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THE EFFECT OF NO-PLOUGHING TILLAGE USING COVER CROPS ON PRIMARY WEED INFESTATION OF CARROT

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Abstract. In the era of sustainable agriculture, is looking for new unconventional methods to control weed infestation. The aim of the study was to determine the effect of cover crop biomass and the manner and time of mixing it with the soil on primary weed infestation of carrot compared with the conventional plough cultivation without the use of cover crops. The cover crop plants modified the state and reduced the degree of primary weed infestation of carrot compared to cultivation without cover crops. White mustard was the most effective in reducing primary weed infestation of carrot in all variants of tillage. Phacelia, buckwheat and oat cover crops also limited largely the number of weeds in carrot. The largest number of weeds was recorded in no-cover crop cultivation in no-tillage objects and those cultivated using subsoiler before winter, and cultivating in spring with aggregate. The largest reduction of primary weed infestation compared to conventional tillage was achieved in cultivation on ridges, with white mustard, phacelia or oats cover crops and weakest after vetch cover crop. In no-ploughing flat tillage system, lack of cover crop significantly increased the degree of weed infestation compared to conventional tillage, while the use of cover crops contributed to the reduction of primary weed infestation of carrot compared to cultivation without cover crops.

Key words: pre-winter, pre-sowing tillage, mulch, catch crops, allelopathy

INTRODUCTION

The critical period of competition between crop and weeds is one in which the presence of weeds causes a significant reduction of the final yield. Crops are at this time in the growth stage most sensitive to weed. In the case of vegetable plants the significant

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threat is the primary weed infestation present in the early stage of vegetation, usually to the first or second manual or mechanical weeding, or the use of post-emergence herbicides. The careful seedbed preparation to ensure the removal of weeds from the field is a guarantee of high yield [Adamczewski and Dobrzański 2012]. The conventional plough cultivation incorporating stubble tillage and pre-winter tillage with deep ploughing and seedbed preparation are largely confined weed infestation. The tendency to the use of tillage simplifications and giving up the ploughing by measures that do not cause the furrow rotation usually leads to increase of weed infestation [Kęsik and Błażewicz-Woźniak 1994, Dabney et al. 2001, Lazauskas and Pilipavičius 2004, Błażewicz-Woźniak et al. 2006, Sosnoskie et al. 2006, Stokłosa et al. 2008].

In the era of sustainable agriculture, the attention is paid for new unconventional methods to control weed that will reduce the use of herbicides or return to the old methods of farming in order to reduce the negative effects of human activity. The cover crops survive renaissance grown not only as a green manures, but also widely used in conservation tillage, as covering plants, catch crops or mulches. Intercrop biomass is not only a source of organic matter and nutrients for the plants, but also depending on the way the development protects the soil from erosion, favourably affects the physical properties of the soil (humidity, infiltration, temperature, state of aggregation, structure et al.) [Kęsik et al. 2006, Hoffbeck 2008, Çakir 2010, Macias et al. 2012, Błażewicz-Woźniak and Konopiński 2013]. The cover crops prevent the loss of mineral components, promote biological activity of soil, have the phytosanitary effect and reduce weed infestation [Dabney et al. 2001, Gaskell and Smith 2007, Zhang et al. 2007, Błażewicz-Woźniak et al. 2008, Kęsik and Błażewicz-Woźniak 2010]. The effect of cover crops on weed infestation results from the many factors. On one side, left on the surface of the soil in the form of mulch, prevent the overgrowth layer by weeds [Anyszka et al. 2010]. On the other side they have important allelopathic impact [Liebman and Davis 2000, Stupnicka-Rodzynkiewicz et al. 2004, Kaczmarek 2009]. Formation of allele-specific inhibitors is closely connected with the activity of soil microflora. They are released from the dead plant tissues and synthesized by soil microorganisms. The important sources of allelochemical compounds are decaying plant residues [Wójcik-Wojtkowiak et al. 1998]. Leaving crop residues on the field, promote the proliferation of microorganisms, which metabolites inhibit the germination of weed seeds [Macias et al. 2003, Parylak et al. 2006, Golisz et al. 2007, Patkowska and Błażewicz-Woźniak 2014]. In studies of Hruszka and Brzozowska [2008] biological weed control methods based on competitive and allelopathic properties of alternative crops limited weed infestation in 68.6 and 72.6%. In plants of the family *Brassicaceae* isothiocyanates release during degradation of glucosinolates may reduce the weed seed germination and growth of seedlings [Haramoto and Gallandt 2005]. The high allelopathic and herbicidal activity of rye is related to the formation of phenolic compounds as well as the content of hydroxamic acids (DIBOA and BOA) [Wójcik-Wojtkowiak et al. 1998]. It was shown that they inhibit germination and growth of many weed species, e.g.: *Chenopodium album*, *Digitaria sanguinalis*, *Lepidium sativum*, *Panicum miliaceum*, *Ambrosia artemisifolia*, *Echinochloa crus-galli*, and *Amaranthus retroflexus* [Bhowmik and Interjit 2003]. Buckwheat is recommended as a weed controlling plant due to rapid biomass growth and high allelopathic potential, resulting among others from the routine content. Common sunflower, due to its high biomass production and high allelopathic potential confirmed in numerous studies, can be used with some restrictions of weed infestation [Macias et al. 2003, Kupidłowska et al. 2006, Anjum and Bajwa 2008].

The aim of the study was to determine the effect of cover crop biomass and the manner and time of mixing it with the soil on primary weed infestation of carrot compared with the conventional plough cultivation without the use of cover crops.

MATERIAL AND METHODS

The field experiment was carried out in 2009–2012 at the Exp. Farm Felin belonging to University of Life Sciences in Lublin, (Poland, 51º23'N, 22º56'E), on podzolic soil developed from loess formations covering the cretaceous marls with a granulometric composition corresponding to medium dusty loam (BN-78/9180-11). Before cover crops sowing, the soil contained 1.06–1.15% of humus in 0–20 cm layer and was characterized by slightly acidic reaction (pH in 1 M KCl 5.76–5.90). Amounts of available phosphorus, potassium, and magnesium were: P – 146.8; K – 111.5; Mg – 102.9 mg·kg^{-1} soil. The experiment was set up by means of completely randomized blocks in 4 replicates. The area of single plot (repetition) was 33 m^2. The experimental design included following factors: I. Cover crop species: spring rye (*Secale cereale* L.), common oat (*Avena sativa* L.), common vetch (*Vicia sativa* L.), white mustard (*Sinapis alba* L.), lacy phacelia (*Phacelia tanacetifolia* Benth.), buckwheat (*Fagopyrum esculentum* Moench), and fodder sunflower (*Helianthus annuus* L.); II. Tillage: 1. Traditional plough cultivation with a set of pre-winter measures (pre-winter ploughing 25–30 cm using mouldboard plough – Oz) and pre-sowing spring measures (cultivator + harrow + string roller) (Aw); 2. Set of pre-sowing measures, sowing the cover crops, stubble grubber cultivator use before winter, forming the ridges in spring (Gz + Aw + Rw); 3. Set of pre-sowing measures, sowing the cover crops, subsoiling tillage before winter, cultivation aggregate in spring (cultivator + harrow + string roller) (GLz + Aw); 4. Set of pre-sowing measures, sowing the cover crops, stubble grubber cultivator use before winter, cultivation aggregate in spring (Gz + Aw); 5. Set of pre-sowing measures, sowing the cover crops, stubble grubber cultivator use in spring (NTz + Gw); 6. Set of pre-sowing measures, sowing the cover crops, cultivation aggregate in spring (NTz + Aw). Cultivation without cover crops was the control.

Sowing the cover crops was performed after the harvest of forecrop, i.e. winter wheat. Directly after wheat harvesting, the disking was made, and then ploughing to the depth of about 15 cm with subsequent harrowing. Every year, the cover crops were sown on the same date, i.e. on August 1st. The norms of cover crop sowing were as follows: rye – 300 kg, oats – 300 kg, vetch – 200 kg, mustard – 200 kg, phacelia – 50 kg, buckwheat – 200 kg, sunflower – 125 kg·ha^{-1}. Before winter, grown mass of cover crops was mixed with ground soil or left on the soil surface as a mulch, according to the experimental scheme. Mineral fertilization was applied in the spring in the following amounts of NPK: 150:50:160 kg·ha^{-1}. Phosphorus in the form of triple superphosphate and potassium in the form of potassium chloride was brought as a whole prior to sowing, while nitrogen in the form of ammonium nitrate in 2 equal doses:

½ before sowing and ½ as a top dressing. The experimental plant was carrot Flakkee 2 cv., which was sown every year on April 26th in rows (at 50 cm spacing). The rate of sowing 2.61 kg·ha^{-1}.

The evaluation of primary weed infestation of carrot was performed after plant emergence and before the cultivating measures (in early June). The species composition and amounts of weeds was determined on each plot, in 4 different randomly selected locations, on areas of 1 m × 1 m dimensions. The weed species were divided into short-term and perennial. Achieved results were statistically processed using variance analysis (ANOVA). The difference significance was determined by means of Tukey test at $p = 0.05$.

RESULTS AND DISCUSSION

A total of 30 weed species including 21 short-term and 9 perennial ones were involved in the primary weed infestation of carrot during 3 years of study (tab. 1). Dicotyledonous class was represented by 27 species, while monocots only 3. Among the short-term weeds the dominant species were: *Echinochloa crus galli*, *Poa annua*, *Chenopodium album* i *Senecio vulgaris*. Among the perennial species the amounts > 0.05 units·m^{-2} exceeded *Taraxacum officinale*, *Elymus repens* and *Plantago maior*. The most species were determined after stubble grubber cultivator use in spring – NTz + Gw and after subsoiling tillage before winter – GLz + Aw, and the least after pre-winter ploughing – Oz + Aw. Pre-winter ploughing reduced the number of short-term species to the 17, and dicotyledonous to the 19 (compared to 25 marked in combination NTz + Gw and 24 in Glz + Aw) (tab. 2). The less perennial species than in the other variants of no-ploughing tillage grew after pre-winter ploughing and cultivation on ridges. The most ones were determined in tillage combination NTz + Gw. 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).

The primary weed infestation of carrot was on average 29.1 units per 1 m^2. The most weeds grow (irrespective of the cover crops) after subsoiling tillage before winter, and the least after pre-winter ploughing and on ridges after stubble grubber cultivator before winter (Gz + Aw + Rw). The short-term species grew most numerous in the tillage combination GLz + Aw, and the lowest was determined after pre-winter ploughing and in cultivation on ridges. The effectiveness of deep ploughing in liquidation of weeds confirms the previous authors research [Błażewicz-Woźniak 2003, 2004, Błażewicz-Woźniak et al. 2006]. Pre-winter ploughing eliminated perennial species and decreased the primary weed infestation of onions, compared to pre-winter and spring disk harrowing [Błażewicz-Woźniak et al. 2006]. Also Zarzecka et al. [2009] noted that pre-winter ploughing significantly limited the weed infestation of potato, as compared to simplified cultivation. In the analysed experience the preferred de-weeding effect of ploughing on the numbers of short-term weeds already occurred during the early spring, while reducing their numbers on ridges resulted largely from insufficient of soil moisture. The germination of weed seeds is worse in the dry soil [Dobrzański 2009], therefore in cultiva-

Table 1. Effect of cover crops on the species composition of primary weed infestation of carrot regardless of tillage (average for 2010–2012)

	Weed species	Cover crop								
		1	2	3	4	5	6	7	8	mean
		number per 1 m^2								
Annual weeds	*Echinochloa crus-galli* (L.) P. Beauv.	9.6	5.8	8.4	5.2	2.9	3.4	6.7	12.1	6.7
	Poa annua L.	11.2	3.4	2.6	5.6	3.6	4.5	6.6	6.9	5.6
	Chenopodium album L.	6.6	7.1	5.8	6.8	4.6	2.9	2.5	3.4	5.0
	Senecio vulgaris L.	5.5	2.1	3.0	4.2	1.4	3.9	2.9	1.2	3.1
	Lamium amplexicaule L.	3.6	1.4	1.5	1.5	0.7	1.1	1.7	2.5	1.8
	Stellaria media (L.)Vill.	1.2	1.7	1.1	2.5	0.8	0.8	0.2	2.1	1.3
	Capsella bursa-pastoris (L.) Medik.	2.0	1.0	1.7	2.0	0.4	0.4	0.4	0.9	1.1
	Polygonum aviculare L.	0.5	1.6	1.0	2.4	0.8	0.2	0.4	0.3	0.9
	Conyza canadensis (L.) Cronquist	1.0	1.2	0.7	0.4	0.2	0.2	0.3	0.4	0.5
	Thlaspi arvense L.	0.9	0.2	0.1	1.9	0.0	0.0	0.0	0.4	0.4
	Polygonum persicaria L.	1.5	0.3	0.2	0.2	0.1	0.4	0.3	0.5	0.4
	Matricaria chamomilla L.	0.1	0.7	0.8	0.6	0.2	0.3	0.3	0.0	0.4
	Veronica persica Poir.	0.5	1.4	0.2	0.2	0.1	0.4	0.3	–	0.4
	Erigeron annuus (L.) Pers	0.1	0.6	0.1	0.2	0.2	0.2	0.2	0.1	0.2
	Urtica urens L.	0.4	0.1	0.1	0.2	**0.0	0.1	0.4	0.6	0.2
	Galinosoga parviflora Cav.	0.3	0.2	–	0.0	0.1	0.1	–	0.6	0.2
	Lamium purpureum L.	0.1	–	0.1	0.2	0.1	0.1	0.4	0.1	0.1
	Amaranthus retroflexus L.	0.2	0.4	–	0.1	0.1	–	–	–	0.1
	Galinsoga ciliata (Raf.) S.F. Blake	0.4	0.2	–	0.0	0.1	–	–	–	0.1
	Galium aparine L.	–	–	–	0.3	–	–	–	–	0.0
	Geranium pusillum L.	–	0.1	–	–	–	–	–	–	0.0
Perennial weeds	*Taraxacum officinale* F.H.Wigg.	0.6	0.3	0.1	0.0	0.1	0.0	0.0	0.2	0.2
	Elymus repens (L.) Gould.	0.8	0.0	0.2	0.2	–	0.0	–	0.0	0.2
	Plantago maior L.	0.1	0.2	0.1	–	0.1	0.1	0.0	0.0	0.1
	Cirsium arvense (L.) Scop.	0.1	–	–	0.0	0.1	–	0.0	0.1	0.0
	Sonchus arvensis L.	–	0.0	0.2	0.0	–	–	0.0	–	0.0
	Epilobium adenocaulon Hausskn.	0.1	0.0	–	–	–	–	–	0.1	0.0
	Rumex obtusifolius L.	0.0	–	0.0	0.0	0.1	0.1	–	–	0.0
	Artemisia vulgaris L.	0.0	0.1	–	0.0	0.0	–	–	0.0	0.0
	Tanacetum vulgare L.	0.0	0.0	–	0.0	–	0.1	–	–	0.0
Total number of weeds		47.2	30.3	27.9	34.9	16.8	19.6	23.8	32.3	29.1

* – absent species; **0.0 species with abundance < 0.05 per 1 m^2; 1 – control, 2 – *Secale*, 3 – *Avena*, 4 – *Vicia*, 5 – *Sinapis*, 6 – *Phacelia*, 7 – *Fagopyrum*, 8 – *Helianthus*

Table 2. Effect of no-ploughing tillage on the species composition of primary weed infestation of carrot regardless of cover crops compared to conventional tillage (average for 2010–2012)

	Weed species	Tillage					
		Oz + Aw	Gz + Aw + Rw	GLz + Aw	Gz + Aw	Gw	Aw
		number per 1 m^2					
Annual weeds	*Echinochloa crus-galli*	5.1	7.7	8.8	8.6	3.6	6.7
	Poa annua	2.1	0.7	8.6	2.2	10.1	9.7
	Chenopodium album	4.8	3.0	7.5	9.0	3.1	2.5
	Senecio vulgaris	2.2	3.1	3.2	3.9	3.0	2.9
	Lamium amplexicaule	0.9	2.2	1.2	2.1	2.7	1.6
	Stellaria media	0.9	1.1	1.5	0.8	1.7	1.7
	Capsella bursa-pastoris	2.4	0.5	1.2	0.5	1.0	1.0
	Polygonum aviculare	1.9	0.0	2.6	0.2	0.2	0.5
	Erigeron canadensis	0.5	0.6	0.1	0.4	0.6	0.9
	Thlaspi arvense	0.3	1.0	0.4	0.5	0.3	0.3
	Polygonum persicaria	0.3	0.2	0.1	0.8	0.4	0.8
	Matricaria chamomilla	0.1	0.3	0.6	0.3	0.4	0.6
	Veronica persica	0.3	0.3	0.2	0.2	0.9	0.4
	Erigeron annuus	0.1	0.2	0.3	0.1	0.2	0.3
	Urtica urens	–	0.6	0.2	0.2	0.3	0.2
	Galinosoga parviflora	**0.0	0.4	0.2	0.1	0.2	0.1
	Lamium purpureum	0.1	0.1	0.1	0.3	0.0	0.2
	Amaranthus retroflexus	–	0.1	0.4	–	0.0	0.1
	Galinsoga ciliata	0.0	0.1	0.1	0.1	0.2	0.1
	Galium aparine	–	0.1	0.1	–	–	–
	Geranium pusillum	–	–	–	–	0.1	–
Perennial weeds	*Taraxacum officinale*	0.1	0.3	0.2	0.1	0.2	0.0
	Elymus repens	0.1	–	0.3	0.0	0.3	0.2
	Plantago maior	0.1	0.0	0.2	0.0	0.1	0.1
	Cirsium arvense	–	0.1	0.0	0.0	0.0	0.0
	Sonchus arvensis	–	0.1	0.0	0.0	–	–
	Epilobium adenocaulon	0.0	–	–	0.0	0.1	–
	Rumex obtusifolius	–	–	–	–	0.1	0.0
	Artemisia vulgaris	0.0	0.1	0.0	–	0.0	0.0
	Tanacetum vulgare	0.1	–	0.0	–	0.0	–
Total number of weeds		22.2	23.1	38.1	30.5	29.7	30.9

Designations as in tab. 1 and 3

Table 3. Effect of cover crops and tillage on degree of primary weed infestation of carrot (average for 2010–2012)

	Cover crops	Tillage							$LSD_{0.05}$ for:
		Oz + Aw	Gz + Rw	GLz + Aw	Gz + Aw	Gw	Aw	mean	
		number per 1 m^2							
Annual weeds	Control	27.2	47.4	54.4	42.2	47.4	55.1	45.6	cover crop B 8.2 tillage C 6.6 B × C 23.8
	Secale	24.8	23.1	42.4	28.6	27.6	31.3	29.7	
	Avena	31.1	14.7	55.2	15.2	23.5	24.8	27.4	
	Vicia	24.0	17.2	50.5	38.4	36.1	41.9	34.7	
	Sinapis	10.3	12.7	17.6	24.8	12.9	20.7	16.5	
	Phacelia	16.5	15.2	20.3	27.7	21.2	14.9	19.3	
	Fagopyrum	17.5	19.0	22.8	30.2	26.4	26.1	23.7	
	Helianthus	24.0	31.1	36.3	34.9	35.8	29.5	31.9	
	Mean	21.9	22.5	37.4	30.2	28.9	30.5	28.6	
Perennial weeds	Control	0.6	1.7	1.3	0.6	3.6	1.6	1.6	cover crop B 0.8 tillage C n.s. B × C n.s.
	Secale	0.3	0.5	2.3	0.0	0.0	0.6	0.6	
	Avena	0.0	1.0	0.5	0.5	1.0	0.1	0.5	
	Vicia	0.0	0.2	1.0	0.1	0.1	0.4	0.3	
	Sinapis	1.0	0.6	0.0	0.0	0.4	0.0	0.3	
	Phacelia	0.6	0.0	0.8	0.0	0.4	0.1	0.3	
	Fagopyrum	0.0	0.0	0.0	0.5	0.0	0.0	0.1	
	Helianthus	0.0	0.7	0.0	0.4	1.1	0.2	0.4	
	Mean	0.3	0.6	0.8	0.3	0.8	0.4	0.5	
Total number of weeds	Control	27.8	49.0	55.7	42.9	51.0	56.7	47.2	cover crop B 8.5 tillage C 6.9 B × C 24.6
	Secale	25.1	23.6	44.7	28.6	27.7	31.9	30.3	
	Avena	31.1	15.7	55.7	15.7	24.5	24.9	27.9	
	Vicia	24.0	17.4	51.4	38.4	36.2	42.3	34.9	
	Sinapis	11.3	13.3	17.6	24.8	13.3	20.8	16.8	
	Phacelia	17.1	15.2	21.1	27.7	21.7	14.9	19.6	
	Fagopyrum	17.5	19.0	22.9	30.7	26.4	26.1	23.8	
	Helianthus	24.0	31.8	36.3	35.3	36.9	29.6	32.3	
	Mean	22.2	23.1	38.2	30.5	29.7	30.9	29.1	

Oz – pre-winter ploughing with 25–30 cm depth; Aw – cultivation with soil aggregate (10–15 cm depth) in spring; Gz – pre-winter tillage with use of stubble grubber cultivator (25 cm depth); Gw – tillage with use of stubble grubber cultivator (25 cm depth) in spring; GLz – pre-winter cultivation with use of subsoiler (30 cm depth); Rw – forming ridges in spring; n.s. – no significant differences tion on ridges more weeds usually occurs in rain summer or on heavy textured soils [Błażewicz-Woźniak and Konopiński 2012]. Growing on ridges particularly reduced occurrence of *Poa annua*. This weed grown the most numerous when cultivation was limited only to the spring cultivation with grubber (NTz + Gw) or aggregate in spring (NTz + Aw), and after subsoiling tillage before winter (GLz + Aw). The resignation of pre-winter soil tillage, and cultivation on ridges reduced the number of *Chenopodium album*. The most numerous lamb's quarters occurred after the pre-winter tillage use stubble grubber cultivator (Gz + Aw).

The cover crop plants modified the composition and amounts of primary weed infestation of carrot (tab. 1, 3). The largest number of short-term and perennial weeds was grown in no-cover crop cultivation (control). The use of cover crops reduced the degree of weed infestation. The most weeds were recorded after vetch cover crop. The mustard cover crop reduced the most primary weed infestation of carrot. Few weeds were also found after phacelia and buckwheat cover crop. The buckwheat reduced number of perennial weeds. The cover crop plants significantly reduced primary and secondary weed infestation of scorzonera in research of Błażewicz-Woźniak and Konopiński [2011]. The least of weeds were grown in objects where oats was a cover crop, and the most in no-cover crop cultivation. Considering the present study, kind of cover crop had no effect on the number of species of monocot weeds, while the biomass of buckwheat and oats reduced to 18 the number of dicotyledonous weed species. The largest number of dicotyledonous weeds and all species together were noted in no-cover crop cultivation and after vetch cover crop. The vetch biomass mixed with soil favoured the occurrence of *Chenopodium album* and *Lamium amplexicaule* in chicory cultivation [Błażewicz-Woźniak and Konopiński 2009] and *Lamium amplexicaule* in cultivation of scorzonera [Błażewicz-Woźniak and Konopiński 2011]. The least of weed species were noted in carrot after the cover crop of buckwheat. (tab. 2). *Echinochloa crus galli* grew most numerous after sunflower cover crop. White mustard and phacelia biomass reduced the most strongly the population of barnyard grass. The most plants *Poa annua* were recorded in primary weed infestation of control objects, while the least when the cover crop was oat or rye. Phacelia, buckwheat and sunflower cover crops reduced the most strongly the numerous of *Chenopodium album*, while sunflower, white mustard and rye – of *Senecio vulgaris*. Common groundsel was the most numerously represented in the control object. Reducing the occurrence of *Senecio vulgaris* and *Capsella bursa-pastoris*, after use of cover crops were also recorded in cultivation of scorzonera [Błażewicz-Woźniak and Konopiński 2011]. The tendency to reduce the occurrence of *Stellaria media* and *Capsella bursa-pastoris* was noted after buckwheat cover crops. Kumar et al. [2009] found that buckwheat and mustard limit the growth of *Galinsoga ciliata*. Studying the allelopathic effect of buckwheat, Iqbal et al. [2003] reported weakening of the growth of roots and shoots of *Trifolium repens*, *Brassica juncea*, *Amaranthus palmeri*, *Echinochloa crus-galli*, and *Digitaria ciliaris*. Research performed by Golisz et al. [2007] demonstrated that buckwheat has high allelopathic potential relative to the number of weed species, particularly to *Elymus repens*.

Analysing the interaction of experimental factors such as cover crops and tillage, the largest number in carrot primary weed infestation was recorded in cultivation without cover crop in no-tillage objects (NTz) or grown using subsoiler (GLz) with spring cultivation using aggregate (+Aw). The conventional tillage (Oz + Aw) reduced the primary field weed infestation two times, as compared with NTz + Aw and GLz + Aw in no-cover crop cultivation. (tab. 3). Mixing mustard biomass with the soil in tillage combinations: Oz + Aw, Aw + Gz + RW and Gw the most limited primary weed infestation of carrots.

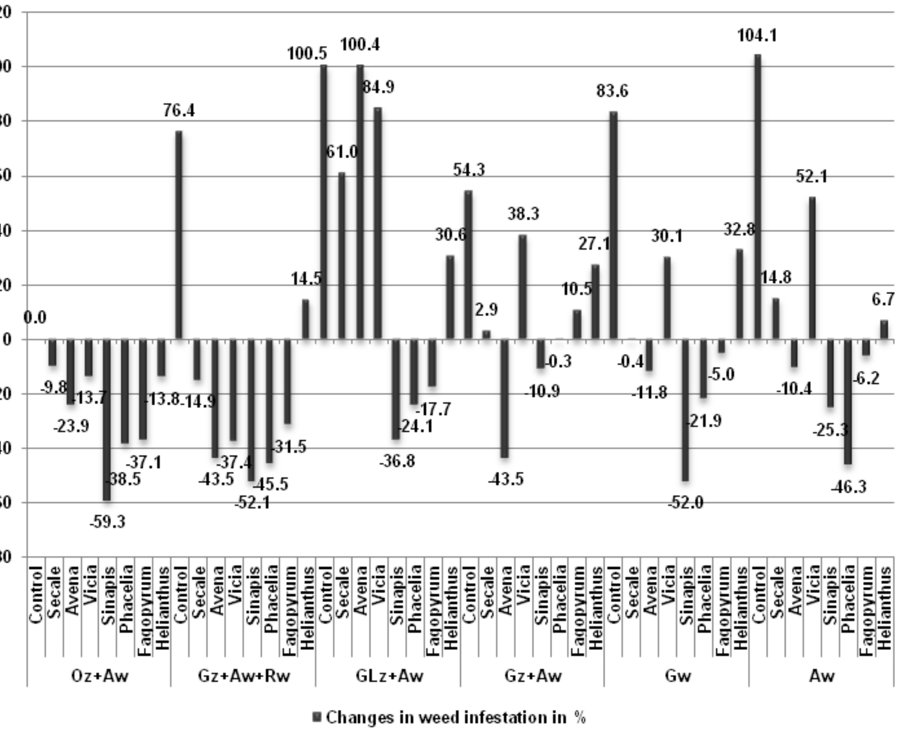

Fig. 1. Combined effect of cover crops and tillage on degree of primary weed infestation of carrot compared to conventional cultivation (Oz) without cover crops (in%) (average for 2010–2012)

Comparing the cultivation variants in combinations cover crop + tillage with traditional plough cultivation (Oz + Aw) without cover crop, it was found that the introduction of plant biomass into the soil and mixing it with using the pre-winter ploughing, reduced the primary weed infestation from 9.8 to 59.3% (fig. 1). The best effect was obtained using white mustard as cover crop, while the weakest – for rye. In other tillage variants, lack of cover crop considerably increased the degree of weed infestation as compared with conventional tillage. The largest increase of weed population (by 104.1%, on average) was observed in combination NTz + Aw and GLz + Aw (100.5%). The pre-winter tillage using grubber and aggregate cultivating in spring (Gz + Aw) resulted in an increased weed infestation average of 54.3%. The greatest reduction of primary weed infestation compared to conventional tillage was obtained in cultivation on ridges, when as cover crop white mustard, phacelia and oats were used, as well as combinations: white mustard + Gw, phacelia + Aw and oats + Gz + Aw.

Among the compared cover crops, regardless of pre-winter and spring soil tillage, the best weed competing effect was recorded for white mustard, which reduced the weed infestation of carrot by 64.4%, on average, in relation to the no-cover crop cultivation (fig. 2). High effect was obtained using phacelia and buckwheat cover crop, while the weakest – vetch cover crop.

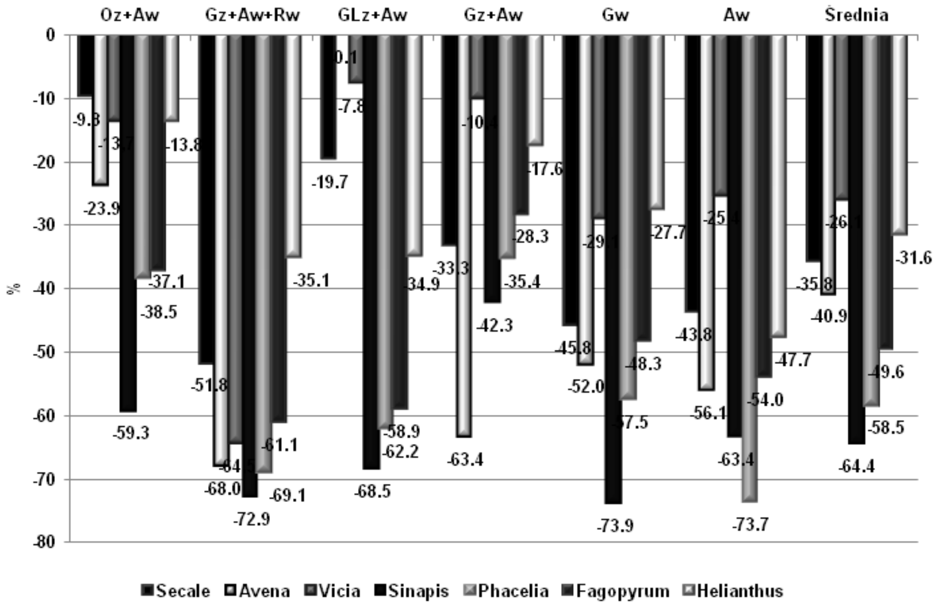

Fig. 2. Reduction of the primary weed infestation of carrot (in %) after use of cover crops depending on the soil tillage

In no-ploughing tillage, the use of cover crop plants reduced primary weed infestation of carrot in relation to cultivation without cover crop (control). The greatest weed reducing effect was assured by white mustard mulch in all tillage combinations: from 42.3% (Gz + Aw) to 72.9% (Gz + Aw + Rw). The high allelopathic effect of buckwheat and mustard in relation to weeds is confirmed in many studies [Iqbal et al. 2003, Haramoto and Gallandt 2005, Golisz et al. 2007, Kumar et al. 2009]. In the combination of cultivation Gz + Aw the strongest reduction of primary weed infestation was noted after oat cover crop (-63.4%), while in objects where only in spring performed cultivation unit (NTz + Aw) the best results gave with phacelia cover crop (-73.7%). Reducing weed infestation of vegetable crops after use of phacelia cover crops was confirmed by other studies [Błażewicz-Woźniak 2004, Franczuk et al. 2010, Błażewicz-Woźniak and Konopiński 2011].

CONCLUSIONS

1. The cover crop plants modified the state and reduced the degree of primary weed infestation of carrot compared to cultivation without cover crops.
2. White mustard was the most effective in reducing primary weed infestation of carrot in all variants of tillage. Phacelia, buckwheat and oat cover crops also limited largely the number of weeds in carrot.
3. The largest number of weeds was recorded in no-cover crop cultivation in no-tillage objects and those cultivated using subsoiler before winter, and cultivating in spring with aggregate.
4. The largest reduction of primary weed infestation compared to conventional tillage was achieved in cultivation on ridges, with white mustard, phacelia or oats cover crops and weakest after vetch cover crop.
5. In no-ploughing flat tillage system, lack of cover crop significantly increased the degree of weed infestation compared to conventional tillage, while the use of cover crops contributed to the reduction of primary weed infestation of carrot compared to cultivation without cover crops.

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WPŁYW BEZORKOWEJ UPRAWY ROLI Z ZASTOSOWANIEM ROŚLIN MIĘDZYPLONOWYCH NA ZACHWASZCZENIE PIERWOTNE MARCHWI

Streszczenie. W dobie rolnictwa zrównoważonego poszukuje się nowych niekonwencjonalnych metod ograniczenia zachwaszczenia. Celem przeprowadzonych badań było określenie wpływu biomasy roślin międzyplonowych oraz sposobu i terminu wymieszania jej z glebą na zachwaszczenie pierwotne marchwi w porównaniu z tradycyjną uprawą płużną bez stosowania międzyplonów. Rośliny międzyplonowe modyfikowały stan i zredukowały stopień zachwaszczenia pierwotnego marchwi w porównaniu z uprawą bez międzyplonu. Gorczyca biała była najbardziej efektywna we wszystkich wariantach uprawy roli, redukując zachwaszczenie pierwotne marchwi. Liczebność chwastów w dużym stopniu ograniczyły także międzyplon z facelii, gryki i owsa. Najwięcej chwastów występowało w uprawach bez międzyplonów w obiektach nieuprawianych przed zimą, gdzie wiosną zastosowano agregat uprawowy, oraz uprawianych głęboszem. Największą redukcję zachwaszczenia w porównaniu z uprawą tradycyjną uzyskano w uprawie na redlinach, gdy jako międzyplon zastosowano gorczycę białą, facelię lub owies, a najsłabszy po międzyplonie z wyki siewnej. W uprawie bezorkowej na płasko brak międzyplonu znacznie zwiększył stopień zachwaszczenia w porównaniu z uprawą tradycyjną, natomiast zastosowanie roślin międzyplonowych przyczyniło się do zmniejszenia zachwaszczenia pierwotnego marchwi w porównaniu z uprawą bez międzyplonu.

Słowa kluczowe: uprawa przedzimowa i przedsiewna, mulcz, poplon, allelopatia

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