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RESEARCH ARTICLE

The influence of biologization of the nutrition system on the formation of photosynthetic productivity of soybean crops

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Abstract

The intensity of photosynthesis, in the process of which energy-rich, complex and chemically diverse organic compounds are formed from simple chemicals and solar insolation, directly affects the level of plant productivity, the size of the crop and its quality. The conducted research is devoted to modern trends in the development of adaptive technologies for growing soybeans, which are based on the number of main directions that take into account both the features of innovative changes and the technological renewal of mechanization tools, as well as the main trends in the development of green agriculture, aimed to ensure the environmental friendliness of the products obtained, the preservation of soils while ensuring proper level of economic and energy efficiency. That's why the purpose of the research was to determine the impact of the combined use of mineral fertilizers, soil biofertilizer and mycorrhizal formative preparation on the process of forming the leaf surface area of soybean crops.

Keywords: Biofertilizer, Mycorrhizal formative preparation, Preparations of natural origin, Photosynthetic potential, Net products of photosynthesis.

Introduction

The use of biologically active substances of natural origin was and remains an effective means of regulating the growth and development of plants, optimizing the process of forming their photosynthetic apparatus and realizing its potential and activity (Didur et al., 2019). Researchers Kaletnik & Lutkovskaya (Kaletnik, 2020; Lutkovska, 2020 and Mazur et al). (Mazur, et al. 2021) claim that due to photosynthesis energy is provided for processes of absorption of mineral forms of nitrogen by plants, reduction of nitrates and inclusion of reduced nitrogen in the composition of organic compounds, as well as their transport to places of utilization or intermediate disposal. Insufficient and excess leaf surface area in the initial phases of plant growth and development is the reason for the decrease in the use of photosynthetically active radiation due to the irrational redistribution of assimilation products (Bulgakov, et al., 2023; Tsyhanskyi, 2021; Mazur, et al., 2020). Other researchers (Mazur, et al., 2021; Didur, et al., 2019) indicate that the productivity of photosynthesis directly depends on the size of the leaf surface area of plants, which can be regulated by creating an optimal optical-

biological structure of the crop and improving growth conditions. Authors Bondarenko et al. (Bondarenko, et al., 2022) analyzing data on high photosynthetic productivity in soybeans indicate that many surprising results have been achieved in rice and tobacco in recent years, but research on high photosynthetic efficiency in soybeans has remained at the same level. Data on the peculiarities of the formation of the leaf apparatus of plants often make it possible to determine the effectiveness of individual technological techniques (Bulgakov, et al., 2023). A number of researchers such as Petrychenko et al. (Petrychenko, et al., 2017; Bondarenko Bondarenko, et al., 2022) claim that the yield of leguminous crops, including soybean, primarily depends on the total photosynthetic productivity, which is determined by the intensity of growth and the size of the leaf surface. The authors (Bakhmat et al. (2023); Pantsyreva (2021)) came to conclusions in their research regarding the satisfaction of manganese needs of soybean crops due to foliar feeding at a concentration of 0.68 gl^{-1}, which can be increased by adding silicon (0.48 gl^{-1}). This synergy of manganese and silicon has shown that foliar spraying benefits the soybean crop, enhances the antioxidant defense system and photosynthetic productivity. That is why, the goal of our research was to determine the effect of the combined use of mineral fertilizers, soil biofertilizer and mycorrhizal formative preparation on the photosynthetic productivity of soybean crops. And determination of the growth dynamics of the photosynthetic potential of soybean plants depending on fertilization and treatment of seeds with a mycorrhizal formative preparation in different variants of the experiment.

Materials and Methods

Field research was conducted in the conditions of the research farm «Agronomichne» of Vinnytsia National Agrarian University, located in the village of Agronomichne of Vinnytsia district, Vinnytsia region. The research was conducted in accordance with the norms of the Convention on Occupational Safety and Health in Agriculture No. 184. On the day of sowing, seeds were inoculated with biological preparations created on the basis of active strains of nodule bacteria (*Bradyrhizobium japonicum*), and foliar fertilization was carried out on the corresponding variants of the experiment in accordance with the experimental scheme. A field experiment that studies the effect of the combined use of mineral fertilizers, soil biofertilizer and mycorrhizal preparation on soybean productivity was conducted during 2017-2021. The scheme of the experiment included the following options:

Factor A – fertilizer:

- N30P60K60 (100%);
- N30P60K60 (100%) + Groundfix (3 l ha^{-1});
- N30P60K60 (100%) + Groundfix (5 l ha^{-1});
- N20P40K40 (70%) + Groundfix (3 l ha^{-1});
- N20P40K40 (70%) + Groundfix (5 l ha^{-1});

Factor B – seed treatment:

- Control - water treatment;
- Mikofrend (1.5 l t^{-1}).

Biological preparations for inoculation and foliar feeding, which were studied, are products of the BTU Center company (BTU-CENTER, 2023). The research was conducted in accordance with generally accepted methodological guidelines. Indicators of photosynthetic activity of soybean plants, namely leaf surface area, Photosynthetic Potential (PP) and Net Photosynthetic Productivity (NPP) were determined according to the method of Nechiporovich (Nechiporovich, 1967). Experimental studies of the plants (both cultivated and wild), including collection of plant material, are followed by institutional, national, or international guidelines.

Results

It was established that the introduction of Groundfix soil biological fertilizer at the rate of 3 l ha^{-1} into the pre-sowing cultivation on the background of NPK (100%) increased the photosynthetic potential of soybean crops to 2.610 million m^{-2} days ha^{-1}, which is 0.193 million m^{-2} days ha^{-1} more than the control. Increasing the rate of Groundfix to 5 l ha^{-1}

ensured the formation of photosynthetic potential at the level of 2.706 million m^{-2} days ha^{-1}, which is 0.289 million m^{-2} days ha^{-1} more than the control. The use of Graunfix at rates of 3 l ha^{-1} and 5 l ha^{-1} on variants where the rate of mineral fertilizers was reduced by 30% ensured the formation of photosynthetic potential, respectively, 2.245 million m^{-2} days ha^{-1} and 2.285 million m^{-2} days ha^{-1}, which is 0.365 million m^{-2} days ha^{-1} and 0.421 million m^{-2} days ha^{-1} lower than on similar options with full rate of mineral fertilizers and 0.172 million m^{-2} days ha^{-1} and 0.132 million m^{-2} days ha^{-1} lower compared to the control with only mineral fertilizers (2.417 million m^{-2} days ha^{-1}). A similar dependence was observed in the variants of the experiment, where pre-sowing treatment of soybean seeds with the mycorrhizal formative preparation Mycofriend (1.5 l t^{-1}) was carried out, while the indicators of the photosynthetic potential were 12.6%-19.8% higher and were within the range of 2.530 million m^{-2} days ha^{-1} to 3.153 million m^{-2} days ha^{-1}. The data obtained in the experiment on the dynamics of the growth of the photosynthetic potential of soybean plants depending on fertilization and treatment of seeds with a mycorrhizal formative preparation are shown in tab. 1.

Table 1. Dynamics of the growth of the photosynthetic potential of soybean plants depending on fertilization and treatment of seeds with a mycorrhizal formative preparation, on average for 2017-2021, million m^{-2} days ha^{-1}, M ± m*

Seed processing	Fertilization	Phases of the growth and development				
		Full seedling growth - the third tripartite leaf	Full seedling growth - the beginning of flowering	Full seedling growth - the end of flowering	Full seedling growth- pouring seeds	Full seedling growth - pouring seeds
Control	1	0,144	0,527	1,208	2,042	2,417
	2	0,148	0,538	1,266	2,192	2,610
	3	0,150	0,560	1,321	2,272	2,706
	4	0,128	0,485	1,116	1,890	2,245
	5	0,132	0,486	1,118	1,914	2,285
Mycofrend	1	0,156	0,564	1,355	2,353	2,786
	2	0,165	0,596	1,447	2,550	3,028
	3	0,171	0,621	1,509	2,658	3,153
	4	0,146	0,531	1,244	2,138	2,530
	5	0,152	0,558	1,363	2,387	2,738
Coefficient of variation V, %		8,8	7,9	10,0	11,4	11,3
Relative error Sx%		2,8	2,5	3,2	3,6	3,4

Note: *1 - NPK (100%); 2 - NPK + Groundfix 3 l ha^{-1}; 3 - NPK + Groundfix 5 l ha^{-1}; 4 - NPK (70%) + Groundfix 3 l ha^{-1}; 5 - NPK (70%) + Groundfix 5 l ha^{-1}.

**M ± m is the confidence interval of the arithmetic mean at the 5% level of significance.

Pre-sowing treatment of seeds with Micofrend (1.5 l t^{-1}) and the use of Groundfix at rates of 3 l ha^{-1} and 5 l ha^{-1} on the background of NPK (100%) ensured the formation of the photosynthetic potential of soybean crops, respectively, 3.028 million m^{-2} days ha^{-1} and 3.153 million m^{-2} days ha^{-1}, which exceeded the control by 0.242 million m^{-2} days ha^{-1} and 0.367 million m^{-2} days ha^{-1}. A decrease in the rate of mineral fertilizers by 30% contributed to a decrease in the level of photosynthetic potential by 15.1%-19.6%. It is worth noting that the treatment of seeds with Micofrend 1.5 l t^{-1} and the introduction of Graunfix at the rate of 5 l ha^{-1} ensured the formation of the photosynthetic potential of sowing and at the same level as when using only mineral fertilizers in the full rate.

The highest level of the net productivity of photosynthesis in the section of the experimental variants of 4.85 g m^{-2}-5.44 g m^{-2} per day was formed during the period from full emergence to the third trifoliate leaf, it happens due to the fact that leaves area is growing fast, under these conditions there is a better penetration of photosynthetic active radiation to the leaves of all layers of the plant. Starting from the phase of the beginning of flowering to the end of flowering, the

intensity of the net productivity of photosynthesis according to the experimental variants decreased and fluctuated between 1.47 g m^{-2}-1.76 g m^{-2} per day (Fig. 1).

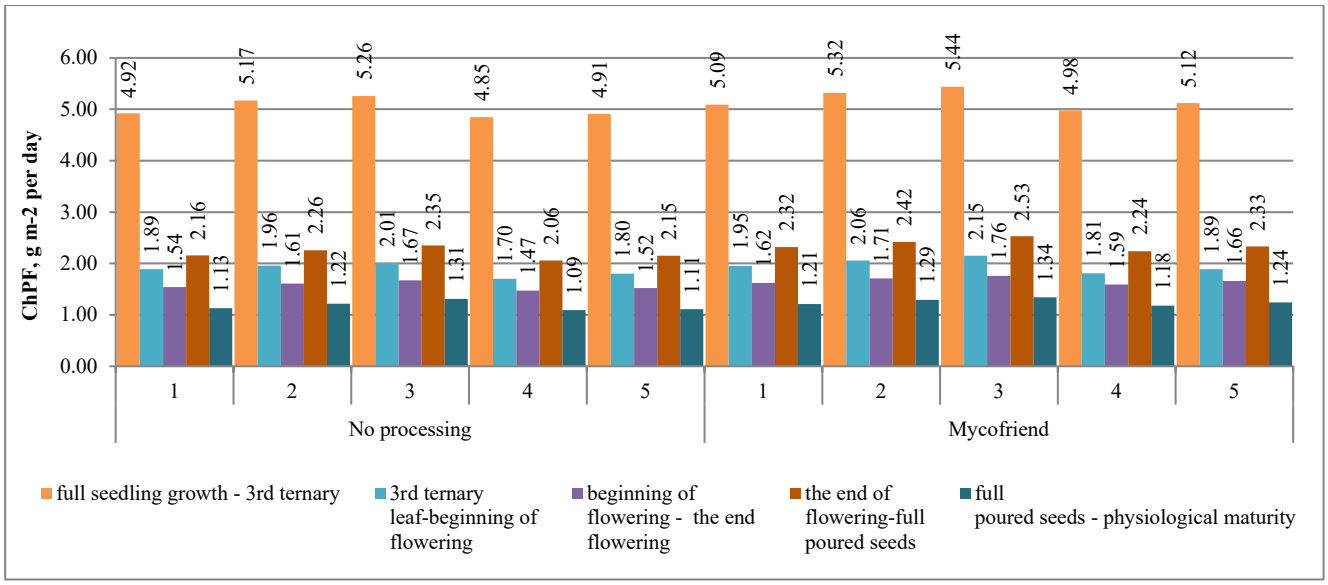

Figure 1. Dynamics of the net productivity of photosynthesis in soybean plants depending on the treatment of seeds with a mycorrhizal formative preparation and the level of fertilization, on average for 2017-2021, g m^{-2} per day

Note: 1 - NPK (100%); 2 - NPK + Groundfix 3 l ha^{-1}; 3 - NPK + Groundfix 5 l ha^{-1}; 4 - NPK (70%) + Groundfix 3 l ha^{-1}; 5 - NPK (70%) + Groundfix 5 l ha^{-1}.

During the interphase period of the end of flowering - full seed filling, the intensity of the net productivity of soybean agrophytocenosis has increased and was within the range of 2.06 g m^{-2}–2.53 g m^{-2} per day, depending on the rate of mineral fertilizers, seed treatment with a mycorrhizal formative preparation and application of soil biofertilizer. The lowest indicators of the net productivity of photosynthesis of 1.09 g m^{-2}–1.34 g m^{-2} were formed during the period from the complete pouring of the seeds to the physiological maturity of the seeds.

Conclusions

As a result of conducting the experiment on the gray forest soils of the Right Bank Forest Steppe, it was established that the pre-sowing treatment of seeds with Micofrend (1.5 l t^{-1}) and the use of Groundfix at rates of 3 l ha^{-1} and 5 l ha^{-1} on the background of NPK (100%) ensured the formation of the photosynthetic potential of soybean crops, respectively, 3.028 million m^{-2} day ha^{-1} and 3.153 million m^{-2} day ha^{-1}, which exceeded the control by 0.242 million m^{-2} day ha^{-1} and 0.367 million m^{-2} day ha^{-1}. A decrease in the rate of mineral fertilizers by 30% contributed to a decrease in the level of photosynthetic potential by 15.1%-19.6%. The obtained data indicate that the use of biological fertilizers and fertilizers of organic origin is a relevant alternative to mineral fertilizers in soybean cultivation technology. The effect of the researched biological fertilizer and mycorrhizal formative preparation on the photosynthetic activity of soybean plants is a confirmation of this. That is why one of the priority measures for effective use of the potential of leguminous crops in agriculture should be a scientifically based structure of sown areas with an optimal share of these crops. A promising direction of the future research is a detailed study of the peculiarities of the photosynthetic activity of legumes under biologization of their nutrition system.

References

Bakhmat M, Padalko T, Krachan T, Tkach O, Pantsyreva H, Tkach L. (2023). Formation of the Yield of Matricaria recutita and Indicators of Food Value of Sychorium intybus by Technological Methods of Co-Cultivation in the Interrows of an Orchard**.** *J Ecol Eng.* **24:**250-259.

Bondarenko V, Havrylianchik R, Ovcharuk O, Pantsyreva H, Krusheknyckiy V, Tkach O, Niemec M. (2022). Features of the soybean photosynthetic productivity indicators formation depending on the foliar nutrition. *Ecol Environ Conserv*. **28:**20-26.

Didur IM, Tsyhanskyi VI, Tsyhanska OI, Malynka LV, Butenko AO, Klochkova TI. (2019). The effect of fertilizer system on soybean productivity in the conditions of right bank forest-steppe. *Ukr J Ecol*. **9:**76-80.

Didur IM, Tsyhanskyi VI, Tsyhanska OI, Malynka LV, Butenko AO, Masik IM, Klochkova TI. (2019). Effect of the cultivation technology elements on the activation of plant microbe symbiosis and the nitrogen transformation processes in alfalfa agrocoenoses. *Mod Phytomorphol*. **13:**30-34.

Didur I, Tsyhanskyi V, Tsyhanska O. (2023). Influence of biologisation of the nutrition system on the transformation of biological nitrogen and formation of soybean productivity. *Plant Soil Sci*. **14:**86-97.

Kaletnik G, Lutkovska S. (2020). Strategic Priorities of the System Modernization Environmental Safety under Sustainable Development. *J Env Manage Tour*. **11:**1124-1131.

Korobko A, Kravets R, Mazur O, Mazur O, Shevchenko N. (2024). Nitrogen-Fixing Capacity of Soybean Varieties Depending on Seed Inoculation and Foliar Fertilization with Biopreparations. *J Ecol Eng*. **25:**23-37.

Lutkovska S. (2020). Methodical Approaches to Evaluation of the Processes of Modernization of the Environmental Sustainable System. *Sci Horiz*. **2:**111-1118.

Mazur V, Didur I, Tkachuk O, Pantsyreva H, Ovcharuk V. (2021). Agroecological stability of cultivars of sparsely distributed legumes in the context of climate change. Sci Horiz. **24:** 54-60.

Mazur VA, Pantsyreva HV, Mazur KV, Didur IM. (2019). Influence of the assimilation apparatus and productivity of white lupine plants. *Agron Res*. **17:**206-219.

Nechiporovich AA. (1967). Ways of controlling the photosynthetic activity of plants in order to increase their productivity. *Physiol Agric Crops*. **1:**309-353.

Pantsyreva H. (2021). Morphological and ecological-biological evaluation of the decorative species of the genus Lupinus L. *Ukr J Ecol*. **9:**74-77.

Petrichenko VF, Kobak SY, Chorna VM. (2017). Influence of inoculation and morphology of the regulator on the peculiarities of soybean plant growth in the Forest-Steppe. *Bull Agric Sci*. **11:**29-34.

Tsyhanskyi VI.(2021). Optimization of the soybean fertilization system based on the use of preparations of biological origin in the conditions of the Forest-Steppe of the Right Bank. *Agric For*. **2:**69-80.

Bulgakov V, Rucins A, Holovach I, Adamchuk O, Aboltins A, Zabolotnyi H, Kolomyets L, Polishchuk S. (2023). Computer investigation of mineral fertiliser particle movement along centrifugal spreader disc inclined under angle to horizontal plane. Eng Rural Dev. **22:**506-516.