



EUROPEAN WEED RESEARCH SOCIETY

Abstracts

**EWRS Workshop
Weeds and Biodiversity**

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Introduction

Biodiversity in agricultural weed communities: is it good or bad?

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The aim of this paper is to provide insights and stimulate discussion on whether a higher diversity in an agricultural weed community has a positive, negative or neutral influence on agroecosystem functions, for example the productive one (crop yield). Starting from an analysis of how weed biodiversity-related issues are tackled in the recent scientific literature, the topic will first be treated in the light of the three biodiversity levels identified by the UN Convention on Biological Diversity (CBD): the genetic/population (within species), community (among species) and habitat (the agricultural field and its management) levels. It is advocated a reappraisal of the methodological approach for such studies, taking into account: (a) a more focussed definition of weed biodiversity based on their *functions* and related to the cropping system; (b) a revised set of indicators/indices that could better highlight the importance of weed biodiversity in sustaining or undermining agroecosystems functions; (c) a well-defined time and space frame. A functional approach - which is rarely encountered in the scientific literature - would help elucidate the agro-ecological role of weed community diversity.

Weeds and Biodiversity – what are the interests of EWRS-members?

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On one hand weeds can be regarded as undesired plants interfering with various agricultural goals. On the other hand weeds have a functional role within the agro-ecosystem and their man-made role as desired plants. These aspects contribute to the multifunctional character of agriculture in the socio-economic system.

A questionnaire was worked out and send via email to EWRS members in December 2006 and January 2007 to collect and document the variation of weeds and biodiversity and the determining background of all countries represented in the EWRS. Several members answered the questionnaire. Because the analysis refer to the country there are in total 124 filled questionnaires. Further analysis constrain to 109 filled questionnaires from 26 European countries including Russia and Turkey. Data are selected and first results can be presented of weeds and biodiversity in socio-economic aspects, nature conservation and protection, legislation and programme towards the policy, farmers and research as well as personal opinion of the respondent. Next to data which can be resumed at different levels; for Europe, resumed and compared between North, West, East and South Europe or between the countries, the questionnaire gather additional information for example special activities for weeds and biodiversity in some countries or regions.

Session 1: Biodiversity for Agriculture - Ecological services of weeds

Sustainable agriculture and the role of seed predators in weed suppression

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Weeds in arable fields attract and sustain a wide variety of organisms, including some that regulate weed densities and weed flora composition. The latter group includes herbivores, granivores and micro-organisms. Recently, post-dispersal seed predation by generalist predators has received renewed interest since it was demonstrated that it significantly reduced the input into weed seed banks and thus allowed for a substantial reduction in herbicide use. The balance sheet of weed seed banks and indirect estimates of seed losses due to predation in a cropping system experiment in Iowa, USA, illustrate these. There is currently insufficient knowledge available to predict the occurrence, identity and abundance of generalist predators at a specific location, or their impact on weed dynamics. Similarly, although most predators exhibit seed preference in the laboratory, changes in weed flora composition caused by seed predators in the field cannot be predicted at this point.

Composition of a weed assemblage: determinant of granivorous carabid diversity?

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Many weed species are beneficial in such way that they promote biodiversity and abundance of many organisms inhabiting agroecosystems, including birds and herbivorous insects. Whether the same effect of composition and abundance of weed community can be detected also for granivorous carabid beetles, which are very important predators of weed seeds, is not known. It is assumed that assemblages of granivorous carabid beetles differ between patches of particular weeds, and that species composition of the patch will interact with the seed preference of particular species. Consequently granivorous carabids should prevail in patches that contain the preferred seed plant. This hypothesis was tested using enclosures in patches of weeds naturally established in cultivated land.

Gradient of weed seed predation from the boarder into a wheat field

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The presentation focuses on the relative importance of vertebrates and invertebrates on weed seed predation and the influence of a sown flowering mixture and a woody hedge at the field margin.

For the investigations enclosure experiments were conducted in 2006, June 6-16th in an organic spring wheat field near the coast of the Baltic Sea (Germany) after a method described by Westerman, 2002. Two weed species, *Thlaspi arvense* L. and *Myosotis arvensis* L. randomly glued on sandpaper with grain size 60 (so called seedcards) were deployed in two experiments. Each experiment was built of 9 transects, starting from the flowering mixture, passing a 4m wide grass-clover strip and ending in the wheat field (44m distance from field margin); respectively starting from the woody hedge and ending in the wheat field in a distance of 62m to the field margin. Additionally we took one patch in the centre of the field (150m from the margin, 9 repeats). In order to take environmental factors in account, a randomly distributed control was laid-out (also 9 repeats). Every second day the remained seeds were counted; total time of exposition was 10 days.

Total rates of predation averaged over all patches in the field were high (89-93 % (95% confidence interval after 10d exposition)). Invertebrates, probably carabid beetles, are responsible for the major part of predation (75-82 %), whereas vertebrates, presumably mice, are responsible for the minor part of predation (6-11 %).

The highest rates were observed in the centre of the field and in the grass-clover mixture which were placed between the flowering mixture and the wheat field. In the flowering mixture we found the lowest rates, probably due to plentiful food availability, but relative rates caused by vertebrates were maximal in the flowering mixture and in the woody hedge (14-38% respectively 6-25%). We determined three homogenous subgroups which are nearly identical with the biotopes flowering mixture, grass-clover mixture and wheat field. Preferences in foraging *Thlaspi arvense* or *Myosotis arvensis* could not be found.

Can species rich communities reduce weed interference with the crop?

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The rationale for the study and conservation of weed species and weed communities can be found in their intrinsic value, in the role they play in providing food to farmland birds or granivorous insects (see other presentations in this Workshop), thus contributing to the conservation of wildlife and in several aspects of weed functional biodiversity related to the improvement of the cropping efficiency such as their possible role as a host of beneficial insects thus increasing biological pest control (Marshall, Brown et al. 2003) or their positive impact on the below-ground microbial biomass and especially on Arbuscular Mycorrhizal Fungi (AMF) thus increasing the crop's nutrient uptake efficiency (Douds and Millner 1999). However, very little is known about how species richness of the weed communities is related to weed biomass production and to crop yield, and if species rich communities can mitigate yield variability in time.

Some of these aspects have been tested for data from a long-term cropping system experiment based on a maize-durum wheat two-year rotation at the Interdepartmental Centre for Agro-environmental Research in San Piero a Grado (Pisa, Italy). The experiment, that was established in 1993, was designed as a split-split plot with four replications including two crop management systems (conventional tillage + pre- and post-emergence herbicide application vs. no tillage + glyphosate + post-emergence herbicide application) in the main plots, four nitrogen fertilisation rates for maize (0, 100, 200 and 300 kg N ha⁻¹) in the sub-

plots and four winter cover types (crop stubble, *Secale cereale*, *Trifolium incarnatum* and *Trifolium subterraneum*) in the sub-sub-plots (21 m wide and 11 m long). Weed density or abundance and weed species richness were measured just before and three weeks after the weed control treatments. Weed and crop biomass were measured at harvest for all crops from 2001 to 2003. Principal Components Analyses determined the variability in weed community composition for the different treatments. Multiple linear regression allowed for determination of all factors (experimental treatments and weed species richness and biomass) that significantly affected maize and wheat grain production.

Data show that the relation between weed species richness and weed biomass production follows more or less a normal distribution. The samples that disturb this pattern contain few highly productive species and therefore result in a higher weed biomass production than what could be expected based on their species richness. Multiple linear regression showed that wheat grain yield in 2001 and 2003 was positively affected by weed species richness and N fertilisation and negatively by weed biomass production. Maize grain yield was independent of weed species richness and biomass but was positively affected by N fertilization, tillage practises and the presence of a *T. incarnatum* or *T. subterranean* cover crop before sowing maize.

References

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Session 2: Agriculture for Biodiversity - diversity at different scales (climate, farming systems, fields)

Sustainable Arable Farming for an Improved Environment (SAFFIE)

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SAFFIE is a collaborative project studying the potential of novel habitat management in the crop and non-cropped margins for enhancing farmland biodiversity, specifically looking at plants, invertebrates and birds. This presentation discusses the work on plant populations in winter wheat crops and some associations with invertebrates. The novel habitat management included comparisons of crop structure (architecture) and manipulation of herbicide inputs.

Conventional crop structure was compared with wide spaced rows (double row width) and small undrilled patches (skylark patches approx 16 m²) at 10 sites across the main arable area of England over two years. Weed cover was different between sites and between years. There was little field-scale effect of the experimental treatments on weed abundance. However, the undrilled patches consistently supported higher weed populations than the surrounding crop and where patches supported relatively high weed populations, they were

also colonised by arthropods. The response of arthropod groups to components of vegetation cover (bare ground, litter, crop cover, broadleaf weed cover and grass cover) was determined using a Generalised Linear Model (GLIM) and community composition data were analysed using RDA to explore associations between arthropod community composition and components of the vegetation. Even where weed cover was relatively low, some relationships between arthropods and vegetation were detected.

A small-scale plot study of a range of herbicide programmes combined with wide spaced rows (WSR) and a spring cultivation was set up in winter wheat at three sites with different soil types. The aim was to use selective herbicides (individually and in combination) to enhance 'beneficial' weed populations whilst controlling agronomically important species. Weed species were grouped according to their desirability with respect to both agronomic issues and biodiversity benefits (Group 1 = very desirable, Group 4 = undesirable). Herbicide treatment had a significant effect on almost all weed groupings, except where weed cover was very low. Weed cover and arthropod abundance were generally higher under single product applications compared to sequences. In most site/years a spring application of amidosulfuron was the most beneficial of those treatments receiving herbicide. The results suggest that, in certain circumstances, there is potential to enhance farmland biodiversity using selective herbicides.

Overall this work suggests that there are opportunities to improve farmland biodiversity within cropped areas, but treatment effects are site and year dependent.

The effect of management (conventional vs. organic) on weeds and insects biodiversity in dryland wheat fields in north-eastern Spain

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Four pairs of wheat fields were selected to study the effect of management on weeds and insects' biodiversity in dryland wheat fields. One organic field was matched with one conventional field. The fields within each pair were of approximately the same size and they were located fairly close to each other. The chosen organic fields had been managed for more than one decade following the guidelines of Organic Farming. The study was carried out in the vicinity of Montblanc (UTM 31T CF3495), NE of Spain in the spring of 2004. The climate at the study site is Mediterranean with a mean annual temperature and precipitation of 13°C and 450 mm, respectively. The fields were surrounded by a heterogeneous landscape and the field boundaries were colonized by dense herbaceous grassland dominated by *Brachypodium phoenicoides* and hedges dominated by *Rubus ulmifolius* and *Prunus spinosa*. Some trees (*Quercus faginea*, *Acer campestre* and *A. opalus*) and shrubs from natural oak woodlands also grow in the boundaries.

Five 1 x 1 m plots 10 m apart were located in the central area of each field; a strip of 25 m wide around the field were left to avoid the hedge effect. Weed species were identified and their cover recorded at each plot following a ground cover scale with the following intervals: 0-1, 1-5, 5-10, 10-25, 25-50, 50-75 and 75-100%. A petrol-driven suction apparatus with a pipe diameter of 20 cm was used to evaluate insects' abundance and diversity. The pipe was

carefully moved over the wheat plants and exhaustion was performed for 60 s per vegetation quadrat. The sample was then removed by inverting the collection bag into a plastic bag. The samples were transferred to 70% alcohol and sorted into families.

Weed vegetation cover and diversity were higher in organic than conventional fields. While cover of broad-leaved weeds was greater in organic than conventional fields, little variation in grasses was found. Although family richness did not differ among organic and conventional fields, some predator families (i.e. Dolichopodidae (O. Diptera) and Nabidae (O. Hemiptera)) clearly preferred organically managed fields. The correlation analysis between insects and vegetation shows that diversity is more related to vegetation cover rather than vegetation diversity regardless of the type of management.

Vegetation composition and soil cover in field margins in semi-arid conditions

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The study area is located in a farm of Zuera (North-eastern Spain) in semi-arid climatic conditions. Even if the total average yearly rainfall is only around 350 mm, summer storms with average rainfall of 30 mm/h are frequent and cause severe erosion problems. The studied vegetation strips were 8 to 10 meter wide, next to cereal fields and set aside since 1, 2, 3 and 4 years ago with the main aims of reducing rain erosion and favouring biodiversity. Vegetation was also assessed in the nearby fields. Two strips of each age were chosen and four 2 x 2 meter plots were maintained in each strip. Soil cover was assessed in winter 2005 and in spring 2006. In spring, vegetation evaluations were made using the Braun-Blanquet notation and counts were made in 1 x 1 squares within the same plots and randomly in the fields. Soil cover and number of total plants increased steadily with the age of the strips. The number of species of all groups (annual, biannual or perennial dicotyledonous plants, annual or biannual or perennial grasses) increased clearly with the age, especially the biannual or perennial plants. However, the total number of species present in the strip remained stable since the second year. Also the diversity index of Shannon was highest with the 3 and 2-year old strips, significantly higher than in the fields. The correspondence analysis showed that the presence of some species including *Anacyclus clavatus*, *Sonchus oleraceus*, *Diplotaxis erucoides*, *Lolium rigidum* and *Papaver rhoeas* was independent of the strip's age while other species, especially biannual and perennial plants as *Mantisalca salmantica*, *Scabiosa atropurpurea* and *Eryngium campestre* were clearly related to older strips. *Fumaria parviflora* was related to the fields.

These results suggest that in the present experimental and climatic conditions soil cover and plant number continues increasing until the fourth year but the highest biodiversity values are achieved earlier. Further observation during the following years is needed to continue studying the evolution of these margins.

The role of rare and infrequent species in regional weed flora diversity

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This paper presents results from weed flora investigations performed between 1999 and 2003, within 8 separate regions in Europe along a climate transect from south Italy up to Finland as well as from investigation in single regions in Hungary and Germany. The investigations have been carried out on different field types.

Nearly two third of the total species number found in our field investigations occurred rarely, only on less than 10% of the observed fields. This group of infrequent species was responsible for describing the regional differences within the weed flora (regionality) as well as the main differences between fields with different kinds of land use (conventional – extensive – fallows).

Beside the infrequent species we have also found species with a very large amplitude of occurrence along the north-south gradient in Europe and on different field types. This group consists of some of the most important target species for weed control in cereals in Europe. These species are wide spread and have a high flexibility to climate conditions. For the predominant species, the composition of the weed flora on extensive fields and fallows was not much different from those on conventional fields. Looking at the most frequent weed species, it becomes evident, that weed management in the past was efficient in reducing species number and in preventing occurrence of infrequent species, but not in eradicating the main noxious weeds. For controlling these species, it seems, new strategies are needed. Many other studies have shown, that it is a statistical problem to proof the effects on the rare-fraction statistically due to the unknown size of the random variation. Also functional evaluations focus often consciously or unconsciously on the group of the most abundant species, what may lead to misinterpretations. By presenting our results, we want to initiate a discussion on methodological alternatives to integrate infrequent species adequately in assessments on the state and function of weed flora diversity.

Session 3: Agriculture and Biodiversity - using the link in programmes and schemes

Application of arable weeds as an indicator for the sustainability of agriculture

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Monitoring of the populations of organisms associated with farmland provide information on the sustainability of cropping measures. Recently, interest in the application of arable weeds as an indicator group has grown. This study aimed at to develop an indicator based on the interactions between weeds and animals associated with weeds for the sustainability of cropping measures.

The relative importance of 25 common weed species for farmland birds, pollinators (wild bees), phytophagous insects and pests was explored by recording the number of linkages between weed species and each animal group found from the literature. The weed species were ranked by weighting them by the relative number of above weed-animal linkages. The application of these weights for the exploration of the importance of the long-term changes in weed populations for each animal group in focus was demonstrated. The data of three weed surveys of Finnish spring cereal fields, those conducted in 1961-1964, in 1982-1984 and in 1997-1999, were used for this purpose. The relative area of the herbicide-treated and organically cropped fields in each survey were involved in the calculations.

The literature review showed the relative importance of weed species to vary between animal groups. For farmland birds, annual weed species that are able to produce a high number of seeds (e.g. *Chenopodium album*, *Polygonum aviculare*) got high ranks. For pollinators, the most important weed species were insect pollinated plants (e.g. *Achillea* species, *Cirsium arvense* and *Sonchus arvensis*). In the case of phytophagous insects, the variation in the number of linkages between weed species was high. Furthermore, some weed species (e.g. *Elymus repens*, *Galium* species) that were not found important for other animal groups was found to be important for phytophagous insects. The number of pest species associated with weeds found in Finland remained low for all weed species. The most important weed species for the pests was *E. repens*.

The general pattern in the changes of the values of indices between decades was similar: a tremendous decline in the values between the 1960s and the 1980s, and a slight increase between the 1980s and the 1990s. The changes in the values of the index of farmland birds were more pronounced between decades compared to other indices, which was due to tremendous changes in the density of some important seed-food plants for farmland birds (e.g. *Chenopodium album*). The changes in the weed density and in the values of pest index followed the same trend as the values of indices of the animal groups.

The results showed all indices to react with tremendous decline in their values to the intensification of agriculture between the 1960s and the 1980s. In the 1990s, some positive changes in the cropping measures for biodiversity has occurred, e.g. increase in the area of organic farming. However, despite the benefits of organic cropping for the biodiversity its significance remained minor due to small acreage. Weed species were shown to differ in their importance to other organisms associated with farmland. Indicator based on these

differences proved to be applicable in the assessment of the long-term changes in weed populations, enabling the interpretation of the ecological importance of the changes.

What affects farmers in intensive arable areas to head for agrobiodiversity?

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Intensively used arable regions still have the lowest share of implemented agri-environmental measures or nature conservation contracts, though they have to deal with the most serious nature conservation and environmental problems. Due to high opportunity costs and deeper changes in the farm management these measures are refused relatively vigorously by the farmers. However, it has been detected, that measures requiring minor changes of the usual farm management are increasingly implemented also in intensively used arable regions.

To better specify and understand the characteristic factors of success and the obstacles for the implementation of agri-environmental measures in intensively used arable regions on single farm level a survey among 865 responding farmers was carried out, that was concentrated exclusively on the scenery of these intensively used arable regions. Aim of the survey was to analyse different factors regarding their impact on the decision of farmers to implement agri-environmental measures on arable land.

The following questions were stated:

- i. Which determining factors on single farm level irrespective of the design of the measures lead to the implementation of agri-environmental measures on arable land?
- ii. Is there an influence between the relation of the farmers with their subsidising institution and the implementation of agri-environmental measures on their farm?
- iii. Can preferences of the farmers towards certain subsidy systems be detected, that allow a conclusion about the optimal way of subsidising agri-environmental measures on arable land to enhance their implementation?

The survey revealed several promotional and inhibitory factors for the implementation of these measures concerning farm structure, socioeconomic data and personal features of the farm manager, the relation with the subsidising institution and the subsidy system.

Tested by logistic regression on single farm level the implementation of agri-environmental measures on arable land is significantly fostered by full-time farming, a high agricultural education level of the farm manager, his or her high willingness to carry a risk and a good relation with the subsidising institution. To the contrary the implementation of those measures is inhibited by dairy farming, elderly farm manager and a small degree of openness towards new and unusual management procedures. It has become apparent, that the most favoured subsidy system for agri-environmental measures on arable land is the well-known receiving of determined standardised subsidies per farm, followed by the grading of subsidies according to the quality of the soil. Due to the fear of more **bureaucracy** and a development towards dumping prices for nature conservation measures new and unfamiliar subsidy systems, like calls for tender, have been clearly refused by the farmers.

Rewarding Ecological Services of Agriculture – a Regional Approach in Germany

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In European countries agri-environmental schemes were introduced to reduce negative side effects of agriculture and to promote biodiversity. However, these schemes are often reviewed as ineffective because measures are not regional adjusted and incentives for farmers are scarce. People, not involved in the agricultural sector, argue whether subsidies are justified. Therefore concepts are needed to develop new schemes with a focus on achievements rather than a focus on measures.

Plants can be seen as elements of biodiversity and as well as indicators for biodiversity, since fauna benefits from plant diversity in several ways. An approach for a regional outcome-based system for rewarding ecological services of agriculture was developed by an interdisciplinary working group.

The concept is based on the principle of bid and ask. Via a tender procedure a set of ecological services is announced. These services are represented by different levels of species richness. Farmers are asked to fulfil these services on parts of their land. Farmers who are willing and able to participate have to describe the level of species richness they aim at. Additionally they have to mention the price to compensate for. A regional board as the steering committee of the concept defines details of the demand. By this way, local preferences and scarcity of diversity can be considered. Principles of market economy are introduced.

During 2004 and 2006 two experimental submissions were carried out for species richness in grassland in the rural district of Northeim (1200 km²). In 2007/2008 in the same region a submission is planned to reward weed species richness in arable fields.