flufenacet-resistance. The more loci are involved in resistance the less often resistance is found in the F2-generation. The separation of the involved loci in the F2-generation could be the reason for this observation. The phenotypic codes varied between and within the F2-families, which suggest an independent inheritance of the loci involved in NTSR. The presumption of a quantitative trait can be confirmed as well as the hypothesis that NTSR genetic control can be very complex.

Mechanisms of resistance to acetolactate synthase-inhibiting herbicides in populations of *Apera spica-venti* from the Czech Republic

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Apera spica-venti is the most prevalent grass weed of winter cereals in the Czech Republic. This study investigates the mechanisms of resistance to acetolactate synthase-inhibiting herbicides in its populations. The cross-resistance to chlorsulfuorn, iodosulfuron and sulfosulfuron has been confirmed on the whole plant level. In most cases, the sulfonylurea-resistant biotypes exhibit varying levels of resistance to the chemically dissimilar, but ALS-inhibiting, triazolopyrimidine herbicides. Using the cytochrome P450 inhibitor malathion with an acetolactate synthase-inhibiting (ALS) herbicide, malathion decreased chlorsulfuron resistance in three resistant populations that were examined. Although a pronounced increase in mortality in the resistant populations has been observed with the presence of malathion, the GR_{50} values were too high to conclude that *A. Spica-venti* has solely non-target-site-based resistance mechanisms. The proportion of resistance due to mutant ALS alleles was estimated by genotyping of 20 individuals from each of three populations for the eight ALS mutations known to confer resistance. Resistance to herbicides in populations of silky bent grass from the Czech Republic has been linked to P197X and W574X substitutions in the ALS enzyme. Three resistance-conferring ALS mutations were identified: P197A, P197T and W574M. Two populations have amino acid substitution at position P197 at frequencies 44 and 36%, respectively. Some individuals had two different resistant alleles. The frequency of double mutant was 4%. In the other population, only the resistant W574M substitution was detected (13%). To our knowledge, this substitution has not been published so far. The resistance profiles were determined more by specific mutation and proportion of resistant and susceptible individuals within the populations than by non-target site mechanisms. In the populations we have studied, target-site resistance is the most important mechanism, because it was more frequent than non-target site.

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Resistance in the Czech *Apera spica-venti* populations to herbicides with different mode of action

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The objective of this study was to examine the extent of herbicide resistance of the troublesome cereal weed *Apera spica-venti*. The rapid emergence of *A. spica-venti* resistance was largely attributed to the lack of herbicide alternation with ALS mode of action. The seeds were collected throughout the Czech Republic in 2010 and 2011 from fields with failures of ALS and PSII herbicide treatments. Susceptibility of 60 biotypes to two ALS inhibitors (pyroxsulam and iodosulfuron), two PSII inhibitors (isoproturon and chlorotoluron) and one ACCase inhibitor (pinoxaden) was determined. Whole plant bioassay experiments were conducted in four replications and herbicide treatments represented 1N, 2N and 4N recommended doses, respectively. Plants were allowed to grow for 28 days after treatment to determine susceptibility to herbicides. A visual evaluation of plant growth and fresh weight were determined. Analysis of populations treated with herbicides indicated that population response varied greatly at 4 times the recommended dose (efficacy from 10 to 100%). To account for this variation, populations that displayed 50% or less control from 4N dose application were classified as highly resistant. Twenty-six of 60 samples were highly resistant to iodosulfuron, while twenty-three other populations were medium resistant (efficacy 51 - 80%). The extent of resistance was significantly lower for pyroxsulam than for iodosulfuron (55% of pyroxsulam-resistant populations and 82% of iodosulfuron-resistant populations, respectively). The remaining eleven samples were susceptible to iodosulfuron and pyroxsulam. Resistance to PSII inhibitors was confirmed in two samples only and all populations were susceptible to pinoxaden. These results were distributed to farmers to alert them to increasing herbicide resistance problems. It was suggested to use ACCase inhibiting herbicides or PSII inhibitiors to control ALS resistant biotypes of *A. spica-venti*.

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Preventing a wide-scale increase in ALS resistant broad-leaved weeds in the UK through effective management in a cereal/oilseed rape cropping rotation

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Loss of herbicides under recent European pesticide legislation has led to very limited herbicide choice across arable rotations, many relying heavily on acetolactate synthase (ALS) products. No new herbicide modes of action are on the horizon. *Papaver rhoeas* (common poppy) resistance has already been found in the UK and is common in other European countries (e.g. Italy, Spain). Although most ALS products are not highly active on *P. rhoeas* their risk to resistance developing is important to determine and manage. World-wide the ALS-inhibiting herbicide class has the greatest incidence of resistance.
A project has just begun that aims to develop practical solutions to prevent a widescale increase in ALS resistant broad-leaved weeds, including *P. Rhoeas*, through effective management in a cereal/oilseed rape crop rotation. The objectives include; (1) To identify and quantify the risks of ALS resistance in broad-leaved weeds; (2) To develop the optimum management practices to manage, reduce or eliminate developing resistance levels; (3) To raise awareness of the issue and provide information about the early warning signs and how to manage the situation. The project is being delivered through a series of container and field-based experiments to provide more detailed data and understanding. The container based experiments, underpinned by field trials, have been proven in previous resistance projects to provide a higher level of understanding and detail in the usually limited timescale and funding available. The container trials include three poppy populations, two resistant populations (collected from where the field trials will be located) and one susceptible. For both the container and field experiments a range of pre- and post-emergence herbicides will be applied over a three year period to assess how rapidly resistance builds up with each herbicide programme. The herbicide treatments will include (1) ALS-inhibitors alone, (2) non-ALS + ALS and (3) all non-ALS. In the two field experiments the cropping rotations vary from continuous wheat, wheat/oilseed rape rotations and wheat/oilseed rape/fallow rotations. At the end of each season poppy seed will be collected from each container treatment, re-sown and treated with exactly the same herbicide programme the following season. In the field the plots will remain in the same location for the three years and will be minimally cultivated to allow for the freshly shed poppy seed to have the highest herbicide pressure. Key outcomes include retention of availability of herbicides, directly by providing strategies to retain their benefit and indirectly by providing evidence of their value in resistance management strategies. It will provide agronomists, farmers and regulators with detailed guidelines to evaluate future resistance management strategies.

I would like to thank HGCA, BASF, Dow and DuPont for funding this project. I would also like to thank Stephen Moss for his consultancy and guidance

Evolution of molecular and biochemical mechanisms of herbicides resistant in *Lolium* spp.

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Lolium spp. (annual ryegrass) are major grass weeds infesting cereal and other crops worldwide. Those weeds evolved resistance to numerous herbicides with different mode of action (MOA). Resistance can be endowed by one or more of the following mechanisms: alteration of the herbicide's target site (TS), enhanced metabolism or sequestration of the herbicide in the plant (NTS). In the current study we aim to characterize the mechanism of resistant in different ACCase resistant *Lolium* populations.

Grains of three resistant populations: Maoz Haim (TS), Ein-Hamifratz and Gilat (NTS) and one susceptible population from Alumim were collected from fields during 2006-2011. Seedlings (3-4 leaves stage) were treated using commercial formulations, and plant survival and shoot fresh weight were recorded 21 days after treatment. The ACCase gene was sequenced using specific primers to understand the resistant mechanism. The enzyme ACCase was extracted from different populations and the activity was recorded in the presence of different herbicides doses. The activity was assayed by following the incorporation of $NaH^{14}CO_3$ into fatty acid and radioactivity was determined by LSS.

Dose response curves of all three resistant populations shown significant resistant up to 4 times that the recommended dose (1440 g' ai ha^{-1}) as compared with the sensitive population, with different survivors percentage. *In vitro* activity tests of the ACCase enzyme shows sensitivity to ACCase inhibitors in Ein Hamifratz and Gilat populations. It is worth noted that the Gilat population showed proportion of 20% heterozygotes to mutation in Ile 2041 to Thr. The Maoz Haim population, on the other hand, showed less sensitivity to the herbicide due to an alteration in Ile 1781 to Leu.

The current understanding on NTS resistance is very limited, mainly due to *Lolium*'s reproductive characteristics that challenge as in understanding those mechanisms. Our results could help shed light on the molecular and biochemical mechanism involved in this mechanism in different populations. Revealing the difference and common mechanisms between the resistance populations of NTS (Ein Hamifratz and Gilat), TS (Maoz Haim), and the susceptible population (Alumim) can serve as a tool in understanding NTS metabolic mechanism.

Accumulation of Pro197 and Trp574 mutations in ALS resistant *Papaver rhoeas*

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Papaver rhoeas, is an economically important weed of winter cereal crops, with a high incidence of resistance to ALS-inhibiting herbicides. Studies on the biochemical basis of ALS herbicide resistance in *P. rhoeas* have shown that it is solely attributed to target-site mutations. The purpose of this study was to identify resistance-endowing ALS gene mutations in five putative resistant populations of *P. rhoeas*, originating from central and northern Greece. For this purpose, plants that survived the recommended application rate of the sulfonylurea herbicide iodosulfuron-methyl-sodium + mesosulfuron-methyl, were subjected to genotyping with derived cleaved amplified polymorphic sequence (dCAPS) assays for positions Pro197 and Trp574. Five resistance-conferring ALS mutations were identified: Pro-197-Leu, Pro-197-Arg, Pro-197-His, Pro-197-Ser and Trp-574-Leu. All populations had mutations at position Pro197, while the Trp574 mutation was confirmed in two populations. The Trp574 mutation in *P. rhoeas* is relatively uncommon and has only been reported once before in a population originating from Italy, indicating an association with Mediterranean populations. One *P. rhoeas* plant was a trans-heterozygote exhibiting mutations that conferred both Pro-197-Ser and Trp-574-Leu substitutions, demonstrating the ability of this species to accumulate mutations at the ALS gene.

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Comparative growth analysis of *Echinochloa crus-galli* (L.) Beauv. resistant and susceptible to ALS inhibitors

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The widespread use of ALS inhibitors and consequent increase of resistance to this herbicide group prompts new studies on the population dynamics of ALS resistant (R) and susceptible (S) biotypes to check whether the resistance evolution process may be reversed. Theoretically, without herbicide selection pressure, an "agronomic" fitness cost is necessary to decrease the R/S allele ratio. Agronomic fitness cost can be defined as the potential advantage of one biotype over another in a specific cropping system. This is an important issue tackled by the four-year EU project PURE (Pesticide Use-and-risk Reduction in European farming systems). In order to study the possible fitness cost associated with a broad ALS inhibitors cross-resistance pattern, a continuous maize field infested by *Echinochloa crus-galli* (barnyardgrass) highly cross-resistant to all ALS inhibitors had previously been identified. To verify the percentage of resistant plants, 800 seedlings were collected, transplanted into pots in the greenhouse and screened for resistance to nicosulfuron (60 g a.i. ha^{-1}) using a precision bench sprayer with three flat-fan (extended range) hydraulic nozzles (TeeJet® XR11002-VK, spray volume 300 L ha^{-1}, pressure 215 kPa and speed 0.75 m s^{-1}). Three weeks after treatment, susceptible and resistant plants were selected and R and S seed stocks with similar genetic background were produced. A growth analysis field experiment was conducted comparing the two biotypes using a target-neighbourhood design. Plants were analysed in competitive and non-competitive situations (i.e. the S target plant was surrounded by plants of the R biotype and vice-versa) at four plant densities. At the end of the maize cropping season, *Echinochloa* plants were harvested and dry weight of the different plant parts (i.e. stems, leaves, panicles and seeds) was recorded. Ninety-seven percent of field-sampled plants survived the nicosulfuron recommended field rate. Molecular analyses proved that all the target resistant plants included in the growth analysis carried a double substitution at position 122 of the ALS gene (GG to AA giving an Ala to Asn amino acid change). The comparative growth analysis showed different growth and development of the two biotypes: R seeds germinated later and R plants development was delayed by about one week in comparison with the S ones. Nevertheless, at harvest, no significant differences were observed considering dry weights of vegetative plant parts. Significant differences ($P<0.05$) were recorded on seeds production: S plants produced almost double the number of panicles (and consequently seeds) than the R ones. In non-competitive situation, S plants produced an average of 780 panicles, whereas R plants produced an average of 430. The effect phased out at high competition level and no differences were observed at 20 plants m^{-2}. These first results suggest that a fitness cost may be associated with the target-site

resistance endowed on *E. crus-galli* by a mutation at position 122 of the ALS gene. Of course, the results need further confirmations and the experiment will be repeated.

Triazine resistant *Echinochloa colona* (junglerice) in Iran

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The most common mechanism of resistance to triazine herbicides is a mutation in the *psb*A gene, which encodes the D1 protein, leading to an alteration at the site of the protein where triazine binding occurs. Suspected resistant *Echinochloa colona* (junglerice) biotypes obtained from sugarcane fields in Khuzestan province, Iran, were subjected to greenhouse and laboratory experiments to study possible metribuzin resistance and their molecular base resistance. The ED_{50} values for the six suspected resistant biotypes (R1, R2, R3, R4, R5 and R6) and a susceptible (S) biotype were 1667.2, 1195, 830.2, 672.4, 4458.7, 140.5 and 54.68 g ai ha^{-1}, respectively. This indicated that the R- biotypes were 30.49, 21.85, 15.18, 12.29, 81.54 and 2.56-fold resistant to metribuzin, respectively, as compared to the S-biotype. Gene sequencing revealed that serine to glycine substitution at residue 264 of the D1 protein was occurred in the R-biotypes (except R4 at residue 264). Also the R-biotypes (R1, R2, R3, R5 and R6) were heterozygous at this residue. It was concluded that one of different mechanisms of herbicide resistance in the R-biotypes was target site based resistance.

Triazine resistance without reduced vigor in germination ability in *Echinochloa colona* (junglerice)

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According to reports of many researchers triazine resistance reduced fitness in the most resistant weed biotypes. Laboratory studies were conducted to evaluate germination ability and dormancy behavior in three biotypes, one susceptible (S3) and two triazine resistant (238/5 and 326/2), of *Echinochloa colona* (junglerice) in response to temperature ranges. The tested temperatures were (10, 30 and 45 ^{o}C constant temperatures) and (30/20 ^{o}C alternating day/night temperature with light/dark) with removing seed coat by H_2SO_4 (95-97%) for 10 min. Germination percent (G%) and Germination rate (RS/day) at 10 ^{o}C for 238/5, 326/2 and S3 biotypes were 19% and 0.36, 1% and 0.02 and 9% and 0.38, respectively. These parameters were not considerable differences at 30 ^{o}C among three biotypes. But, those were 53% and 4.65, 17% and 1.29 and 22% and 1.51 at 45 ^{o}C for these biotypes, respectively. The results showed the 238/5 biotype was superior to other biotypes in G% and RS at experimental temperature ranges. When seeds exposed at 30 ^{o}C, without removing their seed coats, the 238/5 biotype was superior in germination percent 55% and germination rate 9.40 to other biotypes, too. In alternative temperature with light/dark regime, also, the 238/5 biotype was superior to other biotypes in G% and RS 100% and 11. Therefore, we could conclude that the 238/5 resistant biotype is most problematic as compared to resistant and susceptible biotypes in sugarcane fields. In addition, it is likely that resistance to traizine herbicides will increase germination ability in some resistant biotypes.

Black-grass (*Alopecurus myosuroides* Huds.) populations multiply resistant to acetyl-coenzyme A carboxylaze (ACCase) and acetolactate synthase (ALS) inhibiting herbicides found in Poland

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Black-grass (*Alopecurus myosoroides*) becomes more important weed in winter wheat in Poland. Chemical control of this weed species is becoming increasingly difficult due to loss of active ingredients as a consequence of EU legislation and lack of new modes of action. It indicates that in practice growers have got limited chemical options for black-grass control. The negative phenomenon of weeds resistant to herbicides of some mode of action after long term use was observed. Fenoxaprop-P-ethyl (Puma Universal) and mesosulfuron + iodosulfuron (Atlantis) were commonly used to control *A. myosoroides* for a long time .
The aim of research was to determine the range of resistance of blackgrass populations to herbicide with different mode of action in Poland.
Seeds of 5 population of *A. myosuroides* were collected in the beginning of July from selected winter wheat fields in different sites (western and north-western part of Poland). Susceptible population as standard was used. Herbicides were applied using a laboratory sprayer equipped with one TeeJet 11002 nozzle operating at 300 kPa and 3,8 km h^{-1} delivering a spray volume of 250 l ha^{-1}. Seven doses of fenoxaprop-P-ethyl (from 17,25 to 552 g a.i.ha^{-1}), mesosulfuron/iodosulfuron (from 2+0.4 to 80+16 g a.i. ha^{-1}), pinoxaden (from 6,25 to 400 g a.i. ha^{-1}) and sulfometuron (from 18,25 to 1200 g a.i. ha^{-1}) were applied. For each treatment four pots were used with four replications. Foliage fresh weight was recorded 4 weeks after treatment. The obtained results were expressed as percentage biomass reduction as compared with untreated. The effective dose of herbicide causing 50 % reduction of fresh weight (ED50) was estimated from the dose-response curve.
The obtained results in fresh weight reduction indicated that 4 from 5 tested population of black-grass were resistant to mesosulfuron+iodosulfuron. The resistance index for these populations were from 9.6 to 23.8. Two biotypes which were resistant to ALS herbicide (mesosulfuron+iodosulfuron) were also resistant to fenoxaprop-P-ethyl and pinoxaden (resistance index from 18.5 to 24.8). It shows there is multiple resistance because these populations are both resistant to acetyl-coenzyme A carboxylaze (ACCase) and acetolactate synthase (ALS) inhibiting herbicides. Extensive use in greenhouse experiments of the non-selective sulfonylurea herbicide sulfometuron was used as a screen detector for possible ALS target site resistance in *A. myosuroides*. In all 4 populations which survived mesosulfuron/iodosulfuron treatments two of them also survived sulfometuron application. These results indicated that this two population are possibly target site resistant.

Cross resistance and resistant factors of three different target-site mutations in *Chenopodium album* to photosystem-II-inhibitors

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Chenopodium album is one of the most important weeds in spring crops. Resistance to photosystem-II-inhibitors have been well known since the late 1970's. Resistance to triazines are quite common in maize. The only known target-site mutation in the D1-protein of *C. album* that causes resistance to PS-II-inhibitors was at position 264 (Ser to Gly). However, in recent years a new mutation at position 251 (Ala to Val) was found in a Swedish population. This mutation only causes resistance to triazinones, but shows no resistances to triazines. In 2008 a new biotype was detected in a German potatoe field. The biotype showed a resistance to metribuzin but none of the known PS-II-inhibitor mutations could be found. Genetic analysis confirmed a new mutation on position 218 (Leu to Val).
In greenhouse trials dose-response experiments were conducted with different *C. album* biotypes and PS-II-inhibitors. Herbicides (metamitron, metribuzin, chloridazon and terbuthylazin) were applied in cotyledon stage in 6 different dosages. A lab sprayer (Schachtner) was used (Teejet 9502E, 250 l ha^{-1}, 250 kPa and 2 km h^{-1}) for herbicide application. Plant fresh weight was determined 21 days after treatment and ED_{50}-values were calculated by non linear regression model. Resistance factors (RF) were calculated on basis of ED_{50}-values.
The mutation in the D1-protein at position 218 in *C. album* is responsible for resistance to triazinones (metamitron and metribuzin) and also for cross resistance to chloridazon. While no resistance to triazines could be found.. The low resistant factors for 218 and 251 for terbuthylazin (7.9 and 5.6) are not relevant because, normal field rates been given, these biotypes are easy to control. Consequently, the new biotype reacts in the same way like the biotype with a mutation on position 251.
Both biotypes (218 and 251) were detected in sugarbeet-potatoe rotations, where selection pressure due to the frequent use of triazinone herbicides was high. As a consequence especially in these "high risk" rotations *C. album* control should not only focus on triazinones. In potatoes aclonifen and in sugarbeet ethofumesate can be used as alternative or additional active ingredients with other mode of action. Furthermore, in both crops mechanical weed control methods should be used if chemical methods fail to control *C. album.*

Development of herbicide resistance in grass weeds in Germany between 2007 and 2012

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The main annual grass weeds in German cereal growing areas are *Apera spica-venti* and *Alopecurus myosuroides* followed by regional importance of *Bromus* sp., *Avena fatua* and *Lolium* sp. Herbicide resistance has been an increasing problem since the late 1980s. It started on regional basis. However, in recent years nearly in every region herbicide resistant biotypes have been found in *A. spica-venti* and *A. myosuroides*. Additionally in some spots also resistance in *Bromus sterilis*, *Aventa fatua* and *Lolium perenne* was identified. In a nationwide monitoring programme seed samples have been collected since 2008 (*A. spica-venti* n = 558; since 2004 *A. myosuroides* n = 791, *Lolium* sp. n = 10, *A. fatua* n = 12). Plants were grown in greenhouse and treated with different herbicides in post emergence treatments. Efficacy was assessed 21 to 28 dat. From surviving plants leaf samples were taken for target-site-resistance (TSR) analysis (ACC-ase and ALS-inhibitors).
Over the years increasing number of resistant ALOMY biotypes have been found. In 2006 ~40% of the samples showed a pinoxaden resistance while nearly no (< 3%) resistance to cycloxydim could be identified. In 2012 the resistance to pinoxaden increased up to 75 and to cycloxydim up to 25%. On annual basis pinoxaden resistance increased by 6.4% and cycloxydim resistance by 4.5%. TSR-analysis confirmed the rate for increased for DIM resistance and also for other ACCase-inhibitors. However, older samples showed a lower portion of TSR. Consequently, in more and more sites with none TSR additional TSR could be found in ALOMY. ALS resistance occurs in ALOMY biotypes, too, but portion is much lower compared to the ACCase inhibitor resistance. However, there is also a clear tendency that number of mesosulfuron resistant biotypes increases with higher frequency of usage of this herbicide in current weed control practise. Within the APESV biotypes 34 to 59% of the samples per year (in the period 2009-2012) tested showed resistance to ALS-inhibitors, IPU or pinoxaden. However, there is no clear tendency in resistance development comparing different years. Most of the samples (28.6%) showed resistances to iodosulfuron but only 10.2% were cross resistant to pyroxsulam. On average 18% of the biotypes were resistant to isoproturon and less than 5% expressed resistance to pinoxaden. A few *Lolium* sp. samples were included to the resistance monitoring. However, some samples from the Baltic coast expressed resistance to all ALS and ACCase inhibiting herbicides that can be used for selective *Lolium* sp. control in cereals.
Different cross resistance patterns make it nearly impossible to control some grass-biotypes in post emergence treatments. Consequently, more pre-emergence herbicide treatments and other non-chemical control methods are needed in the future to guarantee high yields and quality.

NORBARAG (NORdic BAltic Resistance Action Group) – a new resistance action group covering Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden

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The EU Zone A (or North Zone) for authorisation of pesticides includes the Nordic and the Baltic counties. Although pesticide resistance is less widespread in the Nordic and Baltic countries than in other parts of Europe several new cases of resistance have shown up in the recent years. This recent development and the expectation that EU Regulation 1107/2009, would lead to a reduced number of available modes of action were the reasons for the establishment of a new resistance action group covering the zone. In November 2008 the first NORBARAG meeting was held in Finland followed by annual meetings in Lithuania (2009), Norway (2010), Sweden (2011) and Estonia (2013). Meetings are open for participation of researchers, consultants, pesticide efficacy evaluators and representatives from the agrochemical industry and are organised as an one-day meeting in subgroups for herbicides, fungicides and insecticides respectively followed by a half-day assembly meeting.

The objectives of NORBARAG are:

to provide a forum for information exchange between people actively involved in research into pesticide resistance and efficacy evaluation of pesticides

to ensure that cases of resistance in the Nordic-Baltic region is verified and listed

to discuss strategies to avoid resistance and to manage resistant populations

to define research needs, discuss test methodologies and agree on standards

to promote collaboration on resistance screening and other research topics related to pesticide resistance

to promote awareness on pesticide resistance issues e.g. by producing educational material

to maintain contacts to similar groups in other countries

Resistance patterns in *Alopecurus myosuroides* (Black-grass) – results of a ring test initiated by NORBARAG

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In 2010 the Nordic Baltic Resistance Action Group (NORBARAG) initiated a ring test with the objective of evaluating the consistency of results obtained in a resistance screening test on *Alopecurus myosuroides* conducted by different research units. Four research units participated in the ring test that tested the efficacy of four herbicides (fenoxaprop-P, cycloxydim, pendimethalin, sulfometuron) on seven populations of *A. myosuroides*. All participants followed a detailed protocol based on the Rothamsted Rapid Resistance Test. The resistance patterns of three of the populations were well-known from previous studies (a susceptible standard from Denmark, and two ALS- and/or ACCase resistant populations from the UK). The remaining four populations were sampled in farmer's fields in Sweden (3) and Denmark (1) and were suspected to be resistant to one or more modes of action. Results from all participants confirmed that susceptibility of the susceptible reference to the tested herbicides and resistance to cycloxydim in one of the UK-populations. Six populations were resistant to fenoxaprop-P and were also identified as resistant to pendimethalin by three participants. More variability between research units was obtained in responses to sulfometuron. The response patterns indicated that resistance in the field samples was caused by enhanced metabolism as the populations resistant to fenoxaprop-P were resistant to pendimethalin as well. The variability in responses to sulfometuron was probably due to this herbicide being less affected by enhanced metabolism than the other active substances. In conclusion the results with fenoxaprop-P, cycloxydim and pendimethalin were reasonably consistent between research units showing that for these herbicides the applied test method provides reliable results, which are independent of testing units.

Glyphosate resistance mechanism of *Conyza bonariensis*: Non-target-site-based resistance?

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In this study we discuss the mechanism of glyphosate resistant (GR) *Conyza bonariensis,* a widely spread troublesome weed in the Mediterranean. PCR, sequencing and alignment of an EPSPS DNA fragment demonstrates that Pro 106-mutation is not involved in the GR mechanism. *In vivo* shikimate analyses were conducted in GR population versus GS populations to elucidate glyphosate – target-site interaction activity over time in different plant organs. The findings revealed that the expected translocation pattern of glyphosate from source to sinks occurs in GS plants and the presence of sensitive EPSPS enzyme in both GS and GR biotype. We hypothesized that an impaired translocation of glyphosate in GR plants might be involved in the GR mechanism. ^{14}C-glyphosate's autoradiography of treated leaves over time suggests a delayed export of glyphosate to phloem in GR versus GS plants. Conversely, ^{14}C-glyphosate's whole plant autoradiography and ^{14}C-glyphosate analyses demonstrated similar translocation pattern in all populations. These data support the hypothesis that GR mechanism is related to overexpression of ABC transporters that altered cellular distribution and phloem loading by sequestration of glyphosate in vacuoles. Another observation of higher (two to five folds) accumulation of anthocyanin in GR plants as compared with GS plants when grown under cold stress (16/10°C) and, particularly, after glyphosate treatment, may support this hypothesis. Overexpression of anthocyanin's ABC transporters could cause over accumulation of anthocyanin and glyphosate sequestration in the vacuole. qRT-PCR of related ABC transporters will shed light on this assumption. Furthermore, EPSPS transcripts level analyses in GR population may reveal the possibility of a combined resistance mechanism, target site and non target site, in these plants.

Chloris polydactyla: Differential susceptibility of populations or resistance to glyphosate?

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Glyphosate has been used as the main weed management strategy in many cropping systems, with repeat applications being made throughout the year. In Brazil, this practice has contributed to the selection of glyphosate resistant biotypes. While not listed on the glyphosate label as a susceptible species, *Chloris polydactyla* has been successfully controlled with glyphosate for many years. Recently, glyphosate has failed to control *Chloris polydactyla* (L.) Sw. in a number of annual, semi-perennial and perennial crops. To date, there have been no studies to determine if these failures are due to differential susceptibility *C. polydactyla* populations, or whether they are the result of glyphosate resistant biotype. Thus, a dose-response experiment was conducted to compare the response of biotypes that were characterized under field conditions as having low susceptibility and high susceptibility to glyphosate. The doses used were; 0, 90, 180, 270, 360, 540, 720, 1080, 1440, and 2160 g ae ha^{-1}. Data derived from these experiments were used to calculate GR_{50}, GR_{80}, and GR_{90} values for each biotype based on dry weight compared to control plants. To reduce the dry weight by 50%, 80% and 95%, it was necessary to treat supposed resistant biotypes and the susceptible biotypes with 497 and 217, 946 and 380, and 1949 and 715 g ae ha^{-1}, respectively. Biotypes that appeared more difficult to control under field conditions did require more then twice the glyphosate rate to achieve the same level of growth reduction.

Examining the potential for evolution of glyphosate resistance in UK *Alopecurus myosuroides* (blackgrass) populations

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Glyphosate is the world's most used herbicide and resistance has been reported in populations of 24 weedy plant species in 20 countries, though currently there is no reported glyphosate resistance in the UK. *Alopecurus myosuroides* (blackgrass) is the UK's most problematic arable weed with multiple populations resistant to many herbicide modes of action. As glyphosate use and hence selection pressure for resistance increases in the UK there is an excellent opportunity to conduct proactive research to investigate the evolutionary potential for glyphosate resistance in *A. myosuroides* before it evolves. This is being achieved through investigation of the variability in glyphosate susceptibility in important UK *A. myosuroides* populations using dose-response assay analysis, and subsequent glasshouse selection experiments to test the hypothesis that standing genetic variation for glyphosate sensitivity can be enriched in these populations resulting in the evolution of glyphosate resistant phenotypes. Dose-response analysis has shown variation in glyphosate susceptibility in multiple UK *A. myosuroides* populations, with ED_{50} values ranging from 256 to 341 g/ha for survival and 122 to 199 g/ha for fresh weight. Survival at doses lower than field rate varied widely, from 29-73% at 0.5x and 0-38% at 0.75x. To provide insight into the early stages of resistance evolution and assess if populations with higher survival at below field rate doses are more likely to evolve resistance, first-generation glyphosate selection experiments of 'more' and 'less' susceptible populations have been carried out and results from these ongoing experiments will be presented. We hypothesise that variation in susceptibility to low glyphosate doses represents a response to past selection with glyphosate and that less sensitive populations can be driven towards resistance at field applied doses of glyphosate in glasshouse selection experiments. Results will be considered with a view to the design of proactive glyphosate resistance management strategies in the UK.

Determination of ALS herbicides resistance biotypes of *Cyperus difformis* L. (smallflower umbrella sedge) in rice growing areas by molecular and bioassay methods

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Weed control has been a major concern of growers since the beginning of rice (*Oryza sativa*) production in Turkey as well as other countries. Continuous use of a herbicide or herbicides with the same mode of action leads to the development of herbicide resistance in weed population. Rice is seldom rotated with other crops in many part of Turkey, and the few available grass herbicides have been used continuously to control weed species. The aim of this study were to determine resistance mechanism to ALS inhibiting herbicide of *C. difformis* populations. *C. difformis* populations had been collected from 646 different locations in rice fields of Marmara and Black Sea region. First , this populations were tested for possible resistance to azimsulfuron, bensulfuron methyl, bispyricac-sodium and penoxulam at recommended doses in the greenhouse. Some accession exhibited the highest survival to the treatment with field rates of these herbicides. The Weibull dose-response curve, an asymmetric sigmoid curve was fitted to data to obtain ED_{90} in R program. A whole-plant dose-response assay confirmed 70% ALS inhibiting herbicide resistance and cross-resistance 22,5% of 120 *C. difformis* populations to azimsulfuron, bensulfuron methyl (SU), bispyricac sodium (PB) and penoxulam (TP). The main mechanism of resistance was target-site insensitivity, which results from specific point mutations on the ALS gene in resistant *C. difformis* biotypes. In addition, a 1680 bp contig belonging to the ALS gene was isolated to investigate mutations on this gene that could be related with the resistance patterns observed. The nucleotide and the amino acid sequences did vary within analyzed biotypes. The DNA sequence results by detecting the existence of point mutations at the codon 197 managed to distinguish the R and S alleles and confirmed the results obtained from the sequencing chromatograms analysis. Amino acid substitutions of Arg for Pro at position 197 was detected from R biotype. This target site mutation was responsible for conferring ALS inhibitor resistance in R biotype, the first global report of ALSinhibitor resistance for this species.

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Preliminary datas on mapping of herbicide resistance *Avena sterilis* L. and *Sinapis arvensis* L. biotypes in wheat fields of Adana province/Turkey

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Chemical weed control has been widely used in wheat fields of Adana province. Continuous use of herbicides which have the same modes of action in the same field for many years, resulted in resistant weed biotypes evolution. Almost all registered herbicides used in wheat of Cukurova Region are either ALS (Acetolactate synthase) or ACCase (Acetyl-CoA Carboxylase) inhibitors. *Avena sterilis* L. (sterile wild oat) and *Sinapis arvensis* L. (wild mustard) are two important weeds which were found resistant in previous researches. This research was planned to determine the problem and to confirm a resistance map of Adana for these two weed species, under partnership of University, The Ministry of Agriculture, and pesticide companies. 328 wheat fields were surveyed in 2011 and 326 in 2012 according to certain survey method. The datas such as GPS record and percentage cover of weeds were collected for each field. The seed collection was done if the cover of these two weeds was more than 1%. The seeds of sterile wild oat was collected from 103 fields in 2011 and 102 fields in 2012 and wild mustard was collected from 43 fields in 2011 and 24 in 2012. The susceptible populations were collected locations where no herbicides had been used. The seeds were seperated in the laboratory and preparing for greenhose tests against two ALS inhibitors and one ACCase inhibitor herbicide [(Mesosulfuron-methyl +iodosulfuron-methyl-sodium plus adjuvant), (Pyroxsulam + cloquintocet-sodium), (Clodinafop propargyl)]. The experiments were performed in polystyrene trays with four replications using a range of doses at the greenhouse. Weekly visual observations and dry weight at the end of the experiment was recorded. Dose response curves were performed and the resistance index of the populations were calculated. According to the first year results, 26 wild oat and 13 wild mustard populations were found as resistant against Pyroxsulam+cloquintocet-sodium. Eighteen wild oat and 19 wild mustard populations were determined as resistant against Mesosulfuron-methyl + iodosulfuron-methyl-sodium, while 41 wild oat populations were resistant against Clodinafop propargyl.

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Detection of tribenuron methyl resistant *Sinapis alba* L. and diclofop methyl resistant *Avena sterilis* L. in North Cyprus cereals area

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Cereals, especially barley, have high importance in the Turkish Republic of Northern Cyprus (TRNC) because half of the agricultural areas are used for cereal production. *Avena sterilis* L. and *Sinapis alba* L. are the key weed species in cereal areas. Diclofop methyl has been the only registered herbicide against grass weeds and 2,4-D and tribenuron methyl against broad leaf weeds in cereal production for many years. Tank mix of diclofop methyl and tribenuron methyl has been the most preferable application by farmers due to having problem of both graminae and broad leaf weeds in cereal fields. Escaped weeds from herbicide applications in spite of increased herbicide rates by farmers which were not recommended have been observed in recent years.

Seeds of *A.sterilis* and *S. alba* were collected from cereal fields in TRNC where herbicide was applied for many years. Pot experiments in greenhouse with three or four replications were set. Diclofop methyl was applied at recommended rate (564 g ha^{-1} a.i.), 2X and 4X of it to *A. sterilis*. Tribenuron methyl was applied at recommended rate (7.5 g ha^{-1} a.i.) 2X, 4X and 8X of it to *S. alba*. Both experiments included no-herbicide check pots for each population. *A. sterilis* experiment was evaluated using 0-5 scale, *S. alba* experiment was evaluated 1-3 scale.

Fourteen populations of *A.sterilis* out of 45 were found resistant to diclofop and 15 populations of *S.alba* out of 37 to tribenuron methyl. However, some populations are not considered resistant if they gave erratic results. It was concluded that evolution of resistance process has been going on for both species in TRNC although there was data enough showing resistance clearly in the island. Characterization and confirmation studies are going on. In addition, a resistance map with current results was drawn.

Studies to understand mechanism(s) and control glyphosate-resistant *Conyza* spp. in Greece

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Glyphosate has become the world's most widely used herbicide, exerting selection pressure on various species of weeds. In Greece, a long history (more than 30 years) of sole glyphosate use, no application of residual herbicides, use of relatively low glyphosate rates, and use of no other integrated weed management approaches (rotation of active ingredients, use of mechanical weed control etc.) have resulted in development of horseweed (*Conyza spp*.) glyphosate resistant populations. Data will be presented (from 1998 to 2011), regarding cases (crops, weed species, areas) of low efficacy of glyphosate. Also, specific principles of how to implement integrated weed management systems aiming to eliminate the development of glyphosate resistant weed species in the national context. Studies on the molecular mechanism to glyphosate resistance were conducted on a highly resistant population (GR_{90} = 1.7 Kg a.i. / ha). Biochemical analysis of shikimate revealed that the population had significantly lower levels compared to the S- control. Real-time qRT-PCR was used to study the expression profiles for genes related to EPSPS and some ABC transporter genes (EPS, M10, M11, M7, P3). The expression level was determined at 1 and 4DAT after glyphosate application. The expression levels of the EPSPS gene was 2.7 more unregulated in the R- compared to the S- population. Te two ABC transporter genes (M10, M11) were highly upregulated (more than 20 times) in the R- compared to that of the S- populations. The other two genes (M7, P3) had a similar level of expression between R- and S-populations. Understanding the molecular mechanism of glyphosate resistance would help to design sound integrated weed management systems in perennial crops.

Alopecurus myosuroides – Variation in resistance profile, their geographical spread and impact on herbicidal control options in winter annual cropping systems

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Alopecurus myosuroides Huds. (black grass) is a prevalent and most troublesome annual grass weed in winter annual crops in Western Europe. Intensification of the production system within the last decades, incl. short rotation with focus on winter cereals and winter oilseed rape, reduced or minimized soil tillage, early sowing dates etc., created an ideal environment for the propagation of *Alopecurus myosuroides*. Grass weed herbicides have been and are used for an effective control. However, with the challenge of controlling a grass weed in a graminaceous crop like winter cereals, only few Mode of Actions are available. Repeated use of these herbicides resulted in the development of herbicide resistance in *Alopecurus myosuroides*, which is now a major problem in cereal growing countries of Western Europe.

A resistance monitoring on Alopecurus *myosuroides* was initiated by BASF, collecting seed samples from different locations in Europe. Sampling was not completely randomized, integrating control failure, suspicious or known resistance areas and trial sites into the program as well. First, a greenhouse test with 3 replications was conducted using herbicides with different Mode of Action either pre- or post-emergence at different dose rates. Leaves of surviving plants were sampled and subsequent analyzed via pyrosequencing on known target-site mutations of the ACCase- or the ALS-enzyme.

Results provided by the greenhouse testing and the PCR-analysis were used to describe the individual resistance profiles, indicating a broad variation of single and multiple resistance pattern including the combination of different target-site mutation as well as of target-site- and non-target-site mechanism. The number of biotypes tested over several years does also allow a comparative evaluation of these profiles between countries.

SESSION VII

OPTIONS AND PERSPECTIVES IN WEED MANAGEMET

Oral presentations

Session organizers

Svend Christensen & Bärbel Gerowitt

16th EWRS Symposium 2013, Samsun

The role of models in management and conservation of weeds

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Weeds are both a harmful crop pest and an important component of biodiversity. Moreover, herbicide use must be reduced to limit its impact on environment, and weed control must now combine numerous management techniques with partial efficiency aiming at preventing weed occurrence. Biological regulations of weeds by other biotic components could also contribute to control infestations. Thus, new cropping systems are needed, combining numerous techniques and aiming at both maximising weed-related biodiversity and minimising weed harmfulness.

Weed dynamics models are increasingly used to design innovative cropping systems but usually only consider weed densities and crop yield. The objective of the present work was to illustrate with an existing model how these models can be improved to (1) integrate new knowledge and management techniques, (2) integrate biotic interactions and to assess weed-related harmfulness and biodiversity, and then (3) used to evaluate and design innovative cropping systems.

The FLORSYS model is to date the only multispecific weed dynamics model that integrates the effect of all cropping system components (crop succession, all management techniques) in interaction with pedoclimate. It is a mechanistic (i.e. process-based) model which synthesizes data from different experiments and teams and easily evolves to integrate new knowledge or management techniques. For instance, additional processes (e.g. the blocking of weed seed rain to soil seed banks by permanent grass canopies) were recently added to FLORSYS to adapt it to temporary grassland in arable crop rotations (Doisy et al., this conference). These complex models are though more difficult to validate with field observations, a step still underway for FLORSYS.

To integrate biotic interactions with other organism in weed models, new submodels are needed to quantify the effect (1) of cropping systems on the new organism (here the fungus *Gaeumannomyces graminis* var. *tritici* responsible for the take-all disease in cereals), (2) of the new organism on weeds (here the decrease in seed production of diseased weed plants) and (3) of weeds on the new organism (here pathogen propagation by diseased weed plants). To assess weed-related harmfulness and biodiversity in cropping systems, the predicted weed densities must be translated into indicators. In the present work, five harmfulness indicators (crop yield loss, technical harvest problems, harvest pollution, field infestation and additional crop disease incidence caused by fungi-transmitting weed species) and five biodiversity indicators (species richness, species

equitability, seed resource for birds and insects, pollen/nectar resource for pollinators) were constructed and connected to FLORSYS (Mézière et al., this conference).

These models are interesting for a large range of applications. At short-term, they can be used to optimize individual management techniques in different weed flora contexts, e.g. FLORSYS was used to evaluate different crop sowing strategies (sowing densities and patterns, crop associations etc.). More interestingly, these models can simulate existing cropping systems over several years and with different climate scenarios to test their long-term and climatic robustness. FLORSYS was thus used to evaluate a large range of cropping systems identified in farm surveys and to identify cultural practices pertinent for controlling weed harmful and preserving biodiversity. However, the major interest of models is to test prospective cultural techniques and cropping systems. FLORSYS is now used to evaluate the changes in agricultural practices (e.g. simplified tillage and rotations, no-till, temporary crops, Colbach et al., this conference). Currently, our team is working on a simulation-based methodology to design prospective cropping systems with low herbicide use, minimising weed-related harmfulness and maximising biodiversity.

An evaluation of the effectiveness of different methods for controlling weeds in fig

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Weed management methods other than the herbicides are importantly desired to be investigated for the sake of integrated weed management. Hence, this study represents a comprehensive investigation into the methods including:, olive processing waste (OPW), sawdust, cover crop (*Vicia pannonica*), black polyethylene mulch, soil fumigants metam sodium and dazomet, the herbicides trifluralin in conjunction with fluazifop-p-butyl, glyphosate and hoeing against these weeds.

The experiment was conducted three times; twice in 2005 and once in 2006 using a randomized complete block design. OPW (20 tons ha^{-1}) was added to the soil before planting the fig cuttings and incorporated to a depth of 0-20 cm. Sawdust was scattered over the soil surface and a thickness of 8-10 cm was maintained until the end of the experiment to prevent the sunlight from reaching the soil. Before planting the fig cuttings, *V. pannonica* seeds (120 kg ha^{-1}) were sown. After the fig cuttings had been planted, the *V. pannonica* plants around the cuttings were pulled out by hand to permit better growing conditions for the fig. *V. pannonica* was incorporated into the soil at the flowering stage. The black polyethylene mulch was laid out only during the third repetition of the experiment. The fumigant dazomet was applied evenly at 485 kg a.i. ha^{-1} before the fig cutting plantation. Metam sodium was applied at 500 kg a.i. ha^{-1} before the fig cutting plantation. Trifluralin was applied and incorporated into the soil at 980 g a.i. ha^{-1} prior to the planting of the fig cuttings and when the weed density reached 20% in this treatment, fluazifop-p-butyl was applied at 150g a.i. ha^{-1}. Glyphosate was applied at 2880 g a.i. ha^{-1} after recording the weeds density. In the control (hand-hoed) plots, when the weed density reached 20% the weed density in all the experimental plots was recorded and weeds were pulled out and the practice was repeated 5, 4 and 6 times during the 1st, 2nd and 3rd repetition of the study.

Compared to the other weed management methods, black polyethylene significantly suppressed the annual as well as perennial weeds like *Cyperus rotundus* for a lengthy period of time. OPW was only effective for suppressing the annual weeds particularly *Portulaca oleracea* and was effective until 3 months after its incorporation into the soil. *V. pannonica* as cover crop significantly reduced the population of perennial weeds, especially *C. rotundus* before it was incorporated to the soil. Nevertheless, the effectiveness of *V. pannonica* was reduced after it flowered. Sawdust and Metam sodium decreased the density of annual weeds particularly *P. oleracea*. Dazomet was effective for one and three months against annual and perennial weeds, respectively. Glyphosate had a promising effect on perennial weeds, especially *C. rotundus*.

The studied clearly indicate the importance of methods other than herbicides for controlling weeds. Weed management options like black polyethylene, OPW, cover crop and savdust can be successfully employed either as alternative to chemical weed control or they can act as component of integrated weed management keeping in view the type of weed flora.

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Integrated weed management strategies in maize: Agronomic, environmental and economic impact

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A long-term field experiment was set up in April 2011 in north-eastern Italy, within the European Project PURE (Pesticide Use-and-Risk reduction in European farming systems with Integrated Pest Management, http://www.pure-ipm.eu), to evaluate two strategies with different IPM level against the conventional one in four-year maize-based cropping systems. For the first-year maize crop, the conventional strategy (CONV) to control weeds involved a pre-as well as a post-emergence herbicide application, whereas the integrated weed management (IWM) strategies involved pre- and post-emergence band application (30 cm band, 60% reduction in spraying volume) of herbicides (IWM1) and only a post-emergence in band application (IWM2). After the post-emergence herbicide application, hoeing was also practiced in all strategies to incorporate the urea applied. For the pre-emergence application (CONV, IWM1) a commercial product containing a mixture of mesotrione (3.75%), S-metolachlor (31.25%) and terbuthylazine (18.7%) was used at 4.5 l/ha, while for the post-emergence application in all strategies a tank mix of rimsulfuron (25%, 60 g/ha), dicamba (21%, 1 l/ha) and paraffin oil (1.25 l/ha) was applied. Three weed assessments were conducted (after pre- and post-emergence herbicide application and after hoeing). The models SYNOPS and MEBOT were used to evaluate the environmental and economic impact of the strategies, respectively. Statistical analysis showed significantly higher weed density under the IWM2 strategy after the first assessment. After-post-emergence and after-hoeing weed assessments indicated significantly lower density under the CONV strategy in both cases. Maize grain yields for the IWM strategies were lower compared to the CONV; however, effects were not significant. SYNOPS evaluation (using risk categories of very low, low, medium and high) indicated a low chronic terrestrial risk for the CONV strategy, whereas both IWM1 and IWM2 had a very low risk (84% and 99% risk reduction). The chronic aquatic risk was evaluated as medium for the CONV, followed by IWM1 and IWM2, having a low (78% risk reduction) and very low risk (>99% risk reduction), respectively. Total weed control costs were 70€ and 120€/ha less under IWM1 and IWM2, respectively. These first results indicate that the IWM-based strategies tested have a lower environmental impact, whereas the risk of yield reduction could be partly compensated for by the lower costs due to the reduced herbicide use. Evaluation of the long-term effects of these IWM strategies through further experimentation will be crucial before recommending them for implementation.

DSSHerbicide - testing weed control decisions in winter wheat in North East Germany

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The "Directive on Sustainable Use of Pesticides" of the European Union aims to reduce the use of pesticides. In the EU-Interreg project DSSHerbicide working groups in Denmark, Poland and Germany are developing, adapting and testing decision support systems (DSS) for herbicide use in winter wheat.
Three prototypes of DSSHerbicide were developed, mainly based on the Danish system Crop Protection Online (CPO), one of the prototypes also integrating parts of an existing German system (CeBrUs). A brief overview about the underlying calculations and data of the decision-making by the prototypes is given.
Control advices are tested in field trials in North East Germany together with decisions of the co- operating farmers and advisors. Results of seven field trials in 2011/12 in winter wheat are presented. These include data on the weed infestations of the fields, the treatments advised by the prototypes or the practical partners and the yield of the various treatments.
Three methods to assess the control efficacy were used in all seven trials (i) counting plants, (ii) estimating coverage ratios and (iii) weighing biomass. Based on the experimental data pros and cons of the methods are discussed. Harvested weed biomass was used to investigate seed production of most prominent weed species in the control treatments.

Unmanned aircraft systems (UAS) in weed management

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The objective of this presentation is to demonstrate applications of small unmanned aircraft systems (UAS) imagery in weed research. UAS with cameras offers low-cost sensing of crop and weeds. In order to take advantage of UAS imagery in weed research, we searched the market for small, inexpensive, user-friendly and reliable aircrafts for practical applications of imagery, and acquired a rotary-wing aircraft: A hexacopter with six rotors (Hexa XL) (HiSystems GmbH, Moormerland, Germany). This UAS can automatically hover at up to 13 m s^{-1} wind speed and fly to GPS positions by itself (waypoints). A 10 MP RGB camera (Canon G12) was mounted on the UAS and images were captured at altitudes ranging from 2 to 50 m. This presentation gives three examples of applications: 1) estimation of the crop resistance parameter in weed harrowing research, 2) estimation of dose-response parameters in logarithmic sprayer experiments, and 3) mapping of patchy infestations of noxious perennials weed species. Our studies showed that the crop resistance parameter, which reflects the crop response to post-emergence weed harrowing, was unaffected by image capture altitude in the range from 1 to 50 m. This corresponded to image spatial resolution in the range from 0.3 to 17.1 mm/pixel. We could capture more than 0.2 ha in one image at 50 m altitude without losing information about the impacts of cultivation on crop growth compared with ground true data. In logarithmic sprayer experiments we could capture 37 m long plots in each image and estimate dose-response parameters with high precision. In cereals we could easily identify *Cirsium arvensis*, *Tussilago farfara*, and *Equisetum arvense* from images by the eye. Now we concentrate on automated image analysis procedures to identify and map weeds. In conclusion, our first experiences with UAS imagery show that it is relatively easy to integrate UAS imagery into weed research and that it may offer great potentials in relation to site-specific weed management.

SESSION VII

OPTIONS AND PERSPECTIVES IN WEED MANAGEMENT

Poster presentations

Session organizers

Svend Christensen & Bärbel Gerowitt

16th EWRS Symposium 2013, Samsun

Control of *Amaranthus retroflexus* in soybean

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Amaranthus retroflexus L. (redroot pigweed) is one of the major problematic weeds in soybean. It seriously affects the growth and production of soybean due to its high competitive ability. In addition, it produces large number of seeds, which ensure its infestation in next seasons. Therefore, control of this species is of high importance. Sowing seeds in irrigated seedbed is expected to encourage early establishment of crop and give competitive advantages to the crop when integrated with weed control measures e.g. reduced row spacing. To study the control of *A. retroflexus* in soybean, a field experiment was carried out at Ilam University's agricultural research station, Ilam, Iran, in 2009. Treatments included farming methods (2: sowing seeds on dry and irrigated seedbed), weed control (3: herbicide application including bentazon and haloxyfop-ethoxyethyl, hand weeding and control) and soybean row spacing (3: 35, 50 and 65 cm). The treatments were arranged in a split-strip plot design based on randomized complete blocks with three replications. The farming methods placed in horizontal rows and weed control methods placed in vertical rows. The soybean row spaces were arranged in main plots. Plant height, dry matter, and LAI of soybean and plant height and dry matter of *A. retroflexus* were recorded once a month during the growing season. Soybean yield and its components also were measured in end of the season. The farming methods did not influence *A. retroflexus* control significantly. Row space of 35 cm was found best to increase grain yield, number of pods per plant and leaf area index soybean. Best control of *A. retroflexus* was also achieved under 35 cm row space. In fact, soybean competitiveness over *A. retroflexus* increased due to the rapid crop canopy closure due to increased soybean density under reduced row spacing. It is concluded that to control *A. retroflexus* in soybean a proper integration of cultural methods e.g. reduced row spacing and weed control measures, can be used.

Weed management in fallow fields as indicator of the efficiency of agri-environment schemes in dryland areas

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The loss of farmland biodiversity threatens the sustainability of ecosystem services delivered within agricultural landscapes. The abandonment of traditional practices, intensive agriculture and the use of pesticides, among others, have modified the structure and the ecological role of agro-ecosystems. To counteract this development the Council of Europe took measures to conserve the organism diversity in agro-ecosystems. The 1698/2005 regulation published on 20th September 2005 concerning Rural Development has promoted the development of new Agri-Environmental Schemes (AES) in order to maintain or increase biodiversity in agro-ecosystems. The heterogeneity of these landscapes is positively related to the diversity and the abundance of singular and even endemic species. One group of great importance because of their unfavorable conservation status is dryland farmland birds (steppe birds). In the dryland cereal systems of the Ebro valley (NE Spain), one of the implemented measures is the conservation of certain zones called Important Bird Areas (IBA) as refuges for these kind of birds. The efficiency assessment (ecological benefits provided) of AES, as a concerning issue, has been debated in several European countries where such measures are being implemented for years. In that sense, the main difficulty is to use a correct indicator to measure their efficiency. Interactions between weeds and heterotrophic consumers and strong overall correlations between the number of weed species and the total species diversity indicate that arable weeds are "key species" and that could be used as efficiency indicators of AES. "Key species" are defined as those species the loss of which leads to serious changes in the remaining biocenosis.

The present work attempts to evaluate the effectiveness in fallows, as one of the most important AES for steppe birds, using weed as indicators. Different field managements were carried out in these fallows (soil tillage or herbicide application in different dates) promoting different structure and composition of the spring and summer vegetation, and consequently, trying to provide the optimal habitats for birds, especially in breeding time. Plant species richness and percentage of vegetation cover have been monthly followed from April to June 2012 in four different fallow fields in dryland areas of Lleida (NE Spain), with different age, according to the different management applied. To further examine treatment effects on changes in weed species composition during the sampled months, a multivariate Principal Response Curve (PRC) method was used. Preliminary results show that tillage promotes a higher vegetation cover and richness in summer time, which are the best conditions for steppe birds. On the other hand, herbicide application apparently is less suitable for handling the formation of a proper vegetation structure.

R-based simulation model for longterm management of *Avena fatua* L. in winter wheat

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Decision support systems (DSS) are used for weed control decisions worldwide. Several DSS for weed management have been published, however they are usually not freely available and are adapted to specific agronomic and environmental conditions. Furthermore, published models often cover only parts of the model system that is necessary for DSS, making it difficult to combine all models into a consistent system. We developed a DSS for longterm *Avena fatua* L. control in winter wheat based on two year experimental datasets covering yield loss experiments, population dynamics and dose-response studies on herbicide efficacy. It aims not to completely control *A.fatua* but to keep its population under a certain threshold in the long run. Our hypothesis is that the optimized DSS reduces herbicide input while maintaining high efficacy of weed control, grain yields and net return. The DSS consists of four submodels, i.e. yield loss model, population dynamics model, herbicide efficacy model and economic model and comprises two restrictions: seedling density must not increase and herbicide efficacy has to be at least 75 %. The input variable is *A.fatua* density, which is transformed via a linear relationship into *A.fatua* biomass. The relationship between yield loss and *A.fatua* biomass follows a hyperbolic function, with a maximum relative yield loss of 57 %. For biomasses equivalent to densities of 50, 100 and 200 plants/m² relative yield losses were 18, 27 and 37 %. The herbicide efficacy submodel follows a 3-parametric log-logistic function giving the herbicide dosage dependent residual biomass. This function has been parameterized for pinoxaden and isoproturon. The relationship between seed input and residual biomass follows a hyperbolic function, with an initial seed input of 231 seeds/m² and g weed biomass/m² and a maximum possible seed input of 11329 seeds/m². Seedling density in the following season is calculated out of two soil seedbank cohorts, one consisting of older seeds and one of seeds produced in the previous season. We calculated with a mortality rate for new seeds of 0.57 and for old seeds of 0.65, a germination rate of 0.1, losses by predation of 0.3 and removal due to harvest by 0.2. Finally, the economic submodel calculates the net return in dependency of the herbicide dosage, giving the maxmimum net return with the corresponding herbicide application rate. First results of a five-year simulation showed that herbicide input could be reduced by 2 kg/ha without net return reduction and 1.5 kg/ha could be saved compared to the economic threshold strategy, with additional net return. The model is programmed in *R*. All datasets as well as weather data will be available in the package. It should act as modeling platform so that scientists can use those datasets for modeling with their own data and can help to improve and expand the model and decision support system also to other environments.

Development of a decision support system for integrated weed management

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In the last years only a few new action mechanisms have been introduced in the chemical weed control sector. Consequently, when product innovation slows down, process innovation becomes the only possible solution to reduce dependence on chemical herbicides. To rationalize weed control is a priority in this process. Developing and spreading via the Internet a DSS that can advise farmers about weed management, suggesting the correct timing and appropriate mixture of active ingredients for each situation, may represent a key step for this. The combination of two existing models, GESTINF and AlertInf, makes possible the realization of this complete DSS. GESTINF is an existing DSS that evaluates the cost effectiveness of weed control, providing users with a ranking of possible technical alternatives, i.e. herbicide mixtures, according to their specific economic return and the environmental risk of ground and surface water contamination by leaching and runoff. AlertInf has recently been created to predict weed emergence dynamics of several weeds in maize fields. AlertInf provides the percentage of emergence reached by a given weed species in real time using meteorological data, such as soil temperature and soil water potential. The major cause of poor post-emergence weed control is improper application timing, which can be either too early or too late. AlertInf, estimating daily the percentage of weeds that have already emerged and the successive seedling emergence dynamics, allows to make appropriate evaluation on the timing for post-emergence applications to achieve efficient weed control. The two models are integrated in a unified DSS that is able to indicate to the users the date for the single scouting to be carried out in the field to know the quali-quantitative characteristics of the infestation and estimate the density of each weed species for the rest of the season. The predicted daily density of each species is used by the DSS as input without any further survey. The single time survey method for indicating the survey date and estimating the density for the rest of the season, uses the cumulated emergence estimated by AlertInf; the method is described in Masin et al. (2011). The DSS gives indications on post-emergence treatments in traditional tillage maize and soybean and no-tillage maize in terms of herbicide to use ranked according to economic net return. The output of the combined DSS is a more complete information about if, when and how control weeds in their specific situation. This combination of models has the objective to overcome the constraints that have so far hindered the use of DSS, such as GESTINF, by farmers. Furthermore the combined DSS available on-line should encourage farmers to adopt the criteria and methods of IWM.

Relation between combating with new emerging weeds and controlling weeds

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Weeds in managed and unmanaged areas have native or non-native origin. Recent changes throughout the globe are increasing problems with new non-native species in managed areas with newly emerging weed problems, as well as other agricultural pests. There are three phases of invasive alien plant strategies: Prevention, early detection and rapid response, and containment and control. Weed science mainly focuses on the control of weeds, although there are some attempts in research and implementation to prevent and detect problems earlier. Collaboration and networking at various levels internationally is required in order to prevent the rapid spreading of invasive alien plants.

ESENIAS (the East and South European Network on Invasive Alien Species) was established in 2011 to bring together experts on biodiversity, environmental management and pest control from national and regional environmental and agriculture departments, and governmental and public organizations. Current members of network are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo under UNSC Resolution 1244/99, FYR Macedonia, Montenegro, Serbia and Turkey.

The main goal of ESENIAS is to establish regional cooperation, with the aim of aiding early detection, eradication, control and mitigation of IAS. Developing a common database on IAS for the region is one of the main contributions of the new network, as much data for the region are missing or are not available on a higher level. The list of weeds in this region is based mainly on external datasets, which are created for western or northern Europe. Specific climate and diversity hotspots in ESENIAS countries, as well as geographic orientation, transport network and states (non)harmonization in dealing with weeds do not allow for creating a valid list specific for the region. Creating a specific database for invasive alien plants species, with extra data on weeds will be one of the main goals for “plant group experts”.

Segetal plant conservation in arable fields: Functional role, farmers' perception and farming systems

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Segetal plants, or "messicoles" as they are known in French, are weedy inhabitants of wheat crops (mainly winter cereals). The national list of segetal species includes 102 taxa; of which 7 are extinct, 52 threatened, 30 to be kept under close observation and 12 abundant. Data on their distribution indicates that they are mostly in decline due to intensive farming systems. As their survival is intrinsically linked to farming systems, we need to improve knowledge on their relationships with land management in order to establish a sound scientific basis for protection tools, to support and guide farmer conservation measures and to disseminate concerns for segetal biodiversity to agro-environmental policymakers.

We propose to examine:

1) the relationships between the abundance and/or the segetal richness (flora sampling) and farmer practices (farm evaluation conducted using the "Dialecte" software) in several farms in different regions, especially in segetal-rich areas;

2) the potential ecosystem service provision as resources for foraging insects through identification of the pollen of segetal plants and their abundance in pollen traps fixed on bee hives;

3) the perception of segetals (e.g. as troublesome weeds, or anecdotal biodiversity, or beautiful floral component of the landscape, or plant for services, etc) by professional actors (farmers, technical advisers, actors of biodiversity preservation initiatives, regional collectivity and regulatory authorities, etc) to identify ways of thinking that underlay the diversity of discourses and present practices about them. Joining national efforts for similar goal and participatory approach could help European Community to adopt agro-environmental measures towards biodiversity conservation without cutting productivity.

Evaluation of different weed management methods in *Solanum tuberosum*

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In order to investigate the effects of different integrated weed management methods in potato, an experiment was conducted at research filed in Bardsir, in 2010. This examination was designed in a randomized complete block (RCB) design with 4 replications and 9 treatments included: 1- Metribuzin Herbicide (H), 2- Hand Weeding (HW), 3- Cultivation (C), 4- Metribuzin Herbicide + Hand Weeding (H+HW), 5- Metribuzin Herbicide + Cultivation (H+C), 6- Hand Weeding + Cultivation (HW+C), 7- Reduced Herbicide+ Hand Weeding (RH+HW), 8- Reduced Herbicide+ Cultivation (RH+C), and 9- weed free. The results indicated that (H+HW) and (H+C) treatments showed the lowest weed biomass. It seems that due to trouble and high costs of weeding, H + C treatment was economic and recommend. In all 3 sampling process, H + HW and H + C treatments had the highest effect and C treatment had the lowest effect on weed biomass reduction, respectively. Results also showed that, treatments included herbicide and cultivation had the maximum effect on growth indices, yield, yield components included leaf area index (LAI), dry biomass, yield and small, medium and large tuber number.

Proposing a set of simulation-based indicators to assess harmfulness and biodiversity resulting from weeds in agroecosystems

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Weeds are both a harmful pest and an important trophic resource for many biotic components. Moreover, herbicide use must be reduced to limit its impact on environment and human health. Consequently, new cropping systems are needed that both maximise weed-related biodiversity and minimise weed harmfulness. Weed dynamics models are increasingly used to design innovative cropping systems but they only consider weed densities and/or crop yield loss. Thus, the objective of the present study was to develop a set of indicators to assess weed-related harmfulness and biodiversity and to connect them to the FLORSYS model. The FLORSYS model is to date the only multispecific weed dynamics model that integrates the effect of all cropping system components (crop succession, all management techniques) in interaction with pedoclimate.

In the present study, a web survey was conducted to have farmers identify and rank criteria for weed harmfulness. As a result, five harmfulness indicators were constructed: crop yield loss, technical harvest problems (green weed biomass above cutting harvest), harvest pollution (weed seed and plant biomass exported by the harvest engine), field infestation (average weed biomass in crops) and additional crop disease incidence caused by fungi-transmitting weed species (take-all disease of cereals transmitted by grass weeds). A second set of five indicators was constructed with ecologists to assess the role of weeds as a component of flora biodiversity and as a trophic resource for other biodiversity components: species richness, species equitablity, seed resource for birds during winter, seed resource for insects during spring and summer, and pollen/nectar resource for bees and other pollinators.

These indicators were tested on 31 contrasting cropping systems resulting from farm surveys in two French regions. Simulations started with 16 weed species, ran over 30 years and were repeated 20 times with randomly chosen weather series from the tested region. Indicator values mostly depended on cropping system and little on year or weather. In the last step, correlations between indicators were analysed to identify synergies and antagonisms. The biodiversity indicators were all positively correlated, except that species richness was negatively correlated with species equitability and seed resources for birds or insects. The last two resources frequently co-occurred in the same situtations (Spearman correlation coefficient r=0.54). Generally, equitable weed floras offered more food to birds, insects and pollinators whereas floras dominated by a small number of species were less interesting for predators. Similarly, the various harmfulness indicators were positively correlated, except additional disease risk. Harvest pollution and technical harvest problems usually occurred together (r=0.89), yield loss also increased with field infestation (r=0.59).

Most of the harmfulness indicators were positively correlated with the biodiversity indicators, i.e. there was an antagonism between agricultural production and biodiversity. The correlations were though usually low ($r < 0.20$), indicating that many weed floras resulted in both low harmfulness and high biodiversity. Additional disease risk was not or negatively correlated to biodiversity indicators, e.g. cropping systems with low additional disease risk tended to present a more equitable weed flora (e.g. less dominated by disease-transmitting grass weeds) and to offer more lipidic seeeds for insects (e.g. less grass weed seeds).

In conclusion, though there tended to be an antagonism between weed-related biodiversity and harmfulness, the tested cropping systems differed greatly and some both maximised biodiversity and minimised harmfulness. Our team is now working on identifying the characteristics of these optimal cropping systems and to propose innovative solutions for weed control and conservation.

Effective control methods against European mistletoe (*Viscum album*): Biological control or herbicide treatment?

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The parasiting of European mistletoe (*Viscum album*) contributed to the debilitated stage and lower vitality of woody plants in European forests and orchards. In case of additional unfavorable predisposal influence it can be a significant factor of the forest decline. Pruning of the infected brunches is the only known effective control method of this hemiparasite plant. Using a hyperparasitic fungus ((*Phaeobotryosphaeria visci*) could be an environmental friendly and economical control of mistletoe.

Our aims were to study the efficacy of different systemic herbicides to assess the possibility of a combined fungal-herbicide treatment, and to define the lowest concentration of spore suspension for field experiments.

The efficiency of systemic herbicides such as 2,4-D, MCPA and glyphosate were tested on dioecious (*Acer campestre, Tilia platyphyllos*) hosts in field experiments. While 2,4-D destroyed the shrubs, phytotoxic symptoms and withering of young branches appeared on hosts. Four months after treatment with phenoxyacetic acids *P. visci* appeared on the necrotic shrubs. Therefore, the antifungal effect of systemic pesticides has also been studied. These chemicals have strong antifungal and inhibitory effects for *P. visci*, therefore an incidental combined herbicide and spore suspension treatment is not possible.

Regarding to hyperparasitic fungus, inoculum threshold and pathogenicity of different strains were tested on healthy leaves under *in vitro* laboratory conditions. No difference was observed among the pathogenicity of fungal strains and symptoms also appeared using even a low concentration (6.5×10^3 spore/ml) suspension for infection. The chlorotic symptoms appeared 7-14 days after the inoculation, while pycnidia and further symptoms of the disease appeared 21-28 days later.

Based on these results a spore suspension treatment could destroy mistletoe shrubs using low concentration of spore suspension. A combined herbicide-fungal spraying is not suggested, but a management 2-3 weeks earlier with a very low concentration 2,4-D herbicide spraying could induce a weakened condition on mistletoe shrubs, which can contribute the success of the fungal infection. In the future we would like to study the infection of *P. visci* in field experiments and the possibility of spraying.

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How understanding ecological interactions provides tools for conservation biocontrol of the weedy leafy spurge (*Euphorbia esula*)

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Leafy spurge (*Euphorbia esula* L. subsp. *esula*, Euphorbiaceae) is a well known invasive species, not only in North America but also in Europe, its native range. Since the 1990s, its invasiveness has been reported in the floodplains of Val de Saône in central-eastern France, which are considered the last and largest European flood-meadows. Growing in dense patches, this latex-rich plant is toxic to cattle when present in cut hay. Annually mowed grasslands are losing their profitability as soon as they are infested. This economic loss may lead to ecological issues such as the shifting of mowed pastures into intensive agriculture (corn) and forestry (poplar). Natural annual floods and various agricultural practices such as mowing and grazing promote a rich floral and faunal diversity, which is protected under the Natura 2000 network.

Our project is an original multidisciplinary approach to the study of invasive plant/natural regulator/agricultural practice/biotic factor interactions in two ways: 1) we are determining the biological, genetic, ecological, and agricultural factors triggering leafy spurge invasiveness, and how these factors interact; and 2) we are proposing an integrated biocontrol program combining previously obtained data, by targeting invasive plant/natural regulators interactions, connected with agricultural practices, based upon field and laboratory tests.

Preliminary field results show that, as suspected, all factors tested are influencing the plant/insect complex. Mowing has a major impact on shoot density (shoots/m^2), increasing it by two times on average. Mowing also negatively impacts the population size of the insect *Oberea erythrocephala* (Cerambycidae) by suppressing older shoots. This beetle is one of the natural phytophagous regulators of leafy spurge, and aged shoots are its major oviposition substrate. Grazing, including trampling caused by this practice, has an opposite effect, mainly on non-mowed patches that appear to attract cows. Shoot density decreased by 50 to 95% in August. This practice occurs only after *O. erythrocephala* population and oviposition peaks, reducing the potential impact on the density of its population. The flood factor does not seem to impair plant health. Further studies may show a positive impact on the spread of the seeds.

Significant outputs of national Orobanche project/Turkey

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The National Broomrape (*Orobanche* spp.) Project (2006-2010) is basically divided into three main parts which are namely specify the broomrape problem in Turkey, investigations on the control methods and training activities. Studies concerning the broomrape problem were conducted to determine *Orobanche ramosa* L. (*Phelipanche ramosa* (L.) Pomel) in tomato, potato and tobacco; *O. cernua* Loefl. in sunflower; *O aegyptica* Pers. (*P. aegyptiaca* (Pers.) Pomel.) and *O crenata* Forsk. in red lentil fields. During the survey studies it was found that 27,35 % of the 2041 fields were infested with *Orobanche* species. The mean broomrape density on these fields was 4,67 branch per square meters. Based on these survey studies "Turkeys broomrape map" was created to show the distribution of different *Orobanche* species depending on crop species as well as

provinces. Studies on concerning broomrape control, and germination biology showed that some synthetic stimulants, such as GR24, GR7 and GA3 promoted the germination rates of *O. aegyptiaca* and *O ramosa* seeds. Allelopathy studies showed that the thyme (*Thymus vulgaris*) treatment provided more than 50 % inhibition on the emergence and tubercule formation of *O. ramosa* in tomato. Chicken manure reduced the emergence of broomrape by 50 % in tomato and improved the yield. This treatment reduced the branch number and dry weight of *Orobanche* species by 65 % in potato. Olive processing waste was found to be an effective material to control broomrape in tomato under greenhouse conditions. The seedbank of *Orobanche* spp. in tomato and red lentil was reduced by the candidate bioherbicide named Oroser. Studies with catch plants showed that turnip rape and flax were promising for the control of *O. aegyptiaca* in tomato, as well as for *O. crenata* in lentil, when they were grown on the field previously. Researches on the sowing date and cultivar resistance showed that early sowing of the variety Hydbrid 2710 was the most suitable for broomrape control in tomato. In red lentil the suitable timing for sowing to reduce broomrape problems was determined as the period after the second week of November and the yield from some varieties such as Fırat-87, Çağıl and Altıntoprak were higher than currently sown local variety. In the experiments on soil solarization and application of mulch textile gave successful results on the control of broomrape species. Studies concerning chemical control of *O. ramosa*/*O. aegyptiaca* in potato and tomato showed that some herbicides reduced the shoot number, fresh and dry weights and provided higher yield. Studies on the natural enemies showed that 15,5 % of the 3373 *Orobanche* shoots were infested. *Phytomyza orobanchia* was the major biocontrol agent also *Polyodaspis sulcicollis*, *Smicronyx fulvipes, Trogoderma* sp., *Dasytiscus* sp.*, Lasioderma semirufulum, Dasytes* sp.*, Dasytes seriatopunctatus, Anaspis* sp. and *Pronotalia orobanchia,* a parasitoid of *Phytomyza orobanchia* were identified as natural enemies. In addition to these enemies some fungal agents, such as *Fusarium oxysporium and Alternaria* sp were also identified. Within the frame of National *Orobanche* Project, some brochures and booklets were prepared to inform the growers, and also educational visits were done in 25 provinces in Turkey in which 2328 people were informed about the results of the studies. The results of the Project were also broadcasted to the public media by means of national and local TV, radio, newspaper as well as internet news. As a result, all planned studies concerning broomrape in Turkey have been completed. The aims of further studies were to adapt the successful management treatments under field conditions and to develop an integrated management control methods for broomrape.

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Use of sensors for assessment in herbicide trials

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During the last decades different sensors and signal processing algorithms have been developed with the aim of identifying weeds in crops. This enabled farmers and scientists to automatically map the distribution of weed populations in arable crops and apply herbicides and site-specific r weed control methods using GPS-controlled patch sprayers.
In late May 2012, the EWRS Site Specific Weed Management Working Group arranged a workshop with the aim of using different sensors types and signal processing algorithms in an experimental design with 5 densities of spring barley and oil seed rape, sprayed with 4 herbicides with different mode of actions. The experiment was design in 30 x 3 m stripes and two replicates i.e. in total 400 plots.
The results of the joint experiment showed that dose-response relationships fitted to the output from the different sensors irrespectively the sensing principles. The results also showed that increased number of non-destructive sensing of crop response increased the accuracy of herbicide assessment under field conditions compared to manual assessment.

Parameterizing the "grassland" module in the multispecific model FLORSYS

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The multispecies model FlorSys can predict the effects of cropping systems on the dynamics of weed communities in annual crops; however, it is not configured to predict the fate of weeds in permanent cover such as grasslands. We realized the simulation of a weed seed rain in controlled conditions to estimate the percentage of weed seeds intercepted by a grass cover. Parameters of this linear model will be used to develop a new sub model in FlorSys to be able to simulate weed dynamics in temporary grasslands.
We used twelve weed species selected on the basis of specific morphological characteristics and observations made in the experimental set up of SOERE ACBB (Observatory Environmental Research, Agro-ecosystems, Biogeochemical Cycles, and Biodiversity). Weed seeds have a probability to reach the ground which depends on the height of the cover, but also on seed characteristics. So, we determined the favorable traits in the weed seed interception by a grass cover whatever the species considered.
The next steps will consist of integrating the interception equation in FlorSys and of analyzing the sensitivity of the modified model. We will compare the model simulations with the observations of weed dynamics in SOERE ACBB, to explain the changes observed in cropping systems with temporary grasslands.

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Weed management strategies in conservation tillage

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Conservation tillage methods have become increasingly popular in World due to increasing fuel cost and environment-conscious. But, the sustainability of conservation tillage systems depends on the development of economical and effective weed management systems. While effective weed control is an essential aspect of conservation tillage systems, current herbicide technology may not yet fully achieve this. The aim of this paper is to define strategies for improved weed management in the context of conservation tillage systems and the results of researches conducted on weed management in conservation tillage.
The studies showed that the rotations and cover crops were considered to be essential components in reducing weed problems and the dependence on herbicide usage in no-till systems. The availability of herbicides suitable for control of a wide range of dicotyledonous and monocotyledonous weed species was a paramount requirement for any conservation tillage system. The introduction of glyphosate (Roundup) in 1971 brought many advantages but its effectiveness was reduced by low temperatures and frequent rainfall after application and additional herbicides might be needed. A delay of the autumn rains might cause problems through retarded weed germination in already established winter crops. The lack of effective herbicides for spring sown crops in southern Europe (for example, sunflowers and soya) might limit uptake of no-till for these crops. Also, it was found to be unlikely that weed infestation and reduced yield would be problems in temperate climates if soil disturbance through tillage was reduced. Non-inversion tillage could easily replace inversion tillage, and stubble tillage could be added to primary tillage if needed to reduce weeds. Since no specific tillage method was unequivocally superior to another one, any method well suited to specific regional and farm conditions can be adopted successfully.

Weeds and weed control in Igdir

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Igdir is a province with continental climatic conditions in North-East Turkey. Grasslands and prairies cover 41 % and agriculture land 33 % of its total area, 3588 km^2. However, 28 % of the land that is available for agriculture is not used for agriculture and 16 % is under fallow. Cereals are grown in 36 % area which is followed by fodder crops, 11 %. Maize for silage as a second crop opportunity following cereals has been increasing importance. There is no survey on weeds to determine segetal flora although main weeds have been known. In this presentation, weed problem and weed control in province will be presented using our observations, data and information from the province directorate of ministry of agriculture, and pesticide sellers including some information from farmers. Broadleaf weeds such as *Sinapis arvensis*, *Capsella bursa-pastoris* are main problem in cereal production. *Avena* sp. and *Sorghum halepense* are the most common graminae weeds. Cuscuta on alfalfa and sugar beet, and *Phelipance ramosa* on tomatoes are parasitic weeds in the province.

Can a new herbicide and combined treatments improve *Cynodon dactylon* control?

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Cynodon dactylon (L.) Pers. (Cynodon) is a major weed in the South African sugarcane industry, requiring repeated applications of non-residual herbicides like glyphosate to obtain prolonged control, thereby possibly increasing the risk of herbicide resistance. To avoid this, two new approaches have been considered: firstly, the introduction of an herbicide with an entirely new mode of action to the South African sugarcane industry, and secondly, introduction of an integrated weed management approach (IWM), where glyphosate application together with planting a cover crop (oats) or tillage plus seasonal cold dry weather, is exploited in combination to prolong control of Cynodon. Imazapyr has a different mode of action to glyphosate so would reduce the risk of herbicide resistance. In addition, imazapyr is residual compared with glyphosate and hence allows control of late-emerging Cynodon rhizomes. A large-scale (1.8 hectare) demonstration trial was established during late summer on a sandy soil (8% clay, 6% silt, 0.7% organic matter, pH 6.0) to confirm earlier small-plot replicated trial results and demonstrate research findings to local farm managers. Treatments (T) were: imazapyr applied alone at 1250 g a.i. ha^{-1} (T1); imazapyr with subsequent discing and planting of a winter cover crop (*Avena sativa*) at 7 weeks after herbicide application (T2); imazapyr with subsequent winter tillage at 7 and 23 weeks after herbicide application (T3); glyphosate applied alone at 3600 g a.e. ha^{-1} (T4) or in combination with a subsequent oats crop (T5) or subsequent tillage (T6). Significant differences between means were established with t-test analyses. Results showed that imazapyr provided prolonged control, with 0.1% Cynodon coverage (T1) at 31 weeks after treatment, compared with 18% Cynodon coverage after glyphosate application (T4). This confirmed the results of earlier small-plot replicated trials. Tillage did not improve control after imazapyr application (T3), and the oats cover crop was ineffective (T2), having only 22% of the above-ground dry biomass of the glyphosate treatment (T5). In contrast, glyphosate efficacy was enhanced by subsequent tillage or an oats cover crop, with 18% Cynodon coverage (T4) reduced to 3% (T6) and 0% (T5), respectively, at 31 weeks after treatment. A sugarcane seedling bioassay measuring relative leaf chlorosis indicated that imazapyr had dissipated in soil collected from 0-60 cm depths from T1 and T4 plots after 487 mm rainfall, when the new sugarcane crop was planted. Subsequent crop measurements showed no phytotoxicity when comparing imazapyr and glyphosate treatments, thereby confirming results of earlier small-plot replicated trials. It was concluded that Cynodon control could be enhanced by the appropriate use of these "new mode of action" and IWM approaches, and that technology transfer via the large-scale plot approach shows promise in demonstrating these principles, since local farm managers requested and attended an initial workshop, with a further farmer's day planned during 2013.

Survey of weed control and crop production practices in cotton agriculture in Diyarbakır provience of Turkey

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Cotton Agriculture is very important in South Eastern Anatolia Region of Turkey. Weeds are a major problem in cotton farming systems. In this study, a survey was conducted in Diyarbakır Province of Turkey to evaluate weed management and crop production methods, and to list the most important weed and production problems. Also, effect of agricultural extension on weed control was investigated. In this purpose, over 150 cotton growers were surveyed by applying a questionnaire. The questionnaire included 25 questions about crop rotation, tillage systems, irrigation and weed management methods that growers applied in cotton production. Also, growers were surveyed about the most common weeds that they faced in cotton fields. The survey results showed that the most common weeds in cotton production fields were *Sorghum halepense* (L.) Pers. (johnsongrass), *Cynodon dactylon* (bermudagrass), *Xanthium strumarium* L. (common coclebur), *Portulaca oleracea* L. (purslane), *Amaranthus retroflexus* L. (common amaranth), *Cyperus rotundus* L. (*nutgrass*), *Physalis sp.* (ground cherry), *Solanum nigrum* L. (black nightshade). Most growers used pre-emergence and post emergence herbicides before planting and in the season. The common plant rotation was wheat/cotton or corn/cotton. The tillage system used was commonly conventional tillage method including moldboard plough in the autumn and two times cultivator and scrapper before planting. Over 70 % of growers stated that tillage system influenced significantly the weed population.

Practical experiences with site-specific weed management in winter wheat

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An aggregated distribution pattern of weed populations provides opportunity to reduce the herbicide application if site-specific weed management is adopted. However, site-specific weed management requires the precise setting of control thresholds for effectiveness and reliability. This research is focused on the practical testing of site-specific weed management in a winter wheat and the optimisation of the control thresholds.
Patch spraying was applied to an experimental field in Central Bohemia. Total numbers of 512 application cells were arranged into 16 blocks, which allowed the randomisation of four treatments in four replications. Treatment 1 represented blanket spraying and the other treatments differed by the herbicide application thresholds. The weed infestation was estimated immediately before the post-emergence herbicide application. Treatment maps for every weed group were created based on the weed abundance data and relevant treatment thresholds. The herbicides were applied using a sprayer equipped with boom section control. The herbicide savings were calculated for every treatment and the differences in the grain yield between the treatments were tested using the analysis of variance.
The site-specific applications provided herbicide savings ranging from 15.6 to 100 % according to the herbicide and application threshold used. The highest yield (8752 kg ha^{-1}) was achieved by treatment 4 (highest thresholds) and the lowest (8498 kg ha^{-1}) by treatment 1 (blanket spraying). However, the differences in yield between the treatments were not statistically significant ($p=0.81$). Thus, the yield was not lowered by site-specific weed management.

Weed mapping in cotton using proximal and remote sensing

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Weed mapping using proximal and remote sensing was developed in a cotton field, as part of an EU LIFE+ project (HydroSense, www.hydrosense.org). The objectives were to spatially record and map weed densities by integrating information gathered from multispectral groundbased sensors, analyzing high resolution satellite images and digitally processing RGB photographs. The distribution pattern of NDVI's values produced by groundbased sensors is comparable to the one produced by the satellite image. Yield data was recorded via a yield monitor mounted on a cotton picker at the end of the growing period. A set of WorldView-2 (WV-2) multispectral (2m pixel size) and panchromatic (0.5m pixel size) satellite data in 8th June 2011 was acquired. Preliminary data analysis showed a correlation between field data and the estimated weed density values derived from NDVI maps. Early construction of accurate and reliable weed maps which classify fields into various spatial zones of different weed pressure can lead to better weed management optimizing environmental and input costs.

Weeds and Australian cropping - opportunities and obstacles

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Weeds remain a major constraint to productivity of Australian agriculture, particularly with the increasing number of herbicide-resistant species and populations. Currently, 39 weed species are resistant to many of the key herbicides used in cropping, including five species resistant to glyphosate. This paper summarises the current weed situation in grain production in the Australian sub-tropical region. Then, new chemical and non-chemical tactics as well as the weed management approach with the emphasis on the weed seed-bank are identified and evaluated, to address the current and future weed issues. Finally, brief case studies on the management of the glyphosate-resistant weeds *Conyza bonariensis* and *Echinochloa colona* are presented to highlight how a range of tactics focussing on the different parts of the weed's life cycle is required for successful management.

Storage ability and nutritional value of red cabbage (*Brassica oleracea* var. *capitata rubra*) depending on weed control methods

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Red cabbage (*Brassica oleracea* var. *capitata rubra*) is a valuable vegetable and an important source of biologically active substances. The heads of red cabbage can be stored for a long period and their nutritional value might change during storage. Growth conditions affect the yield and storage ability of cabbage. The aim of the research was to determine the storage ability and nutritional value of red cabbage depending on the methods of weed control during cultivation.

The studies were conducted at the Research Institute of Horticulture in Skierniewice, Poland, in the years 2010-2012. Field trials were set up with 4 replications in a completely randomized block design, on a pseudopodsolic soil (organic matter – 1.6%, pH – 6.2), and the plot size of 12 m^2. Red cabbage plants were planted between May 30 and June 4. The following methods of weed control were compared: the use of herbicides only (oxyfluorfen, metazachlor, pendimethalin, clopyralid), the herbicide oxyfluorfen + mechanical treatments, mechanical treatments, cover crops, soil mulching with polypropylene (PP) and biodegradable foil, and hand weeding. Red cabbage was harvested at the end of October and the yield of heads and their nutritional value were determined. After harvest, they were placed in storage. The heads were packed in plastic crates lined with polypropylene foil. The trials were set up in 4 replications, each consisting of 6 heads of cabbage. The cabbage heads were stored for 206-222 days at a temperature of 0°C. The yield of marketable heads, spoiled and rotten ones, and those with colour defects and weight loss was determined after storage. Chemical analyses of the heads covered: dry matter, total sugars and nitrates content.

The field experiments have shown that the yield of red cabbage heads was affected by the weed control methods. The highest yield was obtained for cabbage grown in polypropylene (PP) mulch, with slightly lower yields obtained for cabbage grown in biodegradable foil, on mechanically weeded plots, and in the combination of oxyfluorfen with mechanical treatments. High yields were also obtained from cabbage sprayed with oxyfluorfen + metazachlor and pendimethalin + clopyralid.

The marketable yield of cabbage heads after storage was also affected by the weed management methods. The best storage ability was shown by red cabbage treated with oxyfluorfen + metazachlor and grown in biodegradable foil and in polypropylene mulch. The differences between the yields of cabbage treated with pendimethalin + clopyralid and from the plots weeded mechanically were not satisfactory. The lowest percentage of rotten heads was found in the combination treated with oxyfluorfen + metazachlor. The results for dry matter and total sugars content in cabbage heads after storage were lower in comparison with fresh heads, but were not affected by the method of weed control. A

higher level of nitrates was recorded in cabbage cultivated in polypropylene mulch and in soil covered with biodegradable foil.
The results of the experiments indicate a varied response of red cabbage to weed management methods, both during field cultivation and during storage.

An integrated approach to weed management in maize (*Zea mays* L.) in Cameroon

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Maize plays an important role in food security and is a source of income for many smallholder farmers in Cameroon. Weeds are among the most serious threats to maize production and contribute to low yields on most farmers' fields. Field experiments were conducted in Buea, Cameroon, in 2010 and 2011 to evaluate glyphosate (Roundup 360g a.e./l) in combination with other methods for weed management in maize. Treatments were: combinations of Roundup® applied at 6 L/ha before planting maize (RBPM), RBPM with or without live mulch (*Cucumeropsis mannii*) and hoeweeded once, hoeweeded (four times) and weedy control checks, and maize density: 53,333 and 80,000 plants/ha. Results indicated that all weed control treatments significantly reduced weed density and biomass, and improved grain yield compared to the weedy control checks. Weed density and biomass in the weedy checks was higher at 53,333 plants/ha than at 80,000 plants/ha. Grain yield was highest in treatments with RBPM at 80,000 plants/ha with or without live mulch and hoeweeded once, and the check with 80,000 plants/ha hoeweeded four times. These treatments had 1.5 times more yield than the hoeweeded control check with 53,333 plants/ha, and 13 times more than the weedy check with 53,333 plants/ha. Economic analyses showed that RBPM at 80,000 plants/ha with or without live mulch and hoeweeded once gave the highest net benefit. We therefore recommend these treatments for weed management in maize in Buea.

Appraisal of a CDA micromax rotary atomizer for weed control

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Spinning disc sprayers were first introduced to control cotton pests and diseases. These atomizers were recognized for their production of a uniform droplet size spectrum than conventional nozzles. They have proved to be the most successful way of delivering pesticides in the form of Controlled Droplet Application (CDA) at very low volume application. But they were almost abandoned since the years of 1990 for high and medium volume application. Their use was found inefficient in arable crops such as cereals due to the use of inappropriate application rate and problem of penetration of spray in cereal canopies. However, these spray generators may be the best solution when the spray was to be targeted to a small weed with hydrophobic leaf surface where adhesion in the impact is essential for treatment efficiency while minimizing drift and splash thanks to reduced droplet span. In this study, aiming to maximize the control of black grass in cereals, characterization of the droplet size spectra was performed to predict the trajectory droplet and estimate the number that will hit the targeted surface. So, a CDA Micromax Ltd rotary atomizer was operated at different rotation speeds (2000, 3500 and 5000 rpm), flow rates and pressures. A camera X stream -3S which allows the acquisition images in PIV mode, connected to a led lightening set at double mode exposure, were placed in front of the edge of the disc on a spray bench. Images were treated through a laboratory developed Matlab code for Particle Tracking Velocimetry Sizing. Droplets speeds according to diameters were extracted. Droplets cumulative volume according to diameters was also obtained. As the flow rate rose, the volume median diameter (VMD) increased. On the other hand, the VMD decreased as the rotation speed increased. Satellites droplets were observed when the atomizer was operating at a disc speed of 2000 rpm. For each flow rate corresponding to a drop size VMD, the number of droplets/cm^2 that will affect pesticide coverage was calculated. Thus, the number of droplets that will effectively adhere depend on their impact at the moment of their arrival to the surface target.

Weed control of GLOBAL G.A.P. certified tomato in Tunisia

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The main of tomatoes exports in Tunisia derived from fresh geothermal tomato crop.Weed tomatoes control is the major challenge for producers in Tunisia because it must be in compliance with EU chemical input (herbicides, pesticides) use restrictions and the GlobalG.A.P. standard, which mainly focuses on food safety, environmental protection, worker health and safety and animal welfare. All these are regulated through in depth audits of production, postharvest produce handling and marketing systems.
The survey made at June 2012 in Tunisia, shows that since certified, Tunisians producers use more preventives methods of weed control and less chemicals products like herbicides while positive effects on the health of farmers and their families and safety are observed. This study shows also that there is some improvement in agricultural efficiency, tending towards more sustainable production in the horticultural sector.