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The influence of delayed sowing of winter rape on the quantity and quality of seed yield

Wpływ opóźnionego terminu siewu rzepaku ozimego na wielkość i jakość plonu nasion

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ABSTRACT

The sowing date of winter oilseed rape affect plant development and yield to a large extent, but yield components have not been well documented yet in the conditions of Poland. Therefore, research was undertaken to determine the impact of the delayed date of winter oilseed rape on the development of plants and the quantity and quality of the seed yield. A field study was conducted in the seasons 2013/2014 - 2015/2016 at the Experimental Institute of Cultivar Assessment in Skołoszów, Poland. Experimental factors were: the seed sowing date (optimal, delayed) and winter oilseed rape cultivars (Monolit, Arsenal F_1). This study has indicated that sowing the seeds in a delayed time affected shortening of the plant growing period, but it did not differentiate the seed yield. It has been found that the optimal sowing date increased the plant density prior to harvest, whereas a delayed sowing date resulted in an increase in the number of seeds per silique. The cultivar Arsenal F_1 increased seed yield by 0.87 t/ha as compared with the cultivar Monolit. Delayed sowing date increased the content of fibre and zinc in seeds, and decreased the content of protein, phosphorus and potassium as compared with the optimal time.

Keywords: cultivar, nutrients, seed chemical composition, vegetation, yield components

STRESZCZENIE

Termin siewu nasion rzepaku ozimego w dużym stopniu wpływa na rozwój i plonowanie roślin, ale komponenty plonu nie zostały jeszcze dobrze przebadane w warunkach Polski. Dlatego podjęto badania w celu określenia wpływu opóźnionego terminu siewu rzepaku ozimego na rozwój roślin oraz wielkość i jakość plonu nasion. Badania polowe przeprowadzono w sezonach 2013/2014 - 2015/2016 w Zakładzie Doświadczalnym Oceny Odmian w Skołoszowie, Polska. Czynnikami doświadczenia były: termin siewu nasion (optymalny, opóźniony) oraz odmiany rzepaku ozimego (Monolit, Arsenal F1). Badanie wykazało, że wysiew nasion w opóźnionym terminie wpłynęło na skrócenie okresu wegetacji roślin, ale nie zróżnicowało plonu nasion. Stwierdzono, że optymalny termin siewu nasion zwiększył obsadę roślin przed zbiorem, natomiast opóźniony termin siewu spowodował wzrost liczby nasion w łuszczynie. Odmiana Arsenal F1 wydała wyższy plon nasion o 0.87 t/ha w porównaniu do odmiany Monolit. Opóźniony termin siewu nasion skutkował zwiększeniem zawartości włókna i cynku w nasionach, natomiast zmniejszył zawartość białka, fosforu i potasu w porównaniu z terminem optymalnym.

Słowa kluczowe: komponenty plonu, odmiana, okres wegetacji, skład chemiczny nasion, składniki odżywcze

INTRODUCTION

In Poland, winter oilseed rape (*Brassica napus* L.) is grown as the main oil crop. The quantity and quality of oilseed rape seed yield is affected by the cultivar (Yousaf et al., 2002; Novickiene et al., 2010; Sattar et al., 2013), environmental conditions and cultivation technology (Montvilas and Mittas, 2000; Pritchard et al., 2000; Balodis and Gaile, 2016). The sowing date of winter oilseed rape is one of the most important elements of cultivation technology (Lääniste et al., 2007; Lääniste et al., 2008; Turhan et al., 2011; Balalić et al., 2017; Ratajczak et al., 2017). Velička et al. (2011) reported that the time when winter oilseed rape should be sown depends primarily on the climatic conditions prevailing in the area. According to Mrówczyński and Pruszyński (2008), the optimal date for sowing winter oilseed rape in Poland usually falls for the second or third decade of August. Yousaf et al. (2002) and Ahmadi et al. (2015) indicated that a delay of sowing date leads to a decline in yield, mainly due to a decrease in the number of siliques per plant. Sattar et al. (2013) proved that a delayed sowing date of oilseed rape reduced the quantity and quality of seed yield. The studies by Turhan et al. (2011) and Ahmadi et al. (2015) indicated that the sowing date of oilseed rape has a strong influence on the course of plant growth, including the time and duration of flowering.

In Poland the weather during autumn months of several last years was warmer and possibility for later sowing of winter rape occurred. The possibility of later sowing allows winter rape sowing after more pre-crops. The introduction of new cultivars of winter oilseed rape for cultivation, including hybrids, requires establishing their optimum sowing date (Ratajczak et al., 2017). Therefore, research was undertaken to determine the impact of the delayed date of winter oilseed rape on the development of plants and the quantity and quality of the seed yield.

MATERIAL AND METHODS

A field experiment was carried out over the seasons 2013/2014-2015/2016. It was situated at the Experimental Institute of Cultivar Assessment in Skołoszów (49°53´N, 22°44´E, altitude above sea level 204 m) Poland. It was a two-factorial experiment (split-plot), conducted in four replications (n=4). The first studied factor: (A) was the date of seed sowing (optimal, delayed). The other factor: (B) was the cultivar (Monolit, Arsenal F_1). The cultivar Monolit is one of the population cultivars that give the highest yields in Poland. The hybrid cultivar Arsenal F_1 is characterized by fast growth in the autumn period, which is a useful feature in conditions of delayed sowing.

The experiment was conducted in loess soil (Food and Agriculture Organization of the United Nations, 2015). It was heavy soil classified as the very good wheat complex. The soil pH was slightly acid or neutral. Soil abundance of available phosphorus was high or very high, of potassium medium or high, and of magnesium high or very high (Table 1). Analysis of soil samples was performed in the accredited laboratory of the District Agricultural Chemistry Station in Rzeszów, according to the Polish standards. Soil samples were collected by a sampling stick to a depth of 0-30 cm.

The area of plot for sowing was 18 m^2, and for harvest, 13.5 m^2. Row spacing was 25 cm and sowing depth was 2 cm. The seeding rate was 60 seeds/m^2 for both cultivars. Spring wheat was the previous crop. Sowing winter oilseed rape was performed at the optimal date (30.08.2013, 29.08.2014, 31.08.2015) or delayed date (13.09.2013, 15.09.2014, 14.09.2015).

Prior to sowing NPK fertilization was performed at rates: 30 kg/ha N as ammonium nitrate, 35 kg/ha P as superphosphate and 100 kg/ha K as potassium chloride. The doses of mineral fertilizers been sown after taking into account their abundance in soil. In spring, prior to starting growth, 100 N kg/ha (20 BBCH) was applied and at the budding stage, 70 N kg/ha (51 BBCH). Weeds, diseases and pests were controlled throughout the growing season and chemical control was applied.

Plant density per 1 m^2 was calculated after emergences (10 BBCH), after starting growth in spring (21 BBCH) and prior to harvest (89 BBCH).

Table 1. Chemical soil properties in Experimental Institute of Cultivar Assessment in Skołoszów (0-30 cm)

Year	Soil reaction pH (1 mol/L KCl)	Soil quality class	Content of available nutrients in soil (mg/kg)		
			P	K	Mg
2013	5.7	II	106	212	105
2014	6.3		73	220	197
2015	6.9		148	265	128

For biometric measurements, 20 plants were collected from each plot to determine: the number of siliques per plant, the number of grains per silique and thousand grain weight - TGW (9% humidity). Data regarding thousand grains weight were recorded by counting randomly selected 1,000 grains from each sub plot and weighed with sensitive electronic balance.

Winter oilseed rape was harvested at full maturity using a small-plot harvester. Seed yield from a plot was calculated for an area of 1 ha, assuming a humidity of 9% DM.

The seeds content of protein, oil, ash and fibre was determined with the NIRS method with the use of FT NIR MPA Bruker (Billerica, USA) spectrometer.

Macro- and microelements were developed (Polish standard, PN-91/R-04014) at the University of Rzeszow (The Laboratory of the Faculty of Biology and Agriculture). To determine macroelements and microelements, plant samples were mineralized in a mixture of concentrated acids HNO_3:$HClO_4$:HS_2O_4 in the ratio 20:5:1, in an open system, in the heating block Tecator. In obtained mineralisates the contents of K, Ca, Mg, Fe, Mn, Zn, Cu were determined with atomic absorption spectroscopy (FAAS), using the apparatus Hitachi Z-2000 (Tokyo, Japan), whereas P was determined with colorimetry, using the spectrophotometer UV-VIS Shimadzu (Kyoto, Japan).

The results were subjected to an analysis of variance, and significant differences were analyzed with the Tukey's HSD test (α=0.05) using Statistica 10 PL (StatSoft, Inc., Tulsa, USA). Values are presented as mean (four repetitions).

RESULTS AND DISCUSSION

The weather conditions during autumn growth were favourable, which ensured the proper development of plants before winter. Heavy rainfalls were recorded in July each year as compared with the long-term mean (Figure 1).

Air temperatures varied in the years of the study, whereas they created favourable conditions for growth and good overwintering of plants. Mean temperatures of November and December were higher than the long-term data, which had a favourable effect on the autumn plant growth. Velička et al. (2011) report that the weather during autumn months of several last years was warmer and possibility for later sowing of winter rape occurred. The possibility of later sowing allows winter rape sowing after more pre-crops. Lääniste et al. (2007) proved that overwintering of winter oilseed rape is significantly dependent on the sowing date.

Seed sowing at a delayed date resulted in a shortening of the budding and flowering stages and the plant growing period (P≤0.05). The tested cultivars did not differ significantly in the course of developmental stages. On average, the growing period of winter oilseed rape amounted to 309.5 days. In the season 2014/2015, the longest plant growing period was recorded, and a significantly shorter one occurred in the seasons 2013/2014 and 2015/2016 (Table 2). Many authors (Kirkland and Johnson, 2000; Robertson et al., 2004; Uzun et al., 2009; Ahmadi et al., 2015) report that a late sowing of oilseed rape results in a delay and shortening of flowering and seed maturity stages.

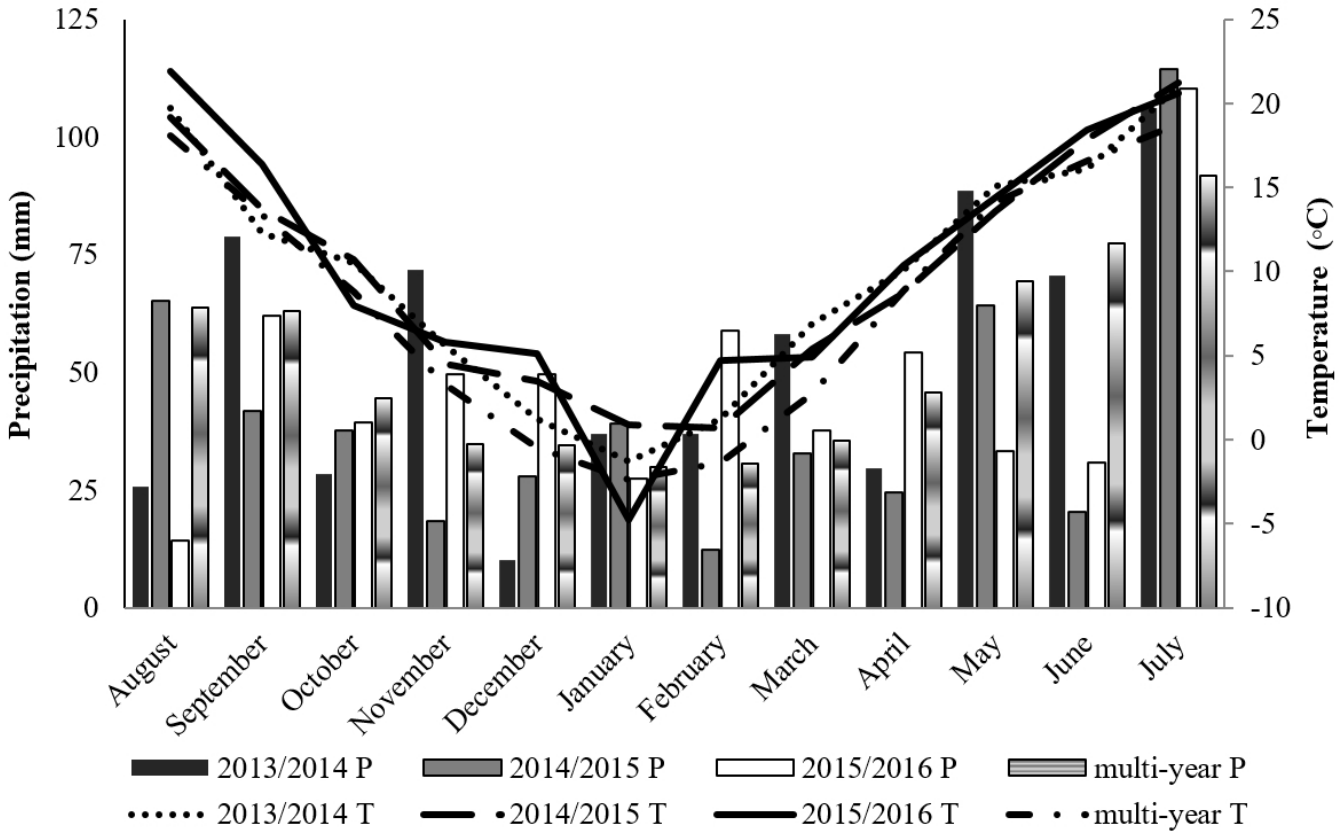

Figure 1. Weather conditions in the years 2013-2016, P - precipitation, T - temperature

Table 2. The course of vegetation in days from the date of sowing

Specification	Emergence	Budding	Flowering	Maturity	
				Technical	Full
Sowing time					
Optimal	16	224[a]	237[a]	306[a]	316[a]
Delayed	16	217[b]	228[b]	292[b]	303[b]
Cultivar					
Monolit	17	221	234	300	310
Arsenal F1	15	219	231	298	309
Years					
2013/2014	16[b]	218[b]	232[a]	296[b]	308[b]
2014/2015	13[c]	226[a]	237[a]	306[a]	312[a]
2015/2016	19[a]	216[b]	229[b]	295[b]	308[b]

* Values followed by the same letter are not significantly different (P>0.05) according to Tukey's HSD test.

The date of sowing seeds did not significantly differentiate yields of winter oilseed rape. It was found that sowing seeds at the optimal date had a beneficial effect on planting before harvest, and at the delayed date increased the number of seeds per silique (Table 3).

The tested cultivars differed significantly in seed yield. The cultivar Arsenal F_1 gave higher yields as compared with Monolit. A significant variability of winter oilseed rape yield in the years of the study has also been proved. Balodis and Gaile (2016) indicated that a delayed sowing date decreases overwintering of oilseed rape plants, which has an effect on plant density before harvest. Sattar et al. (2013) and Ahmadi et al. (2015) report that a delayed sowing date of winter oilseed rape leads to significant reduction in yield structure components. As a result, oilseed rape seed yield increases significantly (Yousaf et al., 2002; Lääniste et al., 2008; Mckenzie et al., 2011). Moreover, Turhan et al. (2011) and Butkutė et al. (2006) confirmed the significant variability of oilseed rape yield in the years of study.

Sowing seeds at the delayed date decreased the content of protein in seeds, and increased the content of fibre, as compared with the optimal date. The cultivar Arsenal F_1 contained significantly more protein in seeds that the cultivar Monolit. The content of fat and total protein in seeds was variable in the years of the study (Table 4).

Many authors (Pritchard et al., 2000; Turhan et al., 2011) report that the content of oil and protein in winter oilseed rape seeds is varied in the years of research. Butkutė et al. (2006) indicated that the sowing date of winter oilseed rape seeds has a significant effect on the chemical composition of seeds, whereas this is variable in the years of the study. Mckenzie et al. (2011) and Lääniste et al. (2016) proved that the sowing date of winter oilseed rape affects a change in fat and protein content in seeds. Sattar et al. (2013) indicated that a delayed sowing date reduces the content of fat in seeds, but does not differentiate protein content. Uzun et al. (2009) and Ahmadi et al. (2015), in turn, report that the seed sowing date has no effect on the content of fat in seeds.

Table 3. The course of vegetation in days from the date of sowing

Specification	Seed yield (t/ha)	Number of plants after emergence (pcs./m^2)	Number of plants before harvest (pcs./m^2)	The number of pods per plants	The number of seeds per pod	TGW (g)
			Sowing time			
Optimal	3.51	51.6	33.4^a	122.3	18.7^b	5.12
Delayed	3.57	50.1	30.9^b	118.8	20.7^a	5.18
			Cultivar			
Monolit	3.11^b	56.8^a	33.6^a	110.8^b	17.5^b	5.4^a
Arsenal F1	3.98^a	45^b	30.7^b	130.3^a	21.9^a	4.9^b
			Years			
2013/2014	3.48^b	47.7^b	24.6^a	142.1^a	17.5^a	4.65^b
2014/2015	4.17^a	52.7^a	39.2^a	103.3^c	21.2^a	6.27^a
2015/2016	2.97^c	52.1^a	32.6^b	116.3^b	20.4^b	4.56^b

Values followed by the same letter are not significantly different (P>0.05) according to Tukey's HSD test. TGW - thousand grain weight.

Table 4. Basic chemical composition of grains (in % of dry matter)

Specification	Total protein	Fat	Fiber	Ash
		Sowing time		
Optimal	23.2[a]	41	7.7[b]	3.9
Delayed	22.2[b]	42.2	8.4[a]	3.8
		Cultivar		
Monolit	22.3[b]	41.2	8.2	4
Arsenal F1	23.2[a]	42	7.9	3.7
		Years		
2014	21.1[b]	43.8[a]	7.8	4
2015	23.7[a]	40.4[b]	8.1	3.8
2016	23.3[a]	40.6[b]	8.2	3.7

Values followed by the same letter are not significantly different (P>0.05) according to Tukey's HSD test.

Delayed sowing date decreased the content of phosphorus and potassium in seeds. Seeds of the tested cultivars differed significantly only in the content of magnesium (Table 5). Additionally, varied contents of macroelements were observed in the years of the study. Fordoński et al. (2015, 2016) proved that the content of macroelements and microelements in winter oilseed rape seeds can be modified by means of different cultivation agents.

Table 5. Macroelement content (g/kg DM)

Specification	P	K	Ca	Mg
		Sowing time		
Optimal	6.7[a]	7.7[a]	3.8	4.3
Delayed	6.3[b]	7.3[b]	3.5	4
		Cultivar		
Monolit	6.3	7.4	3.8	4[b]
Arsenal F1	6.6	7.6	3.5	4.4[a]
		Years		
2014	7.3[a]	8.3[a]	3.3[b]	3.9[b]
2015	6.2[b]	7b	3.6[b]	4.2[ab]
2016	5.9[b]	7.2[b]	4[a]	4.5[a]

Values followed by the same letter are not significantly different (P>0.05) according to Tukey's HSD test. DM – dry matter.

Table 6. Macroelement content (g/kg DM)

Specification	Fe	Mn	Zn	Cu
		Sowing time		
Optimal	84.8	37.8	35.2[b]	3.3
Delayed	82	34.6	39.2[a]	3.1
		Cultivar		
Monolit	79.8[b]	36.8	37.5	3.1
Arsenal F1	87.1[a]	35.7	36.9	3.3
		Years		
2014	87.3[a]	35.2	34.2[b]	3[b]
2015	82.2[b]	37	39.6[a]	3.4[a]
2016	80.8[b]	36.5	37.8[a]	3.2[ab]

Values followed by the same letter are not significantly different (P>0.05) according to Tukey's HSD test. DM - dry matter.

Sowing seeds at the delayed date resulted in an increase in zinc content in seeds. The cultivar Arsenal F_1 contained significantly more iron in seeds than the cultivar Monolit. It was also found that the content of iron, zinc and copper in seeds was varied in the years of the study (Table 6). Jankowski et al. (2016 a, b) determined similar contents of microelements in oilseed rape seeds.

CONCLUSION

This study has indicated that sowing the seeds in a delayed time affected shortening of the plant growing period. It has been found that the optimal sowing date increased the plant density prior to harvest whereas a delayed sowing date resulted in an increase in the number of seeds per silique.

The delayed sowing date of winter oilseed rape did not significantly affect the seed yield quantity in the area of the study, so it is important result, especially for the agricultural practice. However, it a reduced the content of protein, phosphorus and potassium in seeds, and an increased fibre and zinc.

At the same time, a significant variability of the quantity and quality of seed yield between the cultivars and in the years of the study has been indicated.

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