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Changes in soil weed seed bank according to spring barley maturity stages

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Abstract. Soil weed "seed bank" was studied according to harvesting time at different stages of spring barley maturity at the Research Station of the Lithuanian University of Agriculture, during the period of 1997–1999. The aim of the experiment was to identify weed seed species in the soil "seed bank" and changes in the total amount of the soil "seed bank", harvesting spring barley at different stages of maturity. In two years of the three, earlier harvesting of spring barley at the milky stage of maturity essentially decreased reserves of the soil "seed bank". The soil "seed bank" was established by counting 179–344 million ha^{-1} seeds at the stem elongation–milky stage of spring barley maturity and 230–304 million ha^{-1} seeds after harvesting spring barley at the hard stage of maturity. During the experiment, 20 weed seeds species belonging to 11 plant families: *Amaranthaceae*, *Asteraceae, Boraginaceae, Chenopodiaceae, Convolvulaceae, Cruciferae, Euphorbiaceae, Lamiaceae, Polygonaceae, Scrophulariaceae, Violaceae,* were identified in the soil "seed bank". During the three years of the experiment, seeds of the white goosefoot *Chenopodium album* L. and the common chickweed *Stellaria media* (L.) Vill. dominated.

Key words: weed species, soil weed "seed bank", stages of spring barley maturity

INTRODUCTION

In the formation of natural plant communities, natural conditions as well as economic activities have the biggest influence on agro-ecosystems (Grigas, 1995). Historically, most generatively spreading weeds pour seeds before cereal maturity and pollute the soil. The dynamics of soil reserves of weed seeds consists of two parts: cleaning of soil from seeds and replenishing by new ones. It is necessary to choose the means which quicken the decrease of weed "seed bank" (Berhard & Hurka, 1989; Mayor & Dessaint, 2001; Popugaev, 1969) and decrease the amount of new seeds getting into the soil (Mayor & Dessaint, 2001; Popugaev, 1969). Relation between these processes and their speed has an influence on soil "seed bank" dynamics direction (Popugaev, 1969).

One possibility for decreasing the amount of weeds is alternative, non-traditional time of cereal harvesting. By harvesting spring barley at the milky stage of maturity, the amount of weed seeds getting into the soil is decreased by up to 95% (Pilipavičius, 1999, 2002; Pilipavičius & Lazauskas, 2000). The effect is reached by breaking off weed vegetation, seed ripening and "seed rain" at an early stage of maturity.

The aim of the researches was to establish the composition of weed species in soil "seed bank" and investigate changes in their breaking off weed vegetation at different times at corresponding stages of spring barley maturity.

MATERIALS AND METHODS

Experimental field trials were carried out in 1997–1999 at the Research Station of the Lithuanian University of Agriculture. The soil of the trials was Epicalcari–Epihypogleyic Cambisols, CMg–p–w–cap. The agrochemical characteristics of the soil were as follows: pH_{KCl} – 7.08–7.25; humus – 2.22–2.45%; mobile P_2O_5 and K_2O – 245.0–251.3 mg kg^{-1} and 93.6–110.5 mg kg^{-1}, respectively. It was established by using the infrared rays computer system PSCCO/ISI IBM – PC 4250.

The spring barley "*Roland"* was grown and its fore-crop was: winter wheat – in 1997, spring barley – in 1998, and amaranth – in 1999. Crop weed infestation was established by the quantitative-weight method at the early milky stage of spring barley maturity (Dospechov & Vasiljev, 1987). Herbicides were not used. To establish the amount and species composition of weed seeds in the "seed bank", soil samples were taken at the spring barley stem elongation (1998–1999), milky (1997) and hard (1997–1999) stages of maturity from an arable soil layer of 0–25 cm; except for 1997, when soil samples were taken after harvesting spring barley at the hard stage of maturity, from a layer of 0–5 cm. The samples were taken from 10 places to make joint soil samples of every trial plot. Harvesting spring barley at the milky, milky-dough and dough stages of maturity, stubble was not tillaged until the soil "seed bank" calculation. Weed seeds were washed trough a 0.25-mm sieve and separated by a saturated solution of big special mass of NaCl (Rabotnov, 1958; Warwick, 1984).

Research data were evaluated statistically by the dispersion analysis method, using the ANOVA programme (Tarakanovas, 1999).

RESULTS AND DISCUSSION

Carrying out the trials, the established average weed infestation of spring barley crop in 1997–1999 has been presented in Table 1. The trial was arranged in a very weedy field in 1997. The amount of weeds in 1998 was more than three times less and weed air-dry biomass was 2.6 time less than in 1997. The amount of weeds in the crop of 1999 was similar to that of 1998 but the weed air-dry biomass was 6 times less. By evaluating weed dependence on biological groups in the crop, it was established that annual weeds made 84.0–98.2% of the total weed number and 67.6–97.7% of their air-dry biomass. Perennial weeds made 1.8–16% of the total weed number and 2.3–32.4% of their air-dry biomass. During the three years of the research, 34 weed species were identified, among which annual weeds dominated (Table 1).

Table 1. Weed density and air-dry biomass in the crop of spring barley in 1997–1999.

Weed species	Weed density and air-dry biomass					
	1997		1998		1999	
	Weeds, m^{-2}	Air-dry biomass, g m^{-2}	Weeds, m^{-2}	Air-dry biomass, g m^{-2}	Weeds, m^{-2}	Air-dry biomass, g m^{-2}
1	2	3	4	5	6	7
Common chickweed *Stellaria media* (L.) Vill.	37.9	17.13	7.1	3.79	9.2	2.73
Annual meadow-grass *Poa annua* L.	7.5	0.50	0.0	0.00	5.0	0.10
White goosefoot *Chenopodium album* L.	29.5	131.30	70.0	53.96	66.2	5.67
Charlock *Sinapis arvensis* L.	147.9	69.23	1.7	1.05	0.0	0.00
Common hemp nettle *Galeopsis tetrahit* L.	0.0	0.00	1.7	0.29	0.0	0.00
Common spurrey *Spergula arvensis* L.	0.0	0.00	0.4	0.25	0.0	0.00
Catchweed bedstraw *Galium aparine* L.	2.5	0.30	2.1	1.08	0.0	0.00
Common knotweed *Polygonum aviculare* L.	0.4	0.07	0.0	0.00	0.0	0.00
Treacle mustard *Erysimum cheiranthoides* L.	62.1	6.39	1.7	0.19	1.2	0.08
Lesser quickweed *Galinsoga parviflora* Cav.	0.0	0.00	0.8	0.17	0.0	0.00
Wild radish *Raphanus raphanistrum* L.	0.4	0.17	0.0	0.00	0.0	0.00
Curltop ladysthumb *Polygonum lapathifolium* L.	8.3	0.91	3.8	0.56	0.4	0.01
Black bind-weed *Fallopia convolvulus* (L.) A. Löve	2.1	0.14	5.4	1.45	0.0	0.00
Sun-spurge *Euphorbia helioscopia* L.	3.8	0.18	0.8	0.20	0.8	0.05
Wall-speedwell *Veronica arvensis* L.	2.5	0.08	0.0	0.00	4.2	0.09
Amaranth *Amaranthus* spp. L.	0.0	0.00	0.0	0.00	10.8	0.14
Small toadflax *Chaenorhinum minus* (L.) Lange	0.4	0.01	1.2	0.04	2.5	1.57
Succory hawk's-beard *Crepis tectorum* L.	3.3	0.88	0.0	0.00	0.0	0.00
Prickly sowthistle *Sonchus asper* (L.) Hill.	16.4	8.98	3.3	5.21	0.9	0.44
Hop medick *Medicago lupulina* L.	1.2	0.18	0.0	0.00	0.0	0.00

Table 1 (continued)

1	2	3	4	5	6	7
Scentless mayweed *Tripleurospermum inodorum* (L.) Sch. Bip.	34.2	10.92	0.0	0.00	2.9	0.22
Field pennycres *Thlaspi arvense* L.	4.6	0.49	0.0	0.00	0.4	0.08
Field pansy *Viola arvensis* Murray	3.3	0.18	0.4	0.04	1.7	0.05
Field forget-me-not *Myosotis arvensis* (L.) Hill.	1.7	0.13	0.0	0.00	0.0	0.00
Purple deadmettle *Lamium purpureum* L.	1.2	0.05	0.0	0.00	0.8	0.18
Shepherd's purse *Capsella bursa–pastoris* (L.) Medik.	17.1	1.37	2.5	0.44	13.3	1.40
Red clover *Trifolium pratense* L.	1.2	0.02	0.0	0.00	0.0	0.00
Common coltsfoot *Tussilago farfara* L.	0.0	0.00	1.2	0.12	0.0	0.00
Great plantain *Plantago major* L.	2.5	0.13	0.4	0.81	2.9	0.06
Quack-grass *Elytrigia repens* (L.) Nevski	0.0	0.00	0.0	0.00	2.5	2.30
Little starwort *Stellaria graminea* L.	0.0	0.00	0.0	0.00	0.4	0.01
Field sowthistle *Sonchus arvensis* L.	0.3	0.17	15.8	24.77	6.2	3.14
Creeping thistle *Cirsium arvense* (L.) Scop.	2.9	5.58	2.1	3.43	0.8	0.25
Field mint *Mentha arvensis* L.	0.0	0.00	0.0	0.00	1.7	0.28
Annual	388.3	249.59	102.9	68.72	120.3	12.81
Perennial	6.9	5.90	19.5	29.13	14.5	6.04
All weed species	395.2	255.49	122.4	97.85	134.8	18.85

In 1997–1999 field trial, seeds of 20 plant species were found in the soil "seed bank" where annual weeds dominated (Table 2). The identified weed seed species belong to 11 plant families: *Amaranthacea, Asteraceae, Boraginaceae, Chenopodiaceae, Convolvulaceae, Cruciferae, Euphorbiaceae, Lamiaceae, Polygonaceae, Scrophulariaceae,* and *Violaceae*.

The biggest part in the "seed bank" consisted of seeds of *Chenopodium album* L. 38–71% (up to 85%) and *Stellaria media* (L.) Vill. – 13–22% (up to 41%). 179–344 M ha^{-1} weed seeds were found in spring barley soil before the harvest at the stem elongation–milky stage of maturity, and 230–304 M ha^{-1} weed seeds in the "seed bank" where soil samples were taken at the hard stage of spring barley maturity. Similar soil "seed bank" tendencies were determined in Germany and England (Zophel & Hempel, 2000; Marshall et al., 2003), taking into account the importance of separate weed species, especially that of *Chenopodium album* L. and *Stellaria media* (L.) Vill.,

for crop biodiversity (Marshall et al., 2003). In our experiment it was established that the biggest amount of weed seeds in the soil was found during the harvest of spring barley at its hard stage of maturity. In 1997 a statistically reliable soil "seed bank" decrease was established, comparing harvesting spring barley at its hard stage of maturity with its harvesting at the milky, milky-dough and dough stages. In 1998 essential "seed bank" differences were not established but during harvesting spring barley at the hard stage of maturity, the soil "seed bank" decreased compared with the earlier stages of maturity. In 1999 an essential "seed bank" decrease was established when harvesting spring barley at the milky stage compared with the hard stage, but essential differences were not established in comparing the milky-dough and dough stages, however, weed seed decrease tendencies were present (Table 2).

Harvesting cereal (spring barley) at an earlier stage of maturity is an essentially important factor, decreasing the amount of weed seeds in the soil. Weed seed reserves in soil are controlled leaning on weed reproduction and spreading qualities because only a small part of weed seeds pours at milky or milky-dough stages of maturity (Pilipavičius, 2002; Pilipavičius & Lazauskas, 2000). Spreading of weed species that ripen seeds together with cereal is stopped as well as weeds, which pour seeds before harvesting at the dough, milky-dough or milky stages of maturity. When the amount of new weed seeds getting into the soil decreases, the "cleaning" of the soil from these quickens.

Table 2. Weed seed species and density (million ha^{-1}) in the soil "seed bank", harvesting spring barley at different stages of maturity, in 1997–1999.

Spring barley stage of maturity at harvesting time	soil sample taking time	Weed seeds in the soil "seed bank" (million ha^{-1}) Total number	Amaranth *Amaranthus* spp. L.	Shepherd's purse *Capsella bursa–pastoris* (L.) Med.	White goosefoot *Chenopodium album* L.	Creeping thistle *Cirsium arvense* (L.) Scop.	Scentless may weed *Tripleurospermum inodorum* (L.) Sch.Bip.	Curltop ladysthumb *Polygonum lapathifolium* L.	Charlock *Sinapis arvensis* L.	Field sowthistle *Sonchus arvensis* L.	Prickly sowthistle *Sonchus asper* L.	Common chickweed *Stellaria media* (L.)Vill.	Field pennycres *Thlaspi arvense* L.	Other species*
1	2	4	5	6	7	8	9	10	11	12	13	14	15	16
							1997							
Milky	Milky	173	0	0	86	8	8	8	8	0	0	39	0	8
	Hard	177	0	17	65	2	7	2	15	12	5	32	12	8
Late milky – early dough	Milky	126	0	10	39	10	0	9	19	0	10	29	0	0
	Hard	186	0	18	54	2	18	3	23	14	9	19	14	12
Dough	Milky	150	0	16	39	8	0	0	39	0	16	32	0	0
	Hard	229	0	28	47	2	17	10	33	15	18	36	13	10
Caryopsis hard	Milky	276	0	55	47	0	24	15	79	0	24	24	0	0
	Hard	347	0	54	123	0	28	2	37	13	24	56	6	4
LSD_{05}	Milky	152												
LSD_{05}	Hard	94												

Table 2 (continued)

1	2	4	5	6	7	8	9	10	11	12	13	14	15	16
							1998							
Milky	Stem elonga-tion	168	0	18	124	0	0	0	0	0	0	26	0	0
	Hard	225	0	0	152	13	2	0	2	13	13	13	1	16
Late milky – early dough	Stem elonga-tion	196	0	0	168	0	0	0	0	0	0	28	0	0
	Hard	229	0	0	141	5	0	2	0	0	0	53	1	27
Dough	Stem elonga-tion	185	0	26	106	0	26	0	26	0	0	0	0	1
	Hard	203	0	0	169	0	0	0	17	0	0	17	0	0
Caryop-sis hard	Stem elonga-tion	168	0	0	112	0	0	0	0	0	0	56	0	0
	Hard	264	0	0	194	0	2	18	1	0	0	18	1	30
LSD_{05}		127												

Table 2 (continued)

1	2	4	5	6	7	8	9	10	11	12	13	14	15	16
							1999							
Milky	Stem elonga-tion	388	44	15	183	0	0	0	0	0	7	139	0	0
	Hard	229	38	0	76	5	0	0	0	0	0	95	0	15
Late milky – early dough	stem elonga-tion	300	47	0	150	0	0	9	9	0	0	84	0	1
	Hard	284	51	0	139	0	0	0	6	12	6	70	0	0
Dough	Stem elonga-tion	313	25	0	171	0	1	8	16	0	0	55	8	29
	hard	263	33	0	155	0	0	8	0	0	0	66	0	1
Caryop-sis hard	Stem elonga-tion	375	47	16	242	0	0	0	0	0	0	70	0	0
	Hard	442	80	0	252	0	0	8	0	8	8	85	0	1
LSD_{05}		139												

Explanation: * – 9 weed seed species: common winter-cres *Barbarea vulgaris* R.Br., field bindweed *Convolvulus arvensis* L., sun-spurge *Euphorbia helioscopia* L., purple deadmettle *Lamium purpureum* L., field forget-me-not *Myosotis arvensis* (L.) Hill., black bind-weed *Fallopia convolvulus* L., wild radish *Raphanus raphanistrum* L., wall-speedwell *Veronica arvensis* L., field pansy *Viola arvensis* Murr.

CONCLUSIONS

1. In the experimental field trials 34 weed species were identified, among which annual weeds dominated. Annual weeds made 84.0–98.2% of the total weed number and 67.6–97.7% of their air-dry biomass. In separate years of the experiment, the total weed number varied from 122.4 to 395.2 weeds m^{-2} and weed biomass varied from 18.85 to 255.49 g m^{-2}.
2. The investigated "seed bank" consisted of 179–344 M ha^{-1} and 230–304 M ha^{-1} weed seeds, respectively, in the arable layer of soil, when harvesting spring barley crop at the stem elongation–milky and hard stages of maturity.
3. 20 species of weed seeds, belonging to 11 plant families, were determined in the "seed bank". The dominating position was occupied by seeds of the white goosefoot *Chenopodium album* L. that made 38–71% (up to 85% or 252 M ha^{-1} seeds) and the common chickweed *Stellaria media* (L.) Vill., whose seeds made 13–22% (up to 41% or 139 M ha^{-1} seeds) in the soil "seed bank".
4. Harvesting spring barley at the milky stage of maturity as a means of breaking off weed vegetation essentially decreased weed seed reserves in the arable soil layer.

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