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EFFECT OF SOIL TILLAGE SYSTEMS ON WEED INFESTATION OF HUSKED AND NAKED OATS CANOPY

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Abstract. The aim of this study was to evaluate weed infestation (the number, biomass and species composition) of husked and naked oats canopy depending on the soil tillage system (conventional, simplified with a catch crop, simplified, direct sowing) and the method of plant cultivation (mechanical and chemical) The study was carried out in 2000--2002, in Alfisols, formed from loess. The subject of the investigation was husked oats (cultivar Borowiak) and naked oats (cultivar Akt III). The largest number of weeds occurred in the canopy of husked (123 pcs·m^{-2}) and naked (102 pcs·m^{-2}) oats cultivar after the use of direct sowing, and in the cultivar Akt III also after simplified tillage (68.7 pcs·m^{-2}). The largest dry matter of weeds was determined after the application of direct sowing (Borowiak – 104.8; Akt III – 100.5 g·m^{-2}) and simplified tillage (Borowiak – 72.5; Akt III – 64.1 g·m^{-2}). The smallest number and weight of weeds in canopies of both oats cultivars was found after conventional soil cultivation and after simplified tillage with the use of catch crop. Introducing chemical weed control affected a reduction in number and dry matter of weeds in the range from 16 to 22%, both in the canopy of cultivar Borowiak and Akt III. This was particularly effective in treatments where direct sowing and simplified tillage was used. Among weeds short-lived species predominated, but more of them occurred in the canopy of cultivar Akt III than in the canopy of the cultivar Borowiak. Tillage system and the method for weed control had a similar effect on the weed control in canopies of naked and husked oats cultivars.

Key words: cultivation, oats, tillage system, weed infestation

INTRODUCTION

Among four basic cereals in Poland, a decrease in oats cultivation area has been observed in recent years. In 2010 it was cultivated in an area of 577 thousand ha, which accounts for 5.5% of the cereal cropping area [Statistical Yearbook 2010]. Despite decreasing area of oats cultivation, in recent years many its new valuable qualities have been observed. The plant has become a subject of investigation in countries of Western Europe and in Poland. Great interest in oats results from its higher nutritional value than

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that in other cereals [Dzieżyc 1993, Pawłowski and Fordoński 1994, Zawiślak and Adamiak 1997, Gąsiorowski 1999, Bartnikowska 2003]. Moreover, oats is a plant with relatively small soil and temperature requirements [Niewiadomski *et al*. 1980, Adamiak and Zawiślak 1991, Zawiślak i Adamiak 1998]. It is one of few plants in cereal crop rotations which is characterized by a high competitiveness towards weeds, tolerance to simplification in tillage, and additionally it is a phytosanitary plant [Niewiadomski *et al*. 1980, Pawłowski and Deryło 1988, Adamiak and Zawiślak 1991, Bojarczuk and Bojarczuk 1992, Zawiślak and Adamiak 1997, Deryło *et al*. 2003, Andruszczak *et al*. 2010]. The mentioned valuable qualities of oats are essential in the present situation of plant production, since effective chemical technologies of weed control have currently been controversial and limited.

The aim of this study was to estimate the level of canopy weed infestation in oats (naked and husked) cultivated under conditions of different tillage systems and plant cultivation.

MATERIAL AND METHODS

The field experiment comprising two-factorial experiments was carried out in 2000--2002 on the Experimental Farm Czesławice (51°18' N; 22°16' E), owned by UP in Lublin. It was located in Alfisol formed of loess (the good wheat complex) with a slightly acid reaction (pH 6.3-6.5) and a humus content of about 1.6%. the experiment was established with the "split-plot" design in four replications, in plots with an area for harvest of 12 m^2. The subject of the investigation was naked oats (cv. Borowiak) and husked oats (cv. Akt III). Two factors were taken into consideration in the experiment:

factor 1 – four tillage systems:

I – conventional – involving post-harvest cultivation, composed of skimming and two-time harrowing at intervals of 15 days, autumn ploughing, spring harrowing with a medium and heavy harrows, and then sowing the oats seeds and after-sowing harrowing,

II – simplified + catch crop – consisted of shallow ploughing (15 cm), harrowing, sowing of the catch crop (white mustard) and after-sowing harrowing; autumn ploughing was performed before winter, ploughing in also the catch crop; in the spring, harrowing was made with a medium and heavy harrows, as well as sowing oats and after-sowing harrowing,

III – simplified – involved shallow post-harvest ploughing (15 cm), two-time harrowing at intervals of 15 days, in the spring, harrowing with a medium and heavy harrow was made, as well as oats sowing and after-sowing harrowing,

IV – direct sowing – was reduced to post-harvest weed control with the herbicide (Roundup 360 SL in a dose of 5 $dm^3 \cdot ha^{-1}$), in the spring – oats sowing with a special disk drill (Bosch made in USA); in the spring, prior to sowing the seeds, mineral (NPK) fertilization was applied adapted to oats requirements and the expected yield, which amounted to: N – 60, P_2O_5 – 50 and K_2O – 80 $kg \cdot ha^{-1}$ in pure component; oats was sown after a cereal-legume mixture (spring wheat + field pea) in all the years of the experiment;

factor 2 – weed control methods:
- mechanical – consisting in two-time harrowing of oats (with a medium harrow) at the plant germination and tillering stages (5-6 leaves), moreover insecticides and fungicides were used to reduce pests and diseases appearing in the oats canopy,
- chemical – applying appropriate crop-protection preparations, reducing weeds, diseases and pests occurring in oats canopy.

All the plant protection treatments were performed on optimal dates and oats developmental stages recommended by IOR in Poznań. The following pesticides were considered in appropriate doses per 1 ha: Chwastox Turbo 340 SL – 2 dm^3, Tilt Plus 400EC – 1 dm^3, Terpal 460C SL – 1 dm^3, Baytan Universal 19.5 WS – 200 $g \cdot 100\ kg^{-1}$ of oats seeds, Decis 2,5 EC – 0.25 dm^3. In this study the weed infestation of oats canopy was evaluated randomly with the botanical weighing method, annually in each plot, several days before plant harvesting, in two test areas marked with a frame of 1 × 0.5 m. The species composition, number and air dry matter of the aboveground part of weeds were determined on those microplots.

Weather conditions according to the Meteorological Station at GD Czesławice for the long-term period were characterized by the average annual temperature 7.7°C and annual total precipitation 614.0 mm. Detailed data concerning the temperature and precipitation in individual years and growing seasons was presented in Table 1. The data indicates that the first and second year of the study (2000 and 2001) were more favourable for the growth and development of oats plants than the third (2002), since the total precipitation, its distribution and air temperature in critical phases of plants were more favourable for oats growth, which therefore was more competitive towards weeds colonizing the canopies.

RESULTS AND DISCUSSION

The weed infestation of husked oats canopy was differentiated by the tillage system and the cultivation method (Tables 2-4). On average in the three-year period (2000-2002), irrespective of the tillage system, the smallest number of weeds – 65.4 $pcs \cdot m^{-2}$ – was found on treatments with chemical cultivation (Table 2). The difference was 16.8% in comparison with mechanical cultivation. This favourable effect of chemical cultivation in limiting weed infestation was observed on all the treatments of studied tillage systems. Significant differences between plant protection methods were found on the treatment of conventional tillage and direct sowing. Irrespective of the tested factors, the least favourable year in respect of weed infestation of husked oats canopy was 2001, when the largest number of weeds was observed – 98.7 $pcs \cdot m^{-2}$, whereas the most favourable years were 2002 and 2000. Chemical cultivation of the canopy, irrespective of the tillage system, significantly reduced by 24.1% the number of weeds in the husked oats canopy only in 2001 (Table 2).

Irrespective of cultivation method, the largest number of weeds in the tested years (2000-2002) was observed on the treatment of direct sowing – 123.3 $pcs \cdot m^{-2}$, whereas the smallest with simplified tillage + catch crop – 39.0 $pcs. \cdot m^{-2}$. Simplified and conventional tillage were in between in this respect, and the number of weeds there amounted to 71.4 and 54.4 $pcs \cdot m^{-2}$, respectively. On the treatment with conventional tillage, the number of weeds was significantly larger as compared with the treatment of simplified tillage with the catch crop (Table 2).

Table 1. Total precipitation and mean air temperature at the Experimental Station Czesławice in 2000-2002

Year	Specification	Month												Annnual mean
		January	February	March	April	May	June	July	August	September	October	November	December	
2000	precipitation, mm	25.6	37.2	57.1	60.5	51.2	24.7	141.0	75.1	55.6	3.5	36.4	49.6	617.5
	temperature, °C	-2.1	-1.6	3.0	12.2	15.3	17.2	16.9	18.3	11.8	11.3	6.8	1.7	9.2
2001	precipitation, mm	33.0	17.5	47.6	48.8	15.3	55.9	165.2	55.3	144.3	26.8	32.2	18.2	660.1
	temperature, °C	-0.9	-1.5	2.1	8.2	14.4	15.0	20.9	19.6	12.5	10.6	1.2	-6.6	8.0
2002	precipitation, mm	45.9	48.0	31.5	18.2	45.8	79.3	52.2	41.7	45.1	101.5	22.4	8.6	540.2
	temperature, °C	2.0	3.0	4.2	8.3	16.7	17.0	21.2	20.2	13.0	7.0	4.5	7.3	8.8
Many years mean 1963-2003	precipitation, mm	33.2	27.6	31.1	42.5	62.8	79.4	79.9	69.1	58.8	47.6	40.7	41.3	614.0
	temperature, °C	-3.2	-2.1	2.1	7.8	13.5	16.4	18.1	17.6	13.0	8.1	2.7	-1.1	7.7

Table 2. Mean number of weeds in husked oats, pcs·m^{-2}

Year	Tillage system												Methods		Years mean
	conventional			simplified with catch crop			simplified			direct sowing			mean		
	a^{x}	b^{xx}	mean	a	b	mean	a	b	mean	a	b	mean	a	b	
2000	69.6	58.8	64.2	30.3	26.4	28.4	80.8	72.1	76.4	105.1	99.6	102.4	71.4	64.2	67.8
2001	97.0	61.2	79.1	82.1	58.0	70.1	120.0	98.5	109.2	149.6	123.0	136.3	112.2	85.2	98.7
2002	23.2	16.7	20.0	20.2	16.5	18.4	29.8	27.4	28.6	135.8	126.4	131.1	52.2	46.8	49.5
Mean	63.3	45.6	54.4	44.2	33.6	39.0	76.9	66.0	71.4	130.2	116.3	123.3	78.6	65.4	–
$LSD_{0.05}$ for:															
tillage systems				16.8											
cultivation				13.0											
years				18.6											
interaction:															
systems × cultivation				12.9											
systems × year				26.0											
cultivation × year				21.5											

a^{x} – mechanical cultivation, b^{xx} – chemical cultivation

The other component of weed infestation of husked oats canopy, i.e. air-dry weight of weeds, was also differentiated by the tested factors (Table 3). Irrespective of the cultivation method, the largest biomass of weeds was found on treatments with direct sowing and simplified tillage system without the catch crop, which was 104.8 $g \cdot m^{-2}$ and 72.5 $g \cdot m^{-2}$, respectively. Weeds formed significantly the smallest biomass in the oats canopy on treatments with conventional tillage and with simplified one plus the catch crop, which remained on the same level and on average amounted to 20.6 $g \cdot m^{-2}$. It is notable that the chemical cultivation of oats canopies was significantly more effective in reducing their weed biomass as compared with mechanical – only between treatments with direct and simplified sowing without the catch crop.

Irrespective of the tillage system, chemical cultivation of husked oats had a significant effect on reducing the weed biomass in oats canopy (Table 3). Irrespective of the tested factors, the year 2001 was significantly more favourable to increase in weed biomass in oats canopies (79.8 $g \cdot m^{-2}$), whereas 2000 and 2002 were similar to each other in this respect, and on average the biomass amounted to 42.4 $g \cdot m^{-2}$. Thus it was significantly lower in comparison with 2001.

Weed infestation of naked oats was also modified by the tested factors, i.e. the tillage system and the method for canopy cultivation (Tables 5-7). On average in three years (2000-2002), irrespective of the tillage system, significantly the largest number of weeds – 73.3 $pcs \cdot m^{-2}$ – was found on the treatments cultivated mechanically, whereas the smallest – 56.9 $pcs \cdot m^{-2}$ – on plots cultivated chemically. The difference was 22.4%. Chemical cultivation of oats canopies proved significantly effective in the simplified tillage system and with direct sowing. The most favourable growing period in respect of the weed infestation of oats canopies was 2002, when the smallest number of weeds was found – 43.7 $pcs \cdot m^{-2}$, where the worst years were 2001 and 2000 (Table 5).

Irrespective of cultivation and years, the smallest number of weeds in the canopy of naked oats was found on the treatments with simplified tillage with the catch crop and conventional tillage – on average 43.4 $pcs \cdot m^{-2}$, whereas the largest on the treatment with direct sowing – 102.0 $pcs \cdot m^{-2}$ and simplified tillage – 68.7 $pcs \cdot m^{-2}$. It is notable that this tendency was also noticeable in individual years of the study (Table 5).

Air dry matter of weeds in naked oats was also differentiated by the tillage system and cultivation (Table 6). Irrespective of cultivation, the largest weed biomass was found on the treatments with direct sowing and simplified tillage system, which was 100.5 $g \cdot m^{-2}$ and 64.1 $g \cdot m^{-2}$, respectively, whereas significantly the smallest biomass was formed by weeds in oats canopy on the treatments with conventional tillage and simplified tillage with the catch crop; it stayed on the same level and on average, it amounted to 27.0 $g \cdot m^{-2}$.

Irrespective of the tillage system, chemical cultivation of oats canopy significantly reduced the weed biomass by 16.8% as compared with mechanical. By contrast, in individual tillage systems, the chemical cultivation of oats canopy proved to be significantly effective only on the treatment with direct sowing.

Irrespective of the tested factors, the most favourable year for the increase in weed biomass in naked oats canopy was 2001 (77.1 $g \cdot m^{-2}$), where favourable were the years 2000 and 2002, when the weed weight was the smallest and stayed on the same level, on average 43.4 $g \cdot m^{-2}$ (Table 6).

The floristic composition of the weed community colonizing husked oats canopies was differentiated by the tested experimental factors, i.e. tillage systems and cultivation (Table 4). Species of short-lived weeds growing over oats canopies showed a distinct

stability, mainly in the group of dominant weeds (they occurred annually in a high intensity), which included: *Chenopodium album*, *Capsella bursa-pastoris*, *Viola arvensis*, *Galinsoga parviflora*, *Matricaria maritima* ssp. *inodora*, *Apera spica-venti*, *Polygonum nodosum*, *Myosotis arvensis*, *Gnaphalium uliginosum*, *Plantago pauciflora*. They accounted for 83.5% to 75.0% of the total number of weeds. Of perennial weeds, *Elymus repens* and *Cirsium arvense* occurred in the largest proportion (from 95.2 to 57.1%). It is notable that the number of dominant and other weeds increased on the treatments with the simplified tillage system and direct sowing. It is noteworthy that the chemical cultivation of husked oats canopy on the treatment with direct sowing resulted in an increase in the number of some species: *Apera spica-venti*, *Viola arvensis* and *Echinochloa crus-galli*.

The number of weeds in husked oats canopy stayed on a similar level from 29 to 31 on the treatments with tested tillage systems, irrespective of cultivation. Introducing chemical cultivation resulted in a decrease in the number of species from 1 to 3 as compared with mechanical cultivation. Irrespective of the tested factors, a total of 32 weed species were found in the canopy of husked oats, whereas 33 on the treatment with chemical cultivation and 31 with mechanical. The largest number of species was found on treatments with the simplified tillage system – 32 and with direct sowing – 31.

The floristic composition of the weed community occurring in the canopy of naked oats was also modified by the tested experimental factors, i.e. tillage systems and cultivation (Table 7). Weed species occurring in oats canopy were also characterized by a high stability, mostly in the group of dominant weeds. These made the main core of oats weed infestation: *Capsella bursa-pastoris*, *Apera spica-venti*, *Galinsoga parviflora*, *Chenopodium album*, *Viola arvensis*, *Gnaphalium uliginosum*, *Matricaria maritima* ssp. *inodora*, *Myosotis arvensis*, *Plantago pauciflora* and *Galium aparine*. In the group of perennial weeds, the weeds with the highest proportion were *Elymus repens* and *Cirsium arvense*. It is notable that in canopies of naked oats – similarly to the husked one – there was an increase not only in the number of dominant weeds, but also of the other species participating in weed infestation, mainly on treatments with the system of simplified tillage without the catch crop and with direct sowing. Additionally, such species as *Geranium pusillum*, *Spergula rubra*, *Vicia angustifolia*, *Solanum nigrum* appeared, and of perennial ones – *Sonchus arvensis* (Table 7).

Irrespective of the tested factors, a total of 30 weed species were found in the canopy of naked oats, whereas 27 on treatment with chemical cultivation, and 32 with mechanical. The largest number of species was found on the treatment with direct sowing – 35, whereas on the other treatments this ranged from 25 to 28.

The results of present study presenting varied weed infestation of oats canopy, resulting from the adopted tillage systems and cultivation methods, confirm the literature data indicating a considerable increase in weed infestation of crops as a result of tillage simplification involving simplification or reduction in the number of cultivation practices [Niewiadomski *et al*. 1980, Michalski 1993, Budzyński 1999, Deryło *et al*. 2003]. In this study, a significant increase in the analysed indices of weed infestation occurred mainly in the simplified tillage system and direct sowing, under conditions of mechanical canopy cultivation.

Table 3. Air-dry matter of weeds in husked oats canopy, g·m^{-2}

Year	Tillage system												Methods		Years
	conventional			simplified with catch crop			simplified			direct sowing			mean		mean
	a^{x}	b^{xx}	mean	a	b	mean	a	b	mean	a	b	mean	a	b	
2000	36.6	14.4	25.5	9.3	8.2	8.8	83.4	64.5	74.0	96.1	52.2	74.2	56.4	34.8	45.6
2001	41.7	35.9	38.8	40.6	31.3	36.0	118.1	100.4	109.2	138.2	126.4	132.3	84.6	75.0	79.8
2002	10.6	8.4	9.5	5.0	4.2	4.6	41.4	27.2	34.3	119.3	96.5	107.9	44.1	34.1	39.1
Mean	29.6	19.6	24.6	18.3	14.6	16.5	81.0	64.0	72.5	117.9	91.7	104.8	61.7	48.0	–
$LSD_{0.05}$ for:															
tillage systems				19.6											
cultivation				13.2											
years				25.4											
interaction:															
systems × cultivation				16.5											
systems × year				22.8											
cultivation × year				11.2											

for explanations, see Table 2

Table 4. Species composition and number of weeds per 1 m^2 of husked oats canopy, mean from 2000-2002

No	Species	Tillage system														Mean
		conventional			simplified with catch crop			simplified			direct sowing			mean		
		a[x]	b[xx]	mean	a	b	mean	a	b	mean	a	b	mean	a	b	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							I – Short lived									
1	*Chenopodium album*	13.4	4.8	9.1	2.5	1.8	2.2	14.7	8.3	11.5	4.0	6.4	5.2	8.6	5.3	7.0
2	*Capsella bursa-pastpris*	8.3	4.2	6.2	3.5	2.8	3.2	5.8	5.3	5.5	11.5	3.4	7.6	7.2	3.9	5.5
3	*Viola arvensis*	7.1	5.9	6.5	5.9	2.5	4.2	2.6	3.8	3.2	4.7	10.9	7.8	5.0	5.7	5.4
4	*Galinsoga parviflora*	7.0	4.8	7.4	4.5	0.7	2.5	10.3	8.3	9.4	47.0	30.3	38.6	17.2	11.0	14.5
5	*Matricaria maritima* ssp. *inodorum*	5.2	1.8	3.5	5.6	2.1	3.8	12.8	5.5	9.2	4.9	3.0	3.9	7.1	3.1	5.1
6	*Apera spica-venti*	3.1	3.4	3.4	11.9	11.4	11.6	11.7	16.4	14.0	31.1	40.6	35.8	14.4	17.9	16.2
7	*Polygonum nodosum*	2.2	0.3	1.2	1.2	0.2	0.7	0.5	0.3	0.4	0.7	1.2	0.9	1.2	0.5	0.8
8	*Myosotis arvensis*	1.5	0.3	0.9	0.3	0.6	0.4	0.6	0.2	0.4	0.7	0.4	0.5	0.8	0.3	0.6
9	*Gnaphalium uliginosum*	1.2	1.2	1.2	1.2	0.3	0.7	0.7	0.0	0.4	4.9	0.2	2.5	2.0	0.4	1.2
10	*Plantago pauciflora*	1.2	1.5	1.4	1.2	0.3	0.8	3.7	0.0	1.8	3.4	4.8	4.1	2.4	1.6	2.0
11	*Galeopsis tetrahit*	0.9	1.3	1.1	0.6	1.3	1.0	2.7	1.7	2.2	0.2	0.0	0.1	1.1	1.0	1.1
12	*Lamium purpureum*	0.7	0.8	0.8	0.4	0.3	0.4	0.0	0.2	0.1	0.0	0.0	0.0	0.3	0.3	0.3
13	*Galium aparine*	0.6	0.3	0.4	0.9	0.4	0.7	0.5	0.0	0.2	2.0	1.8	1.9	1.0	0.6	0.8
14	*Stellaria media*	0.3	0.9	0.6	0.6	2.3	1.4	0.7	0.7	0.7	0.4	1.7	1.1	0.5	1.4	1.0
15	*Poa annua*	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.1	0.3	0.7	0.9	0.8	0.4	0.4	0.4
16	*Veronica persica*	0.2	0.2	0.2	0.0	0.1	0.1	0.2	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1
17	*Vicia hirsuta*	0.2	0.1	0.1	0.3	0.1	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.2
18	*Spergularia rubra*	0.2	0.1	0.2	0.3	0.0	0.1	0.4	0.0	0.2	0.3	0.0	0.2	0.3	0.0	0.2
19	*Echinochloa crus-galli*	0.2	0.2	0.2	0.7	1.7	1.2	2.0	0.6	1.3	6.0	4.2	5.1	2.2	1.6	1.9
20	*Lamium amplexicaule*	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.4	0.2	0.3	0.9	0.6	0.2	0.4	0.3
21	*Geranium pusillum*	0.1	0.4	0.2	0.1	0.7	0.4	0.1	1.4	0.8	0.3	1.4	0.8	0.2	1.0	0.6
22	*Matricaria discoidea*	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.2	0.0	0.1	0.1
23	*Polygonum convolvulus*	0.1	0.2	0.2	0.3	0.3	0.3	0.6	0.2	0.4	0.4	0.6	0.5	0.4	0.3	0.4
24	*Spergula arvensis*	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.2	0.1	0.0	0.0
25	*Veronica arvensis*	0.0	0.0	0.0	0.4	0.1	0.2	0.3	0.0	0.2	0.5	1.2	0.8	0.3	0.3	0.3

Table 4 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
26	*Solanum nigrum*	0.0	0.1	0.1	0.1	0.9	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.1
27	*Erigeron canadensis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	2.2	0.5	1.4	0.6	0.2	0.4
28	*Sonhus asper*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.0
29	*Sonchus oleraceus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	*Plantago pauciflora*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
31	*Amaranthus retroflexus*	0.0	0.1	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.0
32	*Erodium cicutarium*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	2.2	0.5	1.4	0.6	0.4	0.4
33	*Polygonum aviculare*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.1	0.0	0.1	0.0
34	*Lapsana communis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	Number of weeds I	54.3	33.3	43.8	43.0	31.3	37.2	71.8	54.5	63.2	128.9	114.8	121.8	74.5	58.3	66.5
	Number of species I	24	24	24	24	22	25	23	23	28	25	24	26	26	29	27
								II – Perennial								
35	*Elymus repens*	5.0	12.0	8.5	1.0	2.3	1.6	4.4	11.0	7.7	0.1	0.7	0.4	2.6	6.5	4.6
36	*Cirsium arvense*	2.6	0.1	1.3	0.0	0.2	0.1	0.4	0.1	0.2	0.6	0.2	0.4	0.9	0.2	0.5
37	*Stachys palustris*	0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
38	*Taraxacum officinale*	0.5	0.2	0.4	0.1	0.0	0.1	0.3	0.0	0.2	0.3	0.4	0.4	0.3	0.2	0.2
39	*Sonchus arvensis*	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.2	0.1	0.2	0.1	0.0	0.2	0.1
40	*Equisetum arvense*	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0
	Number of weeds II	9.0	12.3	10.6	1.2	2.5	1.8	5.1	11.5	8.3	1.3	1.5	1.4	4.1	7.1	5.5
	Number of species II	5	3	5	3	3	3	3	3	4	5	4	5	6	5	5
	Total number of weeds I and II	63.3	45.6	54.4	44.2	33.6	39.0	76.9	66.0	71.4	130.2	116.3	123.3	78.6	65.4	72.0
	Total number of species I and II	29	27	29	27	24	28	26	26	32	30	28	31	31	33	32

a^x – mechanical cultivation
b^{xx} – chemical cultivation
0,0 – species occurrence < 0.1

Table 5. Mean number of weeds in naked oats canopy per 1 m^2

Year	Tillage system												Methods		Years
	conventional			simplified with catch crop			simplified			direct sowing			mean		mean
	a^x	b^{xx}	mean	a	b	mean	a	b	mean	a	b	mean	a	b	
2000	60.0	56.5	58.2	29.2	26.1	27.6	78.8	64.8	71.8	100.4	80.1	90.2	67.1	56.9	62.0
2001	83.8	68.1	76.0	76.9	66.3	71.6	116.8	90.2	103.5	131.0	84.2	107.6	102.1	77.2	89.6
2002	27.8	19.2	23.5	14.8	9.8	12.3	34.2	27.6	30.9	126.0	90.1	108.1	50.7	36.7	43.7
Mean	57.2	47.9	52.6	40.3	34.1	37.2	76.6	60.9	68.7	119.1	84.8	102.0	73.3	56.9	–
$LSD_{0.05}$ for:															
tillage systems				15.9											
cultivation				12.7											
years				18.1											
interaction:															
systems × cultivation				15.6											
systems × year				28.8											
cultivation × year				24.9											

for explanations, see Table 2

Table 6. Air-dry matter of weeds of naked oats canopy, g·m^{-2}

Year	Tillage system												Methods		Years
	conventional			simplified with catch crop			simplified			direct sowing			mean		mean
	a^{x}	b^{xx}	mean	a	b	mean	a	b	mean	a	b	mean	a	b	
2000	28.8	21.7	25.2	20.5	17.1	18.8	62.4	58.3	60.4	83.8	71.5	77.7	48.9	42.2	45.6
2001	52.7	49.6	51.2	48.2	36.7	42.4	101.6	97.3	99.5	125.5	104.9	115.2	82.0	72.1	77.1
2002	19.9	11.9	15.9	10.5	5.4	8.0	40.1	24.6	32.4	121.4	95.7	108.6	48.0	34.4	41.2
Mean	33.8	27.7	30.8	26.4	19.7	23.1	68.0	60.1	64.1	110.2	90.7	100.5	59.6	49.6	–
$LSD_{0.05}$ for:															
tillage systems				22.5											
cultivation				9.9											
years				19.6											
interaction:															
systems × cultivation				18.1											
systems × year				23.6											
cultivation × year				10.4											

for explanations, see Table 2

Table 7. Species composition and number of weeds per 1 m^2 of naked oats canopy, mean from 2000-2002

No.	Species	Tillage system														Mean
		conventional			simplified with catch crop			simplified			direct sowing			mean		
		a[x]	b[xx]	mean	a	b	mean	a	b	mean	a	b	mean	a	b	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
								I – Short lived								
1	*Capsella bursa-pastoris*	8.8	2.8	5.8	5.5	3.8	5.7	7.4	3.8	5.6	13.9	7.2	10.6	8.9	4.4	6.6
2	*Apera spica-venti*	8.3	9.3	8.8	5.7	8.2	7.0	12.1	20.2	16.9	35.9	36.8	36.4	15.5	18.6	17.1
3	*Galinsoga parviflora*	6.3	5.4	5.8	2.5	1.3	1.9	9.4	4.5	7.0	18.4	7.3	12.8	9.1	4.6	6.9
4	*Chenopodium album*	5.4	2.3	3.8	8.0	7.0	7.5	16.2	5.3	10.8	11.0	2.6	6.8	10.2	4.3	7.2
5	*Viola arvensis*	4.3	6.8	5.6	3.2	2.2	2.7	3.1	3.5	3.3	8.9	10.8	9.8	4.9	5.8	5.4
6	*Gnaphalium uliginosum*	4.2	0.8	2.5	1.0	0.3	0.6	2.7	0.5	1.6	1.5	1.0	1.3	2.3	0.6	2.1
7	*Matricaria maritima* ssp. inodora	3.0	5.7	4.6	3.3	1.0	2.2	5.2	5.4	5.3	7.5	3.3	5.4	4.8	4.4	4.6
8	*Myosotis arvensis*	1.3	0.7	1.0	0.8	0.1	0.4	4.7	0.4	2.6	0.7	0.6	0.7	1.9	0.4	1.0
9	*Plantago pauciflora*	1.0	1.1	1.0	2.3	0.2	1.4	1.4	0.2	1.1	2.0	2.2	2.1	1.4	0.9	1.4
10	*Galium aparine*	0.9	0.3	0.6	0.9	0.0	0.4	0.0	0.4	0.2	0.1	1.7	0.9	0.5	0.6	0.5
11	*Polygonum nodosum*	0.8	0.6	0.7	1.5	0.5	1.1	0.7	0.1	0.4	1.2	0.7	1.0	1.6	0.5	0.8
12	*Galeopsis tetrahit*	0.5	1.2	0.8	0.3	1.0	0.8	1.9	1.7	1.8	0.1	0.0	0.1	0.7	0.9	0.8
13	*Spergula arvensis*	0.5	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
14	*Lamium purpureum*	0.3	0.2	0.2	0.3	0.8	0.4	0.0	0.4	0.2	0.0	0.3	0.2	0.2	0.4	0.3
15	*Veronica arvensis*	0.2	0.0	0.1	0.2	0.1	0.2	0.1	0.0	0.0	1.2	1.8	1.5	0.4	0.5	0.4
16	*Stellaria media*	0.2	1.0	0.6	0.4	3.1	1.8	0.3	7.0	3.9	0.7	1.2	1.0	0.4	3.1	2.8
17	*Echinochloa crus-galli*	0.1	0.6	0.4	0.3	0.8	0.6	2.3	0.6	1.4	7.4	2.4	4.9	2.5	1.1	1.8
18	*Veronica persica*	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1
19	*Polygonum aviculare*	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
20	*Polygonum nodosum*	0.8	0.6	0.7	1.5	0.6	1.1	0.7	0.1	0.4	1.2	0.7	1.0	1.1	0.5	0.8
21	*Polygonum convolvulus*	0.1	0.1	0.1	0.3	0.3	0.3	0.6	0.1	0.4	0.4	0.3	0.4	0.2	0.2	0.3
22	*Poa annua*	0.1	0.2	0.2	0.3	0.1	0.2	0.6	0.7	0.6	1.3	0.2	0.8	0.6	0.3	0.3
23	*Lamium amplexicaule*	0.0	0.7	0.4	0.2	0.1	0.2	1.7	0.3	1.0	0.3	0.3	0.3	0.6	0.4	0.5
24	*Vicia angustifolia*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0
25	*Sonchus asper*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0

Table 7 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
26	*Plantago maior*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0
27	*Geranium pusillum*	0.0	0.6	0.3	0.0	0.1	0.1	0.4	0.6	0.5	0.3	1.6	1.0	0.2	0.7	0.6
28	*Spergula rubra*	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.3	0.0	0.2	0.2	0.0	0.1
29	*Vicia hirsuta*	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
30	*Vicia angustifolia*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0
31	*Juncus bufonius*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
32	*Solanum nigrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0
33	*Matricaria discoidea*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
	Number of weeds I	47.3	40.4	42.1	39.0	31.7	35.4	71.9	58.3	65.1	117.3	83.3	100.3	68.9	53.4	61.2
	Number of species I	22	20	22	23	21	25	21	22	21	28	22	29	26	23	24
								II – Perennial								
34	*Elymus repens*	5.0	12.0	8.5	1.0	2.3	1.6	4.4	11.0	7.7	0.1	0.7	0.4	2.6	6.5	4.6
35	*Cirsium arvense*	2.6	0.1	1.3	0.0	0.2	0.1	0.4	0.1	0.2	0.6	0.2	0.4	0.9	0.2	0.5
36	*Stachys palustris*	0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
37	*Taraxacum officinale*	0.5	0.2	0.4	0.1	0.0	0.1	0.3	0.0	0.2	0.3	0.4	0.4	0.3	0.2	0.2
38	*Sonchus arvensis*	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.2	0.1	0.2	0.1	0.0	0.2	0.1
39	*Equisetum arvense*	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0
40	*Artemisia vulgaris*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Number of weeds II	9.9	7.5	8.7	1.3	2.4	1.8	4.7	2.6	3.6	1.8	1.5	1.7	4.4	3.5	4.0
	Number of species II	5	3	4	3	4	3	6	3	4	6	4	6	6	4	6
	Total number of weeds I and II	57.2	47.9	52.6	40.3	34.1	37.2	76.6	60.9	68.7	119.1	84.8	102.0	73.3	56.9	65.1
	Total number of species I and II	27	23	26	26	25	28	27	25	25	34	27	35	32	27	30

for explanations, see Table 6

According to the expectations and results of studies by other authors [Adamiak and Zawiślak 1991, Witkowski *et al*. 1994, Zawiślak and Adamiak 1997, Budzyński *et al*. 1999, Deryło *et al*. 2006, Andruszczak *et al*. 2010], the effect limiting weeds was more effective on treatments with chemical control. The number of weeds and their air-dry weight were lower on treatment protected chemically as compared with mechanical cultivation.

Analysing the species composition of weeds occurring in canopies of husked and naked oats, it should be noted that according to the literature data [Adamiak *et al*. 1991, Zawiślak and Adamiak 1997, Deryło *et al*. 2003, 2006], this was typical of this cereal. Dominant species for both forms of oats were: *Chenopodium album*, *Capsella bursa-pastoris*, *Apera spica-venti*, *Viola arvensis*, *Galinsoga parviflora*, *Matricaria maritima* ssp. *inodora, Myosotis arvensis*, *Gnaphalium uliginosum*, *Plantago pauciflora* and *Polygonum nodosum.* In a small group of perennial species, occurred *Elymus repens* and *Cirsium arvense*.

CONCLUSIONS

1. The largest number of weeds in canopy of husked and naked oats were found in the system of simplified tillage and direct sowing.

2. Introduction of chemical cultivation resulted in a significant reduction of weeds in naked and husked oats on treatments with direct sowing and simplified tillage, as compared with conventional tillage and simplified one with a catch crop.

3. Dominant weeds in canopies of both oats forms were mostly short-lived species: *Chenopodium album*, *Capsella bursa-pastoris*, *Galinsoga parviflora*, *Viola arvensis*, *Matricaria quadriradiata*, *Apera spica-venti*, *Polygonum nodosum*, *Myosotis arvensis*, *Gnaphalium uliginosum;* and of perennial ones, *Elymus repens* and *Cirsium arvense*.

4. Chemical cultivation of husked and naked oats canopy decreased the number of weeds and their air-dry matter, as compared with mechanical cultivation.

5. The largest weed biomass in both husked and naked oats canopies was observed on treatments with the simplified tillage system and direct sowing.

6. Introduction of simplified tillage and direct sowing resulted in an increase in weed infestation of canopies in the studied oats forms (husked and naked), and chemical cultivation was not fully effective.

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WPŁYW SYSTEMÓW UPRAWY ROLI NA ZACHWASZCZENIE ŁANU OWSA OPLEWIONEGO I NAGOZIARNISTEGO

Streszczenie. Celem badań była ocena zachwaszczenia (liczby, biomasy i składu gatunkowego) łanów owsa oplewionego i nieoplewionego w zależności od systemu uprawy roli (klasyczny, uproszczony z międzyplonem, uproszczony, siew bezpośredni) i sposobu pielęgnacji roślin (mechaniczny i chemiczny). Badania przeprowadzono w latach 2000-2002, na glebie płowej, wytworzonej z lessów. Przedmiotem badań był owies oplewiony (odmiana Borowiak) i nieoplewiony (odmiana Akt III). Największa

liczba chwastów występowała w łanie oplewionej (123 szt.·m^{-2}) i nieoplewionej (102 szt.·m^{-2}) odmiany owsa po stosowaniu siewu bezpośredniego, a w przypadku odmiany Akt III także po uprawie uproszczonej (68,7 szt.·m^{-2}). Największą suchą masę chwastów oznaczono po stosowaniu siewu bezpośredniego (Borowiak – 104,8; Akt III – 100,5 g·m^{-2}) i uprawy uproszczonej (Borowiak – 72,5; Akt III – 64,1 g·m^{-2}). Najmniejszą liczbę i masę chwastów w łanach obu odmian owsa stwierdzono po klasycznej uprawie gleby oraz po uprawie uproszczonej ze stosowaniem międzyplonu. Wprowadzenie chemicznego zwalczania chwastów wpłynęło na redukcję liczby i suchej masy chwastów w zakresie od 16 do 22%, zarówno w łanie odmiany Borowiak, jak i Akt III. Szczególnie skuteczne było tam, gdzie stosowano siew bezpośredni lub uprawę uproszczoną. Wśród chwastów dominowały gatunki krótkotrwałe, ale w łanie odmiany Akt III występowało ich więcej niż w łanie odmiany Borowiak. System uprawy roli oraz sposób zwalczania chwastów miały podobny wpływ na zachwaszczenie łanów oplewionej i nieoplewionej odmiany owsa siewnego.

Słowa kluczowe: owies, pielęgnacja, system uprawy roli, zachwaszczenie

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