ISBN: 978-93-90847-17-4

13. Biofertilizer – A Potential Approach for Sustainable Agriculture

Santhanambika M. S., G. Maheswari

Department of Zoology,
Avinashilingam Institute for Home Science and Higher Education for women,
Coimbatore, Tamil Nadu, India.

Abstract:

The sustainability of soil and plant health is determined by the beneficial plant-microbe interactions in the rhizosphere. The increased use of inorganic fertilizers has residual effects on the environment, groundwater, and soil micro-flora that ultimately has made the soil to lose its biological activity. This can be reinstated by providing the soil with artificially cultured beneficial microorganisms in the form of biofertilizers. These biofertilizers increase soil fertility by enhancing biological nitrogen fixation or solubilizing the insoluble phosphate or producing hormones, vitamins, and other plant growth-promoting factors. This chapter deals with the significant biological agents as potencial biofertilizers for variety of soil types and climatic conditions.

Keywords: Biofertilizers, sustainable agriculture, microorganisms.

13.1 Introduction:

Plants require specific minerals to provide nutrients essential for their growth and development. Nitrogen and phosphorus are responsible for yield and their proper availability is essential for optimum crop yield (Abbasdokht and Gholami, 2010). The fertilizers containing NPK are applied in soil to improve the crop productivity, but it is not utilized by crops completely.

The remaining fertilizer pollutes the soil, ground and surface water sources through percolation and surface run-off during the monsoon period. There are some other nutrients that contaminate the water bodies leading to Eutrophication. The enormous amount of chemical fertilizers is utilized to reload soil nitrogen and phosphorus, which has caused harmful effects on the environment. Now, agriculture is getting interested in diminishing the detrimental outcomes of commercialized farming and opting out for sustainable agriculture. The emerging importance of biofertilizer will help restore the environment (Whitelaw, 2000). Bio-fertilizers is anticipated to lessen the demand for chemical fertilizers and pesticides as they diminish the health of the soil. (Market watch, 2022)

Biofertilizers are eco-friendly agro-inputs consisting of live or latent efficient strains of nitrogen-fixing, phosphate solubilizing, plant growth-promoting, potassium solubilizing or sulfur-oxidizing microorganisms. It aims to accelerate the microbial process augmenting the availability of nutrients that can be taken up by plants to increase the number of beneficial microbes in the soil (Mahdi *et al.*, 2010). They are supposed to be a safe alternative to chemical fertilizerssupporting sustainable agriculture. During 1950s to 1970s, considerable number of nitrogen-fixing bacteria were found to be associated with crops. Several soil microbiologists suggests that nitrogen-fixing bacteria associated with the plants may be the source of agronomically significant nitrogen inputs to the sugarcane crop in Brazil (Ray and Handerson, 2001). Many microorganisms (bacteria, fungi, and algae) are considered beneficial for agriculture and used as biofertilizers. Microbial consortia are inoculated in the field to improve and supply nitrogen, phosphorus, potassium, and other essential elements necessary for the proper growth of plants. Microorganisms produce a range of extra cellular enzyme which has the potential to mediate utilization of organic sources of nitrogen and phosphorus in soil (Saxena and Joshi, 2002).

Microbes effectively induce plant growth as they secrete plant growth promoters (auxins, abscisic acid, gibberellic acid, cytokinin, ethylene) and affect seed germination and root growth (Ramarethinum*et al.* 2005). They also play considerable role in decomposition of organic materials and enrichment of compost.

13.2 Types of Biofertilizers

The different types of biofertilizers used in agriculture are as follows:

A. Nitrogen-fixing biofertilizers e.g. *Rhizobium Spp*., *Azospirillum Spp.* and Cyanobacteria,
B. Phosphate solubilizing biofertilizer e.g. *Bacillus Sp*., *Pseudomoona Sp*. and *Aspergillus Sp*.
C. Phosphate mobilizing biofertilizers e.g. Mycorrhiza,
D. Plant growth-promoting biofertilizer e.g. *Pseudomonas Spp*.,
E. Potassium solubilizing biofertilizer e.g. *Bacillus Spp*. and *Aspergillus niger*,
F. Potassium mobilizing biofertilizer e.g. *Bacillus Spp*. and
G. Sulfur oxidizing biofertilizer e.g. *ThiobacillusSpp*

Few of the commonly used biofertilizers are discussed in this chapter.

13.2.1 Nitrogen Fixing Biofertilizers:

Nitrogen fixation is converting dinitrogen into nitrogen compounds. *Rhizobium* species are a group of bacteria that fix atmospheric nitrogen symbiotically and stimulate the growth of plants. The enzyme system of bacteria supplies a constant source of reduced nitrogen to the host plant, and the plant in turn provides nutrients and energy for the activities of the bacteria (Singh *et al.,* 2008). *Rhizobium* increases plant growth in various ways such as the production of plant growth hormones, vitamins, siderophores, solubilization of insoluble phosphates, induction of systemic disease resistance, and enhancement in stress resistance (Hussain *et al.*, 2009). The *Azospirillum*inoculation increases germination rate, dry weight accumulation of nitrogen and grain yield, and changes the plants' growth stages (Boddey and Döbereiner, 1988). It fixes nitrogen and helps to absorb water and nutrients for the root system. *Azospirillum* release phytohormone like auxin which enhance root branching and root elongation which is beneficial for plants in dry areas (Dobbelaere *et al*., 1999 and Steenhoudt and Vandereyden, 2000).

Cyanobacteria such as *Nostoc, Anabena, Oscillatoria, Aulosira, Lyngbya*etc are phototrophic. They enrich the soil in paddy field by fixing atmospheric nitrogen and Supplying Vitamin B Complex and growth promoting substance making the plant thrive (Sharma, 1986).

13.2.2 Phosphate Solubilizing Biofertilizers:

Bacteria have more potency than fungi in solubilizing phosphorus (Alam *et al.,* 2002). Phosphorus solubilizing bacterial strains include the genera *Bacillus, Pseudomonas Rhizobium* and *Enterobacter* in conjunction with *Penicillium* and *Aspergillus fungi* (Whitelaw, 2000). Phosphorus solubilizing biofertilizers enhance phosphorus mobility leading to its uptake in the plant body,improving plant growth (Yadav *et al.,* 2011). The application of phosphorus solubilizing biofertilizers reduces the soil pH resulting in the increased solubility of some other minerals, including iron, zinc, manganese and copper. All together, plant nutrient uptake is increased (Saber and Kabesh, 1990)

13.2.3 Plant Growth-Promoting Biofertilizers:

Recently ability of plant growth-promoting rhizobacteria is also studied for microbial control. It is also known as microbial pesticides e.g. *Bacillus spp.* and *Pseudomonas fluorescens.* It was found by Paul *et al*. (2003) that *Pseudomonas fluorescens* application to the Black pepper rhizosphere resulted in the easy mobilization of the essential nutrients in the rhizosphere and resulted in enhanced uptake of nutrients, which reflected in increased plant biomass.

13.2.4 Potassium Solubilizing Biofertilizers:

Cultivating high-yielding crop varieties continuously has led to the exhaustion of potassium levels in the soil faster. Bacterial strains including *Acidothiobacillus ferrooxidans, Paenibacillus* spp., *Bacillus mucilaginosus*, *B. edaphicus,* and *B. circulans* dissolve silicate minerals and release potassium by the production of organic, inorganic acids and exchange reactions (Etesami *et al.,* 2017). Inoculating the seeds and seedlings with potassium solubilizing biofertilizer resulted in a significant enhancement in germination, seedling vigor, plant growth, yield, and potassium uptake by plants under greenhouse and field conditions (Anjanadevi *et al.,* 2016).:

13.3 Application of Biofertilizers:

They are produced in liquid, powder or granules and applied to soil, compost, seed, seedling and plant leaves. There are three ways in using biofertilizers as:

A. Inoculation to seed: Seeds are soaked in the mixture of nitrogen and phosphorus fertilizers, left to dry and sown as soon as possible.
B. Sowing seedling root dip: It is specific for rice. The seedlings are sowed in the water bed with biofertilizer and kept for 8 to 10 hours.
C. Field application: Biofertilizers and compost are blended and kept overnight. This mixture is scattered on to the fields where the seeds has to be sown.

Some liquid biofertilizers can be sprayed to plant leaves (Malusa, 2012).

13.4 Trends Influencing The Growth Of The Biofertilizers Market:

The need for a sustainable alternative to chemical fertilizers is expected to drive the growth of the biofertilizers market. Biofertilizers, unlike traditional fertilizers, boost the nitrogen and phosphorus accessible to plants in a more natural way. Growers can customize the microorganisms employed to the needs of specific plants thanks to the various kinds available. Even for inexperienced small farmers, biofertilizers are simple to use. Chemical fertilizers often result in too much phosphate and nitrogen in the soil, whereas biofertilizers do not harm the land or the environment. Furthermore, it is also safe for human health as it is devoid of any chemicals. Biofertilizers help to lessen reliance on costly petroleum-based chemical fertilizers. Due to a scarcity of fossil fuels, chemical fertilizer prices may rise beyond the grasp of small consumers. Biofertilizers are a low-cost, easy-to-use alternative to petrochemical fertilizers. This cost-effectiveness is expected to drive the growth of the biofertilizers market.

Biofertilizers bring the soil back to normal fertility and bring it back to life naturally. They increase the amount of organic matter in the soil and improve the texture and structure of the soil. The improved soil is more water-retentive than previously. Biofertilizers enrich the soil with essential elements such as nitrogen, proteins, and vitamins. They convert nitrogen from the atmosphere and phosphates from the soil into plant-friendly forms. Natural insecticides are also produced by some animals. This feature is expected to drive the growth of the biofertilizer market. The increasing need to improve yields is expected to drive the growth of the biofertilizers market. Because of the nitrogen and phosphorus they give to the soil, biofertilizers can boost production by up to 30%. Plants grow better during droughts when the soil texture and quality are improved. Biofertilizers aid in the development of stronger root systems and improved plant growth. Harmful organisms in the soil, such as fungi and nematodes, are also reduced by biofertilizers (Valuates report, 2022).

13.5 Constraints in the use of biofertilizer:

A. Only particular strain will have the ability to survive both in the broth and the inoculant carrier.
B. If the suitable carrier is not available, it is not easy to maintain the shelf life of the biofertilizer. The commonly used carriers are peat, lignite, charcoal, farmyard manure, soil, rice husk. It should have a good moisture-holding capacity, free from toxic substances (Bhattacharjee and Dey, 2014)
C. Lack of awareness among farmers
D. It provides lower nutrient density than chemical fertilizers, and hence more product is often required for the same effect
E. Production of biofertilizer requires specific machinery
F. They are often plant specific; what works on one crop does not work on another
G. It can never be exposed to direct sunlight
H. The optimum temperature for its storage will be from 0 °C to 35 °C and has a much shorter shelf-life than chemical fertilizers
I. It possessesa strong, distinctive odor

13.6 Conclusion:

Microbes capable of decomposing the organic matter faster could be a potent biofertilizer for the quick release of nutrients. The ordinary decomposition can be accelerated and the time taken for composting is reduced by 4 to 6 weeks by the inoculation of microbes. Bio-fertilizers are cheaper and significant in affecting the yield in crops. After using it continuously for 3 – 4 years, there will be no need to apply biofertilizers because parental inoculums will be established to get sufficient nutrients for growth and multiplication. They improve soil texture, pH, and other properties of soil. They produce plant growth-promoting substances e.g., IAA amino acids, vitamins etc. Therefore, more awareness should be created among the cultivars to utilise the biofertiliser for both good yield and replenish the soil fertility in a sustainable way.

13.7 References:

1. Abbasdokht, H. and A. Gholami. 2010. The effect of seed inoculation (*Pseudomonas putida* + *Bacillus lentus*) and different levels of fertilizers on yield and yield components of wheat (*Triticum aestivum*L.) cultivars. World Aced. Sci. Eng. Technol., 68: 979-983.
2. Alam, S., S. Khalil, N. Ayub and M. Rashid. 2002. *In vitro* solubilization of inorganic phosphate by phosphate solubilizing microorganism (PSM) from maize rhizosphere. Int. J. Agric. Biol., 4: 454-458
3. Anjanadevi, I.P., John, N.S., John, K.S., Jeeva, M.L. and Misra, R.S. 2016. Rock inhabiting potassium solubilizing bacteria from Kerala, India: characterization and possibility in chemical K fertilizer substitution. *J.Basic Microbial*. 56:67-77.
4. Bhattacharjee, R., & Dey, U. (2014). Biofertilizer, a way towards organic agriculture: A review. *African Journal of Microbiology Research*, *8*(24), 2332-2343.
5. Boddey, R.M. and Döbereiner, J. 1988. Nitrogen fixation associated with grasses and cereals: Recent results and perspectives for future research. *Plant Soil*, 108: 53-65.
6. Dobbelaere, S., Croonenborghs, A., Thys, A., Broek, A.V. and Vanderleyden, J. 1999. Phytostimulatory effect of *Azospirillumbrasilense*wild type and mutant strains altered in IAA production on wheat. *Plant Soil* 6: 155-164.
7. Etesami, H., Emami, S. and Alikhani, H. A. 2017. Potassium solubilizing bacteria (KSB): Mechanisms, promotion of plant growth, and future prospects A review. J. Soil Sci.PlantNutr., 17 (4)
8. Hussain, M.B., Mehboob, I., Zahir, Z.A., Naveed, M. and Asghar, H.N. 2009. Potential of *Rhizobium* spp. for improving growth and yield of rice (*Oryza sativa* L.). *Soil Environ*. 28(1): 49-55.
9. Itelima JU, Bang WJ, Sila MD, Onyimba IA, Egbere OJ (2018) A review: biofertilizer-a key player in enhancing soil fertility and crop productivity. J MicrobiolBiotechnol Rep2(1): 22-28.
10. Mahdi SS, Hassan GI, Samoon SA, Rather HA, Showkat AD, *et al.* (2010) Bio-fertilizers in organic agriculture. Journal of Phytology 2(10): 42-54.
11. Malusa E, Sas-Pasz L, Ciesielska J (2012) Technologies for Beneficial Microorganisms Inocula Used as Biofertilizers. The Scientific World Journal 2012: 491206.
12. Market watch, 2022: https://www.marketresearchengine.com/biofertilizer-market-report

13. Paul, D.; Srinivasan, V.; Anandraj, M. and Sarma, Y.R. (2003). *Pseudomonas fluorescens* mediated nutrient flux in the black pepper Rhizosphere microcosm and enhanced plant growth. 6th International PGPR workshop, 5-10 October, Calicut, India
14. Ray, R.N. and Handerson, G. (2001). Endophytic nitrogen fixation in sugarcane: Present knowledge and futureapplications, Technical expert meeting on increasingthe use of biological nitrogen fixation (BNF) inagriculture, FAO, Rome
15. Saxena, P. and Joshi, N. (2002). In: Role of Microorganisms in the decomposition of organic wastes matter. Ph.D.Thesis, Gurukul Kangri University, Haridwar
16. Sharma, V.K. (1986). A review of recent work on pesticide studies on the nitrogen fixing algae. J. Env. Biol. 7(3): 171-176.
17. Singh, B., Kaur, R. and Singh, K. 2008. Characterization of *Rhizobium* strain isolated from the roots of *Trigonellafoenumgraecum*(fenugreek). *Afri. J. Biotechnol*., 7(20): 3671-3676.
18. Steenhoudt, O. and Vandereyden, J. 2000. *Azospirillum*, freeliving nitrogen fixing bacterium closely associated with grasses: genetic, biochemical and ecological aspects. *FEMS Microbiol. Rev*., 24: 487-506.
19. Valuates report, 2022. https://www.prnewswire.com/in/news-releases/biofertilizer-market-size-to-reach-usd-4459-5-million-by-2028-with-a-cagr-of-8-4-valuates-reports-893325796.html
20. Whitelaw, M.A. 2000. Growth promotion of plants inoculated with phosphate solubilizing fungi. Advance Agron., 69: 99-151
21. https://blog.teamtrade.cz/biofertilizers-what-are-the-pros-and-cons/
22. https://www.onlinebiologynotes.com/biofertilizer-advantages-types-methods-of-application-and-disadvantages/