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Case Report

The Use of Biofertilizers of Microbial Origin to Increase the Yield of Oil Flax and Spring Barley in the Conditions of Northern Kazakhstan

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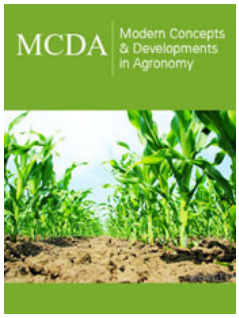

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Introduction

Forest steppes predominate in the north of the Republic of Kazakhstan. Currently, in the northern regions of the country, droughts are periodically observed during the growing season of plants, which leads to a decrease in the yield of grain crops, including spring barley, especially in organic farming. The issue of the effectiveness of the use of biofertilizers for obtaining environmentally friendly organic products in the conditions of Northern Kazakhstan remains poorly studied.

A biofertilizer is a preparation containing live microorganisms that, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere, phyllosphere, or interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant [1]. The use of beneficial microorganisms for growing grain crops in recent years has revealed their positive effect on the yield and quality of grain in adverse environmental conditions [2-4]. Some bacteria are also able to metabolize the soluble form of mineral phosphorus and play an important role in crop production. They also synthesize other substances, such as siderophores, auxins, cytokinins, and vitamins, which significantly improve plant growth by increasing the efficiency of phosphorus uptake by plants [5,6]. Inoculation of plant seeds with phosphorus-solubilizing *B. megaterium* and nitrogen-fixing *B. subtilis* and *Rhizobium leguminosarum* significantly increases crop yields [7]. Fungal strains of the genus *Trichoderma spp*. are used in agriculture as effective bio stimulants. They promote plant development, including root branching and nutrient uptake. Due to this, it is advisable to use them to increase yield and quality under stress [8]. Biofertilizers promote plant growth by supplying them with nutrients, including biologically bound nitrogen, increasing the availability of insoluble nutrients in the soil, and synthesizing substances that stimulate plant growth [9]. The rhizosphere of cultivated plants is inhabited by various beneficial microorganisms that accelerate the absorption of nutrients from the soil to the upper parts of plants [3].

The use as biofertilizers of soil microorganisms that can fix atmospheric nitrogen, dissolve phosphates, and synthesize substances that promote plant growth, or enhance the decomposition of plant residues to release vital nutrients, thereby increasing the humus content in soils, will be an environmentally friendly approach to nutrient and ecosystem management

[10]. Soil microorganisms are important components of the natural soil sub-ecosystem as they not only contribute to soil nutrient availability but also bind soil particles into stable aggregates that improve soil structure and reduce erosion [11,12]. Biofertilizers are an economically and environmentally attractive means of improving the quality and quantity of crops. They are inexpensive and at the same time accelerate growth and improve crop quality by stimulating the direct or indirect release of phytohormones [13,14]. To increase the natural fertility of the soil, it is necessary to introduce new technologies using biofertilizers of microbial origin to ensure the stability of crops. Currently, researchers around the world are paying attention to this issue [14-16].

Case Presentation

In 2022, field studies were carried out on carbonate soils of southern chernozems at the experimental site of the Research and Production Center for Grain Farming named after A.I. Baraev, located in the village «Scientific» of Akmola region. The objects of research were spring barley of the "Tselinny 2005" variety and oilseed flax of the "Kostanai Yantar" variety. Experimental variants were placed randomly in five measurements. The tillage technology was traditional, i.e., flat-cutting, annual deep, autumn tillage with a PG-3-5 tools by 25-27cm. Seed treatment with biofertilizers of microbial origin was carried out immediately before sowing. The titer of biofertilizers was about 100 million spores/ml. The sowing date for oil flax was May 20, the seeding depth was 3-4cm, and the seeding rate was 500pcs/m^2. In the control variant, untreated oil flax seeds were sown. The sowing date for spring barley was May 24, the seeding depth was 6-7cm, and the seeding rate was 500pcs/m^2.

The soil of the experimental plot is heavily loamy in granulometric composition with a characteristic low content of mobile phosphorus (11.2mg/kg) and a high content of exchangeable potassium (571.55mg/kg). It had a high degree of saturation with bases (60%), contained 2.7% humus, and had pH = 7.5. In this study, various consortiums created on the basis of soil microorganisms under the names "Agrarka", "Compo-MIX" and "Agro-MIX" were used as biofertilizers. Biofertilizer "Agrarka" is a liquid concentrated fertilizer made on the basis of effective strains of actinomycetes, consisting of strains of *Streptomyces xantholiticus* 7, *Streptomyces microsporus* 12, *Streptomyces sioyaensis* 41 and producing a complex of biologically active substances that have a fungicidal property against fungal diseases and a Phyto stimulating effect of agricultural crops. Biofertilizer "Compo-MIX" contains strains of growth-stimulating, nitrogen-fixing, cellulose-destroying, and fungicidal microorganisms *Streptomyces sindenensis* PM9, *Streptomyces griseus* PM25, *Bacillus aryabhattai* PM62, *Bacillus aryabhattai* PM68, *Bacillus aryabhattai* PM69, *Bacillus megaterium* PM80B, *Lentzea violacea* isolated from the soils of Northern Kazakhstan. Biofertilizer "Agro-MIX" was created on the basis of strains of growth-stimulating, nitrogen-fixing, anti-putrefactive microorganisms *Bacillus spp*., *Saccharomyces spp*., *Acetobacter spp*., *Streptomyces spp*.

Result and Discussion

During the experiments, the content of organic matter in the soil under crops of barley and oil flax was studied. According to the results of analyzes of soils where crops of spring barley grew, no statistically significant effect of biofertilizers of microbial origin on the humus content was revealed. The mass fraction of organic matter was close to the control variant.

According to the results of analyzes of soils where oil flax crops grew, "Compo-MIX" showed the best result in terms of the content of soil organic matter, and the average mass fraction of soil organic matter exceeded the control variant by 19% ($p<0.05$). In the dry conditions of 2022, the use of biofertilizers of microbial origin also had a positive effect on the structural elements of crop yields. In particular, all types of biofertilizers positively affected the formation of flax seed pods, seeds in one pod, and the mass of seeds from one plant. The treatment of oil flax seeds with liquid bio-fertilizer "Agrarka" gave an increase in the oil flax yield in the amount of 2.7 centners per hectare. The highest increase in barley yield was observed in the variants with the use of Compo-MIX biofertilizer, where the increase in yield was 37.7% ($p<0.05$).

Conclusion

A. The introduction of new technologies using biofertilizers "Agrarka", "Compo-MIX" and "Agro-MIX" ensures a stable crop of plants in the arid conditions of Kazakhstan.

B. Biofertilizers "Agrarka", "Compo-MIX" and "Agro-MIX" can positively influence the structural elements of crop yields and soil humus content, increasing its fertility.

C. The widespread introduction of biofertilizers into agricultural production will improve soil fertility and increase the yield of agricultural crops in the Republic of Kazakhstan.

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