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THE INFLUENCE OF MINERAL FERTILIZERS AND BIOPREPARATION ON THE GROWTH AND DEVELOPMENT OF SOYBEAN PLANTS

Abstract.

According to the results of research and their analysis, it was found that the maximum height of 112,2 cm soybean plants are formed during pre-sowing treatment of seeds with biological product Organic-Balance (1,5 l/t) in combination with foliar fertilization with the same drug (2,0 l/ha) against the background of mineral fertilizers in the dose of $N_{30}P_{45}K_{45}$. The largest average daily linear gain was also observed for this cultivation technology. Thus, the results of our research indicate that for the formation of the maximum leaf surface area – 46,5 thousand m^2/ha, the best conditions are created by providing plants with mineral fertilizers at a dose of $N_{30}P_{45}K_{45}$, and at the same time improving the processes of photosynthesis due to seed treatment before sowing with the biological product Organic-Balance (1,5 l/t) and foliar fertilization in the budding phase with the same drug (2,0 l/ha). It is established that a systematic approach to soybean nutrition, namely its cultivation on the background of optimal doses of mineral fertilizers $N_{30}P_{45}K_{45}$ and the use of biological product Organic-Balance for seed treatment in combination with foliar feeding creates the best conditions for growth, development and preservation of maximum plants full ripeness, which is the basis for obtaining high grain yields.

Keywords: *seed treatment, foliar feeding, biological products, legumes.*

Formulation of the problem. To create a highly productive soybean crop, it is important to form the optimal density of standing plants and ensure their good growth and development. The initial period of plant development is crucial, because at this time the density of standing plants, their subsequent growth and yield potential of sowing is determined [36]. For the formation of highly productive crops, it is important to obtain the optimal number of plants per unit area, taking into account the variety, nutrition background, water supply, etc. [41].

According to the results of research, the recommended soybean sowing rates have been determined. For the soil-climatic zone of the Forest-Steppe for early-ripening varieties the norm is 700 - 800 thousand/ha of similar seeds, for medium-early-ripening - 600 - 700 thousand/ha, and for varieties of later-ripening group of maturity - 500 - 550 thousand/ha of similar seeds [9]. One of the most important problems of plant growth and development in the technology of crops, including soybeans, is their growth processes. In terms of scientific support and practical significance, a significant amount of field research in crop production aims to learn the hypothesis of complex mechanisms of the stages of organogenesis of culture and on the basis of this knowledge and patterns to create favorable conditions for plant growth, development and productivity. Therefore, the formation of leaves and inflorescences, the height of plants and the height of attachment of the lower bean significantly influenced the formation of stems and soybean yields [15, 16]. The highest and best quality crops of agricultural plants can be obtained in crops with the optimal size of the leaves, the optimal course of its formation and structure [5, 20]. The optimal growth of the leaf surface and the formation of high photosynthetic potential of the leaves largely depend on the validity of cultivation technologies that provide longer operation of the leaf apparatus [8, 12].

An integral condition for obtaining high soybean yields is the presence of an optimal leaf surface area and an increase in the organic matter synthesized by it. In the formation of the leaf surface area of crops and the efficiency of their use, the sowing rate and sowing methods play an important role. Providing a more uniform distribution of plant area of nutrition and optimizing the area of nutrition of each plant can achieve maximum efficiency of its functioning and absorption of a larger share of photosynthetic active radiation [7,10]. The small area of the leaf surface is the cause of insufficient use of photosynthetically active radiation, at the same time too large area leads to mutual shading of the leaves and, therefore, a significant part of them in the lower tier falls [54].

Presentation of the main research material. Twice during the growing season of the culture was determined by the density of plants in fixed areas, which were fixed after emergence. At the onset of the full germination phase, the first plant density calculation was performed, and it was counted a second time before harvest. Field germination of seeds is possible to determine by conducting the first record at a known seeding rate, and the second record makes it possible to determine the survival for the harvest period. At the time of full germination, the density of soybean plants ranged from 481 thousand/ha to 527 thousand/ha, while the field germination was, respectively, 87,4 – 95,7% on average over the years of research (2019 - 2020 years), (Tab. 1).

Table 1

Influence of fertilizer level and application of microelement complex on field germination and preservation of soybean plants, on average for 2019–2020.

Fertilizer level	Biopreparation treatment	Density of standing plants, thousand/ha		Field similarity,%	Plant conservation rate,% to the number of seedlings
		Full shoots	Full maturity		
without fertilizers	1	481	414	87,4	86,2
	2	508	441	92,2	86,9
	3	483	426	87,7	88,2
	4	509	453	92,5	89,0
$P_{45}K_{45}$	1	486	431	88,3	88,6
	2	513	461	93,3	90,0
	3	488	447	88,6	91,7
	4	515	476	93,6	92,4
$N_{30}P_{45}K_{45}$	1	489	450	88,8	92,1
	2	525	485	95,4	92,5
	3	492	465	89,4	94,6
	4	527	503	95,7	95,5

Note: 1. Without processing; 2. Seed treatment Organic-Balance; 3. Foliar feeding Organic-Balance; 4. Seed treatment + foliar feeding Organic-Balance.

It was found that the application of mineral fertilizers did not have a significant effect on the growth of field germination rates. An increase in the field germination index by 0,9 % was observed in the variant of application of mineral fertilizers in the dose of $P_{45}K_{45}$, and in the case of application of $N_{30}P_{45}K_{45}$, respectively by 1,4 % in comparison with the control variant without application of fertilizers.

It was found that a significantly better increase in the field germination of soybean seeds provided presowing treatment with the biological product Organic-Balance. Depending on the level of mineral nutrition, pre-sowing seed treatment provided an increase in field germination by 4,8 – 6,6 % on average over the years of research. The highest rate of field germination of seeds on average over the years of research was recorded in the variants of the experiment where mineral fertilizers were applied at a dose of $N_{30}P_{45}K_{45}$ and presowing treatment of seeds with biological product Organic-Balance was 95,7%.

The results of research indicate that the rate of field germination of soybeans increased during presowing seed treatment, while the implementation of foliar fertilization had a positive effect on the preservation of plants during the growing season.

The results of observations of the dynamics of plant density of soybean varieties during the growing season indicate that it decreases slightly as it grows and develops. This phenomenon occurs due to the loss of plants from crops as a result of a number of factors, in particular, hydrothermal, biotic, soil and to a lesser extent anthropogenic. As a result, in the phase of full maturity of plants, their density in all variants of the experiment was at the level of 414 to 503 thousand/ha.

It was found that as a result of the research the most favorable conditions for growth and development, and as a result the highest survival rate of soybean plants, were recorded in the variants of the experiment where mineral fertilizers were applied at a dose of $N_{30}P_{45}K_{45}$ and combined pre-sowing seed treatment with foliar fertilization in budding Organic Balance. The conservation rate of soybean plants in this variant of the experiment was 95,5 %. The survival rate of plants decreased by 9,3% in the control version of the experiment where no fertilizers were used and no treatment with biological product was used.

The coefficient of preservation of soybean plants at the time of the phase of full maturity was lower in the variants of the experiment, where seed treatment and foliar fertilization were carried out with the application of mineral fertilizers at a dose of $N_{30}P_{45}K_{45}$ and amounted to 92,5 – 94,6 %, respectively. That is why it is established that a systematic approach to soybean nutrition, namely its cultivation on the background of optimal doses of mineral fertilizers $N_{30}P_{45}K_{45}$ and the use of biological product Organic-Balance for seed treatment in combination with foliar fertilization creates the best conditions for growth, development and preservation of maximum plants at the time of full ripeness, which is the basis for obtaining high grain yields.

The height of the plant, its lodging and the height of attachment of the lower beans are one of the main features of soybeans, which determine its suitability for full mechanized cultivation from sowing to harvesting. The height of plants varies depending on the variety, year of cultivation, soil and climatic conditions and agronomic techniques used [3]. Due to the height of plants, the number of productive nodes may increase (varieties with incomplete type of growth - indeterminate), but this feature is undesirable due to shading of the lower tiers, while reducing the flow of solar insolation to the plant [7].

The stem height of soybean plants, according to the results of the research, largely depended on the hydrothermal conditions of the year and the factors that were studied and analyzed (doses of mineral fertilizers and methods of treatment with biological products).

During the observations in the experiment it was found that in the initial period soybean plants develop quite slowly. The soybean stalk begins to branch with the development of the first - third true leaf.

From this moment the process of vegetative

phases of growth and development begins, the stem begins to grow actively until flowering, after which the generative stage begins, during which the growth of the stem almost stops, and the formation of leaves is completed.

In general, during the years of research (2019 - 2020) the highest indicator of soybean plant height was formed in the phase of full maturity at the level of 112,2 cm in those variants of the experiment where mineral fertilizers were applied at a dose of $N_{30}P_{45}K_{45}$ and seeds were treated with Organic Balance (1,5 l/t) in combination with the use of foliar fertilization in the budding phase of this drug at a rate of 2,0 l/ha, which is 24,4 cm more than in the control version (without mineral fertilizers and Organic Balance) (Tab. 2).

Table 2

Influence of the level of fertilizer and biological preparation treatment on the height of soybean plants, on average for 2019–2020, cm

Fertilizer level	Biopreparation treatment	The third trifoliate leaf	The beginning of flowering	End of flowering	Full maturity
without fertilizers	1	11,7	30,3	67,6	87,8
	2	13,6	32,1	69,2	89,7
	3	11,7	35,4	71,6	91,9
	4	13,5	36,1	73,5	93,5
$P_{45}K_{45}$	1	13,0	34,7	77,9	98,7
	2	14,7	37,3	80,3	101,0
	3	13,2	39,0	82,1	103,5
	4	15,3	40,8	83,6	104,7
$N_{30}P_{45}K_{45}$	1	14,0	39,3	82,1	104,1
	2	16,1	42,3	85,5	106,2
	3	13,5	44,8	87,5	109,1
	4	15,8	46,0	88,9	112,2

Note: 1. Without processing; 2. Seed treatment Organic-Balance; 3. Foliar feeding Organic-Balance; 4. Seed treatment + foliar feeding Organic-Balance.

The study of stem height indicators in soybean plants in the dynamics of growth and development shows that the use of intensification factors contributed to their significant growth. Thus, the use of mineral fertilizers and complex treatment with biological products has led to more active plant growth and an increase in stem height since the beginning of plant vegetation. Improving the mineral nutrition of soybean plants due to the introduction of $P_{45}K_{45}$ contributes to the growth of their height of 98,7 cm, which is 10,9 cm more than the control.

Seed treatment and foliar feeding with Organic-Balance had a positive effect on the formation of plant height. In those variants of the experiment, where presowing treatment of seeds with a biological product was performed, the height index in soybean plants was 1,9 – 2,3 cm higher at the time of full maturity.

According to the results of research and their analysis, it was found that the maximum height of 112,2 cm soybean plants are formed during pre-sowing treatment of seeds with biological product Organic-Balance (1,5 l/t) in combination with foliar fertilization with the same drug (2,0 l/ha) against the background of mineral fertilizers in the dose of $N_{30}P_{45}K_{45}$. The largest average daily linear gain was also observed for this cultivation technology.

According to the results of many studies, the optimal leaf surface area, which forms the highest yield of soybean seeds, is 40-50 thousand m^2/ha. The level of this indicator depends on the morphobiotype of varieties, weather conditions of vegetation, the nature of the distribution of plants by sown area [13, 31].

If the leaf surface area is smaller, then the optical-biological structure of the crop is not optimized and therefore the headlights are not used rationally. However, a larger leaf surface area is undesirable, because as a result of mutual shading, a significant part of the leaves in the lower tier falls off, and the rest does not work effectively [5, 17].

According to the research of scientists, the best indicators of photosynthetic productivity of soybean varieties of different maturity groups in the southern part of the Western Forest-Steppe of Ukraine were found against the background of mineral fertilizers in the norm $N_{30}P_{45}K_{45}$ [24]. Intensive vegetative growth in soybean plants begins after the emergence of shoots and primordial leaves, and along with this there is an increase in leaf area.

According to the results of the observations, it was found that the doses of mineral fertilizers and methods of treatment with the biological product Organic-Balance had a significant impact on the formation of the leaf surface area. The lowest indicator of leaf area on average during the years of research in the phase of seed filling (2019 - 2020), was recorded in the control version of 30,9 thousand m^2/ha. (tab. 3).

Table 3

Dynamics of the leaf surface area growth of soybean plants varieties depending on the level of fertilizer and biological product treatment, on average for 2019-2020, thousand m^2/ha

Fertilizer level	Biopreparation treatment	Phases of plant growth and development				
		the third trifoliate leaf	the beginning of flowering	end of flowering	pouring seeds	the beginning of physiological maturity
Without fertilizers	1	6,6	17,6	28,8	30,9	16,7
	2	8,5	19,0	30,7	33,0	17,8
	3	6,4	19,9	31,6	34,4	20,0
	4	9,0	21,4	32,7	35,5	21,2
$P_{45}K_{45}$	1	9,9	23,8	35,3	37,8	22,8
	2	12,1	25,7	37,4	40,2	24,2
	3	9,5	26,9	38,6	41,0	25,5
	4	12,0	28,8	40,2	42,4	27,3
$N_{30}P_{45}K_{45}$	1	11,6	27,0	37,1	39,4	23,6
	2	13,9	29,8	40,7	42,2	25,5
	3	11,7	31,1	42,4	44,6	27,3
	4	14,5	33,3	45,0	46,5	28,5

Note: 1. Without processing; 2. Seed treatment Organic-Balance; 3. Foliar feeding Organic-Balance; 4. Seed treatment + foliar feeding Organic-Balance.

The cessation of vegetative growth during the beginning of the generative phase of growth when the beans are formed and the seeds begin to pour leads to a decrease in the growth rate of the leaf surface. The studied elements of soybean growing technology contributed to the lengthening of the process of leaf surface area formation. The largest indicator of leaf surface area on average over the years of research was formed in the phase of pouring seeds on all variants of the experiment.

It is worth noting the effect of mineral fertilizers on the leaf surface area. According to the results of the research presented in the table, it can be concluded that mineral fertilizers play both a leaf-preserving and a regulatory role. Due to the intensive action not only on the growth processes associated with the leaf apparatus, but also with the growth of other parts of plants, fertilizers increase the total weight of the plant and this is the regulatory role of mineral fertilizers.

Fertilization with phosphorus-potassium mineral fertilizers in the dose of $P_{45}K_{45}$ on the corresponding variants of the experiment contributed to the increase of the leaf surface area by 19,0–22,4% or 5,8 – 6,9 thousand m^2/ha in comparison with the control variant, use for fertilization of complete mineral fertilizer $N_{30}P_{45}K_{45}$, the leaf surface area increased by 24,6–27,7% or by 7,5 – 8,5 thousand m^2/ha relative to the control. Thus, the control indicator of the leaf surface area in the seed filling phase was at the level of 30,9 thousand m^2/ha, and for the application of $P_{45}K_{45}$ and $N_{30}P_{45}K_{45}$ this indicator was recorded, respectively, 37,8 and 39,4 thousand m^2/ha.

Not only mineral fertilizers had a positive effect on the growth of the leaf surface, but also pre-sowing seed treatment with Organic-Balance and foliar fertilization with the same drug had a stimulating effect. In the phase of seed filling on the variants of the experiment where pre-sowing treatment with the biological product Organic-Balance was carried out, the leaf surface area was higher in comparison with the variants without the use of the biological product by 6,3–7,1 %. An increase in the leaf surface area by 8,5–13,2 % was also observed in the variants of the experiment with the use of foliar feeding with the biological product Organic-Balance in the budding phase. But it should be noted that as a result of research it was found that pre-sowing treatment of seeds with the biological product Organic-Balance in combination with foliar feeding with the same drug in the budding phase was the most effective technological method. In these variants of the experiment, the indicator of the leaf surface area exceeded the variants without treatment by 12,2 – 18,1%. It should be noted that the largest increase in leaf surface was recorded with the application of complete mineral fertilizer $N_{30}P_{45}K_{45}$.

Conclusions. According to the results of research and their analysis, it was found that the maximum height of 112,2 cm soybean plants are formed during pre-sowing treatment of seeds with biological product Organic-Balance (1,5 l/t) in combination with foliar fertilization with the same drug (2,0 l/ha) against the background of mineral fertilizers in the dose of $N_{30}P_{45}K_{45}$. The largest average daily linear gain was also observed for this cultivation technology. Thus, the results of our research indicate that for the formation of the maximum leaf surface area – 46,5 thousand m^2/ha, the best conditions are created by providing plants with mineral fertilizers at a dose of $N_{30}P_{45}K_{45}$, and at the same time improving the processes of photosynthesis. due to the treatment of seeds before sowing with the biological product Organic-Balance (1,5 l/t) and foliar feeding in the budding phase of the same drug (2,0 l/ha). It is established that a systematic approach to soybean nutrition, namely its cultivation on the background of optimal doses of mineral fertilizers $N_{30}P_{45}K_{45}$ and the use of biological product Organic-Balance for seed treatment in combination with foliar fertilization creates the best conditions for growth, development and preservation of maximum plants full ripeness, which is the basis for obtaining high grain yields.

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