BIOLOGICAL NITROGEN IN INCREASING THE PRODUCTIVITY OF BEANS (GRAINS)

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Abstract

The results of a field experiment to study the effect of seed treatment with the biological product Rhizoactive (company BioNorma, Ukraine) on the formation and functioning of the symbiotic apparatus of common bean (grain) plants are presented.

The experiment examined six varieties of common beans (grain), included in the State Register of plant varieties suitable for distribution in Ukraine: Bukovynka, Halaktyka, Slaviia, Ros, Otrada, Nata. The influence of bacterial fertilizer based on nodule bacteria « Rhizoactive » on the indicators of symbiotic and grain productivity of these varieties of common beans was studied.

It was found, that the maximum number and raw weight of active nodules in the studied varieties of common beans were formed in the flowering phase. A larger number of nodules, compared to the variety Bukovynka (control), was formed on the root system of bean varieties Ros, Otrada and Nata. The maximum raw weight of rhizobia in the plots without the use of Rhizoactive was formed by the common bean variety Otrada – 0.297 g/plant of active nodules. Inoculation of the seeds of the studied common bean varieties with Rhizoactive increased the raw weight of active nodules in the flowering phase by 0.016–0.042 g/plant. A larger mass of nodules, compared to the Bukovynka variety, was formed on the root system of Ros, Otrada and Nata beans. The maximum raw weight of rhizobia in areas without the use of Rhizoactive was formed by the variety of beans Otrada – 0.297 g/plant of active nodules. Inoculation of seeds of the studied varieties of beans with Rhizoactive increased the raw weight of active nodules in the flowering phase by 0.016–0.042 g/plant.

The highest increase in grain yield from seed inoculation was obtained in 2018, which was more favorable in terms of moisture. Thus, the largest increase in grain yield from the use of Rhizoactive was provided by the varieties Halaktyka (0.14 t/ha or 5.7 %), Ros (0.15 t/ha or 5.5 %) and Otrada (0.22 t/ha or 7.7 %). On average, in 2018–2020, inoculation of bean seeds with Rhizoactive, depending on the variety, provided an increase in grain yield from 2.4 to 6.7 %. And the highest level of bean grain yield on average in 2018–2020 was provided by the varieties Otrada (2.60 t/ha), Nata (2.50 t/ha) and Ros (2.40 t/ha) for inoculation of seeds with Rhizoactive.

Keywords: common beans (grain), variety, Rhizoactive, nodules, quantity, raw weight, yield.

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1. Introduction

In Ukraine, in 2020, beans are the most expensive legume crop and the only legume for which the acreage has grown [1]. At the same time, it is necessary to increase the yield of

common beans, primarily through the use of new varieties and improvements in the fertilizer system [2–8]. Common beans respond well to mineral fertilizers, especially nitrogen and phosphorus [9–11]. However, to improve the nitrogen nutrition of bean plants (as well as other legumes) is possible by enhancing the symbiotic nitrogen fixation of nodule bacteria, which requires inoculation of seeds with microbial preparations, containing more active strains of microorganisms [12–16].

Nitrogen-fixing microorganisms can absorb from the air from 40 to more than 300 kg of nitrogen per hectare per year [17–20]. The average size of total nitrogen fixation of beans in Ukraine is 40–60 kg/ha. The share of biological nitrogen in the formation of the bean crop is 30–40 % [21]. Resowing inoculation of seeds with Rhizobophyte, which contains symbiotic nitrogen-fixing bacteria of the genus *Rhizobium phaseoli*, promotes the appearance of nodules, their greater number, mass and activity of nitro [22, 23].

When forming a highly productive bean-rhizobial system *Rhizobium phaseoli* it is necessary to take into account the genetic characteristics of bean varieties, activity, virulence, competitiveness of strains of nodule bacteria used for seed inoculation [24–27]. In the conditions of the western Forest-steppe of Ukraine, the highest symbiotic productivity was found in the crops of the variety Mavka, sown in a wide-row method with a row spacing of 45 cm [28]. A complex preparation of rhizohumin based on a new strain of *R. Phaseoli* FB1 contributed to the formation of a significantly larger (1.4–1.5 times) number of nodules compared to rhizobophyte. An important indicator of the symbiotic activity of nodule bacteria and legumes is not only the number of nodules, but also their mass. Thus, when treating bean seeds with peat form of rhizobophyte and both forms of rhizohumin already in the flowering phase, the mass of nodules was significantly higher than the mass when treated with liquid form of rhizobophyte (0.17 g/plant vs. 0.12 g/plant). In the bean filling phase, the option with seed treatment with peat form of rhizohumin (0.29 g/plant) was the best in this respect. The highest level of molecular nitrogen fixation was also observed with the use of both forms of rhizohumin and peat form of rhizobophyte. From the flowering phase to the bean filling phase, this figure increased 2.4–2.8 times. The maximum values of nitrogen-fixing activity were observed in the variant using the peat form of rhizohumin (9.25 and 25.56 µg N per plant per 1 h). As a result of the conducted researches, it is established, that biological preparations rhizobophyte and rhizohumin on the basis of the offered strain *R. Phaseoli* FB1 provide stable increase in productivity of beans of Shchedra by 16,9–29,2 % in comparison with control without inoculation [29].

Research aim – to determine the influence of the biological product Rhizoactive on the formation and functioning of the symbiotic apparatus of plants of different varieties of common (grain) beans. (Aim of research should be written in Introduction and Abstract).

2. Materials and methods

2. 1. Agrochemical characteristics of the experimental site soil

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.

2. 2. The scheme of the experiment and methods of research

The research was conducted during 2018–2020 in the selection crop rotation of the Bukovinian State Agricultural Research Station of the Institute of Agriculture of the Carpathian

region of NAAS (Ukraine). The influence of the bacterial fertilizer based on nodule bacteria “Rhizoactive” on the indicators of symbiotic productivity of common bean varieties was studied. The subject of research were zoned varieties of common beans – Bukovynka, Halaktyka, Slaviia, Ros, Otrada, Nata.

To determine the number and mass of nodules, used the method of monoliths. The number and weight of nodules per plant was determined by the area of the monolith and the average density of plants [30].

3. Results

As a result of our research, it was found, that the number of active nodules increased from the formation of the third trifoliate leaf to flowering, and from flowering to grain formation there was a decrease in their number. In particular, in areas without seed treatment with Rhizoactive, the number of active nodules during flowering was, depending on the variety, 10.7–26.5 pieces/plant (Table 1).

Table 1

Dynamics of the number of active nodules depending on bacterization of seeds of varieties of common beans, pcs/plant (average for 2018–2020)

Variety	Inoculation	Phases of plant growth and development			
		third trifoliate leaf	budding	flowering	grain filling
Bukovynka	Water (c.)	1.1	11.3	20.7	14.8
	Rhizoactive	1.2	13.1	24.9	17.2
Halaktyka	Water	1.8	7.9	10.7	8.6
	Rhizoactive	1.6	10.5	12.4	7.8
Slaviia	Water	1.4	9.3	12.3	10.4
	Rhizoactive	1.5	11.7	15.2	11.2
Ros	Water	1.2	10.6	18.4	15.2
	Rhizoactive	1.1	14.8	25.7	19.5
Otrada	Water	1.3	14.2	26.5	17.8
	Rhizoactive	1.4	18.7	32.4	21.2
Nata	Water	1.2	12.5	20.3	15.1
	Rhizoactive	1.2	14.4	25.8	18.6

Note: (c.) – control.

Among the cultivars studied, the maximum number of nodules was formed by the cultivar Otrada in the flowering phase. Inoculation of seeds of the studied varieties of beans with Rhizoactive increased the number of nodules in this phase of growth and development by 1.7–7.3 pcs./per plant.

The indicators of the raw mass of active nodules largely depended on the bacterization of seeds of the studied varieties of common beans. These indicators were highest on the roots of Otrada beans in the flowering phase with inoculation of seeds with Rhizoactive – 0.297 g/plant (Table 2).

Larger mass of nodules compared to the variety Bukovynka, was formed on the root system of plants of the varieties of beans Ros, Otrada and Nata. The maximum raw weight of rhizobia in areas without the use of Rhizoactive was formed by the Otrada variety of beans – 0.297 g/plant of active nodules. Inoculation of seeds of the studied varieties of common beans with Rhizoactive increased the raw mass of active nodules in the flowering phase by 0.016–0.042 g/plant.

Average for 2018–2020 the inoculation of beans with Rhizoactive, depending on the variety, provided an increase in grain yield from 2.4 to 6.7 %. And the highest level of yield of beans on average for 2018–2020 provided varieties Otrada (2.60 t/ha), Nata (2.50 t/ha) and Ros (2.40 t/ha) for inoculating seeds with Rhizoactive (Table 3).

By changing the indicators of the symbiotic apparatus of plants, inoculation of seeds with Rhizoactive also significantly affected the grain yield of the studied varieties of common beans.

The highest increase in grain yield from seed inoculation was obtained in 2018, which was more favorable in terms of moisture. Thus, the largest increase in grain yield from the use of Rhizoactive provided varieties Halaktyka (0.14 t/ha or 5.7 %), Ros (0.15 t/ha or 5.5 %) and Otrada (0.22 t/ha or 7.7 %). In 2019–2020, the efficiency of inoculation of seeds of bean varieties (except for the Halaktyka variety) decreased.

Table 2

Dynamics of raw mass of active nodules depending on bacterization of seeds of beans varieties, g/plant (average for 2018–2020)

Variety	Inoculation	Phases of plant growth and development			
		third trifoliolate leaf	budding	flowering	grain filling
Bukovynka	Water (c.)	0.007	0.104	0.178	0.123
	Rhizoactive	0.008	0.119	0.204	0.152
Halaktyka	Water	0.014	0.076	0.167	0.068
	Rhizoactive	0.012	0.095	0.183	0.071
Slaviia	Water	0.010	0.087	0.152	0.089
	Rhizoactive	0.011	0.098	0.191	0.104
Ros	Water	0.008	0.097	0.201	0.137
	Rhizoactive	0.008	0.130	0.232	0.176
Otrada	Water	0.009	0.122	0.245	0.119
	Rhizoactive	0.010	0.148	0.297	0.148
Nata	Water	0.008	0.111	0.198	0.132
	Rhizoactive	0.008	0.129	0.229	0.165

Note: (c.) – control.

Table 3

Yield of bean varieties depending on seed inoculation, t/ha

Variety (factor A)	Years			The average for 2018–2020
	2018	2019	2020	
Inoculation (factor B) – without inoculant (seed treatment with water)				
Bukovynka (c.)	2.46	1.89	1.84	2.06
Halaktyka	2.33	1.57	0.65	1.52
Slaviia	2.28	1.60	2.23	2.04
Ros	2.59	1.96	2.42	2.32
Otrada	2.65	2.22	2.54	2.47
Nata	2.67	2.07	2.48	2.40
Inoculation (factor B) – Rhizoactive				
Bukovynka (c.)	2.55	1.93	1.87	2.12
Halaktyka	2.47	1.61	0.81	1.63
Slaviia	2.35	1.61	2.31	2.09
Ros	2.74	1.99	2.46	2.40
Otrada	2.87	2.30	2.64	2.60
Nata	2.79	2.11	2.59	2.50
HIP ₀₅	2018: A – 0.12; B – 0.07; AB – 0.20; 2019: A – 0.09; B – 0.06; AB – 0.19; 2020: A – 0.13; B – 0.05; AB – 0.22			

4. Discussion

Pre-sowing seed treatment with Rhizoactive had a significant effect on the formation of the symbiotic apparatus of beans, but in quantitative terms, each of the varieties was characterized by its peculiarities in the formation of nodules on the roots of plants. Thus, on the crops of the control variety Bukovynka during flowering 24.9 pieces/plant were formed. This number of nodules exceeded the option without inoculation of seeds with a bacterial preparation by

4.2 units/plant. The maximum increase in the number of nodules from the use of Rhizoactive in the flowering phase was provided by the Ros bean variety – 7.3 pieces/plant.

In addition to counting the number of nodules on the roots of bean plants, we also determined their raw weight. The largest number of active nodules was during flowering, the largest mass of nodules in the experiment was also during this period of growth and development of common beans. However, depending on the factors of the experiment, the accumulation of the mass of nodules had its own characteristics in each of the studied variants. Thus, when sowing beans of the Bukovynka variety without inoculation of seeds, the raw weight of the nodules was 0.178 g/plant. However, this was not the lowest figure in the experiment. Halaktyka and Slaviia cultivars had a lower raw weight of nodules in the flowering phase in the variants without seed inoculation – 0.167 and 0.152 g/plant, respectively.

5. Conclusions

The maximum number and raw weight of active nodules in the studied varieties of common beans were formed in the flowering phase. The maximum number and raw weight of nodules was formed by the Otrada bean variety – 26.5 pieces/plant and 0.245 g/plant, respectively. Inoculation of common bean seeds with the biological product Rhizoactive on the basis of bacteria *Rhizobium phaseoli* increased the number and raw weight of active nodules by 1.7–7.3 pcs./per plant 0.016–0.042 g/plant, respectively.

On average, in 2018–2020, inoculation of bean seeds with Rhizoactive, depending on the variety, provided an increase in grain yield from 2.4 to 6.7 %.

Conflict of interest

There is no conflict of interest

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