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Study of the Kinetics of Changes in the Mobile Forms of P_2o_5 of Traditional and Biomodified Fertilizers in the Soil

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Abstract: The kinetics of changes in the mobile forms of phosphorus (P2O5) of traditional and biomodified phosphorus fertilizers (BMPF) in the soil has been studied. It has been established that the kinetics of the transition of mobile forms of P2O5 of phosphorus fertilizers into an indigestible form depends on the time of interaction of fertilizers with soil. Mobile forms P2O5 of biomodified phosphorus fertilizers BMPF-Ammophos, BMPF-Suprephos NS, BMPF-PS-Agro remain in the soil for a significantly longer time compared to mobile forms P2O5 of traditional phosphate fertilizers Ammophos, Suprefos NS, PS-Agro. It is shown that the highest level of mobile forms of P2O5 fertilizers, one month after application, was found in the soils of biomodified fertilizers BMPF-Ammophos, BMPF-Suprephos NS and BMPF-PS-Agro (respectively 48-50 and 34 mg/kg of soil). While the content of mobile P2O5 in soils with traditional fertilizers on the 30th day, the measurement was only 24-25 mg/kg of soil.

Keywords: Mobile forms of P2O5, phosphate-solubilizing microorganisms, Bacillus subtilis BS-26, phosphate fertilizers.

Introduction.

Phosphorus for plants is an essential macronutrient required for key metabolic processes such as photosynthesis, cell division, macromolecular biosynthesis, membrane integrity, signal transduction and energy production. In addition, phosphorus plays a major role in plant respiration and nitrogen fixation in legumes [1, 2].

Despite the fairly high content of phosphorus (from 50 to 3000 mg/kg of soil) in the soil, due to its precipitation by cations, immobilization, adsorption and interconversion into organic form, only 0.1% of the total amount of soil phosphorus is available to plants [3, 4]. Therefore, it is impossible to obtain agricultural yields without adding phosphorus mineral fertilizers to the soil. The results of chemical and agrochemical studies conducted in recent years have made it possible to find out that, depending on the type of soil and its physical and chemical status, no more than 8-20% of phosphorus added to the soil with fertilizers is absorbed by agricultural crops [5, 6]. When water-soluble forms of phosphorus fertilizers are applied to the soil, about 30-40% of P_2O_5 becomes a water-insoluble state within 15 minutes [7]. Almost complete conversion of phosphorus pent oxide (95.5%) into an insoluble form occurs within a month after applying phosphorus fertilizers to the soil. In this connection, to prevent crop shortages, the application of phosphorus fertilizers to agricultural soils increases annually by 3.2% or more, depending on the condition of the soil [5, 7]. Consequently, the demand for phosphorus fertilizers to maintain plant productivity has increased

over the years. At the same time, a huge part of the applied phosphorus fertilizers containing various heavy metals are fixed in the soil, having a detrimental effect on the fertility of agricultural land, the health of animals and people [8,9]. In this connection, there is a need to find alternative approaches to eliminate shortcomings and reduce the application rates of phosphorus mineral fertilizers, without reducing crop yields.

One of the alternative approaches is the biomodification of traditional phosphorus fertilizers based on phosphate-solubilizing microorganisms. Phosphate - solubilizing microorganisms are bioinoculants; the main mechanisms that ensure the mobilization of hard-to-reach phosphorus compounds are their production of various organic acids and phosphatase enzymes [10].

Purpose of the work: Study of the kinetics of changes in the digestibility of biomodified phosphorus mineral fertilizers (BMFU).

Objects of research: The objects of research were BMFU based on the phosphate-solubilizing strain of the bacterium Bacillus subtilis BS-26 and traditional phosphorus mineral fertilizers Ammophos, PS-Agro and Suprefos-NS.

Research methods: To study the kinetics of changes in mobile P_2O_5 forms of traditional phosphorus fertilizers and BMFCs in the soil, we used a typical sierozem taken in a 0-25 cm layer. 100g soil samples were subjected to heat treatment to sterilize the native microflora and denature their enzymes in a drying oven at 180°C for 3 hours and stored under sterile conditions until experiments were carried out. To conduct the experiment, soil samples weighing 100 grams were fertilized at the rate of 100 mg/kg of soil, carefully mixed and transferred to flasks, and evenly moistened with distilled water to 60% of the total moisture capacity. As a control - soil without fertilizer application. The samples were stored at this humidity until mobile P_2O_5 was determined.

The content of mobile forms of phosphorus (P_2O_5) in the soil was determined using the Olsen method [11]. For this purpose, crushed and passed through a sieve with a hole diameter of 1 - 2 mm, 5 g of soil, previously dried to an air-dry state, is placed in flasks with a capacity of 200 - 250 cm^3. Add 100 cm3 of 0.5 N. $NaHCO_3$ solutions, add 1-3 g of activated carbon and shake on a rotator for 30 minutes. Then it is filtered and 5-40 cm^3 of colorless transparent filtrate is transferred into 100 cm^3 volumetric flasks, carefully neutralized with 6-dinitrophenol with 10% HC_1, stirred to remove the released CO_2 bubbles, and reagents are added to color the solution for photometry.

Soil extracts for the determination of mobile phosphates were prepared at different times: after 15 min; in one hour; in 3 days; 10 days and 30 days after application of fertilizers.

The experiment compared the kinetics of changes in mobile P_2O_5 forms of traditional (Ammophos, Suprefos NS, PS-Agro) and biomodified (BMFU-Ammophos, BMFU-Suprefos NS, BMFU-PS-Agro) fertilizers in the soil.

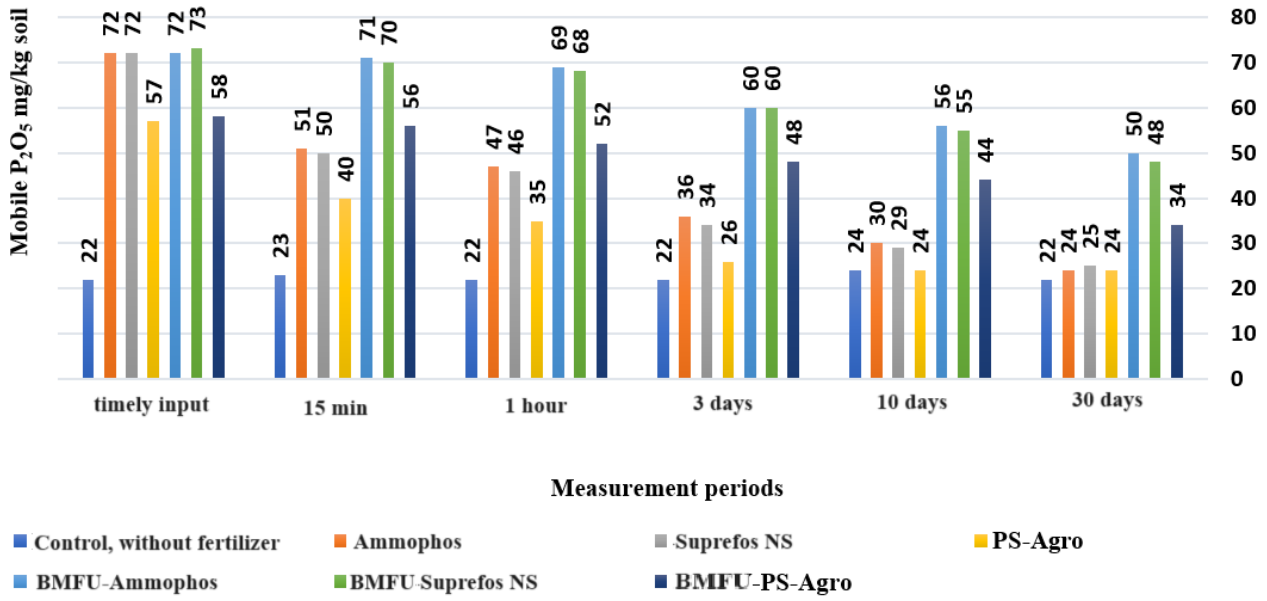

Fig.1. Kinetics of changes in mobile forms (P_2O_5) of traditional and biomodified fertilizers in soil

Research results and discussion.

The results of the study of the kinetics of changes in the digestible forms of P_2O_5 of traditional (Ammofos, Suprefos NS, PS-Agro) and biomodified (BMFU-Ammofos, BMFU-Suprefos NS, BMFU-PS-Agro) fertilizers in the soil showed that the content of mobile forms of P_2O_5 BMFU in the soil in within 30 days decreased from 58-73 at the time of application to 34-50 mg/kg of soil, while the P_2O_5 content of traditional phosphorus fertilizers in the soil decreased from 57-72 to 24-25 mg/kg of soil. In the soils of the control variant (without applying fertilizers), the P_2O_5 content remained practically unchanged during the month (22-23 mg/kg of soil). According to the results of the experiment, a significant decrease in the mobile forms of P_2O_5 of traditional phosphorus fertilizers begins within 15 minutes after applying fertilizers to the soil. The P_2O_5 content at the time of application was 57-72 mg/kg, after 15 minutes it became 40-51 mg/kg of soil, which is consistent with the results of researchers [7], who found that when water-soluble forms of phosphorus fertilizers are introduced into the soil, about 30+40% digestible forms of P2O5 are fixed by soil minerals within 15 minutes. At the same time, the degree of fixation of mobile forms of phosphorus strongly depends on the type of soil and soil solutions in the area of application. Thus, in acidic soils, P_2O_5 is associated predominantly with iron and aluminum in the form of FePO4 and A1PO_4, and in case of an excess of sesquioxides, it is mainly in the form of basic salts - $Fe_2(OH_3)PO_4$ and A12$(OH_3)PO_4$. In alkaline and slightly alkaline soils, the formation of such slightly soluble phosphorus salts as $CaHPO_4$ occurs; $Ca_3(PO_4)_2$; $MgHPO_4$; $Mg_3(PO_4)_2$ and sparingly soluble - hydroxyapatite $Ca_5(PO_4)_3OH$ [2,3,7].

The fixation of mobile forms of P_2O_5 BMFC in the soil occurred significantly slowly compared to traditional fertilizers. At the same time, the highest level of mobile forms of P_2O_5 fertilizer, a month after application, was found in the soil applied with BMFU-Ammophos and BMFU-Suprephos NS (48-50 mg/kg of soil, respectively). The content of mobile forms of P_2O_5, BMFU-PS-Agro on the 30th day was measured at 34 mg/kg of soil. The results obtained are consistent with the opinions of researchers [1,2,5,10], who argue that the main mechanism ensuring the mobilization of hard-to-reach phosphorus compounds is the production of various organic acids by microorganisms, such as gluconic, pyruvic, acetic, oxalic, acetic, malic , lactic, citric acid. As a rule, the production of organic acids is often associated with the production of phosphatases, most often alkaline, as well as other biologically active metabolites, such as IAA, siderophores, and antifungal metabolites [2,3].

Conclusion

A study of the kinetics of changes in mobile forms of P_2O_5 of traditional and biomodified fertilizers in soil showed that the kinetics of the transition of mobile forms of P_2O_5 assimilated by plants into an indigestible form depends on the time of interaction of fertilizers with the soil. The results of the experiment showed that the mobile forms of P_2O_5 BMFU-Ammophos, BMFU-Suprephos NS, BMFU-PS-Agro in the soil remain for a significantly long time in comparison with traditional phosphorus fertilizers Ammophos, Suprephos NS, PS-Agro. This is highly likely due to the physiological activity of the phosphate-dissolving strain Bacillus subtilis BS-26 immobilized in BMFU granules, which releases organic acids, enzymes and other metabolites into the medium, preventing the fixation of P_2O_5 by soil minerals and promoting the dissolution of fixed soil phosphates.

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