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## Role of biofertilizers in vegetable crop production: A review

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### Abstract

The increasing impact of agricultural practices on environment in the world have progressively affected the soil quality in both cases i.e soil structure as well as soil biological balance, which requires the advancement of substitution of practices to minimize and lessen those impacts, parallel to the improvement on yield per cultivated area and economic benefits for producers and farmers. In addition to this, the quantity of foodstuff that today's society require for processing and supply of the industry has encouraged the standard of new options for agricultural practices, tending to be: i) Less invasive to environment ii) Cost effective than conventional methods iii) Enhanced efficiency at low costs iv) Better quality of harvests and v) Simplified use of implements with no undue technical needs.

Consequently, a technology i.e biofertilization came into existence so as to curtail environmental impacts and take full advantage of the available resources. Biofertilizers have clear-cut benefits over chemical inputs. Chemical fertilizers supply N, P, K whereas bio-fertilizers provide besides N,P,K certain growth promoting substances like hormones, vitamins, amino-acids, etc. Bio-fertilizers are well-known as a substitute to chemical inputs to augment soil fertility and crop production in sustainable farming. The application of bio-fertilizers efficiently enriches the soil and costs not more than chemical fertilizers, which harm the environment as well as exhaust non-renewable energy sources. The application of chemical nitrogen and phosphorus fertilizers at higher levels leads to accumulation of  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{PO}_4$  in vegetable product tissues. Therefore clean agriculture recently depends upon using biofertilizers as well as organic products so as to give high yields with the best product quality devoid of contamination and less accumulation with heavy metals.

**Keywords:** Agricultural practices, bio-fertilizers, chemical fertilizers, yield, organic products

### Introduction

Organic farming is emerging as a main concern area worldwide taking into consideration the growing demand for risk-free and healthy food, long term sustainability and concerns on environmental pollution linked with haphazard use of chemical inputs in agricultural system (Mishra *et. al.* 2103) [15]. Biofertilizers, one of the fundamental components of organic farming play an imperative role in maintaining long term soil fertility and sustainability by fixing atmospheric nitrogen, mobilizing various micro and macro nutrients in the soil, hence increasing their availability as well as efficiency (Mahdi *et. al.* 2010) [14]. The term biofertilizer has been coined to include soil micro-organisms which fix nitrogen, mobilize or conserve plant nutrients. Biofertilizers are based on renewable sources available in the soil and nature and are low cost input and eco-friendly. These inocula carrying the organism when applied to soil promotes specific biochemical activity in rhizosphere.

Biofertilizers are the preparations containing specific strains of microorganisms which can boost the microbiological processes *viz*, nitrogen fixation, phosphate solubilisation or mineralization, excretion of plant growth promoting substances and cellulose or lignin biodegradation in soil. Biofertilizers when incorporated into the soil or applied to seed or plant roots, colonize the rhizosphere or the interior of the plant and promote growth by enhancing supply or accessibility of primary nutrients to host plant.

### How biofertilizers work?

- Fixation of atmospheric nitrogen in the soil and root nodules of legume crops and make it available to the plant.

- Solubilising the insoluble forms of phosphates like tricalcium, iron and aluminium phosphates into plant available forms.
- Scavenging the phosphates from soil layers.
- Production of the hormones and anti metabolites that promote root growth.
- Decomposition the organic matter.

### Characteristics of some biofertilizers

#### Rhizobium

Rhizobium is a rod-shaped, gram negative, non-spore forming aerobic, typically mobile bacteria measuring 0.5 to 0.9µm wide and 1.2 to 3.0µm in length. A soil habitat bacterium that is capable of colonizing the legume root and fixes the atmospheric elemental nitrogen symbiotically into plant usable form. It can fix up to 50-100 kg N/ha/year, especially important for legumes and oilseeds. Process of nodulation occurs in the roots of the plant. The growth promoting chemicals excreted by plants into the root zone stimulate the micro-organism's growth (rhizobia) which then aggregate at distinct sites near roots. Little or no adhesion is evident between rhizobia and plants of heterologous cross inoculation group (Bohlool and Schmidt 1974 and Dazzo and Hupbell, 1975) [5, 6]. Invasion of rhizobia occurs through root hairs which curl under the influence of some chemicals. *Rhizobium* excretes one or more compounds probably including nucleic acid and polysaccharide or protein which may be involved in deformation of root hairs (Solheim and Raa, 1973) [17]. A hypha like infection thread is formed due to rhizobial penetration into the root hair. The structure finally consists of central core containing the rhizobia and a surrounding cortical area in which is found the plant vascular system and thus the bacterium establishes contact with host bundles.

Rhizobium inoculation has beneficial effects on legume crop

growth and yield. However, several strains have been identified that are specific to certain crops and named after the crops they infect.

#### Rhizobium groups

Rhizobium groups	Crop groups	Leguminous crops
<i>Rhizobium leguminosarum</i>	Pea	Peas, lathyrus, lentil
<i>R. japonicum</i>	Soybean	Soybean
<i>R. phaseoli</i>	Beans	Kidney and garden beans
<i>R. trifoli</i>	Clover	Clovers
<i>R. meliloti</i>	Alfalfa	Melilotus, medicago(alfalfa)
<i>R. lupini</i>	Lupini	Lupines
Various	cowpea	Cowpea, peanut, pigeonpea

#### Amount of nitrogen fixed by *Rhizobia* in symbiosis with different legumes

Leguminous crops	Nitrogen fixed (kg/ha)
Pigeonpea	7-235
Green gram	9-112
Cowpea	9-201
Common bean	0-125
Faba bean	53-330
Pea	17-244

#### Influence of biofertilizers on plant growth and seed yield of Pea (*Pisum sativum* L.)

Kothiyari *et al* (2017) [12] studied the influence of biofertilizers on plant growth and seed yield of Pea (*Pisum sativum* L.). Based on the mean performance of different treatments, it was observed that treatment 9 (RDF + Rhizobium (200g/kg seed) was found best treatment for plant growth and seed yield. Thus it indicated that the process of seed treatment by biofertilizers may be better option for seed growers to achieve higher yield attributes in pea.

Treat.no.	Treatment	Pl. ht (cm)	No. of leaves/plant	No. of pods/plant	Days of maturity	Pod length (cm)	No. of seeds/pod	Seed yield /plant (g)	Nodules/plan Nodule/plant
T1	control	42.20	30.45	10.75	84.65	7.15	4.80	14.55	160
T2	RDF + Azotobacter (100g/kgseed)	43.15	31.26	13.25	83.00	7.90	5.45	14.95	14.35
T3	RDF +Rhizobium100g/kg seed)	44.45	30.95	13.00	84.00	7.60	5.20	15.20	14.95
T4	RDF +PSB (100g/kg seed)	45.30	31.65	13.90	83.65	7.40	5.30	15.80	15.20
T5	RDF +Azotobacter (150g/kg seed)	45.35	30.75	12.90	82.65	7.35	5.15	15.55	16.55
T6	RDF+ Rhizobium (150g/kg seed)	46.90	32.00	13.15	83.30	7.70	5.25	16.00	18.05
T7	RDF + PSB (150g/kg seed)	47.55	30.80	13.70	82.30	7.75	5.40	15.90	18.00
T8	RDF + Azotobacter (200 g/kg seed)	44.65	30.85	14.60	84.30	7.50	5.60	15.75	18.80
T9	RDF + Rhizobium (200g/kg seed)	50.65	33.10	16.00	81.65	8.10	6.45	17.35	21.95
T10	RDF +PSB (200g/kg seed)	50.30	32.40	14.75	80.00	8.00	5.75	16.30	20.60

#### Azotobacter

It belongs to Azobacteriaceae, and is aerobic, chemo-heterotrophic and free living. The application of *Azotobacter* reduces the use of 10-20 kg N/ha. It produces growth promoting substances that enhances seed germination and extends root growth. It produces polysaccharides which gives better soil aggregation. *Azotobacter* suppresses the growth of saprophytic and pathogenic micro-organisms near the root system of crop plants. *Azotobacter* helps in maintaining better plant population, growth and yield of crops. In general in cereals, the yield increase are of the order of 15-30% and 10-20% in cash crops. This organism is present in the rhizosphere of a number of crop plants viz., rice, maize, sugarcane, bajra, vegetables and plantation crops (Arun,

2007) [2].

#### Effect of *Azotobacter* and nitrogen on seed germination and early seedling growth in Tomato

Mahato *et al* (2009) [13] evaluated the response of biofertilizer and inorganic fertilizer on germination and growth of tomato plant. Nitrogen was used as inorganic fertilizer and *Azotobacter* was used as biofertilizer. The germination was observed higher in treatment 3 (soil + Azotobacter) as compared to other treatments. It was concluded that *Azotobacter* as biofertilizer reported better than inorganic fertilizers in relation to seed germination and all plant growth parameters described.

Treatment	Germination %	Shoot height (cm)	No. Of leaves/plant	Leaf length(cm)	Width of leaves (cm)
Control (only soil)	60	20.4	3.4	4	4.2
Soil + urea	80	29.5	5.4	6.6	5.7
Soil + Azotobacter	90	35.5	5.6	7.8	7.5

### Azospirillum

They belong to the family Spiriliaceae, are chemo-heterotrophic and associative in nature. They fix atmospheric nitrogen @ 15-30kg/ha and secrete growth regulating substances. Initial observations of (Dobereiner and Day 1974) [7] gave the indication that *Azospirillum* is confined to the root system of those tropical grasses where C<sub>4</sub> (Hatch and Slack Pathway) is operative. However, *Azospirillum* has been isolated from the soils and roots of a variety of plants both from the temperate and tropical regions (Okon *et al.* 1977) [16].

Besides C<sub>4</sub> plants, several C<sub>3</sub> plants including weeds also showed abundant distribution of the organism in the roots.

The bacteria has been noticed to survive within the roots of sorghum, pearl millet (bajra) and *ragi* plants. However, they do not produce any visible nodules or outgrowth on root tissue.

### Effect of biofertilizers on yield attributing characters and yield of Okra (*Abelmoschus esculentus* L. Moench)

Anisa *et al* 2016 [3] studied the effect of different biofertilizers and their combination on yield and yield attributing traits of Okra. Among different treatments, treatment 8 (FYM (double dose) +*Azospirillum* +AMF + *Frateuria*) showed best results for all the parameters.

Treatments	Fruit weight (g)	Fruit girth (cm)	No. of fruits/plant	Fruit yield/plant (g)	Total fruit yield (t/ha)
T1) FYM + <i>Azospirillum</i>	16.80	5.87	20.27	318.20	11.06
T2) FYM + Arbuscular Mycorrhizal Fungi (AMF)	17.00	5.93	22.27	353.67	11.14
T3) FYM+ <i>Frateuria</i>	17.13	6.00	22.47	367.93	11.22
T4) FYM + <i>Azospirillum</i> + AMF	17.47	6.07	22.13	358.53	12.88
T5) FYM + <i>Azospirillum</i> + <i>Frateuria</i>	17.47	6.07	25.93	407.27	13.68
T6) FYM +AMF + <i>Frateuria</i>	17.27	5.87	20.53	320.13	11.69
T7) FYM + <i>Azospirillum</i> +AMF + <i>Frateuria</i>	17.88	6.13	27.80	425.80	14.54
T8) FYM (double dose) + <i>Azospirillum</i> +AMF + <i>Frateuria</i>	19.80	6.17	31.67	544.40	16.33
T9) FYM +1/2 NPK + <i>Azospirillum</i> +AMF + <i>Frateuria</i>	17.27	6.07	26.40	431.47	14.34
T10) FYM +3/4 NPK + <i>Azospirillum</i> +AMF + <i>Frateuria</i>	19.40	6.13	29.60	488.73	15.52
T11) <i>Azospirillum</i> +AMF + <i>Frateuria</i>	17.87	6.07	24.93	408.47	12.67
T12) Manures and fertilizers	17.13	6.07	22.00	360.53	11.75

### Phosphate solubilizing micro-organisms:

PSM includes different group of micro-organisms particularly fungi and bacteria that have been reported to solubilize inorganic phosphates. Such bacteria and fungi grow in medium where insoluble phosphates such as tricalcium, ferric, aluminium and rock phosphates and bone meal are present. PSM in addition of assimilating phosphorus for their own requirement, release sufficient quantities in excess of their needs. The genera of bacteria such as *Pseudomonas*, *Bacillus*, *Aspergillus* and *Penicillium* have been reported being active in the solubilization process (Guar, 1990). The counts of PSB may range between 10<sup>4</sup>-10<sup>6</sup>/g of soil.

The production of organic acids by micro-organisms is one of the important mechanisms but other products such as CO<sub>2</sub>, H<sub>2</sub>S and alkalinity production may be one of the mechanisms of solubilization. PSM produced monocarboxylic acid (acetic, formic), monocarboxylic hydroxy (lactic, gluconic, glycolic), monocarboxylic keto (2-keto gluconic), dicarboxylic (oxalic, Succinic), dicarboxylic hydroxyl acids (malic, maleic) and tricarboxylic (citric) in liquid medium from simple carbohydrates (Sperber 1957) [18]. Tricarboxylic and dicarboxylic are more effective than other types. Chelating substances have also an important role in solubilization of insoluble phosphates. 2-Ketogluconic acid (a powerful chelator of calcium) is produced by many aerobic bacteria and is very effective in solubilization of insoluble phosphates such as hydroxyapatite, fluorapatite and aluminium phosphate. PSM also produces phosphatase enzyme along with acids which are involved in the solubilization of phosphate in

aquatic conditions. Another mechanism is the Proton extrusion i.e solubilization without acid production. It could be due to release of protons accompanying respiration or ammonium assimilation (Kucey, 1983) [10]. Insoluble phosphates in this manner are directly solubilised at the microbial cell surface.

### Mycorrhizae

Most of the plant roots are colonized by fungi and transformed into fungus root organ which are known as "Mycorrhizae". Mycorrhizae result from a mutualistic symbiosis between plant roots and certain fungi. These fungi are omnipresent in soil and are found in the roots of many Angiosperms, Gymnosperms, Pteridophyta and Thallophyta. The mycorrhizal fungi carry out the role of root hairs. The fungus takes carbohydrates from the plants and in turn supplies the plants with nutrients, hormones and protects it from root pathogens. They are essential in increasing plant growth and nutrient uptake (Bagyaraj, 1992) [4]. Certain mycorrhizal fungi inhibited *Rhizoctonia solani*, *Pythium* sp. and *Fusarium oxysporium*. *Sclerotinia aurantium* has also been shown to lessen the incidence of disease caused by *Pythium* and *Fusarium*. They also enhances plant growth by improving mineral nutrition. The hyphae extends beyond root zone and directly translocate nutrients from the soil to root cortex (Hayman, 1983) [9] in arbuscules where exchange of carbon and phosphorus is done. The beneficial effects of VAM fungi have also been reported in the drought and saline conditions. The important feature is that in drought conditions

a mycorrhizal root has ability to get additional water sources unavailable to non-mycorrhizal plant roots (Allen and Boosalis, 1983) [1]. Analytical and physiological studies have revealed that mycorrhizal plants show some beneficial effects viz., increased rate of respiration, photosynthesis and higher levels of sugar, amino acids, RNA etc and large or more number of chloroplasts, mitochondria, xylem vessels, motor cells (Hayman, 1983) [9].

### Blue Green Algae

The microscopic as well as macroscopic algae form a very important renewable resource of the aquatic environment. The microscopic algae, which are collectively called as phytoplankton, produce basic organic matter forming the first link in the food chain and simultaneously replenish the oxygen content of the atmosphere. The macroscopic, commonly called as sea weeds flourish in littoral and sub littoral regions of the marine environment where there is appropriate rocky or coral substratum for them to grow. Based on the type of pigmentation, they are classified into Chlorophyceae (green algae), Phaeophyceae (brown algae), Rhodophyceae (red algae) and Cyanobacteria (blue-green algae). Nitrogen fixed by BGA becomes available to the associated plant either by exudation or their mineralization

after the death of blue-greens. Besides the contribution of nitrogen, growth-promoting substances liberated, algae play a significant role in sustaining the crop yield. Production of auxin like substances and vitamins by BGA increased the root growth and yield of the rice crop. Cyanobacteria being phototrophic, continuously add organic compounds during their growth on the upper soil surface. The application of Cyanobacteria in saline soils lowers the pH towards neutrality, replaces  $\text{Na}^+$  by  $\text{Ca}^+$  and thus partially reclaims the problem soils (Kaushik, 1989) [11]. The growth of algae also improves the physical, chemical and biological properties of soil. The infiltration rates, hydraulic conductivity and permeability of the soil due to algal inoculation are improved. Soil compaction is also reduced in the upper soil surface due to algal inoculation.

### Effect of seed soaking with culture filtrate of Blue-green alga, *Microcoleus vaginatus* for the control of root knot nematode, *Meloidogyne incognita* on Okra.

Zakaullah *et al.* (1999) [19] studied the effect of seed soaking treatment with culture filtrate of *M. Vaginatus* on multiplication of *M. Incognita*. The blue green alga, *Microcoleus vaginatus* was found to parasitize and kill plant-parasitic nematodes.

Treatments	Plant ht. (cm)	Dry wt. of shoot (g)	Dry wt. of root (g)	No. of galls	Nematode popl/200CC soil
Control	46.12	5.98	0.44	101.8	2178.94
S	60.31	7.92	0.74	50.3	403.25
S/2	59.84	7.21	0.66	52.40	578.84
S/10	54.93	6.48	0.61	52.40	630.19
S/100	50.44	5.86	0.57	60.63	940.0

### Potential role of Biofertilizers

- Offers new eco-friendly technology that could overcome shortcomings of the conventional chemical based farming
- Positive influence on both soil sustainability and plant growth
- Restores depleted nutrients in the soil
- Eliminate plant diseases
- Gradually improves soil fertility by improving organic matter content in soil
- Increase phosphorus content in the soil
- Improve plant root proliferation by releasing plant growth promoting substances

### Constraints in the use of Biofertilizers

#### 1) Production constraint

- Raw material:** Peat and lignite are regarded as ideal carriers for biofertilizers. However it is not available in India in sufficient quantities and in desirable quality.
- Specificity of strain:** Most of the biological strains of biofertilizers are soil and agro-climatic specific. This limits their widespread and foolproof use with expected performance.
- Biological constraint:** Presence of ineffective or antagonistic strains in the bio-inoculants, which cannot be displaced easily, reduces the overall efficiency of friendly microorganism in the biofertilizer.
- Technical constraint:** Mutation arises during fermentation, resulting in reduction of effectiveness of the bio-inoculants.
- Economics of the Production:** For the production of quality product, use of high-tech instruments and equipments is discernible. In the absence of these facilities, it is difficult to ensure the production of truly

contamination free product.

#### 2) Field level constraints

- Existing soil conditions such as acidity, alkalinity, pesticides application and high nitrate level limit the nitrogen-fixing ability of the inoculants resulting in poor results of inoculants.
- Presence of certain toxic elements and deficiency of P, Cu, Co and Mo is unfavourable for bacterial fertilizers.

#### 3) Marketing constraint

- The life span of biofertilizers is short. The shelf-life of the biofertilizer with carriers like peat or lignite is time and again less than six months.
- Limited demand which is due to lack awareness among farmers.

### Future of biofertilizers

Lack of infrastructure for biofertilizers is a great challenge for the biofertilizer industry, the outlook for the sector is positive. As the EU's 2020 project Bio-Fit explains, "the biofertilizer market is expected to grow at a CAGR Of 12.9% from 2016 to 2025.

This is due to several factors, including;

- The requirement of advertisement of the adverse effects of chemical fertilizers, such as algal bloom
- The further expansion and enhancement of biofertilizer technology
- More acceptance among farmers
- Intensification in awareness about the serious impact of chemical fertilizers and augmented demand for organic produce

## Conclusion

- Biofertilizers increase the availability of plant nutrients and can help in maintenance of long term soil fertility.
- Biofertilizers play a great role in nitrogen fixation, solubilizing insoluble phosphates to plant available forms
- Biofertilizers are cost-effective, recyclable and eco-friendly.
- Biofertilizer use is an imperative component in integrated nutrient management and organic farming.
- The altering set-up of agricultural practices and environmental hazards related to chemical fertilizers demand a more important role of biofertilizers in future.

## References

1. Allen MF, Boosalis MC. Effect of two species of VA mycorrhizal fungi on drought tolerance of winter wheat. *New Phytopathology* 1983;93(1):61-76.
2. Arun KS. Biofertilizers for sustainable agriculture. Mechanism of P-solubilization Sixth edition, Agribios Publishers, Jodhpur, India 2007,196-197p.
3. Anisa NA, Markose BL, Joseph S. Effect of biofertilizers on yield attributing characters and yield of Okra (*Abelmoschus esculentus* L. Moench). *International journal of pure science and agriculture* 2016;2:59-62.
4. Bagyaraj DJ. 19 vesicular-arbuscular Mycorrhiza: Application in agriculture. *Methods in Microbiology* 1992;24:359-373.
5. Bohlool BB, Schmidt EL. Lectin: a possible basis for specificity in the Rhizobium-legume root nodule symbiosis. *Science* 1974;185:269-271.
6. Dazzo FB, Hubbel DH. Cross-reactive antigens and lectin as determinants of symbiotic specificity in the Rhizobium-clover association. *Applied Microbiology* 1975;30(6):1017-1033.
7. Dobereiner J, Day JM. Symposium on Nitrogen fixation-interdisciplinary disussion, Pullman, Washington, USA 1974,518-529p.
8. Gaur AC. Phosphate Solubilizing Microorganisms as biofertilizers. Omega Scientific Publishers, New Delhi 1990,176p.
9. Hayman DS. The physiology of vesicular-arbuscular endomycorrhizal symbiosis. *Canadian Journal of Botany* 1983;61(3):944-963.
10. Kucey RMN. Phosphate solubilizing bacteria and fungi in various cultivated and virgin Alberta soils. *Canadian Journal of Soil Science* 1983;63(4):671-678.
11. Kaushik BD. Reclamative potential of Cyanobacteria in salt-affected soils. *Phykos* 1989;28(1):101-109.
12. Kothiyari HK, Yadav LK, Jat R, Gurjar PC. Influence of biofertilizers on plant growth and seed yield of pea (*Pisum sativum* L.). *International journal of current Microbiology and Applied sciences* 2017;6(11):1810-1817.
13. Mahato P, Badoni A, Chauhan JS. Effect of Azotobacter and Nitrogen on Seed Germination and Early Seedling Growth in Tomato. <http://www.sciencepub.net>. *Researcher* 2009;1(4).
14. Mahdi SS, Hassan GI, Samoon SA, Rather HA, Dar SA, Zehra B. Biofertilizers in organic agriculture. *Journal of Phytology* 2010;2(10):42-54.
15. Mishra DJ, Singh R, Mishra UK, Kumar SS. Role of biofertilizer in organic agriculture. *Research Journal of Recent Sciences* 2013;2:39-41.
16. Okon Y, Albrecht SL, Burris RH. Methods of growing *Spirillum lipoferum* and for counting it in pure culture

and in association with plants. *Applied Environmental Microbiology* 1977;33(1):85-88.

17. Solheim B, Raa. Characterization of the substances causing deformation of root hairs of *Trifolium repens* when inoculated with *Rhizobium trifoli*. *Journal of General Microbiology* 1973;77(2):241-243
18. Sperber J. Solution of mineral phosphates by soil bacteria. *Nature, London* 1957;180:994-995.
19. Zakaullah K, Shamim MJ, Khan MW. Efficacy of seed soaking with culture filtrate of a blue-green alga, *Microcoleus vaginatus* for the control of root knot nematode, *Meloidogyne incognita* on Okra. *Indian Journal of Nematology* 1999;29(1):82-84.