MINI REVIEW

Utilization of Microbial Diversity as Biofertilizers

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Abstract

Biofertilizers are the material which contains living microorganisms. When applied to plant surfaces, they promote plant growth by increasing the supply of primary nutrients to the host plants. Tremendous population increase put a pressure and high demand in agricultural productivity. This results in use of chemical fertilizers, pesticides as well as insecticides at large scale. Though it help in production of crops at a little higher rate but has adversely affected soil fertility. With the use of these chemical fertilizers soil is continuously losing its fertility and essential minerals. The best remedy to overcome this problem is to enhance production and use of biofertilizers. Biofertilizers result is slow in comparison to chemical fertilizers but is soothing and long lasting for soil and host plant. It is also cost effective when compared to chemical fertilizers. Microorganisms like bacteria, fungi and blue green algae are used as biofertilizers. They are effective in enhancing plant growth by several activities such as decomposition of organic materials, nitrogen fixation, suppression of plant diseases, increased nutrient availability, synthesis of antibiotics, phytostimulation, production of phytohormones etc. Biofertilizers include Plant Growth Promoting Rhizobacteria (PGPR), Arbuscular Mycorrhizal Fungi (AMF) and also Rhizobial Biofertilizers. The review provides comprehensive knowledge about the use of microbial diversity as Biofertilizers and its applications.

Keywords: AMF, Biofertilizers, Microorganisms, PGPR, Rhizobial biofertilizers.

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Introduction

Biofertilizers are microorganisms that enhance nutrient availability to plants, contributing to plant nutrition either by facilitating nutrient uptake or by increasing primary nutrient availability in the rhizosphere. The soil management strategies mainly depend on inorganic chemical-based fertilizers, by which human health and environment is at higher risk. For improved nutrient uptake, plant growth and plant tolerance to abiotic and biotic stress there are many eco-friendly approaches *i.e.*, biofertilizers which include plant growth promoting rhizobacteria (PGPRs), endo and ectomycorrhizal fungi, cyanobacteria and many other useful microscopic organisms (Itelima *et al.,* 2018). Soil contains natural reserves of plant nutrients, but these reserves are largely in different forms which are used for plant growth. Conventional agriculture plays a significant role in meeting the food demands of a growing human population that has led to an increasing dependence on chemical fertilizers and pesticides.

Chemical fertilizers are industrially manipulated, substances composed of known quantities of nitrogen, phosphorus and potassium, and their exploitation causes air and ground water pollution by eutrophication of water bodies. Soil nutrients are inactivated by the chemicals hence the plants are unable to utilize it and quality of soil is affected. For getting our soil health back the best solution is Biofertilizers (Patel *et al*., 2014; Desai *et al*., 2016).

In this context recent efforts have been channelized towards the production of 'nutrient rich high quality food' in sustainable manner to ensure bio-safety. In agriculture alternate means of soil fertilization relies on organic inputs to improve nutrient supply and conserve the field management. Organic farming is one among such strategies that not only ensures food safety but also adds to the biodiversity of soil. The additional advantages of biofertilizers include longer time period causing no adverse effects to ecosystem (Tal, 2018).

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Organic farming is mostly dependent on the natural microflora of the soil which constitutes all kinds of useful bacteria and fungi including the arbuscular mycorrhiza fungi (AMF) called plant growth promoting rhizobacteria (PGPR) (Opeyemi *et al.,* 2019). Biofertilizers make the soil environment rich in all kind of micro- and macro-nutrients via organic process, phosphate and potassium solubilization or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter within the soil.

Crop productivity and nutrient cycle is benefited by applying biofertilizers as seed and soil inoculants. In general, 60% to 90% of the entire applied fertilizer is lost and therefore the remaining 10% to 40% is possessed by plants (Bhardwaj *et al.,* 2014). In this regard, microbial inoculants have paramount significance in integrated nutrient management systems to sustain agricultural productivity and healthy environment. The PGPR or co-inoculants of PGPR and AMF can advance the nutrient use efficiency of fertilizers. A synergistic interaction of PGPR and AMF was better suited to 70% fertilizer plus AMF and PGPR for phosphorous uptake (Nanjundappa *et al.,* 2019).

Similar trend were also reflected in nitrogen uptake on a whole-tissue basis which shows that 75%, 80%, or 90% fertilizer plus inoculants were significantly comparable to 100% fertilizer.

Biofertilizers play an important role in supplementing nutrients to the plants and restoring the soil fertility, regenerates soil productivity leading to the sustainable farming (Zarb *et al*., 2005). Plants nutrients are natural reserves for soil. Biofertilizers help in regaining soil fertility leading to soil productivity which plays a vital role in sustainable farming (Patel *et al*., 2014).

Role of Microorganism as Biofertilizers

Microorganisms such as bacteria, fungi and blue green algae are mostly used as biofertilizers (Table 1). These organisms are added to the rhizosphere of the plant to enhance their activity in the soil (Thomas and Singh, 2019). They help plants indirectly through better nitrogen fixation or improving the nutrient availability in the soil (Bargaz *et al.,* 2018).

Microorganisms like *Rhizobium leguminosarum* bv. *viciae*, *Azosprillum* sp. and *Azobacter* sp. was used as biofertilizers for broad bean (*Vicia faba* L.) and wheat (*Triticum aestivum* L.) plants. They showed a high efficiency of nitrogen fixation. The selected biofertilizers were examined on the growth and productivity of the selected plant which were cultivated in sand and clay soil respectively under different levels of inorganic and organic nitrogen fertilizers. Both the selected biofertilizers (*R. leguminosarum* bv. *viciae*, *Azobacter* sp. and *Zospirillum* sp.) were found important to obtain the best performance in growth yield and total nitrogen and mineral contents. It was suggested that plants grown in the soils with the selected biofertilizers showed high yield and high rate of nitrogen and mineral contents (Santos *et al*., 2019). Biofertilizers formulated with soil carriers have an average life of six months. Nevertheless, when the biofertilizer formulation is liquid, nutrients and cell protectants can be added easily so that the shelf-life of the final product will tolerate higher temperatures. As a result, liquid biofertilizers can survive temperatures of up to 50°C and last for even two years, but the only drawback is high price (Kecskes *et al.,* 2015). In recent years, many rhizobacteria such as *Aeromonas veronii, Azotobacter* sp.*, Azoarussp, Cyanobacteria* (predominantly of the genera *Anabaena* and *Nostoc), Alcaligenas, Burkholderia, Comamonas acidororans, Enterobacter, Erwinia, Flavobacterium, Rhizobia* (including the *Allorhizobium, Azorhizobium, Bradyrhizoblum, Mesorhizobium, Rhizobium* and *Sinorhizobium*) *Gluconacetobacter diazotrophicus, Herbaspirillum seroepdicae, Serratia, Variovorax paradoxus* and *Xanthomonas maltophilia* have been identified for their use as biofertilizers (Whane *et al.,* 2020).

Application of Microbial Biofertilizers

The application of microbial biofertilizers is an important step in the Biofertilizer Technology. If the microbial inoculants are not applied properly, benefits from the biofertilizer may not be obtained. During application one should always remember that the most of the microbial biofertilizers are heterotropic, *i.e.*, they cannot prepare their own food and depend upon the organic carbon of soil for their energy requirement and growth (Stamenkovic *et al*., 2018). So they either colonise in rhizosphere zone or live symbiotically within the basis of upper plants. The bacteria which are colonized in the rhizosphere zone obtain their organic carbon compounds from the root exudes of the higher plants. The symbiotic ones obtain organic carbon directly from the basis. So, microbial inoculants must be applied in such a way that the bacteria may adhered with the root surface. In case of transplanting crops, the inoculants are applied through roots. The crops in which seeds are sown directly in the field, inoculants are applied on the seeds so that they can colonize in the rhizosphere region when the young roots are emerged after germination of seed (Kecskes *et al.,* 2015). In particular, successful rhizobial inoculants were applied to leguminous plants and arbuscular mycorrhiza fungi for muskmelons in order to increase the yield and quality. Multifunctional biofertilizers were developed to scale back 1/3 to 1/2 of chemical fertilizer application (Aggani, 2013).

Potential use of Soil Microbes in Sustainable Crop Production

The beneficial soil micro-organisms increase crop production either as biofertilizers or symbiont. They perform nutrient solubilization which facilitate nutrient availability and thereby

Table 1: List of commonly used Biofertilizers (Boraste *et al*., 2009).

Name	*Crops Suited*	*Benefits usually seen*	*Remarks*
Rhizobium strains	Legumes like pulses, groundnut, soybean soil treatment for non-legumes crops including dry land crops	10-35% yield Increase, 50-200 kg N/ha.	Fodders give better results. Leaves residual N in the soil.
Azotobacter	Non-legume like maize, barley, oats, sorghum, millet, Sugarcane, rice, etc	10-15% yield increases adds 20-25 kg N/ha	Also Controls certain diseases. A fodder gives higher fodder response. Produces growth-promoting substances. It can be applied to legumes as co-inoculants.
Azospirillum Phosphate Solubilizers	Soil application for all crops	10-20% yield Increases 05-30% yield increase	Can be mixed with rock phosphate.
Blue-green algae and *Azolla*	Rice/wet lands	20-30 kg N/ha, *Azolla* can give biomass up to 40-50 Tonnes and fix 30-100 kg N/ha	Reduces soil alkalinity, can be used as feed. They have growth promoting hormonal effects. TNAU has developed high yielding *Azolla* hybrids.
Mycorrhizae (VAM)	Many trees, some crops, and some ornamental plants	30-50% yield increase enhances uptake of P, Zn, S and Water.	Usually inoculated to seedlings.

Table 2: PGPR and their effect on crop yields (Sneha *et al.,* 2018).

Plant growth promoting rhizobacteria	*Crop parameter*
Azospirillum brasilense and *A. irakense*	Growth of wheat and maize plants.
Azotobacter and *Azospirillum* spp.	Growth and productivity of canola.
Pseudomonas putida	Early developments of canola seedlings, growth stimulation in tomato plant.
Rhizobium leguminosarum	Direct the growth promotion of canola and lettuce.
P. flurescens	Growth of pearl millet, enhance growth, leaf nutrient contents and high yield of banana.
P. alcaligenes, Bacillus polymyxa and *Mycobacterium phlei*	Improves the uptake of N, P and K by maize crop.
R. leguminismarum and *Pseudomonas* spp.	Enhances the yield and phosphorus uptake in wheat.
P. putida, P. flurescens, A. brasilense and *A. lipoferum*	Enhances seed germination, seedling growth and yield of maize.
P. putida, P. fluorescens, P. fluorescens, P. putida, A. lipoferum, A. brasilense	Enhances seed germination, growth parameters of maize seedling in green house and gain yield on maize.
Pseudomonas, Azotobacter and *Azospirillum* spp.	Stimulates growth and increase the yield of chick pea.

uptake. It improves the plant growth by advancing the root architecture. Their activity provides several useful traits to plants such as increased root hairs, nodules and nitrate reductase activity (Gouda *et al*., 2018). Efficient strains of *Azotobacter*, *Azospirillum*, *Phosphobacter* and *Rhizobacter* can provide significant amount of available nitrogen through nitrogen cycling (Jnawali *et al.,* 2015). The biofertilizers produced plant hormones, which include indole acetic acid (IAA), gibberellins (GA) and cytokinins (CK) (Egamberdieva *et al.,* 2017). Biofertilizers improved photosynthesis performance which confer plant tolerance to stress and increase resistance to pathogens thereby resulting in crop improvement. There are various PGPR stains which help in higher crop yield some of them are mentioned in Table 2 (Sneha *et al*., 2018).

Current status of Biofertilizer Development

Mahanty *et al*. (2016) observed that some microorganisms including plant growth promoting bacteria, fungi, cyanobacteria, etc. have shown biofertilizer-like activities in the cultivation zone. Extensive works on biofertilizers have revealed their capability of providing required nutrients to the crop in sufficient amounts that resulted in the enhancement of crop yield. International Plant Nutrition Institute (IPNI) in January 2011 reported root colonizing bacteria provided benefits to plant development. Benefits demonstrated under laboratory and greenhouse conditions include reduced negative effects of plant pathogens and enhance crop nutrition through increased availability of nitrogen, phosphorus and iron. Like mycorrhizae, efficacy of these products depends greatly on the ability of PGPR to compete with locally adapted strains already present in soils. Field studies investigating efficacy have largely been inconclusive. This is an active area of research. Little guidance currently exists for defining conditions where PGPR will have the greatest likelihood of effectiveness.

The extensive research program on beneficial bacteria and fungi has resulted in the development of a wide range of bio-fertilizers that satisfied the nutrient requirements of crops and increased the crop yield as well. Many experiments in greenhouses and in field conditions have revealed that different crops responded positively to microbial inoculations (Aggani, 2013).

Survey by Yanni *et al*. (2016) revealed that research and application programmes dealing with the biofertilization technology in Egypt include studies on various cultivars of legume fodder crops including new varieties of alfalfa, berseem clover, guar and fodder lupine. A large area available for agriculture is cultivated with summer and winter legumes and cereal crops, in which the biofertilization technology can be successfully adopted to assist their production.

Suryono and Triharyanto (2018) investigated the optimum doses of organic fertilizer composted with liquid biofilm biofertilizer to increase soil nutrients availability and on dry land Lithosols and concluded that the use of biofilms biofertilizer also encourage the development of soil microbial populations. It was also observed that the use of organic fertilizer composted with biofilms biofertilization. Lithosols increased soil organic matter content and available nutrients (nitrogen, phosphorous and potassium).

It has been also found that biopesticides like neem and *Bacillus* based pesticides such as Aurefungin, Kasugamycin, Vaidamycin, Streptomycin and Suiphate and Tetracycline Hydrochloride is useful for controlling different insect pests and diseases in agriculture (Singh *et al.,* 2014).

Conclusion

Global warming and climate change have resulted in unexpected drought, stormy rainfalls, extremely high temperature, cold damage and hurricanes in many places around the world. Establishing an environment friendly co-existing mechanism on earth is of crucial importance. At present the most important challenge is to produce sufficient food for growing population. In recent years, agrochemicals are extensively applied to obtain higher yield. Intensive application of agrochemicals results in several agricultural problems and poor cropping systems. In this context, biofertilizers can provide an economically viable key for realizing an ultimate goal in crop productivity. Several field application trials demonstrated that biofertilization can increase crop production while decreasing the need of high inputs of chemical fertilizers, thereby reducing the demands for high energy-consuming chemical industries and helping to restore ecosystem health. Enhancement and maintenance of soil fertility through microorganisms has vast potential in the future.

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References

Aggani, S.L. 2013. Development of Biofertilizers and its future prospective. *Scholars Academic Journal of Pharmacy* 2(4):327-332.

Bargaz, A., Lyamlouli, K., Chtouki, M., Zeroual, Y. and Dhiba, D. 2018. Soil microbial resources for improving fertilizers efficiency in an integrated plant nutrient management system. *Frontiers in Microbiology* **9**:1606.

Bhardwaj, D., Ansari, M.W., Sahoo, R.K. and Tuteja, N. 2014. Biofertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. *Microbial Cell Factories* **13**:66.

Boraste, A., Vamsi, K.K., Jhadav, A., Khairnar, Y., Gupta, N., Trivedi, S., Patil, P., Gupta, G., Gupta, M., Mujapara, A.K. and Joshi, B. 2009. Biofertilizers: A novel tool for agriculture. *International Journal of Microbiology Research* **1**(2):23-31.

Desai, S., Kumar, G.P., Amalraj, L.D., Bagyaraj, D.J. and Ashwin, R. 2016. Exploitation PGPR and AMF biodiversity for plant health management. *Microbial Inoculants in Sustainable Agricultural Productivity* **535**(1):145-160.

Egamberdieva, D., Wirth, S.J., Alqarawi, A.A., Allah, E.F.A. and Hashem, A. 2017. Phytohormones and beneficial microbes: Essential components for plants to balance stress and fitness. *Frontier in Microbiology* **8**:2104.

Gound, S., Kerry, R.G., Das, G., Paramithiotis, S., Shin, H.-S. and Patra, J.K. 2018. Revitalization of plant growth promoting rhizobacteria for sustainable development in agriculture. *Microbiological Research* **216**:131-140.

Itelima, J.U., Bang, W.J. and Onyimba, I.A. 2018. A review: Biofertilizer, a key player in enhancing soil fertility and crop productivity. *Journal of Microbiology Biotechnology Reports* **2**(1):22-28.

Jnawali, A.D., Ojha, R.B. and Marahatta, S. 2015. Role of *Azotobacter* in soil fertility and sustainability: A review. *Advances in Plants and Agriculture Research* **2**(6):250-253.

Kecskes, M.L., Choudhury, A.T.M.A., Casteriano, A.V., Deaker, R., Lewin, L., Ford, R. and Kennedy, I.R. 2015. Effect of bacterial inoculants biofertilizers on growth, yield and nutrition of rice Australia. *Journal of Plant Nutrition* **39**(3):377-338.

Mahanty, T., Bhattacharjee, S., Goswami, M., Bhattacharyya, P., Das, B., Ghosh, A. and Tribedi, P. 2016. Biofertilizers: A potential approach for sustainable agriculture development. *Environmental Science and Pollution Research* **24**(4) 3315-3335.

Nanjundappa, A., Bagyaraj, D.J., Saxena, A.K., Kumar, M. and Chakdar, H. 2019. Interaction between arbuscular mycorrhizal fungi and *Bacillus* spp. in soil enhancing growth of crop plants. *Fungal Biology and Biotechnology* **6**:23.

Opeyemi, B.S., Oluwarotimi, A.A. and Abimbola, A.D. 2019. Potential significance of beneficial microbes for sustainable soil management and plant utilization. *Acta Scientific Microbiology* **2**(6):88-95.

Patel, N., Patel, Y. and Mankad, A. 2014. Biofertilizer: A promising tool for sustainable framing. *International Journal of Innovative Research in Science Engineering and Technology* **3**(9):15838-15842.

Santos, M.S., Nogueira, M.A. and Hungria, M. 2019. Microbial inoculants: Reviewing the past, discussing the present and previewing an outstanding future for the use of beneficial bacteria in agriculture. *AMB Express* **9**:205.

Singh, S., Singh, B.K., Yadav, S.M. and Gupta, A.K. 2014. Potential of biofertilizers in crop production in Indian agriculture. *American Journal of Plant Nutrition and Fertilization Technology* **4**:33-40.

Sneha, S., Anitha, B., Anjum, S.R., Raghu, N., Gopenath, T., Chandrashekrappa, G.K. and Kanthesh, M.B. 2018. Biofertilizer for crop production and soil fertility. *Academia Journal of Agricultural Research* **6**(8): 299-306.

Stamenković, S., Beškoski, V., Karabegović, I., Lazić, M. and Nikolić, N. 2018. Microbial fertilizers: A comprehensive review of current findings and future perspectives. *Spanish Journal of Agricultural Research* 16(1):e09R01.

Suryono, S. and Triharyanto, E. 2018. The application of biofilm biofertilizer-based organic fertilizer to increase available soil nutrients and spinach yield on dry land (a study case in Lithosol soil type). *IOP Conference Series: Earth and Environmental Science* **200**:1-6.

Tal, A. 2018. Making conventional environmentally friendly: Moving beyond the glorification of organic agricultural and demonization of conventional agriculture. *Sustainability Journal* 10:1078.

Thomas, L. and Singh, I. 2019. Microbial biofertilizers: Types and applications. *Biofertilizers for Sustainable Agriculture and Environment,* pp. 1-19.

Wahane, M.R., Meshram, N.A., More, S.S. and Khobragade, N.H. 2020. Biofertilizer and their role in sustainable agriculture: A review. *Pharma Innovation* **9**(7):127-130.

Yanni, Y., Dazzo, F. and Gomaa, A.-B. 2016. Status of the biofertilization technology and biosafety of biofertilizers in Egypt. *Recent Trends in Biofertilizers* 2:19-36.

Zarb, J., Ghorbani, R., Koocheki, A. and Leifert, C. 2005. The importance of microorganisms in organic agriculture. *Outlooks on Pest Management* 16(2):52-55.