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THE INFLUENCE OF INTERCROP PLANTS AND THE DATE OF THEIR PLOUGHING-IN ON WEED INFESTATION OF ROOT CHICORY (*Cichorium intybus* L.) var. *sativum* (Bisch.) Janch.

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Abstract

The field experiment was carried out in 2006-2008 in the Felin Experimental Farm (University of Life Sciences in Lublin) on podzolic soil developed from dusty medium loam. Root chicory (*Cichorium intybus* L.) var. *sativum* (Bisch.) Janch. cv. Polanowicka was involved in the experiment. The experimental factors were 3 species of intercrop plants: common vetch (*Vicia sativa*), phacelia (*Phacelia tanacetifolia*), oat (*Avena sativa*) and 2 dates of ploughing-in: pre-winter and spring.

In total, 26 taxons characteristic for vegetable plantations were identified in chicory weed infestation. Monocarpic species dominated, among which *Senecio vulgaris*, *Chenopodium album*, *Lamium amplexicaule*, *Galinsoga ciliata*, and *Capsella bursa-pastoris* were predominant. The date of ploughing-in did not significantly affect the status and size of weed infestation of chicory plots. Short-lived species occurred after pre-winter ploughing-in, while perennial – after spring ploughing-in. The application of intercrops significantly reduced chicory weed infestation as compared to the cultivation with no intercrop. The ploughing-in of *Avena sativa* biomass appeared to be the most efficient. The intercrop plants reduced the occurrence of *Senecio vulgaris* and *Capsella bursa-pastoris* which were the most numerous in the treatment without intercrops. Biomass of *Vicia sativa* favored the growth *of Chenopodium album* and *Lamium amplexicaule.* The secondary weed infestation did not depend on agrotechnical factors applied during the experiment.

Key words: weed infestation, chicory, intercrop plants, ploughing-in, tillage

INTRODUCTION

Weeds compete with crops through negative influences on their growth and yielding. The harmfulness of weeds for horticulture can be seen in many aspects, the major ones being as follows: competition for water, light, and nutrients. It leads to a reduction in crop growth, and in consequence, to a yield decrease. To maintain a weed population below the level causing economic losses, there is a general assumption that we need to apply plant protection against weeds (Duer, 1996).

Tillage simplifications, namely the lack of pre-winter ploughing-in, which results from a will to reduce labor and energy inputs during cultivation, most often lead to the increase of weed infestation (Kęsik and Błażewicz-Woźniak, 1994; Kuś, 1998; Boström and Fogelfors, 1999; Dzienia and Dojss, 1999; Błażewicz-Woźniak, 2003; Weber and Hryńczuk, 2005). In sustainable agriculture, weeds are seen not only as crop competitors, but also as an element that improves the diversity in an agrocenosis (Marshall et al. 2003), and even one which has a positive effect on crop growth (Promsakha et al. 2006).

Applying green manures and intercrop plants becomes more and more important when farmyard manure is less and less available. They are an excellent source of organic matter and have a positive influence on maintaining high biological activity of the soil. Modifying the soil environment, they also affect weed infestation of the crop (Hembry and Davies, 1994; Vleeshouwers, 1997; Borowy and Jelonkiewicz, 1999; Gutmański et al. 1999; Błażewicz-Woźniak, 2004).

The present study aimed at evaluating the influence of the application of intercrop plants and the date of their ploughing-in on the status and level of primary and secondary weed infestation on a chicory plantation.

MATERIALS AND METHODS

The field experiment was carried out in 2006-2008 in the Felin Experimental Farm (University of

Life Sciences in Lublin) on podzolic soil developed from dusty medium loam. Root chicory (*Cichorium intybus* L.) var. *sativum* (Bisch.) Janch. cv. Polanowicka was involved in the experiment; it is a valuable industrial plant with a high biological value due to the inulin and intibin content in its roots. The experiment was set up by means of completely randomized blocks in 4 replications. Each experimental plot was 20 m^2 in area.

The experiment included the following factors:

I. Intercrop plants: common vetch (*Vicia sativa*), phacelia (*Phacelia tanacetifolia*), oat (*Avena sativa*);

II. Tillage:

1) traditional with ploughing-in and a set of pre-winter tillage (25-30 cm deep ploughing) and spring pre-sowing tillage;
2) a set of pre-sowing tillage, intercrop plants sowing (in the middle of August), deep pre-winter ploughing-in (mixing the green matter with the soil);
3) set of pre-sowing tillage, intercrop plants sowing (in the middle of August), spring ploughing-in to 15 cm depth (mixing the frozen plant matter with the soil).

Mineral nutrition was applied in spring at the rates of NPK 100:100:150 kg $\times$ ha^{-1}. The whole rates of phosphorus, as triple superphosphate and potassium in the form of potassium chloride, were introduced into the soil prior to sowing of chicory, while nitrogen as ammonium nitrate – in two equal doses: $^1/_2$ before sowing and $^1/_2$ at top-dressing.

Every year, chicory was sown at the beginning of May (8 May) at 50 cm spacing between the rows. The spraying with Kerb 50WP herbicide was carried out after sowing. Plants were nursed by means of manual weeding performed twice during the vegetation period. The following fungicides were applied against fungal diseases: Bravo (10 July) and Nimrod 25 (18 July, 27 July, and 29 August). First plant emergences were recorded on: 18 May 2006, 21 May 2007, and 22 May 2008. The thinning was performed a month after the plant emergence.

Weed infestation of the field was estimated every year at two dates (primary and secondary weed infestation). The first weed infestation assessment was performed on 21 June 2006, 18 June 2007, and 11 June 2008 by means of the quantitative method in 4 replications: the so-called *sample areas* were selected in 4 random places of the investigated treatments using a frame of 1.0 m × 0.5 m in dimension. Within them, the number of every weed species was determined and they were divided into short-lived and perennial ones. The results were expressed in the number of weeds per 1 m^2.

Secondary weed infestation was determined on 20 September 2006, 18 September 2007, and 20 September 2008 by means of the gravimetric method. Besides counting the number of a particular weed species per square meter, their fresh weight was also evaluated (in g $\times$ m^{-2}). The weed infestation assessment was made in 4 replications. The obtained results were statistically processed applying variance analysis. The significant differences were checked using Tukey's test at p = 0.05.

RESULTS

Primary weed infestation

With regard to primary weed infestation of the chicory plots in 2006-2008, a total of 26 weed species, including 19 short-lived and 7 perennial ones, were identified (Tab. 1). Both after pre-winter and spring ploughing-in, *Senecio vulgaris* (9.46 no. $\times$ m^{-2}), *Chenopodium album* (9.17 no. $\times$ m^{-2}), *Lamium amplexicaule* (3.15 no. $\times$ m^{-2}), *Galinsoga ciliata* (2.23 no. $\times$ m^{-2}), and *Capsella bursa-pastoris* (2.08 no. $\times$ m^{-2}) were dominant. The population of *Senecio vulgaris* was higher after pre-winter (11.79 no. $\times$ m^{-2}) than spring ploughing-in (7.13 no. $\times$ m^{-2}). The pre-winter ploughing-in reduced the number of *Capsella bursa-pastoris* to 0.58 per 1 m^2, while up to 3.58 per 1 m^2 of the species were identified after the spring ploughing-in. *Galinsoga ciliata* reacted similarly to the date of ploughing-in, whereas *Chenopodium album* grew at the same rate both after the spring and pre-winter ploughing-in. The spring ploughing-in eliminated *Erigeron Canadensis, Thlaspi arvense, Sonchus asper, Lamium purpureum*, and *Galium aparine* among the short-lived weeds, and *Equisetum arvense* among the perennial ones, from primary weed infestation. Out of durable weed species, *Taraxacum officinale* (2.33 no. $\times$ m^{-2}) and *Artemisia vulgaris* (1.96 no $\times$ m^{-2}) were the most numerous both after pre-winter and spring ploughing-in, but they grew more frequently after spring ploughing-in than pre-winter one. *Sonchus arvensis*, as a short-term lives weed as well as *Matricaria maritima ssp. inodora* and *Polygonum aviculare* as perennial weeds, were not recorded on the plots ploughed in before winter.

The intercrop plants reduced the occurrence of *Senecio vulgaris* and *Capsella bursa-pastoris*, which were the most numerous in the control treatment, while they favored the presence of *Chenopodium album* and *Lamium amplexicaule* that grew more often in the treatments where common vetch was the intercrop (11.42 and 5.58 no. $\times$ m^{-2}, respectively). *Senecio vulgaris* was abundant in chicory cultivated after pre-winter ploughing-in with no intercrop plants (33.67 no. $\times$ m^{-2}), whereas *Capsella bursa-pastoris* after spring ploughing-in with no intercrops (8.00 no. $\times$ m^{-2}, on average).

The average primary weed infestation of the chicory plantation amounted to 34.01 no. $\times$ m^{-2}. The

Table 1
Effect of the date of ploughing-in and intercrop plants on species composition and the amount of primary weed infestation of chicory per m^{-2} (2006-2008).

Tillage	Pre-winter ploughing-in					Spring ploughing-in					Mean				Mean
Intercrop plant	Oat	Vetch	Phacelia	Without	Mean	Oat	Vetch	Phacelia	Without	Mean	Oat	Vetch	Phacelia	Without	
Senecio vulgaris	3.33	5.83	4.33	33.67	11.79	2.83	4.67	3.67	17.33	7.13	3.08	5.25	4.00	25.50	9.46
Chenopodium album	5.50	10.67	9.33	9.17	8.67	7.17	12.17	9.50	9.83	9.67	6.33	11.42	9.42	9.50	9.17
Lamium amplexicaule	3.00	10.50	6.00	1.17	5.17	2.67	0.67	0.33	0.83	1.13	2.83	5.58	3.17	1.00	3.15
Galinsoga ciliata	0.50	1.00	2.50	2.50	1.63	3.00	3.17	3.67	1.50	2.83	1.75	2.08	3.08	2.00	2.23
Capsella bursa-pastoris	0.17	0.17	0.33	1.67	0.58	2.50	1.33	2.50	8.00	3.58	1.33	0.75	1.42	4.83	2.08
Matricaria chamomilla	0.00	0.17	0.83	1.00	0.50	0.33	1.50	1.50	1.50	1.21	0.17	0.83	1.17	1.25	0.85
Echinochloa crus-galli	0.33	0.00	0.67	0.67	0.42	1.00	1.00	1.50	1.00	1.13	0.67	0.50	1.08	0.83	0.77
Galinsoga parviflora	0.83	0.33	0.33	0.00	0.38	0.33	0.83	1.17	0.33	0.67	0.58	0.58	0.75	0.17	0.52
Gnaphalium uliginosum	0.33	0.50	0.33	0.67	0.46	0.00	0.00	0.33	0.67	0.25	0.17	0.25	0.33	0.67	0.35
Sonchus oleraceus	0.33	0.00	0.17	0.00	0.13	0.00	0.17	0.00	0.33	0.13	0.17	0.08	0.08	0.17	0.13
Chenopodium polyspermum	0.00	0.00	0.00	0.17	0.04	0.00	0.17	0.17	0.17	0.13	0.00	0.08	0.08	0.17	0.08
Erigeron canadensis	0.00	0.00	0.50	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Stellaria media	0.00	0.00	0.17	0.00	0.04	0.00	0.17	0.00	0.17	0.08	0.00	0.08	0.08	0.08	0.06
M. maritima ssp.inodora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.08	0.00	0.00	0.17	0.00	0.04
Thlaspi arvense	0.17	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.02
Polygonum aviculare	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.02
Sonchus asper	0.00	0.17	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.02
Lamium purpureum	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02
Galium aparine	0.00	0.17	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.02
Total of short-lived species	14.50	29.50	25.50	50.83	30.10	20.00	25.83	24.67	41.67	28.04	17.25	27.67	24.83	46.25	29.05
Taraxacum officinale	0.67	1.50	1.83	1.50	1.38	3.00	2.83	3.17	4.17	3.29	1.83	2.17	2.50	2.83	2.33
Artemisia vulgaris	0.33	0.17	0.33	3.67	1.13	1.17	1.83	2.50	5.67	2.79	0.75	1.00	1.42	4.67	1.96
Tanacetum vulgare	0.00	0.00	0.17	0.00	0.04	0.83	0.00	2.00	0.50	0.83	0.42	0.00	1.08	0.25	0.44
Agropyron repens	0.17	0.00	0.00	0.33	0.13	0.00	0.00	0.17	0.00	0.04	0.08	0.00	0.08	0.17	0.08
Cirsium arvense	0.00	0.33	0.00	0.17	0.13	0.00	0.17	0.00	0.00	0.04	0.00	0.25	0.00	0.08	0.08
Sonchus arvensis	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.17	0.08	0.08	0.00	0.00	0.08	0.04
Equisetum arvense	0.00	0.00	0.17	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.02
Total perennial species	1.17	2.00	2.50	5.67	2.83	5.17	4.83	7.83	10.50	7.08	3.17	3.42	5.17	8.08	4.96
Total number of weeds	15.67	31.50	28.00	56.50	32.93	25.17	30.67	32.50	52.17	35.13	20.42	31.08	30.00	54.33	34.01

Table 2
Effect of the date of ploughing-in and intercrop plants on species composition and the amount and weight of secondary weed infestation of chicory per m^{-2} (2006-2008).

Tillage	Pre-winter ploughing-in					Spring ploughing-in					Mean				Mean
Intercrop plant	Oat	Vetch	Phacelia	Without	Mean	Oat	Vetch	Phacelia	Without	Mean	Oat	Vetch	Phacelia	Without	
Stellaria media	0.00	0.33	0.67	0.33	0.33	0.00	0.00	0.00	1.17	0.29	0.00	0.17	0.33	0.75	0.31
Chenopodium album	0.17	0.50	0.67	0.17	0.38	0.00	0.17	0.00	0.33	0.13	0.08	0.33	0.33	0.25	0.25
Lamium amplexicaule	0.17	0.00	0.00	0.83	0.25	0.17	0.00	0.00	0.00	0.04	0.17	0.00	0.00	0.43	0.15
Capsella bursa-pastoris	0.00	0.00	0.33	0.17	0.13	0.00	0.00	0.17	0.00	0.04	0.00	0.00	0.25	0.08	0.08
Urtica urens	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.00	0.50	0.13	0.00	0.00	0.00	0.33	0.08
Senecio vulgaris	0.00	0.00	0.33	0.00	0.08	0.17	0.00	0.00	0.00	0.04	0.08	0.00	0.17	0.00	0.06
Echinochloa crus-galli	0.00	0.00	0.17	0.00	0.04	0.00	0.00	0.17	0.00	0.04	0.00	0.00	0.17	0.00	0.04
Galinsoga parviflora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.04	0.00	0.00	0.10	0.00	0.02
Galinsoga hirsuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.00	0.10	0.02
Sonchus asper	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.02
Poa annua	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02
Lamium purpureum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.00	0.08	0.02
Total of short-lived species	0.33	0.83	2.17	1.83	1.29	0.50	0.17	0.50	2.33	0.88	0.42	0.50	1.35	2.08	1.08
Artemisia vulgaris	0.00	0.00	0.00	0.17	0.04	0.17	0.00	0.00	0.33	0.13	0.08	0.00	0.00	0.25	0.08
Taraxacum officinale	0.00	0.00	0.17	0.00	0.04	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.08	0.08	0.04
Urtica dioica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.00	0.08	0.02
Tanacetum vulgare	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.02
Elymus repens	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.04	0.00	0.08	0.00	0.00	0.02
Total perennial species	0.00	0.00	0.17	0.17	0.08	0.33	0.17	0.00	0.67	0.29	0.17	0.08	0.08	0.42	0.19
Total number of weeds	0.33	0.83	2.33	2.00	1.38	0.83	0.33	0.50	3.00	1.17	0.58	0.58	1.43	2.50	1.27
Fresh weight in g per m^{-2}	2.9	23.4	98.1	40.2	41.1	42.7	16.1	1.2	83.8	35.9	22.8	19.8	49.6	62.0	38.5

Table 3

Effect of the date of ploughing-in and intercrop plants on the size of primary weed infestation of chicory per m^{-2} in years 2006-2008.

Experimental factors		2006			2007			2008			Mean		
		*K	*W	Total	K	W	Total	K	W	Total	K	W	Total
		Number of weeds per m^{-2}											
Tillage	Pre-winter ploughing-in	24.1	3.3	27.4	11.3	2.5	13.8	54.8	2.8	57.6	30.1	2.9	32,9
	Spring ploughing-in	26.5	7.0	33.5	13.6	6.3	19.9	44.0	8.0	52.0	28.0	7.1	35,1
Intercrop plant	Oat	17.0	4.5	21.5	10.3	3.0	13.3	24.5	2.0	26.5	17.3	3.2	20,4
	Vetch	31.8	3.5	35.3	10.0	4.3	14.3	41.3	2.5	43.8	27.7	3.4	31,1
	Phacelia	29.0	5.8	34.8	9.3	4.3	13.5	36.3	5.5	41.8	24.9	5.2	30,0
	Without intercrop	23.5	6.8	30.3	19.5	6.0	25.5	95.8	11.5	107.3	46.3	8.1	54,4
Mean		25,3	5.1	30.4	12.4	4.4	16.8	49.4	5.4	54.8	29.0	5.0	34.0
$LSD_{,05}$ for:													
	tillage			5.3			n.s.			n.s.			n.s.
	intercrop plant			10.1			n.s.			34.4			12.3
	year												9.7

*K – short-lived weeds; W – perennial weeds, n.s. – no significant differences

Table 4

Effect of the date of ploughing-in and intercrop plants on the size of secondary weed infestation of chicory per m^{-2} in years 2006-2008.

Experimental factors		2006			2007			2008			Total		
		*K	*W	Total	K	W	Total	K	W	Total	K	W	Razem
		Number of weeds per m^{-2}											
Tillage	Pre-winter ploughing-in	0.8	0.0	0.8	2.6	0.1	2.8	0.5	0.1	0.6	1.3	0.1	1,4
	Spring ploughing-in	0.4	0.0	0.4	2.3	0.4	2.6	0.0	0.5	0.5	0.9	0.3	1,2
Intercrop plant	Oat	0.5	0.0	0.5	0.5	0.0	0.5	0.3	0.5	0.8	0.4	0.2	0,6
	Vetch	0.0	0.0	0.0	1.3	0.3	1.5	0.3	0.0	0.3	0.5	0.1	0,6
	Phacelia	0.3	0.0	0.3	3.5	0.3	3.8	0.3	0.0	0.3	1.4	0.1	1,5
	Without intercrop	1.5	0.0	1.5	4.5	0.5	5.0	0.3	0.8	1.0	2.1	0.4	2,5
Mean		0,6	0.0	0.6	2.4	0.3	2.7	0.3	0.3	0.6	1.1	0.2	1.3
$LSD_{,05}$ for:													
	tillage			n.s.			n.s.			n.s.			n.s.
	intercrop plant			n.s.			n.s.			n.s.			n.s.
	year												n.s.

*K – short-lived weeds; W – perennial weeds, r.n. – no significant differences short-lived species were represented more numerously (29.05 no. × m^{-2}) than the perennial ones (4.96 no. × m^{-2}). The date of ploughing-in had not significant influence on the weed population (Tab. 1). The short-lived species occurred more numerously after pre-winter, while the perennial ones after spring ploughing-in (Tabs 1, 2). The applied intercrop plants considerably reduced the weed population as compared to the control treatment, where weeds grew most numerously (54.33 no.× m^{-2}). Such dependence was observed in all experimental years. Regardless of tillage, the smallest number of weeds was recorded in the treatments where oat mulch was mixed with the soil (20.42 no. × m^{-2}). It was particularly apparent in 2008 when up to 107.3 weeds per 1 m^2 were identified in the treatment with no intercrop, whilst only 26.5 after the application of oat (Tab. 2). Significant differences in chicory primary weed infestation between years were recorded. Weeds were the most abundant in 2008 (43.3 no. × m^{-2}), less in 2006 (30.4), and the least in 2007 (25.3).

Secondary weed infestation

Secondary weed infestation of the chicory plots in all experimental years was very low and amounted to 1.27 plants per 1 m^2 (Tabs 3, 4). In total, 17 weed species were recorded, including 12 short-lived and 5 perennial ones. The experimental factors did not exert any influence on chicory secondary weed infestation: the plant shielding the spacing was crucial. Slightly more weeds grew in the control treatments where no intercrop plants were applied. Also, the fresh weight of weeds growing in chicory at the end of the vegetation period did not depend on the applied intercrops and the date when their biomass was mixed with the soil; it amounted to 38.5 g × m^{-2} (mean for three years) (Tab. 3). A little more weeds per area unit were found in the treatments where no intercrop plants were grown, namely after the spring ploughing-in, which resulted from their larger population.

DISCUSSION

The chicory plantation was grown by 19 monocarpic and 7 polycarpic species within 3 experimental years. *Senecio vulgaris*, *Chenopodium album*, *Lamium amplexicaule*, *Galinsoga ciliata*, and *Capsella bursa-pastoris* among short-lives, and *Taraxacum officinale* among perennial species dominated, thus they were typically horticultural weeds (Dobrzański, 1999) and belonged to the order *Polygono-Chenopodietalia* (R.Tx. et Lohm. 1950) J.Tx. 1961 (Matuszkiewicz, 2008). The presence of weeds typical for orchards as well as ruderal species from other syntaxons (*Sisymbrietalia* J.Tx. 1961 and *Artemisietalia vulgaris* Lohm. i R.Tx. 1947), such as *Erigeron canadensis, Artemisia vulgaris*, and *Tanacetum vulgare*, on the chicory plantation resulted from the neighborhood of an orchard being closed down.

Usually, larger weed infestation in horticultural cultivation is recorded after spring ploughing-in, which moves weed seeds up to the soil surface (Pawłowski and Wesołowski, 1981; Kęsik and Błażewicz-Woźniak, 1994). The date of ploughing-in applied in the present experiment had not any significant influence on the status and size of chicory primary weed infestation. After pre-winter ploughing-in, the short-lived species occurred, while perennial ones were present after spring ploughing-in, which resulted from the cutting of vegetative organs of polycarpic species and stimulating them to grow. Reducing the number of *Equisetum arvense* and the absence of *Galium aparine* after spring ploughing-in may be attributed to lower soil moisture content due to spring soil moisture content. It can also be supposed that the higher number of monocarpic weeds after the ploughing-in before winter resulted from the fact that pre-winter ploughing-in exerted a positive influence on soil moisture content in early spring and at the beginning of the plant vegetation period, which favored weed seed germination (Konopiński et al. 2002), and thus a greater number of *Senecio vulgaris*, which prefers wet soil, grew after pre-winter ploughing-in (Dobrzański, 1999). *Capsella bursa-pastoris* was more numerous after spring ploughing-in which brought its seeds onto the soil surface. *Capsella bursa-pastoris* has modest water requirements, but its seeds germinate the best from 0.5 cm depth (Duer, 1996). *Echinochloa crus-galli* and *Matricaria chamomilla* were also abundant after spring ploughing-in. Rola et al. (2005) reported an increased population of *Capsella bursa-pastoris* and *Echinochloa crus-galli* in the treatment with simplified wheat cultivation as compared to the traditional one. *Chenopodium album* was the species that reacted towards the date of ploughing-in the least, which was confirmed in earlier studies (Zawieja and Kordas, 2003; Conn, 2006; Idkowiak and Kordas, 2006; Sekutowski and Rola, 2006; Wesołowski and Bujak, 2006). The method of ploughing-in, its depth, and even the shape of the mould-board, all determine the distribution of weed seeds in the soil and hence influence their germination and plant emergence (Roger-Estrade et al. 2001; Carter and Ivany, 2006). In the present study, pre-winter ploughing-in reduced the number of perennial weeds, namely *Taraxacum officinale* and *Artemisia vulgaris*. The effect of the date of ploughing-in on the occurrence of polycarpic weeds – among others, *Elymus repens* and *Sonchus arvensis* – was also confirmed in experiments carried out by Boström and Fogelfors (1999).

The efficiency of intercrop plants in reducing chicory weed infestation was found in the experiment performed. The applied intercrop plants significantly decreased the occurrence of weeds as compared to the control treatment where no intercrops were used and weeds grew most abundantly. Ngouajio et al. (2003) observed a considerable decrease in weed infestation when cover crops were applied. It could be attributed to the allelopathic influences of compounds released during the intercrop biomass decomposition and stimulation of the activity of soil microorganisms (Dreksen et al. 1996; Khanh et al. 2005; Parylak et al. 2006). The biomass of intercrop plants ploughed into the soil particularly strongly reduced the populations of *Senecio vulgaris* and *Capsella bursa-pastoris*, while *Chenopodium album* and *Lamium amplexicaule* were positively correlated to the *Vicia sativa* mulch. Stupnicka-Rodzynkiewicz et al. (2004) reported an increase of the *Chenopodium album* and *Stellaria media* populations in barley cultivated after a mixture of leguminous plants with rapeseed as the intercrop and after broad bean. Pawłowski and Wesołowski (1989) as well as Trąba and Wiater (2007) observed positive effects of the *Fabaceae* family plants on *Chenopodium album* growth. The biomass of *Avena sativa* reduced most strongly chicory primary weed infestation in the present experiment. After spring ploughing-in, the number of weeds in the treatment where oat mulch was applied was 48.2% relative to the control, and when fresh oat matter was ploughed in before winter – only 27.7%. It should be supposed that the most favorable conditions for soil microflora development occurred in that combination. According to Stupnicka-Rodzynkiewicz et al. (2004), the smallest number of weed species may be explained by the improvement in the air-water balance in the soil as well as by a larger population of microflora decomposing the weed seeds. The development of soil microflora is more abundant if organic remains are more vulnerable to decomposition (Dąbek-Szreniawska, 2004). The number and composition of soil microorganisms, along with their activity, depend on the plant species (Wielgosz et al. 2002). In the analyzed experiment, the oat biomass reduced the occurrence of *Senecio vulgaris, Chenopodium album, Galinsoga ciliata,* and *Matricaria chamomilla.* Lower weed infestation after the oat forecrop in spring wheat canopy was recorded by Weber and Hryńczuk (2005). Pawłowski and Wesołowski (1989) reported that *Chenopodium album* present in oat did not reach seed ripeness, hence it did not increase the diaspore bank in the soil.

The applied intercrop plants and the ploughing-in date did not exert any influence on chicory secondary weed infestation. It resulted from the biological features of the crop whose well-developed leaves covered the soil, thus efficiently removed weeds. The number of weed species decreased by 9 in relation to primary weed infestation. The following weeds were not identified in secondary weed infestation: *Matricaria chamomilla, Matricaria maritima ssp. inodora, Gnaphalium uliginosum, Thlaspi arvense, Polygonum aviculare, Erigeron canadensis, Galium aparine,* and *Equisetum arvense*, instead *Urtica urens* and *Poa annua* appeared. Weeds grew sporadically and, in addition, they were displaced by well-developed and better-leaved chicory plants. According to Jędruszczak et al. (2004), wintering and winter species such as *Matricaria maritima* ssp. *inodora* or *Galium aparine*, may be displaced by a crop when they appear with delay. Some weed species require light to emerge. The light stimulates their seeds to germinate, while the same plants emerge much worse in the dark. Such species are: *Chenopodium album, Matricaria matricarioides, Polygonum aviculare, Capsella bursa-pastoris, Erodium cicutarium, Matricaria chamomilla, Matricaria maritima* ssp. *inodora, Senecio vulgaris,* or *Lamium amplexicaule*, at which – after Riemens et al. (2004) – the lack of light significantly worsened the emergence. On the other hand, the light deficiency did not have considerable effects on *Urtica urens* (Andersson et al. 1997) and *Poa annua* (Milberg et al. 1996) emergence, which can account for their appearance in secondary weed infestation of chicory plots.

The size and status of chicory weed infestation varied in particular experimental years. Weather conditions affect the fruiting and seed shattering in weeds, as well as the course of their germination and emergence (Pawłowski and Wesołowski, 1989; Riemens et al. 2004; Weber and Hryńczuk, 2005; Wesołowski, 2006; Batlla and Benech-Arnold, 2007).

CONCLUSIONS

1. In total, 26 taxons, characteristic for vegetable plantations, were identified in chicory weed infestation, among which *Senecio vulgaris*, *Chenopodium album*, *Lamium amplexicaule*, *Galinsoga ciliata* and *Capsella bursa-pastoris* dominated.
2. The date of ploughing-in did not significantly affect the status and size of weed infestation of the chicory plots. Short-lived species occurred after pre-winter, while perennial ones – after spring ploughing-in.
3. The application of intercrops significantly reduced chicory weed infestation as compared to the cultivation with no intercrop. The ploughing-in of *Avena sativa* biomass appeared to be the most efficient.
4. The intercrop plants reduced the occurrence of *Senecio vulgaris* and *Capsella bursa-pastoris*

which were the most numerous in the treatment without intercrops. Biomass of *Vicia sativa* favored the growth of *Chenopodium album* and *Lamium amplexicaule*.

5. Secondary weed infestation did not depend on agrotechnical factors applied during the experiment, whereas covering the soil by well-developed chicory leaves was crucial, since it efficiently eliminated weeds.

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Wpływ roślin międzyplonowych i terminu ich przyorania na zachwaszczenie cykorii korzeniowej – *Cichorium intybus* L. var. *sativum* (Bisch.) Janch.

Streszczenie

Doświadczenie polowe przeprowadzono w latach 2006-2008 w Gospodarstwie Doświadczalnym Felin Uniwersytetu Przyrodniczego w Lublinie na glebie płowej wytworzonej z gliny średniej pylastej. Rośliną doświadczalną była cykoria korzeniowa odm. Polanowicka. W badaniach uwzględniono 3 rośliny międzyplonowe: wykę siewną (*Vicia sativa*), facelię błękitną (*Phacelia tanacetifolia*), owies siewny (*Avena sativa*) oraz zróżnicowaną uprawę roli z zastosowaniem głębokiej orki przedzimowej lub płytkiej orki wiosennej.

W zachwaszczeniu cykorii oznaczono łącznie 26 taksonów w większości charakterystycznych dla upraw warzywnych. Dominowały gatunki monokarpiczne, wśród których najliczniej występowały *Senecio vulgaris*, *Chenopodium album*, *Lamium amplexicaule*, *Galinsoga ciliata* i *Capsella bursa-pastoris.* Termin wykonania orki nie wpłynął istotnie na stan i stopień zachwaszczenia cykorii. Po orce przedzimowej liczniej wystąpiły gatunki krótkotrwałe natomiast

po orce wiosennej – wieloletnie. Zastosowanie roślin międzyplonowych istotnie ograniczyło zachwaszczenie cykorii w porównaniu do uprawy bez międzyplonu. Najskuteczniejsze było przyoranie biomasy *Avena sativa.* Rośliny międzyplonowe ograniczyły występowanie *Senecio vulgaris* i *Capsella bursa-pastoris*, które najliczniej rosły w obiekcie bez międzyplonów. Biomasa *Vicia sativa* sprzyjała wystąpieniu *Chenopodium album* i *Lamium amplexicaule.* Zachwaszczenie wtórne nie zależało od czynników agrotechnicznych zastosowanych w doświadczeniu.