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INFLUENCE OF NEW ORGANIC FERTILIZERS ON THE GROWTH, DEVELOPMENT AND YIELD OF COTTON AND SOIL PHOSPHATASE ACTIVITY

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Abstract: The article provides data on the effect of new organic fertilizers on the growth, development and yield of cotton and the phosphatase activity of the soil when growing organic cotton raw materials in the conditions of Uzbekistan. Based on the requirements of organic farming, plant growth stimulants and biofertilizers developed by biological and organic methods were used when cultivating cotton. In experiments when spraying cotton leaves with solutions of biofertilizers (Tandem, Maltamin and Microvac), an increase in yield was noted by 0.28-0.73 t ha^{-1} compared to the control, and when treating the soil with microbiological biofertilizers MBU-1, MBU-2 - by 0 .03-0.97 t ha^{-1}.

The experiments also showed that MBU based on phosphate-solubilizing microorganisms has high phosphatase activity. The phosphatase activity of the experimental plots with added MBU was 622.3 mg p-nitrophenol kg-1 of soil h-1 on the 28th day after application, while the initial value of soil activity was 243.2, which indicates the effectiveness of MBU in increasing the phosphatase activity of soil .

Key words: Organic cotton, cotton plant, biofertilizer, growth stimulants, soil phosphatase activity, foliar feeding,soil nutrition, additional harvest.

Introduction

Traditional agriculture and its main generally accepted practices of cultivating agricultural crops, based on the intensive use of mineral fertilizers and pesticides, pose a serious potential danger to the environment, primarily to the soil, cultivated plants, and through them to animals and people [1].

Tens of millions of tons of chemicals that are applied to the fields every year, even if they are relatively harmless, destroy the physical structure of the soil, the PPK and the species composition of soil microflora [2, 3, 4], thereby leading to a progressive decrease in soil fertility and crop yields [2, 3, 4]. 5]. The problems that arise with the intensive use of mineral fertilizers are mainly associated with the absorption of these fertilizers by plants. Thus, according to the results of researchers, the absorption of nitrogen, depending on the type of crop, averages about 30-50% [6,7], phosphorus 10-25% and potassium, respectively, reaches 50-60% [8]. The remaining mineral elements in the amount of nitrogen 50-60%, 75-90% phosphorus, 40-50% potassium, as well as heavy metals included in mineral fertilizers, cause serious problems associated with environmental consequences [9].

Among mineral fertilizers, the most problematic are phosphorus fertilizers. According to experts, global problems around the world associated with the production and use of phosphate mineral fertilizers are expected in the near future [10-13].

The importance of phosphorus (P2O5) for plants is well known as a limiting element, which is part of the main components of fundamental macromolecules necessary for normal growth, development and productivity of agricultural crops [10]. Research results and conclusions of scientists indicate that modern production technologies and the use of phosphorus fertilizers will inevitably cause global problems associated with environmental and food security throughout the world [11]. Thus, according to the results of researchers, from 75 to 90% of phosphorus added to the soil with traditional fertilizers is fixed by soil minerals, turning into a form that is indigestible by plants. Moreover, reserves of phosphate rock are not renewable, they are quickly running out and, consequently, prices for fertilizers are rising [12,13]. However, to prevent crop shortages, the application of phosphorus fertilizers to agricultural soils increases annually by 3.2% or more [10,11]. As a result, from 3 to 6 or more tons of indigestible fixed phosphates accumulate per 1 ha of arable layer, which is fraught with environmental, financial and sanitary consequences (eutrophication, phosphatization, contamination of soil and crops with heavy metals) [14].

Given the existing opportunities, the above-mentioned problems associated with mineral fertilizers can be solved by the use of organic, microbiological biofertilizers, as they are less expensive and highly effective compared to physical and chemical means. The effectiveness of MBU is based on the presence in its composition of microorganisms capable of dissolving and increasing the absorption of indigestible phosphorus by plants chemically bound by soil minerals (Ca and Mg) [15]. At the beginning of the century, it was established that some microorganisms, especially mycorrhizal fungi and some bacteria, are capable of dissolving calcium phosphates and increasing the supply of phosphorus to the plant [16].

Organic farming is an alternative that, by integrating the use of processed organic substances with microbial biostimulants, not only increases the yield and safety of agricultural products, but also enriches the beneficial microflora of the soil [17,18].

Among microbial biostimulants, within the framework of the development of sustainable agriculture, phosphate solubilizing microorganisms that promote the transition to the digestible form of phosphorus fixed by soil minerals have attracted significant attention [18,19]. The main mechanisms ensuring the mobilization of hard-to-reach phosphorus compounds are the production of various organic acids and phosphatase enzymes by microorganisms [15,19]. The accumulated data allow us to conclude that phosphate-mobilizing microorganisms make a fundamental contribution to the phosphorus nutrition of plants [15,16]. Also

As in developed countries, research on the cultivation of agricultural products on the principles of organic farming is developing at a high pace in Uzbekistan, and the results of the experiments are being successfully introduced into production. Based on scientific research on the cultivation of environmentally friendly fruit and vegetable products and high-quality cotton raw materials, taking into account the climatic conditions of the region, a huge amount of scientific data on organic agriculture in the country is being accumulated.

In organic farming, special attention is paid to preserving soil fertility, crop yields, as well as increasing the safety and quality of target products. The use of organic fertilizers increases the biological activity of the soil, improving its fertility. Biologically active organic substances and minerals in the soil play an important role in converting them into forms that are easily absorbed by plants. It has been noted that plants grown on organic soils are resistant to many factors, including an increase in their resistance to diseases and pests [20].

According to the textile industry's fiber demand, at the global level, petroleum-based synthetic fibers account for 62%, cotton fibers 25%, wood pulp fibers 6.5%, natural fibers 5.5% and wool fibers 1%. Of the 25% of cotton fiber, only 100,000 tons are organic cotton. Organic cotton (92.17%) is mainly grown in

India (66.9%), China (11.69%), Turkey (6.49%), Kyrgyzstan (4.93%) and USA (2.16%).), the remaining 7.84% are produced by other countries [21].

In the work of R.S. Sarmanova [22] noted that the development of organic farming in Kazakhstan will give positive results in accelerating the organization of marketing analysis, consulting and marketing services on a legal basis, considering the possibilities of additional support for organic producers from the state, as well as the allocation of subsidies for use in this direction.

The requirements of regulatory documents regulating the quality indicators of products obtained in organic farming conditions do not allow the use of easily soluble synthetic nitrogen fertilizers. In this regard, research and search for ways to replace mineral fertilizers with organic ones, without reducing the yield and quality of products, is relevant in the development of organic farming.

Objects and methods of research.

The objects of research are the cotton variety S-5707, created by scientists from the Research Institute of Breeding, Seed Production and Agrotechnology of Cotton Growing, as well as the stimulants Tandem, Maltamin and Mikrovak and MBU. Research in the field was carried out according to the methodological manual “Methodology for conducting field tests” (2007), as well as using methods developed at the Uzbek Scientific Research Institute of Chemical Institutions [23]. The results obtained were subjected to statistical processing according to the method of B.A. Dospehov [24].

Experimental studies were carried out on cotton fields in the Tashkent region. The soils of the experimental fields are typical irrigated gray soil. The mechanical composition is medium loamy with a predominance of coarse dust, amounting to 45-50% or more. The soils are quite high-carbonate and have a high absorption capacity - 9-12 mEq. per 100 g of soil, which decreases with depth. In the arable horizon, the humus content is 1.0 - 3.1%. The thickness of the humus layer is 50 – 80 cm.

Phosphatase activity of the soil was determined according to “Methods of soil enzymology” edited by F.Kh. Khaziev [25]. In this case, MBU was introduced into the soil under cotton crops between rows to a depth of 15 cm, normally at the rate of 50 kg/ha. Two weeks later, samples were taken from the same depth where MBU was added to analyze the phosphatase activity of the soil. To do this, place 1 g of air-dry soil in a 50 ml Erlenmeyer flask with a ground stopper, add 4 ml of universal buffer (pH 6.5), 0.25 ml of toluene and 1 ml of 0.115 M solution of sodium p-nitrophenyl phosphate (para-nitrophenyl phosphate- PNFF) and the mixture was stirred for 5 minutes. The flask is closed and placed in a thermostat for 1 hour at a temperature of 37°C. After incubation, add 1 ml of 0.5 M sodium hydroxide and stir for 5 minutes. and the suspension is filtered through an ashless filter into a 50 cm3 volumetric flask. The filtrate is colored yellow from the liberated p-nitrophenol.

The density of the yellow color of the filtrate is measured on a photocolorimeter with a blue filter (400-420 nm). The amount of p-nitrophenol released is calculated from a calibration curve compiled from standard solutions of p-nitrophenol. Phosphatase activity is expressed in mg p-nitrophenol kg^{-1} soil h^{-1} [26].

Research results.

The research was carried out in 2022 at the central experimental site of the Research Institute of Breeding, Seed Production and Agricultural Technology for Cotton Growing.

During the growing season, cotton plants were treated with biological products by spraying the leaves and their effect was determined. Treatment with the Tandem biostimulator was carried out during the budding period, with the Maltamin biostimulator - during the flowering period, and with the Microvac stimulator - during the budding and flowering periods. At the same time, positive results were revealed in all variants using biostimulants compared to the control. More intensive growth and development of plants were noted, as well as an increase in yield by 7.4 c/ha when treated with the biostimulants Tandem and Maltamine and by 2.8 c/ha when treated with the biostimulant Microbiovac (Table 1).

Also, in studies on obtaining high-quality cotton seeds based on the principles of organic farming, the effect of organic fertilizers on the growth, development and productivity of plants was studied. In this experiment, soil without fertilizers was used as a control option, in the standard version, organic fertilizer (rotted manure) was used at the rate of 20 t/ha, and biofertilizers MBU-1 and MBU-2, based on phosphate-solubilizing bacteria, were taken as experimental options. promoting the mobilization and assimilation of P2O5 by plants, fixed by soil cations of indigestible forms ($CaHPO_4$; $Ca_3(PO_4)_2$; $MgHPO_4$; $Mg_3(PO_4)_2$ и $Ca_5(PO_4)_3OH$.) in PPK. MBU-1 fertilizers were used at the normal rate - 70, 260 kg/ha, 90; 365 kg/ha and 120; 420 kg/ha, and MBU-2 - at the rate of 50; 100 kg/ha.

In field studies, phenological observations and biometric measurements of vegetating plants were carried out. Based on the results of the analysis of the data obtained, it was found that the indicators of plant height, number of sympodial branches, buds, flowers, bolls and yield were higher in all experimental variants compared to the control and standard. By the end of the growing season, in variants with MBU -1, the plant height exceeded the control variant by 31.2-38.1 cm, the number of sympodial branches - by 3.7-5.0, and the number of open bolls - by 2 ,8-4.0 pcs., in terms of yield - by 5.0-9.7 c/ha, and in the version with MBU-2, correspondingly higher - by 27.5 cm, 2.8 pcs., 2.4 pcs. ., and 0.03 t ha^{-1}. (Table 2).

Table-1

The influence of biological products on the growth, development and productivity of cotton plants cultivated organically

(Central experimental section of NIISSAVH, 2022)

№	Options	Biostimulator use rate l/ha	Date of observations														Productivity c/ha	Difference relative to control +;-
			July 1					August 1					September 1					
			Plant height, cm	sympodial branches, pcs.	Number of buds, pcs.	Number of flowers, pcs.	Number of boxes, pcs..	Plant height, cm	Number of sympodial branches, pcs.	Number of buds, pcs.	Number of flowers, pcs.	Number of boxes, pcs.	Plant height, cm	Number of sympodial branches, pcs.	Number of unopened boxes, pcs.	Number of opened boxes, pcs.		
1.	**Control**	-	44,4	7,3	6,6	1,7	0,9	67,9	10,3	0,8	0,2	8,6	89,5	13,8	2,4	7,1	38,1	-
2.	**Tandem, Maltamin**	3,0	54,0	10,3	9,8	2,2	3,9	77,9	12,9	2,2	1,2	8,1	117,3	16,1	2,1	9,8	45,4	+7,3
3.	**Microvac**	3,0	48,9	8,4	8,4	1,9	1,1	68,0	11,5	1,5	0,5	8,4	113,0	15,4	2,7	8,7	40,9	+2,8
	$LSD_{0,5}$																***3,87***	

Table-2

The influence of new organic fertilizers on the growth, development and productivity of cotton plants cultivated organically

(Central experimental site of NIISSAVH, grade S-5707, 2022)

№	Options	Rate of use of organic fertilizers t/ha	Дата проведения наблюдений														Productivity c/ha	Difference relative to control +;-
			1-июля					1-августа					1-сентября					
			Plant height, cm	Number of sympodial branches, pcs.	Number of buds, pcs.	Number of flowers, pcs.	Number of boxes, pcs.	Plant height, cm	Number of sympodial branches, pcs.	Number of buds, pcs.	Number of flowers, pcs.	Number of boxes, pcs.	Plant height, cm	Number of sympodial branches, pcs.	Number of unopened boxes, pcs.	Number of opened boxes, pcs.		
1.	**Control**	-	44,4	7,3	6,6	1,7	0,9	67,9	10,3	0,8	0,2	8,6	89,5	13,8	2,4	7,1	38,1	-
2.	**Standard**	20,0	56,7	9,9	7,0	1,0	1,4	84,9	12,1	2,5	0,6	7,3	114,4	16,2	2,8	8,1	40,8	+2,7
3.	MBU **-1**	0,26	57,7	10,4	8,3	1,7	1,9	97,1	14,5	2,8	0,3	8,1	123,5	17,5	1,6	9,9	38,7	+0,6
4.	MBU **-1**	0,365	63,6	11,5	8,8	2,2	2,0	96,4	15,6	3,0	0,7	10,5	128,6	18,8	3,1	11,1	47,8	+9,7
5.	MBU **-1**	0,42	60,5	10,5	8,0	2,2	1,5	92,4	14,9	2,6	0,4	9,6	120,7	17,6	1,6	10,3	43,1	+5,0
6.	MBU **-2**	0,1	59,1	9,9	7,1	1,2	1,8	90,2	13,4	2,8	0,4	8,6	116,0	16,6	2,0	9,5	38,4	+0,3
	$LSD_{0,5}$																***3,66***	

It is known that phosphatases, as specialized exoenzymes produced by microbes, play an important role in the processes of organic phosphorus mineralization. These enzymes hydrolyze various ester (phosphomonoesters) and phosphoanhydride compounds of phosphorus, mobilizing phosphorus fixed in organic matter that is not digestible by plants [27; 28]. In soils, phosphatases not only mineralize organic phosphorus, but also promote the entry of mineral phosphorus into plant roots. Organophosphorus compounds make up the predominant part of soil phosphorus (from 20 to 80%) and are represented by nucleic compounds, adenosine phosphoric acid derivatives, phosphohumic complexes and slightly mobile sugar phosphates and glycerophosphates [29]. Organophosphorus compounds in the soil become accessible to plants during enzymatic hydrolysis with the elimination of phosphoric acid residues [29; thirty].

The results of measuring the phosphatase activity of the soil, two weeks after applying MBU, showed that the fertilizer significantly increases the phosphatase activity of the soil.

The kinetics of increasing phosphatase activity of soils is observed within 21 days. The level of phosphatase activity in soils increased with increasing period of MBU application to the soil (Fig. 1). The highest values of soil phosphatase activity were observed 21 days after application of fertilizers. At the same time, the highest levels of phosphatase activity in test soil samples were observed on the 28th day of measurement.

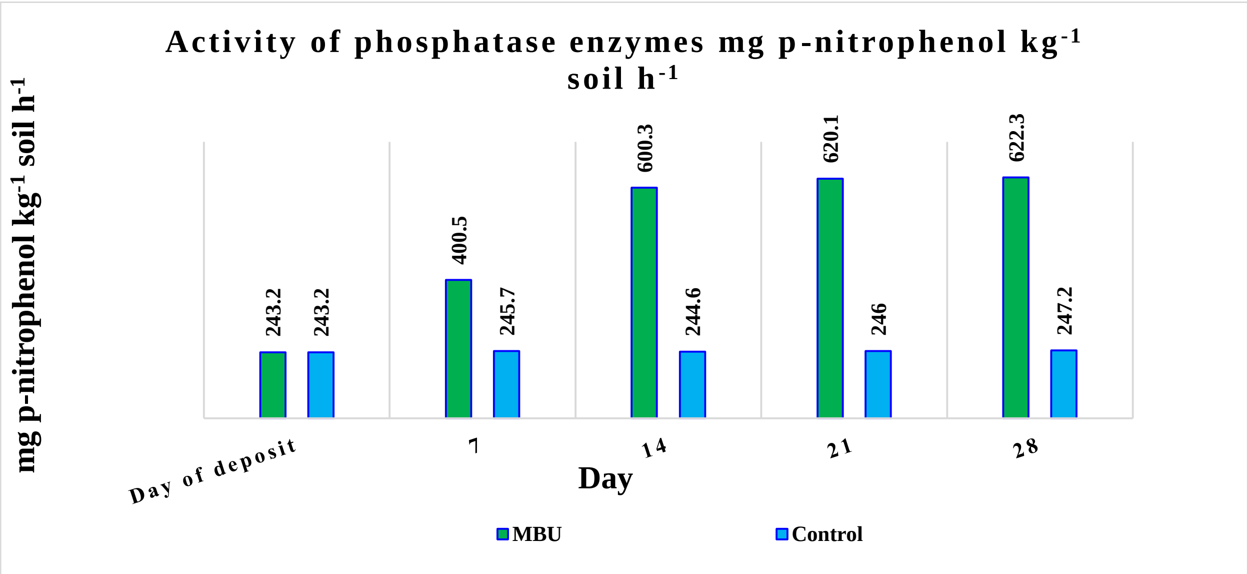

Figure 1. Activity of phosphatase enzymes
mg p-nitrophenol kg^{-1} soil h^{-1}

Changes in the phosphatase activity of the experimental soils varied from 242.8 on the day of application to 622.3 mg of p-nitrophenol kg^{-1} soil h^{-1} on the

28th day of the experiment, while the value of the phosphatase enzyme activity of the control plots changed from the initial value of 243.2 to values varying between 244.6 and 247.2. The phosphatase activity of the experimental plots with added MBU was 622.3 mg p-nitrophenol kg^{-1} of soil h^{-1} on the 28th day after application, while the initial value of soil activity was 243.2, which indicates the effectiveness of MBU in increasing the phosphatase activity of soil and, accordingly, a high level of solubilization of indigestible organic phosphates.

Conclusions and discussions

The experiments showed that MBU has high phosphatase activity, which indicates the effectiveness of fertilizers in solubilizing organic phosphates that are not digestible by plants.

Biofertilizers, as synergists to chemical fertilizers, are valued for their relative ease of use, environmental friendliness, and cost-effectiveness. Recent scientific discoveries are consistent with the notion that microbial phytases play a fundamental role in the life cycle of soil organic phosphorus. Microbial phytases, due to their potentially significant agronomic and environmental value for plant growth under conditions of a lack of available phosphorus in the soil, are becoming an attractive target for agro-industrial use [17,31]. The positive effect of biofertilizers on plant physiology in general is associated not only with an increase in the availability of limiting nutrients such as phosphorus, but they are also sources of plant growth regulators, enzymes, vitamins, amino acids and biologically active substances that help suppress diseases caused by phytopathogens [19,25, 31].

Thus, the use of MBU based on phosphate-solubilizing microorganisms producing phytase enzymes can be considered as an effective and environmentally friendly approach to increasing the bioavailability of soil phosphorus, as well as reducing the norms and increasing the efficiency of inorganic phosphorus fertilizers. Based on the research carried out on the cultivation of cotton on the principles of organic farming in the conditions of Uzbekistan, positive results were obtained using biostimulants Tandem during the budding period, Maltamin - during the flowering period and Microvac - during the budding and flowering period, as well as microbiological fertilizers MBU-1 and MBU- 2, with the help of which it was possible to increase the yield by 0.97 and 0.5 t ha^{-1}.

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