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Influence of Biological Preparations on Melioration of Saline Soils: Case Study from Uzbekistan

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Introduction

The agriculture in Uzbekistan to 99% is based on irrigation; therefore issue of rational water use is highly relevant. Two thirds of Uzbekistan consists of lowland, which caused the problems of shallow groundwater location (~ 2.5 m) as well as of secondary[1] soil salinization. Soil salinization has seasonal character, since a part of water consumption by plants is covered from groundwater. Soil salinization has an influence on crop yields' decrease. The solution of this problem requires application of new technical and technological practices. For example, nowadays, the biotechnologies gain in importance as a promising approach worldwide. This approach is considered more ecologically safe as well as harmonized with nature. Nevertheless, for a wide application of biotechnologies is still required a justification of effectiveness of their safety.

The application of biotechnologies is attractive for combating soil salinization, reducing damage on agriculture from salinization. The main way of soil desalinization is leaching, which is connected with a huge amount of efforts from farmers such as labor expenses, application of machinery with expensive fuel, large amount of water resources as well as appropriate drainage while leaching. At the same time, leaching leads to such negative consequences such as washing out of nutrients from the soil as well as its compaction.

Researchers from different institutes of the Uzbek Academy of Sciences have developed a number of biological preparations, soil application of which can reduce negative effects of salts on soil. Developed biological preparations may be an alternative to soil leaching or may improve desalinization processes of soil. The application of all developed biological preparations is not sufficiently tested for their practical implementation.

Therefore, the purpose of this study was to test on experimental basis a meliorative effect on properties of saline soil by the application of biological preparations within the Soil Lab as well as at experimental and real farm fields of the Research Institute of Irrigation and Water Problems, Tashkent, Uzbekistan. The research experiments were carried out from 2015 under different conditions: laboratory column, cultivation pots and in the field.

Material and Methods

In order to check meliorative effect of in Uzbekistan developed biological preparations, following experiments were conducted:

[1] The term secondary salinization describes salinization, caused by an increase of level of mineralized groundwater due to development and irrigation of new land

- Physical modeling of soil leaching (and irrigation) on laboratory columns;
- Lysimetric experiments on soil leaching (and irrigation) on cotton;
- Field experiments on leaching of saline soils;
- Field experiments on cotton in the farmers' plots.

In all above mentioned experiments, the influence of biological preparations on saline soil was tested and analyzed.

For the physical modeling of soil leaching, following biological preparations initially were selected:

- "FOSSTIM" - bacterial fertilizer, which contains phosphorus mobilizing rhizobacteria Bacillus able to solute soil mineral and organic phosphates developed at the Institute of Microbiology
- "SERXOSIL" based on green microalgae Scenedesmus, having better effect on soil than convenient dung and ecologically cleaner. This preparation was also developed at the Institute of Microbiology.
- Chemical "BIOSOLVENT" - a polymer compound based on an ionic polymer with an adhesion agent serves for neutralization of salts in the soil- developed by the researches of the Institute of Bioorganic Chemistry. The „BIOSOLVENT" is the analogue of Swiss soil conditioner „SPERSAL SL"

Both institutes belong to the Uzbek Academy of Sciences.

In 2015, a preliminary study was conducted in order to determine preparations with most positive effect on properties of saline soils as well as soil moisture maintenance during the irrigation. This was carried out as laboratory experiments on bulk soil columns, which simulates leaching and irrigation processes. In 2016, experiments were carried out in lysimeters (vegetative vessels). In these experiments, the effectivity of selected preparations with maximal effect on saline soils was tested.

For lysimetric experiments on soil leaching on cotton, were selected initially biological preparations:

- "RIZOKOM 1" based on rhizobacteria p. Bacillus и Paenibacillus developed by Institute of Microbiology of the Academy of Sciences of Uzbekistan
- „TRILHODERMIN" based on an antagonistic fungus Trichoderma viride developed by the Uzbek Scientific Research Institute for Plant Protection.

Beside both preparations, also mulching with licorice by-products was applied in these experiments.

Based on experiments in laboratory as well as on lysimeters, it was decided to test more in depth two preparations: biological preparation „RIZOKOM 1" and desalinization preparation „BIOSOLVENT".

In the field, the biological preparation "RIZOKOM 1" was tested for two years by soaking cotton seeds before sowing. The desalinization preparation "BIOSOLVENT" was also tested for two years by two technologies: sprinkling of soil with 10% solution before leaching and in furrows before irrigation of cotton. Loam soil with an initial salinity ranging from 6 to 10 dS/m from the middle reaches of the Syrdarya River were used in the experiments.

To control the processes in experiments, following measurements and analyzes were carried out:

- Soil moisture measurements by thermostatically-weighted method - on columns, lysimeters as well as, partly, in field experiments
- Determination of soil salinity in accordance with electrical conductivity (EC), when measuring EC in soil-water suspensions (soil to water 1: 1) in all experiments, in the

initial state as well as before and after each water supply (leaching or irrigation) of saline soil

The pH level, Total Dissolved Solids (TDS) as well as ionic composition of the aqueous extract from the soil (soil: water 1: 5) were calculated in the soil and in the leacheats during the leaching of saline soil and after irrigation (or leaching). Additionally, phenological observations of the growth and development of cotton plants on the control areas were carried out during the field experiments. The results of observations, measurements and chemical analyzes of the soil were statistically evaluated.

Results and Discussion

The analysis of experiments as well as practical tests on the farm fields showed that the application of „RIZOKOM 1"has positive effects on saline soils under cotton. According to the lysimetric experiments, soil moisture increased in 2,4 % compared to control observations. In the field trials was determined the decrease of pH level up to 0,6 - 1,0. Beside this, was found out that the salt accumulations declines towards the end of the vegetation as well as changes in EC as well as TDS and some ions is also observed. The results showed that application of „RIZOKOM 1" on cotton plants contributes to the enormous water savings for leaching and irrigation (e.g. a water application slot less due to soil moisture accumulation). The total water savings (leaching and irrigation) can be around 3400 м3/ha. Additionally, the application of "Rizokom 1" proves to have a positive influence on growth and development of cotton plants, which leads to the cotton yield increase on 0,74 t/ha. Both, water savings as well as better productivity of cotton bring (economical) advantages for farmers; among other things the application itself is very easy and cheap (no additional skills are needed).

Tests on the desalinization preparation „BIOSOLVENT" in lysimeters and in the fields showed that the total amount of ions HCO_3, SO''_4, *Ca u Mg* leached from the soil was quite high (respectively 52, 26, 49 и 15 % comparing with the control in lysimeters and respectively 35...42 %, 13…16 %, 21…28 %; 21…23 % in the field trials). In total, these results illustrate the ability of „BIOSOLVENT" to reduce negative (osmotic) pressure of soil moisture in saline soil and to create proper conditions for plants' growth and development. Desalinization reached through the application of "BIOSOLVENT" lead to the water savings. For instance, considerable amount of water can be saved for leaching (ca. 25%). Released irrigated water from 1ha allows to irrigate additionally 0,3ha, which means additional economic benefit for respective farmers. Beside this, "BIOLOSVENT" due to its desalinization effects has positive influence on root development of plants. The yield increase was observed (plus 7, 5 t/ha: 22 percent more than in control). Therefore, application of „BIOLOSVENT" with its main effect of salt leaching leads to water savings as well as yield increase.

Conclusions and Outlook

To conclude the experiments on biological preparations' application showed that the "RIZOKOM 1" contributes to the improvement of soil properties (pH, ECe, etc.) due to changes in microbiological conditions in the soil. Additionally, it creates favorable conditions for plants on saline soils and, possibly, reduces toxic effects of salts on soils.

The "BIOSOLVENT enhances effect of saline soil leaching as well as creates salt ventilation during the growing season and, thereby, helps to reduce negative impact of salts on soils and plants, with optimal use of water.

The application of both tested biological preparations during the vegetation of cotton facilitates lower salt accumulation in the soil by autumn, which reduces labor costs, use special equipment we as well less fuel consumption for soil leaching in the winter-spring period.

Несмотря на положительные эффекты «БИОСОЛЬВЕНТа», считаем, что для выявления возможных последствий от его применения, необходимо более продолжительное наблюдение за почвой. Кроме того, следует провести более глубокие почвенные и микробиологические исследования, изучить влияние данного препарата на микро агрегатный состав почвы микроэлементы для различных типов почв, установить длительность его воздействия на почвы, а также возможные необратимые изменения почвы при частом применении.

Another conclusion can be derived that despite the positive effects of "BIOSOLVENT", further longer soil monitoring is needed in order to identify possible consequences from its application. Beside this, further in-depth studies are necessary to investigate effects of "BIOSOLVENT" on the micro-aggregate composition of soil microelements for various types of soils. It is also worth making the effort to research the duration of its effect on soils as well as possible irreversible changes in soil with frequent application.

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