

AGRICULTURAL STRATEGY FOR IMPROVING SOIL HEALTH IN BUKHARA REGION

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Abstract: Oases in Uzbekistan, such as Bukhara and Mirzachul, face a complex of challenges that threaten long-term food security and ecological sustainability. Salinization, desertification, organic matter depletion, and microbial biodiversity are pressing issues that are being exacerbated by climate change and intensive irrigation practices.

Keywords: Silica, Drought, Salinity, Sandy brown soils, Fertilizer, Green manure.

Introduction: Bukhara, one of Uzbekistan's most beautiful cities, was historically a cradle of agricultural development, a center of the Silk Road crossroads. But today, the region's ecosystem and agriculture are at risk in an unprecedentedly difficult situation. Historically, the sustainability of Bukhara's agriculture has depended on a delicate balance between water drawn from ancient river systems (such as the Zarafshan) and the health of the soils that have been cultivated for thousands of years. Today, this balance is disrupted. Secondary salinization caused by intensive irrigation without adequate drainage has made vast areas of land less fertile. Climate change is exacerbating these problems, with frequent droughts and high temperatures increasing evapotranspiration, accumulating salts in the root zone. In addition, decades of conventional farming, often with monocultures such as cotton, have led to widespread depletion of soil organic matter, deterioration of soil structure, and loss of viable microorganisms. The result: degraded soils have poor water absorption and retention, requiring more irrigation, which in turn accelerates salinization and nutrient leaching. This not only reduces yields, but also increases production costs and has negative environmental impacts. Addressing this crisis requires moving beyond single, symptomatic treatments. A systematic understanding of soil types, their specific constraints, and the biological mechanisms that underlie soil health is crucial.

Analysis. Biological processes of alluvial soils of the Bukhara oasis irrigated meadow are biostimulants containing silicon (Si). Although silicon is not an essential plant nutrient for all crops, its beneficial role in increasing resistance to abiotic stresses (drought, salinity, heavy metals) and biotic stresses (pests and diseases) is well documented. However, this study focuses on a relatively unexplored area: the direct and indirect effects of Si on soil microbial communities have been continuously studied by researchers.

Field experiment. A field experiment was conducted on saline alluvial soils of the Bukhara district using cotton (Bukhara-6 variety) as a test crop. The researchers compared three treatments with a control:

1. Aminoside-Aton: A compound containing amino acids and other bioactive components.
2. Aminoside-Silicon (A-Si): The above preparation enriched with silicon.

3. Bionitrogen: Possibly a biological nitrogen-fixing product.

The treatment was carried out by seed treatment and foliar spraying. The main indicator of success was not immediate yield, but the seasonal dynamics of the main soil microbial groups in two soil layers (0-30 cm and 30-70 cm). These groups include:

- Ammofixers: Bacteria that mineralize organic nitrogen to ammonia, a crucial step in the nitrogen cycle.
- Actinomycetes: Filamentous bacteria that are important for the breakdown of complex organic matter (e.g. cellulose) and the production of antibiotics.
- Oligonitrophils: Microorganisms that can grow in low nitrogen environments and contribute to atmospheric nitrogen fixation.
- Aerobic cellulolytics: Essential for the decomposition of plant residues.
- Microscopic fungi and spore-forming bacteria.

Bukhara Soil Landscape: Classification of Problems. To apply specific solutions such as Si fertilizers, it is first necessary to understand the diversity of the battlefield. The analysis of Bukhara region soils, including the pedological map of the oasis, the biological classifier classifying the main irrigated soils of the oasis, and the historical documents of the studies diagnosing soil diseases, indicate how urgent the problem is.

Conduct detailed soil mapping and classification, as modeled in the Bukhara study, at the farm or regional level. This allows for precise management. For example:

- Heavy, saline meadow soils: Prioritize drainage, apply Si fertilizers to encourage microbial-based reclamation, and use salt-tolerant, deep-rooted green manures (alfalfa) to break up the weeds.
- Light, sandy brown soils: Focus on building organic matter with high-biomass green manures (rapeseed, phacelia) and using silica to improve water retention and microbial stability.
- Degraded barren (barren) soils: Initial physical rehabilitation (deep tillage, application of gypsum for fidelity) may be necessary, followed by permanent green manure and microbial inoculation.

Conclusion. Uzbekistan's agricultural oases are at a crossroads. Relying on traditional, input-intensive practices is likely to lead to further soil degradation, jeopardizing food security. However, the research summarized here illuminates a way forward based on the principles of ecological intensification and soil health.

The combined evidence suggests that the synergistic application of silicon-based biostimulants, tailored agronomic interventions based on precise soil knowledge, and systematic use of green manure crops can significantly enhance the resilience and productivity of these vulnerable agroecosystems. This approach is consistent with the global shift to regenerative agriculture, which seeks to work with, rather than against, natural processes.

Long-term trials: Multi-year studies that monitor the combined effects of Si fertilizers and green manure rotations on total crop yield, yield, and soil carbon sequestration.

Molecular microbial ecology: Using modern methods to understand how Si alters microbial community composition and gene expression related to stress tolerance and nutrient cycling.

Identifying the most adapted green manure species and varieties for different conditions through the development of local products will lead to the remediation and improvement of saline soils in the Bukhara region.

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