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WEED FLORA OF CEREALS IN DIFFERENT FARMING SYSTEMS

ABSTRACT

Cereals are important crops all over the world. Cereals are grown on a quarter of cultivated land in Hungary. Cereals are competitive and thus they play a significant role in ecological farming. The most important species in the Hungarian ecological farms are winter wheat and spelt. Weed floras in ecological farming systems are different from those in conventional cropping systems. These differences are due to different cropping practices, including weed control and fertilization methods.

Our goal was to determine how farming systems affected the weed flora. a 2500 ha ecological farm and a neighbouring conventional farm in south-eastern Hungary were surveyed four times during the season in 2007 and 2008. Effects of farming systems were assessed for weed cover, number of species, and Shannon's diversity index.

The ecological farm showed higher weed-cover than conventional farm. The differences were rather high in the inner areas and on the margins, too. Farming systems same differed in values of number of species. More species were found in ecological farm. The Shannon diversity showed significant difference only in the inner areas. The diversity of margins were similar.

Key words: cereals, conventional farming, diversity, ecological farming, weed cover, weed flora

INTRODUCTION

Farming systems differ widely in terms of cropping practices. For example the use of pesticides and fertilizers is not allowed in some systems. Chemical inputs can be used in integrated and conventional systems but their use is forbidden in ecological farming.

In Hungary, ecological farming has been present since 1986. The primary aims of the ecological approach were to produce healthy food and to develop environmentally sustainable farming systems. By 2004, the total regulated area had increased to over 120.000 hectares and this value has been constant for the last five years. Cereals are important crops on ecological farms. Grasslands

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(52%) and cereals (21%) occupy the largest area. Fodder-crops (9%) industrial-crops (7%) grape and fruits (2%) and vegetables (1%) are also important (Biokontroll, 2009; Ökogarancia, 2009).

This particular structure of ecological farming in Hungary influences weed management which is different from other countries in the EU. In this case, a small group of weeds can be identified as main target species for weed management. Alien species can be reported from almost all countries and can be identified as an upcoming problem in ecological farming (Glemnitz *et al*. 2006).

The avoiding of pesticides and fertilizers can cause changing of weed flora. The effects of farming systems have already been surveyed in a sandy-soil area of Hungary (Dornerné *et al.*, 2003, Dorner, 2006). In these works, an ecological and a conventional farm were compared by discriminant analysis and significant differences were found only in the number of weed species at different times.

Lundkvist *et al.* (2008) compared two crop rotations in ecological farming. The results of their long term study showed no change in weed biomass at harvest nor in weed species diversity over 15 years. Over and above the the development of weed flora of the growing area can not be affected by farming system. Two ecological farms under different environmental conditions may generate contrasting results (Zalai *et al.* 2009).

Differences can be caused by many abiotic and biotic factors. The main abiotic factors are the climate and the soil. The climate determines which species can adapt to the local environment. Every species lays claim to optimal height above sea-level, orographic characters, solar radiation and temperature. *Veronica* and *Consolida* species germinate at low temperature while *Amaranthus* and *Chenopodium* species need high temperature for their germination (Otte, 1994). The soil type is important for other species. Viola arvensis is present typically on sandy soils and Sinapis arvense on loam or clay soils (Borhidi, 1995). Correlations between soil factors were observed in many cases. For example, weed species which prefer the arid habitat, also prefer sandy soils, and species which prefer wet habitat prefer clay soils (Holzner, 1991a, 1991b). Weed species have various nutrient requirements. There are species which prefer soils with low nitrogen content (e.g. Veronica praecox) (Borhidi, 1995) and there are nitrogen preferring species (e.g. *Amaranthus retroflexus, Chenopodium album, Galium aparine*) (Lehoczky, 2000). In many cases, these conditions are caused by cultivation.

The relative use of weed control methods has changed in the last decades. In the distant past, physical methods were mainly used. Since the 60's, the relative importance of chemical methods has increased in conventional farming. It was over 80 percent in 1994 in the USA (Forcella and Burnside, 1994). The high-level use of herbicides contributed to the development of herbicide resistance in many weed species (Mikulás, 2004).

In ecological farming, the cultural, mechanical, physical and biological meth-

ods all contribute to weed control. Crop rotation is a generally used part of technology. Rotating crops will change ecological conditions year after year, which will result in reducing the seed bank and weed biomass (Brainard *et al.*, 2008). Weed flora reacts besides using of herbicide on disturbance and the degree of tillage, too. Intensive cultivation as a herbicide free weed control could also affect the decreasing of number of species and diversity (Németh and Dorner, 2004).

Because of unique environmental conditions, farming systems can result in different effects. In this study, we compare systems on a clay-soil in areduced precipitation area of Hungary.

MATERIALS AND METHOD

This study was carried out at an ecological farm (Körös-Maros Biofarm Ltd) and at a neighbouring conventional farm in 2007 and 2008. Farms are located at the south-east of the Great Hungarian Plain (46°39' N, 21° 21' E). Clay-loam or clay soils and average annual 550 mm rainfall with an uneven distribution is typical of this area.

The weed management is based on crop-rotation and weed-harrowing at the ecological farm. The harrowing was done at the end of March in both survey years. Post-emergent herbicide-use was general at conventional farm.

Weed flora

Surveys were conducted in cereals and adjusted to the phenology of the crop plant. Surveys were made four times in 2007 (twice in April, once in May and June) and 2008 (once in March, April, May, June).

During the survey, the inner areas and the margins of fields were investigated. In this case, margins included the area within 2m from the border of the field. In the inner field areas, 88 and 28 samples were surveyed in the ecological and conventional systems, respectively. In the margins, 44 and 14 samples were examined in the ecological and conventional systems, respectively. Each sample consisted of a random area of a 1 m2 square.

The average weed cover and the average number of species were used as our main research parameters. During our weed surveys, we applied the method based on the evaluation of cover percentage (Németh and Sárfalvi, 1998). Weed species were classed into the following life cycle categories: winter annuals, summer annuals, biennials, stationary perennials and creeping perennials (Hakansson, 2003).

Diversity

To complete the comparison between the weed covers and number of species, we used a diversity index which takes into account species richness and abundance. a modified Shannon diversity index was used in our analysis which is based on the number of species and on the relative frequencyof species (Fig. 1).

$$H = -\sum_{i=1}^{S} Pi \log Pi$$

Fig. 1: Shannon diversity index, S – number of species, Pi – relative presence of species

Statistical analysis

The normality of samples was analysed using the Kolmogorov-Smirnov test. In the case of normal distribution, the comparison was made by two samples T test and the equality of variances was analysed by Levene's test. All statistical analyses were made at the 95% confidence level, using the SPSS program package (SPSS Inc.). Two samples T test were used only for species richness and diversity indices from both in the inner areas and field margins.

RESULTS AND DISCUSSION

Weed-cover in the inner field areas

In the conventional fields, two perennial species (*Cirsium arvense*, *Convolvulus arvensis*) had high presence. Annual species were dominant. The most important of these was the winter annuals *Papaver rhoeas*, *Veronica hederifolia* and *V. persica* and the summer annuals *Polygonum lapathifolium* and *Tripleurospermum inodorum*.

At the ecological farm, the role of perennial species was less important. The presence of the perennials (*Cirsium arvense* and *Convolvulus arvensis*) was similar in both of farming systems but the total weed cover was higher in ecological farming. The annuals had a higher importance. The most frequent species were the winter annuals *Adonis aestivalis*, *Viola arvensis* and *Galium aparine* and the summer annual *Tripleurospermum inodorum* and *Ambrosia artemisiifolia*.

In the inner field areas, the weed cover was variable between survey times. It was much higher at the ecological farming fields than in the conventional farm. The average weed cover was 5.91(±0.54) % in the ecological farm and 1.14(±0.28) % in the conventional. Owing to the want of normal distribution of samples ($P_{normality}$=0.010, 0.027) difference between farming systems is presen-

ted on box-plot (Fig. 2a).

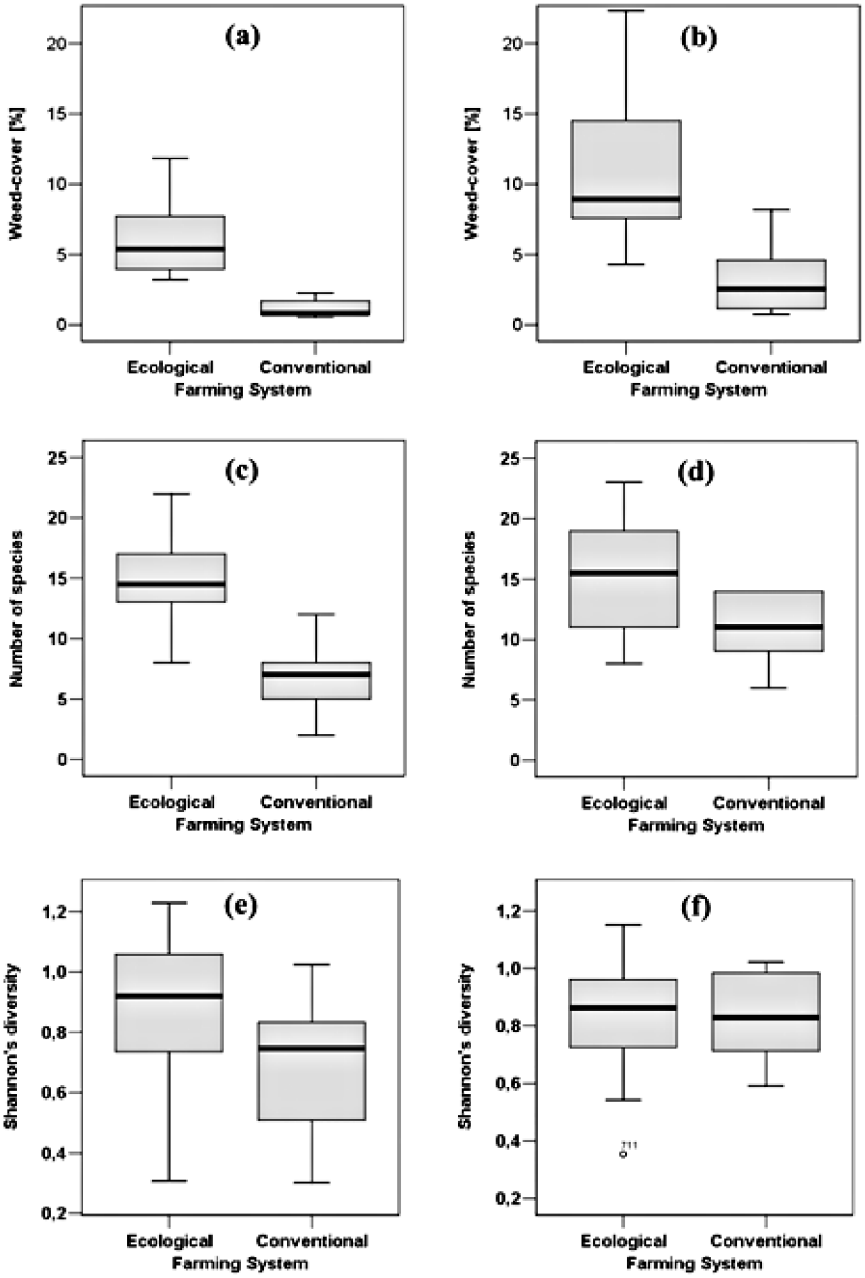

Fig. 2. Average values of all samplings. (a) Weed cover in inner areas. (b) Weed cover on margins. (c) Number of species in inner areas. (d) Number of species on the margins. (e) Shannon's diversity in the inner areas. (f) Shannon's diversity on the margins

Weed cover in field margins

The cover was higher in both of farming systems on the margins than in inner areas. In conventional farming, the perennial species had a higher presence than in inner areas. The most important species were not only creeping perennials (*Cirsium arvense*, *Elymus repens* and *Rubus caesius*) but also stationary perennials (*Cichorium intybus* and *Artemisia vulgaris*). The most important annual species were different on margins than in inner areas. The presence of winter annuals was lower and summer annuals became frequent. These winter annuals were *Lamium* and *Veronica species* and *Galium aparine* and the summer annuals were *Chenopodium* species *Ambrosia artemisiifolia* and *Urtica urens*.

The margins of ecological fields also had high cover values. The characteristic perennial species were not different from those in inner areas, including *Cirsium arvense* and *Convolvulus arvensis* as well as the presence of *Rubus caesius*. The importance of perennials was higher. The winter annual *Lamium*, *Veronica* and *Consolida* species (mainly *C. regalis*) and summer annual *Ambrosia artemisiifolia*, *Chenopodium album* and *Tripleurospermum inodorum* and some biennial species (*Conium maculatum*, *Daucus carota*) were also present.

The average weed cover was 11.06(±1.20) % for ecological systems and 3.29(±0.12) % for the conventional system. Only one distribution was normal ($P_{normality}$=0.003, >0.200). Differences between farming systems are presented in box-plots (Fig. 2b).

Number of species in inner field areas

The number of species was higher in the inner areas in ecological fields than at the conventional farm. In spite of the high cover of perennials, there were few species present in conventional quadrats. All of the perennials were creeping species. The importance of annuals changed over time. The winter annuals were important only at the spring survey times and the summer annuals became dominant until the harvest of cereals.

In ecological farming, the annual species were dominant during surveys. Winter annuals remained important until harvest. More winter annual and less summer annual species were present. The distribution of perennials was same different from conventional samples. At ecological fields, stationary species were present in low numbers, in addition to creeping perennials.

The average numbers are 15.30(±0.93) in ecological samples and 6.50(±1.41) in conventional samples (Fig. 2c). Both of distributions are normal ($P_{normality}$>0.200). The two samples T test with assumed equal variances (P=0.417) shows the difference of samples is statistical significant (P<0.001).

Number of species in field margins

On the margins, more species were present on average in both farms. The difference was higher on the conventional fields. Here more other perennials could be found over *Convolvulus arvensis* and *Cirsium arvense*. The total number of perennials was higher on the margins than inside of fields. The most important annuals were *Lamium, Veronica* and *Chenopodium species, Galium aparine*, *Ambrosia artemisiifolia* and *Urtica urens*.

On the ecological farming margins the role of perennials was higher and more species were present. The annuals were more variable. Lots of species were present with low significance. Only *Tripleurospermum inodorum* was found at every survey time.

On average 15.70(±1.03) species were present in ecological samples and 10.50(±1.31) in conventional samples (Fig. 2d). Both of distributions are normal ($P_{normality}$=0.176, >0.200). The two samples T test with assumed equal variances (P=0.106) shows the difference of samples is statistical significant (P=0.035).

Diversity in the inner field areas

The diversity indices for inner field areas were slightly higher in ecological fields. These higher values are affected by the higher number of weed species and by the higher total weed cover. The difference between diversity values is not as considerable as that between either weed cover or number of species.

The Shannon's diversity index values are 0.902((0.052) at ecological fields and 0.723((0,101) at conventional fields on average (Fig. 2e). Both of distributions are normal (Pnormality=0.198, >0.200). The two samples T test with assumed equal variances (P=0.623) gives statistical significant difference between samples (P=0.048).

Diversity in field margins

The diversity index values are similar in both farms. The averages are 0.830(±0.047) and 0.833(±0.064) in ecological and conventional samples (Fig. 2f). Both distributions are normal ($P_{normality}$>0.200). The two samples T test with assumed equal variances (P=0.637) does not show statistical difference between the samples (P=0.969). Differences between the values of weed cover and average number of species of different farming systems are not reflected in diversity values. The low diversity values are caused by the relative high frequency of the most cover species in ecological farming.

On the whole the weed flora of ecological farming was more variable than

the flora of conventional fields. More weed species including some rare species such as *Myagrum perfoliatum, Erysimum repandrum* or *Brassica rapa*, were found in the ecological farm,. Overall, the differences in life cycle categories were higher between inner areas and margins in conventional fields than in ecological fields (Table 1).

Table 1

Distribution of life cycle categories

Life cycle categories*	In the inner areas				On the margins			
	Ecological farming		Conventional farming		Ecological farming		Conventional farming	
	Cover [%]	Percent of total	Cover [%]	Percent of total	Cover [%]	Percent of total	Cover [%]	Percent of total
WA	3.23	54.66	0.42	36.84	5.33	48.28	1.48	44.98
SA	1.46	24.70	0.14	12.28	2.67	24.14	0.57	17.33
CP	0.73	12.35	0.58	50.88	1.73	15.64	0.68	20.67
SP	0.45	7.61	0.00	0.00	0.87	7.87	0.41	12.46
B	0.04	0.68	0.00	0.00	0.45	4.07	0.15	4.56
Total	5.91	100	1.14	100	11.06	100	3.29	100

CONCLUSIONS

Differences were observed between farming systems. The differences between weed cover were high but they could not be verified by statistical test. For both the inner field areas and margins, the differences in species richness between farming systems were high and statistically significant. The diversity index was only different only for the inner field areas .

In the margins, both the average weed cover and the average number of species were higher at ecological fields but the two samples T test did not show differences between farms in case of diversity on margins. Reason can be the considerable presence of most cover species.

In the margins perennial species were more important. These species could spread from the non-cultivated borders and could be present with higher cover.

In ecological samples, species from all of life cycles categories were found in both the inner areas and in the margins. In conventional fields, only winter and summer annuals and creeping perennials were present in the inner areas (Table 1).

Our results differ from the results of Dorner (2006) and Lundkvist *et al*. (2008). In the present study, more differences in the weed flora and the diversity were found between the ecological and the conventional farms. These results

suggest that effects of farming systems will be variable according to environmental conditions.

REFERENCES

Biokontroll (2009): Annual Report of the activities of Biokontroll-Hungária-Nonprofit Ltd in 2008. p.1-9.

Borhidi, A. (1995): Social behaviour types, the naturalness and relative ecological indicator values of the higher plants in the Hungarian flora. Acta Boc. Sci. Hug. 39:97-181.

Brainard, D.C., Bellinder, R.R., Hahn, R.R., Shah, D.A. (2008): Crop rotation, cover crop, and weed management effects on weed seedbanks and yields in snap bean, sweet corn and cabbage. Weed Science, 56:434-441.

Dorner, Z. (2006): Analysis of weed flora of ecological farming system at the Ecological Model Farm of Kishantos, PhD thesis. Crop Science PhD School, Gödöllő

Dornerné Fejős, Z., Arnold, Cs., Németh, I. (2003): Weed survey on the area of the ecological plot farm at Kishantos. Növényvédelem, 39: 25-32.

Forcella, F., Burnside, O.C. (1994): Pest Management-Weeds. In Hatfield, J.L., Karlen, D.L. (eds.), Sustainable Agriculture Systems. Lewis Publishers, London, p.157-198.

Glemnitz, M., Radics, L., Mackensen, K. (2006): Status quo of weed management in organic farming in the new EU members states and the acceding countries, Journal of Plant Diseases and Protection, Sp.Iss. 20: 627-634.

Hakansson, S. (2003): Weeds and Weed Management on Arable Land. An Ecological Approach (first ed), CABI Publishing, Oxon. p.7-12.

Holzner, W. (1991a): Unkraut-Typen. Eine Einteilung der Ruderal- und Segetalpflanzen nach komplexen biologisch-ökologischen Kriterien. I. Die ein- und zweijährigen Arten. Die Bodenkultur, 42:1-20.

Holzner, W. (1991b): Unkraut-Typen. Eine Einteilung der Ruderal- und Segetalpflanzen nach komplexen biologisch-ökologischen Kriterien. II. Die ausdauernden, dominanten Arten. Die Bodenkultur, 42:135-146.

Lehoczky, É. (2000): a gyomnövények tápanyagfelvétele és tápelemtartalma. In: Hunyadi K., Béres I., Kazinczi G. (szerk.): Gyomnövények, gyomirtás, gyombiológia. Mezőgazda kiadó, Budapest. p.321-333.

Lundkvist, A., Salomonsson, L., Karlsson, L., Gustavssone, A.M.D. (2008): Effects of organic farming on weed flora composition in a long term perspective. European Journal of Agronomy, 28: 570-578.

Mikulás, J. (2004): Weeds and weed control of vineyard, Növényvédelem, 40: 343-357.

Németh, I., Dorner, Z. (2004): Intensive cultivation causes change in the weed flora. Növénytermelés, 53:405-414.

Németh, I., Sárfalvi, B. (1998): Comparative studies on methodology of weed surveys. Növényvédelem. 34:15-21.

Ökogarancia (2009): Annual Report of the controlling and certification activities of Hungária-Öko-Garancia Ltd in 2008. p.1-8.

Otte, A. (1994): Die Temperaturansprüche von Ackerwildkräutern bei der Keimung – auch eine Ursache für den Wandel im Artenspektrum auf Äckern. Aus Liebe zur Natur, 5:103-122.

Zalai, M., Juhász, L.T., Raboczki, É., Dorner, Z. (2009): Differences between ecological farms in weed flora and diversity in Hungary, Herbologia, 10: 49-58.