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The Effect of Foliar Nutrition with Sulphur and Boron, Amino Acids on Morphological Characteristics of Rosette and Wintering Winter Rape (*Brassica napus* L.)

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ABSTRACT

The field experiment was carried out in 2016-2019 at the Agricultural Experimental Station – Zawady belonging to the University of Natural Sciences and Humanities in Siedlce. The experiment was established in a random split-plot system in three repetitions. The surface of one plot was 21 m^{-2}. The examined factors were: I – three varieties of winter rape: Monolit (population variety), PX115 (hybrid variety restored with a semi-dwarf growth type), PT248 (hybrid variety restored with a traditional growth type); II – four types of foliar feeding: 1. control object (without foliar feeding and biostimulator), 2. biostimulator Aminoplant, 3. Foliar fertilizer Siarkomag + foliar fertilizer Bormax, 4. Foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant. The aim of the study was to determine the effect of foliar nutrition on the number of leaves in the rosette, elevation height of the cone of growth, root collar diameter, length of pile root and wintering of three varieties of winter rape. Foliar nutrition with sulphur, boron combined with amino acids increased the number of rosette leaves (on average by 27.1%), root diameter (on average by 11.0%), pile root length (on average by 9.7%) and provided the best wintering of plants compared to the control variant. Irrespective of the foliar nutrition used, the elevation height of the growth cone was the same. The genetic factor did not affect the number of leaves in the rosette. The population morphotype and the long-stemmed hybrid had the same elevation height of the growth cone, while the population variety was distinguished by the greater diameter of the root neck, while the restored hybrid with the traditional type of growth with a longer pile root compared to the remaining varieties. Diverse climatic conditions prevailing during summer and autumn vegetation and winter dormancy in the years of research have influenced the cut of plants and wintering.

Keywords: *Brassica napus*, number of leaves per rosette, height elevation of shoot apex, diameter of root collar, pile root length, planting

INTRODUCTION

Diepenbrock (2000) and Velička et al. (2010) emphasize that the development of plants before winter, taking into account the morphological features of the rosette, determines the hardiness of rape. According to many authors (Fageria et al., 2009, Kocoń, 2009, Szewczuk and Sugier, 2009), the use of foliar fertilizers containing micro and macro elements during autumn vegetation has a positive effect on winter crops. They are the best way to avoid and replenish ingredients shortages, mainly due to speed and efficiency of operations, and according to Sharma et al. (2014) and Kocira et al. (2016) increase the resistance of plants to stress.

The aim of the study was to determine the effect of foliar nutrition on the number of leaves in the rosette, elevation height of the cone of growth, root collar diameter, length of pile root and wintering of three varieties of winter rape. The paper assumes a research hypothesis that foliar fertilizers containing sulphur and boron in combination with or without amino acids can affect the biometric features of plants marked in the autumn before inhibiting vegetation and provide more complete wintering of plants.

MATERIAL AND METHODS

The field experiment was carried out in 2016-2019 at the Agricultural Experimental Station Zawady (52°03'N and 22°33'E) belonging to the University of Natural Sciences and Humanities in Siedlce. The experiment was established in a random split-plot system in three repetitions. The surface of one plat was 21 m^{-2}. The examined factors were I – three varieties of winter rape: Monolit (population variety), PX115 (hybrid variety restored with a semi-dwarf growth type), PT248 (hybrid variety restored with a traditional growth type). II – four types of foliar feeding: 1. control object – without using foliar feeding and a biostimulator were sprayed with distilled water, 2. biostimulator Aminoplant (N_{total} - 8.5%): I term - in autumn in the 4–6 leaf phase (BBCH 14-16) at a dose of 1.0 $dm^3 \cdot ha^{-1}$. 3. foliar fertilizer Siarkomag (MgO - 5%. SO_{3total} - 85%. $SO_{3soluble}$ in water - 10%) + foliar fertilizer Bormax (B - 11%): I term - in autumn in the 4–6 leaf phase (BBCH 14-16) at a dose of 2.0 $dm^3 \cdot ha^{-1}$ + 0.5 $dm^3 \cdot ha^{-1}$. 4. foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant: I term - in autumn in the 4–6 leaf phase (BBCH 14-16) at a dose of 2.0 $dm^3 \cdot ha^{-1}$ + 0.5 $dm^3 \cdot ha^{-1}$ + 1.0 $dm^3 \cdot ha^{-1}$

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). The experiment was carried out on soil classified in the order of soils with clay translocation, type – Luvisols, subtype – Albic Luvisols. This soil was classified as IVa bonitation class soil, of very good rye complex for agricultural use. During the years of the experiment, soil pH (in 1n KCl) was slightly acidic, ranging from 5.68 to 5.75. The soil was characterized by low abundance in assimilable forms of phosphorus and moderate assimilability in potassium and magnesium (Table 1). After forecrop harvest, a set of post-harvest procedures was carried out using the ploughing aggregate + open cage roller, and then two weeks after the first procedure, pre-sow ploughing at the depth of 20.0 cm was carried out, using a ring roller at the same time. To prepare the soil for sowing and to mix fertilizers, a complex soil tillage unit was used. Before sowing. phosphorus-potassium fertilization was applied at the dose 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 at the dose of 600 kg. Fertilizing doses were supplemented with 55.9 $kg \cdot ha^{-1}$ of ammonium nitrate (19 kg $N \cdot ha^{-1}$), 29.6 $kg \cdot ha^{-1}$ triple superphosphate (13.6 kg $P \cdot ha^{-1}$) and 29 $kg \cdot ha^{-1}$ potassium salt (17.9 kg $K \cdot ha^{-1}$). The second dose of nitrogen in the amount of 100 $kg \cdot ha^{-1}$ was applied in spring, before vegetation started (BBCH 28–30) applying ammonium nitrate at the dose of 255.5 $kg \cdot ha^{-1}$ (86.9 kg $N \cdot ha^{-1}$) and ammonium sulphate at the dose of 62.5 $kg \cdot ha^{-1}$. The third dose of ammonium 60 $kg \cdot ha^{-1}$ was applied at the inflorescence emergence (BBCH 50). by applying ammonium nitrate at the dose of 176.5 $kg \cdot ha^{-1}$ (60 kg $N \cdot ha^{-1}$).

Winter rapeseed sowing was made at spacing between rows of 22.5 cm. assuming the sow of 60 $pcs \cdot m^{-2}$. Sowing was made at the optimal time recommended for this region (in 2016 - on 12 August, 2017 - on 14 August, and in 2018 - on 13 August).

Chemical protection against weeds, diseases and pests was applied in accordance with the recommendations of good agricultural practice.

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 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.

The results of the study were statistically analysed with the use of the analysis of variance. The significance of variation sources was tested with the "F" Fischer-Snedecor test. and the assessment of significance at the significance level of p=0.05 between compared means - with Tukey's range test.

In the periods of summer and autumn vegetation and winter dormancy, there were varied humidity and thermal conditions prevailing (Table 2). Based on the calculated Sielianinov hydrothermal coefficient, it was found that the first test season (from August to March) 2016–2017 was optimal (K=1.42). The sum of rainfall was

Table 1. Characteristics of soil conditions - Zawady Meteorological Station, Poland (2016-2019)

Soil characterization	Vegetation seasons		
	2016-2017	2017-2018	2018-2019
Bonitation class	IV b		
Agricultural fitness complex	Rye soil complex very good		
pH (1 mol·dm^{-3} KCl)	5.70	5.68	5.75
The content of available forms of elements (mg·kg^{-1})			
P	80.0	75.0	79.0
K	200.0	199.0	205.0
Mg	61.0	60.0	59.0

Table 2. Characteristics of weather conditions in the years 2016-2019 (Zawady Meteorological Station, Poland)

Months	Rainfalls, mm				Air temperature, °C			
	Multiyear sum	Monthly sum			Multiyear mean	Monthly mean		
	1996-2010	2016-2017	2017-2018	2018-2019	1996-2010	2016-2017	2017-2018	2018-2019
VIII	59.9	31.7	54.7	24.5	18.5	18.0	18.4	20.6
IX	42.3	13.6	80.6	27.4	13.5	14.9	13.9	15.9
X	24.2	69.8	53.0	23.3	7.9	7.0	9.0	9.6
XI	20.2	19.5	21.3	9.8	4.0	2.4	4.1	7.9
XII	18.6	22.5	15.8	9.0	-0.1	0.0	2.7	0.3
I	19.0	0.4	10.1	7.9	-3.2	-6.6	-0.7	-3.0
II	16.0	15.9	3.2	4.7	-2.3	-1.3	-4.0	2.2
III	18.3	25.1	15.4	15.0	2.4	5.5	-0.3	4.8
Mean	218.5	198.5	254.1	121.6	5.1	4.9	5.4	7.2
Sielianinovs hydrothermic coefficients*								
	2016-2017		2017-2018			2018-2019		
VIII	0.61		1.00			0.40		
IX	0.28		1.92			0.71		
X	3.02		2.36			0.94		
III	1.79		2.97			1.16		
Mean	1.42		2.06			0.80		

* 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 $1.3<k\leq1.6$, rather humid $1.6<k\leq2.0$, humid $2.0<k\leq2.5$, very humid $2.5 < k \leq 3.0$, extremely humid $k > 3.0$.

lower on average by 20.0 mm compared to the average from 1996–2010, while the average air temperature was similar as for the long-term period and averaged to 4.9°C. In August, the total rainfall was 31.7 mm, which was only 52.9% of the long-term average, while the average daily temperature was slightly below 0.5°C. September was very dry, with the total rainfall of 32.1% of the average long-term and average air temperature bigger than 1.4°C. In October there was abundant rainfall, exceeding the long-term average by more than 2.5 times, and the average air temperature this month was lower by 0.9°C. In November, the total rainfall was comparable to the average for 1996–2010, with the average daily temperature of 1.6°C lower than for the multiannual period. Based on the calculated Sielianinov coefficient, it was found that in the second year of testing, the period from August to March was wet (K=2.06). The total rainfall in this period was higher by an average of 35.6 mm compared to the average of many years. In August, the total rainfall was lower by 5.2 mm, while in September and October it was almost twice as high as the average from 1996–2010. In November, atmospheric precipitation exceeded the average of many years only by 1.1 mm. In December, the average daily temperature and total rainfall was greater by 2.8°C and 2.8 mm compared to the multiannual period. In the last year of the study, the period of summer-autumn vegetation and winter dormancy was dry (K=0.80). The total rainfall was smaller by as much as 96.9 mm compared to many years, while the average air temperature was higher by 2.1°C. August and September were characterized by a very small total rainfall (24.5 mm and 27.4). The average daily air temperature was higher on average by 2.1°C and 2.4°C from the multiannual period. The average daily temperature of November exceeded the average from the average of the multiannual period almost 2-times, and the total rainfall was over 2-times smaller.

RESULTS AND DISCUSSION

Based on the conducted tests, it was found that preparations containing sulphur, boron and amino acids influenced the increase in the number of rosette leaves produced during the autumn vegetation (Table 3). After the application of the Aminoplant biostimulator, the number of leaves in the rosette was the same as in the control object. The greatest significant increase of 1.9 pcs. on average compared to the control variant was noted after the use of the Siarkomag foliar fertilizer with the Bormax foliar fertilizer and Aminoplant amino acid (object 4). Gugała et al. (2018) found a significant increase in the number of leaves in the rosette only after using the Asahi SL biostimulator. Other biopreparations (Tytanit and Silvit) equally increased the number of rosette leaves in relation to the control variant. Own research showed that the genetic factor did not significantly affect the number of leaves in the rosette (Table 3). Different results were obtained by Gugała et al. (2018) who recorded the largest number of rosette leaves in the Monolit population morphotype. Similarly, Wielebski and Wójtowicz et al. (2018) showed the highest value of this feature in the Starter population form, significantly smaller in the restored hybrids Poznaniak and PR45D03, while Velička et al. (2012) found on average 15.3% more leaves in the rosette in the restored hybrid Kronos compared to the population variety.

Own studies showed that after using the Aminoplant biostimulator, the elevation height of the growth cone was the same as in the control object (Table 4). In object 3, where the Siarkomag and Bormax foliar fertilizer were applied, the elevation height of the growth cone decreased by an average of 0.06 mm compared to the control object. The impact of biostimulators and foliar fertilizers on the elevation height of the growth cone determined the climatic conditions prevailing in the analysed study periods (Table 5). In the summer-autumn vegetation and winter dormancy period, in all the vegetation seasons examined, the elevation height of the growth cone after using the Aminoplant biostimulator was the same as in the control object. Statistically insignificant differences were also noted on objects 2 and 3 in the first and last autumn season, and 3 and 4 in the first and second year of the studies. In autumn of the last year of research, the highest placed cone of growth was noted on object 4, while on object 2 and 3 the value of the feature was the same as on the control object, while the lowest on object 3 and 4 in the second research period. Own studies have shown that the population morphotype did not significantly differ in the height of the elevation of the growth cone from the restored hybrid with the traditional type of growth (Table 4). This is in line with the results of Gugała et al. (2018). Wielebski and Wójtowicz (2018) obtained a higher placed cone of growth by an average of 1.3 cm compared to a restored hybrid with a traditional type of growth.

Table 3. Number of leaves per rosette (pcs.) manufactured during autumn vegetation, depending on the factors of the experiment

Cultivars	Years			Types of foliar feeding				Mean
				Objects				
				1.	2.	3.	4.	
	2016-2017	2017-2018	2018-2019	Control variant	biostimulator Aminoplant	foliar fertilizer Siarkomag + foliar fertilizer Bormax	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	
Monolit	7.7	7.1	8.6	6.8	7.1	8.3	8.9	7.8 a
PT 248	7.8	7.5	8.5	6.9	7.6	8.2	9.0	7.9 a
PX 115	7.6	7.4	8.8	7.2	7.6	8.1	8.8	7.9 a
Mean	7.7 a	7.3 b	8.6 c	7.0 a	7.4 a	8.2 b	8.9 c	-

$LSD_{0.05}$ for: years - 0.3; cultivars – n.s.; types of foliar feeding - 0.4; interaction: years x cultivars – n.s.; cultivars x types of foliar feeding – n.s.

Table 4. Height elevation of shoot apex (cm), depending on the factors of the experiment

Cultivars	Years			Types of foliar feeding				Mean
				Objects				
				1.	2.	3.	4.	
	2016-2017	2017-2018	2018-2019	Control variant	biostimulator Aminoplant	foliar fertilizer Siarkomag + foliar fertilizer Bormax	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	
Monolit	2.10	1.88	2.21	2.12	2.08	2.03	2.02	2.06 a
PT 248	1.96	1.88	2.17	2.02	2.01	1.98	2.00	2.00 a
PX 115	1.90	1.79	1.99	1.91	1.91	1.86	1.90	1.89 b
Mean	1.99 a	1.85 b	2.12 c	2.02 a	2.00 ab	1.96 b	1.97 b	

$LSD_{0.05}$ for: years – 0.06; cultivars - 0.06; types of foliar feeding – 0.04; interaction: years x cultivars – n.s.; cultivars x types of foliar feeding – n.s.

Table 5. Height elevation of shoot apex (cm), depending on the years and types of foliar feeding

Years	Types of foliar feeding				Mean
	Objects				
	1.	2.	3.	4.	
	Control variant	biostimulator Aminoplant	foliar fertilizer Siarkomag + foliar fertilizer Bormax	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	
2016-2017	2.06 a	2.02 ab	1.96bc	1.91c	1.99
2017-2018	1.91 ac	1.89 ad	1.81b	1.80b	1.85
2018-2019	2.09a	2.09a	2.10a	2.21e	2.12
Mean	2.02	2.00	1.96	1.97	

$LSD_{0.05}$ for: years – 0.06; types of foliar feeding – 0.04; interaction: years x types of foliar feeding – 0.07.

Types of foliar nutrition influenced the diameter of the root neck. After using the Aminoplant biostimulator, an average increase of 0.12 mm was noted, which was statistically insignificant in comparison to the control variant. While Przybysz (2008) and Gugała et al. (2018) after the application of the Asahi SL bioregulator received a significant increase of this feature. Wenda-Piesik et al. (2017) after the application of a growth promoter based on plant-derived amino acids and extracts of marine brown algae, found that the diameter of the plant root neck was reduced by 0.1 cm on average compared to the control object. In own studies, after the application of the Siarkomag foliar fertilizer with the Bormax foliar fertilizer and the Aminoplant biostimulator, the diameter of the root neck was increased – on average by 11.0%, significantly lower under the influence of foliar fertilizers without a biostimulator (object 3) (Table 6). Aisha et al. (2014) after the use of humic acids, and Szczepanek et al. (2016) after the application of the Humistar humic preparation and the Drakar foliar potassium fertilizer, received a significantly larger diameter of the root neck compared to the control object, but there was no significant difference in the feature after the application of the Humistar humic preparation, Drakar foliar potassium fertilizer and Drakar foliar fertilizer. The morphotype significantly influenced the diameter of the root neck. The highest value of this feature was noted in the Monolit population variety, significantly smaller in the PT248 restored hybrid, while the lowest in the PX115 semi-dwarf hybrid (Table 6). Different research results were obtained by Wielebski and Wójtowicz (2018), who recorded statistically insignificant differences between morphotypes, and Velička et al. (2012) found a 4.3% higher average value of this feature in the Kronos restored hybrid compared to the population variety.

The foliar fertilizers and biostimulator used in own research significantly influenced the increase of the length of the pile root on average from 0.19 to 1.70 cm (Table 7). The highest value of this feature was noted on object 4 after the use of Siarkomag foliar fertilizer with Bormax foliar fertilizer and Aminoplant biostimulator. The Aminoplant biostimulator was able to increase the length of the pile root by only 0.19 mm. Albayrak and Çarnas (2005) and Aisha et al. (2014)

Table 6. Diameter of root collar (mm), depending on the factors of the experiment

Cultivars	Years			Types of foliar feeding				Mean
				Objects				
				1.	2.	3.	4.	
	2016-2017	2017-2018	2018-2019	Control variant	biostimulator Aminoplant	foliar fertilizer Siarkomag + foliar fertilizer Bormax	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	
Monolit	8.33	8.07	9.18	8.09	8.23	8.70	9.08	8.53 a
PT 248	8.24	8.13	8.78	7.98	8.12	8.54	8.90	8.39 b
PX 115	7.95	7.93	8.58	7.83	7.92	8.29	8.58	8.16 c
Mean	8.18 a	8.04 b	8.85 c	7.97 a	8.09 a	8.51 b	8.85 c	-

$LSD_{0.05}$ for: years – 0.105; cultivars – 0.105. types of foliar feeding – 0.127; interaction: years x cultivars – 0.182; cultivars x types of foliar feeding – n.s.

Table 7. Pile root length (cm) depending on the factors of the experiment

Cultivars	Years			Types of foliar feeding				Mean
				Objects				
				1.	2.	3.	4.	
	2016-2017	2017-2018	2018-2019	Control variant	biostimulator Aminoplant	foliar fertilizer Siarkomag + foliar fertilizer Bormax	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	
Monolit	18.15	16.15	19.82	17.16 b	17.40 b	18.50 d	19.10 f	18.04 a
PT 248	18.36	17.23	19.34	17.60 a	17.83 ac	18.52 d	19.28 f	18.31 b
PX 115	18.30	17.48	18.80	17.66 a	17.76 ac	18.24 e	19.12 f	18.19 c
Mean	18.27 a	16.95 b	19.32 c	17.47 a	17.66 b	18.42 c	19.17 d	-

$LSD_{0.05}$ for: years – 0.12 cultivars – 0.12. types of foliar feeding – 0.15; interaction: years x cultivars- 0.20; cultivars x types of foliar feeding – 0.24.

after using humic acids, received a higher value of this feature. From the compared varieties, the largest length of the pile root was distinguished by a restored hybrid with a traditional type of growth, a significantly smaller by a semi-dwarf hybrid, while the smallest by the population variety (Table 7). Different results were obtained by Gugała et al. (2018), who found that the Monolit population variety had a longer length of pile root – an average of 17.3 cm compared to the heterosis ones: PR 44D06 and PT 205. The influence of biostimulators and foliar fertilizers on the elevation height of the growth cone was determined by the genetic factor (Table 7). After using the Aminoplant biostimulator, differences in the value of the discussed feature between the restored hybrids were statistically insignificant and identical in all tested varieties as in the control object. The length of the pile root after application of foliar fertilizers containing sulphur and boron was the same in the Monolit population variety and the PT248 hybrid, while in object 4 where foliar fertilizers containing sulphur and boron were used, as well as a biostimulator with amino acids, the value of the feature was the same in all tested varieties. The impact of biostimulators and foliar fertilizers on the height of elevation of the growth cone were determined by the climatic conditions prevailing in the years of conducting the experiment (Table 8). In the last research season, the length of the pile root after using the Aminoplant biostimulator was the same as in the control object. The favourable effect of autumn foliar fertilizers on wintering of plants was demonstrated by Wenda-Piesik and Hoppe (2018). Similarly, Szczepanek et al. (2016) after using the Humistar humic preparation and Drakar potassium foliar fertilizer showed that the plants were more resistant to freezing. In own research, rapeseed plants were the most resistant to freezing after applying foliar fertilizers with sulphur and boron in combination with or without the Aminoplant biostimulator – an average of 98.3%. After the application of the Aminoplant biostimulator and on the control object, the percentage of wintering of plants was similar.

According to Jankowski and Budzyński (2007), semi-dwarf hybrids produce a short and strong root neck and a flat rosette, which increases their chances for good wintering. This is confirmed by the results of own research (Table 9).

Table 8. Pile root length (cm depending on the years and types of foliar feeding

Years	Types of foliar feeding				Mean
	Objects				
	1.	2.	3.	4.	
	Control variant	biostimulator Aminoplant	foliar fertilizer Siarkomag + foliar fertilizer Bormax	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	
2016-2017	17.81 a	18.07 ab	18.46 c	18.74 c	18.27
2017-2018	16.01 b	16.34 d	17.37 e	18.09 b	16.95
2018-2019	18.59 c	18.58 c	19.44 f	20.67 g	19.32
Mean	17.47	17.66	18.42	19.17	-

$LSD_{0.05}$ for: years – 0.12; types of foliar feeding – 0.15; interaction: years x types of foliar feeding – 0.24

Table 9. Winter survival of plants (%) depending on the factors of the experiment

Factory experience			The number of plants per 1m^{-2}		Overwintering, %
			before winter	spring	
Types of foliar feeding	1.	control variant	56.1	53.7	95.7
	2.	biostimulator Aminoplant	56.1	54.3	96.8
	3.	foliar fertilizer Siarkomag + foliar fertilizer Bormax	56.0	55.0	98.2
	4.	foliar fertilizer Siarkomag + foliar fertilizer Bormax + biostimulator Aminoplant	56.4	55.5	98.4
Cultivars		Monolit	54.9	52.7	96.0
		PT 248	56.4	55.0	97.5
		PX 115	57.2	56.2	98.3
Years		2016-2017	57.0	53.9	94.6
		2017-2018	52.8	51.8	98.1
		2018-2019	58.6	58.2	99.3

Among the tested varieties, the greatest hardiness was found in the PX115 half-dwarf hybrid (on average 98.3%), smaller in the long-stem hybrid (on average 97.5%) and the population form (96%). Similar results were obtained by Velička et al. (2012), who found that wintering of the Kronos hybrid winter rape variety was better than of the traditional Sunday.

Own research showed that rapeseed produced rosettes with the highest values of conformation features (root neck diameter, elevation of the cone of growth, root collar diameter, pile root length) and best wintered in the driest and warmest summer-autumn period and of winter dormancy (2018–2019), while the lowest in the second wet period of research (2017–2018) (Tables 2–4, 6–7). The largest loss of plants was recorded in the first optimal research year (2016–2017), in which the winter dormancy period was characterized by a total rainfall of 0.4 mm, which was only 2.1% of the long-term average and average daily temperature significantly lower than for the multiannual period.

CONCLUSIONS

Foliar feeding with sulphur and boron combined with amino acids increased the number of rosette leaves (on average by 27.1%), root collar diameter (on average by 11.0%), length of the pile root (on average by 9.7%) and ensured the best wintering of plants in comparison to the control variant. Irrespective of the foliar nutrition used, the elevation height of the growth cone was the same.

The genetic factor did not affect the number of leaves in the rosette. The population morphotype and the long-stemmed hybrid had the same elevation height of the growth cone, while the population variety was distinguished by the greater diameter of the root neck, while the restored hybrid with the traditional type of growth with longer piling root compared to the other varieties.

Diverse climatic conditions prevailing during summer and autumn vegetation and winter dormancy in the years of research have influenced the habit of plants and wintering. The highest values of parameters describing the state of the rosette in autumn before the inhibition of vegetation were obtained in the dry and the hottest growing season, and the lowest in the second wet period of research, with the largest loss of plants in the first years of research.

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