International Journal of Science, Environment and Technology, Vol. 14, No 6, 2025, 600 – 603

ISSN 2278-3687 (O)
2277-663X (P)

SOIL MICROBIAL DYNAMICS *vis A vis* SUSTAINABLE AGRICULTURE

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Abstract: Soil health management is very important for sustainable agriculture production. The enormous use of synthetic materials in crop production soil health deteriorates and soil organic carbon (SOC) reduces below the threshold level. Land degradation, deforestation, urbanization, environmental pollution, global warming etc. lead to reduction in texture, fertility and productivity of soil. Depletion of soil microbial population due to intensive use of inorganic materials in soil results in reduction in essential macro and micro nutrients as well as organic resources from the rhizosphere. The microbes not only the resources of fertilizers but also the protector of soil-borne diseases. The microbes produce antimicrobial compounds, induce systemic resistance in plants, and compete with harmful diseases for space and resources. Thus, keeping the suitable soil microbial dynamics for fertility and sustainable crop production needs the protection of microbiome through organic inputs with flora of microbial environment in the rhizosphere.
Keywords: Soil, Microbes, Plant, Health, Cosortium.

Introduction

Soil is rich source of microbial population and one teaspoon of healthy soil contains approximately one billion micro-organisms accounts about 25% of the world's biodiversity. The plant microbiome is most diversified and specific microbes need for specific crops because the interactions between the plants and soil microbiome are very complex. The crop-soil-microbes interactions make a suitable environment surrounding the roots support the availability, absorption and transportation of nutrients to the crop. These interactions depends on mutual benefits that plants' root exudates supply nutrients to microbes and microbes do the job of fixation of nutrients in rhizosphere and make them available for plant. The interaction created either by symbiotic or by associative within the cell or outside the cell. There are billions of microbes but few of them characterized for their beneficial effects and they are placed under Plant growth-promoting bacteria (PGPB) and the member of this groups have been extensively studied for crop production. The elaboration of microbial communities in terms of their beneficial effects on crop production is the major challenge in the present scenario to keep the sustainable and ecofriendly agriculture which preserve the environment for present and future agriculture (Zhang et al. 2021).

*Received Nov 23, 2025 * Published Dec 2, 2025 * www.ijset.net*

Single strain with a set of plant growth-promoting traits is not effective as compared to consortia, hence bacterial species with different strain or species combine together to give the more productive and fertile soil. So, intricate designing of synthetic bacterial consortia with suitable strain keeping antagonistic interactions in mind for a specific crops provide better growth and yield of the crops in comparison to single strain. The contributions of each individual microorganisms at the organismal and molecular levels combined together exert major impacts on management of stress and nutrients (Levy et al., 2018). Hence it is the era of development of effective consortia by identifying their traits for specific crops.

Microbial Consortia

The soil microbiome species not exists in isolation; they interact with each other either positively, negatively and combined interactive effects on soil and plant. The role of microbiome relies upon the abundant and positive interactions for cumulative effects. The availability of nutrients and their recycling in the ecosystem govern by the interactions among the species that form soil microbial communities. Hence, sustainable crops production needs multispecies consortia for developing inoculants (Liu et al., 2020). The hydrolytic enzymes cellulase and chitinase are widely distributed in bacteria. However intermicrobial interactions limit the application of unknown consortia in the soil. The unknown consortia may face for resources, synergism, and antagonism among different incompatible species. Another aspect of their survival in particular soil needs other microbes which perform the same function and acts like helper for them. Moreover, the morphological, physiological and ecological characterization require before going to isolate, culture, and study pure cultures because it becomes difficult to culture individually under laboratory conditions.

Plant-microbe-soil interactions play a pivotal role in design of synthetic microbial communities (SynComs) to improve soil fertility as well as crop productivity keeping in view of the large diversity of environmental challenges encountered in practice. Diversity of nutrient availability, pest and disease infestation and several abiotic factors become the range and aim of SynComs and it has been proved that microbial consortia are far better than the single-strain inoculants in biocontrol practices of major soil born pest and diseases. Besides the bacterial consortium the positive interaction of fungal and bacterial consortium may exert the additive effects on diversified nutrient acquisition, uptake and transport in the plant. Hence, for the congenial envionment of rhizosphere for plant needs the combining of both bacteria and fungi in SynComs for a multifunctional and more resilient product for biocontrol and nutrient acquisition (Pozo et al., 2021). Certain Bacteria and fungi of rhizosphere more effectively defense the plant system and also create defense environment from subsequent attacks of pest and diseases and this is referred to as induced systemic resistance (ISR) (De Kesel et al., 2021).

There are numerous microorganisms, such as Trichoderma spp., arbuscular mycorrhizal fungi (AMF), rhizobacteria, non-pathogenic Pseudomonas and Bacillus, Azotobacter, Serratia, Azospirillum etc. are the microbes or microbial consortia having the multiple plant beneficial functions such as biostimulant, biofertilizer and biopesticide effectively promote agricultural production and soil health management (Pineda et al., 2015). Biostimulant from microbial consortia, rhizobacteria, and rhizofungi acts as an agricultural probiotics ensure the plant and soil health. There are several bioactive metabolites produced by the Trichoderma spp. including hydrolytic enzymes *viz.* cellulase, chitinase, peptidase, which stimulate plant growth and development as well as improve defend against microbes (Lombardi et al., 2018). Azotobacter and Azospirillum are the free-living microbes that fix atmoshpheric nitrogen to the rhizosphere, thus increasing the soil level nitrogenous fertilizer for plants which directly influence the nutrition in agroecosystems (Van Oosten et al., 2018). Rhizosphere engineering and Plant microbiome engineering creates a structured biological networks in native soils which are compatible with addition of effective microbial inoculants for the acquisition of nutrients and biocontrol practices. These approaches lead to activation of nitrogen fixation, siderophore production, phosphate solubilization, phytohormone, and exopolysaccharide production (Kong et al., 2018). The microbial consortia of Trichoderma and Azotobacter functionally complementary in a plant growth promotion consortium and they become more effective when integrated with sea weeds and animal-derived products. These microbial consortia induce the production of ACC deaminase and indole-3-acetic acid which regulate the equilibrium between plant growth and defense (Hermosa et al. 2012). Thus, Trichoderma, Azotobacter, Azospirillum, AMF and suitable designed microbial consortia considered as agricultural probiotics for sustainable agricultural production which improve the quantity and quality of yield in present synthetic fertilizers and pesticides era (Soni et al., 2017).

Conclusion

The biological components of soil such as microbiome diversity, abundance, activity, and stability, are key indicators of soil health for sustainable crop production. The design of microbial consortia might provide the long term fertility of soil, decrease of soil erosion and pollution and it is essential factor to soil microbial dynamics for sustainable crops health and their production.

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