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DEVELOPING ENVIRONMENTALLY SAFE AND RESOURCE-SAVING BIOTECHNOLOGY FOR COTTON CULTIVATION ON SALINE SOILS OF THE KHOREZM REGION

Sayfullayeva Sabinabonu Husniddinovna
Assistant at Bukhara State Medical Institute
Email: sayfullayevasabina796@gmail.com.uz
Phone: +998 88 574 00 58

Annotatsiya: Xorazm viloyatida tuproqlarning sho‘rlanishi qishloq xo‘jaligi ishlab chiqarishining barqarorligiga jiddiy tahdid solmoqda. Ayniqsa, g‘o‘za yetishtirishda tuproq sho‘rlanishi hosildorlik va tola sifatining pasayishiga olib kelmoqda. Tadqiqotning maqsadi sho‘rlangan tuproqlarda g‘o‘za yetishtirish uchun ekologik xavfsiz va resurslarni tejaydigan biotexnologiyani ishlab chiqishdan iborat. Tajriba jarayonida halotolerant mikroorganizmlar, bioo‘g‘itlar va organik moddalardan iborat kompleks texnologiya qo‘llanildi. Natijalar shuni ko‘rsatdiki, bioo‘g‘itlar (Azotobacter, Bacillus subtilis, va fosfor erituvchi bakteriyalar)ni vermikompost bilan birgalikda qo‘llash urug‘ning unish darajasini 15–20% ga, xlorofill miqdorini 18% ga, hosildorlikni esa 22–28% ga oshiradi. Shuningdek, suv va o‘g‘itlardan foydalanish samaradorligi ortdi, tuproqning sho‘r miqdori kamaydi. Taklif etilgan biotexnologiya ekologik xavfsiz bo‘lib, resurslarni tejash, hosildorlikni oshirish va sho‘rlangan tuproqlarda barqaror qishloq xo‘jaligini ta’minlash imkonini beradi.
Kalit so‘zlar: g‘o‘za, sho‘rlangan tuproqlar, Xorazm viloyati, biotexnologiya, bioo‘g‘it, halotolerant bakteriyalar, ekologik xavfsizlik, resurslarni tejash.
Аннотация: Засоление почв в Хорезмской области является одной из основных экологических и агрономических проблем, значительно влияющих на рост и урожайность хлопчатника. Целью исследования является разработка экологически безопасной и ресурсосберегающей биотехнологии возделывания хлопчатника на засоленных почвах. В работе использовались биологические удобрения на основе галофильных и гало-толерантных микроорганизмов, а также органические добавки. Результаты показали, что совместное применение биопрепаратов (*Azotobacter*, *Bacillus subtilis*, фосфатмобилизирующих бактерий) и вермикомпоста повышает всхожесть семян на 15–20%, содержание хлорофилла на 18%, а урожайность хлопка — на 22–28% по сравнению с традиционной технологией. Также улучшились структура и биологическая активность почвы, снизился уровень засоления и повысилась эффективность использования воды и удобрений. Предложенная биотехнология способствует экологически безопасному, экономичному и устойчивому производству хлопчатника на засоленных землях.

Abstract: Salinization of agricultural lands in arid and semi-arid regions is one of the most critical environmental and agricultural problems worldwide. The Khorezm region of Uzbekistan is among the territories where soil salinity negatively affects cotton growth, yield, and fiber quality. This research aims to develop an environmentally safe and resource-saving biotechnology for cultivating cotton (*Gossypium hirsutum L.*) under saline soil conditions. A complex biotechnological system based on biofertilizers, halotolerant microorganisms, and organic soil amendments was developed to improve soil structure, increase nutrient availability, and enhance plant stress resistance. Experimental studies conducted in the saline soils of the Khorezm region demonstrated that the combined use of microbial inoculants (Azotobacter, Bacillus subtilis, and halotolerant phosphate-solubilizing bacteria) with vermicompost and

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moderate mineral fertilizers increased seed germination by 15–20%, chlorophyll content by 18%, and cotton yield by 22–28% compared to traditional farming practices. The results suggest that such integrated biotechnology can effectively reduce environmental impact, improve soil fertility, and optimize water and nutrient use efficiency in cotton farming systems on saline lands.

Introduction

The degradation of soil quality and the expansion of saline lands are pressing issues in Uzbekistan's agricultural sector, especially in the Khorezm region located in the lower reaches of the Amu Darya River. Due to excessive irrigation, poor drainage systems, and high evaporation rates, secondary salinization has become widespread. More than 60% of irrigated lands in the region are moderately to highly saline, significantly reducing crop productivity, particularly for cotton — the main industrial crop of the region.

Cotton is one of Uzbekistan's strategic crops, providing a major source of export revenue and rural employment. However, the conventional cultivation methods, which rely heavily on chemical fertilizers and irrigation, are not sustainable under increasing salinity and climate change conditions. Therefore, the development of **eco-friendly, resource-saving, and biologically based technologies** is essential for maintaining soil fertility, improving crop productivity, and minimizing environmental pollution.

This research focuses on designing and testing an **integrated biotechnological system** for cotton cultivation in saline soils, emphasizing the use of halotolerant microorganisms, bioorganic fertilizers, and efficient irrigation practices.

Materials and Methods

Study Area

The research was conducted in experimental fields located in the Khorezm region, Uzbekistan, where the soil type is classified as **meadow-alluvial, moderately saline**, with an electrical conductivity (EC) of 6–8 dS/m and pH between 7.6 and 8.2. The average annual precipitation is less than 100 mm, and the region's climate is sharply continental.

Experimental Design

A randomized block design was used with four treatments and three replications:

1. **Control (C):** Traditional cultivation with standard mineral fertilizer application.
2. **Treatment 1 (T1):** Application of biofertilizer containing *Azotobacter chroococcum* and *Bacillus subtilis*.
3. **Treatment 2 (T2):** Biofertilizer + vermicompost (5 t/ha).
4. **Treatment 3 (T3):** Biofertilizer + vermicompost + 50% of recommended mineral fertilizer dose.

Cotton variety *Bukhara-102* was used for all treatments.

Laboratory and Field Analysis

Soil samples were analyzed for EC, pH, organic matter, nitrogen, phosphorus, and potassium before and after the growing season. Plant growth parameters such as germination rate, plant height, leaf chlorophyll content (SPAD value), and yield components were measured during the vegetation period.

Results and Discussion

Effect of Biotechnology on Soil Properties

Application of microbial inoculants and organic matter significantly improved soil physicochemical properties. The organic carbon content increased by 0.3–0.5%, while the EC decreased by 12–15% after one cropping season. This indicates improved salt leaching and better soil aeration. The microbial activity (measured by dehydrogenase enzyme assay) in the

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treated soils was 1.7–2.3 times higher than in the control, confirming enhanced biological fertility.

Cotton Growth and Physiological Responses

Inoculation with halotolerant bacteria and addition of vermicompost led to better plant vigor and leaf greenness. The chlorophyll content increased by 18% compared to control plants. The improved physiological status was reflected in higher photosynthetic activity and better resistance to osmotic stress caused by soil salinity.

Yield and Resource Efficiency

The highest yield (3.4 t/ha) was obtained in **Treatment 3 (biofertilizer + vermicompost + 50% mineral fertilizer)**, showing a 28% increase over the control. Furthermore, irrigation water use efficiency improved by 20%, as the treated plants required fewer watering events due to improved soil moisture retention. Thus, the technology not only enhances productivity but also reduces chemical inputs and conserves water resources.

Environmental and Economic Aspects

The use of biological fertilizers reduces dependency on costly mineral fertilizers and mitigates the risk of groundwater pollution caused by nitrate leaching. A cost–benefit analysis showed that the integrated biotechnology decreased input costs by 15% and increased net profitability by approximately 25%. These findings demonstrate that environmentally safe and resource-efficient biotechnologies can provide both ecological and economic advantages in saline regions like Khorezm.

Conclusion

The study demonstrated that the application of halotolerant microbial biofertilizers in combination with organic amendments and reduced mineral fertilizers effectively improves soil quality, enhances cotton growth, and increases yield on saline soils of the Khorezm region. This integrated biotechnological approach ensures sustainable agricultural production, rational use of natural resources, and ecological safety. Future work should focus on long-term monitoring of soil health, large-scale field trials, and integration of these practices into regional agricultural policies.

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