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EFFECT OF SOIL CULTIVATION AND INTERCROP PLANT GROWING UPON WEED INFESTATION OF SPANISH SALSIFY (*Scorzonera hispanica* L.)

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Abstract: The quantity of weeds depends on biotopic factors, on the supply of seeds in the soil and agrotechincal procedures, which stimulate or inhibit weed germination and development. Intercrop plants applied in contemporary systems, modifying the soil environment, also influence the weed infestation of crops. The aim of conducted studies was to determine the effect of intercrop plant application and kind of ploughing upon the state and degree of Spanish salsify weed infestation. In the field experiment with growing Spanish salsify (*Scorzonera hispanica* L.) the following intercrop plants were applied: common vetch (*Vicia sativa* L.), tansy phacelia (*Phacelia tanacetifolia* Benth.), oat (*Avena sativa* L.), as well as differentiated soil tillage: conventional plough cultivation with pre-winter mouldboard ploughing without intercrop; intercrop plant sowing plus deep pre-winter ploughing; intercrop plant sowing plus spring ploughing. In Spanish salsify weed infestation jointly 37 taxons of weeds were determined, among which the most numerously occurred: *Chenopodium album* L.*, Senecio vulgaris* L., *Capsella bursa-pastoris* (L.) Med.*, Lamium amplexicaule* L.*, Galinsoga ciliata* (Raf.) S.F. Blake and *Urtica urens* L. The numerical force of primary and secondary Spanish salsify weed infestation after pre-winter and spring ploughing was similar. Intercrop plants significantly limited the primary and secondary weed infestation of this plant. The smallest quantities of weeds grew in objects where oat was the intercrop plant, and the largest – in cultivation without intercrops. Intercrop plants limited the occurrence of *Senecio vulgaris* and *Capsella bursa-pastoris* in primary weed infestation, and oats intercrop also limited the occurrence of *Lamium amplexicaule* and *Senecio vulgaris* in secondary weed infestation of Spanish salsify.

Key words: *Scorzonera hispanica*, weed infestation, intercrops, oat, phacelia, vetch, ploughing

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INTRODUCTION

The quantity of weed infestation depends on biotopic factors, soil seeds supply and on agrotechnical procedures, which stimulate or inhibit weed germination and development [Santon et al. 2000, Feledyn-Szewczyk and Duer 2007, Wojciechowski and Sowiński 2007].

The more weeds we provoke to germination and destroy in pre-sowing period, the more we will decrease the supplies of their diaspores in the soil [Dobrzański and Adamczewski 2006, Hruszka and Brzozowska 2008]. The most weeds are destroyed in the after-harvest soil treatment and cultivating measures. A special role in diminishing crop weed infestation is played by deep pre-winter ploughing [Kęsik and Błażewicz-Woźniak 1994, Lazauskas and Pilipavičius 2004, Błażewicz-Woźniak et al. 2006]. The intercrop plants, more and more commonly applied in the contemporary crop systems, are an excellent source of organic matter. Modifying the soil environment, they also affect the weed infestation of cultivable plants [Błażewicz-Woźniak 2004].

The aim of this paper, which is a fragment of complex studies, was evaluation of the effect of applying intercrop plants (common vetch, phacelia and oats), as well as the kind of ploughing (prewinter ploughing and spring ploughing) upon the state and degree of Spanish salsify weed infestation.

MATERIAL AND METHODS

The field experiment was conducted in the years 2006–2008 in Felin Experimental Station of the University of Life Sciences in Lublin (Poland, 51°23'N, 22°56'E), on a grey-brown podzolic soil derived from medium loam. The experimental plant was Spanish salsify (*Scorzonera hispanica* L.) of Duplex cultivar. The experiment was established by means of the method of completely randomized blocks in 4 replications. The surface of the experimental plot was 20 m^2.

The following factors were considered in the studies: I. Intercrop plants: common vetch (*Vicia sativa* L.), tansy phacelia (*Phacelia tanacetifolia* Benth.), common oats (*Avena sativa* L.); II. Soil tillage: 1) Control – conventional plough cultivation with a complex of pre-winter tillage (deep mouldboard ploughing 25–30 cm) and spring pre-sowing cultivation without intercrop; 2) a complex of pre-sowing cultivation, sowing intercrop plants, deep pre-winter mouldboard ploughing (mixing intercrop biomass with soil) and spring pre-sowing cultivation; 3) a complex of pre-sowing cultivation, sowing intercrop plants, spring ploughing on the depth of 15 cm (mixing the frozen intercrop biomass with the soil) and spring pre-sowing cultivation. The intercrop plants: common vetch (150 kg), phacelia (50 kg) and oats (200 kg ha^{-1}), had been sown in the in the 2nd decade of August and the biomass that had been produced averaged: vetch – 11,9 t ha^{-1}, phacelia – 14,8 t ha^{-1} and oats – 8,2 t ha^{-1}.

Mineral fertilization was applied in spring in the following amounts: N – 100 kg, P – 44 kg and K – 124,5 kg·ha^{-1}. Phosphorus, in the form of triple superphosphate and potassium in the form of potassium salt, were contributed to the soil in total, before sowing, whereas nitrogen was in the form of ammonium saltpeter in two equal doses: ½

before sowing and ½ after sowing. Every year seeds of Spanish salsify were sown on the 10th day of May, in rows, every 50 cm, to the depth of 1,5 cm, in the amount of 12 kg ha^{-1}. After sowing spraying with Kerb 50WP herbicide (propyzamide 50%) was applied (2 kg ha^{-1}). During vegetation manual weeding was performed twice a year. The first Spanish salsify emergence were reported on the 20th day of May 2006, 21st May 2007 and 22nd May 2008. One month after emergence plant thinning was performed. The weather conditions during the Spanish salsify cultivation period are shown in table 1.

Table 1. Mean monthly air temperatures and amount of precipitation at ES Felin in the years 2006–2008

Tabela 1. Średnie miesięczne temperatury i sumy opadów w GD Gelin w latach 2006–2008

Month	Temperature °C				Amount of precipitation mm			
	2006	2007	2008	mean for 1951–2000	2006	2007	2008	mean for 1951–2000
IV	8.7	8.7	9.3	7.5	30.3	17.4	55.8	40.6
V	13.6	15.0	12.8	13.0	59.5	81.5	101.6	58.3
VI	16.9	18.1	17.7	16.5	37.9	87.8	25.9	65.8
VII	21.9	19.2	18.3	17.9	6.8	87	77.1	78.0
VIII	17.4	18.4	19.3	17.3	132.6	37.6	55.0	69.7
IX	15.7	13.0	12.6	12.9	11.0	129.8	102.2	52.1

The state of field weed infestation was determined every year in two terms (primary and secondary weed infestation). For the first time weed infestation assessment was performed at the beginning of Spanish salsify vegetation (21.06.2006, 18.06.2007 and 11.06.2008) by quantitative (frame) method in 4 repetitions. The number of weeds of each species, dividing them into annual and perennial, were determined in pcs.·m^{-2}. Secondary weed infestation was evaluated on 20.09.2006, 18.09.2007 and 20.09.2008 using quantitative-weighting method. For this purpose, besides determining the number of weeds of particular species occurring on a surface unit (1 m^2) also their fresh weight was determined in g·m^{-2}. The obtained results were statistically elaborated, by means of variance analysis. The significant differences were checked using Tukey's test, at $p = 0.05$.

RESULTS

Primary weed infestation. In the primary Spanish salsify weed infestation in the years 2006–2008 23 species of weeds were determined, including 17 monocarpic and 6 polycarpic ones (tab. 2). The species occurring in the largest quantity was *Chenopodium album* L. Besides the fallowing species grew in large numbers: *Senecio vulgaris* L., *Lamium amplexicaule* L., *Capsella bursa-pastoris* (L.) Med., and *Galinsoga ciliata* (Raf.) S.F. Blake. Among perennial species *Taraxacum officinale* F.H. Wigg. and *Artemisia vulgaris* L. predominated. The way of performing soil tillage did not affect the number of weed species determined in examined objects. Differences, however, occurred in species composition. After pre-winter ploughing no *Sonchus oleraceus* L., *Lamium purpureum* L. and *Tanacetum vulgare* L. were found in plots, and after spring

ploughing no *Conyza canadensis* (L.) Cronq., *Stellaria media* (L.) Vill., *Sinapis arvensis* L. and *Sonchus arvensis* L. were found. More weed species (from 18 to 19) grew in objects where no intercrop plants were applied, as well as in those where vetch mulch was mixed with soil and the least (15), where the intercrop plant was oats. Intercrop plants limited the occurrence of *Senecio vulgaris* L. and *Capsella bursa-pastoris* (L.) Med., which grew in greatest numbers in control objects. The occurrence of *Lamium amplexicaule* L. (4.3 pcs.·m^{-2}) was enhanced by biomass of phacelia mixed with soil. *Artemisia vulgaris* L. grew in larger numbers in control objects (2.9 pcs.·m^{-2}) than in those where intercrops were applied, especially oats (0.8 pcs.).

The degree of primary weed infestation of Spanish salsify was on average 32.6 pcs.·m^{-2}, including 28.3 pcs. of short-lasting species, and 4.3 pcs. were perennial (tab. 2 and 4). The numerical force of Spanish salsify primary weed infestation after pre-winter and spring ploughing was similar, but after spring ploughing more perennial species occurred (on average: 6.5 pcs.·m^{-2}) than after pre-winter (2.2 pcs.·m^{-2}), which was caused by a greater number of *Artemisia vulgaris* L. plants in these objects (2.5 pcs.·m^{-2}). The application of intercrop plants significantly decreased the numerical force of weeds (tab. 4). In that term the control objects had the most weeds (42.3 pcs.·m^{-2}) and the least where those the intercrop plant was oats (25.1 pcs.·m^{-2}). Significant differences in primary weed infestation were reported between the study years. The most weeds grew in Spanish salsify in spring 2008, and the least – in the year 2007.

Secondary weed infestation. The state of Spanish salsify weed infestation in autumn increased, as compared to primary weed infestation (tab. 3). In the secondary weed infestation of this plant as many as 36 weed species were found. The number of short-lasting weeds increased to 26, and the number of perennial species increased to 10. *Capsella bursa-pastoris* (L.) Med. and *Stellaria media* (L.) Vill. became the predominant ones. Compared to spring period, the numerical force of *Chenopodium album* L. and *Senecio vulgaris* L. increased. *Urtica urens* L. appeared in quite large numbers. Among perennial plants the number of *Taraxacum officinale* F.H. Wigg. increased and new species appeared, in. a. *Epilobium adenocaulon* Hausskn. and *Urtica dioica* L. After spring ploughing at that time less short-lasting species grew in Spanish salsify (21) than after pre-winter ploughing (25). In the objects ploughed before winter no *Elymus repens* (L.) Gould. and *Equisetum arvense* L. were reported, whereas after spring ploughing there grew up to 10 perennial species, but less of short-therm ones. *Galium aparine* L., *Lamium purpureum* L., *Polygonum persicaria* L., *Solanum nigrum* L., *Papaver rhoeas* L. did not occur there. From among the applied intercrop plants, only after application of oats the number of weed species was smaller (24) than in the remaining objects (from 27 to 28). Compared to other combinations, the oat intercrop limited the occurrence of *Lamium amplexicaule* L. and *Senecio vulgaris* L., whereas vetch biomass limited the numerical force of *Urtica urens* L. In control objects (without applying intercrop plants) *Stellaria media* (L.) Vill. and *Chenopodium album* L. grew in greater number.

The degree of Spanish salsify secondary weed infestation was on average, for the period of three years: 25.8 pcs.·m^{-2} (tab. 5). The term when ploughing was performed did not significantly affect the number of weeds that grew in Spanish salsify at that time. Only in the year 2008, after spring ploughing, the secondary weed infestation of

Table 2. Effect of soil tillage and intercrop plants on species composition and number of primary weed infestation of Spanish salsify per m^{-2}
Tabela 2. Wpływ uprawy roli i roślin międzyplonowych na skład gatunkowy i liczebność zachwaszczenia pierwotnego skorzonery w szt. m^{-2}

Tillage – Uprawa	Pre-winter ploughing – Orka przedzimowa					Spring ploughing – Orka wiosenna					Mean – Średnia				Mean Średnia
Intercrop plant – Międzyplon	A	B	C	K	mean	A	B	C	K	mean	A	B	C	K	
Chenopodium album L.	7.8	11.5	13.5	13.5	11.6	10.8	12.8	9.0	8.2	10.2	9.3	12.2	11.3	10.9	10.9
Senecio vulgaris L.	5.5	3.8	10.2	12.5	8.0	5.7	4.7	4.5	10.3	6.3	5.6	4.3	7.4	11.4	7.2
Lamium amplexicaule L.	4.3	5.3	6.3	4.3	5.1	1.3	0.7	2.2	0.7	1.2	2.8	3.0	4.3	2.5	3.1
Capsella bursa-pastoris (L.) Med.	0.0	0.8	1.0	1.2	0.8	1.7	1.3	2.3	7.0	3.1	0.9	1.1	1.7	4.1	1.9
Galinsoga ciliata (Raf.) S.F. Blake.	1.2	1.5	0.8	2.2	1.4	1.7	2.3	1.8	3.0	2.2	1.5	1.9	1.3	2.6	1.8
Galinsoga parviflora Cav.	0.2	0.7	0.0	0.3	0.3	0.3	3.0	2.5	1.3	1.8	0.3	1.9	1.3	0.8	1.0
Echinochloa crus-galli (L.) P.Beauv.	0.0	0.8	0.0	0.5	0.3	0.3	0.8	2.2	3.3	1.7	0.2	0.8	1.1	1.9	1.0
Gnaphalium uliginosum L.	0.0	0.3	1.0	2.5	1.0	0.0	0.2	0.3	0.0	0.1	0.0	0.3	0.7	1.3	0.5
Matricaria chamomilla L.	0.5	0.2	0.2	0.5	0.4	0.7	0.2	0.3	1.5	0.7	0.6	0.2	0.3	1.0	0.5
Conyza canadensis (L.) Cronq.	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Thlaspi arvense L.	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.0	0.1	0.1
Amaranthus retroflexus L.	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1
Sonchus oleraceus L.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.1	0.0	0.1	0.0	0.1	0.1
Stellaria media (L.) Vill.	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Sonchus asper L.	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Lamium purpureum L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.1	0.0
Sinapis arvensis L.	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Total of short-term species Razem gatunki krótkotrwałe	19.8	25.5	33.5	37.8	29.2	22.5	26.2	25.2	36.0	27.5	21.2	25.9	29.4	36.9	28.3
Taraxacum officinale F.H.Wigg.	1.7	1.8	1.5	1.2	1.6	3.7	2.2	3.7	2.2	2.9	2.7	2.0	2.6	1.7	2.2
Artemisia vulgaris L.	0.0	0.0	0.0	1.8	0.5	1.7	2.0	2.3	4.0	2.5	0.8	1.0	1.2	2.9	1.5
Tanacetum vulgare L.	0.0	0.0	0.0	0.0	0.0	0.3	0.3	1.3	1.2	0.8	0.2	0.2	0.7	0.6	0.4
Cirsium arvense (L.) Scop.	0.2	0.2	0.0	0.2	0.2	0.2	0.2	0.0	0.2	0.2	0.2	0.2	0.0	0.2	0.2
Elymus repens (L.) Gould.	0.2	0.0	0.0	0.0	0.1	0.0	0.2	0.3	0.0	0.1	0.1	0.1	0.2	0.0	0.1
Sonchus arvensis L.	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Total of perennial species Razem gatunki wieloletnie	2.0	2.0	1.7	3.2	2.2	5.8	4.8	7.7	7.5	6.5	3.9	3.4	4.7	5.4	4.3
Number of weeds totally Łączna liczba chwastów	21.8	27.5	35.2	41.0	31.4	28.3	31.0	32.8	43.5	33.9	25.1	29.3	34.0	42.3	32.6

A – oat – owies, B – vetch – wyka, C – phacelia – facelia, K – without intercrop – bez międzyplonu

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Tabela 3. Wpływ uprawy roli i roślin międzyplonowych na skład gatunkowy i liczebność zachwaszczenia pierwotnego skorzonery w szt. m^{-2}

Tillage – Uprawa	Pre-winter ploughing – Orka przedzimowa					Spring ploughing – Orka wiosenna					Mean – Średnia				Mean Średnia
Intercrop plant – Międzyplon	A	B	C	K	mean	A	B	C	K	mean	A	B	C	K	
Capsella bursa-pastoris (L.) Med.	2.7	3.5	5.0	3.7	3.7	4.3	5.8	5.3	6.2	5.4	3.5	4.7	5.2	4.9	4.6
Stellaria media (L.) Vill.	3.3	2.3	3.2	3.5	3.1	3.8	4.8	5.0	7.8	5.4	3.6	3.6	4.1	5.7	4.2
Chenopodium album L.	2.8	3.0	3.7	6.3	4.0	1.8	1.5	2.7	1.8	2.0	2.3	2.3	3.2	4.1	3.0
Urtica urens L.	2.3	0.7	3.5	3.0	2.4	0.7	0.0	1.0	1.0	0.7	1.5	0.3	2.3	2.0	1.5
Lamium amplexicaule L.	1.3	2.0	2.5	1.7	1.9	0.0	2.0	0.3	0.5	0.7	0.7	2.0	1.4	1.1	1.3
Senecio vulgaris L.	0.5	0.5	2.0	1.8	1.2	0.0	1.5	2.5	0.5	1.1	0.3	1.0	2.3	1.2	1.2
Galinsoga ciliata (Raf.) S.F. Blake.	0.2	0.0	1.5	1.7	0.8	1.5	1.8	0.8	1.7	1.5	0.9	0.9	1.2	1.7	1.2
Conyza canadensis (L.) Cronq.	1.2	0.3	0.5	2.5	1.1	0.2	0.3	0.5	1.5	0.6	0.7	0.3	0.5	2.0	0.9
Galinsoga parviflora Cav.	0.5	0.3	1.7	0.3	0.7	0.3	0.3	2.8	0.5	1.0	0.4	0.3	2.3	0.4	0.9
Poa annua L.	1.5	0.7	1.0	0.5	0.9	1.2	0.7	0.5	0.2	0.6	1.4	0.7	0.8	0.4	0.8
Matricaria chamomilla L.	0.8	0.7	0.3	0.5	0.6	0.2	0.3	1.0	0.3	0.5	0.5	0.5	0.7	0.4	0.5
Gnaphalium uliginosum L.	0.2	0.0	0.3	0.8	0.3	0.8	0.3	0.5	0.5	0.5	0.5	0.2	0.4	0.7	0.4
Echinochloa crus-galli (L.) P.Beauv.	0.3	0.3	0.0	0.3	0.2	0.3	0.0	0.3	0.5	0.3	0.3	0.2	0.2	0.4	0.3
Erigeron annuus (L.) Pers.	0.2	0.0	0.0	0.5	0.2	0.0	0.3	0.8	0.2	0.3	0.1	0.2	0.4	0.4	0.3
Thlaspi arvense L.	0.0	0.0	0.2	0.0	0.1	0.3	0.5	0.2	0.0	0.3	0.2	0.3	0.2	0.0	0.2
Sonchus asper L.	0.0	0.0	0.3	0.0	0.1	0.2	0.2	0.3	0.0	0.2	0.1	0.1	0.3	0.0	0.1
Chenopodium polyspermum L.	0.0	0.3	0.0	0.5	0.2	0.0	0.0	0.2	0.0	0.1	0.0	0.2	0.1	0.3	0.1
Matricaria inodora (L.) Fl. Suec.	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.3	0.2	0.1	0.0	0.1	0.2	0.1	0.1
Amaranthus retroflexus L.	0.2	0.0	0.0	0.2	0.1	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.1	0.1	0.1
Galium aparine L.	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1
Sonchus oleraceus L.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.1	0.0	0.1	0.1	0.0	0.1
Lamium purpureum L.	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1
Polygonum persicaria L.	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Solanum nigrum L.	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Papaver rhoeas L.	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Arctium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.0

Total of short-term species Razem gatunki krótkotrwale		18.2	15.2	25.7	28.7	21.9	15.7	20.7	25.7	23.3	21.3	16.9	17.9	25.7	26.0	21.6
Artemisia vulgaris L.		0.2	0.0	0.2	3.2	0.9	1.2	0.5	1.8	1.7	1.3	0.7	0.3	1.0	2.4	1.1
Tanacetum vulgare L.		0.0	0.3	0.0	0.5	0.2	2.7	2.2	0.8	2.0	1.9	1.3	1.3	0.4	1.3	1.1
Taraxacum officinale F.H.Wigg.		1.0	0.3	0.7	1.0	0.8	0.0	1.0	0.8	1.8	0.9	0.5	0.7	0.8	1.4	0.8
Epilobium adenocaulon Hausskn.		0.2	0.2	0.0	0.2	0.2	0.3	0.8	0.5	1.2	0.7	0.3	0.5	0.3	0.7	0.4
Urtica dioica L.		0.0	0.0	0.3	0.7	0.3	0.0	0.0	0.0	1.8	0.5	0.0	0.0	0.2	1.3	0.4
Cirsium arvense (L.) Scop.		0.0	1.0	0.3	0.0	0.3	0.0	0.3	0.0	0.2	0.1	0.0	0.7	0.2	0.1	0.2
Plantago major L.		0.2	0.0	0.2	0.0	0.1	0.2	0.0	0.3	0.2	0.2	0.2	0.0	0.3	0.1	0.1
Equisetum arvense L.		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0
Sonchus arvensis L.		0.0	0.2	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.1
Elymus repens (L.) Gould.		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Total of perennial species Razem gatunki wieloletnie		1.5	2.0	1.7	5.5	2.7	4.5	5.3	4.3	8.8	5.7	3.0	3.7	3.0	7.2	4.2
Number of weeds totally Łączna liczba chwastów		19.7	17.2	27.3	34.2	24.6	20.2	26.0	30.0	32.2	27.1	19.9	21.6	28.7	33.2	25.8
	in g per m^{-2} w g m^{-2}	182.9	255.9	422.0	333.7	298.6	283.7	338.7	363.1	364.3	337.4	233.1	297.3	392.6	349.0	318.0
Fresh weight of weeds Świeża masa chwastów	$NIR_{0.05}$ dla: $LSD_{0.05}$ for: Tillage uprawa Intercrop międzyplon															 18.7 40.1

A – oat – owies, B – vetch – wyka, C – phacelia – facelia, K – without intercrop – bez międzyplonu

Table 4. Effect of soil tillage and intercrop plants on number of primary weed infestation of Spanish salsify per m^{-2} in years 2006–2008
Tabela 4. Wpływ uprawy roli i roślin międzyplonowych na liczebność zachwaszczenia pierwotnego skorzonery w szt. m^{-2} w latach 2006–2008

Factors of experiment Czynniki doświadczenia		2006			2007			2008			Mean – Średnia		
		*S	*P	total razem	S	P	total razem	S	P	total razem	S	P	total razem
		number of weeds per m^{-2} – liczba chwastów w szt. m^{-2}											
Tillage Uprawa	pre-winter ploughing orka przedzimowa	30.5	2.6	33.1	11.3	2.4	13.6	45.8	1.6	47.4	29.2	2.2	31.4
	spring ploughing orka wiosenna	27.9	8.0	35.9	12.8	5.8	18.5	41.8	5.6	47.4	27.5	6.5	33.9
Intercrop plant Międzyplon	oat – owies	28.5	5.5	34.0	12.5	5.3	2.8	22.5	1.0	23.5	21.2	3.9	25.1
	vetch – wyka	33.0	4.8	37.8	11.5	3.0	14.5	33.0	2.5	35.5	25.8	3.4	29.3
	phacelia – facelia	29.8	6.3	36.0	10.0	3.3	13.3	48.3	4.5	52.8	29.4	4.7	34.0
	without – bez międzyplonu	25.5	4.8	30.3	14.0	4.8	18.8	71.3	6.5	77.8	36.9	5.4	42.3
Mean – Średnia		29.2	5.3	34.5	12.0	4.1	16.1	43.8	3.6	47.4	28.3	4.3	32.7
$LSD_{0.05}$ for:													
tillage – uprawa				n.s			n.s.			n.s.			n.s.
intercrop plant – międzyplon				n.s.			n.s.			20.6			9.0
year – rok													7.1

*S – short-term weeds – chwasty krótkotrwale; P – perennial weeds – chwasty wieloletnie,
n.s. – no significant differences – różnice nieistotne statystycznie

Table 5. Effect of soil tillage and intercrop plants on number of secondary weed infestation of Spanish salsify per m^{-2} in years 2006–2008
Tabela 5. Wpływ uprawy roli i roślin międzyplonowych na liczebność zachwaszczenia wtórnego skorzonery w szt. m^{-2} w latach 2006–2008

Factors of experiment Czynniki doświadczenia		2006			2007			2008			Mean – Średnia		
		*S	*P	total razem	S	P	total razem	S	P	total razem	S	P	total razem
		number of weeds per m^{-2} – liczba chwastów w szt. m^{-2}											
Tillage – Uprawa	pre-winter ploughing orka przedzimowa	18.1	6.9	25.0	26.0	1.1	27.1	21.6	0.0	21.6	21.9	2.7	24.6
	spring ploughing orka wiosenna	12.1	13.1	25.3	21.5	2.9	24.4	30.4	1.3	31.7	21.3	5.8	27.1
Intercrop plant Międzyplon	oat – owies	8.3	8.3	16.5	25.8	0.5	26.3	16.8	0.3	2.0	2.0	3.0	19.9
	vetch – wyka	12.8	6.8	19.5	22.8	3.0	25.8	18.3	1.3	19.5	18.0	3.7	21.6
	phacelia – facelia	19.0	6.8	25.8	23.8	2.0	25.8	34.3	0.3	34.5	25.7	3.0	28.7
	without – bez międzyplonu	20.5	18.3	38.8	22.8	2.5	25.3	34.8	0.8	35.5	26.0	7.2	33.2
Mean – Średnia			10.0	25.1	23.8	2.0	25.8	26.0	0.6	26.6	21.6	4.2	25.8
$LSD_{0.05}$ for:													
tillage – uprawa				n.s.			n.s.			5.1			n.s.
intercrop plant – międzyplon				19.4			n.s.			9.8			7.5
year – rok													n.s.

*S – short-term weeds – chwasty krótkotrwale; P – perennial weeds – chwasty wieloletnie,
n.s. – no significant differences – różnice nieistotne statystycznie

Spanish salsify was significantly greater than after pre-winter ploughing. In objects where intercrops were oats or vetch, the number of weeds was significantly smaller than in control objects. This relationship was observed in the years 2006 and 2008, where oats biomass decreased the degree of Spanish salsify secondary weed infestation almost two times, compared to growing without intercrops. In the year 2007, however, no effect of intercrop plants upon this feature was reported.

The weight of weeds growing in Spanish salsify crop during the three study years was on average 318.0 g m^{-2} (tab. 3). After spring ploughing the biomass of weeds was significantly greater than after pre-winter ploughing. The applied intercrop plants affected the quantity of fresh weight formed by weeds. The greatest weight of Spanish salsify secondary weed infestation was found in objects where phacelia intercrop was applied. Large fresh weight was also created by weeds in Spanish salsify grown without intercrop plants. Oats and vetch limited the growth of weeds. In objects where these species were applied as intercrops, the fresh weight of weeds was smaller. The smallest weed weight was found in objects where oat mulch was mixed with soil.

DISCUSSION

During the three years of the conducted studies, in the cultivation of Spanish salsify 27 taxons of short-term weed species and 10 perennial species were determined. The species composition of weed infestation was typical for vegetable crops. The following weeds were represented in the greatest numbers: *Chenopodium album* L., *Senecio vulgaris* L., *Capsella bursa-pastoris* (L.) Med., *Lamium amplexicaule* L., *Galinsoga ciliata* (Raf.) S.F. Blake and *Urtica urens* L. The presence of weeds, which were non-specific for vegetable crops, such as: *Epilobium adenocaulon* Hausskn., *Tanacetum vulgare* L., *Urtica dioica* L., *Erigeron sp.,* should be explained by the vicinity of a neglected orchard.

The numerical force of primary and secondary weed infestation in Spanish salsify after pre-winter and spring ploughing was similar, but after spring ploughing there occurred more perennial species. The deeper soil cultivation influences the increased share of annual dicotyledonous species and the decrease in the numerical force of perennial ones [Duer 1985, Błażewicz-Woźniak 2004]. Ploughing performed in spring caused cutting runners and roots of perennial weeds and stimulated their growth. In objects ploughed before winter no *Elymus repens* (L.) Gould. and *Equisetum arvense* L., were reported in secondary weed infestation, whereas after spring ploughing up to 10 perennial weed species grew, but less short-therm ones. *Galium aparine* L., *Lamium purpureum* L., *Polygonum persicaria* L., *Solanum nigrum* L. and *Papaver rhoeas* L. did not occur there. In the studies by Lazauskas and Pilipavičius [2004] deep ploughing significantly decreased the regrowth of *Cirsium arvense* L. and *Elymus repens* (L.) Gould. compared to shallow cultivation (5, 10 and 15 cm). Pre-winter ploughing eliminated perennial species and decreased the primary and secondary weed infestation of onions, compared to pre-winter and spring disk harrowing [Błażewicz-Woźniak et al. 2006]. It also significantly limited the weed infestation of potato, as compared to simplified cultivation [Zarzecka et al. 2009].

The species composition of weed infestation was also differentiated by intercrop plants. This is confirmed by the studies by Woźniak [2005]. Intercrops limited the occurrence of *Senecio vulgaris* L. and *Capsella bursa-pastoris* (L.) Med., in primary weed infestation. In control objects *Stellaria media* (L.) Vill. and *Chenopodium album* L. grew in greater numbers. Plant mulch, covering the soil in spring, delayed germination of these weeds. Riemens et al. [2004] report, lack of light significantly decreased germination of *Chenopodium album, Capsella bursa-pastoris and Senecio vulgaris*. This can explain the higher intensity of *Capsella bursa pastoris* occurrence in Spanish salsify secondary weed infestation. The biomass of phacelia mixed with soil enhanced the occurrence of *Lamium amplexicaule* in spring.

The application of intercrop plants and mixed their biomass with soil reduced weed infestation of Spanish salsify. Similar relationships were reported in growing root chicory [Błażewicz-Woźniak and Konopiński 2009]. The most weeds, both in primary and secondary weed infestation, were determined in control objects, where no intercrops were applied. A significant decrease in lettuce weed infestation after applying covering plants was also reported by Ngouajio et al. [2003]. In growing wheat, however, ploughing in the biomass of Italian ryegrass and serradella increased the weed infestation. Also in the experience by Hruszka and Brzozowska [2008] ploughing in the horse bean straw after rye intercrop caused more than twofold increase of the number and weight of weeds, compared to conventional cultivation. In Spanish salsify cultivation the highest fresh weight was created by weeds growing in objects where phacelia biomass was ploughed in with soil, and the lowest – where oat was the intercrop. Oats significantly limited the numerical force of primary and secondary weed infestation of Spanish salsify. In these objects the lowest quantities of weeds were growing. Also in the studies by Franczuk et al. [2010] oat mulch reduced the fresh mass of weeds before cabbage harvest and oat and phacelia mulches reduced the number of weeds before onion harvest. Decrease of weed fresh weight by oats by 80% was reported by Lanini et al. [1999]. The advantageous effect of oat and vetch mulch upon the decrease of weed quantity was found in growing onions [Kęsik et al. 2000]. The effect of intercrops upon the numerical force and composition of weed infestation may be explained on one hand by allelopathic activity, and on the other – by modification of soil conditions resulting from introducing organic matter [Fay and Duke 1977, Lanini et al. 1999, Batish et al. 2001, Khanh et al. 2005, Kęsik et al. 2006, Błażewicz-Woźniak et al. 2008]. The highest weed fresh weight in secondary Spanish salsify weed infestation was found in objects where phacelia intercrop was applied. The ploughed-over phacelia biomass is a rich source of nutrients for subsequent plants and gives high yield-forming effect [Kęsik et al. 2000], which can also explain the high weight of weeds growing in these objects.

CONCLUSIONS

1. The numerical force of primary and secondary weed infestation of Spanish salsify after pre-winter and spring ploughing was similar. After spring ploughing perennial weeds occurred in greater numbers.

2. Intercrop plants significantly limited the primary and secondary weed infestation of Spanish salsify. The smallest quantity of weeds grew in objects, where the intercrop plant was oat, and the largest – in cultivation without intercrops.

3. Spring ploughing and phacelia intercrop increased the fresh weight of weeds growing in Spanish salsify.

4. The intercrop plants limited the occurrence of *Senecio vulgaris* L. and *Capsella bursa-pastoris* (L.) Med. in the primary weed infestation and the oat intercrop – also the occurrence of *Lamium amplexicaule* L. and *Senecio vulgaris* L. in the secondary weed infestation of Spanish salsify.

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WPŁYW SYSTEMU UPRAWY ROLI I ROŚLIN MIĘDZYPLONOWYCH NA ZACHWASZCZENIE SKORZONERY (*Scorzonera hispanica* L.)

Streszczenie. Wielkość zachwaszczenia zależy od czynników siedliskowych, od glebowego zapasu nasion oraz od zabiegów agrotechnicznych, które stymulują lub hamują kiełkowanie i rozwój chwastów. Stosowane we współczesnych systemach uprawy rośliny międzyplonowe modyfikując środowisko glebowe, oddziałują również na zachwaszczenie upraw. Celem przeprowadzonych badań było określenie wpływu stosowania roślin międzyplonowych oraz rodzaju orki na stan i stopień zachwaszczenia skorzonery. W doświadczeniu polowym z uprawą skorzonery (*Scorzonera hispanica* L.) zastosowano rośliny międzyplonowe: wyka siewna (*Vicia sativa* L.), facelia błękitna (*Phacelia tanacetifolia* Benth.), owies siewny (*Avena sativa* L.), oraz zróżnicowaną uprawę roli: tradycyjna uprawa płużna z orką przedzimową bez roślin międzyplonowych; siew roślin międzyplonowych + głęboka orka przedzimowa; siew roślin międzyplonowych + orka wiosenna. W zachwaszczeniu skorzonery oznaczono łącznie 37 taksonów chwastów, wśród których najliczniej występowały *Chenopodium album* L.*, Senecio vulgaris* L., *Capsella bursa-pastoris* (L.) Med.*, Lamium amplexicaule* L.*, Galinsoga ciliata* (Raf.) S.F. Blake and *Urtica urens* L. Liczebność zachwaszczenia pierwotnego i wtórnego skorzonery po orce przedzimowej i wiosennej była zbliżona. Rośliny międzyplonowe istotnie ograniczyły zachwaszczenie pierwotne i wtórne skorzonery. Najmniej chwastów rosło w obiektach, w których rośliną międzyplonową był owies, a najwięcej w uprawie bez międzyplonów. Rośliny międzyplonowe ograniczyły występowanie *Senecio vulgaris* i *Capsella bursa-*

pastoris w zachwaszczeniu pierwotnym, a międzyplon z owsa także występowanie *Lamium amplexicaule* i *Senecio vulgaris* w zachwaszczeniu wtórnym skorzonery.

Słowa kluczowe: *Scorzonera hispanica*, zachwaszczenie, międzyplony, owies, facelia, wyka, orka

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