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Unlocking the Green Potential: Harnessing Biofertilizers for Enhanced Vegetable Production

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Vegetable crops are highly valued globally for their essential nutrients, serving as protective foods to fight malnutrition for people of all backgrounds. Their widespread cultivation and availability make them accessible options for promoting health and wellness worldwide. Despite their nutritional richness, vegetable crops face challenges posed by the escalating use of agrochemicals used to enhance yield and combat pathogens. The worsening soil quality due to agrochemical use necessitates alternative farming methods to counteract environmental damage while increasing yields and economic benefits for farmers. In this context, biofertilizers, comprising living or latent cells of beneficial micro-organisms, synergistically interact with plants in the rhizosphere, enhancing nutrient uptake when applied to seeds or soil, presenting a viable solution to agricultural nutrient management. Despite their recognized benefits, biofertilizers suffers lack of awareness or information about commercially available options. Hence, this article underscores the critical importance of biofertilizers as a sustainable agricultural practice and provides the information about commercially available biofertilizers to optimize their benefits for farmers on a global scale.

Keywords: Vegetable crops, Biofertilizers, Sustainable agriculture, commercial bioagents

Introduction

Vegetables, vital for global nutrition, face challenges from conventional farming as heavy reliance on agrochemicals, causing soil degradation and environmental harm. Biofertilizers, containing beneficial microorganisms, offer a sustainable alternative. By fostering symbiotic relationships in the rhizosphere, they enhance nutrient uptake, improve soil structure, and boost plant resilience. Biofertilizers boosts the microbiological processes through various mechanisms such as nitrogen fixation in soil and root nodules, phosphate mineralization and solubilization of insoluble forms of phosphates like tricalcium, iron and aluminium phosphates to available form, scavenging the phosphates from deep soil layers, hormones and antimetabolites production to promote root growth and decomposition of organic matter. Biofertilizer used in long term are economical, efficient, productive and accessible to farmers over agrochemicals.

Types of biofertilizers are mentioned below:

1. Nitrogen-Fixing Bacteria (NFB): Although nitrogen makes up 78% of the atmosphere by mass, it is not in a form that plants can use. Dinitrogen must first be converted into soluble, non-toxic ammonia. This ammonia is then transformed into nitrites and nitrates by ammonia-oxidizing bacteria and nitrifying bacteria, respectively (Roy *et al*., 2020). Nitrogen is a vital macronutrient as it enhances growth, chlorophyll content, and grain size in crops.

***Rhizobium*: *Rhizobium* is a rod-shaped, gram negative, aerobic bacteria. *Rhizobium* is most widely used biofertilizers which colonizes the roots forming tumor like growth called root nodules. The *Rhizobium* legume association can fix upto 100-300 kg N/ha in one crop season. *Rhizobium* species are crop specific (Table 1).

Table 1: *Rhizobium* species specificity to the leguminous crops

Rhizobium groups	Leguminous crops	*Rhizobium* groups	Crop groups
R. leguminosarum	Peas, lathyrus, lentil	*R. trifoli*	Clover
R. japonicum	Soybean	*R. meliloti*	Alfalfa
R. phaseoli	Kidney, garden beans	*R. lupini*	Lupini

Azotobacter are aerobic, non symbiotic, free living bacteria. It is capable of fixing an average of 20 kg N/ha/year. It also known for production of thiamine, riboflavin, indole acetic acid and gibberellins , polysaccharides which aggregates the soil, suppresses pathogenic microbes apart from nitrogen fixation.

Azospirillum is a gram negative. They are capable to fix atmospheric nitrogen of 15-30kg/ha. *Azospirillum brasilense* and *Azospirillum lipoferum* are most widely used among 17 currently identified species.

Blue green algae: Microscopic algae, collectively called phytoplankton produce primary link in food chain *i.e*., organic matter and also replenishes the oxygen. The macroscopic algae, called sea weeds flourishes in rocky or coral substratum. Chlorophyceae (green algae), Phaeophyceae (brown algae), Rhodophyceae (red algae) and Cyanobacteria (blue-green algae) are groups based on their pigmentation. BGA provides fixed nitrogen to plants by mechanism of exudation or mineralization. Cyanobacteria lowers the pH and replaces Na^+ by Ca^+ in problematic soils.

Azolla- Azolla is a symbiotic diazotroph, has the ability to fix atmospheric nitrogen through anabaena which is in a symbiotic relationship and benefitted by carbon source in return.

2. Phosphorous Solubilizing Bacteria (PSB): Biofertilizers has the ability to solubilize the fixed soil phosphorous and phosphates (95-99%) resulting in ready uptake by plants. The mechanism involved is by production of phosphatase enzymes, organic acids (succinic acid, oxalic acid, glutamic acid, citric acid, malic acid and fumaric acid), CO_2, H_2S, alkalinity production and interacts symbiotically with the other fungal mycorrhiza which are involved in mobilization (Etesami *et al*., 2021). Proton extrusion *i.e* solubilization without acid production is another mechanism. Microbes involved are *Bacillus polymyxa, Aspergillus awamori and Penicillium digitatum etc.*

3. Vesicular Arbuscular Mycorrhiza (VAM): VAM are intercellular and obligatory endosymbionts. Mycorrhiza is a mutualistic symbiosis between plant roots and fungi which mobilizes phosphates and micronutrients from adjacent soil to roots. VAM has the ability to inhibit *Rhizoctonia solani*, *Pythium sp*. and *Fusarium oxysporium* in addition to beneficial effects in drought and saline conditions.

4. Potassium-solubilizing bacteria (KSB): These are soil microbes capable of releasing potassium (K) from insoluble minerals, aiding in plant uptake (Patel *et al*., 2021). They secrete organic acids like gluconic and citric acid, which dissolve potassium from minerals like feldspar. Bacteria such as *Bacillus*, *Pseudomonas*, and *Enterobacter* are known as KSB. Their activity enhances soil fertility, promoting plant growth, yield, and soil health.

5. Zinc-solubilizing bacteria (ZSB): They convert insoluble zinc into soluble forms (Zn^{+2}) *via* organic acids secretion (Nitu *et al*., 2020). Common species include *Bacillus*, *Pseudomonas*, and *Rhizobium*. Their action improves soil fertility and boosts zinc availability for plants, enhancing growth and health.

Method of application of biofertilizers in vegetables

There are mainly four methods of application which includes seed treatment, cuttings treatment, seedling dip and soil application. Various commercially available biofertilizers are given in the table 2.

1. Seed treatment: About 200g of bio-fertilizers in 400 ml water is sufficient to treat 10-14 kg of seed. Spread the seeds in shade for drying for 10-15 minutes then sow them immediately.

2. Cutting/Set treatment: Culture suspension is prepared by mixing 1 kg of culture in 50-60 litres water. The cut pieces of planting material required for 1 acre kept immersed in the suspension for 10-15 minutes followed by drying and planting. Eg: Potato

3. Seedling treatment: Prepare the suspension by mixing 1 kg of culture in 10-15 litres of water. Get seedlings required for 1 acre and make small bundles of seedlings and dip them for 15- 20 minutes followed by immediate transplant. Recommended for transplantable crops like tomato, chilli, onion etc.

4. Soil Application: Culture prepared by mixing 2-3 kg of bio-fertilizer in 40-60 kg of soil/compost. Broadcast the mixture in one acre of land either at sowing time or 24 hr before sowing.

Advantage of Bio-Fertilizers

1. Biofertilizers are capable of nitrogen fixing, phosphate solubilizing, phosphate mobilizing, and promotion of rhizobacteria. 2. Offers eco-friendly substitute for the adverse effects of agrochemicals used in recent agricultural practices. 3. Biological fertilizers can mobilize nutrients that favour the development of physical, chemical and biological activities in soils. 4. Help to eliminate plant phytopathogens causing diseases and provide continuous supply of micronutrients to the soil.

Table 2: Commercially available biofertilizers

Biofertilizer	Bacteria	Beneficial Effect
Advene	*Fraturia* sp	Enhances the potash uptake in plants, prevent soil erosion, improves the soil texture & fertility, plant immune system and soil health. Dosage: Mix 2-3ml per liter of water can be used as seed treatment/ drip irrigation / FYM.
Zinc Solubilising Biofertiliser	Zinc Solubilising bacteria	Dosage: 1. Root Treatment: Take 250 ml liquid biofertilizer and make the solution in 4-5 liters of water. 2. Soil Treatment: Mix 300-400ml liquid biofertilizer with 50-100 kg of soil/sand/compost.
Soil Gold	*Azotobacter* sp.	Improves germination percentage, increases the number of tillers and develops an effective root zone. Provides tolerance against soil-borne diseases by secretion of metabolites. Dosage: Soil application - 3.5 Kg per acre Nursery Application: 50 g / 100 sqm
Bacsubtil	*Bacillus subtilis*	Provides zinc and phosphorous to the plant, stimulates plant growth, activates soil biologically Dosage: Root dipping 500 ml/acre. Soil drenching 2 litres mixed with water at 0.5 percent concentration and applied to root zone

Vici Routz GR	Phosphate Solubilizing Bacteria	Improves soil health, stimulates the crop growth and root system, nutrient uptake, drought tolerance and disease resistance. Dosage: Seasonal crops: 3 – 6 kg per acre. Perennial crops: 3 – 6 kg. Use 500 gm to nursery plants raising for one acre.
Rhizobium	Brady Rhizobium	Rhizobium colonizes the root nodules of legumes and fixes nitrogen utilizing the host carbohydrates as an energy source. A minimum of 25 – 30 kg nitrogen per hectare per season is fixed through its actions, which exceeds plant usage.

Constraints in the use of Biofertilizers

1) Production constraint a) Raw material: Peat and lignite, being the ideal carriers are not available in India in sufficient quantity and quality. b) Specificity of strain: Living strains of biofertilizers are soil and climate specific which limits widespread and expected use. c) Biological constraint: Ineffective and antagonistic strains are unable to remove easily and also reduce efficiency of beneficial microbes present within biofertilizers. d) Technical constraint: Mutation arises during fermentation, resulting in reduction of effectiveness of the bio-inoculants. e) Economics of the Production: Initial bioformulation preparation needs high-tech machines and sophisticated environment, absence of which results in contamination of the product.

2) **Field level constraints**- Existing soil conditions such as acidity, alkalinity, pesticides application and high nitrate level, toxic and deficient nutrients limit the nitrogen-fixing ability of the inoculants resulting in poor results of inoculants.

3) Marketing constraint- a) The life span of biofertilizers is short. b) Limited demand which is due to lack awareness among farmers.

Conclusion

Biofertilizers can be eco-friendly sustainable approach for improved nutrient availability, organic carbon, accumulation of soil enzymes and soil fertility which enhances the vegetable production. Awareness about ill effects of using agrochemicals and benefits of living strains has set a demand among the farmers to use biofertilizers.

References

1. Etesami, H., Jeong, B. R. and Glick, B. R. (2021). Contribution of arbuscular mycorrhizal fungi, phosphate–solubilizing bacteria, and silicon to p uptake by plant. *Front. Plant Sci*. **12**, 699618. doi: 10.3389/fpls.2021.6 99618.
2. Nitu, R., Rajinder, K. and Sukhminderjit, K. (2020). Zinc solubilizing bacteria to augment soil fertility—A comprehensive review. *Int. J. Agri. Sci. Vet. Med.* **8**, 38–44.
3. Patel, S. H., Viradiya, M. B. and Prajapati, B. J. (2021). Effect of potassium and potassium mobilizing bacteria (KMB) with and without FYM on yield of wheat (*Triticum aestivum* L.). *Pharmac. Phytochem.* **10**, 1615–1620.
4. Roy, S., Liu, W., Nandety, R. S., Crook, A., Mysore, K. S. and Pislariu, C. I. (2020). Celebrating 20 years of genetic discoveries in legume nodulation and symbiotic nitrogen fixation. *Plant Cell.* **32**, 15–41. doi: 10.1105/tpc.19.00279.
5. Table 2: Commercially available biofertilizers (Online): Information taken from Amazon shopping portal.