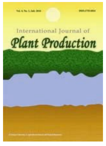

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Structure of weed communities occurring in crop rotation and monoculture of cereals

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Abstract

A strict field experiment with crops sown in crop rotation and monoculture was carried out in the years 1988-2012 at the Experimental Station Uhrusk belonging to the University of Life Sciences in Lublin, south-eastern Poland. The study was aimed at evaluating the structure of weed communities occurring in crop rotation and monoculture of cereals. The highest weed density m^{-2} was determined in the second (1992-1996) and the third crop rotation (1997-2000), whereas the highest weight of weeds was noted in the third crop rotation. Weed community in cereals sown in crop rotation and monoculture was constituted by species belonging to 6 syntaxonomic classes: *Stellarietea mediae*, *Artemisietea vulgaris*, *Molinio-Arrhenatheretea*, *Agropyretea intermedio-repentis*, *Koelerio glaucae-Corynephoretea canescentis* and *Bidentetea tripartiti*.

Keywords: Weeds; Syntaxonomic class; Crop rotation; Monoculture; Cereals.

Introduction

Segetal weeds are permanent elements of stands of field crops. Their significance in phytocenoses of farmlands is diversified, but most frequently consists in competing with field crops for nutrients, water, light and other factors, which usually decreases their yielding (Mahmoodi et al., 2009; Woźniak and Soroka, 2014a). In the well-designed crop rotation, weeds are inferior to field crops, but in the monoculture they pose severe risk to the latter (Struik and Bonciarelli, 1997). A solution to this problem might be herbicides, however as reported by Deike et al. (2008) – their efficacy depends on many agrotechnical and habitat factors. In general, better effects of weed control are achieved in crop rotation than in monoculture. According to Chauhan et al. (2012), crop cultivation in monoculture leads to discrimination of a few prevailing species that are difficult to remove. As reported by Soroka (2008), certain agrotechnical and habitat conditions cause the development of characteristic communities of segetal weeds, different for cultivated cereals in crop rotation with leguminous plants and different in the monoculture. This study was aimed at evaluating the structure of weed communities occurring in crop rotation and long-term monoculture of cereals.

Material and Methods

Localization, experiment design and soil conditions

A strict field experiment was conducted in the years 1988-2012 at the Experimental Station Uhrusk (51° 18' 11" N, 23° 36' 50" E) belonging to the University of Life Sciences in Lublin, south-eastern Poland. The experiment was established with the method of randomized blocks (7.5 m × 25 m in size) in 4 replications, at which cereals were cultivated in two systems: (1) crop rotation and (2) monoculture, accordingly to the scheme presented in Table 1. The soil the experiment was established on was Rendzic Phaeozem (IUSS Working Group WRB, 2006) with the composition of poorly sandy light clay. The content of available forms of phosphorus in soil is 127 mg P kg^{-1}, that of potassium is 163 mg K kg^{-1} and pH value of soil is slightly alkaline (pH_{KCl}=7.2). The content of total N in the soil is 1.01 g kg^{-1}, whereas that of organic C is 6.30 g kg^{-1}.

Table 1. Scheme of crop succession in the experiment.

Study years	Rotation	Crop succession in crop rotation	Monoculture
1988-1992	1	Potato – winter triticale – pea – winter triticale	Winter triticale
1992-1996	2	Potato – winter triticale – pea – winter triticale	Winter triticale
1997-2000	3	Potato – spring triticale – pea – spring triticale	Spring triticale
2000-2004	4	Potato – winter wheat – pea – winter wheat	Winter wheat
2005-2008	5	Pea – spring wheat – pea – spring wheat	Spring wheat
2009-2012	6	Pea – spring wheat – pea – spring wheat	Spring wheat

Cropping systems, fertilization, sowing and field crops

In both cropping systems, ploughing tillage was applied to all crops. In the case of winter triticale and winter wheat, shallow ploughing and harrowing were applied after the harvest of the previous crop and pre-sow ploughing was applied 10-14 days before sowing. In the case of spring triticale and spring wheat, first shallow ploughing and harrowing were applied and then pre-winter ploughing in the autumn. In the spring, before sowing spring cereals, a tillage was applied that included a cultivator, a string roller and a harrow. The following doses of fertilizers were used in the experiment: (a) in winter triticale: 90 kg N ha^{-1}, 40 kg P ha^{-1} and 116 kg K ha^{-1}; (b) in winter wheat: 90 kg N ha^{-1}, 35 kg P ha^{-1} and 99 kg K ha^{-1}; (c) in spring triticale: 80 kg N ha^{-1}, 30 kg P ha^{-1} and 83 kg K ha^{-1}; (d) and in spring wheat: 80 kg N ha^{-1}, 30 kg P ha^{-1} and 83 kg K ha^{-1}. Each year of the study, winter triticale (Presto cv.) and winter wheat (Korweta cv.) were sown between 25th-30th September, whereas spring triticale (Migo cv.) and spring wheat (Koksa cv.) – between 5th-10th April. Sowing density reached 400 grains m^{-2} for winter triticale, 450 grains m^{-2} for winter wheat and 550 grains m^{-2} for spring triticale and spring wheat. Weed control consisted in the harrowing of crops. For winter triticale and winter wheat this treatment was performed in the springtime in April at the stage of cereals tillering (23/24 in Zadoks scale) (Zadoks et al., 1974), whereas for spring triticale and spring wheat – at the beginning of May (22/23 in Zadoks scale).

Traits and statistical analysis

In each year of the study, the following traits were evaluated on all plots: 1) species composition of weeds, 2) number of weeds m^{-2}, 3) air-dry weight of weeds g m^{-2}, 4) syntaxonomic units of weed communities, 5) coefficients of similarity of weed communities: (a) Sørensen's (S), (b) Jaccard's (K_J) and (c) Bray-Curtis' (K_B). The species composition, the number of weeds and their air-dry weight were determined with the botanical-gravimetric method at the 75th stage in Zadoks scale from the area of m^2 of each plot, that was selected two times, at random, using a frame 1.0 m × 0.5 m in size. All weeds were collected from the determined areas, transferred to a dry room and kept therein until they reached 15% moisture content, then their air-dry weight was measured (Woźniak and Soroka, 2014b).

The syntaxonomic evaluation of weed communities was carried out according to the method of Braun-Blanquet (1964). The quantity of weeds was determined in a scale of 5 to 1 and with symbols: (+) and (r), where: 5 – free number of specimens, ground coverage >75%; 4 – free number of specimens, coverage 50-75%; 3 – free number of specimens, coverage 25-50%; 2 – high number of specimens, coverage 5-25%; 1 – higher number of specimens (from 5 to 50), ground coverage 1-5%; (+) – low number of specimens (from 2 to 5), coverage <1%; and (r) – 1-3 specimens with a small range. The following scale was applied to evaluate the constancy degree of weeds occurrence: V (80-100%), IV (60-80%), III (40-60%), II (20-40%) and I (<20%). Names of plant species were provided according to Flora Europaea (Tutin et al., 1964-1980). Names and structure of syntaxons were adopted after Matuszkiewicz (2001) and Soroka (2008).

In order to compare weed communities in crop rotation and monoculture, use was made of the following coefficients of similarity between samples:

(a) Sørensen's (S)

$S = \frac{2C}{A+B}$, where: A – number of species in sample A; B – number of species in sample B; C – number of species common for both samples.

(b) Jaccard's (K_J)

$K_J = \frac{c}{a+b-c}$, where: a – number of species in sample a; b – number of species in sample b; c – number of common species in both samples.

(c) Bray-Curtis' (K_B)

$K_B = \frac{a+b-c}{a+b}$, where: a – number of species in sample a; b – number of species in sample b; c – number of common species in both samples.

The data were analyzed statistically using the analysis of variance (ANOVA) and the means were compared with F-test protected LSD values calculated for $P<0.05$.

Weather conditions

The course of weather conditions was provided based on data originating from Agrometeorological Station of the Experimental Station in Uhrusk (Table 2). In the experimental period, the sums of annual precipitation varied. The lowest precipitation (from 400 to 500 mm) occurred in the years 1989, 1991, 1993 and 2012, whereas the highest (>700 mm) in the years 1997, 2001, 2007, 2009 and 2010. When evaluating precipitation distribution in years, it may be concluded that the greatest rainfalls occurred in the following months: May – 64 mm (on average), June – 71 mm, July – 86 mm and August – 75 mm. The warmest months turned out to be: June (average monthly air temperature: 16.4 °C), July (18.4 °C) and August (17.6 °C), whereas the coldest months included: December (-1.8 °C), January (-4.0 °C) and February (-2.8 °C).

Table 2. Distribution of atmospheric precipitation in study years.

Precipitation (mm)	Years
400-500	1989, 1991, 1993, 2012
501-600	1990, 1992, 1994, 1995, 1996, 2003, 2004, 2005, 2008, 2011
601-700	1998, 1999, 2000, 2002, 2006
701-800	1997, 2001, 2007, 2010
> 800	2009

Results and Discussion

Number and air-dry weight of weeds

Irrespective of the cropping system, the highest number of weeds occurred in the second and the third rotation, were significantly lower number of weeds – in the first, the fifth and the sixth rotation. In turn, when comparing the cropping systems, a considerably higher number of weeds m^{-2} was found in the cereal monoculture than in crop rotation, especially in the second and the third rotation (Table 3). Also the air-dry weight of weeds was significantly higher in monoculture than in crop rotation, but the greatest differences between plots occurred in the third rotation. It may be speculated that it was due to the accumulation of weed seeds in the soil – the main source of crop infestation with weeds (Swanton et al., 2000; Tørresen and Skuterud, 2002). Similar conclusions were formulated by Struik and

Bonciarelli (1997) and Woźniak (2007a), who demonstrated significantly greater seedbanks in cereal monoculture than in crop rotation. Also the study by Woźniak (2007b) showed a significantly higher number of weeds in monoculture than in crop rotation of wheat, which resulted from a low contribution of wheat crop in the monoculture caused by reduced competitiveness of cereals to weeds.

Table 3. Number and air-dry weight of weeds in cereal crop.

Cropping systems (CS)	Years (Y) / Crops						Mean
	1988-1992 / Winter triticale	1992-1996 / Winter triticale	1997-2000 / Spring triticale	2000-2004 / Winter wheat	2005-2008 / Spring wheat	2009-2012/ Spring wheat	
	Rotation						
	1	2	3	4	5	6	
Number of weeds m^{-2}							
Crop rotation	16.2	33.1	21.5	25.0	16.5	21.5	22.3
Monoculture	18.9	48.8	49.9	30.9	26.9	19.3	32.5
Mean	17.6	41.0	35.7	28.0	21.7	20.4	-
$LSD_{0.05}$ for CS = 6.1, Y = 9.7, CS × Y = 12.1							
Air-dry weight of weeds g m^{-2}							
Crop rotation	15.8	17.1	39.5	20.2	11.8	16.8	20.2
Monoculture	19.5	20.4	54.1	25.3	16.1	16.5	25.3
Mean	17.7	18.8	46.8	22.8	14.0	16.7	-
$LSD_{0.05}$ for CS = 4.5, Y = 7.6, CS × Y = 10.3							

Species composition of weeds

Crop succession and study years were found to affect both the number of weed species and the species composition of weeds (Table 4). In the first rotation of crop succession, 25 species of weeds occurred in triticale, whereas in the monoculture the number of weed species reached 30. In the crop rotation, the most abundant were: *Stellaria media* (L.) Vill., *Galium aparine* L., *Viola arvensis* Murr. and *Fallopia convolvulus* (L.) A. Löve, whereas in the monoculture: *Elymus repens* (L.) Gould, *Apera spica-venti* (L.) P.B., *Stellaria media* and *Viola arvensis* (Figure 1). In the second rotation, 26 species occurred in crop rotation and 25 in monoculture. In the crop rotation, the predominating species included:

Chenopodium album L., *Galium aparine*, *Stellaria media* and *Fallopia convolvulus*, whereas in the monoculture: *Apera spica-venti*, *Stellaria media*, *Consolida regalis* Gray. and *Viola arvensis* (Figure 2). In the third rotation winter triticale was replaced by spring triticale, which led to a reduction in weed species number to 8 in crop rotation and to 12 in monoculture. In spring triticale grown in crop rotation, the most abundant species included: *Sonchus asper* (L.) Hill., *Chenopodium album*, *Veronica persica* Poir. and *Echinochloa crus-galli* (L.) P.B, whereas in the monoculture: *Consolida regalis*, *Amaranthus retroflexus* L., *Avena fatua* L., *Galium aparine* and *Stellaria media* (Figure 3). In the fourth rotation, winter wheat was sown instead of spring triticale. Then, 19 weeds species were identified in crop rotation and 23 in monoculture. In the crop rotation, the most frequently occurring species were: *Chenopodium album*, *Galium aparine*, *Fallopia convolvulus* and *Veronica persica*, whereas in monoculture: *Consolida regalis*, *Stellaria media*, *Galium aparine* and *Papaver rhoeas* (Figure 4). In the fifth rotation, winter wheat was replaced by spring wheat and the number of weeds species in crop rotation and monoculture accounted for 30 and 27, respectively. In crop rotation, the predominating species included: *Avena fatua*, *Stellaria media, Amaranthus retroflexus* and *Galium aparine,* whereas in monoculture *Stellaria media*, *Avena fatua*, *Fallopia convolvulus* and *Papaver rhoeas* (Figure 5). In the sixth rotation, the number of weeds species decreased to 11 in crop rotation and to 23 in monoculture. In crop rotation, the most abundant were: *Avena fatua*, *Amaranthus retroflexus*, *Euphorbia helioscopia* L. and *Capsella bursa-pastoris* (L.) Medicus, whereas in monoculture: *Avena fatua*, *Amaranthus retroflexus*, *Veronica persica* and *Solanum nigrum* L. (Figure 6). Also in studies by Struik and Bonciarelli (1997) and Woźniak (2007b), a higher number of weed species was observed in monoculture than in crop rotation of cereals. Noteworthy are varying quantitative ratios of predominating weed species in particular rotations (study years). For instance, in the monoculture of winter triticale (second rotation), over 25% of the weed community was represented by *Apera spica-venti*, but in the successive rotation when winter triticale was replaced by spring triticale (third rotation), this weed species did not occur at all. This may indicate that the change in the cultivable form of cereal from winter into spring may inhibit or even eliminate the predominance of some weed species. A different example is *Avena fatua*, which was abundant in spring cereals and did not occur in winter cereals. According to Vanasse and Leroux (2000) and Woźniak (2007a), the species composition of weeds in the field reflects, to a large extent, diaspores deposited in the soil.

Table 4. Number of weeds species in crop rotation and monoculture.

Years / Crops	Rotation	Cropping systems	
		crop rotation	monoculture
1988-1992 / Winter triticale	1	25	30
1992-1996 / Winter triticale	2	26	25
1997-2000 / Spring triticale	3	8	12
2000-2004 / Winter wheat	4	19	23
2005-2008 / Spring wheat	5	30	27
2009-2012 / Spring wheat	6	11	23

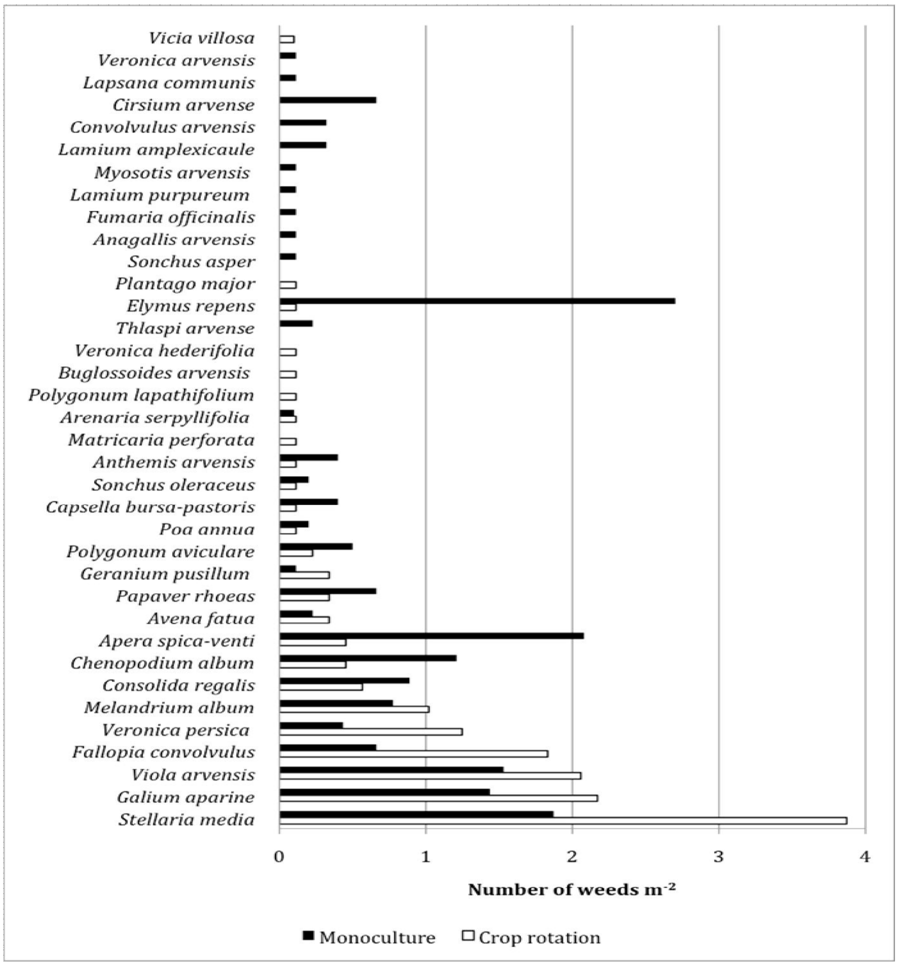

Figure 1. Species composition of weeds in winter triticale crop in the first rotation (1988-1992).

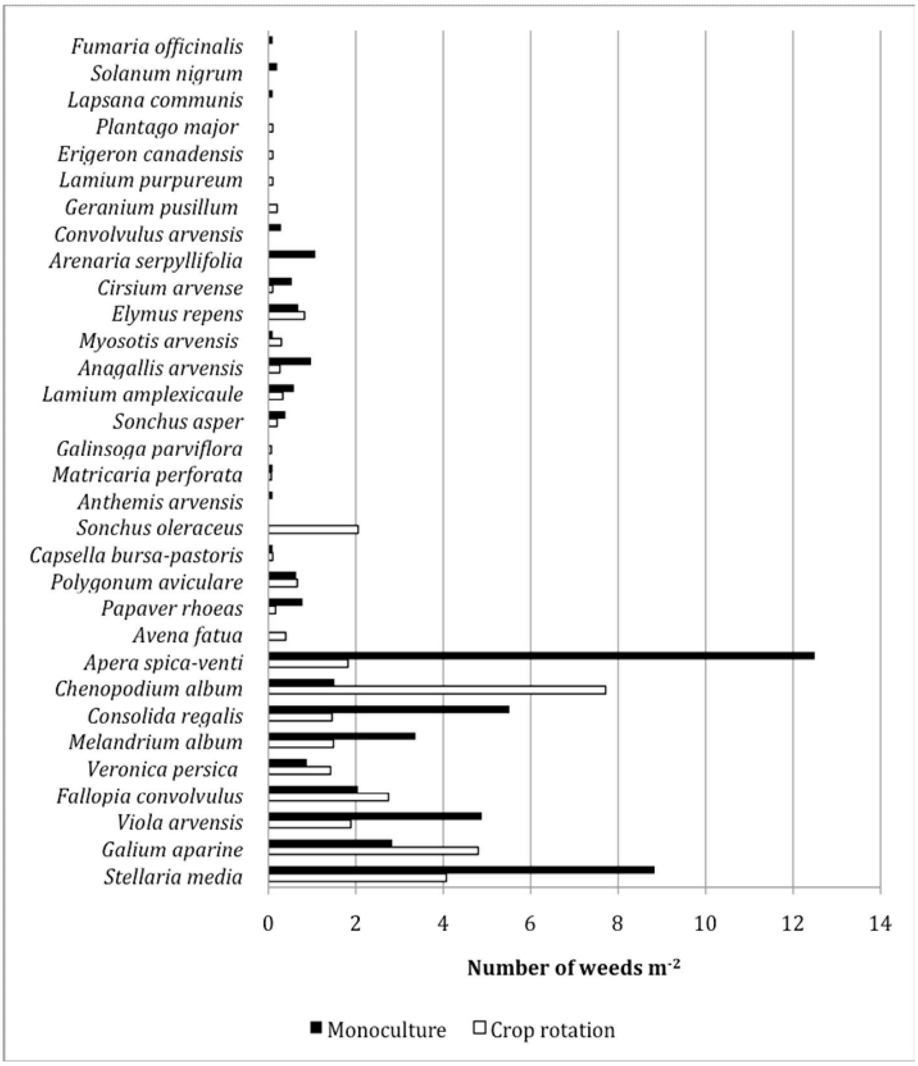

Figure 2. Species composition of weeds in winter triticale crop in the second rotation (1992-1996).

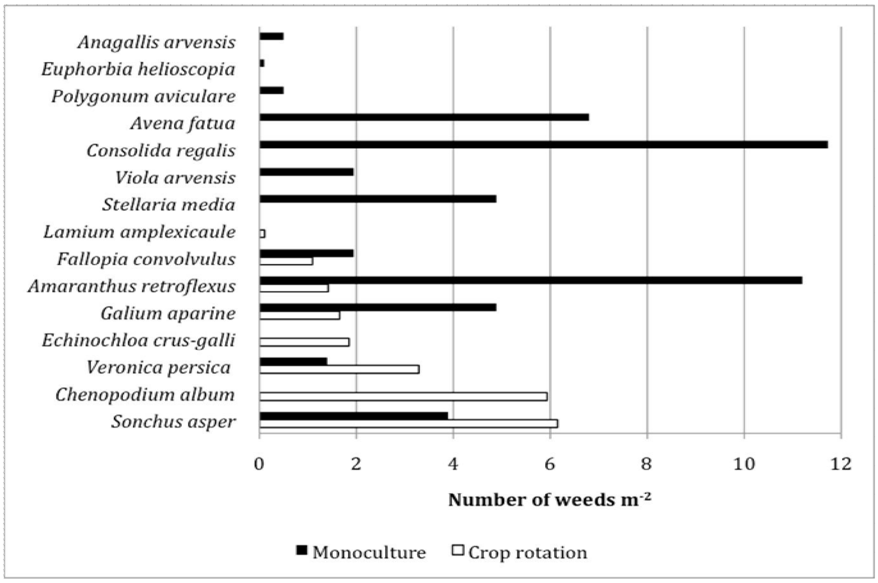

Figure 3. Species composition of weeds in spring triticale crop in the third rotation (1997-2000).

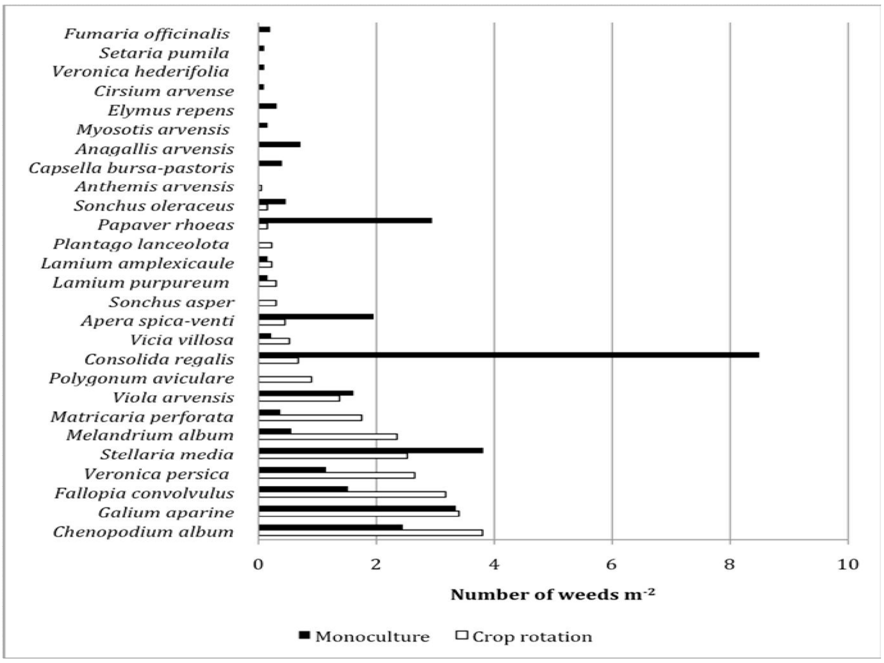

Figure 4. Species composition of weeds in winter wheat crop in the fourth rotation (2000-2004).

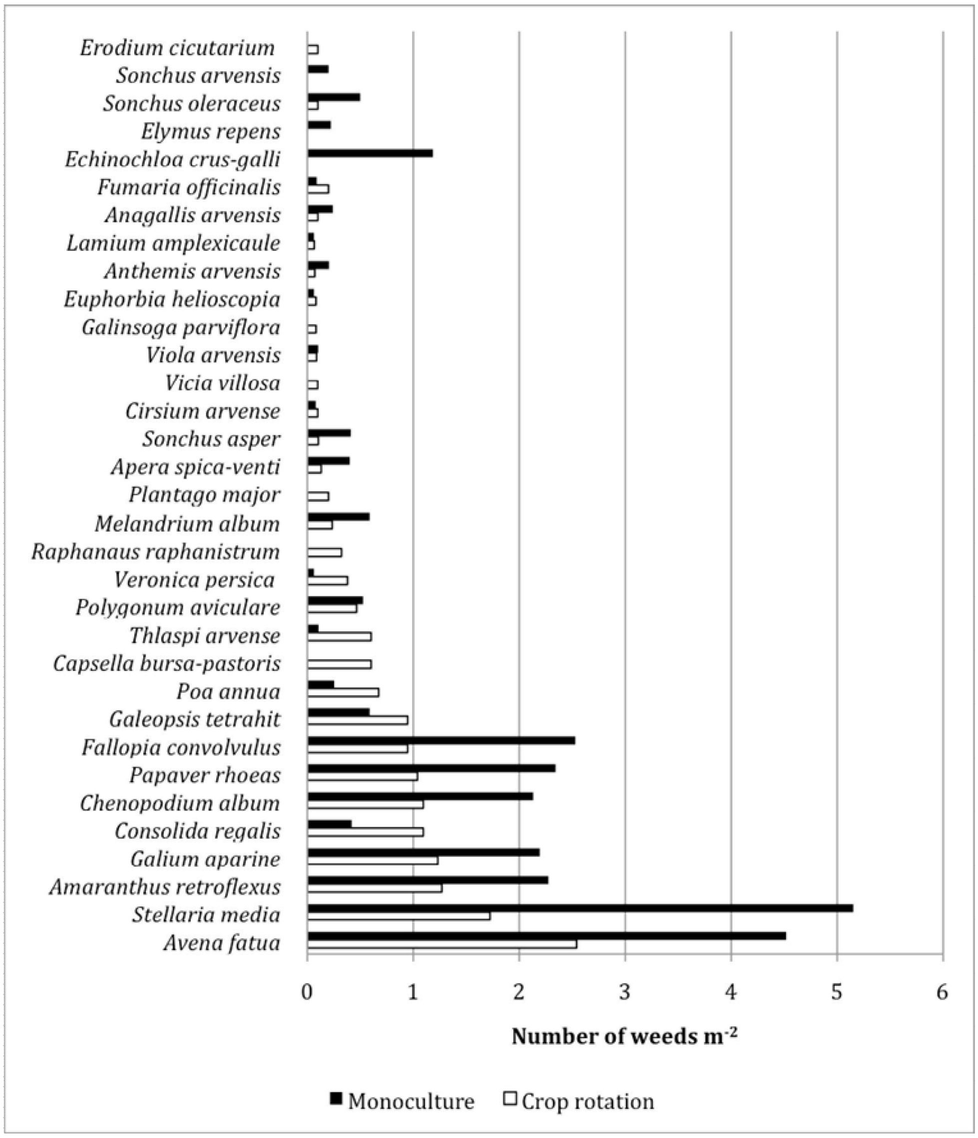

Figure 5. Species composition of weeds in spring wheat crop in the fifth rotation (2005-2008).

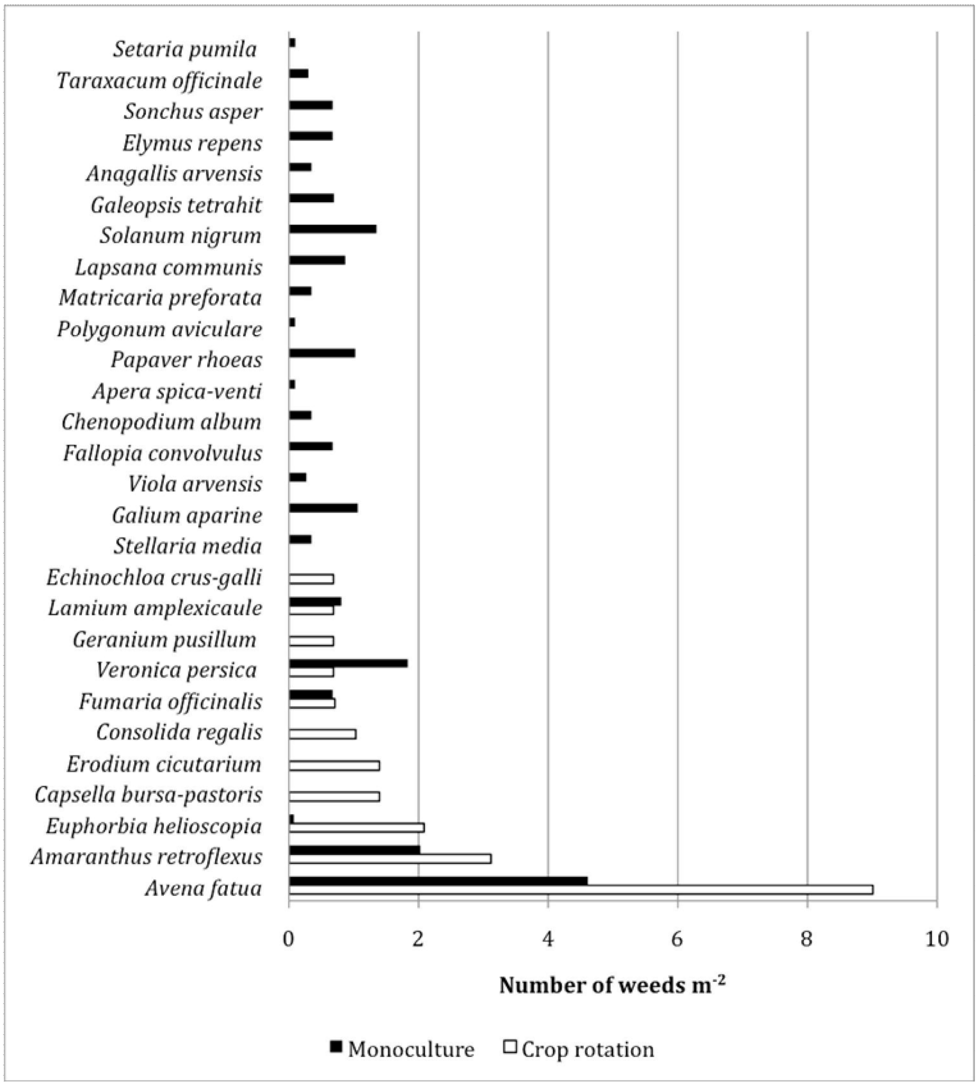

Figure 6. Species composition of weeds in spring wheat crop in the sixth rotation (2009-2012).

Syntaxonomic evaluation of weed communities

In the community of weeds occurring in cereals that were sown in crop rotation and monoculture, analyses enabled identifying species representing the following classes: *Stellarietea mediae* (Table 5) and *Artemisietea vulgaris*, *Molinio-Arrhenatheretea*, *Agropyretea intermedio-repentis*, *Koelerio glaucae-Corynephoretea canescentis* and *Bidentetea tripartiti* (Table 6). In the class *Stellarietea mediae,* the most abundant weed species in winter triticale sown in crop rotation (first and second rotation) included: *Apera spica-venti*, *Fallopia convolvulus*, *Stellaria media*, *Viola arvensis,* as well as *Veronica persica*, *Chenopodium album* and *Sonchus oleraceus* L., whereas in monoculture: *Apera spica-venti, Stellaria media*, *Viola arvensis*, *Chenopodium album*, *Consolida regalis*, *Fallopia convolvulus* and *Papaver rhoeas*. In the third rotation, the greatest abundance in spring triticale sown in crop rotation was noted for: *Sonchus asper* (L.) Hill., *Chenopodium album*, *Echinochloa crus-galli*, *Fallopia convolvulus* and *Veronica persica* , whereas in monoculture for: *Stellaria media*, *Consolida regalis*, *Avena fatua* i *Sonchus asper*. The in fourth rotation of crop succession, in winter wheat the prevailing species included: *Fallopia convolvulus*, *Stellaria media*, *Viola arvensis*, *Matricaria perforata* Mérat, *Chenopodium album* and *Veronica persica*, whereas in monoculture: *Consolida regalis*, *Apera spica-venti*, *Papaver rhoeas*, *Stellaria media* and *Chenopodium album*. In the fifth and sixth rotation of crop succession, the greatest abundance was found for: *Avena fatua*, *Consolida regalis*, *Capsella bursa-pastoris*, *Euphorbia helioscopia*, *Fumaria officinalis* L., *Lamium amplexicaule* L. and *Veronica persica*, whereas in monoculture for: *Papaver rhoeas*, *Avena fatua*, *Fallopia convolvulus*, *Stellaria media*, *Chenopodium album* and *Veronica persica*. In the class *Artemisietea vulgaris,* the greatest abundance in crop rotation and monoculture was determined for *Galium aparine* and *Melandrium album* (Mill.) Garcke. In the other syntaxonomic classes, the weeds were characterized by low degrees of cover abundance.

Table 5. Communities of weeds from the class *Stellarietea mediae* in cereals.

Cropping system	Crop rotation							Monoculture						
Years	1988-1992	1992-1996	1997-2000	2000-2004	2005-2008	2009-2012	Constancy degree	1988-1992	1992-1996	1997-2000	2000-2004	2005-2008	2009-2012	Constancy degree
Crops	Winter triticale		Spring triticale	Winter wheat	Spring wheat			Winter triticale		Spring triticale	Winter wheat	Spring wheat		
Rotation	1	2	3	4	5	6		1	2	3	4	5	6	
Ch.sp. Ass. *Apero spica-venti-Papaveretum rhoeadis*														
Anagallis arvensis	-	+	-	-	r	-	II	+	+	+	+	+	+	V
Apera spica-venti	1	2	-	+	+	-	IV	2	3	-	2	-	+	IV
Papaver rhoeas	+	+	-	+	2	-	IV	1	+	-	2	2	2	V
D. sp. Cl.: a) *Stellarietea mediae;* b) *Centauretalia cyani;* c) *Aperion spicae-venti;* d) *Aphanenion arvensis;* e) *Papaverion rhoeadis;* f) *Caucalidion lappulae;* g) *Polygono-Chenopodietalia;* h) *Polygono-Chenopodion;* i) *Sisymbrietalia, Sisymbrion officinalis*														
a) *Fallopia convolvulus*	2	2	2	2	2	-	V	1	1	1	1	2	1	V
a) *Galeopsis tetrahit*	-	-	-	-	2	-	I	-	-	-	-	+	1	II
a) *Lapsana communis*	-	-	-	-	-	-	-	+	r	-	-	-	1	III
a) *Myosotis arvensis*	-	+	-	-	-	-	I	+	r	-	+	-	-	III
a) *Raphanus raphanistrum*	-	-	-	-	+	-	I	-	-	-	-	-	-	-
a) *Stellaria media*	2	2	-	2	2	-	IV	2	2	2	2	2	+	V
a) *Thlaspi arvense*	-	-	-	-	1	-	I	+	-	-	-	+	-	II
a) *Viola arvensis*	2	2	-	2	+	-	IV	2	2	1	2	+	+	V
b) *Anthemis arvensis*	+	-	-	r	+	-	III	1	+	-	-	+	-	III

Continue Table 5.

b) *Buglossoides arvensis*	+	-	-	-	-	-	I	-	-	-	-	-	-	-
b) *Consolida regalis*	1	1	-	+	2	1	V	1	2	2	3	+	-	V
b) *Vicia villosa*	r	-	-	+	+	-	III	-	-	-	+	-	-	I
d) *Matricaria perforata*	+	r	-	2	-	-	III	-	+	-	+	-	+	III
d) *Veronica hederifolia*	+	-	-	-	-	-	I	-	-	-	r	-	-	I
f) *Avena fatua*	+	+	-	-	2	3	IV	+	-	2	-	2	2	IV
g) *Capsella bursa-pastoris*	+	r	-	-	1	2	IV	+	+	-	+	-	-	III
g) *Echinochloa crus-galli*	-	-	2	-	-	1	II	-	-	-	-	1	-	I
g) *Geranium pusillum*	+	r	-	-	-	1	III	+	-	-	-	-	-	I
g) *Chenopodium album*	+	2	3	2	2	-	IV	2	1	-	2	2	+	V
g) *Setaria pumila*	-	-	-	-	-	-	-	-	-	-	r	-	+	II
g) *Solanum nigrum*	-	-	-	-	-	-	-	-	r	-	-	-	1	II
g) *Sonchus arvensis*	-	-	-	-	-	-	-	-	-	-	-	+	-	I
h) *Euphorbia helioscopia*	-	-	-	-	+	2	II	-	-	+	-	+	+	III
h) *Fumaria officinalis*	-	-	-	-	r	1	II	+	r	-	r	+	+	V
h) *Galinsoga parviflora*	-	r	-	-	+	-	II	-	-	-	-	-	-	-
h) *Lamium amplexicaule*	-	+	+	+	+	1	V	+	+	-	+	+	+	V
h) *Lamium purpureum*	-	r	-	+	-	-	II	+	-	-	+	-	-	II
h) *Sonchus asper*	-	+	3	+	+	-	IV	+	+	2	-	+	+	V
h) *Sonchus oleraceus*	+	2		+	r	-	IV	+	-	-	+	+	-	III
h) *Veronica persica*	2	1	2	2	+	1	V	+	+	+	1	r	2	V
i) *Erigeron canadensis*	-	r	-	-	-	-	I	-	-	-	-	-	-	-
Number of species	17	20	6	15	22	9	-	21	18	9	19	19	18	-

Table 6. Communities of weeds from the other classes in cereals.

Cropping system	Crop rotation							Monoculture						
Years	1988-1992	1992-1996	1997-2000	2000-2004	2005-2008	2009-2012	Constancy degree	1988-1992	1992-1996	1997-2000	2000-2004	2005-2008	2009-2012	Constancy degree
Crops	Winter triticale		Spring triticale	Winter wheat	Spring wheat			Winter triticale		Spring triticale	Winter wheat	Spring wheat		
Rotation	1	2	3	4	5	6		1	2	3	4	5	6	
D.sp.Cl.: a) *Artemisietea vulgaris;* b) *Artemisienea vulgaris;* c) *Galio-Urticenea*														
a) *Cirsium arvense*	-	r	-	-	+	-	II	1	+	-	+	+	-	IV
b) *Melandrium album*	2	1	-	2	+	-	IV	1	2	-	+	+	-	IV
c) *Galium aparine*	2	2	2	2	2	-	V	2	2	2	2	2	2	V
D. sp. Cl.: a) *Molinio-Arrhenatheretea*; b) *Plantaginetalia majoris, Polygonion avicularis;* c) *Arrhenatheretalia*														
b) *Plantago major*	+	-	-	-	+	-	II	-	-	-	-	-	-	-
b) *Poa annua*	+	-	-	r	1	-	III	+	-	-	-	+	-	II
b) *Polygonum aviculare*	+	+	-	1	+	-	IV	1	+	+	-	+	+	V
c) *Taraxacum officinale*	-	-	-	-	-	-	-	-	-	-	-	-	+	I

Continue Table 6.

D. sp. Cl.: a) *Agropyretea intermedio-repentis, Agropyretalia intermedio-repentis, Convolvulo-Agropyrion repentis*														
a) *Convolvulus arvensis*	-	-	-	-	-	-	-	+	+	-	-	r	-	III
a) *Elymus repens*	+	+	-	-	-	-	II	2	+	+	+	+	1	V
D.sp.Cl.: a) *Koelerio glaucae-Corynephoretea canescentis, Corynephoretalia canescentis*														
a) *Arenaria serpyllifolia*	+	r	-	-	-	-	II	+	+	-	-	-	-	II
D.sp.Cl.: a) *Bidentetea tripartiti, Bidentetalia tripartiti*														
a) *Polygonum lapathifolium*	+	-	-	-	-	-	I	-	-	-	-	-	-	-
Other														
Amaranthus retroflexus	-	-	2	-	2	2	III	-	-	-	-	2	2	III
Erodium cicutarium	-	-	-	-	r	2	II	-	-	-	-	-	-	-
Veronica arvensis	-	-	-	-	-	-	-	+	-	-	-	-	-	I
Number of species	8	6	2	4	8	2	-	9	7	3	4	8	5	-

In our study, the highest number of weed species were representatives of the class *Stellarietea media*. Out of these, the highest degree of phytosociological constancy in crop rotation was determined for: *Fallopia convolvulus, Consolida regalis, Lamium amplexicaule* and *Veronica persica*, whereas in monoculture for: *Anthemis arvensis* L., *Fallopia convolvulus, Stellaria media, Viola arvensis, Consolida regalis, Papaver rhoeas, Chenopodium album, Fumaria officinalis, Lamium amplexicaule, Sonchus asper* and *Veronica persica*. Weed communities occurring therein were formed by synanthropic species, mainly by annual and biennial species, but also by ruderal species especially these representing the class *Artemisietea vulgaris*. It may be hypothesized that syntaxonomic properties of such communities depend not only on soil fertility and species of field crops, but also on plants succession in crop rotation (Soroka, 2008). Results achieved in the experiment indicate that in the compared cropping systems, apart from the *Apero spica-venti-Papaveretum rhoeadis* association being typical of cereals, there occurred also species typical of root plants, mainly of the order *Polygono-Chenopodietalia*. In our opinion, it results from the adopted cultivating measures which assume the application of natural fertilizers (manure) once per rotation (meaning every 4 years). As reported by Rasmussen et al. (2006), significant quantities of seeds of weeds belonging to various species are introduced to soil with manure, which affects weed infestation of crop. In our case, it additionally influenced results of the phytosociological and syntaxonomic analysis of weed communities in cereals.

Coefficients of similarity of weed communities

The presented coefficients determine similarity between weed communities occurring in crop rotation and monoculture (Table 7). In our experiment, values of Sørensen's and Bray-Curtis' coefficients indicated high similarity (60-70%) between weed community in crop rotation and monoculture and significantly lesser similarity according to Jaccard's coefficient, especially in the sixth rotation.

In summary, it needs to be concluded that cereals grown in monoculture leads to an increase in the number and weight of weeds, compared to crop rotation. The study demonstrated also increased weed infestation of cereals in the first years of monoculture as well as reduction and stabilization of the number and biomass of weeds in its successive years. The highest number of species occurred in the class *Stellarietea mediae* with a typical association *Apero spica-venti-Papaveretum rhoeadis*. In both systems of crops succession, present were also species typical of root plants, mainly of the order *Polygono-Chenopodietalia* as well as ruderal species, especially these representing the class *Artemisietea vulgaris*.

Table 7. Coefficients of similarity of weed communities between crop rotation and monoculture.

Similarity coefficients	Years / Crops					
	1988-1992 / Winter triticale	1992-1996 / Winter triticale	1997-2000 / Spring triticale	2000-2004 / Winter wheat	2005-2008 / Spring wheat	2009-2012 / Spring wheat
	Rotation					
	1	2	3	4	5	6
Sørensen (S)	0.68	0.68	0.60	0.70	0.68	0.60
Jaccard (K_J)	0.48	0.51	0.42	0.53	0.51	0.26
Bray-Curtis (K_B)	0.66	0.66	0.70	0.65	0.66	0.79

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