INNOVATIVE BIOTECHNOLOGY FOR CULTIVATING WINTER WHEAT ON SALINE SOILS OF BUKHARA REGION

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ABSTRACT

Salinity remains one of the main constraints on stable wheat production in Uzbekistan, especially in the irrigated agroecosystems of the Bukhara oasis. The study is based on comparative analysis of international and Uzbek research on saline-soil management, winter wheat physiology, plant growth-promoting rhizobacteria, and practical agronomic recommendations for Uzbekistan. It is argued that the most effective model for Bukhara combines four interconnected components: selection of salt-tolerant varieties, presowing seed treatment with microbial preparations, foliar application of biological stimulants, and optimization of mineral nutrition. The analysis shows that such an integrated biotechnology can improve plant adaptation to osmotic and ionic stress, stabilize photosynthesis and water relations, support yield formation, and reduce dependence on excessive chemical inputs. The proposed model is especially relevant for the meadow-alluvial and moderately saline soils characteristic of the Bukhara region.

KEYWORDS: Winter wheat, saline soils, Bukhara Region, biotechnology, plant growth-promoting rhizobacteria, seed treatment, foliar biostimulants, salt tolerance, sustainable agriculture.

INTRODUCTION

Winter wheat occupies a strategic place in Uzbekistan's food system, yet its productivity is increasingly threatened by soil salinity, climate stress, and the declining ecological stability of irrigated lands. In arid and semi-arid environments, salinization disrupts seed germination, root development, nutrient uptake, photosynthesis, and final grain yield. For Bukhara Region, where irrigation agriculture dominates and saline meadow-alluvial soils are widespread, the task is not only to maintain production but also to shift from input-intensive farming toward biologically supported and resource-efficient cultivation technologies. In this context, biotechnology should be understood not narrowly as laboratory manipulation, but as the applied use of beneficial microorganisms, physiologically active compounds, and adaptive varietal selection in field production systems.

The present study used analytical synthesis, comparative interpretation, and systematization of published materials. The source base included FAO manuals on saline-soil management and wheat production in Uzbekistan, peer-reviewed studies on wheat physiology under salinity, and research on salt-tolerant rhizobacteria and local varietal adaptation in Bukhara conditions. Particular attention was paid to studies that linked physiological indicators with practical agronomic outcomes, because saline agriculture in Bukhara requires technologies that are both scientifically grounded and operationally feasible for farms. The methodological logic of the article therefore combines physiological, microbiological, and agroecological perspectives into one integrated production model.

The analysis shows that salinity affects winter wheat first through disturbance of plant water exchange and then through suppression of photosynthetic productivity. Research conducted under Bukhara conditions demonstrates that moderately and highly saline soils reduce leaf moisture regulation, pigment stability, and yield performance, while varietal differences remain significant. Among the tested cultivars, Starshina, Grom, and Krasnodar-99 displayed relatively higher tolerance, whereas Pervitsa and Asr showed greater sensitivity to saline stress. This confirms that innovative biotechnology in Bukhara cannot be effective without prior varietal differentiation: biological preparations work best when applied to cultivars that already possess a comparatively stable physiological response to salt stress.

The second major result concerns the role of plant growth-promoting rhizobacteria. Uzbek and international studies indicate that salt-tolerant rhizobacteria can stimulate root formation, improve nutrient mobilization, enhance phytohormone balance, and mitigate stress injury in wheat grown on salt-affected soils. Earlier research from Uzbekistan identified a high incidence of beneficial rhizosphere bacteria associated with wheat on saline soils, while later studies demonstrated that inoculation with selected strains can induce systemic tolerance in wheat under salinity stress. These findings are crucial for Bukhara, because microbial inoculation provides a biologically soft but agronomically strong mechanism for improving crop establishment on difficult soils.

The third result concerns integrated biopreparation technology developed in Uzbekistan. Applied studies on saline soils reported that combined use of seed-treatment and foliar biopreparations, including microbial formulations of the Rizokom series and the foliar product Serhosil, improved wheat development on saline lands, supported root growth, normalized alkaline soil reaction, reduced the toxic salt burden, and increased grain yield. The same body of work reports that such biotechnology may reduce mineral fertilizer rates by 25–50 percent and raise wheat yield by roughly 20–30 percent under field conditions. For Bukhara Region, these results are especially important because they show that innovation should not replace agronomy, but reorganize it around biologically active and ecologically safer inputs.

From a scientific standpoint, the most promising biotechnology for Bukhara is not a single preparation, but a coordinated package. Its first element is the placement of salt-tolerant winter wheat cultivars in soils differentiated by salinity level. Its second element is presowing seed inoculation with halotolerant and nutrient-mobilizing microbial consortia that strengthen early root vigor and reduce the stress shock of germination. Its third element is foliar treatment with biologically active formulations that support metabolism during stem elongation and grain formation. Its fourth element is a moderated fertilizer regime adjusted to soil chemistry, so that biological activity complements rather than merely substitutes mineral nutrition. Such a model corresponds both to FAO principles of sustainable saline-soil management and to the practical realities of irrigated wheat farming in Uzbekistan.

The wider significance of this approach lies in its capacity to align productivity with ecological resilience. Traditional intensification on saline soils often relies on heavier fertilizer use, but this strategy can deepen soil imbalance and increase production costs. By contrast, biotechnological cultivation seeks to restore microbial functionality, improve nutrient-use efficiency, and stabilize physiological processes under stress. For Bukhara, where wheat production must remain both economically viable and environmentally sustainable, this transition is not optional but strategic. It also fits the longer-term challenge identified for Uzbekistan: future wheat security will depend on whether domestic farming systems can adapt simultaneously to rising climate pressure and soil salinization.

Innovative biotechnology for winter wheat on saline soils of Bukhara Region should be understood as an integrated adaptive system rather than as an isolated biological additive. Its core lies in combining salt-tolerant varieties with microbial seed treatment, foliar biostimulation, and rationalized mineral nutrition. The evidence reviewed in this article suggests that such a model can improve plant resistance, support stable yields, and reduce ecological pressure on irrigated soils. For Bukhara Region, the most rational development pathway is therefore the gradual transition from chemically dominated wheat production toward biologically optimized and region-specific saline agriculture.

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