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Soil Health Management through Microbes in Natural Farming

Baljeet Singh Saharan* and Poonam Ranga

Department of Microbiology, CCS Haryana Agricultural University, Hisar 125 004 India

*Corresponding Author
Baljeet Singh Saharan*

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INTRODUCTION

Natural farming is a protocol in which the principles of nature are utilized. This system promotes nonchemical and homemade bioformulations for insect-pest control and disease management. In natural farming, neither chemical nor organic fertilizers are added to the soil. In fact, no external fertilizers are added to soil or given to plants. Subhash Palekar natural farming (SPNF) is the most popular model in India. This is developed by Padma Shri Subhash Palekar. Commercial level farming can be done by using locally available and farm-based resources. The soil is always covered with natural mulch, which creates humus and encourages the growth of microflora. The system requires cow dung and cow urine. A farm made bio-culture named '*Jeevamrit'* is added to the soil instead of any fertilizers to improve microflora of soil. *Jeevamrit* is prepared from cow dung and cow urine of desi cow breed. Natural, farm-made bioformulations like *Dashparni ark* and *Neem Astra* are used to control pests and diseases. Weeds are considered essential and used as living or dead mulch layer. In SPNF, multi-cropping is encouraged over monocropping. *Ghanjeevamrit* is also used to enhance nutritional status of the soil. Seeds are treated with *beejamrit* before sowing. Natural environment/microecosystem is created in the field and the microbes possessing/exhibiting following properties are enriched in the field:

Biological nitrogen fixation

In the natural farming fields, symbiotic N_2-fixing organisms *i.e. Azorhizobium, Bradyrhizobium, Mesorhizobium, Rhizobium, Sinorhizobium* and *Sinorhizobium*e establish symbiotic relationships with legumes. Free-living diazotrophic microorganisms such as *Azotobacter* sp., *Azospirillum* sp. (Associative biological nitrogen fixer), and cyanobacteria fix atmospheric N_2 in the rhizosphere and bulk soil. (Saharan and Nehra, 2011).

Phosphate solubilization

Microbes are capable of converting insoluble soil P into plant available form (Alori *et al*., 2017). One mechanism consists in the excretion of organic acids, hydroxyl ions and CO_2, which dissolve the insoluble phosphates directly by lowering the soil pH, then leading to ion exchange of PO42−PO42- by acid ions (Wei *et al*., 2018). Microbes release chelating compounds which capture and mobilize cations from different insoluble phosphates such as Ca^{+2}, Al^{+3}, and Fe^{+3}, resulting in the release of associated soluble phosphates (Riaz *et al*., 2020). The most important P solubilizers belong to *Aspergillus, Bacillus, Enterobacter, Penicillium, Pseudomonas* and *Rhizobium* (De Freitas *et al*., 1997; Anand *et al*., 2016) which play very role during natural farming practices.

Potassium solubilizers

In case of natural farming practices, several groups of bacteria (*Acidithiobacillus, Bacillus, Burkholderia, Paenibacillus, Pseudomonas* and *Rhizobium*) and fungi (*Trichoderma, Sclerotinia, Penicillium, Macrophomina, Glomus, Cladosporium* and *Aspergillus*) solubilize potassium minerals (Kour *et al*., 2020).

Bioavailability of Sulphur

It is carried out by *Xanthobacter, Alcaligenes, Bacillus, Pseudomonas, Streptomyces,* and *Thiobacillus,* as well as fungi like *Fusarium, Aspergillus,* and *Penicillium* (Grayston *et al*., 1986; Germida and Janzen, 1993; Macik *et al*., 2020) present in the natural farming fields.

Biocontrol agents

In natural farming fields, siderophore production by *Pseudomonas fluorescens* play a role in Iron nutrition and Plant growth promotion in *Solanum lycopersicum* (Nagata, 2017), *Pisum sativum* (Lurthy *et al*., 2020 and *Sorghum bicolor* (Abbaszadeh-Dhaji *et al*., 2020) in case of Iron limiting conditions. Apart from Fe, siderophores are also known to bind other metals (Al^{3+}, Cd^{2+}, Co^{2+}, Cu^{2+}, Hg^{2+}, Mn^{2+}, Ni^{2+}, and Pb^{2+}) (Saha *et al*., 2013).

Zinc solubilization

Zn deficiency causes root necrosis, reduction of biomass and yield, and high plant mortality (Caldelas and Weiss, 2017). About 84% of total soil Zinc occurs as structurally lattice bound, while only 1% is in water soluble form and available for plant uptake (Sharma *et al*., 2013); Prasad *et al*., 2016). In natural farming, ZSM solubilize Zinc by acidification, chelation, and chemical transformation (Kushwaha *et al*., 2020; Macik *et al*., 2020).

Silicate-solubilizing bacteria

Silicate-solubilizing bacteria occurring in soils and rhizosphere act by solubilizing silicates. The most important bacteria in this case are from the genera *Burkholderia, Aeromonas, Rhizobium, Enterobacter,* and *Bacillus* sp. (Santi and Goenadi, 2017) ; Lee *et al*., 2019) and play crucial role during natural farming.

Mycorrhiza

In natural farming fields, the most important among root-associated fungi are arbuscular mycorrhizal fungi (AMF), form symbiotic relationships with about 80% of land plant sp. (Berruti *et al*., 2016). AMF enhance the uptake of mineral nutrients (P, N, S, Cu, and Zn) and water by the respective host (Buecking and Kafle, 2015)) in exchange for C sources (Hodge and Fitter, 2010; Veresoglou *et al*., 2012). The extraradical AMF mycelium increases the volume of soil explored not only by reaching far beyond the rhizosphere but also by penetrating smaller soil pores (Berruti *et al*., 2016). AMF are known for their ability to enhance P acquisition (Kumar *et al*., 2018).

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