ID: 772

Climate-Smart Agriculture and Soil Resilience: Strategies for Arid and Semi-Arid Regions

Usman Mir Khan[1], Muhammad Yasir Naeem[2], Yaira Rakhmetova[3], Tulkinzhon Gaipov[4*]

[1]National Institute of Food Science and Technology, University of Agriculture, Faisalabad, 38000, Pakistan
[2]Department of Agronomy, Animals, Food, Natural Resources and the Environment (DAFNAE), University of Padua, Italy
[3]Department of Biotechnology, Faculty of Biology and Biotechnology, Al Farabi Kazakh National University, Almaty, Kazakhstan
[4]Khoja Akhmet Yassawi International Kazakh-Turkish University, Center for Strategic Development, Rating and Quality, Turkestan, Kazakhstan

*Presenter Author's Email: tulkinjon.gaipov@gmail.com

Abstract

Arid and semi-arid regions face enhanced food insecurity due to rising climate variability, land degradation, and water scarcity. Climate-smart agriculture (CSA) has an integrated approach to enhancing the environment sustainability, productivity, and resilience of crops under such tight conditions. From this review, CSA strategies, including precision irrigation (e.g., drip irrigation system), drought-tolerant cultivars, conservation agriculture, mulching, and organic soil manures, improve soil retention capacity, reduce erosion, and stabilize yield under changing climate. In addition, soil microbiome enhancement through the use of biofertilizers and microbial consortia is an area to advance drought resistance. Case study-based context-specific adaptations in Iran, the Sahel, and the Indian Thar Desert are highlighted, such as zai pits, sand mulching, and fog-harvesting. The review also mentions the deployment of digital agriculture—remote sensing, artificial intelligence-based weather forecasting, and sensor-based monitoring of soil—to enable decision-making. Socio-economic barriers to CSA adoption, including access to finance, knowledge transfer, and land tenure insecurity, are examined. Policy frameworks for inducing CSA using incentives, extension, and integrated watershed management are also discussed. The importance of context-specific and participatory approaches to CSA is discussed in this paper. Its novelty lies in the integration of indigenous ecological insights with new climate-resilient technologies for adaptive capacity building and food system resilience in risk-prone lands.

Keywords: Climate-smart agriculture, soil resilience, arid lands, drought adaptation, precision farming, microbial biofertilizers.