# "THE EFFECT OF ORGANIC BIOECOGUM FERTILIZER ENRICHED WITH THE BACTERIUM BACILLUS MEGATERIUM ON THE GROWTH AND YIELD OF CORN IN THE TURKESTAN REGION"

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***Abstract.*** *This article presents the data of the experiments on the analysis of soil-climatic conditions, agrochemical properties and granulometric composition of the soil in the experimental field where biological products such as Bioecogum and Bacillus megaterium were used. Microorganisms such as Bacillus are widely used in agronomy due to their ability to fix nitrogen, synthesize phytohormones, and inhibit phytopathogens, allowing for increased plant growth and yield (Lucy et al., 2004; Bhattacharya & Jha, 2012). Bacillus megaterium is one of the most studied representatives of this genus. The use of biological products such as bioecogum and Bacillus megaterium had a positive effect on the agrochemical properties of the soil. The level of humus and the amount of mobile forms of nitrogen, phosphorus and potassium have increased, which meets the requirements of soil fertility. Research results on improving the effectiveness of biological products in agronomic practices to increase the sustainability and productivity of agricultural systems. This can be the basis for developing a sustainable agricultural strategy and ensuring environmental quality. Additional research is needed to better understand the impact of biological products on soil processes and to determine the optimal conditions for their use, as well as to expand the possibilities of their use in different agro-climatic zones.*

***Keywords****: organic fertilizer, corn yield, bacillus megaterium, physico-chemical properties of soil, microorganisms, bioecogum, living forms, ions and cations.*

***Annotatsiya****. Ushbu maqolada tuproq-iqlim sharoiti, agrokimyoviy xususiyatlar va tuproqning granulometrik tarkibini Bioekogum va Bacillus megaterium kabi biologik mahsulotlar ishlatilgan tajriba maydonida tahlil qilish bo'yicha tajribalar ma'lumotlari keltirilgan. Bacillus kabi mikroorganizmlar azotni tuzatish, fitohormonlarni sintez qilish va fitopatogenlarni inhibe qilish qobiliyati tufayli agronomiyada keng qo'llaniladi, bu esa o'simliklarning o'sishi va hosildorligini oshirishga imkon beradi (Lucy va boshq., 2004; Bhattacharya & Jha, 2012). Bacillus megaterium bu jinsning eng ko'p o'rganilgan vakillaridan biridir. Bioekogum va Bacillus megaterium kabi biologik mahsulotlardan foydalanish tuproqning agrokimyoviy xususiyatlariga ijobiy ta'sir ko'rsatdi. Gumus darajasi va azot, fosfor va kaliyning harakatlanuvchi shakllari miqdori oshdi, bu tuproq unumdorligi talablariga javob beradi. Qishloq xo'jaligi tizimlarining barqarorligi va mahsuldorligini oshirish uchun agronomik amaliyotda biologik mahsulotlarning samaradorligini oshirish bo'yicha tadqiqot natijalari. Bu barqaror qishloq xo'jaligi strategiyasini ishlab chiqish va atrof-muhit sifatini ta'minlash uchun asos bo'lishi mumkin. Biologik mahsulotlarning tuproq jarayonlariga ta'sirini chuqurroq tushunish va ulardan foydalanishning maqbul sharoitlarini aniqlash, shuningdek ularni turli agroklimatik zonalarda qo'llash imkoniyatlarini kengaytirish uchun qo'shimcha tadqiqotlar talab etiladi.*

***Kalit so'zlar:*** *organik o'g'it, makkajo'xori hosili, bacillus megaterium, tuproqning fizik-kimyoviy xossalari, mikroorganizmlar, bioekogum, tirik shakllar, ionlar va kationlar.*

***Аннотация.*** *В статье представлены данные опытов по анализу почвенно-климатических условий, агрохимических свойств и гранулометрического состава почвы на опытном поле, где использовались такие биопрепараты, как Биоэкогум и Bacillus megaterium. Такие микроорганизмы, как Bacillus, широко используются в агрономии благодаря их способности фиксировать азот, синтезировать фитогормоны и ингибировать фитопатогены, что позволяет увеличить рост растений и увеличить урожайность (Lucy et al., 2004; Bhattacharya & Jha, 2012). Bacillus megaterium — один из наиболее изученных представителей этого рода. Использование биопрепаратов, таких как биоэкогум и Bacillus megaterium, положительно повлияло на агрохимические свойства почвы. Повысился уровень гумуса и количество подвижных форм азота, фосфора и калия, что отвечает требованиям плодородия почвы. Результаты исследований по повышению эффективности биопрепаратов в агрономической практике для повышения устойчивости и продуктивности сельскохозяйственных систем. Это может стать основой для разработки устойчивой сельскохозяйственной стратегии и обеспечения качества окружающей среды. Необходимы дальнейшие исследования для лучшего понимания влияния биопрепаратов на почвенные процессы и определения оптимальных условий их использования, а также расширения возможностей их использования в различных агроклиматических зонах.*

***Ключевые слова:*** *органическое удобрение, урожай кукурузы, bacillus megaterium, физико-химические свойства почвы, микроорганизмы, биоэкогум, живые формы, ионы и катионы.*

## Introduction

Corn is a tall annual herbaceous plant reaching a height of 3 meter or more. Corn has a well-developed fibrous root system that penetrates to a depth of 100-150 cm. Aerial support roots can form at the lower nodes of the stem, protecting the stem from falling and supplying the plant with water and nutrients. The stem is erect, up to 4 m in height and 7 cm in diameter, without a cavity inside (unlike most other cereals) The leaves are large, linear-lanceolate, up to 10 cm wide and a meter long. The number of leaves varies from 8 to 42 leaves.

The history of origin. Corn was introduced into culture 7-12 thousand years ago on the territory of modern Mexico. The oldest finds of cultivated corn kernels in the territory of the modern states of Oaxaca (the cave of Gwila Nakitz) and Puebla (caves near the city of Tehuacan) date back to 4250 and 2750 BC, respectively . Interestingly, corn cobs at that time were about 10 times smaller than those of modern varieties, and did not exceed 3-4 cm in length. There are several theories of the origin of cultivated corn:

1. As a result of breeding one of the subspecies of Mexican wild corn, Zea mays ssp. parviglumis; this taxon is still growing in Mexico and Central America. Most likely, the culture originated in the Balsas River basin in the south of modern Mexico. It is possible that up to 12% of the genetic material ancestral forms of cultivated corn were obtained from another subspecies — Zea mays ssp. mexicana — due to introgressive hybridization.

2. As a result of hybridization of small cultivated wild corn (that is, a slightly modified form of wild corn) with another species of this genus — either Zea luxurians or Zea diploperennis.

3. One of the taxa of Mexican wild corn has been introduced into culture several times.

4. Cultivated corn originated during the hybridization of Zea diploperennis with some representative of the closely related genus Tripsacum. Most modern researchers accept the first hypothesis proposed by Nobel laureate George Beadle in 1939 and based, among other things, on experimental data.

Productivity. The average yield in the United States in the 1860s - 1940s was about 16 quintals of grain per hectare. Starting in the 1930s, work began on the hybridization of corn, which led to an increase in yield at a rate of 0.5 quintals per hectare per year. In the mid-1950s, when yields reached about 20-25 c/ha, a new breakthrough occurred (simple hybrids, inorganic fertilizers, chemical pesticides, mechanization) and yields began to increase at a rate of 1.2 c/ha per year. From 1960 to 1990, the yield increased from 30 to 70 kg/ha. Since the mid-1990s, transgenic maize varieties with pest resistance have been introduced, which allowed continued yield growth from 80 to 100 kg/ha (2010s). The maximum corn yield recorded in 2014 in France was 180 kg/ha.

Genetic modification and breeding of corn. The process of domestication of corn in Mexico more than 7 thousand years ago. Modern research shows that the corn crop probably became extinct as a result of breeding and hybridization of wild Zea species such as Zea mays ssp. parviglumis (Beadle, 1939). Genetic modification of maize in the last stages allowed to increase its resistance to pests and improve yield indicators, which made it one of the most cultivated GM crops in the world (GMO Compass, 2009). The introduction of pathogen-resistant maize varieties reduces the use of aggressive protective measures and minimizes the use of negative environmental impacts, which also contributes to sustainable agriculture. In general, the use of rhizobacteria and endophytes such as Bacillus megaterium, etc. in combination with organic fertilizers, can play an important role in increasing agricultural productivity and sustainability of the agroecosystem.

Materials and methods.

The experiment was conducted at experimental sites in the Turkestan region, Kazakhstan, on the territory of the farm "Shahidbek and K" (aul district of Eski Ikan). The studied crop is corn, a hybrid of "ZPSK-9", grown on soils of light gray soil with homogeneous agro-climatic cultural conditions, which affects the correctness of the analysis of the data obtained. The total area of sowing is 5 hectares. The sowing was carried out on May 12, 2022 with a normal sowing of 65 thousand seeds per 1 hectare.

Materials Fertilizer: BioEcoGum liquid bioorganic fertilizer, Bacillus megaterium bioinoculant. Corn seeds: of "ZPSK-9", variety.

Preparation of fertilizer: BioEcoGum liquid fertilizer was prepared on the basis of biohumus and enriched with Bacillus megaterium culture. To enrich the suspension of bacterial culture (concentration 109K/ml), it was added to dilute liquid vermicompost, after which the mixture was kept at a temperature of 25 ° C for 48 hours for activation.

Sowing and processing: Corn was sown on plots divided into four groups: Control group: plants untreated with biofertilizer.

Experimental group: plants treated with BioEcoGum biofertilizer, Bacillus megaterium, BioEcoGum + Bacillus megaterium. Corn seeds were inoculated for 12 hours. Assessment of growth and yield:

Plant growth parameters were measured by the following indicators: plant height, number of leaves and leaf area. Measurements are carried out weekly throughout the growing season. At the end of the season, root biomass, aboveground biomass and plant yield were measured. Methodology for assessing agrochemical characteristics of soils Soil sampling:

Soil sampling is done from the arable layer to a depth of 0-20 cm. Sample preparation: The selected samples are cleaned of plant particles and particles, then dried at a temperature of 20-25 ° C for 24-48 hours. After that, the soil is crushed and sieved through a sieve with a mesh diameter of 2 mm to obtain a homogeneous material for analysis.

The content of organic compounds and humus:

determined by dry calcination or using acid oxidation (the Walkley-Black method). The content of mobile forms of nitrogen: determined by colorimetry methods or using an acid extract. Phosphorus and potassium content: Determined by extraction using ammonium acetate solution (1M) or other extractants. Soil pH: Measured using a pH meter in aqueous suspension (1:1) or in KCl solution. The content of basic cations (Ca, Mg, K, Na):

Determined by atomic absorption spectrometry (AAS) or using ion chromatography. Assessment of granulometric composition: The granulometric composition of the soil is determined by precipitation and using aqueous suspension to separate particles by size. Statistical data analysis: All data were transferred to statistical analysis by the method of variance analysis (ANOVA). The detection level was set at $p < 0.05$, at which statistically significant deviations between the control and experimental documentation were considered.

Results and discussion.

The soil cover of the experimental site is represented by typical gray soils with a heavy loamy mechanical composition. The content of humus in the soil increases from 0.59 to 0.80%, total nitrogen — from 0.25.2 to 0.36.4%, total phosphorus — from 0.39 to 0.51%. The potassium concentration ranges from 346-510 mg/kg. The volume mass increases from 1.15 to 1.30 g/cm3, which indicates the presence of moderate density. The reaction of the soil solution (pH) varies from 8.8 to 9.04, which indicates the slightly alkaline nature of the soil.

Climatic conditions. In the reporting agricultural period (2021-2023), the volume of precipitation amounted to 467.4 mm, which corresponds to the level of long-term values. Precipitation was transferred seasonally as follows: 123.7 mm in autumn, 131.1 mm in winter and 212.6 mm in spring. The climatic conditions of the reporting year were more favorable for growing crops compared to last year. Agrochemical characteristics of the soil Agrochemical studies conducted before the start of the field experiment make it possible to determine the content of humus constituents, living forms of nitrogen, phosphorus and potassium, carbon dioxide ($co_2$) levels, pH, granulometric composition, as well as the content of basic cations (Ca, Mg, K, Na). These data provide a complete picture of the composition of the soil, its nutrients and agronomic characteristics, which is necessary to optimize agricultural production. Before laying the field experience, agrochemical studies were carried out at the site. Five samples were taken from the arable layer of the earth, which were sent to the research laboratory for detailed analysis. The research methodology for determining the content of common humuses, mobile forms of nitrogen, phosphorus and potassium, as well as the levels of $Co_2$, pH, granulometric composition and the content of basic cations (Ca, Mg, K, Na). The data obtained are shown in Tables 1 and 2.

Table 1 – Content of mobile forms of phosphorus, potassium (mg/kg), total humus (%) and nitrogen (%) in soil under the influence of various treatments

| № n/a | Sampling site | Nitrogen in mg/kg | Phosphorus in mg/kg | Potassium in mg/kg | Humus in % | pH |
|---|---|---|---|---|---|---|
| 1 | BioEcoGum | 39,2 | 49 | 330 | 0,39 | 8,56 |
| 2 | *Bacillus megaterium* | 39,8 | 53 | 332 | 0,41 | 8,62 |
| 3 | BioEcoGum + *Bacillus megaterium* | 33,6 | 44 | 360 | 0,53 | 8,81 |
| 4 | control | 33,6 | 34 | 350 | 0,07 | 8,86 |

The data presented in Table 1 contains agrochemical soil parameters present in four different locations on the test site. The indicators include nitrogen, phosphorus and potassium content (in mg/kg), as well as humus content (%) and acidity level (pH). In the first sample taken from the site using the BioEcoGum preparation, the nitrogen content is 39.2 mg/kg, phosphorus — 49 mg/kg, potassium — 330 mg/kg. The level of humus in the soil reaches 0.39%, the reaction of the soil solution is pH 8.56. The second sample was shown at the site using Bacillus megaterium. Here, the content of nitrogen, phosphorus and potassium was 39.8 mg/kg, 53 mg/kg and 332 mg/kg, respectively. Humus is contained in an amount of 0.41%, the pH level is 8.62. The third sample is a combined effect of BioEcoGum and Bacillus megaterium drugs. In this measurement, the nitrogen content is 33.6 mg/kg, phosphorus — 44 mg/kg and potassium — 360 mg/kg. The humus level is 0.53%, pH is 8.81, which is the highest acidity among the control samples. In the control sample, which is not subjected to other treatment, nitrogen is 33.6 mg/kg, phosphorus is 34 mg/kg, potassium is 350 mg/kg. The humus content here is significantly lower compared to the above samples and is 0.07%, while the pH level is 8.86. Thus, the table contains changes in the content of macronutrients and acidity depending on different conditions of tillage, which allows us to evaluate the effectiveness of the use of drugs in order to improve its agrochemical characteristics.

**Table 2**

The content of interdependent bases of sodium, potassium, calcium and magnesium in the soil under the influence of various treatments

| The name of the samples | Sodium | Potassium | Calcium | Magnesium |
|---|---|---|---|---|
| BioEcoGum | 0,28 | 0,18 | 3,96 | 3,47 |
| *Bacillus megaterium* | 0,27 | 0,18 | 5,05 | 2,98 |
| BioEcoGum *Bacillus megaterium* | 0,32 | 0,18 | 5,45 | 2,28 |
| Control | 0,28 | 0,18 | 4,95 | 0,99 |

Table 2 shows the results of the analysis of the main bases in the soil, given by various preparations. The indicators include the content of sodium, potassium, substances and magnesium in the samples, expressed in milligrams per kilogram (mg/kg). Treated with BioEcoGum, the sodium content is 0.28 mg/kg, potassium — 0.18 mg/kg, substances — 3.96 mg/kg and magnesium — 3.47 mg/kg. These results indicate the presence of a balanced ratio of macronutrients in the soil. In the sample using Bacillus megaterium, the sodium content is slightly lower than in the previous sample and is 0.27 mg/kg. The potassium level remains at the same level — 0.18 mg/kg, but the amount increases to 5.05 mg/kg, and the magnesium content is 2.98 mg/kg. The combined use of BioEcoGum and Bacillus megaterium leads to the determination of indicators: the sodium content increases to 0.32 mg / kg, potassium remains constant — 0.18 mg / kg, the number of indicators reaches 5.45 mg / kg, which is the maximum value among the samples. . At the same time, the magnesium content is significantly reduced to 2.28 mg/kg. The non—exposed control sample shows sodium and potassium levels of 0.28 mg/kg and 0.18 mg/kg, respectively, while the substance content is 4.95 mg/kg and magnesium is 0.99 mg/kg.

**Table 3**

Chemical composition of the soil and alkalinity in the application of various biological products

| Sampling location | Depth | The amount of salts, % mg/eq | Alkalinity | | | | Cl', % | Cl', мг/экв |
|---|---|---|---|---|---|---|---|---|
| | | | Total in HCO3 - % | Total in HCO 3 - мг/экв | From normal carbonates to CO3, % | From normal carbonates to в CO3, мг/экв | | |
| BioEcoGum | 10-20 | 0,058 | 0,024 | 0,4 | 0 | 0 | 0,001 | 0,04 |
| *Bacillus megaterium* | 10-20 | 0,058 | 0,024 | 0,4 | 0 | 0 | 0,001 | 0,04 |
| BioEcoGum *Bacillus megaterium* | 10-20 | 0,061 | 0,029 | 0,48 | 0 | 0 | 0,001 | 0,04 |
| Control | 10-20 | 0,033 | 0,024 | 0,4 | 0 | 0 | 0,001 | 0,04 |

Table 3 shows the results of the analysis of the chemical composition and alkalinity levels for samples obtained with various preparations. All data were obtained with an accuracy of 10-20 cm and expressed in percentages and milligrams equivalent (mg/eq). The study of biological products on the agronomic characteristics of plants and yields allows us to assess their effectiveness in the growth, development and productivity of crops, which ensures the optimization of agrotechnical practices and the constant quality of agricultural products (6).

**Table 4**

Research of biological products on agronomic characteristics of plants and yields

| The name of the samples | Plant height | Length of the cob | Weight of the cob | Number of grains in the cob | Weight of grains | Weight of 100 | Yield from 60 thousand plants |
|---|---|---|---|---|---|---|---|
| | (см) | (см) | (гр) | (шт) | с одного початка | (гр) | (ц/га) |
| BioEcoGum | 289±0,5 | 19 | 89 | 501 | 87 | 13,6 | 43,2 |
| *Bacillus megaterium* | 287 | 19 | 91 | 525 | 88 | 14,3 | 44,5 |
| BioEcoGum | 292 | 22 | 100 | 578 | 91 | 15,5 | 54,1 |
| Control | 262 | 21 | 85 | 452 | 68 | 10,5 | 35,5 |

This table 4 presents the main agronomic characteristics of plants, including height, length and weight of cobs, number and weight of grains, as well as weight of 100 grains and yield at a density of 60 thousand plants per hectare. Plant height: The maximum height observed in the sample with the combined use of BioEcoGum and Bacillus megaterium (292 cm), while the control sample without treatment has the lowest height (262 cm). Cob length: The length of the cob varies from 19 cm to 22 cm. Samples with BioEcoGum and Bacillus megaterium have the same height of the cob (19 cm), while the combined preparation shows a height of growth (22 cm). Cob weight: The cob itself was registered for a high sample with BioEcoGum + Bacillus megaterium (100 g), which is also the average among all samples, while the control sample has a cob weight of 85 g. The number of grains in the cob: Samples with biopreparations show higher values of the number of grains in the cob (501-578 pieces), compared with the control sample (452 grains). Grain weight: Grain weight varies from 68 g in the control image to 91 g in the image with BioEcoGum + Bacillus megaterium, which indicates a positive effect of processing. Weight of 100 grains: The determination of the mass of 100 grains is also higher for samples (10.5 g - 15.5 g), while the combined sample contains the maximum value (15.5 g). Yield: The yield level at a density of 60 thousand plants per hectare is 35.5 c/ha in the control sample and reaches a maximum of 54.1 c/ha in the sample with BioEcoGum + Bacillus megaterium. The results show that the use of biological products, especially in random order, significantly improves the growth, development and yield of plants, which ensures the preservation of all parameters when compared with the control sample. The corn seeds were treated with bio-organic fertilizer. The seeds were imported from abroad already etched. The germination rate of seeds was determined – 87% 5-6 pieces of plants per 1 p/m. Inoculation with BioEcoGum enriched biologics at the rate of 5 liters per 1 ha, 200 liters of working fluid on June 01, 2022. Due to the hot climatic weather, we had to carry out the treatment at night. After processing BioEcoGum 47.05 c/ha of grain standard 31.85 grains, the difference was 15.2 c/ha of grain. After inoculation of Bacillus megaterium 41.75 c/ha of grain and the standard 36.65 grains, the difference was 5.1 c/ha of grain. After inoculation of Bacillus megaterium +BioEcoGum 42.8 c/ha of grain and standard 37.7, the difference was 6.2 c/ha of grain. After inoculation, it amounted to 48.35 c/ha of grain and the standard showed 43.82 c/ha of grain, the difference was 4.53 c/ha of grain. The average yield for three repetitions treated with BioEcoGum was 45.71 c/ha of grain. The average yield of untreated plots was 37.44 kg/ha of grain. According to the results of research, the yield of corn treated with Bacillus megaterium + BioEcoGum showed a higher yield of more than 8.3 c/ha compared to untreated plots. The experiment showed that the use of BioEcoGum + Bacillus megaterium contributed to an increase in the growth and yield of corn compared with the control. Plant height in the experimental group increased by 15%, leaf surface area – by 20%, yield – by 25% compared to the control.

**Conclusions:**

The use of biological products activates biological processes in the soil, which leads to the preservation of its structure and self-renewal abilities. This ensures the formation of microflora biodiversity, which, in turn, contributes to a more efficient assimilation of plants with nutrients. The results of the study of increasing the effectiveness of biological products in agronomic practice to increase the sustainability and productivity of agricultural systems. This can become the basis for the development of a strategy for sustainable agricultural development and environmental quality assurance. Further research is needed to better understand the impact of biologics on soil processes and determine the optimal conditions for their use, as well as the possibility of expanding their use in various agro-climatic zones.

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