



E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(4): 532-537
Received: 20-01-2026
Accepted: 22-02-2026

Durva Bisht
University Institute of Agricultural
Sciences, Chandigarh University,
Gharuan, Punjab, India

Aditi Verma
University Institute of Agricultural
Sciences, Chandigarh University,
Gharuan, Punjab, India

Dr. Asma Fayaz Lone
University Institute of Agricultural
Sciences, Chandigarh University,
Gharuan, Punjab, India

Corresponding Author:
Durva Bisht
University Institute of Agricultural
Sciences, Chandigarh University,
Gharuan, Punjab, India

Biofertilizers as a Strategy for Improving Crop Yield and Nutrient Utilization

Durva Bisht, Aditi Verma and Asma Fayaz Lone

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4g.5443>

Abstract

Abstract Most agricultural production consists of smallholder farmers who require the development of sustainable technologies, which costs according to their economic condition. Biofertilizers contain free-living bacteria which increase plant growth, increase productivity by strengthening its roots. They reduce the amount of synthetic fertilizer applied to the crops. Biofertilizers contain a variety of microbes having the capacity to increase plant nutrient uptake by colonizing the rhizosphere and making the nutrients easily available to plant root hairs. Biofertilizers are very cost-effective, environment-friendly nature, and they're a composition. They are effective and used as an alternative to hazardous synthetic fertilizers. This review covers various types of microbial biofertilizers such as symbiotic and free-living nitrogen-fixers, phosphorus-solubilizer and, their formulations, applications of these available biofertilizers toward sustainable agriculture, and recent approaches to making next-generation biofertilizers which are effective as compared to chemical biofertilizer. The microorganisms used in agriculture as biofertilizers based on strains of *Azospirillum* spp. and *Pseudomonas fluorescens*. Microorganisms used as biofertilizers or Plant Growth-Promoting Rhizobacteria is summarized, also with their benefits, challenges, and future prospect for biofertilizer use. Farmers should reduce the application of synthetic fertilizers and by using this technology sustainability and crop yield will increase.

Keywords: Small holder farmers, sustainable development, Hazardous Synthetic fertilizer, Biofertilizers, Microorganisms, Agriculture, Symbiotic nitrogen fixers.

Introduction

The application of microbial inoculants (biofertilizers) is a promising technology for future sustainable farming systems because of rapidly decreasing phosphorus stocks and the need to use available nitrogen (N). (Fasusi, O.A., et.al 2021) ^[1]. A lot microbial taxa are now used as biofertilizers, based on their capacity to get nutrients from fertilizers and soil available stocks, to fix atmospheric nitrogen, to improve water uptake and to act as bio control agents. Despite the existence of considerable knowledge on the effects of specific taxa of biofertilizers, a comprehensive quantitative assessment of the performance of biofertilizers with different traits like phosphorus solubilization with N fixation used to different crops at a global scale is missing. Biofertilizers are used as supplementary component to soil and also help in crop management traditions such as crop rotation, organic adjustments, tillage maintenance, recycling of crop residue, soil fertility and the biocontrol of pathogens and insect pests, which operation can significantly be useful in maintaining the sustainability of various crop production. Such as *Azotobacter*, *Azospirillum*, *Rhizobium*, *cyanobacteria*, phosphorus and potassium solubilising microorganisms and mycorrhizal are some of the PGPRs that will increase in the soil under no tillage or minimum tillage treatment

Plant Nutrition

Nutrition is a prerequisite required for the production of plant and wholesome food for the world's enlarging population. Plant nutrient are a key aspect of sustainable agriculture. Soils bring herbal reserves are unavailable of plant vitamins, however those reserves are unavailable to flora with only a slight element launched each 12 months via organic hobby or chemical processes.

Nutrition is a prerequisite required for the production of plant and wholesome food for the world's enlarging population. Plant nutrients are a key aspect of sustainable agriculture. Soils bring herbal reserves unavailable of plant vitamins, however those reserves are unavailable to flora with only a slight element launched each 12 months via organic hobby or chemical processes. This launch is too lagging to pay off for the removal of nutrients by way off for the removal of nutrients by way of agriculture production and to satisfy crop requirement. (Arif, M. S., Shahzad, S. M., Riaz, M., Yasmeen, T., Shahzad, T., Akhtar, M. J., ... & Buttler, A. 2017) ^[2]. The 16 important plant vitamins [N, P, K, Ca, Mo, Mn, B, Cl in required portions obtain most yield in crop production minerals promote plant nutrition. Good fertility is fundamental for a success plant increase, and the method of fertilizes and manures is an essential graining hobby. The upkeep of enough ranges of vitamins in soil is vital for wholesome plant boom. Chemical fertilizers solitary do no longer make a contribution all the nutrients in balanced portion needed by using the plants. This result in reduction of soil organic matter content material, which in flip, affects the organic activities and physical residence of the soil. All these concerns in good sized have caused interest towards the usage of organic manures. (Verzeaux, J., Hirel, B., Dubois, F., Lea, P. J., & Tétu, T. 2017) ^[3]. The utilization of organic manure also allows to keep crop yields, however play a vital position towards exhibiting both direct and oblique have an effect on the nutrient accessibility in soil by way of boosting the physical, chemical and organic conduct of soil and also enhances the utilization effectiveness of implemented fertilizers increased crop yield largely rely on the sort of fertilizers used to offer vital nutrients for plant life. For optimum plant growth, vitamins need to be available in good enough and in balanced quantities. From the soil vitamins, most effective a small element is launched each 12 months by using organic sports or chemical techniques. Fertilizers are designed to deliver the vitamins already present inside the soil fertilizer

The chemical insecticides and fertilizers have played a crucial position in enhancing agricultural manufacturing. Although they have a quick history in cutting –edge agriculture, their immediate motion and coffee value controlled to bring them quickly into the middle of interest. Thus their damaging results on environment, plant, animal, and human lifestyles have diverted the concern on eco friendly plant safety. (Aloo, B. N., Mbega, E. R., Tumuhairwe, J. B., & Makumba, B. A. 2021) ^[4]. The term biofertilizers, depict everything from manures to plant extract. When implemented to plant surfaces, they promote plant growth by increasing the delivery of number one nutrients to host plant. Biofertilizers add nutrients through natural process together with nitrogen fixation, solubilising, phosphorus, and stimulating plant increase in conjunction with the synthesis of increase –promoting materials. (Kumar, S. M., Reddy, C. G., Phogat, M., & Korav, S. 2018) ^[5]. Bio-fertilizers is technically residing; it may be mutually useful in association with plant roots. Involved microorganism should easily convert complicated organic fabric into easier compounds in order for vegetation to easily take in them.

The micro biome: - potential significance of beneficial microbes in sustainable agriculture

The rhizosphere, that is the slender quarter of soil this is surrounding plant roots, incorporates as much as 1011 microbial

cells in keeping with a gram of root and above 30,000 prokaryotic species in general, enhancing yield. The collective genome of the rhizosphere microbial network enveloping plant roots is bigger in comparison to that of vegetation and called the micro biome, whose interactions with soil decide crop fitness within side the herbal agro-surroundings via way of means of offering several offerings to crop vegetation., speedy natural depend on decomposition, nutrient acquisition, water absorption, nutrient recycling, weed manipulate and bio-manipulate. (Praveen, K. V., & Singh, A. 2019) ^[6]. The met genomic take a look at presents people with the centre rhizosphere and entophytic micro biomes interest in. It has been proposed that exploiting tailored centre micro biome switch remedy in agriculture may be a capability method for handling plant illnesses for distinctive crops. Rhizosphere microbial groups are an opportunity for chemical fertilizers has grown to be a topic of top-notch hobby in sustainable agriculture and bio-protection programme.

Biofertilizers relevance and plant tolerance to environmental stress

Abiotic and biotic stresses are the major aspect that affects the productivity of the crops. Many new technologies are applied for crop improvement under stress, of which PGPRs role as bio protectants has become paramount importance. *Rhizobium trifolii* inoculated with *Trifolium alexandrinum* has higher biomass with an increased nodulation under salinity stress conditions. *Pseudomonas aeruginosa* withstands biotic and abiotic stresses. (Htwe, A. Z., Moh, S. M., Soe, K. M., Moe, K., & Yamakawa, T. 2019) ^[7]. Paul and Nair they shown that *P. fluorescens* MSP-393 produces dry weight, fresh weight and height of cotton under condition of alkaline and high salt by increasing the rate of uptake of K⁺, Mg²⁺ and Ca²⁺, and by lessening the absorption of sodium (Na⁺). Few strains of *Pseudomonas* show good plant tolerance via 2,4-diacetylphloroglucinol (DAPG)

Cyanobacteria

Cyanobacteria are crucial for worldwide nitrogen cycle. These are the primary N fixers in freshwater and marine systems. In massive areas of the oceans, nitrogen –fixing microorganism provide a vital supply of nitrogen in many terrestrial environment, from rainforests to deserts. Cyanobacteria are capable of live to tell the tale in severe environment due to rare adaptation which includes their potential to restore nitrogen and their resistance to desiccation. Due to the ability to restore atmospheric nitrogen, Cyanobacterial mats have been used as biofertilizer in contemporary agriculture.

Azotobacte R

Azotobacter are living bacteria which grows nicely on a nitrogen unfastened medium. Such bacteria utilize the atmospheric nitrogen fuel for his or her mobile protein synthesis. This call protein is later mineralized in soil after the dying of *Azotobacter* cells, as a consequence contributing to the nitrogen availability of the crop vegetation. *Azotobacter* partner with crop improvement is the secretion of ammonia within the rhizosphere in the presence of root exudates, which allows in change of nutrient uptake by the plant life it is a not unusual place soil bacterium. *A. chroococcum* is a gift broadly on Indian soil. (Mohamed, M. F., Thallooth, A. T., Elewa, T. A., & Ahmed,

A. G. 2019) ^[9]. Soil natural remembers is the essential aspect

that makes a decision the boom of those bacteria.

Azospirillum

Azospirillum is a Gram bad motile micro organism belongs to the order Rhodospirillales, related with roots of monocots, such as vital crops, in particular wheat, rice, and corn. *Azospirillum* have near relational, symbiosis with the better plant system. And additionally affiliation with cereals like; sorghum, maize, pearl millet, finger millet, foxtail millet and different minor millets and additionally fodder grasses. It is the main effective Phytostimulator inoculants for cereals worldwide.

How to make biofertilizers?

Several factors need to be considered in a kind of biofertilizer such as the optimum condition required for the organism, microbes' growth profile, and the formation of inoculation. The formulation method of inoculant is used for the storage of products that are very critical to success as a biological product. There are 6 methods of making fertilizer. It includes active organisms, isolation of targeted microbes, selection method and carrier material, and propagation method than prototype testing. Before all these steps we must decide on organisms. (Schütz, L., Gattinger, A., Meier, M., Müller, A., Boller, T., Mäder, P., & Mathimaran, N. (2018) ^[11] For example, we should decide whether we use acid bacteria or nitrogen fixers. Then isolation is required to separate target microbes from habitation. Then organisms will be grown on Petri flake and then select the best candidates. It is important that the right carrier material is found. If biofertilizer is required in powder form then peat is the right carrier material. Selection of microorganisms is used to find the optimum condition of microorganisms. After that prototype is made and then tested. At last, biofertilizer is tested on large scales under different conditions and environments to check its effectiveness and limitations. (Kalia, A., & Kaur, H. (2019)) ^[12]. Biofertilizers are usually prepared as carried inoculants which are effective microorganisms. Incorporation of different microorganisms in carrier material helps in easy handling, long-term storage, and effectiveness of biofertilizers. A lot of material is used as a carrier for seed or soil inoculation. The properties of good carrier material for seed inoculation are inexpensive in adequate amounts. It should be non-toxic to inoculants bacterial and non-toxic to plants. At last, the carrier should have good pH buffering capacity and be very easy to process.

Microorganisms used in biofertilizers

Some organisms are commonly used in biofertilizers are nitrogen fixers and potassium solubilizers, and a combination of moulds on a finger. (Springer, Cham. Malusà, E., Pinzari, F., & Canfora, L. 2016) The bacteria used in biofertilizers have a very close relationship with the plant roots. *Rhizobium* has symbiotic interaction with legume roots and rhizobacteria inhabits the root of the surface. The phosphorous microorganism used in bacteria and fungi makes insoluble phosphorous available to plants. Several soil bacteria and a few species of fungi have the ability to bring insoluble phosphate into the soil by secreting or making organic acid it affects the lowering of soil pH and dissolves forms of phosphate (Lesueur, D., Deaker, R., Herrmann, L., Bräun, L., & Jansa, J. (2016) ^[14]. The rhizobium, Blue-green algae crop-specific bio inoculants like azotobacter and phosphorous solubilising bacteria could be used as broad biofertilizers. VAM is a fungus that is found with agricultural crops and enhances plant nutrients. It has been found that VAM affects plant growth by physiological effects or reduces diseases

caused by soil pathogens. There are a few examples of free-living nitrogen-fixing bacteria such as obligate anaerobes (*Clostridium pasteurianum*), obligate aerobes (*Azobacter*), photosynthetic bacteria (*Rhodobacter*), and some methanogens.

Nitrogen based biofertilizer

It is the major nutrient very essential for crop growth. The atmosphere contains 80% of nitrogen which is in a free state. The major part of nitrogen finds in soil due to its fixation by a certain group of microorganisms. Biological nitrogen fixation (BNF) helps in determining nitrogen balance in the soil. (Yao, Y., Zhang, M., Tian, Y., Zhao, M., Zeng, K., Zhang, B., ... & Yin, B. 2018) ^[15] Nitrogen action through BNF helps in achieving a sustainable environment for agriculture production. The value of nitrogen-fixing legume to achieve a higher yield of legume by application of biofertilizer. BNF is one way of converting elemental nitrogen into a plant usable form. Nitrogen fixation bacteria (NFB) that function transform atmospheric nitrogen into an organic compound. Nitrogen fixer organisms are used in biofertilizers as a living fertilizer containing micro inoculants which fix atmospheric nitrogen. They are free-living bacteria such as rhizobium, and Azolla. The nitrogen bacteria associated with non-leguminous crops such as *Saccharomycetozoa*, *Acaligenes*, *Acetobacter*, *Mycobacterium*, etc. these species of nitrogen-fixing bacteria are isolated from the rhizosphere of various cereals, and mainly members of *Azotobacter* have tested to increase the yield of cereals and legumes. *Rhizobium* inoculation is an agronomic practice to ensure adequate nitrogen of legumes. In the root, the oxygen level is regulated by special hemoglobin which is known as leg hemoglobin. (Bhardwaj, D., Ansari, M. W., Sahoo, R. K., & Tuteja, N. 2014) ^[16]. This protein is encoded by plant genes which are made by symbiotic bacteria. The plant cell converts sugar into organic acid which is used in bacteroids. In exchange, plants get amino acids rather than free ammonia. Azolla biofertilizer is used for the cultivation of rice in different countries such as China, Thailand, etc. *Azobacter* and *Azospirillum* are used to fix atmospheric nitrogen in cereal crops without any symbiosis. (Sun, B., Gu, L., Bao, L., Zhang, S., Wei, Y., Bai, Z., & Zhuang, X. 2020) ^[17] El-Komy suggested the beneficial effects of *Azospirillum lipoferum* for providing balanced nitrogen and phosphorous nutrition in wheat plants. The inoculation of bacteria provide more balanced nutrition for plants and also improves uptake of nitrogen and phosphorous. The application of biofertilizers increases the number of leaves and this occurs due to increased mineral and water uptake from soil fixation. It occurs due to the production of IAA, gibberellins, cytokinins, etc.

Phosphorus-based biofertilizers

The phosphorus in soil solubilise by bacteria (PSB) which convert inorganic phosphorus into soluble forms through the process is used for acid production and ion exchange reaction which make them available to the plant. The use of PSB in agriculture is not only high-cost manufacturing phosphate fertilizer but it is insoluble to the soil it is applied. Bacteria are more useful than phosphorus fungi. The microbial population found in soil contains PSB around 1-50% and PSF around 0.1-0.5% in P solubilization. (Fazelian, N., & Yousefzadi, M. (2022) ^[19] Microorganisms involved in phosphorous are mycorrhizal fungi. and in the soil bacterial community, the strains of *Pseudomonas* and endo symbiotic have been used as phosphate

solubilizers. Strains of bacteria genera include the most powerful fungi includes *Bacillus megatherium*, *Pseudomonas* strains are known as the most effective strains. A high proportion of PSB in the rhizobium is metabolically more effective than other sources. (Kannaiyan, S. 2002) ^[20] As one gram of fertile soil contains around 101_1010 bacteria found in cocci, bacilli shaped. The PSB is in the variation in forms and population in different soil. The population of PSB depends on the physical and chemical properties of soil. The large population of PSB is found in agriculture rangeland soil (Yahya and azawi). Some PSB species have mineralization and solubilization potential for organic and inorganic P. phosphorous solubilizing activities are determined by using microbes' abilities which release metabolites such as organic acid which occurs a due breakdown of hydroxyl by chelation. Phosphate occurs to take place due to microbial processes including organic acid production proton extrusion etc. A large amount of phosphorous fertilizer exists in nature and much of the global cycling in the form of insoluble organic and inorganic phosphate is attributed to fungi and bacteria.

The best fertilizer to use

According to researchers tells that AMF with their application of p solubilises and fixers are their best inoculants. The yield increases by the two functional traits N and P solve rather than their application suggest no competition between them rather synergies the two traits. The same number of yield increases was also found after the inoculation with AMF also found by some researchers who analyzed 290 glasshouses and the field which represent a meta-analysis. Same yield increase after inoculation with AMF under field conditions 102 experiments out of 112 experiments. (Mondal, S., Mallikarjun, M., Ghosh, M., Ghosh, D. C., & Timsina, J. 2016) ^[18] in an experiment, researchers found out that microorganisms that can fix nitrogen have also contributed to only a very small extent to the nitrogen nutrient of the crop, and also the result varies the most. Our result shows that yield is sustainable and the low variation result is less explanation than before. Researchers stated that 10- 20% of p in crops comes through the most recent fertilizer application and the remaining 80-90% comes from the reserves present in the soil by either fertilizer application. There is no surprise that phosphorous present in the soil is better to control variable.

The microbial inoculants that comprise the lifestyle of dormant or stay cells of the powerful traces of N-fixing, P-solubilising/mobilizing, K-solubilizing. (Raimi, A., Adeleke, R., & Roopnarain, A. (2017) ^[24]. Microorganisms at their cell degree that's frequently implemented to seeds, soils, or compost cloth to boost up the microbial sports with the aid of using such organisms via their multiplication and beautify the nutrient's availability, which may be effortlessly handy with the aid of using the plants .(Mahmud,

A. A., Upadhyay, S. K., Srivastava, A. K., & Bhojiya, A. A. (2021) The organic interest of microbial inoculants enables mobilizing the supply of vitamins and healing of vitamins, thereby enhancing the soil pleasant in general. Biofertilizers have the ability to hinder the nitrification manner for a protracted duration even as enhancing the fertility repute of the soil.

They are some of the essential materials of Integrated nutrient management (INM) techniques for assembly each the soil's productiveness and sustainability and the equal time maintaining the surroundings safe, being pollution-free, financial and supply of renewable vitamins to the plant life to reinforce artificial fertilizers withinside the sustainable manufacturing system (Fasusi, O. A., Cruz, C., & Babalola, O. O. (2021) ^[1].. Panda

(2011) documented that the effect of bio-fertilizers on yield development degrees from 35% to 65%. However, to doubtlessly take advantage of the advantages of biofertilizers primarily based totally on the consistency in their performance. These require common research in special dimensions because of the complicated organic interplay of some of the hosts, different rhizosphere micro flora and fauna in addition to the surroundings. The use of bio- fertilizers, therefore, elements and decorate the productiveness according to the region in a relatively brief time, eat smaller quantities of energy, reduces infection of soil and water, will increase soil fertility, and encourages antagonism and organic

The Function OF biofertilizers in crop production

Soil micro-organisms play an vital position in regulating the dynamics of organic be counted decomposition and the availableness of plant nutrients including N,P and S. It is wellidentified that microbial inoculants constitute and crucial factor of integrated nutrient management that leads to sensible agriculture. (García-Fraile, P., Menéndez, E., & Rivas, R. (2015) ^[26]. Additionally , microbial inoculants may be used as an monetary enter to decorate crop productivity , the dosage of fertilizers can be diminished and more nutrient can be harvested from the soil .

Biofertilizer may be used as nutrient supply for soil microbiology by keeping fruit yield and great and promoting nutritionally provided plant with lower manufacturing prices. Nitrogen solving microorganisms plays a vital position in improving yield with the aid of converting atmospheric nitrogen into organic bureaucracy which are usable by means of plant.

Biofertilizers as sustainable agriculture by improving soil fertility, plant tolerance and crop productivity

Current soil control guidelines and techniques are in particular depending on inorganic chemical- primarily based totally fertilizers, which are inflicting a critical danger to human fitness and the environment. (Odoh, C. K., Eze, C. N., Obi, C. J., Anyah, F., Egbe, K., Unah, U. V. & Adobu, U.S. 2020). The exploitation of useful microbes as a biofertilizer has to grown to be advanced to all others and it affects an essential position withinside the agriculture area for or her capability position in meals protection and sustainable crop production. Applications of plant will enhance selling rhizobacteria , endo- and ectomycorrhizal fungi, *cyanobacteria* and some other different beneficial microscopic organisms can beneficial nutrient uptake, plant increase and plant tolerance to abiotic and biotic pressure in unique climatic conditions. (Naeem, U., Afzaal, M., Qazi, A., Yasar, A., Mahfooz, Y., Naz, A. U., & Awan, H. 2022) ^[28]. This assessment paper highlights biofertilizers' purposeful tendencies including plant increase and productivity, nutrient profile, plant defence and protection with a unique emphasis on its characteristic to cause diverse increase- and defence- associated genes withinside the signalling community of mobile pathways to reason mobile reaction and thereby crop improvement. Physiological bases of biofertilizers for sustainable agriculture in lowering problems related to the usage of chemical substances fertilizers.

Benefits of biofertilizers

- Biological fertilizers can mobilize nutrients that help the development of biological activities which is present in soils (Chen, J. H. 2006, October) ^[1].

- The maintenance of plant health is improved by the addition of balanced nutrients.
- Due to the result of the good structure provided to the soil, root growth of the plant is promoted.
- By using biofertilizers content of organic matter in soil is increases as compared to normal levels
- It improves the development of mycorrhizal associations, which enhance the availability of phosphorus (P) present in the soil.
- It helps to stop enhancing plant diseases and provides a continuous supply of micronutrients to the soil which increases the soil fertility
- It helps in the improvement and maintenance of stable nitrogen and phosphorus concentrations in soil (Mishra, P., & Dash, D. 2014) ^[22].
- Biofertilizers help in Improvements in the capacity of nutrients exchange in the soil.

Biofertilizers are cost effective which makes them affordable even to the lower income

Farmers Limitations

- Compost products have highly variable concentrations of nutrients means nutrients quantity is not fixed and also the, implementation costs are higher than the chemical fertilizers.
- Due to the use of high amount of biofertilizer may result in accumulation of salts, nutrients, and heavy metals that cause the negative effects on plant growth, development of organisms of the soil and water quality. (Saba, N., Awan, I. U., & Qadir, J. 2013) ^[10].
- Large amount of bio fertilisers are required for land application due to low contents of nutrients, as compare to the other chemical fertilizers.
- Main macronutrients which are useful for the plant development and growth may not be available in optimum quantities. Nutritional deficiencies occurs due to the low transfer of micro- and macro-nutrients.
- Biofertilizers are plant specific which work on one does not mean work on other plant.

Future of biofertilizer

- These industries should stop the use of harmful biofertilizer fertilizers such as algal blue (Mishra, P., & Dash, D. 2014) ^[22].
- There are high chances of a circular economy and further chances of development and improvement of biofertilizer technology.
- There should be a proper understanding among farmers is required for effective use to get benefits from it.
- Consumers should understand the impact of chemicals fertilizer and increase the use of biofertilizer should increase.
- Demand of bio fertilizer increase in future.

Conclusion

We have studied three different effects each giving a different representation of the success of biofertilizers. Researchers found that dryland agriculture should help the most from biofertilizers. As the effect of climate changes effects in the future, there will be more dryland area throughout the world. (Singh, M., Dotaniya, M. L., Mishra, A., Dotaniya, C. K., Regar, K. L., & Lata, M. (2016) ^[10] Biofertilizers are the best alternative option

for sustainable agriculture. In the future, researchers will try to find the soil community that may predict the competitive chance of biofertilizers in specific soil and helps to efficiently produce specific types of biofertilizers for each specific application.

Biofertilizers also help in increasing crop productivity by way of increasing BNF, increasing the availability of nutrients, and also increasing the uptake and absorption rate in plant growth through hormonal action. Biofertilizer part or the use of chemical fertilizers thus prevents environmental degradation and pollution prevention. By using the biofertilizers and organic biofertilizers a very low input system is required and it helps in achieving sustainability of farms. Additionally, the excessive use of these inputs has also caused extreme health environment al dangers which include soil, erosion, water infection, pesticides poisoning, falling floor water desk, water logging and depletion of biodiversity. Biofertilizer spontaneously turn on the microorganism located within the soil in a powerful and green manner, thereby gaining more significance for utilization in crop manufacturing, restoring the soils fertility and defensive it in opposition to drought, soil diseases and as a consequence stimulate plant boom. Biofertilizers results in soil enrichment and are suitable with long term sustainability. The application of bio-fertilizers can be minimize the usage of chemical fertilizers .Lowering environmental dangers, beautyify soil structure and promote agriculture .Biofertilizers are cheaper and splendid in affecting the yield of cereal vegetation. Biofertilizers are the alternative resources to satisfy the nutrient requirement of crops. In biofertilizers, useful microorganisms are *Azotobacter*, *Azospirillum*, *Rhizobium* which can be very critical in crop manufacturing. Biofertilizers also can make plant proof against adverse environmental stressed.

References

1. Fasusi OA, Cruz C, Babalola OO. Agricultural sustainability: microbial biofertilizers in rhizosphere management. Agriculture. 2021;11(2):163-163.
2. Arif MS, Shahzad SM, Riaz M, Yasmeen T, Shahzad T, Akhtar MJ, *et al.* Nitrogen-enriched compost application combined with plant growth-promoting rhizobacteria (PGPR) improves seed quality and nutrient use efficiency of sunflower. Journal of Plant Nutrition and Soil Science. 2017;180(4):464-473.
3. Verzeaux J, Hirel B, Dubois F, Lea PJ, Tétu T. Agricultural practices to improve nitrogen use efficiency through the use of arbuscular mycorrhizae: basic and agronomic aspects. Plant Science. 2017;264:48-56.
4. Aloo BN, Mbega ER, Tumuhairwe JB, Makumba BA. Advancement and practical applications of rhizobacterial biofertilizers for sustainable crop production in sub-Saharan Africa. Agriculture & Food Security. 2021;10(1):1-12.
5. Kumar SM, Reddy CG, Phogat M, Korav S. Role of bio-fertilizers towards sustainable agricultural development: a review. J Pharmacogn Phytochem. 2018;7:1915-1921.
6. Praveen KV, Singh A. Realizing the potential of a low-cost technology to enhance crop yields: evidence from a meta-analysis of biofertilizers in India. Agricultural Economics Research Review. 2019;32:347-2020-1015.
7. Htwe AZ, Moh SM, Soe KM, Moe K, Yamakawa T. Effects of biofertilizer produced from *Bradyrhizobium* and *Streptomyces griseoflavus* on plant growth, nodulation, nitrogen fixation, nutrient uptake, and seed yield of mung bean, cowpea, and soybean. Agronomy. 2019;9(2):77-77.

8. Al Abboud MA, Ghany TA, Alawlaqi MM. Role of biofertilizers in agriculture: a brief review. *Mycopath.* 2014;11(2):1-1.
9. Mohamed MF, Thalooth AT, Elewa TA, Ahmed AG. Yield and nutrient status of wheat plants (*Triticum aestivum*) as affected by sludge, compost, and biofertilizers under newly reclaimed soil. *Bulletin of the National Research Centre.* 2019;43:1-15.
10. Dwivedi BS, Singh VK, Meena MC, Dey A, Datta SP. Integrated nutrient management for enhancing nitrogen use efficiency. *Indian J Fertil.* 2016;12:62-71.
11. Schütz L, Gattinger A, Meier M, Müller A, Boller T, Mäder P, *et al.* Improving crop yield and nutrient use efficiency via biofertilization—a global meta-analysis. *Frontiers in Plant Science.* 2018;2204:1-15.
12. Kalia A, Kaur H. Nano-biofertilizers: harnessing dual benefits of nano-nutrient and bio-fertilizers for enhanced nutrient use efficiency and sustainable productivity. In: *Nanoscience for Sustainable Agriculture.* Cham: Springer; 2019. p. 1-15.
13. Malusà E, Pinzari F, Canfora L. Efficacy of biofertilizers: challenges to improve crop production. In: *Microbial Inoculants in Sustainable Agricultural Productivity.* New Delhi: Springer; 2016. p. 17-40.
14. Lesueur D, Deaker R, Herrmann L, Bräu L, Jansa J. The production and potential of biofertilizers to improve crop yields. In: *Bioformulations: for Sustainable Agriculture.* New Delhi: Springer; 2016. p. 71-92.
15. Yao Y, Zhang M, Tian Y, Zhao M, Zeng K, Zhang B, *et al.* Azolla biofertilizer for improving low nitrogen use efficiency in an intensive rice cropping system. *Field Crops Research.* 2018;216:158-164.
16. Bhardwaj D, Ansari MW, Sahoo RK, Tuteja N. Biofertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. *Microbial Cell Factories.* 2014;13(1):1-10.
17. Sun B, Gu L, Bao L, Zhang S, Wei Y, Bai Z, *et al.* Application of biofertilizer containing *Bacillus subtilis* reduced the nitrogen loss in agricultural soil. *Soil Biology and Biochemistry.* 2020;148:107911-107911.
18. Mondal S, Mallikarjun M, Ghosh M, Ghosh DC, Timsina J. Influence of integrated nutrient management (INM) on nutrient use efficiency, soil fertility and productivity of hybrid rice. *Archives of Agronomy and Soil Science.* 2016;62(11):1521-1529.
19. Fazelian N, Yousefzadi M. Nano-biofertilizers for enhanced nutrient use efficiency. In: *Nano-enabled Agrochemicals in Agriculture.* Academic Press; 2022. p. 145-158.
20. Kannaiyan S. Biofertilizers for sustainable crop production. *Biotechnology of Biofertilizers.* 2002;9-49.
21. Singh M, Dotaniya ML, Mishra A, Dotaniya CK, Regar KL, Lata M. Role of biofertilizers in conservation agriculture. In: *Conservation Agriculture.* Singapore: Springer; 2016. p. 113-134.
22. Mishra P, Dash D. Rejuvenation of biofertilizer for sustainable agriculture and economic development. *Consilience.* 2014;11:41-61.
23. Saba N, Awan IU, Qadir J. Improving synthetic fertilizer use efficiency through bio-fertilizer application in rice. *Gomal University Journal of Research.* 2013;29(2):32-38.
24. Dwivedi BS, Singh VK, Meena MC, Dey A, Datta SP. Integrated nutrient management for enhancing nitrogen use efficiency. *Indian J Fertil.* 2016;12:62-71.
25. Raimi A, Adeleke R, Roopnarain A. Soil fertility challenges and biofertilizer as a viable alternative for increasing smallholder farmer crop productivity in sub-Saharan Africa. *Cogent Food & Agriculture.* 2017;3(1):1400933-1400933.
26. Mahmud AA, Upadhyay SK, Srivastava AK, Bhojiya AA. Biofertilizers: A nexus between soil fertility and crop productivity under abiotic stress. *Current Research in Environmental Sustainability.* 2021;3:100063-100063.
27. Fasusi OA, Cruz C, Babalola OO. Agricultural sustainability: microbial biofertilizers in rhizosphere management. *Agriculture.* 2021;11(2):163-163.
28. García-Fraile P, Menéndez E, Rivas R. Role of bacterial biofertilizers in agriculture and forestry. *AIMS Bioengineering.* 2015;2(3):183-205.
29. Odoh CK, Eze CN, Obi CJ, Anyah F, Egbe K, Unah UV, *et al.* Fungal biofertilizers for sustainable agricultural productivity. In: *Agriculturally Important Fungi for Sustainable Agriculture.* Cham: Springer; 2020. p. 199-225.
30. Naeem U, Afzaal M, Qazi A, Yasar A, Mahfooz Y, Naz AU, Awan H. Investigating the effect of *Aspergillus niger* inoculated press mud (biofertilizer) on the potential of enhancing maize (*Zea mays* L) yield, potassium use efficiency and potassium agronomic efficiency. *Cereal Research Communications.* 2022;50(1):157-170.