Impact of Nature-based Innovative Biofertilizers on Agriculture

Cultivating a Nutritious, Resilient, and Sustainable Food System from the Ground Up

To increase the crop yield, farmers make extensive use of chemical nitrogen fertilizers that are accompanied by a number of environmental repercussions. Their application in excess not only accelerates soil acidification but also contaminates groundwater and the atmosphere. Authors, **Dr Mandira Kochar** and **Dr Vatsala Koul**, in this article, elucidate environmentally benign alternatives.

Global climate changes have resulted in unexpected drought, extreme temperatures, excessive rainfall, and unanticipated storms, causing disasters that had never occurred in the past. Considering this, establishment of an environment friendly mechanism is of vital importance. In recent years, there has been an unrestricted and unchecked use of agrochemicals to obtain higher yield which on the flip side has given rise to several agricultural problems and damaged soils. Excessive use of chemical nitrogen fertilizers not only accelerates soil acidification but also risks contaminating groundwater and the atmosphere. Biofertilizers and those inputs containing soil's native microbiota offer a safer option for mitigating the negative impacts of adverse climatic changes.

Mycorrhiza, a soil fungus, establishes a mutualistic symbiotic association between itself and host plant roots. It contributes significantly to plant nutrition, particularly to phosphorus uptake and the selective absorption of immobile (such as Zn) and mobile (S, Ca, K, Fe, Mn, and N) elements to plants along with water uptake while providing resistance against abiotic and biotic stresses. Mycorrhiza-associated bacteria and other soil beneficial bacteria are very closely associated with the rhizosphere microbiome and act as a third partner involved in the well-studied mycorrhizal–plant symbiosis. They are involved in influencing plant hosts directly and indirectly as well as interact at varying levels to enhance the plant's immune responses, mycorrhizal activity, root nutrient uptake, and provide resistance against various abiotic/biotic stresses.

TERI has successfully recreated the model mycorrhizal–bacterial interactions in symbiosis with plant roots. This not only helps to examine the effects on bacterization/mycorrhization of plant roots but also physiological impacts on

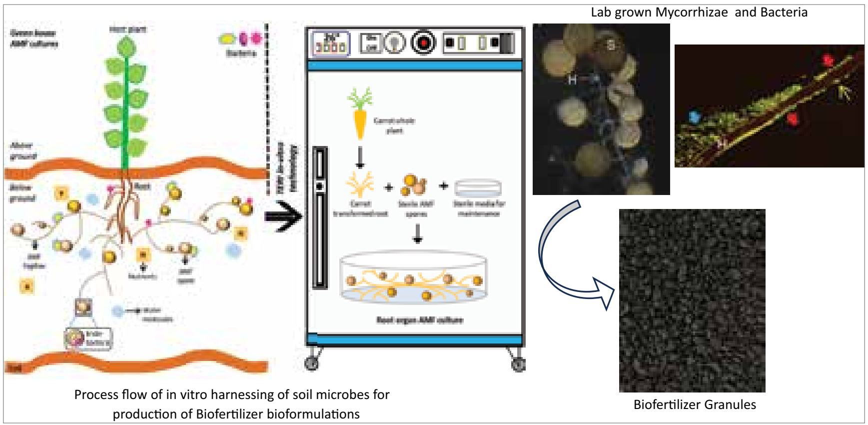

***Figure 1** Process flow of in-vitro harnessing of soil microbes for production of biofertilizer bioformulations*

plant growth and productivity during the host plant's life cycle. These are affected through their capability of producing growth regulators, forming biofilms, phosphate solubilization, micronutrient exchanges, sequestration of carbon, and nitrogen fixation.

A disruptive mycorrhiza product—Uttam Superrhiza—powered by the native biofilm-forming microbiome of the arbuscular mycorrhizal fungi has been developed by TERI's Sustainable Agriculture Programme. Being marketed in India by Chambal Fertilizers and Chemicals Limited in India, 1900 tonnes of Uttam Superrhiza granular mycorrhiza product were sold in the market, enough to fertilize 450,000 acres of agricultural land. It is produced in a contamination-free environment through TERI's patented *in vitro* technology and is enriched with natural mycorrhizal partner bacteria that form a biological film around the mycorrhiza (outlined in Figure 1). This provides Superrhiza a unique edge over other mycorrhiza products in the market as it not only provides additional functional benefits to the product, thereby making Superrhiza a truly *Uttam* (Hindi word literally meaning superior) mycorrhiza product. It delivers soil nutrients more effectively to a wide variety of plants, across different types of soils and responding to drastic changes in climates, thereby contributing towards sustainability in agriculture and combating changing climates and environments. It is a one-of-a-kind

mycorrhiza product which contains its native microbiome, leading to superior performance and re-establishment of its natural interactions once applied in soil.

Superrhiza benefits a variety of crop types including wheat, maize, pearl millet, sorghum, chickpea, potato, cotton, paddy, sugar cane, plantation crops, chilli, spices, pulses, oilseeds, and many other vegetables and ornamentals. It also delivers efficient access to and use of water and plant nutrients; positive impacts on soil microflora; improved soil health and structure; and benefits to environmentally stressed land. It is compatible with chemical fertilizers such as urea, diammonium phosphate (DAP), potash, compost and manure, and its formulation is stable at room temperature for at least two years.

Such soil microbiome components when formulated as advanced biofertilizers and tested for their impact on plants showed multiple beneficial results such as better productivity (15%–18% yield), increase in macronutrient (N, P ,K) and micronutrient (Fe, Zn, Mg, Ca, Cu, Mn) content of the plant tissues, implying synergistic behaviour to plants. Farmers across India have found an increase in overall plant productivity across different crops such as wheat, maize, onion, fenugreek, okra, chickpea, and cotton from 10%–15%. Individually, their observations have been: "increased grain filling, better response in fluctuating environments (such as unexpected heavy rain falls), increased plant height, plant canopy and root biomass (10%–22%), early harvesting from plants which allowed the farmers to take their produce earlier than others to the market" (Figure 2). Superrhiza also helped the farmers "reduce the chemical fertilizer input by upto 30% while providing the benefits in productivity, thereby saving money for the farmers". The inoculated soil was also directly impacted through increase in soil organic carbon.

Understanding this functional co-existence of the mycorrhizae and bacteria in the rhizosphere microbiome (associated with host plants) is aiding us in the development of superior performing biofertilizers for sustainable crop production. This aids in bringing the naturally existing microbial diversity into functional applications for ensuring climate responsiveness, long-term benefits to soil health and agriculture. It is attempting to change the dynamics of agri inputs usage towards improvement of soil quality and health.

This is a remarkable growth promoter technology that provides native biological inputs to supplement biofertilizer performance for synergistic effects and superior field performance. Further use of sustainable practices such as composting and no-till farming will enhance soil fertility and water retention, leading to higher yields and decreased dependence on irrigation. Together with minimizing addition of chemical inputs will promote a healthier environment for farm families and communities. Additionally, it will help build healthy soils and diverse ecosystems to increase farm resilience to extreme weather events, and climate change, contributing to food security and reducing reliance on external food sources. ■

Figure 2 *Impact of Superrhiza granular formulation on the growth of okra in field conditions*

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