

Soybean yield in mixed crops

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Abstract. The research was carried out at a field experimental station in 2023, in the conditions of a field stationary experiment. The object of research is an early (early-ripening) soybean variety Mageva, zoned for this zone. The research was aimed at studying the features of crop formation and morphoarchitectonics of soybean plants in semi-specific (mixed) crops with cereals and legumes. Studies have established changes in plant height, the number of beans, seeds, and seed weight depending on the studied variant.

1 Introduction

Currently, a great interest of researchers is associated with the use of poly-species (joint) crops [1-2]. Cover crops prevent soil erosion and support nutrient cycling and soil biota, but little is known about their effect on soybean yields. Soy (*Glycine max* (L.) Merr.) over the past 20 years, in Russia, due to the growth of intensive animal husbandry, due to a significant increase in acreage and yield, gross soybean harvests are at more than 6 million tons, having increased almost 5 times over the past 10 years [3]. Soy is the most important legume crop currently grown worldwide in various climatic conditions, it plays an important role in global food security, as well as in the sustainability of agriculture due to the high content of protein and oil in seeds and low dependence on nitrogen fertilizers, due to the biological fixation of atmospheric nitrogen. Despite the world experience of using poly-species soybean crops with other crops, which significantly increase the productivity of soybeans and the quality of oilseeds, these practices are not widespread in Russia. The use of soybeans in poly-species crops with other crops that affect not only the humidity, temperature, and chemical composition of the soil, but also changes in plant architectonics can have a positive effect on the growth of seed yield [4, 5, 7]. Especially in conditions of lack of moisture, joint crops can affect the moisture content, due to transpiration of cover crops, increase the moisture content of the upper soil layer. The biomass of cover crops can also delay the germination of soybeans and, thus, affect the formation of the soybean crop [6, 8-10]. The advantage of cover crops of the legume family is their ability to accumulate nitrogen in the soil. Therefore, researches were conducted to study the formation of the main parameters of soybean productivity in poly-species crops with plants of the cereal and legume families.

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2 Materials and Methods

The research was conducted in 2023 at the Field Experimental Station of the Russian State Agrarian University – RSAU-MAA named after K.A. Timiryazev (city of Moscow).

The object of the study is poly-species crops of the early-maturing Mageva variety with grain and legumes (rye, wheat, oats, barley, corn, white and narrow-leaved lupine, field and seed peas, common vetch). Field studies were conducted in conditions of small-scale field experiment, based on the method of organized repetitions in 4-fold repetition. The placement of options in the experiment is randomized. The soil of the experimental site is sod-weakly podzolic medium loam on moraine loam. The depth of groundwater is more than 3 m. The arable horizon with a capacity of 20-22 cm contains 2.0-2.2% humus. According to the availability of mobile phosphorus, the soil belongs to class V, mobile potassium belongs to class IV, the pH value is 5.4–5.6, the hydrolytic acidity is very low - 1.04-1.16 mg-eq./100 g of soil. The sowing method is wide-row with row spacing of 45 cm. The seeding rate is 0.5 million germinating seeds/ha. The seeds were embedded in the soil to a depth of 3-4 cm. The yield was harvested in the phase of grain full ripeness manually. Grain threshing (after drying the plants by ventilation) and its sorting were also carried out manually. The yield data was processed statistically by the method of variance analysis using Microsoft Office Excel 2019 software. To analyze the yield structure, the density of standing plants, the mass and number of seeds, the number of beans, the mass of 1000 seeds were determined.

3 Discussion

In the studied poly-species crops in the conditions of 2023, significant differences in plant height were noted, which varied from 44.7 to 64.6 cm (Table 1). The height of soybean plants increased most significantly in joint soybean crops with wheat (by 8.4 cm compared to the control), with chickpeas (by 7.2 cm), by 5.2...5.6 cm in soybean crops with seed peas and oats, respectively. The following pattern was noted – cereals, due to their high bushiness and powerfully developed root system, influenced the reduction in the height of soybean plants - by 9.0 cm (soy + barley) and 11.5 cm (soy + rye).

According to the number of beans/pieces per plant, the following pattern was noted: the number of beans increased in poly-species crops of soybeans with wheat - 32.4 pieces/plant (+4.7 to control), soybeans with garden pea – 33.4 (+5.7 pieces/plant), soybeans with field peas - 32.3 (+4.6 pieces per plant). Agrophytocenoses of soybeans with vetch and rye were characterized by low fruit formation – 19.1 pieces of beans/plant (-8.6 pieces compared to the control) and 21.4 (-6.3), respectively.

Table 1. Plant height and structure of soybean yield in poly-species crops, 2023.

Option	Plant height, cm	Beans, pcs/plant	Seeds in a bean, pcs.	Seeds pcs/plant	Seeds g/plant	Weight of 1000 seeds, g
Soy (control)	56.2	27.7	2.1	56.7	10.8	190.5
Soy + rye	44.7	21.4	2.0	42.8	9.1	213.6
Soy + wheat	64.6	32.4	2.0	65.4	12.1	185.0

Soy + oat	61.8	31.2	2.1	66.7	13.3	199.4
Soy + barley	47.2	26.7	2.1	55.4	11.0	198.6
Soy + corn	51.8	18.7	2.1	39.9	7.50	188.7
Soy + blue lupin	57.2	22.8	2.1	47.3	9.80	207.2
Soy + white lupin	54.5	24.8	2.6	64.3	9.90	154.0
Soy + chickpea	63.4	28.5	2.1	59.2	11.7	197.6
Soybeans + garden pea	61.4	33.4	2.1	70.2	13.2	188.0
Soy + field pea	58.4	32.3	2.1	68.4	12.4	181.3
Soy + common vetch	52.9	19.1	2.3	44.3	8.6	194.1
LSD ₀₅	3.08	1.4	0.11	3.11	0.59	10.5

According to the number of seeds, the following pattern was observed: agrophytocenoses of soy with oat were distinguished by high rates of formed seeds – 66.7 pieces/plant (+10 pieces of seeds compared to the control), with wheat - 65.4 pieces of seeds/plant (+8.7 pieces compared to the control); joint sowing of soy with leguminous crops allowed to increase the number of seeds for 13.5 pieces/plant (soybeans + seed peas) and for 11.7 pieces (soybeans + field peas). In the conditions of 2023, corn (-16.8 pieces of seeds compared to the control), rye (-13.9), and vetch (-12.4) had the most noticeable effect on reducing the formation of soy seeds.

Soy yield varied from 25.3 to 44.7 c/ha (Table 2). The statistically significant increase to the control was in the soy + oat variant (the increase to the control was +8.4 c/ha), soy + garden pea (+8c/ha), soy + field pea (+5.4 c/ha).

Joint sowing of soybeans with rye, despite the increase in the mass of 1000 seeds (+ 23.1 g to the control), did not provide a significant increase in yield (-5.6 c/ha compared to the control).

Table 2. Soybean yield in poly-species crops, c/ha.

Option	Yield, c/ha
Soy (control)	36.3
Soy + rye	30.7
Soy + wheat	40.6
Soy + oat	44.7
Soy + barley	36.9
Soy + corn	25.3
Soy + blue lupin	32.9
Soy + white lupin	33.3
Soy + chickpea	39.3
Soybeans + garden pea	44.3
Soy + field pea	41.7
Soy + common vetch	28.9
LSD ₀₅	1.61

A significant decrease in soy yield was noted in joint crops with corn – the yield in this variant was 25.3 c/ha (-11.0 c/ha compared to the control).

4 Conclusion

The conducted studies have shown that poly-specific soy crops with cereals allowed to significantly influence the architectonics of plants - joint soy crops with rye and barley reduced the height of plants by an average of 10.3 cm compared to the control (56.2 cm); at the same time, soy crops with wheat allowed to influence an increase in height by 8.4 cm, with chickpea by 7.2 cm.

Joint sowing of soy with oat was the most promising in increasing the yield index – the increase compared to the control was 8.4 kg/ha, this is due to an increase in the number of beans (+3.5 pieces per plant), the number of seeds (+10 pieces) and the weight of 1000 seeds (+8.9 g). In joint crops of soy with corn, a significant decrease in yield was noted (-11 c/ha compared to the control) due to the powerful development of the vegetative mass of corn, especially during the critical period of fruit formation in soy - during flowering, which led to a decrease in the number of fruits formed (- 9 pieces), seeds (-16.8 pieces), and the weight of 100 seeds (-1.8 g) compared to the control.

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References

1. K.R. Grint, et al., *Frontiers in Agronomy*, **4**, 888349 (2022).
2. Q. Li, et al., *Fermentation*, **8(4)**, 140 (2022).
3. N.V. Zarenkova, et al., *BIO Web of Conferences*, EDP Sciences, **66**, 05006 (2023).
4. K. Koudahe, S.C. Allen, K. Djaman, *International Soil and Water Conservation Research*, **10(3)**, 343-354 (2022).
5. T. Zeng, et al., *Fermentation*, **8(4)**, 174 (2022).
6. H.K. Levenson, A.E. Sharp, D.R. Tarpay, *Agriculture, Ecosystems & Environment*, **331** 107901 (2022).
7. K. Kehl, et al., *Pesquisa Agropecuária Brasileira*, **57**, e02702 (2022).
8. P.T. Bo, et al., *Plants*, **11(13)**, 1752 (2022).
9. P. Euteneuer, et al., *Agronomy Journal*, **114(6)**, 3193-3205 (2022).
10. W. M. Bracey, et al., *Agronomy*, **12(5)**, 1214 (2022).