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Effect of planting density and row spacing on the yielding of soybean (*Glycine max* L. Merrill)

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Abstract: The paper presents the effect of planting density and row spacing on the growth, development and yield of soybean, cv. Merlin, under very diversified thermal and humidity conditions in the north-central part of Poland. The field experiment was performed in 2016–2019. Three planting densities were applied (70, 90 and 110 seeds per 1 m^2) with two row spacing (16 and 32 cm), in 4 replications. Under good humidity and thermal conditions in 2016 and 2017, the yield of seeds and protein in soybean was 3.3 times higher than if exposed to extreme drought and accompanying high air temperatures in 2018 and 2019. The highly diversified thermal and humidity conditions also contributed to a significant decrease in the effect of the factors applied on the structural yield components, leaf area index and dry matter of nodules. As a result, no need of increasing soybean density was observed; along with row spacing, it should be chosen according to the region.

Keywords: density effect; abiotic stress; plant morphology; sowing ratio; inter-row width; weather conditions

In the last circa dozen years, an increased interest in large-scale soybean cultivation has been observed. The trend is found especially in the Danube region, Europe's most favourable soybean cultivation area (Dima 2017). However, due to the climate changeability over the recent years and the resulting variability in the soybean yields in various parts of the world (Ray et al. 2015), the results of research on the effect of planting density and row spacing are ambiguous. Commonly known, water deficit considerably shortens the vegetative stage and/or generative stage in soybean and decreases the seed yield (Wojtyla et al. 2020), while excessively low air temperature at those stages significantly reduces the formation of generative organs and thus decreases the intensity of photosynthesis and shortens the plant growth stage, which results in a significant reduction in the soybean yield (Desclaux and Roumet 1996, Hu and Wiatrak 2012). Stress caused by drought shortens the seed filling stage and reduces the seed number per plant and 1 000 seed weight (Desclaux and Roumet 1996) as well as it significantly decreases the activity of nitrogen (N) fixation during drought (Streeter 2003).

The planting density and row spacing in the stand substantially determines the use of resources, especially light, nutrients and water, which enhances the rate of vegetative growth and plant development, especially the leaf area index (LAI) and plant height (Holshouser and Whittaker 2002). With a lower planting density, soybean plants show a greater potential to enhance photosynthesis and the biological N fixation, while increasing planting density translates into additional expenses, e.g. the seed material and plant protection products. As commonly known, it demonstrates significant environmental and economic implications (De Luca and Hungria 2014). Carciochi et al. (2019) indicate that a lower planting density per m^2 increases the seed weight per plant; hence the plant productivity depends mainly on the number of seeds per pod. According to De Luca et al. (2014), a lower plant density in the stand improves nodulation (number of nodules and their weight), however,

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generally, it does not affect the plant supply with nitrogen significantly, thus indicating a high flexibility of soybean plants to adjust photosynthesis and N fixation to various planting densities. At the same time, the low sowing density of soybean causes high seed losses during harvest, especially under insufficient rainfall conditions (Rebilas et al. 2020).

With an increasing planting density in soybean, changes in morphology and the growth rate were observed, as well as a decrease in the number and weight of nodules (Kapustka and Wilson 1990) and, at the same time, in the number of branching in soybean plants (Blumenthal et al. 1988). A higher planting density is also accompanied by an increase in the plant height and stand lodging as well as by a decrease in the number of pods per plant and seeds per pod (Ball et al. 2001, Kahlon et al. 2018). Sobko et al. (2019) found that the seed yield and the height of the 1st pod setting increased with the planting density, while the number of pods per plant decreased; with a higher planting density, the LAI value also increased. However, in the experiment reported by Schutte and Nleya (2019), an increase in the seed yield in soybean due to an increasing planting density was inconsiderable. However, in regions with favourable or expected good humidity conditions, higher soybean sowing density is accompanied by higher yields (Rebilas et al. 2020).

The right row spacing in soybean can be of key importance for the plants competing for water, nutrients and sunlight, as well as for photosynthesis and biomass production (De Luca et al. 2014). According to Flajšman et al. (2019), the space between rows shows a visible effect on the soybean yield, yet with lower row spacing, the seed yield is significantly higher than with higher row spacing (Kocjan Ačko and Trdan 2008). Holshouser and Whittaker (2002) found that narrowing row spacing increases the seed yield and the LAI value. However, in Romania, higher yields were reported with a higher width of the inter-rows (Dima 2017). Under favourable humidity conditions in the USA, soybean produces higher yields in lower row spacing, than when exposed to drought in high inter-row spacing (Devlin et al. 1995). Masino et al. (2018) recommends adjusting the row spacing to current environmental conditions in a given region.

Sowing density and inter-row width in soybean cultivations strongly diversified, however in Poland a significantly higher plant density is used than in the world and in Europe. Yet, the optimal soybean plan density and inter-row width to be accepted to get at least the mean European yield the studies have not been specified so far. The aim of our research has been to assess the effect of the row spacing and planting density on the soybean yield and on the structural components of the seed yield under highly diversified environmental conditions in the research years.

MATERIAL AND METHODS

Site description. The research investigated the early soybean cultivar, Merlin (000++) (Saatbau Linz, Austria). A 2-factor field experiment was performed in 2016–2019 in a randomised block design in 4 replications in Poland (latitude 53°13', longitude 17°51', 89.8 m a.s.l.). The soil type, classified according to the WRB as Haplic Luvisols (Cutanic) was a typical lessive soil formed by light loamy sand, deposited in a shallow layer on light loam (IUSS WRB 2015). The content of phosphorus was very high (90 mg/kg of soil), the content of potassium high (134.25 mg/kg of soil), and the content of magnesium low (28.75 mg/kg of soil). The content of available forms of potassium and phosphorus was defined with the Egner-Rhiem DL method. The content of magnesium was recorded by the Schachtschabel method. The concentrations of nitrate and ammonium ions were determined by the Colometrics methods through Behelot and Griess-Ilosvay reactions, respectively. Soil pH was measured potentiometrically in 1 mol/L KCl.

In all the research years, the soil pH was suitable for soybean cultivation (Table 1). The forecrop in all years was spring wheat. Before sowing, 70 kg P/ha, 90 kg K/ha and 30 kg N/ha were applied.

The date of sowing soybean in the following years of research was on: 18, 20 and 20 April and 6 May. Two row spacing were applied (factor A): 16 cm and 32 cm, as well as 3 different planting densities (factor B): 70, 90 and 110 plants per m^2 in 4 replications. The plot area for seeding was 21.24 m^2, while for harvest it was 20.0 m^2. The seeds were inoculated with HiStick® Soy inoculant (BASF Agricultural Specialities Limited, Wick, UK) and sown to the depth of 3–4 cm. Directly after seeding, Sencor (550 mL/ha) was applied into soil and, after emergence, Corum 502, 4 SL was used with an adjuvant Dash HC (1.25 + 1.0 L/ha), as well as Fusilade Forte (0.8 L/ha) to control monocotyledonous weeds.

In 2018 and 2019, the plant growth coincided with the average monthly air temperature in July and August of 20.2 °C and 19.1 °C, respectively, i.e. significantly higher than in 2016 and 2017: 17.3 °C and 17.7 °C, respectively (Table 2).

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Table 1. Characteristics of the soil before sowing soybean in the years 2017–2019

Year	P	K	Mg	NO_3^--N	NH_4^+-N	pH_{KCl}
	(mg/kg of soil in 0–60 cm)			(mg/kg in dry matter in 0–60 cm)		
2016	109.0	127.0	30.0	9.53	5.73	6.3
2017	92.0	149.0	31.0	5.90	7.96	6.3
2018	82.0	112.0	27.0	6.12	6.97	6.8
2019	77.0	149.0	27.0	8.69	2.27	6.5
Mean	90.0	134.25	28.75	6.90	5.73	6.5

On the other hand, a high and well-distributed total rainfall in July and August was recorded only in 2016 and 2017 (98.1 mm and 133.8 mm as well as 119 mm and 126 mm, respectively), which facilitated a good growth in soybean plants, as well as their development and yield. However, in the subsequent research years, soil drought was recorded in 2018; only 86 mm was noted in July and 23.7 mm in August, while in 2019 it was 22.4 mm and 37.7 mm, respectively. In order to analyse the weather conditions, the Sielianinov's hydrothermal coefficient was used. The K index was calculated as follows:

$$K = \frac{P10}{\Sigma t}$$

Where: P – monthly precipitation sum (mm); Σt – sum of average daily air temperature > 10 °C.

Plant development monitoring. In each plot, soybean plant density after full emergence (BBCH 11) and before harvest (R 7–8) was calculated to 1 m^2 in 4 replications at each field.

Just before harvest, samples of 10 plants from each plot were collected to assess structural yield components of soybean i.e. number of pods per plant, number of seeds in a pod, weight of seeds per pod and 1 000 seeds weight. The following measurements in the full flowering phase of soybean (BBCH 65) were made on 10 randomly selected plants from each plot: plant height, seating height of the 1^{st} pod, dry matter (DM) of nodules and leaf area index (LAI) with the use of SunScan Canopy Analysis System (ΔT Devices Ltd., Cambridge, UK).

Table 2. Mean monthly air temperature, precipitation and the Sielianinov's hydrothermal index in 2016–2019

	IV	V	VI	VII	VIII	IX	Mean/sum
Temperature (°C)							
2016	8.3	14.7	17.7	18.3	16.4	14.3	15
2017	6.8	13.4	16.8	17.7	17.7	13.1	14.3
2018	12.3	16.9	18.4	20.5	19.9	15.6	17.3
2019	9.3	12.1	21.9	18.6	19.7	13.5	15.9
1981–2010	7.9	13.3	16.1	18.6	17.9	13.1	14.5
Precipitation (mm)							
2016	28.7	51.4	98.1	133.8	55.3	19.4	386.7
2017	40.8	56.3	54.3	118.9	126.1	78.4	474.8
2018	40.4	14.2	26.4	86	23.7	17	207.7
2019	1.5	89.2	17.7	22.4	37.7	98.5	267
1981–2010	27	49.3	52.8	69.8	62.6	46	307.5
Sielianinov's hydrothermal index (K)							
2016		1.1	1.8	2.4	1.1	0.5	1.4
2017		1.4	1.1	2.2	2.3	2.0	1.8
2018	1.1	0.3	0.5	1.4	0.4	0.4	0.6
2019		2.4	0.3	0.4	0.6	2.4	1.2
1981–2010		1.2	1.1	1.2	1.1	1.2	1.2

Sielianinov's index: < 0.5 – drought; 0.5–1.0 – semi-drought; 1.0 –1.5 – optimal moisture; > 1.5 – excessive moisture

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Soybean was harvested after reaching full maturity (R8) after 140–145 days of vegetation. Seed yield at 14% of humidity and protein yield were measured. The Kjeldahl's method was used to determine the N content (%) in dry matter of the seeds in accordance with PN-75/A-04018 (1975).

Data analysis methods. Statistical analyses of the seed yield and morphological and biological traits of plants and seeds were made with the Statistica 13.3 software (StatSoft, Krakow, Poland). The data were collected from a two-factor experiment design in randomised complete blocks with 4 replications. For the statistical evaluation, the two-way analysis of variance (ANOVA) was used, while the significance of the results was verified with the *HSD* (honestly significant difference) Tukey's test at the significance level of $\alpha = 0.05$. For the purpose of analysis, long-term observations involved repeated ANOVA measures. The tables and charts provide the data presented in the form of means ± standard error (SE). The means in tables and charts provided with the same letters did not differ significantly.

RESULTS AND DISCUSSION

Soybean seed yield. The variability in the crop yields worldwide observed over the recent years, estimated 32–39%, results mostly from the variability in climate and its components (Ray et al. 2015). In our research, a significant decrease in the yield in the subsequent research years was observed due to a significant deviations from the long-term precipitation, a gradual decrease in total rainfall in the research years and an accompanying increase in the air temperature in the period critical for soybean. High and well-distributed total rainfall in July and August was only observed in 2016. However, in the subsequent years, 2017, 2018 and 2019, the plant growth and yielding coincided with higher mean monthly air temperature and gradually lower total rainfall (Figure 1).

Under such highly diversified and only partially favourable thermal and humidity conditions, the mean long-term yield of seeds and protein in soybean was relatively high, 3.05 t/ha and 1 194 kg/ha, respectively (Figure 1). In Europe, high diversification is observed in the soybean yield, resulting from the pattern of temperature and total rainfall in the growing season. When soybean is exposed to water deficit, the development stages get significantly shortened, especially at the stage of seed filling (Descelaux and Roumet 1996), which essentially decreases the yield of seeds and protein. In 2016, with very high and well-distributed total rainfall, the soybean seed yield was almost 5.5 t/ha, while the protein yield was less than 2 200 kg/ha. However, with every subsequent year, the yields of seeds and protein were getting significantly lower, and in 2019 they accounted for 1.23 t/ha and 464 kg/ha, respectively, i.e. merely 22.4% and 21.2% of the yields recorded in 2016, which was the most favourable year in terms of humidity. It was probably the result of disturbing the intracellular water relations and the inhibition of plant growth (Wojtyla et al. 2020), a decreasing supply of nutrients to generative organs (Du et al. 2020) and a significant decrease in the activity of N fixation (Streeter 2003) under such conditions, which decreased the yield of seeds and protein in soybean. An almost 100% correlation between a decrease in the yield of seeds and protein in soybean in the subsequent years indicates

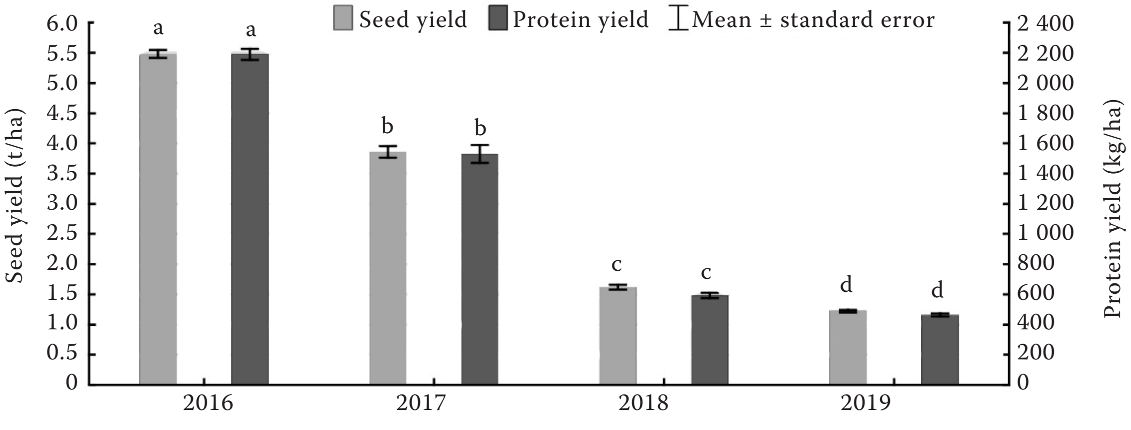

Figure 1. Dynamics of the yield of seeds and protein in soybean in the research years. Means ± standard error followed by the same letters are not significantly different at $P < 0.05$

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a significant effect of humidity on the value of both traits, however most probably without an essential change in the seed protein content. Popović et al. (2012) claim that environment is a dominant element determining protein content in soybean seeds, regardless of the planting density (Sobko et al. 2019).

The right planting density in soybean is of key importance for the plants competing for water, nutrients and light. The agronomic optimal plant density (AOPD) is defined as the minimum number of plants per area unit required for the maximum yield (Carciochi et al. 2019). The most probable AOPD depends mostly on the environmental conditions of soybean cultivation. The planting density above the AOPD increases the risk of lodging and the development of diseases in soybean, and thus decreasing the planting density prior to harvest. In our research, right after emergence, the field planting density determined as the percentage of the seeds sown with a full capacity to germinate, decreased and ranged from 95.6% to 90.2% increasing the planting density planned from 70 to 110 plants in the soybean sown into narrow rows, and from 98.3% to 91.7% into wide rows. These differences accounted for 5.40% and 6.60% less plants prior to harvest than after emergence, respectively. According to Sobko et al. (2019), the planting density prior to harvest is usually lower than after full plants emergence. Similarly, Schmitz et al. (2020) found the average 6.6% plant loss in the stand during growth, irrespective of the row spacing.

A lower planting density is accompanied by higher assimilation surface area of leaves, which allows every plant to absorb more light and develop a higher number of branchings and pods (De Luca et al. 2014), as well as by a 4-fold higher intensity of photosynthesis and a higher carbon supply to nodules and, as a result, by an increased nodulation and the rate of atmospheric N fixation (De Luca and Hungria 2014). As a consequence, low planting density in soybean is accompanied by lower mineral N uptake (Blumenthal et al. 1988) and higher post-harvest seed yield losses due to low pods (Rebilas et al. 2020). In our research, on average for the years, no significant effect of planting density was observed on the yield of soybean sown into wide rows (Figure 2). However, when planting soybean into narrow rows, the seed yield was significantly highest with the highest planting density. According to Schutte and Nleya (2019), in the United States an increase in the soybean seed yield triggered by an increase in the planting density is merely 3–7%. In Germany, the soybean yield increased significantly along with an increase in the planting density (Sobko et al. 2019). According to De Luca et al. (2014), soybean shows a significant yield flexibility. Masino et al. (2018) stated soybean ability to compensate the seed yield. In our research, such dependence was observed when cultivating soybean in wide rows, where planting density did not diversify the soybean seed yield significantly. Many authors indicate significant differences in the soybean yield resulting from the width of inter-rows in various countries. For example, Devlin et al. (1995) stated that under high efficiency, maximum seed yields were higher with lower (8–12 inches), than with higher (24–30 inches) row spacing.

Flajšman et al. (2019) reported higher seed yields after applying 12.5 cm and 25 cm spacing between rows than with 37.5 cm, while Kocjan Ačko and Trdan (2008) obtained better results at a higher

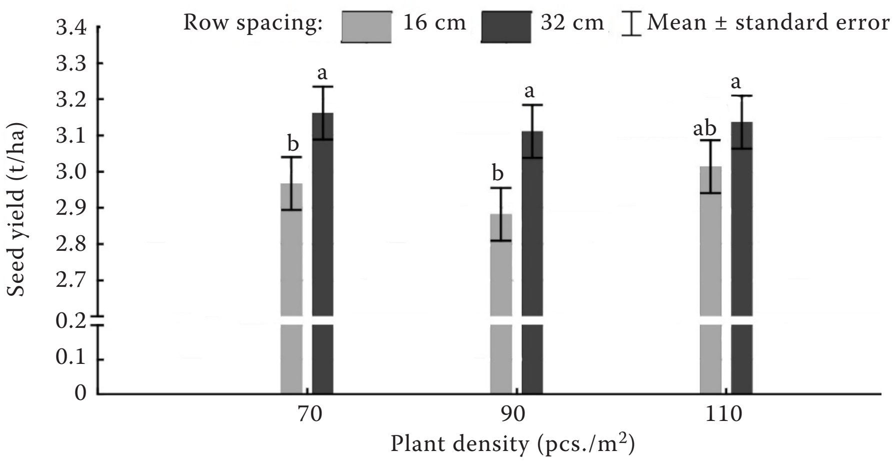

Figure 2. Mean soybean seed yield depending on the planting density and row spacing in 2016–2020. Means ± standard error followed by the same letters are not significantly different at $P < 0.05$

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Table 3. Effect of planting density and row spacing on the seed yield (t/ha) in 2016–2019

Row spacing (cm)	Plant density (pcs./m^2)	Yield			
		2016	2017	2018	2019
	70	5.39 ± 0.22	3.74 ± 0.22^b	1.52 ± 0.1^b	1.22 ± 0.05^{ab}
16	90	5.29 ± 0.03	3.41 ± 0.22^b	1.56 ± 0.09^b	1.26 ± 0.02^a
	110	5.64 ± 0.08	3.79 ± 0.23^b	1.51 ± 0.12^b	1.11 ± 0.05^b
	70	5.48 ± 0.27	4.21 ± 0.28^a	1.76 ± 0.1^a	1.21 ± 0.07^{ab}
32	90	5.43 ± 0.14	4.09 ± 0.19^a	1.69 ± 0.07^a	1.24 ± 0.04^{ab}
	110	5.66 ± 0.17	3.91 ± 0.11^b	1.68 ± 0.01^a	1.31 ± 0.02^a
Mean					
16		5.44 ± 0.08	3.65 ± 0.13^b	1.53 ± 0.05^b	1.2 ± 0.03
32		5.52 ± 0.11	4.07 ± 0.11^a	1.71 ± 0.04^a	1.25 ± 0.03
	70	5.43 ± 0.16	3.97 ± 0.19	1.64 ± 0.08	1.21 ± 0.04
	90	5.36 ± 0.07	3.75 ± 0.19	1.63 ± 0.06	1.25 ± 0.02
	110	5.65 ± 0.09	3.85 ± 0.12	1.59 ± 0.06	1.21 ± 0.04
Year		5.48 ± 0.07^a	3.86 ± 0.09^b	1.62 ± 0.04^c	1.23 ± 0.02^d

Means ± standard error followed by the same letters are not significantly different at $P < 0.05$

width between rows (50 cm) than at 15 cm. Dima (2017) found a high variability in the soybean yield in Romania, resulting, above all, from diversified environmental conditions, and less considerably from the row spacing, which is also confirmed by the results of our research. In our research, only in 2016 under very favourable humidity, no significant effect of row spacing was found on the soybean yield (Table 3). However, in the subsequent years, with a decreasing total rainfall, and with higher row spacing, significantly higher soybean yields were observed, except for the most critical year 2019, in terms of satisfying soybean water requirements.

Yield components. Carciochi et al. (2019) reported on the yielding capacity of soybean plants studied with the use of structural seed yield components facilitating the verification of the optimal planting density. Kahlon et al. (2018) found that the pod number per soybean plant enhances the soybean yield, whereas, according to Ball et al. (2001), it decreases significantly with an increasing planting density. Also, Flajšman et al. (2019) found a significant positive correlation between the seed yield and the pod number per plant, which, in our research, was significantly diversified by both the row spacing and the planting density (Table 4). However, only with lower row spacing, a significantly higher pod number was recorded than with wider row spacing when applying the lowest planting density planned (70 plants per 1 m^2). Increasing the planting density up to 90 and 110 plants per m^2 both with 16 cm and 32 cm row spacing did not diversify the pod number per soybean plant significantly. The seed number per pod is mainly determined genetically and does not depend significantly on the planting density, however according to Sobko et al. (2019), it decreases with an increasing planting density, similarly as reported by Blumenthal et al. (1988). In our research, the average seed number per pod was 1.8, and it was not significantly diversified by any of the factors. Carciochi et al. (2018) found that the seed weight per plant increases with a decreasing planting density and it depends mostly on the seed number per pod, which was not confirmed in our experiment. The size of the obtained results of the yielding elements was very diverse in the years of the study.

According to Sobko et al. (2019), 1 000 seed weight in soybean does not significantly depend on the planting density. In our research, significant yet inconsiderable differences were observed for the 1 000 seed weight resulting from the planting density, and insignificant differences resulting from the row spacing.

Plant morphology. Morphological traits of soybean plants mostly depend on the genotype and the weather pattern during growth (Popović et al. 2002). In our research, the average long-term plant height (62.6 cm) and height of the 1st pod setting (9.53 cm) were not diversified significantly by any of the experimental factors (Table 5). The height of

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Table 4. Effect of row spacing and planting density on structural yield components of soybean seeds

Row spacing (cm)	Plant density (pcs./m^2)	No. of pods per plant	No. of seeds per pod	Seed weight per pod (g)	Weight of 1 000 seeds (g)
	70	25.97 ± 3.48^a	1.84 ± 0.06	0.32 ± 0.01^b	174.15 ± 3.09^{ab}
16	90	19.69 ± 2.48^b	1.87 ± 0.06	0.31 ± 0.02^b	168.76 ± 6.40^b
	110	17.31 ± 2.33^b	1.88 ± 0.09	0.34 ± 0.02^a	181.01 ± 4.56^a
	70	22.00 ± 2.66^a	1.85 ± 0.06	0.33 ± 0.02^a	180.16 ± 3.30^a
32	90	19.53 ± 2.11^{ab}	1.86 ± 0.06	0.30 ± 0.02^b	163.08 ± 5.70^b
	110	16.51 ± 1.72^b	1.80 ± 0.05	0.31 ± 0.01^b	173.11 ± 3.92^{ab}
Year					
2016		26.26 ± 0.99^a	2.04 ± 0.02^a	0.37 ± 0.004^a	183.71 ± 1.93^a
2017		27.99 ± 2.18^a	1.99 ± 0.05^a	0.34 ± 0.012^b	172.00 ± 3.56^b
2018		8.04 ± 0.36^c	1.73 ± 0.05^b	0.28 ± 0.009^c	161.51 ± 5.15^c
2019		18.38 ± 1.29^b	1.63 ± 0.02^b	0.29 ± 0.006^c	176.29 ± 2.97^{ab}

Means ± standard error followed by the same letters are not significantly different at $P < 0.05$

the lowest pod setting depends significantly on the cultivar and the total rainfall, and it increases with an increasing planting density (Sobko et al. 2019), which was not confirmed in our research either. Probably with the average low 1st pod setting, it can be concluded that yield losses during soybean harvest were equal, regardless of the experimental factors. Soybean shows a high flexibility in N fixation; with a lower planting density in soybean demonstrating a more effective symbiosis (De Luca et al. 2014). However, our research results do not indicate a significant effect of row spacing, planting density and their interaction, on the dry weight of nodules, which was, on average, 0.47 g per plant. Morphological traits did not depend on the studied factors, but their value was modified by weather conditions in each year of the study.

Also, Sobko et al. (2019) found no effect of the planting density on the number of nodules. LAI value indices in our research did not significantly depend on the experimental factors applied, or on their interaction. As mentioned above, Sobko et al. (2019) as well as Kahlon et al. (2019) claim that with a higher planting density and seeding of soybean into narrow rows, the LAI value is higher. According to Holshouser and Whittaker (2002), an increase in the LAI value as a result of an increasing density of plant population or decreasing the row spacing can enhance the

Table 5. Effect of planting density and row spacing on selected morphological traits, leaf area index (LAI) and dry matter (DM) of nodules per plant

Row spacing (cm)	Plant density (pcs./m^2)	Plant height (cm)	Height of the first pod (cm)	DM of nodules (g)	LAI (m^2/m^2)
	70	63.06 ± 7.14	9.19 ± 0.71	0.44 ± 0.16	4.55 ± 0.64^a
16	90	62.12 ± 6.7	9.18 ± 0.72	0.55 ± 0.21	4.44 ± 0.53^a
	110	63.27 ± 7.47	9.43 ± 0.62	0.33 ± 0.14	4.30 ± 0.51^a
	70	61.41 ± 6.17	9.01 ± 0.66	0.52 ± 0.19	3.88 ± 0.67^a
32	90	63.81 ± 6.17	9.94 ± 0.65	0.39 ± 0.13	3.14 ± 0.61^b
	110	61.98 ± 6.82	10.47 ± 0.76	0.61 ± 0.34	3.99 ± 0.81^a
Year					
2016		98.85 ± 1.18^a	12.29 ± 0.31^a	1.32 ± 0.21^a	5.89 ± 0.33^a
2017		74.44 ± 1.21^b	11.05 ± 0.38^b	0.80 ± 0.18^b	4.79 ± 0.31^b
2018		33.95 ± 0.70^d	7.55 ± 0.27^c	0.51 ± 0.08^c	2.03 ± 0.33^d
2019		43.20 ± 0.77^c	7.26 ± 0.35^c	0.11 ± 0.04^d	3.45 ± 0.14^c

Means ± standard error followed by the same letters are not significantly different at $P < 0.05$

soybean yield, especially in the year with a significant rainfall deficit. However, in our research, the lack of the effect of the factors studied on LAI must have been due to a decrease in the growth and development of plants in the subsequent years of research due to a significant water deficit. Summing up, the deteriorating moisture conditions in the subsequent years of research contributed to lowering the structural values of the yielding elements and, to a lesser extent, the morphological features of soybean.

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