

During the study, it was found that the size of the root crop is controlled by the genotype, but its formation is more dependent on external environmental factors. For selection according to the parameter «length of the root crop», the following samples were selected: 18 days (Russia) and White breakfast (Germany), according to the «width of the root crop» — Belaya (Czech Republic), Zhara (Netherlands)

Key words: *radish, morphotype, gene pole, leaf blade, coefficient of variation.*

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INFLUENCE OF MICROBIAL PREPARATIONS ON THE FORMATION OF PLANT STRUCTURE INDICATORS AND GRAIN YIELD OF SOYBEAN AND BEAN VARIETIES

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У статті визначено ефективність використання мікробних препаратів у технології вирощування сої та квасолі звичайної. Показано вплив біологічних препаратів на зміну елементів структури урожаю досліджуваних сортів сої та квасолі звичайної та встановлено рівень прибавки урожаю зерна від бактеризації насіння.

Ключові слова: *соя, квасоля звичайна, мікробіологічні препарати, елементи структури врожаю, урожайність зерна.*

Introduction. Grain yield of soybean and bean varieties is a complex indicator, and its implementation largely depends on individual productivity: the number of productive nodes, beans per node, the number of seeds in the bean, grain size, determinant type of growth and height of the bottom bean, etc. [1–3]. The yield level of soybeans, as well as of other crops, is determined by the quantitative parameters of the structural elements and their combination both with each other and with other plant traits [4].

Analysis of recent research and publications. The main elements of soybean productivity, which determine the level of its yield, are the number of plants per unit area, the number of beans per plant, seeds per bean and the mass of 1000 seeds [5, 6]. As a rule, the most productive forms of soybeans either combine the average values of the main elements of productivity, or some of them have maximum values, and

others - the average. The number of productive nodes can increase due to the height of plants (varieties with incomplete type of growth — indeterminate), but this feature is undesirable due to the shading of the lower tiers, while reducing the flow of solar insolation to the plant. In the future there is a struggle for assimilators between the vegetative mass of the plant and the generative, where the first indicator has the advantage. This feature is inherent in the old varieties and varieties that are grown under irrigation in conditions of sufficient heat supply [3]. The formation of elements of soybean productivity and the degree of their development largely depend on environmental conditions, biological characteristics of the variety and technological measures of its cultivation [7–11].

The indicator of grain productivity of bean plants (grain weight per plant) is one of the main elements of the yield structure, due to the interaction of many genes, the influence of soil-climatic and agronomic conditions [12]. Thus, it is known about the positive effect of fertilizer on increasing the structure of the bean yield [13–15]. Growth-regulating drugs have a significant effect on the formation of the elements of the bean yield [16]. Also, in the process of research, a significant influence of the factors under study on the variability of the yield of beans was proved, the proportions of factors in its variability were determined, the tightness of relationships between the seeding rate of seeds and performance indicators of beans of different morphobiotypes was determined [17].

Soybeans, as a high-protein crop, need a lot of nitrogen. Nitrogen is often a limiting nutrient for the growth and development of soybean plants [18]. In the Forest-Steppe of Ukraine, in connection with the introduction of soybeans, a mandatory element of the technology of growing this crop is pre-sowing inoculation of seeds with bacterial preparations, which makes it possible to abandon the use of mineral nitrogen fertilizers or significantly reduce their use. This agricultural measure is important because soybeans use a lot of nitrogen for the formation of 1 quintal of seeds and the corresponding amount of by-products — 7.2–10.1 kg, and seed inoculation, as shown by the results of many years of research, increases nitrogen fixation by 40-60%, intensifies the yield increase by 18% and promotes additional protein accumulation by 225 kg / ha compared to the control [19]. Studies carried out at the Institute of Feed and Agriculture of Podillia NAAS showed that bacterial fertilizers used to inoculate seeds increased nitrogen fixation, provided plants with nitrogen, and some drugs and phosphorus, which means they increased the immunity of soybeans, resistance against various diseases, that is, manifested the general effect of three different groups of biological products, positively influenced the formation of the grain yield of this crop [20]. Seed inoculation increased the number of beans and the weight of seeds on soybean plants. Each soybean variety has its own optimal parameters of the performance elements. There is a compensation mechanism for the formation of productivity elements in soybean crops. At a lesser density of plants, more beans and seeds are formed on plants and a large mass of 1000 seeds, and this reduces the loss of yield from crop density [21]. Highly efficient strains of nodule bacteria increase yield and quality of beans [22].

Research methodology. Scientific research was performed by conducting field and laboratory experiments. The researches were conducted at the State Agrarian and Engineering University in Podilya and Bukovinian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region NAAS. The soil of the experimental field of the State Agrarian and Engineering University in Podilya — it is deep leached heavy-loam chernozem on forest-like loams. The experimental plot has the following agrochemical parameters (in the soil layer 0–30 cm): humus content — 4.34 %; pH — 6.8; easily hydrolyzed nitrogen — 124 mg/kg of soil; mobile phosphorus — 86 mg/kg of soil; exchangeable potassium — 167 mg/kg of soil. The soil of the experimental field of Bukovinian State Agricultural Research Station — it is meadow chernozem podzolic with heavy loam. The experimental plot has the following agrochemical parameters (in the soil layer 0–30 cm): humus content — 3.91 %; pH 6.1; mobile phosphorus — 110 mg / kg of soil; exchangeable potassium — 195 mg/kg of soil. The research was conducted in accordance with generally accepted modern methods in crop production [23].

Research results. Harvest structure analysis is an important method for assessing the development of soybeans and common beans. Plant height, lodging and attachment height of the lower beans are some of the main attributes of soybeans that determine its suitability for full mechanized cultivation from sowing to harvesting. In our studies, the height of the plants changed depending on the variety, the year of cultivation and agricultural techniques, studied. But varietal characteristics were decisive. So, in the variant without the use of biological products, the height of soybean plants of the Estafeta variety was 82.1 cm, the Constellation variety — 76.5 cm, the Danae variety — 109.8 cm (table 1).

Table 1. Structure of soybean yield depending on cultivar, seed inoculation and nutrition (State Agrarian and Engineering University in Podilya, 2017-2019)

Variety	Plant height, cm	Bottom bean attachment height, cm	Quantity, pieces.			Grain weight per plant, g	Weight of 1000 grains, g
			grains in beans	beans per plant	grains per plant		
Without inoculation							
Estafeta	82.1	9.7	1.86	26.1	48.5	7.8	160.8
Suzirria	76.5	9.1	1.91	33.1	63.2	10.2	161.4
Danaia	109.8	17.8	2.01	30.9	62.1	9.8	157.8
Rhizobiohyte							
Estafeta	85.7	10.3	1.85	26.7	49.1	7.9	160.9
Suzirria	82.8	9.5	1.89	34.4	65.0	10.5	161.4
Danaia	118.4	19.9	1.98	32.1	63.6	10.1	158.2
Rhizobiohyte + Phosphoenterine + Biopolycid							
Estafeta	84.4	10.2	1.88	26.9	50.6	8.2	162.1
Suzirria	82.1	9.8	1.92	35.7	68.5	11.2	163.5
Danaia	120.0	19.7	2.0	32.5	65.0	10.3	158.5

No less important indicator than the height of soybean plants is the attachment height of the bottom bean. After all, the location of the bottom bean at least 10–12 cm above the soil surface is considered optimal for direct harvesting with a combine. In our studies, in the non-biological version, the height of attachment of the bottom bean on soybean plants of the Estafeta variety was 9.7 cm, that of the Suzirria variety was 9.1 cm, and that of the Danaia variety was 17.8 cm. On average, for 2017–2019, the maximum height of the studied plants was 120 cm in the Danaia soybean variety when treating seeds with Rhizobophyte, Phosphoenterine and Biopolycid. The same variety in the variant with Rhizobophyte seed inoculation had a high attachment height of the bottom bean — 19.9 cm.

One of the main features of the structure of the soybean crop is the number of beans per plant. In our studies, the range of this indicator in the studied soybean varieties was noted in the range from 26.1 to 35.7 pcs./plant. Closely related to the indicators of the number of beans is the number of grains per plant of soybeans, which in the studied varieties varied from 48.5 to 68.5 pcs./plant.

The mass of grains from the plant is one of the main features that determines the final productivity of soybeans. In the control (without the use of biological products) the weight of grains from one soybean plant of the Suzirria variety was 10.2 g, the Danaia variety — 9.8 g, and the Estafeta variety — only 7.8 g. Inoculation of Rhizobophyte seeds and complex use of biological products (Rhizobophyte + Phosphoenterine + Biopolycid) increased the individual productivity of soybean plants. In particular, in the variant with seed treatment of Rhizobophyte, Phosphoenterine and Biopolycid, the weight of grains from one soybean plant of the Estafeta variety increased to 8.2 g, of the Danaia variety to 10.3 g, and of the Suzirria variety to 11.2 g.

In our studies, the use of different types of fertilizers and genetic characteristics of varieties significantly affected the structure of the bean yield. The smallest number of beans per plant of the Bukovynka bean variety was observed in areas without seed inoculation — 9.6 pcs. The Nata bean variety was characterized by a large number of beans (10.0 pcs.) and grains (41.9 pcs.) per plant. Seed inoculation increased the number of beans and seed weight on plants of the studied varieties. Thus, with the use of Rhizoactive on crops of Bukovynka beans 10.1 beans and 42.3 pieces of grains per plant were formed, Nata variety — 10.8 beans and 46.3 pieces of grains on one plant. In addition to the number of beans and grains per plant, the weight of thousands of grains is of great importance in individual productivity. The Nata bean variety was characterized by a greater mass of 1000 grains. In the control (without inoculation) the weight of 1000 grains of this variety was 219.6 g, and the Bukovynka bean variety — 217.0 g (table 2).

The use of Rhizoactive increased the weight of 1000 grains in the Bukovynka bean variety from 217.0 to 219.9 g, in the Nata bean variety — from 219.6 to 224.6 g.

Studies have shown that biological products based on nitrogen-fixing and phosphate-mobilizing bacteria can significantly increase soybean productivity.

Table 2. The structure of the bean harvest depending on the variety, seed inoculation and nutrition (Bukovinian State Agricultural Research Station, 2017-2019)

Variety	Plant height, cm	Bottom bean attachment height, cm	Quantity, pieces			Grain weight per plant, g	Weight of 1000 grains, g
			grains in beans	beans per plant	grains per plant		
Without inoculation							
Bukovynka	48.6	9.3	4.2	9.6	40.1	8.7	217.0
Nata	55.5	11.8	4.2	10.0	41.9	9.2	219.6
Rhizoactive							
Bukovynka	50.7	9.7	4.2	10.1	42.3	9.3	219.9
Nata	56.1	12.0	4.3	10.8	46.3	10.4	224.6

Thus, on average for 2017–2019, the yield of soybean grain under control (the Estafeta variety, seed treatment with water) was 2.23 t/ha. However, this was not the best indicator and among the studied varieties in the variant without the use of biological products, the maximum yield was 2.66 t/ha in the soybean of the Suzirria variety. Bacterization of seeds with Rhizobophyte increased the grain yield in the Estafeta variety by 0.05 t/ha compared to the control, but the best level of grain yield in this variant was observed in the Suzirria soybean variety and amounted to 2.81 t/ha, which was 0.15 t/ha more than in the control. The highest yields in the experiment were provided by treatment of soybean seeds with Rhizobophyte, Phosphoenterin and Biopolycid. Thus, the yield of the Estafeta soybean variety was 2.35 t/ha and was 0.12 t/ha higher than the control variant (table 3).

Table 3. Yield of soybean varieties in the experimental field of the State Agrarian and Engineering University in Podilya depending on the use of biological products (average for 2017-2019)

Biologics	Variety	Grain yield, t/ha
Seed treatment with water (k)	Estafeta	2,23
	Suzirria	2,66
	Danaia	2,61
Rhizobophyte	Estafeta	2,28
	Suzirria	2,81
	Danaia	2,78
Rhizobophyte + Phosphoenterine + Biopolycid	Estafeta	2,35
	Suzirria	2,97
	Danaia	2,98
<i>LSD</i> ₀₅	—	0,12

The maximum yield in this seed treatment was in the Suziria and Danaya soybean varieties and was 2.97 and 2.98 t/ha, respectively.

It was found that the average yield of beans under control in 2017-2019 (the Bukovynka variety without bacterial fertilizers) was 2.22 t/ha (table 4).

Table 4. Productivity of common beans varieties on the experimental field of Bukovinian State Agricultural Research Station depending on the use of Rhizoactive (on average for 2017-2019)

Biologics	Variety	Grain yield, t / ha
Seed treatment with water (k.)	Bukovynka	2,22
	Nata	2,38
Rhizoactive	Bukovynka	2,31
	Nata	2,58
<i>LSD</i> ₀₅	—	0,09

Among the studied varieties in the variant without the use of fertilizers, the higher grain yield was in the Nata bean variety — 2.38 t/ha.

The productivity of beans was significantly affected by inoculation of seeds with Rhizobophyte: the Bukovynka variety grain yield was increased by 0.09 t/ha or 4 %, Nata variety — by 0.17 t/ha or 7 %.

Conclusions. On average for 2017–2019, the maximum height of the studied plants was in Danaia soybeans when treating seeds with Rhizobophyte, Phosphoenterin and Biopolycid and it was 120 cm. In the same variant of using biological products, the Suzirria soybean variety produced the largest number of beans, grains and grain weight per plant. The Suzirria soybeans provided the best yield structure. In particular, in the variant with seed treatment with Rhizobophyte, Phosphoenterin and Biopolycid, the weight of grains from one soybean plant of the the Suzirria variety was 11.2 g, the Danaia variety — 10.3 g, and the Estafeta variety — only 8.2 g. Bacterization of sowing material with biological products contributed to the increase of grain productivity of soybean plants by 5–12 %. The highest grain gain from the use of microbiological preparations was provided by the Suzirria and the Danaia varieties.

In terms of research, the Nata bean variety was more productive, forming 10.2–10.4 g of grain per plant, which was 0.2–1.2 g more than the Bukovynka bean variety. The highest grain gain from the use of Rhizoactive was provided by the Nata variety.

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Аннотация

Чинчик А.С., Олифирович С.И., Олифирович В.А., Гуменюк И.И.
Влияние микробных препаратов на формирование показателей структуры растений и урожайность зерна сортов сои и фасоли обыкновенной

Научные исследования выполнено путем проведения полевых и лабораторных опытов. Исследования проводились в Подольском государственном аграрно-техническом университете и Буковинской

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В наших исследованиях отмечено размах количества бобов в исследуемых сортах сои в пределах от 26,1 до 35,7 шт/на растение. Тесно связано с показателями количества бобов количество зерен с растения сои, которое на исследуемых сортах изменялась в пределах от 48,5 до 68,5 шт/на растение. На контроле (без использования биопрепаратов) масса зерен с одного растения сои сорта Созвездие составляла 10,2 г, сорта Даная — 9,8 г, а сорта Эстафета — только 7,8 г. Инокуляция семян Ризобифитом и комплексное использование биопрепаратов (Ризобифит + Фосфоентерин + Биополицид) повышали индивидуальную продуктивность растений сои. В частности, на варианте с обработкой семян Ризобифитом, Фосфоентерином и Биополицидом масса зерен с одного растения сои сорта Эстафета выросла до 8,2 г, сорта Даная — до 10,3 г, а сорта Созвездие — до 11,2 г. Самые высокие показатели урожайности при исследовании обеспечивала обработка семян сои Ризобифитом, Фосфоентерином и Биополицидом. Так, урожайность сои сорта Эстафета составила 2,35 т/га и была на 0,12 т/га больше, по сравнению с вариантом контроля. Максимальная урожайность при указанной обработке семян была в сое сортов Созвездие и Даная и составила соответственно 2,97 и 2,98 т/га.

В наших исследованиях применение различных видов удобрений и генетические особенности сортов существенно влияли на структуру урожая фасоли. Наименьшее количество бобов на одном растении фасоли сорта Буковинка отмечено на участках без инокуляции семян — 9,6 шт. Сорт фасоли Ната характеризовался большим количеством бобов (10,0 шт.) и зерен (41,9 шт.) на одном растении. Инокуляция семян увеличивала количество бобов и массу семян на растениях исследуемых сортов. Так, при использовании Ризоактива на посевах фасоли сорта Буковинка формировалось 10,1 бобов и 42,3 шт. зерен на одном растении, сорта Ната — 10,8 бобов и 46,3 шт. зерен на одном растении. Среди изучаемых сортов на варианте без применения удобрений высшая урожайность зерна была у сорта фасоли Ната — 2,38 т/га. В значительной степени на производительность фасоли влияла инокуляция семян Ризобифитом: урожайность зерна сорта Буковинка выросла на 0,09 т/га или 4%, сорта Ната — на 0,17 т/га или 7 %.

Ключевые слова: соя, фасоль обыкновенная, микробиологические препараты, элементы структуры урожая, урожайность зерна.

Annotation

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Influence of microbial preparations on the formation of plant structure indicators and grain yield of soybean and bean varieties

The mass of grains from the plant is one of the main features that determines the final productivity of soybeans. In the control (without the use of biological products), the weight of grains from one soybean plant of the Suzirria variety was 10.2 g, of the Danaia variety — 9.8 g, and of the Estafeta variety — only 7.8 g. Seed inoculation with Rhizobophyte and complex use of biological products (Rhizobophyte + Phosphoenterin + Biopolycid) increased the individual productivity of soybean plants. In particular, in the variant with seed treatment with Rhizobophyte,

Phosphoenterin and Biopolycid, the weight of grains from one soybean plant of the Estafeta variety increased to 8.2 g, of the Danaia variety to 10.3 g, and of the Suzirria variety to 11.2 g.

The lowest number of beans per plant of Bukovynka beans was observed in areas without seed inoculation — 9.6 pcs. Nata beans were characterized by a larger number of beans (10.0 pieces) and grains (41.9 pieces) per plant. Seed inoculation increased the number of beans and seed weight on plants of the studied varieties. Thus, with the use of Rhizoactive on crops of Bukovynka beans, 10.1 beans and 42.3 grain pieces per plant were formed, Nata variety — 10.8 beans and 46.3 grain pieces on one plant. Among the studied varieties in the variant without the use of fertilizers, the higher grain yield was in the Nata bean variety — 2.38 t/ha. The productivity of beans was significantly affected by inoculation of seeds with Rhizobophyte: grain yield of Bukovynka variety increased by 0.09 t/ha or 4 %, Nata variety — by 0.17 t/ha or 7 %.

Conclusions. *Suzirria soybeans provided the best yield structure. In particular, in the variant with seed treatment with Rhizobophyte, Phosphoenterin and Biopolycid, the weight of grains from one soybean plant of the Suzirria variety was 11.2 g, Danaia variety — 10.3 g, and Estafeta variety — only 8.2 g. Bacterization of seed by biological products contributed to the increase in grain productivity of soybean plants by 3–17 %.*

Under the conditions of the research, the Nata bean variety was more productive, forming 10.2–10.4 g of grain per plant, which was 0.2–1.2 g more than the Bukovynka bean variety.

Key words: *soybeans, common beans, microbiological preparations, elements of crop structure, grain yield.*