IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Potential approach of biofertilizers towards sustainable agriculture: A Review

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Abstract

India's economy thrives on farming, which is the country's most popular occupation. Agricultural fertilisers are essential for proper crop growth and yield. Chemical fertilisers have recently been used by farmers to increase yield and speed up the process. These fertilisers, on the other hand, put habitats, soil, plants, and human and animal lives in jeopardy. Natural biofertilizers, on the other hand, not only have a higher yield but are also safe for humans. Biofertilizers are gaining traction as a viable alternative to toxic chemical fertilisers in the pursuit of sustainable agriculture. Biofertilizers are important for the crop yield and preserving long-term soil fertility.The role of biofertilizers in the growth of crops and the maintenance of long-term soil fertility, which is crucial to satisfy global food demand, is crucial. Microbes can interact and improve their immunity, growth and development with crop plants. The main nutrients required for the proper growth of the plants are nitrogen, phosphorous, potassium, zinc and silica, but these nutrients naturally take form as insolubilized or complex. Some microorganisms make them soluble and accessible to the plants. This review discusses the potentials of microbes, their mode of action and their impact on crops. The cost-effective, non-toxic and eco-friendly biofertilizers are a good replacement for costly and harmful chemical fertilisers. The knowledge gained from this review can help us understand the significance and methods of microbial production as biofertilizers for sustainable crop production in agriculture.

Keywords: Biofertilizers, microbes, sustainable, solubilizers, environment.

1.Introduction

The global population is currently still on the rise, with an estimated worldwide population of around 9.7 billion around 2050. (Ehrlich and Harte, 2015). Intensive industrialization, urbanisation and farm production are inextricably linked to this rapid growth. Due to the growing global population, traditional agriculture is essential to satisfy humanity's food needs, expected to reach 321 million tonnes by 2020, and to enhance the self-sufficiency of the countries in food production (Gizaki *et al*., 2015; Mahanty *et al*., 2016; Santos *et al*., 2012).However, the conventional methods of agriculture are mainly based on the widespread use of plant food and disease treatment synthetic fertilisers and pesticides (Vasile*et al*., 2015). The prudent dose of these chemical inputs has unquestionable advantages, not only for the crop growth and quality, but also for farmers' income. The increased use of artificial supplies can unfortunately pose a considerable risk to the natural environment by water, air and soil contaminants (Rahman and Zhang, 2018).The mindless application of agro-chemicals and lack of biodegradation ability lead to their belowground accumulation, which result in unfavourable change of soil parameters in matters of its structure, fertility and water holding capacity (Savci, 2012).

In addition to increasing land use for agriculture, further action to address new demands for food is necessary, according to the agricultural outlook for 2008-2017 drawn up by the Organization for Economic Co-operation and Development (OECD) and the Organization for Food, Food and Agriculture in the United Nations (FAO). Agronomic measures should therefore be taken to improve plant nutrient absorption through the use of microbial inoculants in view of the high prices of mineral nitrogen and phosphorus fertiliser.

The rational use of chemicals and pesticides together with organic manures for better soil health depends on sustainable crops.The latter is progressively depleted of its nitrogen and other nutrients by constant crop production from soil. Ordinary nitrogen (N) from an acre is taken in an ordinary crop. Thus, the soil must be filled with elements which are removed year after year by the cultivation. In addition, the rising fertiliser cost in recent years and concern for sustainable productivity in soils and ecological stability in the use of chemical fertilisers have emerged as crucial issues. Furthermore, heavy reliance on chemical fertilizers tends to favour economically those farmers with large hectarage. These considerations have led to a renewed interest in the biofertilizers and organic manures such as FYM, compost and green manures.

2. Biofertilizers

Green manure and organics are biofertilizers. Biofertilizers are carry or based inoculants that are used by agriculturists for the improvement of soil productivities in order to fix the air-borne or solubilize phosphates or stimulate plant growth by synthesiser of growth-promoting substances, containing cells that contain efficient strains of special organisms (namely bacteria).

Biofertilizers are products of useful micro-organisms, which, through their nutrient provision especially nitrogen and phosphorus, improve agricultural production. These biofertilizers are cheap, easy to use and are environmentally friendly. The judgmental use of biofertilizers and chemical or other organic plant nutrient sources have shown promising results, not only in maintaining productivity and soil health but also fulfilling a part of the fertiliser requirements of different plants.

3. Role of biofertilizers

Selection of the immobility (P, Zn, Cu) and the movement of plant components (C, S, Ca, K, Mn, Cl, Br and N) is mainly related to biofertilisers (Tinker, 1984). Bacteria of the rhizosphere secrete growth substances and secondary metabolism that contribute to the germination and growth of plants (Subba Rao, 1982, 2002; Dwivedi, 1989). Free living bactéria(Azotobacter), associates and symbiotic bacteria (Rhizobium) have been gaining popularity over the last few years and phosphate solubilizers (Bacillus megaterium, B. polymyxa and Ps. Striata).

The main role of biofertilisers is to promote plant growth without adverse environmental effects and increase harvest yields (Mishra *et al*., 2013). Inoculation with biofertilizers has increased the crop yield by an average of 16.2 percent compared to non-inoculated controls according to studies carried out by Schutz et al. (2018). Microbial biofertilisers play a critical role in agriculture to ensure the proper preservation of soil fertility by influenced the aggregation of soil particles and improve their structure (Rashid *et al.*, 2015).They contribute to better relations between plant and water (Xiang *et al*. 2012). They provide dry protection, reduce the pricing of plants for certain soil-borne diseases, including fungal diseases which also produce mycotoxins (Simarmata*et al.* 2016) and reduce the incidence of insect pests (Dey *et al.*, 2014).

4. Biofertilizers and its types

Plant growth is accelerated and improved by biofertilizers, which often protect plants from pest and disease attacks (El-yazeid *et al.* 2007). Many researchers around the world have examined the role of soil micro-organisms in sustainable agricultural development (Lee and Pankhurst 1992, Wani *et al*. 1995). Biofertilizers are now more used in crop production for some days, and different types of biofertilizers are available on the market.

In 1896 Nobe and Hiltner first patented the idea of microbial inoculation, which began with the legume Rhizobium inoculant (Fred *et al.*, 1932). In developed countries such as the United States and France, biofertilization is limited to Rhizobium, while in Brazil, China, and India, it has expanded to include a wide range of bacteria, fungi, and actinomycetes. Biofertilizers are divided into three categories: nitrogen, phosphate, and plant growth supporting biofertilizers, which involves potassium solubilizing microorganisms.

Table 1. Biofertilzers and its target crops

Biofertiliser	**Target crop**
Rhizobium	Leguminous crops
Azotobacter	Wheat, maize, cotton, mustard and vegetables (Potato, onion, tomato, brinjal and others)
Azospirillum	Cereal crops like wheat, maize, millets, sorghum, barley and sugarcane.
Blue green algae (BGA)	Rice
Phosphate solubilizing microorganisms	All
Potassium solubilizing microorganisms	All
Plant Growth Promoting Rhizobacteria (PGPR)	All
Arbuscular mycorrhiza	Nursery raised crops and orchard trees

Biofertilizers are classified into various categories based on their roles and modes of action. The commonly used biofertilizers include Nitrogen Fixers (N-Fixers), Potassium Solution stabilisers (K-Solution stabilizers), Phosphorus Solubilizers (PSs), and PGPR. Up to 1010 bacteria with a live weight of 2000 kg/ha can be found in 1 gram of fertile soil. Bacteria of soil may be cocci (sphere, 0.5 µm), ruby bacteria (rubber 0.5–0.3 microns), or spiral (1–100 microns). The presence of bacteria in the soil depends on the physical and chemical properties of the soil, the organic matter and the contents of phosphorus.

Table 2. Characteristics of different biofertilizers

Sr. No	Types of Biofertilizers	Characteristics	Microorganisms
1.	Nitrogen fixing biofertilizers	Obtain Nitrogen from the atmosphere and convert this into organic forms usable by plants	Rhizobium, Azospirillum, Azotobacter
2.	Phosphorous solubilizing biofertilizers (PSB)	Solubilize insoluble inorganic phosphate compounds	Bacillus, Pseudomonas and Aspergillus
3.	Phosphate mobilizing biofertilizers	Symbiotic association between host plants and certain group of fungi at the root system	Mycorrhiza
4.	Plant growth promoting biofertilizers	Increasing the growth and yield of plant	Pseudomonas sp.

4.1 Nitrogen Fixing Biofertilizers

Nitrogen is one of the most important plant growth and productivity nutrients. Despite the fact that there is 78 percent N2 in the atmosphere, plants cannot use it. To use atmospheric nitrogen, it must first be converted to ammonia, which can be easily assimilated by plants through the mechanism of biological nitrogen fixation (Tairo and N dakidemi 2013).Symbiotic and non-symbiotic nitrogen-fixing species are classified as symbiotic and non-symbiotic, respectively. Members of the Rhizobiaceae family, which form a symbiotic relationship with leguminous plants, are examples of symbiotic species (Ahamed and Khan 2012). On contrary, non symbiotic organisms include free-living and endophytic forms of microorganisms such as Cyanobacteria, Azospirillum, Azotobacter etc.

4.1.1 Rhizobium

Rhizobium is part of the Rhizobiaceae bacterial family and is the best example of nitrogen fixation symbiotically. In both legumes and non-legume plants, it can fix N2. In various legume crops, rhizobium has been shown to be fixed to 300 kg N/ha/year. The collectively referenced names are Rhizobium, Bradyrhizobium, Sinorhizobium, Azorhizobium and Mesorhizobium. Non-symbiont rhizobacteria which fasten nitrogen to non-home plants are called diazotrophic and can form non-binding interactions with the host plants (Verma *et al.* 2010). Rhizobial formation is also an important aspect. Most legume plants produce root lateral organs which are called “root nodules” to accommodate the symbiotic bacteria Rhizobium. Thus, it significantly increases plant growth, soil microbial population, and consequently, plant biomass; reduces weed population, etc.

4.1.2 Azospirillum

They are gram-negative, aerobic nitrogen-fixing bacteria that do not form nodules and belong to the Spirilaceae family. Although many types such as Azospirillum amazonense, Azospirillum halopraeferens and Azospirillum brasilense are known to exist, Azospirillum lipoferum and A. brasilense are among the most beneficial types (Mishra *et al.* 2013). Inoculation with azospirillum has a great effect on the roots and exudation (Trabelsi and M hamdi 2013). Thus, maize, sugarcane, sorghum, pearl millet are mostly advised for development. They develop growth promoters and enhance the development and use of plant nutrients (IAA, gibberellins and cytokinin) (N, P, and K).

4.1.3 Azotobacter

Azotobacter is a nitrogen-fixing diazotrophic bacterium that plays a key role in the nitrogen cycle due to its diverse metabolic functions. It is a biofertilizer for all non-leguminous plants, particularly rice, cotton, vegetables, sugarcane, sweet potato, and sweet sorghum, and belongs to the Azotobacteriaceae family. It fixes nearly 30 kg of nitrogen per year and is primarily used in the sugarcane industry to increase cane yield by 25–50 tonnes per hectare and sugar content by 10–15 percent. Azotobacter can be found in both acidic and alkaline soils.

4.1.4 Anabaena Azollae

It is a symbiotic bacterium that is primarily used in rice to fix atmospheric nitrogen. It is often associated with Azolla, a free-floating fern. The main advantage of using Azolla as a biofertilizer is that it decomposes quickly in the soil and makes nitrogen readily accessible to rice plants. It also contributes to the provision of important micronutrients such as phosphorus, potassium, zinc, iron, molybdenum, and others (Al Abboud *et al*. 2013). The Azolla-Anabaena method provides 1.1 kg N/ha/day to the rice crop; one Azolla crop given 20–40 kg N/ha to the rice crop in around 20–25 days**.**

4.1.5 Blue-Green Algae (Cyanobacteria)

Nitrogen-fixing bacteria Cyanobacteria are the most common nitrogen fixers on the planet. Nostoc, Anabaena, Oscillatoria, Aulosira, and Lyngbya are among the prokaryotes known as cyanobacteria, or blue green algae. When applied at 10 kg/ha, they fix 20–30 kg/N/ha in submerged rice fields and increase crop yield by 10–15 percent. Cyanobacteria have been shown to improve wheat and rice seed germination, shoot and root development, and yield.

4.2 Phosphate Solubilizing and Mobilizing Biofertilizers

On a dry weight basis, plants produce about 0.2 percent phosphorus, which is an important nutrient for plant growth and development. Phosphorus is the least mobile macronutrient available to plants in most soil conditions as compared to other macronutrients. Phosphate-solubilizing bacteria (PSB) use a variety of mechanisms to turn insoluble phosphates including HPO4 and H2PO4 into soluble forms, including the synthesis of organic acids, chelation, and ion exchange reactions. Phosphate, as well as other trace elements like Fe and Zn, are provided by the PSB, which helps the plant grow.

4.3 Potassium Solubilizing and Mobilizing Biofertilizers

After nitrogen and phosphorus, potassium (K) is the second most abundant and essential nutrient in plants. While K is abundant in the soil, only 1–2% of it is accessible to plants, while the rest is present as mineral K, which plants cannot absorb. It is extremely important for plant growth and development. The plants will grow slowly, have poorly formed roots, and produce small seeds and low yields if they are not given enough water. Bacillus spp. and Aspergillus niger, Arthrobacter spp., Cladosporium, and Sphingomonas aminobacter are examples of potassium-solubilizing biofertilizers with varying potential for K solubilization.

4.4 Sulfur Oxidizing Biofertilizers

Plants require sulphur as a micronutrient as well. Sulfur has been shown to play an important role in enhancing the biological and physical properties of soil. Sulfur is well-known for its ability to protect soil from high pH levels. Thiobacillus spp. is an example of a sulfur-oxidizing microbe; Thiobacillus thioparous and T. thioxidans can oxidise sulphur to plant-usable sulphates, which aid in plant nutrition. Sulfur oxidising bacteria also play an important role in environmental protection by removing sulphur emissions biologically.

4.5 Zinc Solubilizing Biofertilizers

Zinc is an important micronutrient that plants need in relatively small amounts (5–100 mg/kg) in their tissues for growth and reproduction. Zinc deficiency is very common in soil, and it is caused by an imbalanced fertiliser application, intensive agriculture, and poor soil health. If the contributing factors are ignored, zinc deficiency is expected to rise from 42 percent to 63 percent by 2025. Mycorrhiza, Saccharomyces spp., and other rhizobacteria genera, including Pseudomonas spp. and Bacillus spp., have all been found to increase Zn availability in soil.

4.6 Plant Growth Promoting Rhizobacteria (PGPR)

PGPR refers to a group of free-living rhizosphere bacteria that colonise plant roots and have a beneficial effect on plant development. They function as biofertilizers by encouraging plant growth and development, fostering biotic and abiotic stress tolerance, and aiding soil mineralization by decomposing organic matter.

5. Application practices of microbial biofertilizers

Biofertilizers are mostly supplied as conventional carrier-based inoculants with the advantage of being cheap and easier to produce.

5.1 Seed Treatment

Seed treatment is a very safe, cost-effective, and widely used procedure for all forms of inoculants (Sethi *et al.* 2014). The seeds are mixed and evenly coated in a slurry (inoculant mixed with 200 mL rice kanji) before being shade-dried for 24 hours before being sown.

5.2 Seedling Root Dipping

Plantation crops such as cereals, grains, fruits, trees, sugarcane, cotton, grapes, bananas, and tobacco are commonly used in this manner. Treatment times vary by crop; for example, vegetable crops are treated for 20–30 minutes, while paddy is treated for 8–12 hours before transplantation.

5.3 Soil Application

Biofertilizer is used either alone or in combination directly on the soil in this practise. A phosphate-solubilizing microbial biofertilizer, cow dung, and rock phosphate mixture is held in the shade overnight and added to the soil with a moisture content of 50%. (Pindi and Satyanarayana 2012).

6. Potential of biofertilizers for sustainable crops

Biofertilizers are critical for increasing crop yield and improving soil fertility. They take part in nutrient cycling and improve the soil structure and crop productivity when they are used in soil. The uniqueness and ability of microbes in the environment and culture have made them potential agriculture candidates to solve food issues. The use of potential biofertilisers will not only play a major role in efficiency and soil sustainability, but also preserve the environment by reducing the negative consequences of farming practises and enhancing food quality.

7. Conclusion

As a result, biofertilizers are cost-effective, organic, and environmentally sustainable, but they cannot completely substitute chemical fertilisers. Integrated Nutrient Management and organic farming also require the use of biofertilizers. Sustainable agriculture is characterised as farming practises that are friendly to the environment and allow for the development of crops and livestock without causing harm to human or natural systems. Sustainable agriculture development is a mode of human development that seeks to meet human needs while protecting the environment, so that these needs can be fulfilled for both current and future generations.In today's agricultural practises, these technologies are becoming increasingly important. In the coming years, the changing landscape of agricultural practises and the environmental risks associated with chemical fertilisers would necessitate a greater position for biofertilizers.

References

1. Bhoopander Giri , Ram Prasad, Qiang-Sheng, Wu Ajit Varma, Biofertilizers for Sustainable Agriculture and Environment, ISBN 978-3-030-18932-7.

2. Daniel Uribe, Jimena Sanchez-Nieves, and Javier Vanegas, Role of Microbial Biofertilizers in the Development of a Sustainable Agriculture in the Tropics, Soil Biology and Agriculture in the Tropics, Soil Biology 21.

3. Dr. Paul S. Teng,(2007).Business potential for agricultural biotechnology products, Asian Productivity Organization,ISBN: 92-833-7054-6.

4. Dr.Debiprasad Dash, Dr.Pallabi Mishra, (2014). Rejuvenation of Biofertilizer for Sustainable Agriculture and Economic Development, Consilience: The Journal of Sustainable Development, Vol. 11, Issue. 1, Pp. 41–61.

5. G.P. Brahmaprakash and Pramod Kumar Sahu, Biofertilizers for Sustainability, Journal of the Indian Institute of Science, ISSN: 0970-4140.

6. Govind Gupta, Shailendra Singh Parihar, Narendra Kumar Ahirwar, Sunil Kumar Snehi and Vinod Singh, (2015).Plant Growth Promoting Rhizobacteria (PGPR): Current and Future Prospects for Development of Sustainable Agriculture, Gupta et al., J Microb Biochem Technol.

7. Itelima, J. U.,Bang, W. J., Onyimba, I. A.,Sila, M. Dand Egbere, O. J., (2018).Bio-fertilizers as key player in enhancing soil fertility and crop productivity: A Review, Direct Research Journal of Agriculture and Food Science,Vol.6 (3), pp. 73-83, March.

8. Kamlesh Kumar Yadav, Smriti kana Sarka, Biofertilizers, Impact on Soil Fertility and Crop Productivity under Sustainable Agriculture, Environment and Ecology 37 (1) : 89—93.

9. Khosro Mohammadi and Yousef Sohrabi, (2012).Bacterial biofertilizers for sustainable crop production: a review, ARPN Journal of Agricultural and Biological Science, VOL. 7, NO. 5, MAY .

10. M Santhosh Kumar, G Chandramohan Reddy, MamtaPhogat and Santosh Korav, (2018).Role of bio-fertilizers towards sustainable agricultural development: A review, Journal of Pharmacognosy and Phytochemistry; 7(6): 1915-1921.

11. Mahendra Singh, M.L. Dotaniya, Amit Mishra, C.K. Dotaniya,K.L. Regar, and Manju Lata, Role of Biofertilizers in Conservation Agriculture, Conservation Agriculture,978-981-10-2558-7_4.

12. Manashi Barman, Srijita Paul, Aditi Guha Choudhury, Pinaki Roy, and Jahnavi Sen, (2017) .Biofertilizer as Prospective Input for Sustainable Agriculture in India, Int.J.Curr.Microbiol.App.Sci 6(11): 1177-1186

13. Mateusz Mącik, Agata Gryta, Magdalena Frąc, Biofertilizers in agriculture :An overview on concepts, strategies and effects on soil microorganisms, Advances in Agronomy, Volume 162 ISSN 0065-2113.

14. Meenakshi Suhag ,Potential of Biofertilizers to Replace Chemical Fertilizers, (2016).International Advanced Research Journal in Science, Engineering and Technology ,Vol. 3, Issue 5, May.

15. Mirza Hasanuzzaman, (2019).Agronomic Crops Volume 2: Management Practices, Springer Nature Singapore Pte Ltd.

16. Mishra D.J., Singh Rajvir,Mishra U.K. and Shahi Sudhir Kumar, (2013).Role of Bio-Fertilizer in Organic Agriculture: A Review, Research Journal of Recent Sciences, ISSN 2277-2502 Vol. 2(ISC-2012), 39-41.

17. MohdMazid and Taqi Ahmed Khan, (2014). Future of Bio-fertilizers in Indian Agriculture: An Overview ,International Journal of Agricultural and Food Research, Vol. 3 No. 3, pp. 10-23.

18. Nicholas O. Igiehon1 &Olubukola O. Babalol, (2017) .Biofertilizers and sustainable agriculture: exploring arbuscularmy corrhizal fungi, Appl Microbiol Biotechnol 101:4871–4881.

19. P.K.Senthilkumar and P.Sivagurunathan, (2012) .Comparative effect on bacterial biofertilizers on growth and yield of greengram (Phaseolus radiata L.) and cow pea (Vigna siensisEdhl.),Int.J.Curr.Microbiol.App.Sci 1(1):34-39

20. Raja N,(2013). Bio pesticides and biofertilizers: eco friendly sources for sustainable agriculture. J Biofertilzers, Biopesticides, vol.4 (1).

21. Rakesh Kumar, Narendra Kumawat and Yogesh Kumar Sahu, (2017).Role of Biofertilizers in Agriculture ,Kumar et al., Pop. Kheti, 5(4): 63-66 .

22. Ramesh Kumar Kushwaha, Vereena Rodrigues, Vinay Kumar,HimaniPatel, (2020). Soil Microbes-Medicinal Plants Interactions: Ecological Diversity and Future Prospect, Plant Microbe Symbiosis, Springer Nature Switzerland AG .

23. Surender Singh, Raman Jeet Singh, Kuldeep Kumar, Balkar Singh and Livleen Shukla, Biofertilizers and Green manuring for sustainable agriculture.

24. Swapna Latha Aggani, (2013).Development of Bio-Fertilizers and its Future Perspective, Scholars Academic Journal of Pharmacy (SAJP) ISSN 2320-4206Sch. Acad. J. Pharm., 2(4):327-332.

25. T.M. Abdel Ghany, M.M. Alawlaqi and M.A. Al Abboud , (2013) .Role of biofertilizers in agriculture: a brief review ,Mycopath ,11(2): 95-101 .

26. Trishna Mahanty & Surajit Bhattacharjee & Madhurankhi Goswami & Purnita Bhattacharyya &Bannhi Das, Biofertilizers: a potential approach for sustainable agriculture development, Environ Sci Pollut Res ,DOI 10.1007/s11356-016-8104-0.