AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 02 (February, 2026)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Biofertilizers: An Eco-Friendly Approach to Managing Plant Diseases

*Challa Avinash[1], Tammineni Naga Jyothi[2], Thandra Rakesh[3] and Talakayala Asha[4]
[1]Department of Plant Pathology, College of Horticulture, Dr.YSR Horticulture University, Venkataramannagudem, Andhra Pradesh, India
[2]Department of Plant Pathology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India
[3]Department of Entomology, Tamil Nadu Agricultural University, Coimabatore, India
[4]Department of Agronomy, Sam Higginbottom University of Agriculture, Technology, and Sciences, Uttar Pradesh, India
*Corresponding Author's email: avinashabhichalla@gmail.com

Plant diseases cause nearly 10–20% global crop losses annually, causing a serious threat to food security (Oerke, 2006). Excessive use of chemical pesticides has led to environmental contamination and the development of resistant pathogen strains (Pimentel & Burgess, 2014). Biofertilizers have therefore emerged as sustainable alternatives in plant disease management. Beneficial microbes such as *Trichoderma spp.* suppress soil-borne pathogens through mycoparasitism and enzyme secretion (Harman et al., 2004), while fluorescent *Pseudomonas* control root pathogens via antibiotic production (Weller, 2007). Plant growth-promoting rhizobacteria induce systemic resistance through jasmonic acid and ethylene signaling pathways (Kloepper et al., 2004). Furthermore, *Trichoderma* plays a dual role in growth promotion and resistance induction (Woo et al., 2014), PGPR consortia effectively suppress pathogens under field conditions (Backer et al., 2018), and microbial biofertilizers enhance defense enzyme activity while reducing disease severity (Elnahal et al., 2022). Thus, biofertilizers act as both nutrient enhancers and biological control agents, offering an eco-friendly approach to sustainable disease management.

Modes of Action of Biofertilizers in Disease Control

Biofertilizers suppress plant diseases through diverse biological processes operating in the rhizosphere. A key mechanism involves competition for nutrients and ecological niches, where beneficial microbes rapidly colonize root surfaces and prevent pathogen establishment. Harman et al. (2004) demonstrated that *Trichoderma spp.* effectively outcompete soil-borne pathogens through aggressive colonization and efficient nutrient utilization.

Another important strategy is antibiosis, where in microorganisms such as *Pseudomonas fluorescens* and *Bacillus subtilis* produce antibiotics and secondary metabolites that inhibit pathogen growth (Weller, 2007). In addition, *Trichoderma* species exhibit mycoparasitism by secreting lytic enzymes such as chitinases and glucanases that degrade fungal cell walls (Woo et al., 2014).

Plant growth-promoting rhizobacteria (PGPR) also produce siderophores that chelate iron, thereby restricting its availability to pathogens and suppressing their proliferation (Backer et al., 2018). Furthermore, biofertilizers trigger induced systemic resistance (ISR) by activating jasmonic acid and ethylene signaling pathways, leading to enhanced production of defense-related enzymes and improved plant immunity (Pieterse et al., 2014).

Methods of Application of Biofertilizers

1. Seed Treatment

Seed treatment ensures early establishment of beneficial microbes on the seed surface and emerging roots. Approximately 200 g of biofertilizer is mixed with water to prepare a slurry and coated uniformly on seeds before sowing. Bashan, Y. et al. (2014) reported that seed inoculation with plant growth-promoting bacteria significantly enhanced root colonization and improved plant health under field conditions.

2. Seedling Root Dip

In transplanted crops such as rice and vegetables, seedling roots are dipped in a biofertilizer suspension before transplanting to facilitate rapid rhizosphere colonization. Compant, S. et al. (2005) demonstrated that root inoculation with beneficial bacteria enhanced plant growth and reduced pathogen infection by establishing strong rhizosphere competence. In addition, Lucy, M. et al. (2004) reported that root application of PGPR improved microbial persistence around roots, thereby contributing to effective biological disease control.

3. Soil Application

For soil application, biofertilizers are mixed with compost or farmyard manure and broadcast in the field to ensure uniform distribution in the rhizosphere.

Adesemoye, A. O. et al. (2009) showed that soil-applied PGPR combined with organic amendments significantly reduced disease incidence while improving nutrient use efficiency.

Furthermore, Glick, B. R. (2012) highlighted that soil inoculation enhances microbial population density in the rhizosphere, strengthening plant defense responses against pathogens.

Table:1 Major Biofertilizers and Their Nutrient Contribution

Biofertilizer	Major Crops	Nutrient Contribution	References
Rhizobium spp.	Legumes	50–300 kg N ha^{-1}	Peoples et al., 2009
Azotobacter spp.	Cereals	10–20 kg N ha^{-1}	Bhattacharyya & Jha, 2012
Azospirillum spp.	Cereals	10–20 kg N ha^{-1}	Bashan & de-Bashan, 2010
Blue-Green Algae	Rice	20–30 kg N ha^{-1}	Singh et al., 2016
Azolla	Rice	40–60 kg N ha^{-1}	Wagner, 1997

Benefits of Biofertilizers in Crop Production and Soil Health

Biofertilizers provide long-term agronomic and ecological benefits that support sustainable crop production. Long-term field experiments have shown that biofertilizer application enhances soil microbial biomass and improves soil enzymatic activities, thereby strengthening soil fertility over time. Non-symbiotic and associative nitrogen fixers significantly reduce the need for chemical nitrogen fertilizers while maintaining crop productivity (Hungria et al., 2010). In addition, Richardson et al. (2009) reported that beneficial rhizosphere microorganisms enhance phosphorus acquisition efficiency, improving nutrient use efficiency in various cropping systems.

Biofertilizers also stimulate root growth and plant vigor through the production of phytohormones and improved nutrient uptake efficiency (Vessey, 2003). Multi-location trials demonstrated that integrated use of biofertilizers increased crop yield by 10–25% compared to uninoculated controls. Furthermore, certain beneficial microbes contribute to the suppression of soil-borne pathogens by enhancing plant defense capacity and improving rhizosphere competitiveness (Berg, 2009).

Although biofertilizers may not produce rapid visible responses like synthetic fertilizers, their cumulative effects improve soil structure, nutrient cycling, and overall plant health, making them reliable components of sustainable agricultural systems.

Conclusion

Biofertilizers represent a sustainable and environmentally responsible approach to plant disease management and crop production. By enhancing nutrient availability, stimulating plant growth and suppressing pathogens through multiple biological mechanisms, they contribute to improved soil fertility, strengthened plant immunity, and reduced dependence on chemical fertilizers and pesticides. Their long-term benefits on soil health, nutrient cycling, and ecosystem stability make them essential components of integrated and sustainable agricultural systems. Thus, the adoption of biofertilizers not only supports higher productivity but also ensures ecological balance and long-term agricultural sustainability. Furthermore, their compatibility with organic and integrated farming practices makes them highly suitable for climate-resilient agriculture. Continued research and field-level validation will further strengthen their role in achieving global food security in an eco-friendly manner.

References

1. Adesemoye, A. O., Torbert, H. A., & Kloepper, J. W. (2009). Plant growth-promoting rhizobacteria allow reduced application rates of chemical fertilizers. *Microbial ecology*, *58*(4), 921-929.
2. Backer, R., Rokem, J. S., Ilangumaran, G., Lamont, J., Praslickova, D., Ricci, E., Subramanian, S., & Smith, D. L. (2018). Plant growth-promoting rhizobacteria: Mechanisms and applications in agriculture. *Soil Biology and Biochemistry*, 122, 10–25.
3. Bashan, Y., de-Bashan, L. E., Prabhu, S. R., & Hernandez, J. P. (2014). Advances in plant growth-promoting bacterial inoculant technology: formulations and practical perspectives (1998–2013). *Plant and soil*, *378*(1), 1-33.
4. Berg, G. (2009). Plant–microbe interactions promoting plant growth and health: perspectives for controlled use of microorganisms in agriculture. *Applied microbiology and biotechnology*, *84*(1), 11-18.
5. Bhattacharyya, P. N., & Jha, D. K. (2012). Plant growth-promoting rhizobacteria (PGPR): emergence in agriculture. *World Journal of microbiology and biotechnology*, *28*(4), 1327-1350.
6. Compant, S., Duffy, B., Nowak, J., Clément, C., & Barka, E. A. (2005). Use of plant growth-promoting bacteria for biocontrol of plant diseases: principles, mechanisms of action, and future prospects. *Applied and environmental microbiology*, *71*(9), 4951-4959.
7. Elnahal, A. S. M., El-Saadony, M. T., Saad, A. M., Desoky, E. S. M., El-Tahan, A. M., Rady, M. M., & El-Tarabily, K. A. (2022). The use of microbial inoculants for biological control, plant growth promotion, and sustainable agriculture. *Frontiers in Microbiology*, 13, 901880.
8. Glick, B. R. (2012). Plant growth-promoting bacteria: mechanisms and applications. *Scientifica*, *2012*(1), 963401.
9. Harman, G. E., Howell, C. R., Viterbo, A., Chet, I., & Lorito, M. (2004). Trichoderma species—opportunistic, avirulent plant symbionts. *Nature reviews microbiology*, *2*(1), 43-56.
10. Hungria, M., Campo, R. J., Souza, E. M., & Pedrosa, F. O. (2010). Inoculation with selected strains of Azospirillum brasilense and A. lipoferum improves yields of maize and wheat in Brazil. *Plant and soil*, *331*(1), 413-425.
11. Kloepper, J. W., Ryu, C. M., & Zhang, S. (2004). Induced systemic resistance and promotion of plant growth by *Bacillus* spp. *Phytopathology*, 94(11), 1259–1266.
12. Lucy, M., Reed, E., & Glick, B. R. (2004). Applications of free living plant growth-promoting rhizobacteria. *Antonie van leeuwenhoek*, *86*(1), 1-25.
13. Oerke, E. C. (2006). Crop losses to pests. *Journal of Agricultural Science*, 144, 31–43.
14. Peoples, M. Á., Brockwell, J., Herridge, D. F., Rochester, I. J., Alves, B. J. R., Urquiaga, S., ... & Jensen, E. S. (2009). The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems. *Symbiosis*, *48*(1), 1-17.
15. Pimentel, D., & Burgess, M. (2014). Environmental and economic benefits of reducing pesticide use. In *Integrated Pest Management: Pesticide Problems, Vol. 3* (pp. 127-139). Dordrecht: Springer Netherlands.

16. Richardson, A. E. (2009). Richardson AE, Barea JM, McNeill AM, Prigent-Combaret C. Acquisition of phosphorus and nitrogen in the rhizosphere and plant. *Plant Soil*, *321*, 305-339.
17. Singh, J. S., Kumar, A., Rai, A. N., & Singh, D. P. (2016). Cyanobacteria: a precious bio-resource in agriculture, ecosystem, and environmental sustainability. *Frontiers in microbiology*, *7*, 529.
18. Vessey, J. K. (2003). Plant growth promoting rhizobacteria as biofertilizers. *Plant and soil*, *255*(2), 571-586.
19. Wagner, G. M. (1997). Azolla: a review of its biology and utilization. *The Botanical Review*, *63*(1), 1-26.
20. Weller, D. M. (2007). Pseudomonas biocontrol agents of soilborne pathogens: looking back over 30 years. *Phytopathology*, *97*(2), 250-256.
21. Woo, S. L., Ruocco, M., Vinale, F., Nigro, M., Marra, R., Lombardi, N., ... & Lorito, M. (2014). Trichoderma-based products and their widespread use in agriculture. *Open Mycol. J*, *8*(1), 71-126.