

ASSESSMENT OF THE EFFECT OF SOWING DENSITY ON WEED INFESTATION AND YIELDS OF THREE SPRING WHEAT CULTIVARS

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Abstract. The aim of this study was to estimate the quantitative indexes of stand weed infestation and yields of three cultivars of spring wheat sown in sowing densities 500 and 800 grains per 1 m². The study was conducted in 2006-2009 in the gray-brown podsolic soil formed from loess. The experimental factors were three cultivars of spring wheat different in respect of morphology: Nawra, Zadra and Korynta, as well as their two sowing densities: 500 and 800 grains per 1 m². Assessment of the effect of research factors on weeds occurring in stand was carried out on treatments without herbicides. State of weed infestation of stand was assessed with the quantitative-gravimetric method before spring wheat harvest. Quantitative weed infestation indexes were significantly modified by the sowing density of spring wheat. Increasing sowing density from 500 to 800 grains per 1 m² resulted in a decrease by 22% in the number of weeds and by 27% in their air-dry weight. Of the assessed cultivars, Korynta and Zadra showed a satisfactory competitiveness against weeds, particularly in conditions of increased sowing density (800 grains·m⁻²). No differences in yield were statistically indicated either between cultivars or depending on sowing density.

Key words: number of spikes per area unit, perennial weeds, short-duration weeds, species composition of weeds, weed weight, wheat canopy

INTRODUCTION

Weeds inseparably accompany agricultural crops. Their negative effect on growing in field is undeniable. Limiting their numbers is particularly troublesome in the organic and integrated systems of agricultural production. Research indicated that agrotechnological methods play a leading role in weed infestation control [Kuś 1996, Domaradzki 2009]. It was indicated that a suitably close and dense stand of cereals decreases light intensity in its lower layers, limiting the growth and development of

undesirable vegetation. This effect can be obtained among other things by increasing the seeding rate and growing properly selected cultivars – high, strongly propagating, with a large area of leaves placed horizontally with a deviated flag leaf and with lower light requirements [Kapeluszny and Haliniarz 2000, Korres and Froud-Williams 2002, Kapeluszny 2002, 2004, Starczewski and Żądelek 2003, Feledyn-Szewczyk and Duer 2005, 2006, Parylak *et al.* 2006, Leszczyńska *et al.* 2007, Noworolnik 2007].

The research hypothesis assumed that a dense and close stand, obtained by increasing the seeding rate, and selection of cultivars with a specific habit will allow spring wheat plants to successfully compete with weeds, decreasing their number and biomass to the level when the application of herbicides will not be necessary. To verify those assumptions, a study was carried out aiming at the assessment of quantitative indexes of stand weed infestation and yields of three cultivars of spring wheat differing in respect of morphology depending on their sowing rate.

MATERIAL AND METHODS

The study was carried out in 2006-2009 on the Experimental Farm at Czesławice (51°18' N, 22°16' E) (the Nałęczów Plateau), in the gray-brown podsolcic soil formed from loess (the good wheat complex). The experiment was established with the randomized complete block design in three replications. The area of plots for sowing and harvest was 13.5 m². The experimental factors were three cultivars of spring wheat, different in respect of morphology: Nawra, Zadra and Korynta and their two sowing densities: 500 and 800 grains per 1 m². No weed controlling treatments were used on the plots.

The cultivar Nawra was characterized by a short stem (on average 82 cm), whereas Korynta and aristate Zadra are classified as long-straw wheats, whose mean length was 97 cm and 92 cm, respectively [Descriptive list... 2008]. Competitiveness of cereals against weeds is also determined by such parameters as the leaf area index (LAI) and their mean angle (MTA). They were determined in 2007 and 2008, making measurements with the LAI-2000 gauge made by Li-COR, at the stage of spring wheat earing (BBCH=49-50). The cultivar Zadra was characterized by the highest leaf area index (LAI = 5.73) and also the least leaf angle (MTA = 56), Nawra was characterized by moderate values of those indexes (LAI = 5.50, MTA = 57), whereas Korynta had the largest leaf angle (MTA = 59) and the least average index LAI = 5.31.

The forecrop of wheat was sugar beet. Tillage was carried out in a typical way of plowing. Mineral fertilization in kg per 1 ha was: N – 80, P – 22, K – 50. The half of the N rate was applied preplant and the half at the stage of earing.

Grain before sowing was dressed with the seed dressing Raxil Gel 206 (tiuram + tebuconazole) in a dose of 500 cm³ per 100 kg of grain. Chemical control against fungal diseases and pests involved the application of the fungicide Alert 375 SC (flusilazole + carbendazim) in a dose of 1.0 dm³·ha⁻¹ and the insecticide Decis 2.5 EC (deltamethrin) in a dose of 0.25 dm³·ha⁻¹ at the initial stage of shooting [BBCH-30].

The assessment of stand weed infestation with the quantitative-gravimetric method and the number of spikes per area unit were carried out before the harvest of spring wheat. Species composition, numbers and air-dry weight of above-ground parts of weeds were determined in the area 1.0 x 0.5 m, in two randomly selected places of the

plot. Wheat spikes were counted in the same areas. Harvest was carried out between 10th and 20th August, at the stage of grain full maturity.

The obtained results were subject to the analysis of variance, and significances of differences were estimated with Tukey's test. Also correlation coefficients between the yield and the number of spikes of spring wheat and the number and air-dry weight of weeds were calculated.

RESULTS

Weed infestation of spring wheat stand was significantly different in the years of the study (Table 1, 2). The smallest quantitative indexes of weed infestation were recorded in 2008, when at the initial developmental stages of wheat heavy rainfalls occurred exceeding long-term means. Weeds occurred in largest amounts in 2007, their number amounted to 217.5 plants·m⁻². They in turn produced the largest biomass in 2006 and 2007. The year 2006 was characterized by rainfalls on the level of the long-term mean and an average temperature of 15.4°C, and in 2007 rainfalls were less by 82.9 mm than the long-term mean, and the average temperature amounted to 15.8°C.

Table 1. Precipitation and air temperature in April-August in comparison with long-term means according to Meteorological Station in Czesławice

Tabela 1. Opady i temperatura powietrza od kwietnia do sierpnia w zestawieniu ze średnimi wieloletnimi według Stacji Meteorologicznej w Czesławicach

Year Rok	Month – Miesiąc					Total Suma
	April kwiecień	May maj	June czerwiec	July lipiec	August sierpień	
Precipitation – Opady, mm						
2006	26.1	68.1	23.2	26.6	202.5	346.5
2007	16.4	46.4	85.1	70.0	31.4	249.3
2008	52.2	103.8	30.2	77.1	55.1	318.4
2009	0.0	72.5	126.1	54.7	56.2	309.5
Mean from Średnie z lat 1966-1995	44.5	59.5	80.2	79.4	68.6	332.2
Temperature – Temperatura, °C						Mean Średnia
2006	8.5	13.3	16.9	21.1	17.4	15.4
2007	8.2	14.9	18.2	18.8	18.8	15.8
2008	8.2	12.5	16.8	18.4	18.6	14.9
2009	10.2	12.9	15.8	19.7	18.4	15.4
Mean from Średnie z lat 1966-1995	7.6	13.4	16.3	17.9	17.4	14.5

Diversification of sowing rate into 500 and 800 grains per 1 m² significantly modified the weed infestation of spring wheat (Table 2). On average in the four-year period, an increase in sowing rate by 300 grains per 1 m² decreased by 22% the number of weeds and by 27% their air-dry weight. A tendency to less weed infestation in the thicker stand of spring wheat was noticeable in each year of the study. In the experiment

a total of 37 weed species were registered, including 29 short-duration and 8 perennial (Table 3). In the thinner stand, 36 weed species were observed, including 28 short-duration plants. In the thicker stand the weed flora was poorer by 4 species – 1 short-duration and 3 perennial. In respect of the number, short-duration weeds definitely predominated. In wheat sown at a rate of 500 grains per 1 m² the number of short-duration weeds was 195.3 plants·m⁻², whereas perennial 6.8 plants·m⁻². On treatments with an increased sowing density the number of short-duration weeds, in comparison with the thinner stand, decreased by 23%, whereas the number of perennial weeds stayed on the same level. Irrespective of the sowing density, the predominating species was *Chenopodium album*. Taxons with the number of specimens higher than 10 plants·m⁻² were: *Galinsoga parviflora*, *Galinsoga ciliata* and *Polygonum lapathifolium* subsp. *lapathifolium*. An increase in stand density affected a considerable reduction in the population of *Chenopodium album* and *Galinsoga parviflora*, as well as a decrease in number or absence of 13 other species of weeds.

Table 2. Number and air-dry weight of weeds per 1 m² before spring wheat harvest

Tabela 2. Liczba i powietrznie sucha masa chwastów na 1 m² przed zbiorem pszenicy jarej

Year Rok	Sowing density, grains·m ⁻² Gęstość wysiewu, szt.·m ⁻²		Cultivar – Odmiana			Mean Średnia
	500	800	Korynta	Nawra	Zadra	
Number of weeds, plants·m ⁻² – Liczba chwastów, szt.·m ⁻²						
2006	217.8	125.1	154.3	210.2	149.8	171.4
2007	228.8	206.2	214.1	227.5	210.9	217.5
2008	161.1	121.7	135.8	164.4	124.0	141.4
2009	200.7	178.2	221.3	163.0	184.0	189.4
Mean Średnia	202.1	157.8	181.4	191.2	167.2	–
LSD _{0.05} – NIR _{0.05} for – dla:						
cultivars – odmian						ns – ni
density – gęstości						30.5
years – lat						57.2
Air-dry weight of weeds – Powietrznie sucha masa chwastów, g·m ⁻²						
2006	160.8	128.3	130.5	141.9	161.5	144.6
2007	122.0	102.9	111.7	130.5	95.2	112.4
2008	35.1	27.4	26.3	44.2	23.2	31.2
2009	100.8	45.3	76.6	65.8	76.9	73.1
Mean Średnia	104.7	76.0	86.3	95.6	89.2	–
LSD _{0.05} – NIR _{0.05} for – dla:						
cultivars – odmian						ns – ni
density – gęstości						20.3
years – lat						38.1

ns – ni – non significant differences – różnice nieistotne

Table 3. Species composition and number of weeds depending on sowing density (mean from 2006-2009)

Tabela 3. Skład gatunkowy i liczba chwastów w zależności od gęstości siewu (średnia z lat 2006-2009)

Lp.	Species – Gatunek	Sowing density, grains·m ⁻² Gęstość wysiewu, szt.·m ⁻²	
		500	800
Short-duration – Krótkotrwałe			
1	<i>Chenopodium album</i> L.	121.8	84.3
2	<i>Galinsoga parviflora</i> Cav.	26.5	17.8
3	<i>Galinsoga ciliata</i> (Raf.) S.F. Blake	14.6	12.8
4	<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	10.4	11.9
5	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	7.3	8.9
6	<i>Viola arvensis</i> Murray	5.3	5.3
7	<i>Capsella bursa-pastoris</i> (L.) Medik.	2.2	0.5
8	<i>Fallopia convolvulus</i> (L.) Á. Löve	1.6	1.7
9	<i>Galepsis tetrahit</i> L.	1.0	2.2
10	<i>Galium aparine</i> L.	0.7	1.6
11	<i>Stellaria media</i> (L.) Vill.	0.6	0.8
12	<i>Matricaria maritima</i> L. subsp. <i>inodora</i>	0.5	0.1
13	<i>Solanum nigrum</i> L. emend. Mill.	0.4	0.3
14	<i>Lamium amplexicaule</i> L.	0.4	0.6
15	<i>Veronica persica</i> Poir.	0.3	0.3
16	<i>Amaranthus retroflexus</i> L.	0.3	0.0
17	<i>Thlaspi arvense</i> L.	0.3	0.5
18	<i>Polygonum aviculare</i> L.	0.2	0.2
19	<i>Vicia hirsuta</i> (L) Gray	0.2	0.1
20	<i>Lapsana communis</i> L. s. str.	0.1	0.4
21	<i>Geranium pusillum</i> Burm. F. ex L.	0.1	0.2
22	<i>Avena fatua</i> L.	0.1	0.1
23	<i>Veronica arvensis</i> L.	0.1	–
24	<i>Lamium purpureum</i> L.	0.1	0.1
25	<i>Gnaphalium uliginosum</i> L.	0.1	0.1
26	<i>Myosotis arvensis</i> (L.) Hill	0.1	0.1
27	<i>Vicia angustifolia</i> L.	0.0	–
28	<i>Conyza canadensis</i> (L.) Cronquist	0.0	0.1
29	<i>Poa annua</i> L.	–	0.0
Total short-duration – Razem krótkotrwałe		195.3	151.0
Number of short-duration species Liczba gatunków krótkotrwałych		28	27
Perennial – Wieloletnie			
1	<i>Equisetum arvense</i> L.	1.7	2.5
2	<i>Cirsium arvense</i> (L.) Scop.	0.5	0.6
3	<i>Stachys palustris</i> L.	0.1	–
4	<i>Elymus repens</i> (L.) Gould	3.1	2.5
5	<i>Taraxacum officinale</i> F. H. Wigg.	1.3	1.1
6	<i>Plantago intermedia</i> Gilib.	0.1	0.1
7	<i>Urtica dioica</i> L.	0.0	–
8	<i>Convolvulus arvensis</i> L.	0.0	–
Total perennial – Razem wieloletnie		6.8	6.8
Number of perennial species – Liczba gatunków wieloletnich		8	5
Total number of weeds – Łączna liczba chwastów		202.1	157.8
Number of species – Liczba gatunków		36	32

0.0 – number of weeds less than 0.1 plants·m⁻² – liczba chwastów mniejsza niż 0,1 szt.·m⁻²

The studied cultivars did not significantly affect the number and air-dry weight of weeds in the stand (Table 2). Nevertheless, it was observed that the most weeds and with the highest biomass was in the stand of the short-straw cultivar Nawra. The smallest number of weeds was recorded in the stand of the aristate cultivar Zadra, and the smallest biomass was made by weeds in the stand of the cultivar Korynta. No significant effect of cultivars and sowing density on weed infestation parameters was not statistically proved (Figs 1, 2). However, it was observed that in the case of the cultivar Nawra limiting the weed infestation of the stand after increasing the seeding rate was the smallest. In contrast, the highest competitive effect of an increased cereal thickness on weeds was revealed in stands of the cultivar Zadra (the number smaller by 33% and a reduction of air-dry weight by 41%).

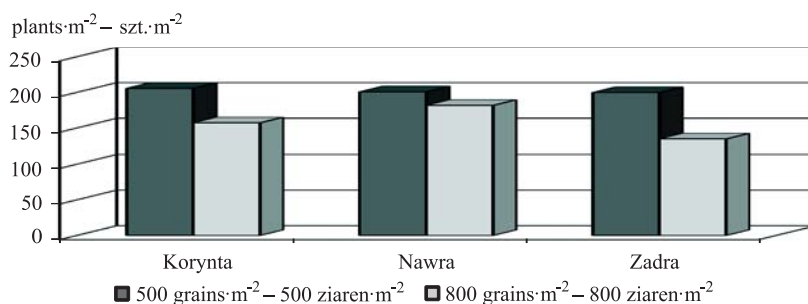


Fig. 1. Effect of sowing density and cultivars of spring wheat on number of weeds occurring in stand (mean from 2006-2009)

Rys. 1. Wpływ gęstości siewu i odmian pszenicy jarej na liczbę chwastów występujących w łanie (średnia z lat 2006-2009)

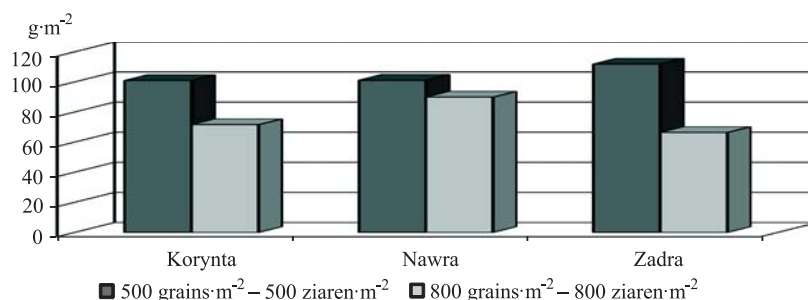


Fig. 2. Effect of sowing density and cultivars of spring wheat on air-dry weight of weeds occurring in stand (mean from 2006-2009)

Rys. 2. Wpływ gęstości siewu i odmian pszenicy jarej na powietrznie suchą masę chwastów występujących w łanie (średnia z lat 2006-2009)

Agrophytocenoses of the studied cultivars differed slightly in species composition and the number of occurring weeds (Table 4). In the stand of the cultivar Korynta 26 short-duration taxons and 8 perennial ones were recorded. A similar set of species occurred in stands of the cultivar Nawra. In the variant with the cultivar Zadra 25 short-duration taxons and 6 perennial were found. In each of the studied cultivars, the predominant species were *Chenopodium album*, *Galinsoga parviflora* and *G. ciliata*.

Table 4. Species composition and number of weeds in stand of three cultivars of spring wheat (mean from 2006-2009), plants·m⁻²Tabela 4. Skład gatunkowy i liczba chwastów w łanie trzech odmian pszenicy jarej (średnia z lat 2006-2009), szt.·m⁻²

Lp.	Species – Gatunek	Cultivar – Odmiana		
		Korynta	Nawra	Zadra
Short-duration – Krótkotrwałe				
1	<i>Chenopodium album</i> L.	84.5	101.8	92.8
2	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	32.9	6.5	7.4
3	<i>Galinsoga parviflora</i> Cav.	19.9	27.7	17.5
4	<i>Galinsoga ciliata</i> (Raf.) S.F. Blake	11.5	16.8	12.3
5	<i>Viola arvensis</i> Murray	6.7	5.9	5.8
6	<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	6.5	11.8	6.6
7	<i>Stellaria media</i> (L.) Vill.	2.9	0.9	0.6
8	<i>Lamium amplexicaule</i> L.	1.6	0.5	0.3
9	<i>Galium aparine</i> L.	1.5	1.1	1.0
10	<i>Fallopia convolvulus</i> (L.) Á. Löve	0.7	1.5	1.7
11	<i>Matricaria maritima</i> L. subsp. <i>inodora</i>	0.7	0.4	0.7
12	<i>Lapsana communis</i> L. s. str.	0.6	0.2	–
13	<i>Myosotis arvensis</i> (L.) Hill	0.6	0.0	0.1
14	<i>Galeopsis tetrahit</i> L.	0.5	2.6	2.8
15	<i>Veronica persica</i> Poir.	0.5	0.4	0.2
16	<i>Avena fatua</i> L.	0.4	0.1	0.1
17	<i>Capsella bursa-pastoris</i> (L.) Medik.	0.4	2.1	3.0
18	<i>Geranium pusillum</i> Burm. F. ex L.	0.3	0.0	0.2
19	<i>Solanum nigrum</i> L. emend. Mill.	0.3	0.6	0.2
20	<i>Polygonum aviculare</i> L.	0.3	0.3	0.3
21	<i>Gnaphalium uliginosum</i> L.	0.2	0.1	–
22	<i>Lamium purpureum</i> L.	0.1	0.1	0.0
23	<i>Vicia hirsuta</i> (L.) Gray	0.1	0.3	0.1
24	<i>Veronica arvensis</i> L.	0.1	0.2	0.1
25	<i>Vicia angustifolia</i> L.	0.0	–	–
26	<i>Poa annua</i> L.	0.0	–	–
27	<i>Conyza canadensis</i> (L.) Cronquist	–	–	0.1
28	<i>Amaranthus retroflexus</i> L.	–	0.1	0.5
29	<i>Thlaspi arvense</i> L.	–	0.6	0.6
Total short-duration – Razem krótkotrwałe		173.9	182.6	155.0
Number of short-duration species		26	26	25
Liczba gatunków krótkotrwałych				
Perennial – Wieleoletnie				
1	<i>Equisetum arvense</i> L.	4.1	2.6	3.2
2	<i>Cirsium arvense</i> (L.) Scop.	1.7	1.3	1.9
3	<i>Stachys palustris</i> L.	0.8	1.4	5.2
4	<i>Elymus repens</i> (L.) Gould	0.4	2.4	1.1
5	<i>Taraxacum officinale</i> F. H. Wigg.	0.4	0.9	0.7
6	<i>Urtica dioica</i> L.	0.1	0.0	–
7	<i>Plantago intermedia</i> Gilib.	0.0	0.0	0.2
8	<i>Convolvulus arvensis</i> L.	0.0	–	–
Total perennial – Razem wieloletnie		7.5	8.6	12.3
Number of perennial species		8	7	6
Liczba gatunków wieloletnich				
Total number of weeds – Łączna liczba chwastów		181.4	191.2	167.2
Number of species – Liczba gatunków		34	33	31

0.0 – number of weeds less than 0.1 plants·m⁻² – liczba chwastów mniejsza niż 0,1 szt.·m⁻²

Sowing density significantly differentiated the number of wheat spikes before harvest (Table 5). The number of ear-bearing stems in a thinner stand amounted to 441.1 stems·m⁻² and was by 11.2% smaller than the number of sown grains. In the stand with a higher seeding rate by as many as 30.4% less spikes per area unit were observed in comparison with the number of sown grains.

Table 5. Number of spikes per area unit before harvest of three cultivars of spring wheat depending on sowing density, spikes·m⁻² (mean from 2006-2009)

Tabela 5. Obsada kłosów przed zbiorem trzech odmian pszenicy jarej w zależności od gęstości wysiewu, szt·m⁻² (średnia z lat 2006-2009)

Cultivar – Odmiana	Sowing density, grains·m ⁻² Gęstość siewu, szt·m ⁻²		Mean – Średnia
	500	800	
Korynta	435.6	558.4	497.0
Nawra	436.8	529.7	483.3
Zadra	459.9	581.6	520.8
Mean – Średnia	441.1	556.6	–
LSD _{0.05} – NIR _{0.05} for – dla:			
cultivars – odmian			35.9
density – gęstości			24.4

Increasing the seeding rate from 500 to 800 grains·m⁻² was not reflected in grain yields (Table 6). In both variants wheat yielded on the same level. Also no significant differences were recorded in yields of the studied cultivars. The highest yields were obtained by the cultivar Zadra, which formed significantly more spikes per area unit and was characterized by the lowest weed infestation, as compared with the other cultivars.

Table 6. Grain yield of three cultivars of spring wheat depending on sowing density, Mg·ha⁻¹ (mean from 2006-2009)

Tabela 6. Plon ziarna trzech odmian pszenicy jarej w zależności gęstości wysiewu, Mg·ha⁻¹ (średnia z lat 2006-2009)

Cultivar – Odmiana	Sowing density, grains·m ⁻² Gęstość siewu, szt·m ⁻²		Mean – Średnia
	500	800	
Korynta	5.00	4.96	4.98
Nawra	4.92	4.94	4.93
Zadra	5.09	5.25	5.17
Mean – Średnia	5.00	5.05	–
LSD _{0.05} – NIR _{0.05} for – dla:			
cultivars – odmian			ns – ni
density – gęstości			ns – ni

ns – ni – non significant differences – różnice nieistotne

The grain yield of spring wheat from all the period of the study as negatively correlated with air-dry weight of weeds (Table 7). A significantly negative correlation was found in all the variants of the experiment, and correlation coefficients (r) ranged from -0.53 to -0.91. Productivity of spring wheat was negatively correlated with the number of weeds per area unit (Table 8). Statistically significant correlation coefficients

were recorded only in the case of the cultivars Korynta and Nawra, sown at a density of 500 grains·m⁻².

Table 7. Correlation coefficients (r) between air-dry weight of weeds and grain yield of spring wheat (mean from 2006-2009)

Tabela 7. Współczynniki korelacji (r) między powietrznie suchą masą chwastów i plonem ziarna pszenicy jarej (średnia z lat 2006-2009)

Cultivar – Odmiana	Sowing density, grains·m ⁻² – Gęstość siewu, szt.·m ⁻²	
	500	800
Korynta	-0.63*	-0.64*
Nawra	-0.71*	-0.52*
Zadra	-0.91*	-0.67*

* significant correlation coefficient (0.05) – istotny współczynnik korelacji (0,05)

Table 8. Correlation coefficients (r) between number of weeds and grain yield of spring wheat (mean from 2006-2009)

Tabela 8. Współczynniki korelacji (r) między liczbą chwastów i plonem ziarna pszenicy jarej (średnia z lat 2006-2009)

Cultivar – Odmiana	Sowing density, grains·m ⁻² – Gęstość siewu, szt.·m ⁻²	
	500	800
Korynta	-0.55*	-0.01
Nawra	-0.54*	-0.15
Zadra	-0.09	-0.24

* significant correlation coefficient (0.05) – istotny współczynnik korelacji (0,05)

A negative correlation was also indicated between the biomass of weeds and the number of ear-bearing stems of spring wheat (Table 9). A significant relationship was found in relation to all three cultivars sown at a density of 500 grains per m² as well as the cultivars Korynta and Nawra sown in an amount of 800 grains per m². The number of spikes was negatively correlated with the number of weeds in stands of thinner cultivars Korynta and Zadra (Table 10).

Table 9. Correlation coefficients (r) between air-dry weight of weeds and number of spikes of spring wheat (mean from 2006-2009)

Tabela 9. Współczynniki korelacji (r) między powietrznie suchą masą chwastów i liczbą kłosów pszenicy jarej (średnia z lat 2006-2009)

Cultivar – Odmiana	Sowing density, grains·m ⁻² – Gęstość siewu, szt.·m ⁻²	
	500	800
Korynta	-0.61*	-0.67*
Nawra	-0.58*	-0.52*
Zadra	-0.72*	-0.01

* significant correlation coefficient (0.05) – istotny współczynnik korelacji (0,05)

Table 10. Correlation coefficients (r) between number of weeds and number of spikes before harvest of spring wheat (mean from 2006-2009)Tabela 10. Współczynniki korelacji (r) między liczbą chwastów i obsadą kłosów przed zbiorem pszenicy jarej (średnio z lat 2006-2009)

Cultivar – Odmiana	Sowing density, grains·m ⁻² – Gęstość siewu, szt.·m ⁻²	
	500	800
Korynta	-0.58*	-0.40
Nawra	-0.15	-0.17
Zadra	-0.67*	-0.20

* significant correlation coefficient (0.05) – istotny współczynnik korelacji (0,05)

DISCUSSION

Increasing the sowing density from 500 to 800 grains per 1 m² resulted in a significant decrease in the number and air-dry weight of weeds. An example of suppressive effect of increased sowing density on weeds is the study carried out by Kapeluszny [2002, 2004] in the experiment with the spring wheat cultivar Helia. Similarly to the study presented in this work, particularly short-duration weeds responded with a decrease in numbers. Winter wheat, at the higher species diversity of weed flora, also drives them from the stand, if we sow it denser than it is recommended [Piekarczyk 2010]. Improvement of the competitiveness of wheat against weeds after increasing its seeding rate was also reported by Blackshaw *et al.* [2000] and Weiner *et al.* [2001]. Analyzing the response of individual weed species to diverse density of cereal stand it was found that increasing the seeding rate of spring wheat from 204 to 449 to 721 grains per 1 m² resulted in a decrease in the biomass of *Chenopodium album*, *Lolium multiflorum* and *Stellaria media*, whereas *Sinapis alba* turned out to be a considerably larger competitor for cereal [Olsen *et al.* 2006]. Increasing the sowing density of spring wheat in lessive soil from 300 to 550 grains does not always result in a decrease of all the parameters of weed infestation, which is proved by results obtained by Wesołowski [2003].

Increased interest in non-chemical methods of weed infestation control in agrophytocenoses creates the need for selecting cultivars highly competitive against weeds. The conducted study does not allow us to state definitely which cultivar showed the highest competitiveness. The long-strawed Korynta and aristate Zadra, with the highest LAI index, show a certain similarity. Also Lemerle *et al.* [1996], as well as Feledyn-Szewczyk and Duer [2005, 2006], in their studies reported signs of competitive effect on weeds of wheat cultivars with a large leaf area and long stems..

In scientific works it is stressed that the number of plants per area unit is not directly proportional to the number of sown grains, since along with more dense sowing, an increased plants losses during growth is observed [Leszczyńska and Noworolnik 2002, Leszczyńska *et al.* 2007]. This phenomenon is also observed in the conducted study. The large number of lost wheat plants and the significantly lower weed infestation of the denser stand may be explained with increased competition between plants for water, light and nutrients. This process is called the self-regulation of stand density [Leszczyńska *et al.* 2007].

Increasing the seeding rate of wheat by 80% did not contribute to an increase in grain yield. Such a response of spring wheat to thickened sowing finds confirmation in

literature. According to Leszczyńska *et al.* [2007], along with an increase in seeding rate to the level of the optimal stand density the yield grows, then undergoes stagnation, and with further increase in seeding rate it decreases.

Productivity of spring wheat and the number of spikes per area unit were significantly negatively correlated with the biomass of weeds. However, statistically proved relationships between the number of weeds and the yield and the number of ear-bearing stems were observed only in variants of thinner sowing. According to Kwiatkowski [2009], the productivity and yield structure components of spring cereals are usually negatively correlated with quantitative indexes of weed infestation, and a significant correlation coefficient most often refers to the weed dry weight. Moreover, Starczewski and Czarnocki [2004] indicated that spring cereals in comparison with winter ones are characterized by a smaller competitive ability against weeds, which manifests itself in statistically proved negative correlations between the weight of weeds and grain yield.

CONCLUSION

The results of the four-year study indicated a higher competitiveness of a more dense stand of spring wheat against weeds, in comparison with a thinner stand. Satisfactory weed controlling effect was obtained for the cultivars Korynta and Zadra, and slightly weaker for the cultivar Nawra, sown at a rate of 800 grains·m⁻². The grain yield of wheat did not depend significantly on the cultivar and the sowing rate.

Therefore it seems appropriate to conduct further breeding work over obtaining highly competitive cultivars and to work out a technology of their growing, ensuring effective reduction of weed infestation at a limited herbicide interference.

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OCENA WPŁYWU GĘSTOŚCI SIEWU NA ZACHWASZCZENIE I PLONOWANIE TRZECH ODMIAN PSZENICY JAREJ

Streszczenie. Celem pracy była ocena ilościowych wskaźników zachwaszczenia ładu oraz plonowania trzech odmian pszenicy jarej, wysiewanych w obsadzie 500 i 800 ziarniaków na 1 m². Badania prowadzono w latach 2006-2009 na glebie płowej wytworzonej z lessu. Czynnikiem badawczym były trzy, zróżnicowane pod względem morfologicznym odmiany pszenicy jarej: Nawra, Zadra i Korynta oraz dwie gęstości ich wysiewu 500 i 800 ziaren na 1 m². Ocenę wpływu czynników badawczych na występujące w łanie chwasty przeprowadzano w obiektach bez herbicydów. Stan zachwaszczenia ładu metodą ilościowo-wagową oceniono przed zbiorem pszenicy jarej. Ilościowe wskaźniki zachwaszczenia były istotnie modyfikowane przez gęstość siewu pszenicy jarej. Zwiększenie ilości wysiewu z 500 do 800 ziaren na 1 m² wpłynęło na obniżenie o 22% liczby chwastów i o 27% ich powietrznie suchej masy. Spośród ocenianych odmian zadowalającą konkurencyjność względem chwastów wykazały odmiany Korynta i Zadra, zwłaszcza w warunkach zwiększonej gęstości wysiewu (800 ziaren·m⁻²). Statystycznie nie wykazano różnic w plonowaniu ani pomiędzy odmianami, ani w zależności od gęstości siewu.

Słowa kluczowe: chwasty krótkotrwałe, chwasty wieloletnie, ład pszenicy, masa chwastów, obsada kłosów, skład gatunkowy chwastów

Accepted for print – Zaakceptowano do druku: 29.02.2012