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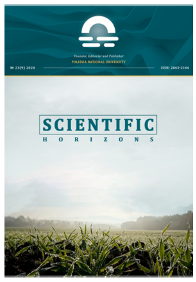

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Varietal features of elements of organic soybean cultivation technology

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Abstract. A reliable element of the technology for growing environmentally friendly products of early-ripening soybean varieties, and improving soil fertility, is the introduction of environmentally friendly growing technology based on the optimal functioning of the symbiotic system, without using mineral fertilisers, in particular nitrogen and pesticides. The purpose of the research was to explore the effect of inoculation of seeds of diverse soybean varieties with nitrogen-fixing and phosphorus-mobilising preparations, foliar fertilisation and their combination on growth, plant development and productivity under organic cultivation technology. The research was conducted using generally accepted methods, the field method, and the method of statistical evaluation of results. Experimental studies have established that with the introduction of high-yielding soybean varieties, using post-harvest residues (straw, stubble and root residues), green manure and legumes in a short rotation crop rotation, 136 kg of nitrogen and 142 kg of biologically fixed nitrogen enters the soil. It was demonstrated that seed treatment with AgriBacter inoculant and soybean fertilisation with Nanovit Super complex fertiliser ensures a yield of 4.08 t/ha for Mentor and leaves almost 30% of biological nitrogen in the soil. Studies have demonstrated that an integrated approach to the treatment of soybean seeds of the tested varieties with AgriBacter and Phosphoenterin inoculants, a strain of bacteria that decomposes hardly soluble organic phosphates, which in turn contributes to better nutrition of soybean plants, development of the root system, and has a positive effect on the development of an optimal stem density of 410-490 thousand units/ha, which provides an increase in the yield of soybean varieties by 1.88 t/ha. It was established that simultaneous inoculation of seeds and foliar feeding of soybeans with the biologically active complex Nanoactiv with the addition of magnesium sulfate in the macrostage BBCH 60-63 provides the highest yield of Niagara variety – 4.08 t/ha and Astor variety – 2.88 t/ha. Thus, in a short-rotation 4-season crop rotation saturated with legumes, using nitrogen-fixing, phosphorus-mobilising preparations and the active growth stimulator Nanovit Super + Magnesium sulfate, soil fertility increases and the nitrogen content in the soil doubles. The scientific results can become the foundation for improving soil fertility, which will ensure sustainable yields in organic soybean cultivation

Keywords: varietal composition, soil fertility, seed inoculation, foliar fertilisation, soybean yield

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INTRODUCTION

Maintaining soil fertility by using biological air nitrogen in organic soybean cultivation is an urgent issue in modern agricultural production. According to the Law of Ukraine No. 2496-VIII "On Basic Principles and Requirements for Organic Production, Accounting and Sales of Organic Products" (2018), organic biotechnology in crop production, environmental protection, and rural development is a key factor influencing the development of agriculture. In the organic farming system, legumes are one of the tools that can mitigate ecosystem deficiencies and reduce nutrient imbalances, but in most European farms, there is a decrease in legume acreage without a satisfactory explanation. Organic and inorganic legume residues have a positive effect on crop yields, and increase soil fertility and nitrogen content (Haryati *et al.*, 2021; Hussain *et al.*, 2021).

Petrychenko *et al.* (2016; 2020) note that a reliable element of the technology for growing environmentally friendly soybean products, and for increasing soil fertility, the main task in modern agricultural production is the introduction of environmentally friendly cultivation technology based on the optimal functioning of the symbiotic system, without using mineral fertilisers, especially nitrogen and pesticides. Khomenko *et al.* (2019) and Mazur *et al.* (2017) consider the development and implementation of appropriate modern models of soybean cultivation technologies to be the main task in implementing the genetic potential of the varietal composition. Carkner *et al.* (2017) demonstrate that most non-genetically modified soybean varieties are grown and tested under conventional conditions but rarely on organic farms. The introduction of varieties and hybrids adapted to specific soil and climatic conditions, as indicated by Kravchuk *et al.* (2015), and using microbiological preparations are mandatory for soybean cultivation. After analysing the studies by Nahornyi, (2009); Magrini *et al.* (2016), it is believed that in recent years, microbial biological products that are environmentally friendly and contribute to the preservation of organic matter in the soil, the decomposition of which by microorganisms results in the development of more complex organic matter, including humus, have been increasingly used in agriculture. Inoculation of legumes with Rhizobium strains, as indicated by Albareda *et al.* (2009), is a necessary agricultural practice on most European soils that are free of soybean-specific rhizobia. And in organic soybean production, as Mandal *et al.* (2009) and Zimmer *et al.* (2016) have demonstrated, the establishment of an effective rhizobial symbiosis is crucial for soybean production and, in general, for improving soil fertility, grain yield, and protein content, and yield.

Nahornyi (2009) considers seed bacterisation to be the main component of modern soybean cultivation technologies, an important element of ecologisation and energy saving. It is essential that the processes of photosynthesis and biological fixation of air nitrogen do not inhibit each other, as this significantly affects the nutritional conditions of soybean plants. O. Marushchak proved that the activity of the symbiotic apparatus affects the yield of soybeans and subsequent crops in the crop rotation, soil fertility and nitrogen content in it in a straightforward way. It is possible to obtain high yields of different soybean varieties without inoculation, but according to Marushchak's (2013) research, this dramatically increases the removal of nitrogen from the soil. To fully provide soybean plants with available forms of nutrients, Novytska *et al.* (2017) suggest using multicomponent chelated foliar fertilisers such as Polyfid, Vuksal, Plantafol, Crystalon, Reakom and others, which have a fairly high absorption rate, in addition to seed inoculation during the growing season.

The purpose of these studies was to explore the development of high production of soybean varietal composition due to the elements of organic cultivation technology. The main objectives were to explore the impact of nitrogen-fixing and phosphorus-mobilising preparations and foliar fertilisation on plant growth, development, biological nitrogen accumulation, and soybean yield.

MATERIALS AND METHODS

The research was conducted during 2019-2022 on the experimental field of Polissia National University in the conditions of Right-Bank Polissia of Ukraine in a short-rotation 4-crop rotation: perennial legumes on one mowing (clover); winter wheat – by-products and root residues and green manure; soybeans – straw, crop and root residues and soil incorporation; barley with addition of legumes.

The type of soil is a light grey forest soil. The area of the sowing plot is 39.6 m² (3.6x11 m), and the accounting plot is 25 m² (2.5x1.0 m), replicated four times. The research was conducted on soybean varieties Mentor, Tanais, Niagara, Astor during seed treatment with nitrogen-fixing and phosphorus-mobilising preparations and foliar fertilisation with Nanovit Super multicomponent fertiliser and magnesium sulfate. Inoculation of seeds in the first 3 variants was performed with AgriBacter at a rate of 1.25 l/t, Phosphoenterin – 3 kg/t, and in a combination of AgriBacter 1.25 l/t + Phosphoenterin 3 kg/t. In the 5th variant of the research, in the flowering phase of soybean plants, foliar fertilisation was performed with the biological preparation Nanovit Super at a rate of 3 kg/ha + magnesium sulfate 2 kg/ha. In variants 6 and 7, inoculation of soybean seeds and foliar feeding were combined. In variant 6, soybean seeds were treated only with AgriBacter inoculant 1.25 l/t and foliar fertilisation with Nanovit Super 3 kg/ha + Magnesium sulfate 2 kg/ha was performed. In the 7th variant of the research, seeds were inoculated with AgriBacter 1.25 l/t + Phosphorus Ester 3 kg/t and foliar fertilisation with Nanovit Super 3 kg/ha + Magnesium Sulfate 2 kg/ha (Table 1).

***Table 1**. Research options*

No. s/n	Variants		Varietal composition of soybeans		
	Mentor		Tanais	Niagara	Astor
1	Control	–	No fertilisers		
2	AgriBacter	Seed inoculation	1.25l/t		
3	Phosphoenterine		3 kg/t		
4	AgriBacter + Phosphoenterine		1.25 l/t + 3 kg/t		
5	Nanovit Super + Magnesium sulfate	Foliar fertilisation	(3 + 2) kg/ha		
6	AgriBacter + Nanowit Super + Magnesium sulfate	Inoculation + foliar fertilisation	1.25 l/t3 kg/ha + 2 kg/ha		
7	AgriBacter + Phosphoenterine + Nanowit Super + + Magnesium sulfate		1.25 l/t + 3 kg/t + 3kg/ha +2 kg/ha		

***Source:** developed by authors*

Inoculant AgriBacter is a preparation based on nitrogen-fixing bacteria (*Bradyrhizobint japonicum*, strain 532 C), has a liquid form, and has a multifunctional effect on the growth and development of soybeans. Nitrate nitrogen is not deposited in plant tissues, but rather is used for protein synthesis. Nitrogen-fixing bacteria enter the root system and secrete mucus, resulting in the development of long infectious threads that penetrate deep into the root parenchyma and begin to multiply intensively, which contributes to the development of nodules. The nodules fix airborne nitrogen N_2 and convert it into a highly available form for plants – NH_4. Nitrogen fixation lasts until the soybean plants begin to ripen, which allows absorbing up to 100-200 kg of nitrogen during the growing season. Phosphoenterin is an inoculant for improving phosphorus nutrition and intensive plant growth and development. The bacterial strain included in the product is capable of decomposing hardly soluble organic phosphates and converting them into more accessible forms for plants.

Nanovit Super – a highly effective multicomponent fertiliser based on the unique biologically active complex Nanoactiv, which contains a large amount of nitrogen, potassium and magnesium, trace elements, amino acids, phytohormones, polysaccharides, organic acids, etc. Magnesium sulfate with trace elements MgS 23-33, ZMgO – 23, 33%, (SO_3) soluble in water (chelates) and trace elements 0.1% boron and 0.2% zinc.

The number and weight of nodules and the duration of general and active symbiosis were determined according to the method of G.S. Posypanov (1991). The biometric evaluation of soybean varieties was performed on 50 plants from each plot in two non-contiguous replications. Plant density was determined by taking average samples of 100 plants in duplicate from two non-contiguous plots (Ermantraut *et al.*, 2013).

RESULTS AND DISCUSSION

The results of long-term studies have established that in equivalent weather conditions of the growing season, using soybean cultivation technology without using synthetic fertilisers and pesticides, the field germination of different varieties was within 70-79% (Table 2).

***Table 2**. Development of soybean plant density depending on varietal composition and elements of organic cultivation technology*

Variant*	Varietal composition											
	Mentor			Tanais			Niagara			Astor		
	Field germination, %	Plant density, thousand units/ha	Survival rate, %	Field germination, %	Plant density, thousand units/ha	Survival rate, %	Field germination, %	Plant density, thousand units/ha	Survival rate, %	Field germination, %	Plant density, thousand units/ha	Survival rate, %
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	70	300	71	75	324	72	75	388	86	79	369	88
2	75	313	75	80	360	75	85	412	89	84	405	90

Table 2, Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
3	73	310	72	75	360	80	78	406	87	82	397	91
4	73	350	82	78	385	82	88	468	89	84	439	93
5	72	335	77	76	370	80	74	403	91	84	431	96
6	75	380	84	80	418	87	87	477	92	87	424	95
7	79	410	86	87	454	90	88	490	92	91	439	94

Note: **1 – No fertiliser, 2 – AgriBacter, 3 – Phosphorus, 4 – AgriBacter + Phosphorus, 5 – Nanowit Super + Magnesium sulfate, 6 – AgriBacter + Nanowit Super + Magnesium sulfate, 7 – AgriBacter + Phosphorus + Nanowit Super + Magnesium sulfate*
Source: *developed by authors*

When seeds were inoculated with the nitrogen-fixing preparation AgriBacter at a rate of 1.25 l/t, field germination of soybean plants increased by 6-13%, while treatment of soybean seeds with Phosphoenterin at a rate of 3 kg/ha increased this indicator by only 3-4%. The combination of AgriBacter and Phosphoenterin during seed inoculation provided the highest field germination of soybean seeds in the Niagara variety – 17% more compared to the control variant; in the Mentor and Tanais varieties – 4%, Astor variety – 6%. In the 5th variant of the research, where in the flowering phase of soybean plants foliar fertilisation with the biological preparation Nanovit Super and magnesium sulfate at a rate of 3 kg/ha + 2 kg/ha was performed, no significant increase in field germination was observed except for Astor variety by 6%, and even a decrease in this indicator by 1.5% in Niagara variety. With the simultaneous inoculation of soybean seeds and foliar fertilisation, field germination increased by 6-16% in variant 6, and by 12-17% in variant 7 compared to the variant without fertilisation.

In the control variant, the stem density of soybean varieties Mentor, Tanais, Niagara and Astor ranged from 300-324-388-369 thousand units/ha. Pre-sowing treatment of seeds with AgriBacter inoculant, due to the assimilation of air nitrogen, provided an increase in plant density during the growing season by 13-36-24-36 thousand pcs/ha, respectively, with plant survival within 75-84-90%. When treating the seeds with phosphorus-mobilising preparation Phosphoenterin, the density of soybean plants of different varietal composition increased by 10-36-18-28 thousand pcs/ha, respectively. Simultaneous treatment of seeds with nitrogen-fixing and phosphorus-mobilising preparations contributed to an increase in plant density by 50-80 thousand units/ha compared to the control variant and by 25-56 thousand units/ha compared to variants 2 and 3, where these preparations were used separately. Foliar fertilisation with Nanovit Super and Magnesium Sulfate biological products provided an increase in stem density by 15-62 thousand units/ha compared to the 1st variant, and their combination with inoculation of soybean seeds with AgriBacter, respectively, by 55-94 thousand units/ha. Foliar feeding of soybeans during the critical period of growth and development with multicomponent preparations of organic origin and inoculation of seeds with nitrogen-fixing and phosphorus-mobilising preparations contributes to the formation of the largest non-laying stem of Mentor – 410, Tanais – 454, Niagara – 490 and Astor – 439 thousand. units/ha, which is 110-130-102-70 thousand units/ha more than in the variant without fertilisation and 10-30% more than in the case of these preparations alone (Fig. 1).

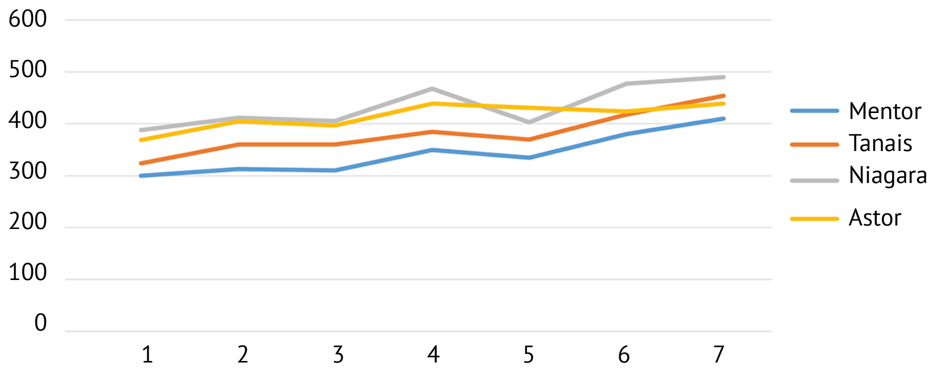

***Figure 1**. Development of plant density depending on varietal composition and elements of organic soybean cultivation technology*
Note: **1 – No fertiliser, 2 – AgriBacter, 3 – Phosphorus, 4 – AgriBacter + Phosphorus, 5 – Nanowit Super + Magnesium sulfate, 6 – AgriBacter + Nanowit Super + Magnesium sulfate, 7 – AgriBacter + Phosphorus + Nanowit Super + Magnesium sulfate*
Source: *developed by authors*

In addition, elements of organic soybean cultivation had a significant impact on plant survival. During the growing season, soybeans of the Mentor variety increased this indicator from 71% in the control variant to 86% in 7; Tanais – from 72% to 90%; Niagara – from 86% to 92% and Astor – from 88% to 94%.

The results of research on the effect of biological products on the development of nodule bacteria of different varietal composition conducted during 2019-2022 at the experimental field of Polissia National University demonstrated that in the variant without using agrochemicals, up to 100 nodules developed on one plant, and their weight is only 0.56 g. During the growing season, their weight reaches 180-300 kg/ha, and the fixation of symbiotic nitrogen from the air is 47-72 kg/ha. When seeds are inoculated with the biological preparation AgriBacter, the mass of nodules on the root system doubles (Table 3, Figure 2, 3).

***Table 3**. Development of biological nitrogen depending on varietal composition and elements of organic cultivation technology, nitrogen kg/ha*

Variant*	Varietal composition											
	Mentor			Tanais			Niagara			Astor		
	Organic residues	Biologically fixed	Total	Organic residues	Biologically fixed	Total	Organic residues	Biologically fixed	Total	Organic residues	Biologically fixed	Total
1	35.2	47.5	82.7	48.6	51.0	99.6	71.6	82.4	154.0	43.6	52.1	95.7
2	57.5	52.8	110.3	64.1	69.3	133.4	101.9	106.1	208.0	65.2	67.1	132.3
3	48.8	51.1	99.9	51.4	69.3	120.7	82.7	88.3	171.0	52.5	57.7	110.2
4	66.1	63.7	129.8	70.0	84.0	154	84.8	114.2	199.0	71.1	77.1	148.2
5	49.5	58.4	107.9	56.5	70.9	127.4	138.5	139.5	278.0	57.6	62.8	120.4
6	72.4	74.7	147.1	82.4	93.4	175.8	110.5	142.5	253.0	83.5	94.5	178.0
7	79.5	80.5	160	87.2	105.0	192.2	136.3	141.7	278.0	88.1	96.1	184.2
Average	58.4	61.2	119.7	65.7	77.6	143.3	103.8	116.4	220.1	65.9	72.5	138.4

***Note:** *1. – No fertiliser, 2. – AgriBacter, 3. – Phosphorus, 4. – AgriBacter + Phosphorus, 5. – Nanowit Super + Magnesium sulfate, 6. – AgriBacter + Nanowit Super + Magnesium sulfate, 7. – AgriBacter + Phosphorus + Nanowit Super + Magnesium sulfate*
***Source:** developed by authors*

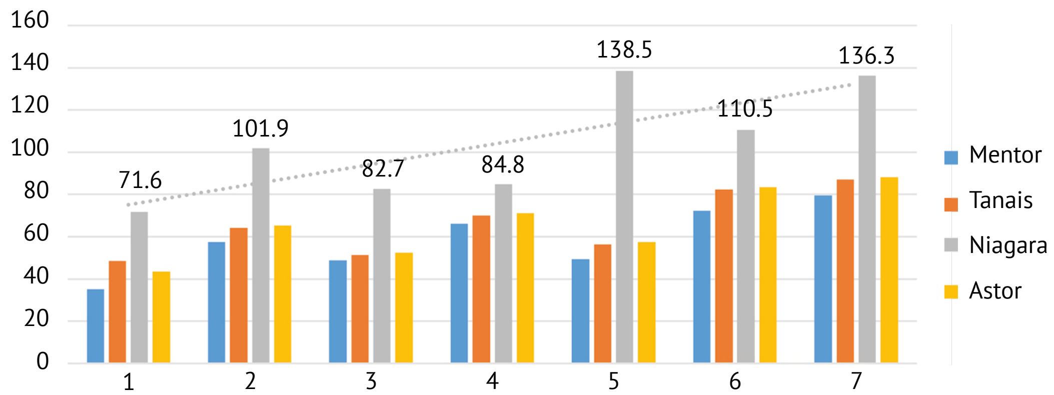

***Figure 2**. Nitrogen of by-products, kg/ha*
***Note:** *1 – No fertiliser, 2 – AgriBacter, 3 – Phosphorus, 4 – AgriBacter + Phosphorus, 5 – Nanowit Super + Magnesium sulfate, 6 – AgriBacter + Nanowit Super + Magnesium sulfate, 7 – AgriBacter + Phosphorus + Nanowit Super + Magnesium sulfate*
***Source:** developed by authors*

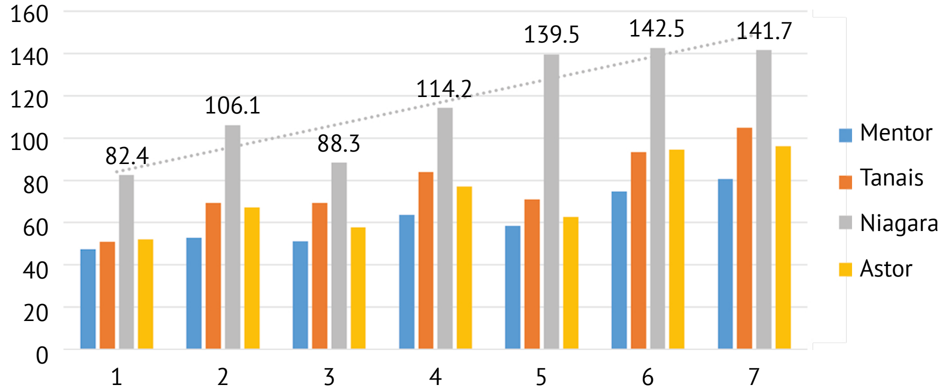

Figure 3. *Nitrogen of by-products, kg/ha*

Note: **1 – No fertiliser, 2 – AgriBacter, 3 – Phosphorus, 4 – AgriBacter + Phosphorus, 5 – Nanowit Super + Magnesium sulfate, 6 – AgriBacter + Nanowit Super + Magnesium sulfate, 7 – AgriBacter + Phosphorus + Nanowit Super + Magnesium sulfate*

Source: *developed by authors*

AgriBacter is an inoculant, a two-component preparation of the genus *Bradyrhizobium*, which initiates the massive establishment of nitrogen-fixing bacteria at the macro stage of BBCH 13-19 according to the *Sadokca* classification (Zadoks scale) and during this period of active symbiosis develops biologically fixed nitrogen of the Mentor 52.8 kg, Tanais variety – 69.3 kg, Niagara variety – 106.1 kg and Astor variety – 67.1 kg, which is higher than the control variant by 5.3-33.4 – 23.7-15.0 kg/ha, respectively. The joint inoculation of soybean seeds with AgriBacter and Phosphoenterin increases nitrogen development by 6.2-18.3-0.9-0.56 kg.

Foliar feeding of soybeans at the macro stage BBCH 60-65 (the name of the first flower buds) before 50% of the flowers open, with Nanovit Super complex fertiliser, promotes the intensive development of nodule bacteria and, accordingly, the increase in biologically fixed air nitrogen in the Niagara variety increases by 57.1 kg compared to the AgriBacter inoculant. The highest results of symbiotic nitrogen accumulation of all soybean varieties were obtained in the variant of pre-sowing inoculation of seeds with nitrogen-fixing and phosphorus-mobilising preparations, followed by foliar fertilisation with the multicomponent Nanovit Super in a mixture with magnesium sulfate: in the Mentor variety, it is 33 kg, in the Tanais variety – 54, in the Niagara variety – 60.1 and the Astor variety – 44 kg/ha.

Figures 2 and 3 demonstrate the symbiotic fixation of air nitrogen by soybean varieties depending on biological products. Considering the supply of nitrogen with by-products (straw, stubble and root residues), the soil is provided with biological nitrogen in the range of 115-220 kg/ha and is used specifically for feeding soybean plants and generating a yield increase in the Niagara variety – 0.11-0.38 t/ha compared to the Mentor, Tanais and Astor varieties (Table 4).

Table 4. *Yields of soybean varieties depending on treatment with organic products, t/ha (2019-2022)*

No. s/n	Variant		Variety				Average per drug	Crop growth, t/ha
			Mentor	Tanais	Niagara	Astor		
1	No fertilisers	–	1.10	1.24	2.15	1.69	1.54	0.44
2	AgriBacter	Inoculation	1.44	1.66	3.02	1.94	2.01	0.57
3	Phosphoenterine		1.28	1.45	2.49	1.85	1.77	0.49
4.	AgriBacter + Phosphoenterine		1.27	1.33	2.92	1.99	1.88	0.61
5	Nanovit Super + Magnesium sulfate	Foliar fertilisation	1.70	1.95	2.88	2.03	2.14	0.44
6	AgriBacter + Nanovit Super + Magnesium sulfate	Inoculation + foliar fertilisation	1.86	2.05	3.31	2.39	2.40	0.54
7	AgriBacter + Phosphoenterine + Nanowit Super + + Magnesium sulfate		2.45	2.25	4.08	2.88	2.91	0.46
Average by variety			1.59	1.70	2.98	1.97	2.09	0.50
Deviation from the average			0.49	0.46	0.89	0.28	0.55	0.06
LSD_{05}			0.043	0.07	0.13	0.5	–	–

Source: *developed by authors*

Seed treatment with AgriBacter inoculant has a positive effect on soybean nutrition and provides an average yield increase of 0.57 t/ha for varieties, with Niagara at 0.87, Tanais – 0.42 and Mentor – 0.34 t/ha. Combined treatment of soybean seeds with AgriBacter inoculant and Phosphoenterin provides a yield increase of –1.88 t/ha.

Foliar feeding of soybeans with a highly effective multicomponent fertiliser with a high content of macro- and microelements based on the unique biologically active complex Nanoactiv, which includes amino acids, phytohormones, polysaccharides, organic acids in a mixture with the preparation Magnesium sulfate with trace elements based on chelate, restores the development of nodule bacteria in the macro stage of BBCH 60-63, which provides an average yield of 2.4 t/ha, Niagara – 3.31 and Astor – 2.4 t/ha, and the increase to the inoculation of seeds with AgriBacter varies within 0.42-0.39-0.29-0.45 t/ha, respectively, for varieties Mentor, Tanais, Niagara and Astor The highest yields over the years of research were obtained in varieties Niagara – 2.98 and Astor – 1.97 t/ha in the 7th variant of the study.

Didur *et al*. (2019), and Zabolotnyi *et al*. (2020), having conducted an energy analysis in the conditions of the Right-Bank Forest-Steppe on grey forest soils, confirm that the cultivation of soybean varieties using the technology that involves the application of mineral fertilisers at a dose of $N_{30}P_{60}K_{60}$, seed treatment (150 g/t) and foliar feeding in the budding phase (0.5 kg/ha) with a complex of microelements Microfol Combi provides the highest coefficient of complex assessment for competitiveness in the Gorlytsia variety – 1.25 and the Vinnychanka variety – 1.24 and clearly expressed intensive growth and development of plants. According to Semenyaka (2010), bioorganic fertilisers significantly improve the mineral nutrition of plants, stabilise and restore soil fertility, and increase soybean yields. Khomenko *et al*. (2019) indicate that nitrogen-fixing bacterial fertilisers should be used on soybean crops: foliar feeding of soybeans on the green leaf with chelated growth stimulants is recommended as an environmentally friendly element of cultivation technology, which significantly improves the formation of nodule bacteria and nitrogen accumulation in the soil. According to Nahornyi (2010), soybeans are the best precursor for many crops, as they can, in symbiosis with nodule bacteria of the Bradyrhizobium japonicum species, leave behind 90-280 kg of biologically fixed nitrogen and a weed-free field, while simultaneously meeting the nitrogen requirements of soybean plants. According to research by Toleikiene *et al*. (2021), in a wet year, inoculated soybeans accumulate a large number of nodules, which increases the yield of soybean seeds by 98% on average over two sowing dates and significantly improves grain quality and protein content.

Research by Naryi (2009) confirmed that soybean plants should be nodulated with specific strains of *Bradyrhizobium japonicum* to maintain nitrogen fixation efficiency. Zimmer *et al*. (2016) confirm the effectiveness of inoculation with Bradyrhizobium strains, which significantly increases grain yield, protein content and protein yield. The average yield of soybean variety Merlin in trials with organic treatment with Bradyrhizobium strains in Germany in 2012-2013 reached 1.6 t/ha (Zimmer, 2016), and worldwide it was 2.3 t/ha Bujak (2009), which is 57% more than the control variant. According to Kushmetova's research (2020), the application of the bacterial fertiliser Rizotorfin during sowing increases soybean yields. Soybeans treated with rhizotorphin leave more nitrogen-rich residues on the field and are therefore an excellent predecessor.

According to the research of Peleh (2021), the highest seed yield of soybean varieties SG Anzer and Cardiff at the level of 2.79-3.02 t/ha was obtained with two-time fertilising in the budding phase and in the phase of green bean establishment with multicomponent microfertiliser Vuksal Microplant, which is 0.37-0.51 t/ha more than in the control variant. Trace elements in sufficient quantities, together with seed inoculation, contribute to better growth and development of plants, and increase stress resistance to external factors (low or high temperatures, uneven moisture, diseases). It is confirmed by Babych & Babych-Poberezhna (2011), who reported that the simultaneous introduction of microelements on the background of inoculation resulted in an increase in soybean yield by 0.26 c/ha.

Thus, the choice of soybean variety is important when growing soybeans, as most of them are suitable for growing only in certain soil and climatic conditions and are characterised by narrow ecological adaptability.

CONCLUSIONS

According to the results of long-term scientific research conducted at Polissia National University on light grey medium nutrient-rich soils, it was established that under equivalent weather conditions of the growing season, using soybean cultivation technology without using synthetic fertilisers and pesticides, the density of soybean stems of Mentor, Tanais, Niagara and Astor varieties ranged from 300 to 369 thousand units/ha. Pre-sowing treatment of seeds with inoculants and foliar feeding provided an increase in plant density during the growing season of Mentor variety from 313 to 410 thousand pcs/ha; Tanais – 360-454 thousand pcs/ha; Niagara variety – 412-490 thousand pcs/ha and Astor variety – 405-439 thousand pcs/ha, the highest rates were observed in variant 7, where all measures were combined. In addition, elements of organic soybean technology increased plant survival from 7 to 25% compared to the control variant.

Pre-sowing inoculation of seeds with nitrogen-fixing and phosphorus-mobilising preparations, followed by foliar fertilisation with the multi-component preparation Nanovit Super in a mixture with magnesium sulfate, stimulated biological processes in soybean plants, contributed to an increase in chlorophyll content, restoration of the rhizobial system, reduction of pest infestation, and the greatest accumulation of symbiotic nitrogen of all varieties: Mentor – 33 kg, Tanais – 54 kg, Niagara – 60.1 kg, and Astor – 44 kg/ha.

The highest soybean yield over the years of research was obtained by managing the processes of growth and development during the growing season in variant 7 with simultaneous seed inoculation and foliar feeding in Niagara – 4.08 and Astor – 2.88 t/ha, which is 1.7-2 times more than in the control variant. In the varieties Mentor and Tanais, the yield increased by 1.8-2.2 times compared to the variant without fertiliser and amounted to 2.45-2.25 t/ha.

The prospect of further research will be the soybean variety Niagara, which is prone to lodging at a plant density of 490 thousand units/ha, thus it is necessary to conduct field studies to explore inhibitors that suppress the growth process and their impact on plant resistance to lodging. The results of field germination and plant survival should be considered when calculating seeding rates for soybean varieties and hybrids.

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Сортові особливості елементів органічної технології вирощування сої

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Анотація. Надійним елементом технології вирощування екологічно чистої продукції ранньостиглих сортів сої, а також підвищення родючості ґрунту є впровадження у виробництво екологічно безпечної технології вирощування, яка базується на оптимальному функціонуванні симбіотичної системи, без використання мінеральних добрив, особливо азотних та пестицидів. Метою роботи було вивчення впливу інокуляції насіння різних сортів сої азотфіксуючими і фосформобілізуючими препаратами, позакореневого підживлення та їх поєднання на ріст, розвиток рослин і продуктивність за органічної технології вирощування. При виконанні досліджень використовували загальноприйняті методи, польовий метод, метод статистичного оцінювання результатів. У результаті виконаних експериментальних досліджень встановлено, що за впровадження високоврожайних сортів сої, використання післяжнивних решток (соломи, стерньових і кореневих решток), сидератів та бобових трав в короткоротаційній сівозміні в ґрунт надходить 136 кг азоту та 142 кг біологічно фіксованого азоту. Було досліджено, що обробка насіння інокулянтом АгріБактер та проведення підживлення сої комплексним добривом208Hановіт Супер забезпечує врожайність сорту Ментор 4,08 т/га та залишає в ґрунті майже 30 % біологічного азоту. Дослідженнями було доведено, що комплексний підхід до проведення обробки насіння сої досліджуваних сортів інокулянтами АгріБактер та Фосфороентерином, штам бактерій яких розкладає важкорозчинні органічні фосфати, що в свою чергу сприяє кращому живленню рослин сої, розвитку кореневої системи, позитивно впливає на формування оптимальної густоти стеблестою 410–490 тис. шт./га, що забезпечує приріст урожайності сортів сої на 1,88 т/га. Встановлено, що одночасна інокуляція насіння та позакореневе підживлення сої біологічно-активним комплексом Nanoactiv з додаванням Сульфат магнію у макростадії ВВСН 60–63 забезпечує найвищу врожайність сорту Ніагара 4,08 т/га та сорту Астор – 2,88 т/га. Таким чином, в короткоротаційній 4-х пільній сівозміні насиченій зернобобовими культурами при застосуванні азотфіксуючих, фосформобілізуючих препаратів та активного стимулятора росту Нановіт Супер + Сульфат магнію підвищується родючість ґрунту, а вміст азоту в ньому подвоюється. Наукові результати можуть стати основою для вдосконалення родючості ґрунту, що забезпечить формування сталих врожаїв за органічного вирощування сої

Ключові слова: сортовий склад, родючість ґрунту, інокуляція насіння, позакореневе підживлення, урожайність сої