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AGROECOLOGICAL EVALUATION OF APPLICATION THE MICROBIOLOGICAL FERTILIZERS IN LENTIL CULTIVATION TECHNOLOGY

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Abstract

In a stationary field experiment on leached chernozem and in laboratory studies, an agroecological assessment of the influence of the microbiological fertilizers Azotovit and Phosphatovit on the productivity of lentil plants was carried out. It was established that inoculation of seeds with microbiological fertilizers at a dose of 2 liters per ton of seeds, in the technology of growing the crop in the soil and climatic conditions of the forest steppe of the Middle Volga region, provides intensive growth and development of plants at the initial stages of ontogenesis, which leads to accelerated formation of cotyledons and true leaves and activation bean-rhizobial apparatus. The resistance of lentil plants to adverse soil and climatic conditions increases (germination energy increases by 2.3%, laboratory germination - by 2.0%, plant safety for harvesting - by 9.6%). Lentil grain productivity from seed inoculation increased by 26.3%, protein collection - by 37.2%. The data obtained make it possible to rationally use the method of t with microbiological fertilizers in lentil cultivation technology.

Key words*: lentil plants, microbiological fertilizers Azotovit and Phosphatovit, pre-sowing seed treatment, lentil cultivation technology.*

INTRODUCTION

The development of new techniques in the technology of cultivation of lentil plants largely determines the possibility of obtaining a high and sustainable crop of this valuable legume crop (Antipova et al., 2010). Of particular interest in this light is the increase in the agricultural background in the implementation of a range of agrotechnical and organizational measures, the development of a science-based zonal farming system (Gursoy, 2010; Muehlbauer et al., 2006).

An important factor in increasing the yield of lentils is the improvement of mineral nutrition and the activation of legume-rhizobial symbiosis from the use of biological bacterial fertilizers. The interaction of factors and the identification of their mechanisms plays an important role in increasing the productivity of crops, obtaining ecologically clean products and increasing soil fertility (Koryagina et al., 2017; Kulikova et al., 2015; Chebotar et al., 2015; Tsyganova et al., 2013).

It is important to use new microbiological fertilizers that increase the biological activity of the soil, improve nitrogen fixation, protect plants from diseases and pests with increased immunity and stress resistance of plants, and also stimulate plant growth.

The positive effects of biological products on crop yield and plant quality have been reported in many studies (Koryagin et al., 2018; Koryagin, 2014). However, work on the physiological evaluation of the stimulation effect during seed treatment with microbiological fertilizers (in the Middle Volga region, Russia) was carried out either at the initial stages of vegetation, or the quality of the crop was analyzed.

Since lentils in our area are a promising leguminous crop and have high plasticity to the effects of external environmental factors, studies of physiological changes affecting its productivity and new microbiological preparations are of great interest (Zavarzin, 2012).

In this regard, the article presents material on the agroecological assessment of the use of new microbiological fertilizers “Azotovit” and “Phosphatovit” in the technology of cultivating lentils in the soil-climatic conditions of the forest-steppe of the Middle Volga (Russia).

MATERIALS AND METHODS

Microbiological fertilizers "Azotovit" and "Phosphatovit" (manufactured by the company "Industrial Innovations") have State Registration (certificate of State Registration No. 1085 and No. 1086 issued by the Federal Service for Veterinary and Phyto-Supervision).
The active substance of the drug "Azotovit": live bacterial cells (Beijerinckia fluminensis), a concentration of at least 1 x 109 CFU/cm^3. Bacteria fix molecular nitrogen and, during a series of transformations, convert it to ammonium, nitrite, and nitrate forms, which are easily absorbed by plants; prevent the loss of mineral nitrogen during its conversion in the soil.
The active substance of the drug "Phosphatovit": spores and living cells of bacteria Paenibacillus mucilaginosus, the concentration of not less than 0.12 x 109 CFU/cm^3. Organic acids secreted by the bacteria *Paenibacillus mucilaginosus* mobilize inaccessible phosphorus (20 to 30 kg/ha per season) and potassium (15 to 20 kg/ha per season) from insoluble compounds in the plant rhizosphere; interfere with the processes of the enrichment of soils with assimilable phosphates.
Beijerinckia fluminensis and *Paenibacillus mucilaginosus* are not genetically modified strains, belong to microorganisms that are non-pathogenic for humans, do not require special precautions during operation.
The influence of the "Azotovit" and "Phosphatovit" microbiological fertilizers was studied on lentils of the CDC Redcliff variety (The origin of the variety is Crop Development Center, University of Saskatchewan, Canada).
The studies were carried out in a stationary field experiment on leached chernozem and in laboratory studies, accompanied by observations, counts and analyzes in accordance with the methodology and technique of setting up field experiments in the soil and climatic conditions of the Penza region (Kulikova et al., 2019).
The experience was laid on plots with a total area of 15,000 m^2, the accounting area was 10,000 m^2, triplicate three times, the placement of options randomized (random).

Scheme of experience:
1. Inoculation of seeds with water (control);
2. Inoculation of seeds "Azotovit";
3. Inoculation of seeds "Phosphatovit";
4.Inoculation of seeds "Azotovit" + "Phosphatovit".

The seeds of lentil plants were treated at a dose of 2 liters per ton before sowing with microbiological fertilizers.
Meteorological conditions for the entire period of research (2016-2018) were generally favorable for the growth and development of lentils. The average air temperature was in the range of long-term average values. The highest rainfall during the growing season (239 mm) was noted in 2016. Compared with long-term average values, the deviation of the indicator was + 24 mm.
In 2017, the amount of rainfall during the growing season was 175 mm, which is 40 mm below the long-term average.
In 2018, the amount of precipitation during the growing season was 137.3 mm, which is 18.7 mm lower than the annual average.

RESULTS AND DISCUSSIONS

The quality of the sowing material of grains and leguminous crops largely depends on weather conditions during the growing season of plants and seed ripening. It is known that timely, friendly and full-fledged seedlings of optimal density are one of the main factors for obtaining high and stable yields with good quality products. In the practice of seed production, to obtain high-quality seeds, various techniques are recommended: maintaining the harvested crops in sheaves, ensuring their drying and ripening due to the influx of additional substances from the vegetative organs into the reproductive ones; pre sowing treatment with various growth substances and organo-mineral mixtures. Of great importance is the treatment of seeds before sowing with solutions of salts of trace elements, especially when seeds are obtained when grown under conditions of a deficiency of certain trace elements in the soils.
The initial changes that occur in seeds after treatment lead to processes associated with the intensity and direction of metabolism in the

early stages of plant development during the period of its greatest plasticity and susceptibility, could have a decisive influence on the passage of the further stage of development of the adult body.

Inoculation of lentil seeds with "Azotovit" and "Phosphatovit" microbiological fertilizers increased the seed germination energy by an average of 2.3% and laboratory germination of lentil seeds by 1.3-2.0% compared with inoculation of seeds with water, which ultimately determined the field germination of seeds, which increased by 3.4-6.3%.

The combined use of drugs was most effective (Table 1).

Table 1. Characterization of the growth processes of CDC Redcliff lentil plants in laboratory and field conditions (2016-2018)

Experience option	Germination, %		Density of plants, thousand units/ha		Vegetation period, days	Crop thinning %
	laboratory	field	in the germination phase	before harvesting		
Inoculation of seeds with water (control)	92.9	85.5	1711.0	1295.9	84	24.4
Inoculation of seeds "Azotovit"	94.4	89.2	1785.0	1464.3	82	18.0
Inoculation of seeds "Phosphatovit"	94.2	88.9	1778.0	1432.9	83	19.4
Inoculation of seeds "Azotovit" + "Phosphatovit"	94.9	91.8	1836.0	1564.4	81	14.8

Our long-term experiments have found that changes in some aspects of the metabolism and increased growth processes ultimately affect yield, as it is an integral indicator of all physiological and biochemical processes during the individual development of lentil plants.

In our research, inoculation of lentil seeds with microbiological fertilizers did not have a significant effect on the duration of interphase periods; the growing season was 81-84 days according to the experimental variants. Observations of the growth of lentil plants showed that the growth of the vegetative mass went most intensively from the seedling phase to the onset of seed maturation of lentil plants.

The full germination phase began 6-11 days after sowing the seeds, the number of plants per 1 ha in varieties ranged from 1711.0 to 1836.0 housand, and before harvesting, from 1295.9 to 1564.4 thousand per hectare.

The sowing thinness varied during the years of research from 14.8% to 24.4%: the greatest was observed in the variant with the treatment of seeds of lentil plants before sowing with water (control), the smallest - in the variant with joint treatment of seeds with drugs.

Accordingly, in the control variant, the lentil grain yield was lower than in the variant with the pre-sowing treatment of lentil seeds with the "Azotovit" microbiological fertilizer together with "Phosphatovit".

Studies have shown that the highest grain yield of plants was obtained with the combined use of microbiological fertilizers "Azotovit" and "Phosphatovit", where it was 1.73 t/ha, which is 26.3% higher than in the control variant. Separate use of the preparations ensured a yield increase of 21.2 and 18.2% to the control, respectively (Figure 1).

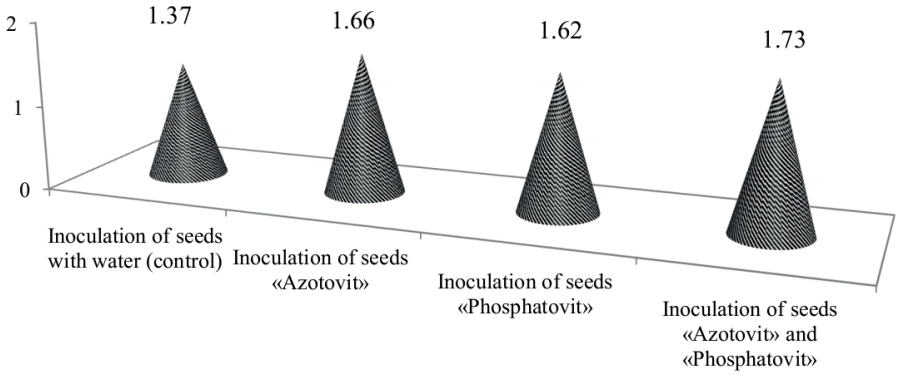

Figure 1. The effect of microbiological fertilizers on the yield of lentil grain (2016-2018), t/ha

When using the microbiological fertilizer "Azotovit" together with "Phosphatovit", a synergistic effect is manifested, that is, an increase in their interaction.

According to the data obtained in the course of scientific research over the years, it can be stated that the reaction of plants to microbiological fertilizers "Azotovit" and "Phosphatovit" is more dependent on the growing conditions of the plant, since they determine the nature of metabolic processes, and the action of microorganisms only enhances or weakens the pace of these processes.

Therefore, our studies indicate the effectiveness and feasibility of using pre-sowing seed treatment, both in terms of synergy and interaction coefficient. Presowing seed treatment with the "Azotovit" microbiological fertilizer together with "Phosphatovit", as an agrotechnical technology, fits organizationally easily into the technology of growing lentil plants.

Seed productivity of leguminous crops depends primarily on the number of beans in the plant, the seeds in the bean and the mass of 1000 seeds. Structural and morphological analysis of the crop of lentil plants showed that microbiological fertilizers positively affect all elements of the yield structure. The combined use of the "Azotovit" and "Phosphatovit" microbiological fertilizers increases the plant height by 11.8 cm, the attachment height of the lower beans by 11.3 cm, the weight of 1000 seeds by 2.7 g and the nature of lentil grain by 7 g/l.

The following physiological features are inherent in high-protein nature: the ability of the plant's root system to absorb nitrogen from the soil throughout the entire individual development; high nitrate reduction potential; high photosynthetic activity; more complete outflow of nitrogenous compounds from vegetative organs into seeds.

These processes are activated under the influence of the drugs used, due to which protein accumulates.

The use of microbiological fertilizers in the processing of lentil seeds before sowing leads to an increase in protein by 1.7-2.4% compared with the control variant.

This increase in the protein content of lentil grains leads to an increase in protein collection from the hectare of crops of lentil plants by 25.6-37.2% (Table 2).

With the combined use of the "Azotovit" and "Phosphatovit" preparations, the maximum effect is achieved: the protein content increases by 2.4%, protein collection - by 37.2% of the control.

Table 2. The effect of microbiological fertilizers on the content and collection of protein in lentil grain (2016-2018)

Experience option	The protein content, %	Deviation from the control, %	Protein harvest, kg/ha	Deviation from the control	
				kg/ha	%
Inoculation of seeds with water (control)	27.1	–	369.5	–	–
Inoculation of seeds "Azotovit"	29.2	2.1	481.8	112.3	30.4
Inoculation of seeds "Phosphatovit"	28.8	1.7	464.1	94.6	25.6
Inoculation of seeds "Azotovit" + "Phosphatovit"	29.5	2.4	506.9	137.4	37.2

CONCLUSIONS

Lentil production cannot occur only due to the expansion of sown areas, but should be carried out as a result of intensification of production and the search for new ways to further increase the yield of leguminous crops.

Among the promising agricultural practices that provide a further increase in yield and improve product quality should include the method of pre-sowing treatment of seeds before sowing with microbiological fertilizers.

Inoculation of seeds with "Azotovit" and "Phosphatovit" at a dose of 2 liters per ton of seeds, in the technology of growing the crop in the soil and climatic conditions of the forest steppe of the Middle Volga region (Russia), provides intensive growth and development of plants at the initial stages of ontogenesis, which leads to accelerated formation of cotyledons and true leaves and activation of the legume-rhizobial apparatus.

Thus, pre-sowing treatment of lentil seeds with microbiological fertilizers, as an agrotechnical technology, fits easily into the technology of cultivating lentils and has a positive effect on the germination and preservation of lentil plants before harvesting, which leads to increased yield and increased protein collection.

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