ACTA SCIENTIARUM POLONORUM
Acta Sci. Pol. Agricultura 17(4) 2018, 205–214
www.agricultura.acta.utp.edu.pl pISSN 1644-0625 eISSN 2300-8504 DOI: 10.37660/aspagr.2018.17.4.3

ORIGINAL PAPER

Received: 09.11.2018
Received in revised form: 03.12.2018
Accepted: 05.12.2018

RESPONSE OF WINTER RAPESEED TO BIOSTIMULATOR APPLICATION AND SOWING METHOD PART I. FIELD ARCHITECTURE ELEMENTS

Anna Sikorska✉[1], Marek Gugała[2], Krystyna Zarzecka[2]

[1]Department of Agriculture, The State Higher School of Vocational Education in Ciechanów, Narutowicza 9, 06-400 Ciechanów, **Poland**
[2] Department of Agrotechnology, Faculty of Natural Sciences, Siedlce University of Natural Sciences and Humanities, Prusa St. 14, 08-110 Siedlce, **Poland**

ABSTRACT

Background. In plant production, reaching high and good quality yields of cultivated plants is achieved mostly thanks to the ability to counteract the occurrence of stress and the amendment of damage caused by stress. The aim of the study was to determine the effect of the applied biostimulator types and the sowing methods on the filed architecture elements of three winter rapeseed cultivars.
Material and methods. Field experiment was carried out in years 2013-2016 at the Agricultural Experimental Station in Zawady (52°03' N; 22°33' E), which is part of the University of Natural Sciences and Humanities in Siedlce, Poland. The experiment was carried out in a split-split-plot design in three repetitions. The studied factors were: I – winter rapeseed cultivar: Monolit (open-pollinated), PR44D06 (restored hybrid of semidwarf growth type), and PT205 (restored hybrid of traditional growth type); II – sowing method: row sowing (row spacing 22.5 cm, sowing density 60 seeds per 1 m^2), single-seed sowing (row spacing 45.0 cm, sowing density 40 seeds per 1 m^2); III – types of the applied biostimulators: control (no biostimulators), Tytanit®, Asahi®SL, and Silvit®.
Results. Research demonstrated significant effect of the applied biostimulator types and the sowing method on the biometric plant characteristics before harvest, such as: plant density, plant height, stem thickness at the base, first productive branch placement. The greatest plant height was found in the restored morphotype of traditional growth type and in the open-pollinated cultivar, whereas the highest first productive branch placement in cultivar PT205. Restored hybrids PT205 and PR44D06 were characterized by greater stem thickness at the base in comparison with the open-pollinated morphotype.
Conclusion. Biostimulator Asahi SL had the greatest effect on plant density, plant height, stem thickness at the base, and first productive branch placement, whilst biostimulator Tytanit had the lowest effect. Applied bioregulator types did not affect canopy lodging. Sowing method significantly affected stem thickness at the base, although it did not significantly affect canopy lodging. Genetic factor did not determine plant number established before harvest or changes in canopy lodging. Diversified weather conditions in the study years affected the studied elements of field architecture.

Key words: *Brasscia napus* L., canopy lodging, growth bioregulators, plant density, plant height, stem thickness at the base, sowing methods

✉anna.sikorska@pwszciechanow.edu.pl, marek.gugala@uph.edu.pl, krystyna.zarzecka@uph.edu.pl

INTRODUCTION

In recent years, constant increase in unfavourable weather phenomena has been observed during the growth season (ground frost, hail damage, drought, and rainstorms). This makes agriculturalists search for new solutions that would make it easier for plants to regenerate after the occurrence of stress factors, as well as improve the quality and quantity of the obtained yield. Gawrońska and Przybysz (2011) state that in plant production, reaching high and good quality yields of cultivated plants is achieved mostly thanks to the ability to counteract the occurrence of stress and the amendment of damage caused by stress. At present, in order to limit the negative effects of the occurrence of various kinds of biotic and abiotic stress in plant development, agricultural practice more and more often resorts to different types of preparations regarded as biostimulators. According to Xu and Huang (2012), plant growth and development regulators used as lodging-preventive preparations may play a significant role in cultivated plant protection against abiotic stress.

In the present work, study hypothesis was assumed which stated that the sowing method and plant growth and development regulators may affect favourably the elements of winter rapeseed field architecture. Due to rather few studies on the effect of the above factors on the biometric characteristics of plants before harvest, as well as due to wide interest in agricultural practice, research was undertaken the goal of which was to determine the effect of two sowing methods and types of applied biostimulators on the field architecture elements of three winter rapeseed cultivars.

MATERIAL AND METHODS

Field experiment was carried out in the years 2013-2016 at the Agricultural Experimental Station in Zawady (52^{o}03' N; 22^{o}33' E), which is part of the University of Natural Sciences and Humanities in Siedlce, Poland. The experiment was carried out in a split-split-plot design in three repetitions. Area of a single harvest plot was 18 m^2. Table 1 presents the studied agrotechnical factors.

Table 1. Agrotechnical factors studied in the experiment (Agricultural Experimental Station in Zawady)

Agrotechnical factors	
winter rapeseed cultivars	Monolit – open-pollinated cultivar
	PR44D06 – restored hybrid cultivar of semidwarf growth type
	PT205 – restored hybrid cultivar of traditional growth type
sowing method	row sowing – row spacing 22.5 cm, sowing density 60 seeds per 1 m^2
	single-seed sowing – row spacing 45.0 cm, sowing density 40 seeds per 1 m^2
types of applied biostimulators	control – no biostimulators
	biostimulator Tytanit®: I date in the autumn at the 4-8 leaf stage (BBCH 14-18), II date in the spring after the onset of growth (BBCH 21-36), III date at the budding stage – early flowering (BBCH 50-61), at the doses of 0.20 dm^3·ha^{-1}
	biostimulator Asahi®SL: I date in the autumn at the 3-5 leaf stage (BBCH 13-15), II date in the spring after the onset of growth (BBCH 28-30), III date two weeks after the second treatment, at the doses of 0.60 dm^3·ha^{-1}
	biostimulator Silvit®: I date three weeks after emergence (BBCH 12-14), II date in the spring after the onset of growth (BBCH 28-30), III date two weeks after the second treatment, at the doses of 0.20 dm^3·ha^{-1}

Forecrop for winter rapeseed was spring wheat (first study year) and winter triticale (second and third study years). Studies were carried out on Haplic Luvisol soil, according to IUSS Working Group WRB (2014), arenic, of very good rye complex. In the study years, soil pH oscillated between 5.68 and 5.75. Soil was characterized by low richness in the assimilable forms of phosphorus (on average from 75.0 to 80.0 $mg \cdot kg^{-1}$) and average potassium assimilability (from 200 to 205 $mg \cdot kg^{-1}$) and magnesium assimilability (on average from 59.0 to 61.0 $mg \cdot kg^{-1}$). Before sowing, phosphorus and potassium fertilization was applied at the doses of 40 kg $P \cdot ha^{-1}$ and 110 kg $K \cdot ha^{-1}$ and the first dose of 40 kg $N \cdot ha^{-1}$. Fertilization was applied in the form of Lubofos under rapeseed at the dose of 600 $kg \cdot ha^{-1}$. Fertilization doses were complemented with 55.9 $kg \cdot ha^{-1}$ ammonium nitrate, 29.6 $kg \cdot ha^{-1}$ triple superphosphate, and 29 $kg \cdot ha^{-1}$ potassium salt. Second nitrogen dose of 100 $kg \cdot ha^{-1}$ was applied in the spring before the onset of growth (BBCH 28-30) using ammonium nitrate at the dose of 255.5 $kg \cdot ha^{-1}$ and ammonium sulphate at the dose of 62.5 $kg \cdot ha^{-1}$. Third nitrogen dose of 60 $kg \cdot ha^{-1}$ was applied at early budding (BBCH 50) using ammonium nitrate at the dose of 176.5 $kg \cdot ha^{-1}$. Directly after harvest of the previous crop, herbicide Command 480 EC was applied at the dose of 0.25 $dm^3 \cdot ha^{-1}$. Subsequently, at the BBCH 13–14 stage, Fusilade Forte 150 EG was applied at the dose of 2.0 $dm^3 \cdot ha^{-1}$. At the 4-8 leaf stage (BBCH 14–18), fungicide Horizon 250 EW was applied (0.75 $dm^3 \cdot ha^{-1}$). At the main shoot growth stage (BBCH 30), bud development (BBCH 50-58), and flowering (BBCH 60-69), insecticide Proteus 110 OD was applied at the dose of 0.6 $dm^3 \cdot ha^{-1}$. At the beginning of flowering (BBCH 61), fungicide Propulse 250 SE was applied at the dose of 1.0 $dm^3 \cdot ha^{-1}$, and at the stage of first petal falling, Mondatak 450 EC was applied at the dose of 1.0 $dm^3 \cdot ha^{-1}$.

Winter rapeseed sowing was carried out as row sowing (row spacing 22.5 cm, sowing density 60 seeds per 1 m^2) and single-seed sowing (row spacing 45.0 cm, sowing density 40 seeds per 1 m^2).

Sowing was carried out on the optimum dates recommended for the region (in 2013 on August 13th, in 2014 on August 11th, and in 2015 on August 14th).

Directly before harvest (BBCH 86-87), plant density per 1 m^2 was marked and the following field architecture elements were determined on the sample of 20 plants from every plot:

– plant height before harvest (cm),
– stem thickness at the base (mm),
– first productive branch placement (cm),
– canopy lodging (%).

Study results were statistically processed with the analysis of variance. Significance of the sources of variation was tested with the „F" Fischer-Snedecor test, and the evaluation of significance of differences at the significance level of $P < 0.05$ between the compared average values using Tukey's multiple range test.

In the study years, diversified weather conditions occurred (Table 2). During the growth season 2013–2014, described as optimal (K = 1.32), precipitation sum was higher by 60.0 mm in comparison with the many-years' average precipitation sum, whereas average temperature was higher by 0.8°C. The highest annual precipitation sum, on average 599.2 mm, and the lowest average annual temperature, on average 8.8°C, were noted in the growth season 2014–2015. Annual precipitation sum in that period was higher by 171.7 mm in comparison with the many-years' average precipitation sum. On the basis of Sielianinow's hydrothermal index value (K = 1.71), the second study year was marked as rather humid. Third study year was the warmest. Annual precipitation sum was lower by 43.8 mm from the many-years' average, whereas average annual temperature was higher by 1.3°C in comparison with the average from the years 1996–2010. In terms of humidity, the discussed year was described as optimal, according to Sielianinow's hydrothermal index (K = 1.37) (Skowera, 2014).

Table 2. Characteristics of the weather conditions in the years 2013-2016 (Zawady, Poland)

Month	Precipitation, mm				Temperature, °C			
	many-years' sum	monthly sum			many-years' average	monthly average		
	1996–2010	2013–2014	2014–2015	2015–2016	1996–2010	2013–2014	2014–2015	2015–2016
August	59.9	15.0	105.7	11.9	18.5	18.8	18.1	21.0
September	42.3	94.3	26.3	47.1	13.5	11.7	14.1	14.5
October	24.2	32.8	3.0	37.0	7.9	9.3	8.5	6.5
November	20.2	34.7	32.5	42.2	4.0	5.1	3.4	4.7
December	18.6	15.4	90.4	16.5	-0.1	1.2	0.1	3.7
January	19.0	28.6	51.4	10.9	-3.2	-4.5	0.6	-4.5
February	16.0	34.0	0.7	29.0	-2.3	0.7	0.7	2.5
March	18.3	29.6	53.1	33.5	2.4	5.8	4.6	3.5
April	33.6	45.0	30.0	28.7	8.0	9.8	8.2	9.1
May	58.3	92.7	100.2	54.8	13.5	13.5	12.3	15.1
June	59.6	55.4	43.3	36.9	17.0	15.4	16.5	18.4
July	57.5	10.0	62.6	35.2	19.7	20.8	18.7	19.1
August-July	427.5	487.5	599.2	383.7	8.2	9.0	8.8	9.5

Sielianinow's hydrothermal index*			
	2013–2014	2014–2015	2015–2016
August	0.31	1.87	0.20
September	2.63	0.66	1.20
October	1.01	0.22	2.15
March	1.48	4.63	3.49
April	1.41	1.35	1.07
May	2.33	2.91	1.47
June	1.23	0.84	0.72
July	0.16	1.20	0.64
August-July	1.32	1.71	1.37

* Index value (Skowera, 2014): extremely dry $k \leq 0.4$, very dry $0.4 < k \leq 0.7$, dry $0.7 < k \leq 1.0$, rather dry $1.0 < k \leq 1.3$, optimal $1.3 < k \leq 1.6$, rather humid $1.6 < k \leq 2.0$, humid $2.0 < k \leq 2.5$, very humid $2.5 < k \leq 3.0$, extremely humid $k > 3.0$

RESULTS AND DISCUSSION

It results from the present study that biostimulators applied in the research affected the increase in plant number established directly before harvest per area unit in comparison with the control (Table 3). The greatest increase in plant density, on average by 6.9%, was found on plots with biostimulator Asahi SL. However, according to Harasimowicz-Hermann and Borowska (2006), Asahi SL did not affect significantly plant number established before harvest. The above authors noted the highest plant density on plots with no biostimulators, whereas their single and double application caused a slight decrease in the value of the above characteristic.

On the basis of the present research, it was demonstrated that in the conditions of narrower row spacing, where the density amounted to 60 seeds per 1 m^2, plant number reached 65% of target density, whereas with wider spacing and the sowing of 40 seeds per·m^2, it reached 58.7%. Research demonstrated that when cultivating rapeseed at the row spacing of 22.5 cm and sowing density of 60 seeds per 1 m^2, more plants were obtained by 15.5 per area unit in comparison with the row spacing of 45.0 cm and sowing density of 40 seeds per 1 m^2. On the other hand, according to Malarz *et al*. (2006), the above factor did not affect significantly the value of the discussed characteristic.

In the present research, the genetic factor did not diversify significantly plant density before harvest. The value of the characteristic was similar in all the studied cultivars. This corresponds to the study results by Czarnik *et al*. (2015), who also did not find any significant differences between genotypes. However, Malarz *et al*. (2006) found a higher number of plants established before harvest in composite hybrid Kaszub than in open-pollinated Lisek. According to Kotecki *et al*. (2005), value of the discussed characteristic was to a low extent determined by the studied factor.

Weather conditions in the study years had a significant effect on rapeseed plant density established directly before harvest. The highest density was noted in the season 2013–2014, in which March and April were warm and optimal, whereas May was humid. Significantly lower plant number before harvest was obtained in the season 2014–2015, in which there were changeable weather conditions in the spring, and the lowest plant number was in the last study year (on average by 35.9% in comparison with the first growth season), in which extremely unfavourable growth conditions occurred alternately. Studies by Wielebski and Wójtowicz (2001) confirmed a significant effect of the weather conditions on plant number before harvest. The above authors observed the highest value of the discussed characteristic in the growth seasons with annual precipitation sum within the range of 484.0 to 539.0 mm, which is in agreement with the results of the present research, in which the highest plant number before harvest was found in years with annual precipitation sum at the level of 487.5 mm.

The conducted research demonstrated that the applied biostimulators had a significant effect on plant height before harvest in comparison with the control (Table 4). The highest plants were found on plots on which biostimulator Asahi SL was applied, significantly lower (on average by 1.7% and 2.8%) after the application of bioregulators Silvit and Tytanit, and the lowest, on average by 5.3%, on the control plots. This confirmed the studies by Harasimowicz-Hermann and Borowska (2006), Przybysz *et al*. (2008), and Matysiak *et al*. (2012). Similarly, Gawrońska *et al*. (2008) stated that plants sprayed with Asahi SL were higher and more advanced in their development.

Effect of the sowing method on plant height before harvest was presented in the studies by Oad et al. (2001), Johnson and Hanson (2002), Ozer (2003), Saren (2009), and Uzun *et al*. (2012). According to the above authors, plants grown at wider row spacing (30.0–40.0 cm) were higher. However, the present research did not confirm this finding. Higher plants, on average by 3.3 cm, were obtained at the sowing density of 60 seeds per 1 m^2, and Shahin and Valiollah (2009), as well as Różyło and Pałys (2011) did not find any significant effect of the studied factor on the values of the discussed characteristic.

Diversification in plant height under the effect of genotype was described by Shahin and Valiollah (2009). The authors demonstrated significant differences between cultivars Hyola 401, RGS-003, and Hyola 60. In the present research, open-pollinated cultivar

Monolit and heterosis long-stem cultivar PT205 did not differ significantly in plant height. Similar tendency was observed by Kotecki *et al*. (2007), who did not observe any significant differences between open-pollinated cultivar Lisek and composite hybrids Kaszub and Mazur, with the exception of restored hybrid BOH 3103, which was the lowest. Different results were obtained by Malarz *et al*. (2006), who found that heterosis cultivar Kaszub was lower by 2.0 cm from open-pollinated cultivar Lisek.

All the cultivars grown in the season 2014–2015, which was rather humid, and the vegetative rest period was the warmest from the three study years, were the highest. In the years 2013–2014 Monolit and PT205 did not differ significantly in the values of the discussed characteristic. Similar tendency was also obtained in the growth season 2015–2016. The above results confirm the studies by Wielebski and Wójtowicz (2001), who obtained the highest plants in the growth season with the highest annual precipitation sum. Also Kotecki *et al*. (2005) demonstrated that sufficient amount of water available in spring and summer, at higher temperatures in comparison with the many-years' average, was favourable to intensive rapeseed development.

Biostimulators affected the increase in stem thickness at the base on average by 0.7 to 1.2 mm in comparison with the control (Table 5). The highest values of the discussed characteristic were found on plots where biostimulators Asahi SL and Silvit were applied. The cultivars demonstrated diversified response to the application of growth biostimulators. Under the effect of bioregulator Tytanit, significant increase in stem thickness occurred only in the open-pollinated cultivar. In comparison with the control plots, biostimulators Asahi SL and Silvit significantly increased stem thickness at the base in the open-pollinated cultivar and in PR44D06. In cultivar PT205, the applied biostimulators did not cause changes in tem thickness in comparison with the control.

Sowing methods had a significant effect on stem thickness at the base. Higher value of the above characteristic was obtained after the application of single-seed sowing at the density of 40 seeds per 1 m^2, whereas after row sowing (density 60 seeds per 1 m^2), stem thickness was lower on average by 1.5 mm.

Among the compared cultivars, the greatest stem thickness at the base was obtained in restored hybrids, which did not differ significantly in the values of the discussed characteristic, whereas the lowest thickness was found in the open-pollinated hybrid.

The greatest stem thickness at the base, on average 16.5 mm, was obtained in the season 2014–2015, in which during the vegetative rest period favourable weather conditions occurred, and during spring growth, after small precipitation shortage in April, intensive precipitation occurred in May. The smallest stem thickness at the base was noted in the season 2015–2016, in which precipitation shortages occurred in May and June.

Under the effect of the biostimulators applied in the experiment, increase in the first productive branch placement occurred in comparison with the control plots, on average by 1.5 to 4.6 cm (Table 6). The greatest increase in the discussed characteristic (on average by 14.3%) was found after spraying with biostimulator Asahi SL, whereas the lowest (on average by 4.7%) as a result of the application of formulation Tytanit. Effect of biostimulators on the value of the discussed characteristic depended on the genotype. The applied growth bioregulators usually caused an increase in first productive branch placement in comparison with the control plots. The only exception was cultivar Monolit, in which first productive branch placement after the application of biostimulator Silvit was the same as in the control. Cultivar PR44D06 sprayed with biopreparations Tytanit and Silvit was characterized by the same value of the discussed characteristic. In cultivar PT205, biostimulator application caused an increase in first productive branch placement in comparison with the control, mainly after the application of Asahi SL.

Sowing method significantly affected first productive branch placement. Higher values of the discussed characteristic were obtained using row sowing, whereas after single-seed sowing, the values of the discussed characteristic were lower on average by 7.1 cm.

Among the cultivars, the highest first productive branch placement was noted in cultivar PT205, significantly lower in open-pollinated cultivar Monolit, and the lowest in PR44D06.

First productive branch placement significantly depended on the weather conditions in the study years. The highest values of the discussed characteristic were noted in the years 2014–2015, lower by 10.3 cm in the first study year, and the lowest (by 25.6 cm) in the growth season 2015–2016. This corresponds to the findings by Kotecki *et al.* (2005), who found the highest values of the discussed characteristic in a humid and warm study season.

The highest canopy lodging occurred in the years 2014–2015, in which the highest annual precipitation sum was noted (Table 7). The lowest values of the discussed characteristic were obtained in the warmest growth season of 2015–2016. No statistically proven interaction between the years and cultivars was found, which means that the cultivars responded uniformly to the weather conditions in the study years. In the present research, no significant effect was found of the types of the applied biostimulators, sowing methods, or the studied cultivars on canopy lodging.

Table 3. Plant number before harvest (plants)

Cultivar	Study years			Sowing methods*		Types of applied biostimulators				Average
	2013–2014	2014–2015	2015–2016	single-seed	row	control	Tytanit®	Asahi®SL	Silvit®	
Monolit	36.5	32.9	24.7	24.1	38.6	30.6	31.1	32.5	31.2	**31.3**
PR 44D06	36.0	35.7	23.0	23.3	39.8	30.9	31.3	32.6	31.4	**31.5**
PT 205	36.2	34.3	22.0	23.0	38.7	29.4	30.6	32.3	31.0	**30.8**
Average	**36.2**	**34.3**	**23.2**	**23.5**	**39.0**	**30.3**	**31.0**	**32.4**	**31.2**	–

$HSD_{0.05}$ for:
years 0.395 cultivars ns types of applied biostimulators 0.400 sowing methods 0.250
interactions:
years × cultivars 0.684 cultivars × types of applied biostimulators 0.630 sowing methods × cultivars ns

*single-seed sowing – row spacing 45.0 cm, sowing density 40 seeds per 1 m^2
row sowing – row spacing 22.5 cm, sowing density 60 seeds per 1 m^2
ns – non-significant

Table 4. Plant height before harvest (cm)

Cultivar	Study years			Sowing methods		Types of applied biostimulators				Average
	2013–2014	2014–2015	2015–2016	single-seed	row	control	Tytanit®	Asahi®SL	Silvit®	
Monolit	129.9	141.7	108.2	123.9	129.3	123.0	125.9	129.1	128.5	**126.6**
PR 44D06	117.7	123.0	101.4	113.2	114.8	111.3	113.8	117.7	113.3	**114.0**
PT 205	130.8	140.3	107.4	124.8	127.5	121.9	125.8	129.2	127.8	**126.2**
Average	**126.1**	**135.0**	**105.7**	**120.6**	**123.9**	**118.7**	**121.8**	**125.3**	**123.2**	–

$HSD_{0.05}$ for:
years 0.543 cultivars 0.543 types of applied biostimulators 0.640 sowing methods 0.342
interactions:
years × cultivars 0.940 cultivars × types of applied biostimulators 1.008 sowing methods × cultivars 0.593

Table 5. Stem thickness at the base (mm)

Cultivar	Study years			Sowing methods		Types of applied biostimulators				Average
	2013–2014	2014–2015	2015–2016	single-seed	row	control	Tytanit®	Asahi®SL	Silvit®	
Monolit	14.9	16.0	11.8	15.0	13.5	12.7	14.3	15.3	14.7	**14.2**
PR 44D06	15.5	16.6	12.4	15.7	14.0	14.4	14.8	15.1	15.1	**14.9**
PT 205	15.9	17.0	12.5	15.6	14.6	14.9	15.1	15.2	15.2	**15.1**
Average	**15.4**	**16.5**	**12.2**	**15.5**	**14.0**	**14.0**	**14.7**	**15.2**	**15.0**	–

$HSD_{0.05}$ for:
years 0.397 cultivars 0.397 types of applied biostimulators 0.310 sowing methods 0.208
interactions:
years × cultivars ns cultivars × types of applied biostimulators 0.489 sowing methods × cultivars 0.360

Table 6. First productive branch placement (cm)

Cultivar	Study years			Sowing methods		Types of applied biostimulators				Average
	2013–2014	2014–2015	2015–2016	single-seed	row	control	Tytanit®	Asahi®SL	Silvit®	
Monolit	38.8	49.1	23.0	32.0	42.0	35.2	37.7	39.4	35.6	**37.0**
PR 44D06	28.6	38.9	14.2	25.0	29.6	25.7	26.8	29.2	27.4	**27.3**
PT 205	40.0	50.3	24.4	35.0	41.4	35.2	36.3	41.4	39.8	**38.2**
Average	**35.8**	**46.1**	**20.5**	**30.6**	**37.7**	**32.1**	**33.6**	**36.7**	**34.3**	–

$HSD_{0.05}$ for:
years 0.461 cultivars 0.461 types of applied biostimulators 0.508 sowing methods 0.460
interactions:
years × cultivars 0.798 cultivars × types of applied biostimulators 0.802 sowing methods × cultivars 0.797

Table 7. Canopy lodging (%)

Cultivar	Study years			Sowing methods		Types of applied biostimulators				Average
	2013–2014	2014–2015	2015–2016	single-seed	row	control	Tytanit®	Asahi®SL	Silvit®	
Monolit	7.3	11.6	3.6	7.8	7.2	7.8	7.8	7.2	7.3	**7.5**
PR 44D06	5.0	13.0	3.5	6.3	8.0	6.2	6.1	10.3	6.0	**7.2**
PT 205	6.6	13.3	3.2	7.7	7.7	7.8	7.7	7.7	7.6	**7.7**
Average	**6.3**	**12.6**	**3.5**	**7.3**	**7.6**	**7.3**	**7.2**	**8.4**	**6.9**	–

$HSD_{0.05}$ for:
years 2.422 cultivars ns types of applied biostimulators ns sowing methods ns
interactions:
years × cultivars ns cultivars × types of applied biostimulators ns sowing methods × cultivars ns

CONCLUSIONS

1. Biostimulator Asahi SL had the greatest effect on the formation of plant density, height, first productive branch placement, and stem thickness, whilst Tytanit had the lowest effect. None of the applied biostimulants had an effect on canopy lodging.
2. Sowing method significantly affected stem thickness at the base although it did not significantly affect canopy lodging.
3. Genetic factor did not affect plant density or canopy lodging.
4. Diversified weather conditions in the study years affected the studied field architecture elements.

REFERENCES

Czarnik, M., Jarecki W., Bobrecka-Jamro, D., Jarecka, A. (2015). Wpływ gęstości siewu oraz nawożenia dolistnego na plonowanie odmian rzepaku ozimego. Rośliny Oleiste – Oilseed Crops, 36(1), 60–68.

Gawrońska, H., Przybysz, A. (2011). Biostymulatory: mechanizmy działania i przykłady zastosowań. Mat. konf. Targi sadownictwa i warzywnictwa, Warszawa, 7-13.

Gawrońska, H., Przybysz, A., Szalacha, E., Słowiński, A. (2008). Physiological and molecular mode of action of Asahi SL biostimulator under optimal and stress conditions. In: H. Gawronska ed., Biostimulators in modern agriculture, General Aspects, Wieś Jutra, 54–76.

Harasimowicz-Hermann, G., Borowska, M. (2006). Effect of biostimulant Asahi SL in winter rapeseed depending on pluviothermic conditions. Rośliny Oleiste – Oilseed Crops, XXVII(1), 95–106.

IUSS Working Group WRB. (2015). World Reference Base for Soil Resources 2014, update 2015 International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

Johnson, B.L., Hanson, B.K. (2002). Row-Spacing interactions on spring canola performance in the northern great plains. Agronomy J., 95, 703–708.

Kotecki, A., Kozak, M., Malarz, W. (2005). Wpływ zróżnicowanej technologii uprawy na rozwój i plonowanie odmian rzepaku ozimego. Rośliny Oleiste – Oilseed Crops, XXVI(1), 111–124.

Kotecki, A., Malarz, W., Kozak, M., Pogorzelec, A. (2007). Wpływ rozmieszczenia roślin w łanie na rozwój i plonowanie mieszańcowych i populacyjnych odmian rzepaku. Część I. Morfologia roślin i plony nasion. Zesz. Nauk. Uniwersytetu Przyrodniczego we Wrocławiu, Rolnictwo, XC (553), 7–39.

Malarz, W., Kozak, M., Kotecki, A. (2006). Wpływ zagęszczenia roślin w łanie na wysokość i jakość plonu trzech odmian rzepaku ozimego. Rośliny Oleiste – Oilseed Crops, XXVII (1), 299–310.

Matysiak, K., Kaczmarek, S, Kierzek, R. (2012). Wpływ wyciągu z alg morskich *Ecklonia maxima* (Kelpak SL) na rośliny rzepaku ozimego. Rośliny Oleiste – Oilseed Crops, XXXIII(1), 81–88.

Oad, F.C., Solangi, B.K., Samo, M.A, Lakho, A.A., Zia-Ul-Hassan, Oad, N.L. (2001). Growth, yield and relationship of rapeseed (*Brassica napus* L.) under different row spacing. IJAB, 3, 475–476.

Ozer, H. (2003). The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. Plant, Soil and Environ., 49(9), 422–426.

Przybysz, A., Małecka-Przybysz, M., Słowiński, A., Gawrońska, H. (2008). The effect of Asahi SL on growth, efficiency of photosynthetic apparatus and yield of field grown oilseed rape. In Z.T. Dąbrowski ed, Biostimulators in Modern Agriculture: Field Crops, Warsaw: Editorial House Wieś Jutra, 7–17.

Różyło, K., Pałys, E. (2011). Plonowanie rzepaku ozimego uprawianego na rędzinie w zależności od jego udziału w zmianowaniu i rozstawy rzędów. Zesz. Probl. Post. Nauk Rol., 599, 161–169.

Saren, B.K. (2009). Effect of irrigation and row spacing on growth and productivity of rapeseed. J. Interacademicia, 13, 19–22.

Shahin, Y., Valiollah, R. (2009). Effects of row spacing and seeding rates on some agronomical traits of spring canola (*Brassica napus* L.) cultivars. J. Cent. Eur. Agric., 10 (1), 115–122.

Skowera, B. (2014). Zmiany warunków hydrotermicznych na obszarze Polski (1971–2010). Fragm. Agron., 31(2), 74–87.

Uzun, B., Yol, E., Furat, S. (2012). The influence of row and intra-row spacing to seed yield and its components of winter sowing canola in the true Mediterranean type environment. Bulg. J. Agric. Sci., 18, 83–91.

Wielebski, F., Wójtowicz, M. (2001). Wpływ gęstości siewu na plon nasion oraz cechy morfologiczne i elementy struktury plonu odmian populacyjnych i mieszańcowych rzepaku ozimego. Rośliny Oleiste – Oilseed Crops, XXII (2), 349–362.

Xu, C., Huang, B. (2012). Proteins and metabolites regulated by trinexapac-ethyl in relation to drought tolerance in kentucky bluegrass. J. Plant Growth Reg., 31(1), 25–37.

ACKNOWLEDGEMENTS

The research was carried out under the research project No. 363/S/13, financed from a science grant by the Ministry of Science and Higher Education.

REAKCJA RZEPAKU OZIMEGO NA STOSOWANIE BIOSTYMULATORÓW ORAZ SPOSÓB SIEWU. CZĘŚĆ I. ELEMENTY ARCHITEKTURY ŁANU

Streszczenie

Celem przeprowadzonych badań było określenie wpływu rodzajów stosowanych biostymulatorów oraz sposobów siewu na elementy architektury łanu trzech odmian rzepaku ozimego. Doświadczenie polowe przeprowadzono w latach 2013–2016 w Rolniczej Stacji Doświadczalnej Zawady (52°03' N; 22°33' E), należącej do Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach. Eksperyment przeprowadzono w układzie split-split-plot w trzech powtórzeniach. Badanymi czynnikami były: I – odmiana uprawna rzepaku ozimego: Monolit (populacyjna), PR44D06 (mieszańcowa zrestorowana o półkarłowym typie wzrostu), PT205 (mieszańcowa zrestorowana o tradycyjnym typie wzrostu); II – sposób siewu: siew rzędowy (rozstawa rzędów 22,5 cm, gęstość siewu 60 nasion na 1 m^2), siew punktowy (rozstawa 45,0 cm, gęstość siewu 40 nasion na 1 m^2); III – rodzaje stosowanych biostymulatorów: wariant kontrolny (bez stosowania biostymulatorów), biostymulator Tytanit®, biostymulator Asahi®SL, biostymulator Silvit®. Badania wykazały istotny wpływ rodzajów stosowanych biostymulatorów oraz sposobów siewu na cechy biometryczne roślin oznaczone przed zbiorem takie jak: obsada, wysokość roślin, grubość łodygi u nasady, wysokość osadzenia pierwszego rozgałęzienia produktywnego. Największą wysokość roślin stwierdzono w morfotypie zrestorowanym o tradycyjnym typie wzrostu i odmianie populacyjnej, zaś wysokość do pierwszego rozgałęzienia produktywnego u PT205. Mieszańce zrestorowane PT205 i PR44D06 cechowała większa grubość łodygi u nasady w porównaniu z morfotypem populacyjnym. Biostymulator Asahi SL wywierał największy wpływ na obsadę roślin, wysokość roślin, grubość łodygi u nasady, wysokość osadzenia do pierwszego rozgałęzienia produktywnego, zaś najmniejszy – Tytanit. Rodzaje stosowanych bioregulatorów nie determinowały ugięcia łanu. Sposób siewu istotnie kształtował grubość łodygi u nasady, jednak nie oddziaływał istotnie na ugięcie łanu. Czynnik genetyczny nie determinował liczby roślin oznaczonej przed zbiorem oraz zmian w ugięciu łanu. Wartości badanych elementów architektury łanu zależały istotnie od warunków klimatycznych panujących w latach prowadzenia doświadczenia.

Słowa kluczowe: bioregulatory wzrostu, *Brasscia napus* L., grubość łodygi u nasady, obsada roślin, sposoby siewu, ugięcie łanu, wysokość roślin