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IMPACT OF WEED CONTROL METHOD AND SOWING DENSITY ON YIELDING OF SELECTED WINTER SPELT (*TRITICUM SPELTA* L.) CULTIVARS

WPŁYW METODY OGRANICZANIA ZACHWASZCZENIA I ILOŚCI WYSIEWU NA PLONOWANIE WYBRANYCH ODMIAN PSZENICY ORKISZ (*TRITICUM SPELTA* L.)

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Streszczenie. Badania polowe przeprowadzono w latach 2010–2013 w Rolniczej Stacji Doświadczalnej Zachodniopomorskiego Uniwersytetu Technologicznego w Lipniku koło Stargardu Szczecińskiego (Polska). Celem badań było określenie wpływu dwóch metod ograniczenia zachwaszczenia (mechanicznej i chemicznej) i trzech gęstości siewu na plonowanie, komponentów plonowania i parametrów fizjologicznych niektórych odmian pszenicy orkisz i pszenicy zwyczajnej. Zastosowanie herbicydu w 2011 roku nie miało istotnego wpływu na plon ziarna roku w porównaniu z metodą mechaniczną, ale zwiększyło plonowanie w 2012 i 2013 roku. Zwiększenie gęstości siewu z 300 do 500 ziaren na m^2 zwiększyło plon ziarna i obsadę kłosów oraz zmniejszyło liczbę ziaren w kłosie. Masa tysiąca ziaren była podobna niezależnie od gęstości siewu. Największy plon ziarna w badanym okresie otrzymano od pszenicy zwyczajnej odmiany Tonacja, mniejsze od niezarejestrowanych odmian pszenicy orkisz ze Stacji Hodowli Roślin Strzelce, a najmniejszy od odmiany pszenicy orkisz Oberkulmer Rotkorn. Reakcja odmian pszenicy orkisz na metodę kontroli zachwaszczenia oraz różne gęstości siewu była podobna.

Key words: common wheat, grain yield, sowing density, spelt wheat, weed control.
Słowa kluczowe: gęstość siewu, ograniczanie zachwaszczenia, plon ziarna, pszenica orkisz, pszenica zwyczajna.

INTRODUCTION

The health-promoting properties of spelt grain products (*Triticum spelta* L.) encourage customers to buy items produced with its use (Tyburski and Żuk-Gołaszewska 2005, Ceglińska and Cacak-Pietrzak 2009). Spelt grain contains more protein and mineral

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compounds than common wheat grain (Capouchova 2001, Abdel-Aal and Hucl 2002). This cereal is particularly predestined to be cultivated in low-input (extensive) conventional (Moudrý and Dvořáček 1999, Rachoń et al. 2009) as well as in organic farms (Pałys and Kuraszkiewicz 2003, Sulewska 2004). Spelt's particular usefulness for cultivation in organic farms is a result of its characteristics, which decrease habitat pressure including diseases and weeds (Hoffmann et al. 1970, Wiwart et al. 2004, Feledyn-Szewczyk and Duer 2008, Feledyn-Szewczyk 2012).

The aim of this research was to assess the impact of different weed control methods and sowing densities on yield components of spelt cultivars compared to common wheat.

MATERIAL AND METHODS

The field experiment was carried out in the years 2010–2013 at the Experimental Agricultural Station in Lipnik, a property of West Pomeranian Technological University, near Stargard Szczeciński. The experiment was established on light, good rye soil. The soil is classified as brown soil developed from light loamy sand, with slightly acidic pH (pH 1 M KCl = 6.5), moderate content of phosphorus (103 mg $P_2O_5 \cdot kg^{-1}$ of soil) and potassium (117 mg $K_2O \cdot kg^{-1}$ of soil) and low magnesium (28 mg $Mg \cdot kg^{-1}$ of soil).

The experiment included the following factors: I – a weed control method (mechanical – double harrowing at the three leaves phase; chemical – application of a herbicide containing a. i. diflufenican + isoproturon, II – sowing density (300, 400, 500 germinating grains per m^2) and III – a cultivar of spelt and common wheat (STH 8, STH 11, STH 28–4609, STH 28–4614, STH 28–4619 – spelt non-registered cultivars, Oberkulmer Rotkorn – spelt registered cultivar, Tonacja – common wheat cultivar). The following spelt cultivars STH 8, STH 11, STH 28–4609, STH 28–4614, STH 28–4619 belongs to Plant Breeding Strzelce Sp. z o.o. – IHAR Group. The forecrop consisted of oat + spring vetch grown for the seeds. After harvesting the forecrop classic soil tillage for winter cereals was carried out. Before sowing there was an NPK fertilizer applied (24 kg N and 90 kg P_2O_5 and 120 kg K_2O per hectare). Sowing was conducted in 3rd decade of September using an Oyord crop seeder. The experiment was set in a split-split-plot configuration in four replications. After sowing a Legato Plus 500 SC herbicide was applied onto the crops where the chemical weed control had been planned. The mechanical weeding was conducted at three leaves phase using a tooth harrow.

The measurement of leaves' area was conducted during flowering at three locations on the crop using an AccuPAR LP–80 Decagon device as well as a measurement of greenness index of a flag leaf for 30 plants using a SPAD–502 Konica Minolta chlorophyll measurement device. Before harvesting a measurement of plants' height was conducted (at 20 sites) and plants were sampled from the area of 0.125 m^2 from four localizations on each crop. One-step harvesting using a plot harvester was carried out during the phase of grains full-maturity. The area of the harvested crop stood at 18 m^2. After harvesting the mixture of spikelets and grain of a spelt was threshed in a laboratory thresher.

A sample was taken from the obtained grain and the mass of 1000 grains was determined [according to Polish norm PN-68/R-74017]. The numbers of ears were counted in the plant samples before threshing and subsequently the number of grains in an ear was determined.

The results were processed statistically separately for each study year using the variance analysis for a split-split-plot configuration. The results' synthesis was carried out according to the inaccuracies model. The values of LSD was calculated with the Tukey's test at p = 0.05. The statistical analysis was carried out using the ANALWAR – 5.3 FR programme by Franciszek Rudnicki (University of Life Science and Technology in Bydgoszcz, Poland).

Table 1. Temperature and sum of rainfall during spring vegetation season in Agricultural Experimental Station in Lipnik compared to multi-year average of 1980–2009
Tabela 1. Temperatura powietrza i suma opadów w okresie wiosennej wegetacji w Rolniczej Stacji Doświadczalnej w Lipniku w porównaniu z wieloleciem 1980–2009

Month Miesiąc	Average monthly temperature Średnia miesięczna temperatura [^{o}C]				Average monthly rainfall Średnia miesięczna suma opadów [mm]			
	2011	2012	2013	1980–2009	2011	2012	2013	1980–2009
March – Marzec	3.5	5.7	–1.7	3.9	23.9	9.4	6.9	39.6
April – Kwiecień	11.4	8.3	7.7	8.3	11.6	23.4	23.2	34.1
May – Maj	14.0	14.1	14.2	13.6	28	18.2	42.5	47.7
June – Czerwiec	17.6	15.5	16.5	16.2	32.3	31.2	14.4	65.3
July – Lipiec	17.4	18.2	19.2	18.5	150.5	111.3	4.7	62.4
Mean temperature Średnia temperatura Sum of rainfall Suma opadów	12.8	12.3	11.2	12.1	246.3	193.5	91.7	249.1

The data in the Table 1 indicates that mean temperatures in the spring months were close to the multi-year average (1980–2009). However, the precipitation in March, April, May (apart from 2013), June and July 2013 was significantly lower compared to the multi-year average, whilst in June 2011 and 2012 – significantly higher. As a result there was a shortage of moisture during the spring vegetation period of spelt in the years 2012 (55.6 mm less) and 2013 (157.4 mm less) compared to the analogical periods in the multi-year average (1980–2009).

RESULTS AND DISCUSSION

The impact of a weed control method on yielding was variable in the three years of the study (Table 2). In 2011 there was no significant difference recorded in yielding of crops protected with both weeding methods. In the two following years it was the chemical method that was significantly more effective. Despite the mean for the three years not showing any statistically significant difference, there was a trend observed in favour of the chemical weed control method. There was no correlation between the cultivars and the weeding methods, which indicated that the requirements of all of the cultivars of spelt and common wheat were similar.

The increase in sowing density from 300 to 500 grains per m^{-2} significantly increased grain yield (Table 2) by 2.4 dt · ha^{-1}, on average in the three years. A similar pattern was observed in particular study years, but the differences ranged from 1.0 dt · ha^{-1} (2011) to 3.9 dt · ha^{-1} (2013). The responses of particular cultivars of spelt to the increase in sowing density were similar. The recorded significant increase in yielding was consistent with the results of Troccoli and Codianini (2005), Sulweska et al. (2008) and Podolska et al. (2015), but not with the results of Bepirszcz and Budzyński (2011) and Pospišil et al. (2011) or Podolska and Wyzińska (2011). From all of the analysed cultivars the highest mean yield in the three years was observed in Tonacja cultivar of common wheat and the lowest – in Oberkulmer Rotkorn spelt (Table 3).

Table 2. Grain yield and its components in dependence of methods of weed control and sowing density of winter spelt
Tabela 2. Plon ziarna i elementy struktury w zależności od metody odchwaszczania i ilości siewu orkiszu ozimego

Years Lata	Method of weed control Metoda odchwaszczania			Sowing density, grains per 1 m^2 Ilość wysiewu ziaren na 1 m^2			
	mechanical mechaniczna	chemical chemiczna	$LSD_{0.05}$ $NIR_{0,05}$	300	400	500	$LSD_{0.05}$ $NIR_{0,05}$
Grain yield – Plon ziarna [dt · ha^{-1}]							
2011	29.2	25.9	n.s.	27.3	27.0	28.3	n.s.
2012	23.5	29.8	5.43	25.4	26.7	27.9	1.12
2013	27.1	41.8	14.0	32.4	34.7	36.3	1.16
2011–2013	26.6	32.5	n.s.	28.4	29.5	30.8	1.30
Number of ears [pc. · m^{-2}] – Liczba kłosów [szt. · m^{-2}]							
2011	345	344	n.s.	290	359	383	29.4
2012	261	293	21.7	229	286	316	21.8
2013	292	305	n.s.	250	303	343	29.1
2011–2013	299	314	n.s.	256	316	347	26.9
Number of grains per ear – Liczba ziaren w kłosie [pcs, szt.]							
2011	24.8	23.5	n.s.	26.6	24.2	21.7	1.54
2012	25.0	28.9	1.90	28.6	26.2	25.9	1.60
2013	21.4	25.7	n.s.	26.6	22.8	21.4	1.63
2011–2013	23.7	26.0	n.s.	27.2	24.4	23.0	1.69
Thousand grains weight – Masa tysiąca ziaren [g]							
2011	44.2	42.2	n.s.	44.3	43.3	42.0 b	1.65
2012	37.5	40.2	0.57	40.1	38.5	38.0	n.s.
2013	47.1	49.9	n.s.	48.9	48.6	48.0	n.s.
2011–2013	42.9	44.1	n.s.	44.4	43.4	42.7	n.s.

n.s. – not significant – nieistotne.

Table 3. Grain yield and its components in dependence of cultivar of winter spelt
Tabela 3. Plon ziarna i elementy struktury w zależności od rodu / odmiany orkiszu ozimego

Year Lata	Cultivars* Odmiana*							$LSD_{0.05}$ $NIR_{0,05}$
	A	B	C	D	E	F	G	
Grain yield – Plon ziarna [dt · ha^{-1}]								
2011	26.2	28.1	30.1	27.8	25.2	18.7	37.0	2.85
2012	26.3	24.7	25.3	28.3	25.2	22.9	33.8	1.71
2013	29.3	38.3	37.9	33.8	35.1	32.2	34.5	2.30
2011–2013	27.3	30.4	31.1	30.0	28.5	24.6	35.1	3.65
Number of ears (pc.) – Liczba kłosów [szt. · m^{-2}]								
2011	369	360	334	349	323	327	347	n.s.
2012	294	295	307	282	261	250	249	38.6
2013	296	334	309	235	330	251	336	49.8
2011–2013	320	330	317	288	304	276	310	n.s.
Number of grains per ear – Liczba ziaren w kłosie [szt.]								
2011	27.0	23.4	25.0	22.0	24.2	18.2	29.4	2.86
2012	30.4	24.6	26.6	27.6	25.6	21.5	32.1	3.44
2013	25.6	22.2	24.0	26.9	20.7	23.2	22.4	3.29
2011–2013	27.7	23.4	25.2	25.5	23.5	21.0	28.0	3.76
Thousand grain weight – Masa tysiąca ziaren [g]								
2011	40.5	43.4	44.0	38.0	46.7	46.4	43.4	3.06
2012	33.9	36.8	37.0	38.8	43.3	40.3	41.8	3.95
2013	42.8	47.7	49.1	48.5	51.8	49.5	50.3	1.61
2011–2013	39.0	42.6	43.4	41.8	47.3	45.4	45.2	3.39

* spelt non-registered cultivars – rody orkiszu: A – STH 8; B – STH 11; C – STH 28–4609; D – STH 28–4614; E – STH 28–4619; F – spelt registered cultivar – odmiana orkiszu Oberkulmer Rotkorn; G – common wheat cultivar – odmiana pszenicy zwyczajnej Tonacja.
n.s. – not significant – nieistotne.

The yielding of the nonregistered cultivars from Plant Breeding Strzelce oscillated at intermediate level between wheat and Oberkulmer Rotkorn spelt. The differences in yielding of particular cultivars of spelt as well as wheat were variable in the particular years of the study. In 2011 and 2012 the yielding of common wheat was higher than that of spelt non-registered cultivars and Oberkulmer Rotkorn cultivar by a few to several dt · ha^{-1}. Only in 2013, when there was little precipitation in June and July, the yields of common wheat and spelt were similar and STH 11 and STH 28–4609 spelt cultivars gave even higher yields than wheat. The results confirm those by Rachoń et al. (2009), who received a significantly lower yield of winter spelt cultivars compared to common wheat. High variability in winter spelt yield was reported by several Polish and foreign researchers (Lacko-Bartošová and Otepka 2001, Sulewska et al. 2008, Lacko-Bartošová et al. 2010, Pospišil et al. 2011).

A weed control method did not significantly influence the number of ears (Table 2). Only in 2012 more ears were observed in plants treated with herbicides. Harrowing significantly decreased the number of ears compared to the chemical method (by 11% of 261 per m^{-2}). Presumably it was caused by lower efficacy of harrowing against weeds, which compete with crop for water, light and nutrients. As a consequence crops plant creates fewer ears. A sowing density was a factor influencing the number of the ears. In all of the study years the highest ear number was observed on the plots with the sowing density of 500 grains per m^2. The response of all of the cultivars to an increase in sowing density was similar.

The differences between the non-registered and registered cultivars in the mean number of ears for the three years were not significant. Higher differences were observed in particular years. The highest ear number in 2011 was observed in STH 8 cultivar (369 ears per m^2), and in 2012 – STH 28–4609 cultivar (307 per m^2) and in 2013 – common wheat cultivar Tonacja (336 per m^2). The results of studies on the influence of sowing density and spelt variety on ear number are ambiguous: Pałys and Kuraszkiewicz (2003) reported significant differences between varieties. Sulewska et al. (2008) claimed that the number of ears varied depending on both sowing density and varietal characteristics. Pospišil et al. (2011) and Rachoń et al. (2009), on the other hand, reported that the number of ears was only dependent on the amount of precipitation during the spelt vegetation period.

The weed control method did not significantly influence the number of grains in an ear in the compared spelt cultivars. This factor was only significant in 2012, when more grains were found in the ears of the plants treated chemically. The advantage of chemical weed control on harrowing in winter wheat has been noted by Brzozowska et al. (2008). The number of grains in the ears was significantly influenced by the sowing density: the highest number of grains (27.2) was found in the ears of the plants sown in the density of 300 grains per m^2. The number of grains in an ear decreased with the increase of sowing density. Higher number of grains in the ears of plants sowed in lower density confirmed the report of Sulewska et al. (2008).

The cultivar factor also significantly differentiated the mean number of grains in the ears in the study period. The highest number of grains was found in the ears of common wheat (28 on average) and the lowest in Oberkulmer Rotkorn spelt (21). The number of grains in the ears of plants from Hodowla Strzelce remained at intermediate levels; however number of grains in ears of non-registered cultivars: STH 8, STH 28–4614 and STH 28–4609 was

statistically similar to common wheat, whereas STH 28–4619 and STH 11 were similar to number of grains in ears of Oberkulmer Rotkorn spelt. In 2013 there was lower grain number except in the ears of STH 28–4614 and Oberkulmer Rotkorn cultivars than in 2011 and 2012, which could have been caused by significant shortage of precipitation starting at the beginning of June. Significant differences between various spelt cultivars were confirmed by Rachoń et al. (2009) and Pospišil et al. (2011).

The weight of 1000 grains of the compared non-registered and registered cultivars was not influenced by the weeding method on average and in 2011 and 2013, however, in 2012 there was a statistically significant difference observed; the number of grains in the plants treated chemically was higher than in the harrowed. Brzozowska et al. (2008) noted a significant differences between thousand grain weights of winter wheat without any weed treatment and when harrowing or a herbicide usage. Also sowing density did not differentiate the weight of 1000 grains. On the other hand, this feature was significantly influenced by the cultivar factor: the highest grain mass was observed in STH 28–4619 cultivar. Sulewska et al. (2008) reported that in their studies the mass of 1000 grains was strongly dependent on both the cultivar factor and sowing density. A higher mass was obtained in case of less densely sowed plants. On the other hand, Pospišil et al. (2011) only observed an influence of cultivar whilst sowing density was irrelevant. Similarly, Podolska et al. (2015) confirmed that sowing density did not influence this feature.

A weed control method did not significantly affect the height of the plants (Table 4).

Table 4. Impact of weed control method and sowing density on plant height, leaf area index and chlorophyll content of winter spelt
Tabela 4. Wpływ metody odchwaszczania i ilości wysiewu na wysokość roślin, współczynnik powierzchni liściowej i indeks zieloności liścia orkiszu ozimego

Year Lata	Method of weed control Metoda odchwaszczania			Number of sowing grains per 1 sq m. Ilość wysiewu ziaren na 1 m^2			
	mechanical mechaniczna	chemical chemiczna	$LSD_{0.05}$ $NIR_{0.05}$	300	400	500	$LSD_{0.05}$ $NIR_{0.05}$
Plant height – Wysokość roślin [cm]							
2011	68.0	65.2	n.s.	68.0	66.2	65.5	2.23
2012	83.2	86.9	n.i	85.9	85.1	84.2	n.s.
2013	84.4	92.0	n.s.	90.2	87.9	86.5	2.22
2011–2013	78.6	81.4	n.s.	81.4	79.8	78.8	n.s.
Leaf area index LAI – Współczynnik powierzchni liściowej [$m^{-2} \cdot m^{-2}$]							
2011	1.32	1.32	n.s.	1.24	1.28	1.44	0.10
2012	2.36	2.31	n.s.	2.19	2.33	2.48	0.13
2013	1.87	1.61	n.s.	1.69	1.72	1.81	0.09
2011–2013	1.85	1.75	n.s.	1.71	1.7	1.91	0.12
Leaf greenes index – Indeks zieloności liścia (SPAD)							
2011	42.5	43.2	n.s.	43.9	42.8	41.8	1.27
2012	34.5	36.5	0.33	36.2	35.4	34.9	0.86
2013	34.0	36.6	n.s.	36.7	35.1	34.0	1.04
2011–2013	37.0	37.7	n.s.	38.9	37.8	36.9	1.12

n.s. – not significant – nieistotne.

There was only a tendency observed of an increased length of a stem in the plants treated chemically. Similarly, sowing density did not significantly affect the examined feature in the study, however, the plants grown more densely were shorter. The biggest differences were

observed between cultivars (Table 5). On average, the longest blades were recorded in Oberkulmer Rotkorn registered cultivar (93.4 cm) and STH 28–4614 non-registered cultivar (87.9 cm), and the shortest – in common wheat cultivar Tonacja (71.9 cm). Significant differences between cultivars were confirmed in the research by Lacko-Bartošova and Otepki (2001) as well as Pałys and Kuraszkiewicz (2003).

Table 5. Impact of cultivar on plant height, leaf area index and chlorophyll content of winter spelt
Tabela 5. Wpływ rodu / odmiany na wysokość roślin, współczynnik powierzchni liściowej i indeks zieloności liścia orkiszu

Year Lata	Cultivar Odmiana							$LSD_{0.05}$ $NIR_{0.05}$
	A	B	C	D	E	F	G	
Plant height – Wysokość roślin [cm]								
2011	70.0	62.6	63.1	68.8	63.0	75.6	63.2	5.13
2012	86.5	79.0	81.5	94.8	76.4	101.4	75.9	6.63
2013	89.0	85.0	85.7	100.1	78.1	103.2	76.6	3.25
2011–2013	81.8	75.5	76.8	87.9	72.5	93.4	71.9	6.00
Leaf area index – Współczynnik powierzchni liściowej [$m^{-2} \cdot m^{-2}$]								
2011	1.35	1.19	1.16	1.48	1.45	1.40	1.23	0.21
2012	2.29	2.25	2.31	2.52	2.37	2.62	1.98	0.29
2013	1.79	1.77	1.89	1.71	1.64	1.72	1.67	n.s.
2011–2013	1.81	1.74	1.79	1.90	1.82	1.91	1.63	0.28
Leaf greenes index – Indeks zieloności liścia (SPAD)								
2011	36.9	43.0	43.0	40.4	47.6	43.4	45.6	2.40
2012	33.2	35.1	35.0	34.5	36.3	35.9	38.6	1.64
2013	33.4	36.1	35.0	33.5	36.5	34.7	37.8	2.71
2011–2013	34.5	38.1	37.6	36.1	40.1	38.0	40.7	2.58

* spelt non-registered vcultivars – rody orkiszu: A – STH 8; B – STH 11; C – STH 28–4609; D – STH 28–4614; E – STH 28–4619; F – spelt registered cultivar – odmiana orkiszu Oberkulmer Rotkorn; G – common wheat cultivar – odmiana pszenicy zwyczajnej Tonacja.
n.s. – not significant – nieistotne.

A weed control method had no significant effect on the leaf area index (Table 4). An increase in sowing density systematically increased LAI. The differences were not big but clear in all of the study years. The feature was also significantly influenced by the cultivar factor. The biggest leaf surface was observed in Oberkulmer Rotkorn cultivar (1.91 $m^{-2} \cdot m^{-2}$) and STH 28–4614 non-registered cultivar (1.90 $m^{-2} \cdot m^{-2}$), the surface was significantly bigger than in the case of common wheat (by 1.63 $m^{-2} \cdot m^{-2}$). The increased leaf surface of spelt compared to common wheat was also reported by Feledyn-Szewczyk and Duer (2006) and Feledyn-Szewczyk (2012). Lepiarczyk et al. (2005) proved that leaf area index of winter wheat is dependant on such factors as soil tillage, previous crop or cultivar of the crop, especially during the shooting growth stage.

The leaf greenness index in the study period was not affected by a weed control method; however, higher greenness index was recorded in leaves of the plants treated chemically. A sowing density significantly influenced this feature in all of the study years. A higher index was observed in the leaves of the plants sowed less densely. The feature also differed between the cultivars. The highest mean greenness index in the studied period was observed in winter common wheat (40.7 SPAD) and STH 28–4619 spelt non-registered cultivar (40.1 SPAD).

CONCLUSIONS

1. The application of the chemical weed control method compared to the mechanical method did not significantly influence the grain yielding in 2011 but significantly increased it in 2012 and 2013.
2. An increase in sowing density from 300 to 500 grains per m^2 increased the grain yield and the ears number and decreased the number of grains in an ear. The mass of 1000 grains was constant regardless of sowing density.
3. The highest mean grain yield in the three subsequent years was observed in common wheat Tonacja, lower yield was recorded in the spelt non-registered cultivars from Plant Breeding Strzelce and the lowest – in Oberkulmer Rotkorn spelt cultivar.
4. The responses of the non-registered and registered cultivars of spelt and common wheat to the applied weed control methods and to various sowing densities were similar.

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Abstract. The field experiment was carried out in the years 2010–2013 at the West Pomeranian University of Technology Experimental Agricultural Station in Lipnik, near Stargard Szczeciński (Poland). The research included the determination of an impact of two weed control methods (mechanical and chemical) and three sowing densities on the yield of selected winter spelt and common wheat cultivars, the yield components and their physiological parameters. The application of a chemical herbicide did not significantly influence grain yielding in 2011 compared to a mechanical weed control method, and increased it in the years 2012 and 2013. An increase in sowing density from 300 to 500 grains per m^2 increased the yielding, the number of ears and at the same time, decreased the grain number in an ear. The mass of 1000 grains was similar regardless of sowing density. The highest mean yields in the three years were observed in common wheat Tonacja, lower in spelt cultivars of Plant Breeding Strzelce and the lowest in Oberkulmer Rotkorn spelt cultivar. The responses of spelt various cultivars to different weed control methods and to various sowing densities were similar.