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THE EFFECT OF SOWING METHOD AND BIOSTIMULATORS ON AUTUMN DEVELOPMENT AND OVERWINTERING OF WINTER RAPE

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ABSTRACT

Background. The aim of the study was an assessment of the effect of using various sowing methods and types of applied biostimulators on pre-dormancy plant habit as well as on overwintering of three types of winter rape cultivars.
Material and methods. A field experiment was carried out in a split-split-plot design in three replications. The studied factors included: I – three cultivars of winter rape: Monolit (population cultivar), PR 44D06 (restored hybrid cultivar with a semi-dwarf type of growth), PT 205 (restored hybrid cultivar with a conventional type of growth); II – two sowing methods: row spacing of 22.5 cm (row sowing – sowing density of 60 seeds per 1 m^2), row spacing of 45.0 cm (single seed sowing – sowing density of 40 seeds per 1 m^2); III – three types of applied biostimulators: control variant (without an application of biostimulators), Tytanit® biostimulator, Asahi®SL biostimulator, Silvit® biostimulator.
Results. Biostimulators applied in the experiment affected an increase in the number of leaves per rosette, root collar diameter, height of elevation of shoot apex as well as taproot length compared with the control plot. The highest values of morphological traits of plants determined in autumn before inhibition of growth as well as plants most complete winter survival were obtained under conditions of spraying with Asahi SL biostimulator, applied at the stage BBCH 13-15. The population cultivar overwintered better in comparison to the two heterotic cultivars, produced rosettes with a higher number of leaves (on average 8.4 leaves), a thicker root collar (on average 7.9 mm), as well as a longer taproot (on average 17.3 cm).The smallest plant losses occurred in cultivar Monolit after winter dormancy. Sowing method did not affect this trait of plant habit.
Conclusion. Asahi SL biostimulator significantly affected an increase in all morphological traits of the leaf rosette determined in autumn before inhibition of growth, when compared with the control variant. The restored hybrid morphotypes: PR 44D06 and PT 205, compared with the population cultivar Monolit, were characterized by a poorer autumn development of the leaf rosette. Diversified climatic conditions in the autumn-summer periods of vegetation and in the winter dormancy in the years of the research affected plant habit.

Key words: Asahi SL, bioregulators, cultivars, plant habit, winter rape, winter survival

INTRODUCTION

In plant production, beside conventional chemical plant protection products, also certified preparations are used which are referred to as regulators of plant development or biostimulators (Maciejewski *et al.*,

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2007), algae extracts (Dobrzański *et al*., 2008), microbial preparations (Emitazi *et al*., 2004), or resistance stimulators (Koziara *et al*., 2006).

The basic task of biostimulators is to increase resistance in plants against abiotic and biotic stress. They do this through the stimulation of plant development in both its aboveground part and the root system, as well as in the stimulation of plants towards a more efficient use of environmental conditions, including nutrients in the soil. Biostimulators applied on healthy plants should change their metabolism in such a way that plants become stronger and more resistant to the effect of stress factors such as: drought, falling temperature, or occurrence of a pathogen (Czeczko and Mikos-Bielak, 2004), owing to which, their beneficial effect can be observed (Harasimowicz-Herman and Borowska, 2006, Budzyński *et al*., 2008).

Sowing method is an agronomic factor that may have an influence on the morphological traits of a leaf rosette. According to Morteza *et al*. (2008), proper row spacing results in a more effective use of water and light, as well as the nutrients in the soil. Currently, more and more frequently rape is cultivated at wider row spacing, which are above the current – standard width of 12.5 cm.

In the research hypothesis it was assumed that sowing method and biostimulators may favorably affect plant habit traits and the overwintering of winter rape. Due to a limited number of or inconsistent studies concerning these factors, as well as due to a great interest of the authors in agricultural practice, this study has been undertaken with the aim of assessing the use of various sowing methods (single-seed sowing, row sowing) and types of the applied biostimulators on the pre-dormancy plant habit and overwintering of three types of winter rape cultivars.

MATERIAL AND METHODS

The field experiments with winter rape were carried out in the years 2013-2016 at the Agricultural Experiment Station, Zawady (52°03' N; 22°33' E), property of the Siedlce University of Natural Sciences and Humanities. The experiment was set up in a split-split plot design in three replications. The area of a plot for harvest was 18 m^2. The following factors were studied in the experiment:

factor I – three rape cultivars:

1. Monolit (population cultivar),
2. PR 44D06 (restored hybrid cultivar with a semi-dwarf type of growth),
3. PT 205 (restored hybrid cultivar with a conventional type of growth);

factor II – two sowing methods:

1. Row spacing of 22.5 cm (seed drill – sowing density of 60 seeds per 1 m^2),
2. Row spacing of 45.0 cm (precision seeder – sowing density of 40 seeds per 1 m^2);

factor III – three types of applied biostimulators:

1. Control variant – without an application of biostimulators,
2. Tytanit® biostimulator: I date – in autumn at 4-8 leaves stage (BBCH 14-18) at a rate of 0.20 $dm^3 \cdot ha^{-1}$,
3. Asahi®SL biostimulator: I date – in autumn at 3-5 leaves stage (BBCH 13-15) at a rate of 0.60 $dm^3 \cdot ha^{-1}$,
4. Silvit® biostimulator: I date – 3 weeks after emergence (BBCH 12-14) at a rate of 0.20 $dm^3 \cdot ha^{-1}$.

The research was carried out on soil included in the order of lessive soils, type and subtype – lessive soils, sandy, included in a very good rye complex, bonitation class IVa (Marcinek and Komisarek, 2011). The soil was characterized by a low content of nitrogen, phosphorus, potassium and calcium, as well as an average content of magnesium and sulphur. It had a low content of available forms of phosphorus, and an average content of available forms of potassium and magnesium.

The forecrop for winter rape in particular years of the research was spring wheat (1st year of research), winter triticale (2nd year of research), winter triticale (3rd year of research). Before sowing, phosphorus and potassium fertilization was applied at a rate of 40 kg $P \cdot ha^{-1}$ and 110 kg $K \cdot ha^{-1}$, respectively, and the first application of nitrogen at a rate of 40 kg $N \cdot ha^{-1}$. Fertilization was used in the form of Lubofos for Rape at a rate of 600 $kg \cdot ha^{-1}$, i.e. 21 kg $N \cdot ha^{-1}$, 26.4 kg $P \cdot ha^{-1}$, 92.1 kg $K \cdot ha^{-1}$, 34.8 kg $S \cdot ha^{-1}$, 1.2 kg $B \cdot ha^{-1}$. Rates of fertilization were supplemented with 55.9 $kg \cdot ha^{-1}$ of ammonium saltpeter (19 kg $N \cdot ha^{-1}$), 29.6 $kg \cdot ha^{-1}$ of triple superphosphate (13.6 kg $P \cdot ha^{-1}$), as well as 29 kg·ha^{-1} of potassium salt (17.9 kg K·ha^{-1}). A second rate of nitrogen of 100 kg·ha^{-1} was applied in spring before the start of growth (BBCH 28-30), using ammonium saltpeter at a rate of 255.5 kg·ha^{-1} (86.9 kg N·ha^{-1}), as well as ammonium sulphate at a rate of 62.5 kg·ha^{-1} (13.1 kg N·ha^{-1} + 15 kg S·ha^{-1}). A third nitrogen rate of 60 kg·ha^{-1} was applied at the beginning of budding (BBCH 50) using ammonium saltpeter at a rate of 176.5 kg·ha^{-1} (60 kg N·ha^{-1}). Sowing was carried out on an optimum date recommended for this region (in 2013 – 13th August, 2014 – 11th August, and in 2015 – 14th August).

Chemical protection against weeds, diseases and pests were used in accordance with the recommendations of good agricultural practice. Rape was harvested at two stages in the first and second decade of July.

Plant density per 1 m^2 was determined after emergence and after overwintering of rape, as well as in spring after the start of growth. Directly before an inhibition of autumn vegetation, the following biometrical traits were determined on a randomly selected sample of 20 plants from each plot:

– number of leaves per rosette (leaves),
– root collar diameter (mm),
– height of elevation of shoot apex (cm),
– taproot length (cm).

Winter survival of plants was calculated based on the difference in plant density before winter and in spring after the start of growth.

Research results were elaborated statistically with the use of the analysis of variance. Significance of variation sources was tested with the ‘F’ Fisher-Snedecor test, while evaluation of significance of the differences was given at the level of p = 0.05 between the compared means with the use of Tukey's range test (Trętowski and Wójcik, 1988). Statistical calculations were carried out based on our algorithm written in Microsoft Excel.

Climatic conditions occurring in the years of the research are given in Table 1. In the years of the research the summer and autumn periods of vegetation and winter dormancy were quite diversified. In the growing season of 2013-2014 only a slight rainfall was observed in August (during sowing time), constituting merely 25.0% of the long-term mean for this period. The average daily temperature in August was higher by 0.3°C compared with the long-term period. Based on the calculated Sielianinov’s hydrothermal coefficient it was found that August was characterized by a strong drought (K = 0.31). In September, rainfall was over double the long-term mean (K = 2.63). In October and November, rainfall and average daily air temperatures were higher compared with the long-term period. Similarly, December was warmer by 1.3°C, and drier than the long-term period. From January to March rainfall exceeded values from the long-term period.

In August 2014 an above-average rainfall total was observed (which exceeded the long-term mean by 45.8 mm). The average daily air temperature was lower by 0.4°C compared with the long-term period. This month was characterized by a lack of drought (K = 1.87). Exceptionally warm and dry was September (drought) and October (strong drought). However, in November rainfall total was higher by 12.3 mm, while the mean temperature lower by 0.6°C, compared with the means from the years 1996–2010. In December and January rainfall significantly exceeded rainfall total from the long-term period. In this period, the average daily air temperature was higher than the mean from the long-term period by 0.2°C and 3.8°C, respectively.

In the last year of the research, August was particularly dry (K = 0.20) with the rainfall total constituting only 19.9% of the long-term value. Lack of drought was observed in September (K = 1.20). The average daily temperature in that month significantly exceeded the mean from the long-term period, while in October it was lower by 1.4°C than the long-term period. In other months it was higher by 0.7°C (November) and 3.8°C (December) than the long-term mean. Abundant rainfall exceeding the long-term mean was also observed in October and November. In January the average daily air temperature was lower by 1.3°C compared with the long-term mean. February was particularly warm and humid. The average daily temperature in this month was higher than the long-term mean by 4.8°C, while rainfall total was higher by 13 mm. Similarly, in March rainfall total was higher by 15.2 mm than the long-term mean, while the average daily temperature exceeded by 1.1°C the mean from the long-term period.

Table 1. Weather conditions in the years 2013–2016 (Zawady Meteorological Station)

Month	Rainfall, mm				Air temperature, °C			
	Long-term total	Monthly total			Long-term mean	Monthly mean		
	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
Mean	427.5	487.5	599.2	383.7	8.2	9.0	8.8	9.5

Sielianinov's hydrothermal coefficient			
	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
Mean	1.32	1.71	1.37

Coefficient value (Bac *et al*., 1998): up to 0.5 strong drought, 0.51-0.69 drought, 0.70-0.99 mild drought, ≥1 lack of drought

RESULTS AND DISCUSSION

Statistical calculations indicated that the morphological traits of rape plants during autumn growth and development significantly depended on climatic conditions occurring in the years of research, on genetic factor, and the type of applied biostimulators.

The effect of climatic conditions on the morphological traits of a leaf rosette has been indicated by Wielebski and Wójtowicz (2001) and Wielebski (2007). Those authors highlighted that a warm and long autumn resulted in a greater diameter of the root collar and higher location of the shoot apex, while a cool and short autumn had the effect of significantly smaller leaf rosettes being developed in plants. Statistical analysis indicated that the highest number of rosette leaves (on average 8.8 leaves), diameter of the root collar (on average 8.4 mm) and elevation of shoot apex (on average 2.29 cm), as well as length of the taproot (on average 18.1 cm), were obtained in the second year of the research, which was characterized by abundant rainfall during sowing and an exceptionally warm and dry September and October, whereas the lowest values of the discussed traits were obtained in the growing season of 2015-2016, in which there occurred a strong drought in August and during plant emergence.

The more favorable climate conditions during autumn and summer development and winter dormancy that occurred in the second year of the research resulted in rape overwintering the best in the studied three-year period (on average 89.4%). It was also indicated that among the studied cultivars, the population cultivar Monolit overwintered best (on average 87.8%), while the highest losses in plants after winter dormancy were observed in the restored hybrid with a conventional type of growth – PT 205 (on average 83.6% of winter survival) (Table 2). However, Malarz *et al.* (2006) in the population morphotype Lisek obtained a degree of winter survival of 92.5% on average, while in the restored hybrid Kronos it ranged from 90.4 to 96.5%. According to Kotecki *et al.* (2007), the best winter survival was characteristic of the heterotic cultivar Baldur (on average 92.7%). On the other hand, according to Wielebski and Wójtowicz (2001), the studied population cultivars and complex cultivar were characterized by the same degree of winter survival of plants.

Table 2. Winter survival of plants (%) depending on the experimental factors

Experimental factor	Number of plants per 1 m^2		Overwintering, %
	before winter	in spring	
Cultivars			
Monolit	39.4	34.6	87.8
PR 44D06	38.6	33.5	86.8
PT 205	39.6	33.1	83.6
Monolit	39.4	34.6	87.8
Methods of sowing			
45.0 cm	31.8	25.7	80.8
22.5 cm	46.6	41.7	89.5
Types of biostimulators used			
Control variant	38.2	32.6	85.3
Tytanit®	39.2	33.6	85.7
Asahi ®SL	40.1	35.1	87.5
Silvit®	39.3	33.6	85.5
Years			
2013–2014	43.9	38.8	88.4
2014–2015	41.5	37.1	89.4
2015–2016	32.2	25.3	78.6

Winter rape plants were the most resistant to cold after applying the Asahi SL biostimulator – on average 87.5%. However, under the effect of the other growth biostimulators, the percentage of plants' overwintering was similar and on average reached 85.5% (Table 2). In our studies it was also indicated that rape cultivated at narrower row spacing (22.5 cm) overwintered better (on average 89.5%) (Table 2). Similar research results were obtained by Wielebski and Wójtowicz (1998), who found higher losses in plants with a wider row spacing. On the other hand, Kotecki *et al.* (2007) obtained a similar percentage of winter survival in plants with narrow and wide row spacing.

The effect of morphotype on the morphological traits of leaf rosette has been presented by Wójtowicz and Wielebski (2000), Malarz *et al.* (2006), as well as Kotecki *et al.* (2007).

Based on our studies it was found that the population cultivar Monolit had a higher number of rosette leaves, on average 8.4 leaves, a greater diameter of the root collar, on average 7.9 mm, as well as length of the taproot, on average 17.3 cm, compared with the heterotic cultivars: PR 44D06 and PT 205 (Tables 3, 4, 6). These results are in line with the studies of Kotecki *et al.* (2007), who also obtained higher values of the discussed traits in the population cultivar Lisek compared with the heterotic hybrids Baldur and Titan. However, according to Wielebski and Wójtowicz (2001), Malarz *et al.* (2006), Jankowski and Budzyński (2007), as well as Wielebski (2007), it was heterotic forms produced plants with a greater diameter of the root collar.

Table 3. Number of leaves per rosette developed during autumn vegetation, depending on the experimental factors

Years	Cultivars			Mean
	Monolit	PR 44D06	PT 205	
2013-2014	8.5	8.1	8.4	8.3
2014-2015	9.5	8.3	8.5	8.8
2015-2016	7.1	6.5	6.8	6.8
Mean	8.4	7.6	7.9	–

$LSD_{0.05}$ for:
years 0.2 cultivars 0.2
interaction:
years × cultivars 0.4

Types of biostimulators used	Methods of sowing		Mean
	45.0 cm	22.5 cm	
Control variant	7.8	7.5	7.6
Tytanit®	8.2	7.7	7.9
Asahi®SL	8.4	8.1	8.2
Silvit®	7.9	7.9	7.9
Mean	8.1	7.8	–

$LSD_{0.05}$ for:
methods of sowing ns types of biostimulators used 0.3
interaction:
methods of sowing × types of biostimulators used ns

ns – non-significant

Table 4. Diameter of the root collar (mm) depending on the experimental factors

Years	Cultivars			Mean
	Monolit	PR 44D06	PT 205	
2013-2014	8.5	7.5	7.9	7.9
2014-2015	8.7	8.3	8.4	8.4
2015-2016	6.5	5.8	6.0	6.1
Mean	7.9	7.2	7.4	–

$LSD_{0.05}$ for:
years 0.3 cultivars 0.3
interaction:
years × cultivars ns

Types of biostimulators used	Methods of sowing		Mean
	45.0 cm	22.5 cm	
Control variant	7.5	7.0	7.2
Tytanit®	7.6	7.5	7.5
Asahi®SL	7.8	7.7	7.7
Silvit®	7.6	7.5	7.5
Mean	7.6	7.4	–

$LSD_{0.05}$ for:
methods of sowing ns types of biostimulators used 0.3
interaction:
methods of sowing × types of biostimulators used ns

ns – non-significant

In our studies, no significant differences were indicated between morphotypes in terms of shoot apex (Table 5), which is in accordance with the research results of Malarz *et al.* (2006). Different results were obtained by Kotecki *et al.* (2007), who found that the population morphotype was characterized by the highest location of shoot apex, whereas according to Wielebski and Wójtowicz (2001) it was a heterotic cultivar.

The types of applied biostimulator diversified the number of rosette leaves developed during autumn vegetation compared with the control variant. The highest significant increase in the value of the discussed trait was observed on the plots where the Asahi SL biostimulator was applied (on average 8.2 leaves). The other biostimulators (Tytanit and Silvit) increased the number of rosette leaves in a similar way when compared with the control variant, however, these differences were not statistically confirmed (Table 3).

In the studies of Przybysz *et al.* (2008), a greater diameter of the root collar was obtained after use of the Asahi SL bioregulator. This is in accordance with our study results, which indicate that Asahi SL brought about the highest value of the discussed trait (on average 7.7 mm), (Table 4) when compared with the biostimulators Silvit and Tytanit. Biostimulators also significantly affected the height of elevation of the shoot apex. The highest value of the discussed trait was obtained on plot 3, where the Asahi SL biostimulator was applied (on average 2.24 cm), a lower value of the discussed trait, but still statistically significant compared with the control plot, was obtained under the effect of the Silvit biostimulator (on average 2.23 cm), (Table 5).

The cultivars indicated a diversified response to the types of applied biostimulators. The height of elevation of the shoot apex in the population form Monolit, regardless of the type of the applied biostimulator, was the same as on the control plot. In the semi-dwarf hybrid the value of the discussed trait was higher after applying the preparations Asahi SL and Silvit than on the control plot, whereas in the cultivar PT 205 it was higher only after applying Asahi SL (Table 5).

Statistical calculations indicated a significant effect from the types of biostimulators used on the length of the taproot (Table 6). Under their influence, there occurred an elongation of the taproot of from 0.4 to 0.6 cm compared with the control variant (16.6 cm). The highest value of this discussed trait, on average 17.2 cm, was observed after spraying with Asahi SL, while a significantly lower one on plots where Tytanit and Silvit were applied (on average 17.0 cm).

Cultivar PR 44D06 in the first two years of the research did not differ statistically in the length of the taproot (Table 6). A similar correlation was also observed in the cultivar PT 205. However, the population cultivar Monolit responded significantly to weather conditions occurring in particular research periods, developing the longest root during autumn vegetation in 2014 (on average 18.7 cm), while the shortest one (on average 15.3 cm) was in 2015. The hybrid cultivars also developed the shortest root in the last year of the research.

The analysis of variance did not indicate an effect of sowing methods on the morphological traits of the leaf rosette (Tables 3-6), which is in accordance with the results presented by Wielebski and Wójtowicz (2001), as well as Kotecki *et al.* (2007). However, Malarz *et al.* (2006) found that a change in row spacing from 15.0 to 30.0 cm resulted in a higher elevation of the shoot apex.

Table 5. Height of elevation of the shoot apex (cm) depending on the experimental factors

Cultivars	Types of biostimulators used				Years			Mean
	control variant	Tytanit®	Asahi®SL	Silvit®	2013-2014	2014-2015	2015-2016	
Monolit	2.23	2.23	2.24	2.26	2.29	2.30	2.13	2.24
PR 44D06	2.14	2.16	2.24	2.23	2.22	2.25	2.11	2.19
PT 205	2.17	2.23	2.24	2.19	2.26	2.32	2.05	2.21
Mean	2.18	2.21	2.24	2.23	2.26	2.29	2.10	–

$LSD_{0.05}$ for:
years 0.03 cultivars ns types of biostimulators used 0.04
interaction:
years × cultivars ns
cultivars × types of biostimulators used 0.06

ns – non-significant

Table 6. Taproot length depending (cm) on the factors of the experiment

Years	Types of biostimulators used				Methods of sowing			Cultivars		Mean
	control variant	Tytanit®	Asahi®SL	Silvit®	45.0	22.5	Monolit	PR44D06	PT 205	
2013-2014	17.5	18.0	18.2	18.0	17.9	17.9	18.0	17.5	18.2	17.9
2014-2015	17.8	18.1	18.2	18.2	18.2	18.1	18.7	17.5	18.2	18.1
2015-2016	14.6	14.8	15.1	14.8	15.0	14.8	15.3	14.4	14.8	14.8
Mean	16.6	17.0	17.2	17.0	17.0	16.9	17.3	16.5	17.1	–

$LSD_{0.05}$ for:
years 0.1 cultivars 0.1 methods of sowing ns types of biostimulators used 0.1
interactions:
years × cultivars 0.3 years × methods of sowing ns
years × types of biostimulators used 0.2

ns – non-significant

CONCLUSIONS

1. Morphological traits of the leaf rosette were determined by the course of weather in the years of the research, type of the applied biostimulators and the cultivar.
2. The greatest effect on autumn traits of the plants' habit and their overwintering was observed under the effect of Asahi SL biostimulator.
3. Restored hybrid cultivars PR 44D06 and PT 205, when compared with the population cultivar Monolit, were characterized by a poorer autumn development of the leaf rosette and overwintering.
4. Sowing method did not affect the morphological traits of winter rape plants.

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WPŁYW SPOSOBU SIEWU I BIOSTYMULATORÓW NA JESIENNY ROZWÓJ I PRZEZIMOWANIE RZEPAKU OZIMEGO

Streszczenie

Celem badań była ocena wpływu stosowania różnych sposobów siewu i rodzajów stosowanych biostymulatorów na przedspoczynkowy pokrój roślin oraz zimowanie trzech typów odmian rzepaku ozimego. Doświadczenie polowe przeprowadzono w układzie split-split-plot w trzech powtórzeniach. Badanymi czynnikami były: I – trzy odmiany rzepaku ozimego: Monolit (odmiana populacyjna), PR 44D06 (odmiana mieszańcowa zrestorowana o półkarłowym typie wzrostu), PT 205 (odmiana mieszańcowa zrestorowana o tradycyjnym typie wzrostu); II – dwa sposoby siewu: rozstawa 22,5 cm (siew rzędowy – gęstość siewu 60 nasion na 1 m^2), rozstawa 45,0 cm (siew punktowy – gęstość siewu 40 nasion na 1 m^2); III – trzy rodzaje stosowanych biostymulatorów: wariant kontrolny (bez stosowania biostymulatorów), biostymulator Tytanit®, biostymulator Asahi®SL, biostymulator Silvit®. Zastosowane w doświadczeniu biostymulatory wpływały na zwiększenie liczby liści rozetowych, średnicy szyjki korzeniowej, wysokości wyniesienia stożka wzrostu oraz długości korzenia palowego w porównaniu z poletkami kontrolnymi. Największe wartości cech morfologicznych roślin oznaczonych jesienią przed zahamowaniem wegetacji oraz najpełniejsze ich przezimowanie otrzymano w warunkach opryskiwania biostymulatorem Asahi SL, aplikowanym w stadium BBCH 13-15. Odmiana populacyjna w porównaniu z heterozyjnymi lepiej zimowała, tworzyła rozety o większej liczbie liści (średnio 8,4 szt.), grubszej szyjce korzeniowej (średnio 7,9 mm) oraz dłuższy korzeń palowy (średnio 17,3 cm). U odmiany tej wystąpiły najmniejsze straty roślin po zimowym spoczynku. Sposoby siewu nie wpływały na cechy pokroju roślin. Biostymulator Asahi SL wpływał istotnie na zwiększenie wszystkich cech morfologicznych rozety liściowej oznaczonych jesienią przed zahamowaniem wegetacji w porównaniu z wariantem kontrolnym. Morfotypy mieszańcowe zrestorowane: PR 44D06 i PT 205 w porównaniu z odmianą populacyjną Monolit odznaczały się słabszym jesiennym rozwojem rozety liściowej. Zróżnicowane warunki klimatyczne panujące w okresach letnio-jesiennej wegetacji i zimowego spoczynku w latach prowadzenia badań wpływały na pokrój roślin.

Słowa kluczowe: Asahi SL, bioregulatory, odmiany, pokrój roślin, przezimowanie, rzepak ozimy