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EFFECT OF SIMPLIFIED TILLAGE AND DIRECT SOWING ON WEED SEEDBANK IN SOIL

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Abstract. The effect of simplified tillage and direct sowing on weed seedbank in soil was determined in the last year of four-year crop rotation. The tillage simplifications and direct sowing were found to have contributed to a considerable weed infestation. Conventional cultivation including at least one deep plough reduced the occurrence of weed diaspores in topsoil, particularly in 1-10 and 10-20 cm layers.

Key words: direct sowing, simplified tillage

INTRODUCTION

In market economy the choice of tillage depends on the costs of respective cultivation treatments. Conventional tillage is one of the most energy-consuming and labour-intensive treatments. It takes up to 40% of the total energy needed in agrotechnical treatments of a given plant; hence a growing interest in tillage methods based on simplified tillage and, finally, direct sowing.

Dzienia et al. [1995] as well as Pałys and Podstawka-Chmielewska [1995] claim that such agrotechnical modifications are justifiable as a link in crop rotation, but not as a single treatment. Simplified tillage can, in the long-term, increase crop weed infestation [Radecki and Opic 1995, Opic 1996, Kordas and Parylak 1998].

This present research aimed at defining the effect of different tillage methods and various organic fertilisation applied into soil in the initial plant in crop rotation on potential weed infestation in the final year of crop rotation.

MATERIAL AND METHODS

The experiment was performed at the Swojec Agricultural Experiment Station in Wrocław. The research was based on a 1994 field experiment with randomised split-plot method with four replications. The sugar beet stands differed in their tillage and mineral fertilisation methods. Experimental scheme is given in Table 1.

Table 1. Experimental scheme
Tabela 1. Schemat doświadczenia

Treatment Zabieg	Sugar beet – Burak cukrowy	Winter triticale – Pszenżyto ozime			
		Soil tillage – Orka			
	after harvest – po zbiorze	autumn – jesienna	spring – wiosenna	pre-sowing – przedsiewna	sowing – siew
I	Skimming Podorywka	deep plough orka głęboka	conventional tradycyjna	medium plough średnia orka	conventional sowing siew tradycyjny
II	Skimming, white mustard Podorywka, biała gorczyca	deep plough orka głęboka	conventional tradycyjna	medium plough średnia orka	conventional sowing siew tradycyjny
II	Chisel, medium plough, white mustard Głębosz, średnia orka, biała gorczyca	medium plough średnia orka	conventional tradycyjna	medium plough średnia orka	conventional sowing siew tradycyjny
IV	Chisel, medium plough, white mustard ++* Głębosz, średnia orka, biała gorczyca ++*	medium plough średnia orka	conventional tradycyjna	medium plough średnia orka	conventional sowing siew tradycyjny
V	Chisel, rotary harrow, white mustard Głębosz, brona rotacyjna, biała gorczyca	–	–	–	direct sowing siew bezpośredni
VI	Chisel, medium plough, white mustard Głębosz, średnia orka, biała gorczyca	–	–	–	direct sowing siew bezpośredni
VII	Medium plough, white mustard ++* Średnia orka, biała gorczyca ++*	–	–	–	direct sowing siew bezpośredni
VIII	Rotary harrow, white mustard ++* Brona rotacyjna, biała gorczyca ++*	–	–	–	direct sowing siew bezpośredni

++* 40 t manure·ha^{-2} – 40 t obornika·ha^{-2}

The content of weed seeds in soil was determined with the direct method following Pawłowski's modification [1963]. To determine weed seedbank, soil was sampled following the winter triticale harvest in 1998 (the final year of crop rotation) using a cylinder of 25 cm^2 diameter from three layers: 0-1, 1-10 and 10-20 cm. The soil was rinsed with water with the 0.2 mm-in-diameter-mesh sieve and then the weed seeds were separated with K_2CO_3 solution of about 70% concentration. The weed species were determined using the Kulpa's key [1988] as well as own collection of seeds.

RESULTS

As given in Table 2, the greatest number of weed seeds in topsoil (0-20 cm) was recorded in simplified tillage and direct sowing objects. Depending on the seedbed preparation for direct sowing, the lowest number of weed diaspores was found in the field tilled for forecrop with chiseling and medium ploughing in post-harvest tillage, while somewhat greater in that tilled with chiseling and rotary harrow. A simplified post-harvest tillage for sugar beets when a rotary harrow was applied only increased the accumulation of weed seeds during full rotation. Each simplification in soil tillage for conventional sowing increased the accumulation of weed seeds in topsoil.

Table 2. Weed seed store in soil, no.·m^{-2}
Tabela 2. Zachwaszczenie gleby diasporami, szt.·m^{-2}

Treatment Zabieg	Soil layer – Warstwa gleby, cm			Total Razem
	0-1	1-10	10-20	
Conventional sowing – Siew tradycyjny				
I	2920	15960	16760	35640
II	1720	20040	27200	48960
III	1280	28320	29360	58960
IV	2800	28400	28240	59440
Mean – Średnia	2188	23188	25390	50750
Direct sowing – Siew bezpośredni				
V	4760	34240	40520	79520
VI	6520	29480	32080	68080
VII	10120	29080	40520	79720
VIII	12640	41600	37720	91960
Mean – Średnia	8510	33600	37710	79820

There was also recorded an effect of different tillage and sowing methods during rotation on the distribution of weed diaspores in respective layers of the soil profile. In the 0-1 cm layer, the lowest number of diaspores was found in the soil sampled from the object in which the post-harvest tillage for the forecrop involved chiseling, medium plough and conventional sowing (1280 seeds·m^{-2}). Most diaspores were observed in soil sampled from the object where the post-harvest tillage involved rotary harrowing only and sowing with direct-sowing drill (12640 seeds·m^{-2}). Over the four-year rotation and as a result of simplified tillage, the store of weed diaspores accumulated in the 1-10 cm layer was most reduced by chiseling and medium plough as post-harvest cultivation (object 6). The store of weed seeds in the 10-20 cm layer was most affected by the pre-

winter plough depth in conventional tillage and chiseling combined with medium plough for the forecrop in direct sowing.

The most infested soil layer, as expressed in relative values, was the 0-1 cm layer (Fig. 1), which was particularly evident in direct sowing. The number of diaspores determined in that layer was most affected by simplified post-harvest tillage for sugar beets. The fewer and the shallower the tillage treatments, the higher the infestation of soil with weed diaspores. *Amaranthus retroflexus* L. appeared to be the most predominant species (Fig. 2); its diaspores accounted for 61.4% of the total number of species determined. This weed species finds particularly favourable development conditions in simplified tillage and direct sowing. It was just in the soil sampled from simplified-tillage objects that the share of *Amaranthus retroflexus* L. was almost 2.5 times higher than that found in soil from plants cultivated with conventional methods (Table 3). In soil vertical distribution of predominating weed diaspores showed that the density of such species as *Chenopodium album* L., *Stellaria media*, *Geranium pusillum* L. and *Galium aparine* L. was almost the same in all the three soil layers (Fig. 3), whereas the diaspores of *Amaranthus retroflexus* L., *Echinochloa crus-gali* (L.) and *Viola arvensis* Murr. accumulated mainly in the 0-1cm layer and their number decreased with depth.

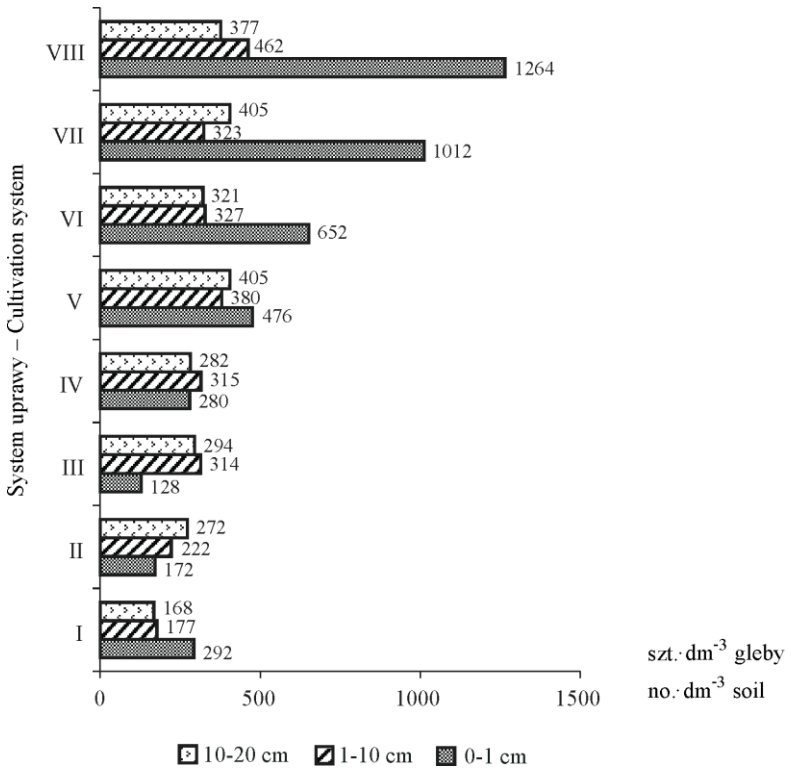

Fig. 1. Infestation of soil with weed diaspores
Rys. 1. Zanieczyszczenie gleby diasporami chwastów

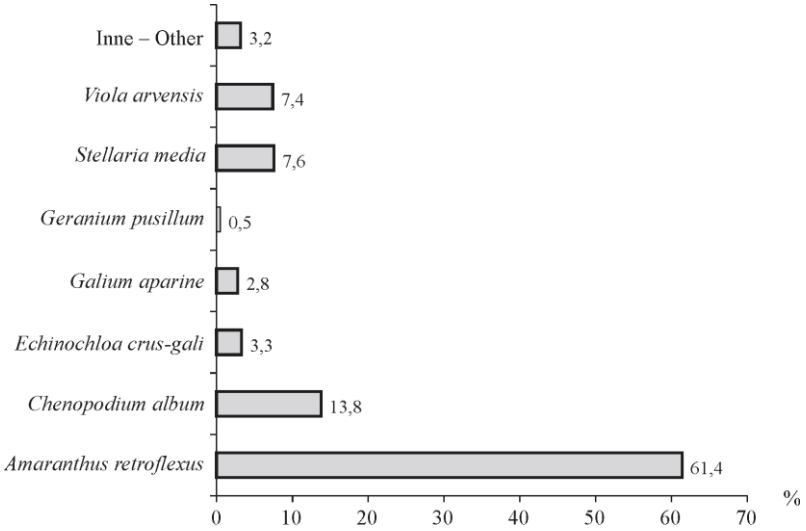

Fig. 2. Share of predominant weed species diaspores in soil
Rys. 2. Udział diaspor dominujących gatunków chwastów w glebie

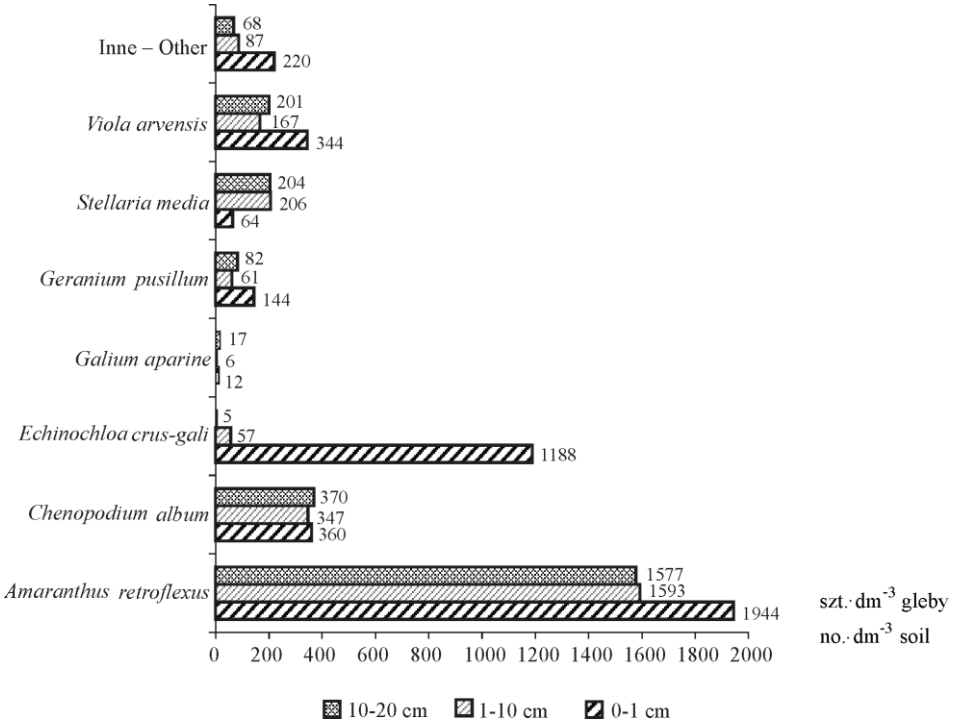

Fig. 3. Number of diaspores of important weed species in respective soil layers
Rys. 3. Liczba diaspor ważniejszych gatunków chwastów w poszczególnych warstwach gleby

Table 3. Vertical distribution of weed seeds of dominant weed species in soil layers, no.·m^{-2}
Tabela 3. Pionowe rozmieszczenie diaspor dominujących chwastów w glebie, szt.·m^{-2}

Treatment Zabieg	*Amaranthus retroflexus*			*Chenopodium album*			*Echinochloa crus-galli*			*Galium aparine*			*Geranium pusillum*			*Stellaria media*			*Viola arvensis*		
	Soil layer – Warstwa gleby, cm																				
	0-1	1-10	10-20	0-1	1-10	10-20	0-1	1-10	10-20	0-1	1-10	10-20	0-1	1-10	10-20	0-1	1-10	10-20	0-1	1-10	10-20
Conventional sowing – Siew tradycyjny																					
I	1200	9880	8120	280	1720	1880	0	400	0	0	120	920	120	0	520	120	1480	2280	800	1080	2120
II	1200	11080	16400	0	4280	3720	0	0	0	0	280	120	120	1080	1200	0	1320	2280	400	1080	3080
III	520	19720	18000	120	2800	3880	0	0	120	0	0	0	0	640	1320	0	3200	3480	520	1720	1600
IV	1600	18120	17880	280	2920	3720	0	0	120	0	0	120	280	280	4000	120	4520	3200	400	1880	2000
Mean Średnia	1130	14700	15100	170	2930	3300	0	100	60	0	100	290	130	500	860	60	2630	2810	530	1440	2200
Direct sowing – Siew bezpośredni																					
V	3320	19320	24400	920	4520	6920	0	280	0	0	120	0	120	1720	1600	0	2520	2920	400	3880	4000
VI	2680	19080	20400	280	3600	4400	1320	680	120	0	0	120	280	800	1080	400	2000	2000	120	2120	2520
VII	2800	19080	25600	520	4280	6920	5850	1200	120	120	0	120	400	400	1600	0	1720	2280	120	1480	2680
VIII	6120	27200	26920	1200	7080	5600	4680	2520	0	0	0	280	120	500	520	0	1720	1880	280	1880	2120
Mean Średnia	3730	21170	24330	1030	4870	5960	2962	1170	60	30	30	30	230	855	1200	100	1990	2270	230	2340	2830

DISCUSSION AND CONCLUSIONS

Research into the potential of direct sowing shows the threat of an increased weed infestation in both crop field and in soil [Radecki and Opic 1995, Opic 1996, Kordas and Parylak 1998], which is confirmed by the present results showing, on average, a 57% higher soil infestation with weed diaspores as a result of tillage simplifications and direct sowing after a full four-year crop rotation, as compared with conventional objects. The present research showed *Amaranthus retroflexus* L. to be most invasive. However Radecki and Opic [1995] as well as Davies and Cannell [1975] show a greater threat of the occurrence of perennial species in direct sowing, which has not been confirmed in the present research.

The results of the experiment indicate that simplified tillage increases infestation of soil with weed diaspores considerably. Out of all the weed species, the seeds of *Amaranthus retroflexus* L. are found to be most numerous. The experiment demonstrates also that traditional soil cultivation with at least one deep plough in the rotation reduces the number of weed diaspores in topsoil.

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WPŁYW UPROSZCZEŃ W UPRAWIE ROLI I SIEWU BEZPOŚREDNIEGO NA ZAPAS DIASPOR CHWASTÓW W GLEBIE

Streszczenie. W ostatnim roku czteroletniego zmianowania określono wpływ uproszczeń w uprawie roli i siewu bezpośredniego na zapas nasion chwastów w glebie. Stwierdzono, iż zastosowane uproszczenia – aż po siew bezpośredni – przyczyniły się do znacznego wzrostu zachwaszczenia gleby. Wykazano, że gleba uprawiana tradycyjnie z przynajmniej jedną orką głęboką w rotacji charakteryzuje się znacznie mniejszym zapasem diaspor chwastów niż spod upraw uproszczonych, szczególnie w warstwie 1-10 i 10-20 cm.

Słowa kluczowe: uproszczenia w uprawie roli, siew bezpośredni, zapas nasion, diaspory chwastów

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