Plant Archives **Vol. 25, Special Issue (ICTPAIRS-JAU, Junagadh) Jan. 2025 pp. 127-130**
e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.SP.ICTPAIRS-022

BIOFERTILIZERS: A SUSTAINABLE SOLUTION FOR TROPICAL FRUIT CROPS

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ABSTRACT

India, the world's second-largest fruit producer, faces challenges in increasing production due to reliance on costly and environmentally harmful chemical fertilizers. To address this, organic alternatives have emerged, particularly biofertilizers. Bio-fertilizers are microorganism-based products that enhance soil fertility, promote plant growth, and increase nutrient availability. These beneficial bacteria and fungi colonize the rhizosphere, mobilizing nutrients and reducing chemical fertilizer dependence. It comprising nitrogen-fixing and phosphate-solubilizing microorganisms, biofertilizers are a viable solution for Indian farmers, mitigating chemical fertilizer dependence and ensuring long-term soil health. Bio-fertilizers offer numerous environmental benefits, including reduced water pollution, improved soil sustainability, increased crop yield and quality, fixed atmospheric nitrogen, mobilized macro, micro nutrients and converted insoluble phosphorus into plant-available forms. As chemical fertilizers' costs and environmental impacts rise, bio-fertilizers become a vital component of organic farming. Excessive chemical fertilizer reliance is unsustainable due to high production costs, foreign exchange expenses and environmental degradation. Bio-fertilizers provide a viable alternative for farmers to boost productivity, ensuring long-term soil fertility and sustainability. By adopting bio-fertilizers, farmers can reduce their dependence on chemical fertilizers, improve crop quality and contribute to environmentally sustainable agriculture. This shift is crucial for maintaining ecological balance, promoting sustainable agriculture and ensuring a healthy environment for future generations.

Key words : Biofertilizers, Chemical fertilizer, Environmental, Farmer, Fertility, Microorganism, Sustainability.

Introduction

India is the second largest producer of fruits in the world with annual production of 10,71,02,000 MT from 70,19,000 ha (Anonymous, 2021). Now, farmers are facing difficulty in further increase in fruit production. In the recent years, there is an urgent need to supplement the fossil fuel based inorganic fertilizers not only due to the hike in prices of chemical fertilizers but also a need is felt to maintain long term soil productivity and ecological sustainability (Hazarika and Ansari, 2007). The increasing cost of chemical fertilizers and their harmful effects on soil health became a major issue for the growers. Hence, in the recent years, many organic fertilizers have been introduced that act as natural stimulators for plant growth.

A particular group of organic fertilizers includes outcomes based on plant growth promoting microorganisms identified as 'Biofertilizers'. Biofertilizers are use in live formulation of beneficial microorganism which on application to seed, root or soil. Biofertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilize plant nutrients in soil from unusable to usable form through biological process. They are environmental and ecofriendly and play significant role in crop production. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.

These biofertilizers comprised efficient strains of nitrogen fixing or phosphate solubilizing microorganism. Biofertilizers are microorganisms which are capable of mobilizing nutrients from non-usable form to usable form through biological process. They are a cost effective and inexpensive source of plant nutrients, do not require non-renewable source of energy during their production, improve crop growth and quality of the product by producing plant hormones and help in sustainable crop production through maintenance of soil productivity. They are also useful as biocontrol agents, since they control many plant pathogens. Certain biofertilizers have ability to absorb and convert atmospheric nitrogen to readily available form to the plants. Certain biofertilizers solubilize the bound phosphates of soil and their by make them available to the plants. Stimulate plant growth through synthesis of growth promoting substance (IAA and gibberellins).

Different types of biological fertilizers

There are several types of biofertilizers, each playing a unique role in improving soil health and increasing crop production. Some of them are nitrogen fixing biofertilizers, such as *Rhizobium*, *Azospirillum* etc. convert atmospheric nitrogen into a form that plants can use, thus reducing the need for chemical fertilizers. Phosphate solubilizing biofertilizers, such as *Bacillus* and *Pseudomonas etc*. make insoluble phosphorus in the soil available to plants, enhancing rot development and overall growth. Some potassium solubilizing biofertilizers, like *Rhizoctonia* and others help release potassium from soil minerals, making it more accessible for plant uptake. Over all as per the work of biofertilizer that can be different type as per given in Table 1.

Application methods of biofertlizer

Review of literatures

Mango (*Mangifera indica* L.), Family: Anacardiaceae

Kundu *et al.* (2011) revealed that the soil application of 100% NPK + 250 g/plant VAM + 250 g/plant *Azotobacter* were most effective to yield (98.1 kg/plant), fruit weight (318.3 g), TSS (19.55 °Brix), total sugar (12.77%), acidity (0.32%) and ascorbic acid (68.3 mg/100g) of mango cv. Amrapali.

Dutta *et al.* (2016) concluded that the biofertilizer 150 g/plant *Azotobacter* + 100 g/plant PSM along with 50% inorganic fertilizer significantly increased the plant height (6.72 m), canopy spread (6.37 × 6.92 m), trunk girth (79.32 cm), fruit weight (285.15 g) and yield (57.20 kg/plant) of mango cv. Himsagar.

Sau *et al.* (2017) studied that combined application of *Azotobacter chorococcum* + *Azospirillum brasilense* + AM + Panchagavya 3% showed maximum plant height (11.12 m), canopy spread (11.11 m), fruit weight (237.12 g), fruit yield (42.14 kg/plant), fruit biochemical qualities like TSS (19.70 °Brix) and total sugar (13.41%) and soil properties like soil bacterial population (3.1×10^6 cfu/g soil) along with prolonged shelf life of 10 days in mango.

Rathod *et al.* (2022) revealed that the maximum fruit weight (345.31 and 335.56 g), fruit length (13.50 and 12.93 cm), fruit diameter (8.22 and 7.90 cm), number of fruits

Table 1. Types of biofertilizers

Nitrogen (N_2) fixing Biofertilizers		
1.	Free-living	Azotobacter, Clostridium, Anabaena, Nostoc
2.	Symbiotic	Rhizobium, Frankia, Azolla
3.	Associative Symbiotic	Azospirillum
P solubilizing biofertilizers		
1.	Bacteria	*Bacillus megaterium* var. *phosphaticum*, *Bacillus circulans*, *Pseudomonas striata*
2.	Fungi	*Penicillium* spp., *Aspergillus awamori*
K mobilizing biofertilizers		
1.	Arbuscular mycorrhiza	*Glomus* spp., *Gigaspora* spp., *Acaulospora* spp.
2.	Ectomycorrhiza	*Laccaria* spp., *Pisolithus* spp., *Boletus* spp., *Amanita* spp.
3.	Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for Micro nutrients		
1.	Silicate and Zinc solubilizers	*Bacillus* spp.
2.	PGPR	*Pseudomonas fluorescens*

Table 2 : Method of biofertilizer applications.

	Methods	Rate
1.	Seed Treatment	25-30 g per 1.0 kg seeds *i.e.* 200-250 g per 8 -10 kg seeds
2.	Seedling Treatment	1-2 kg per ha
3.	Soil Treatment	2-3 kg per ha
4.	Sets Treatment	2-3 kg per quintal of sets

per tree (204.95 and 198.58), fruit yield (85.75 and 82.62 kg/tree), fruit yield (13.38 and 12.89 t/ha), TSS (23.89 and 23.04 °Brix), Vitamin - A (1.41 and 1.38 mg/100g) and total sugar (19.33 and 18.89 %) were found in the combined effect of drenching of biofertilizers like Bio NPK Consortium (10 ml/tree) + VAM (10 g/tree) at pea stage with spraying of novel organic liquid nutrient (2%) per tree twice at 2nd week of April and 1st week of May showed of mango cv. Mallika.

Sapota (*Manilkara achrus* Mill. Forsberg), Family: Sapotaceae

Baviskar *et al.* (2011) revealed that the soil application of 1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant obtained significantly higher number of fruits/plant (1569.33), fruit yield (197.53 kg/plant), fruit weight (125.87 g), fruit volume (117.20 cc), pulp weight/fruit (101.66 g), peel weight/fruit (22.50 g), TSS (23.16°Brix), total sugar (18.03%) and lower acidity (0.050%) in sapota.

Patel *et al.* (2017) obtained maximum TSS (24.50 °Brix), ascorbic acid (20.37%), shelf life (8.05 days), reducing sugar (10.52%), non-reducing sugar (12.01 %), total sugar (22.53%) and lower acidity (0.21%) with soil application of 75% NPK + vermicompost 15 kg + AAU Bio NPK 10 ml/tree in sapota cv. Kallipati.

Papaya (*Carica papaya* L.), Family: Caricaceae

Singh and Varu (2013) observed that ½ RDF (100:100:125 NPK g/plant) + *Azotobacter* @ 50 g/plant + PSB @ 2.5 g/m2 gave maximum survival (98.67 %), plant height at harvesting stage (286.67 cm), stem girth at harvesting stage (39.00 cm), number of leaves per plant (24.00), harvesting span (104.00 days), fruit length (30.00 cm), fruit girth (22.00 cm), fruit weight (1670.00 g), seed weight/fruit (80.60 g), maximum number of fruit/ plant (45.33), fruit yield (78.00 kg/plant), fruit yield (313.00 kg/plot), marketable fruit yield (299.00 kg/plot), fruit yield (259.97 t/ha) and minimum days taken to first flowering (65.33), days taken to first fruit harvest (161.00) in papaya cv. Madhubindu.

Srinu *et al.* (2017) revealed that the application of 75% RDF + 10 kg VC + 100 g *Azotobacter* + 100 g PSB per plant gave higher values of growth characters viz., plant height (212.85 cm), trunk girth (52.48 cm), petiole length (52.93 cm), number of leaves per plant (46.85), minimum days taken to first flowering (139.64) and lowest days taken to fruit maturity (200.82), yield characters *viz.*, highest numbers of fruits per plant (32.22), fruit yield (31.72 kg/plant) and quality parameters *viz.*, maximum firmness (8.36 kg/cm^2), TSS (10.62°Brix), ascorbic acid (23.63 mg/100g of pulp), minimum PLW (9.71%) and titrable acidity (0.13%) in papaya cv. Red Lady.

Agrawal and Sahu (2021) reported that maximum fruit yield/plant (38.95 kg) and per ha (116.86 kg), were found significant in papaya plants supplied with RDF + *Azospirillum* @ 10 g/plant + PSB @ 10 g/plant. Regarding quality parameters, lowest titratable acidity (0.015%) and higher content of total soluble solids (8.00 °Brix), total sugars (9.73%) were also noted in treatment RDF + *Azospirillum* @ 10 g/plant + PSB @ 10 g/plant.

Banana (*Musa paradisiaca* L.), Family:Musaceae

Lenka and Lenka (2014) revealed that significantly maximum number of hands per bunch (8.53), number of fingers per hand (135.94), weight of bunch (19.17 kg), fruit yield (53.67 t/ha), weight of finger (136.71 g), length of finger (23.77 cm) was observed in combination of RDF 100% + PSB @ 25 g/plant + *Azospirillum* @ 25 g/plant in banana var. Grand Naine.

Hussain *et al.* (2015) studied that the application of 80% RDF + 20% RDN through vermicompost + biofertilizers *viz.*, 50 g *Azospirillum*, 50 g PSB and 25 g KMB/plant gave maximum number of hands/bunch (10.75), number of fruits/bunch (156.50), fruit length (23.12 cm), fruit girth (14.37 cm), bunch weight (24.53 kg) and fruit yield (68.02 t/ha) in banana var. Grand Naine.

Chhuria *et al.* (2016) concluded that the maximum pseudostem height (185.24 cm), pseudostem girth (59.60 cm), total number of leaves (38.73), number of leaves at shooting (12.82), number of hands per bunch (9.45) and number of finger per bunch (152.40), weight of finger (133.67 g), weight of bunch (24.86 kg), length of finger (22.31 cm), pulp:peel ratio (4.2), ascorbic acid (12.33 100 µg/ml), and yield (76.72 t/ha) were observed in combination of 100% RDF + 125 g *Azotobactor* + 125 g *Azospirillum* + 125 g PSB at 3rd, 5th and 7th month after planting in banana cv. Grand Naine.

Guava (*Psidium guajava* L.), Family: Myrtaceae

Dutta *et al.* (2014) revealed that the application of *Azospirillum* @ 50 g/plant +*Azotobacter* @ 50 g/plant +VAM @ 50 g/plant were most effective for improving the fruit weight (132.40 g), fruit length (5.92 cm), fruit yield (6.43 t/ha), TSS (9.20 °Brix), total sugar (7.77%) , ascorbic acid (167.22 mg/100 g), lower acidity (0.29%) and maximum content of leaf minerals viz., nitrogen (1.49% dry weight), phosphorus (0.42% dry weight) and potassium (1.52 % dry weight) in guava cv. L-49.

Jamwal *et al.* (2018) studied that the maximum number of fruits/tree (21.00), average fruit weight (190.10 g), fruit length (7.10 cm), fruit diameter (7.15 cm), fruit yield/tree (3.99 kg), fruit yield (199.58 q/ha) and fruit volume (192.13 cc) were observed in combination of *Azotobacter* @ 25 g/plant + 75% nitrogen through urea + 25 % vermicompost in guava cv. Allahabad Safeda.

Lodaya and Masu (2019) reported that the soil application of 30% RDF through chemical fertilizers + 30% RDN through poultry manure + 20 ml Bio NPK Consortium per tree treatment was most effective for total soluble solids (11.93 °Brix), reducing sugar (6.35%), non-reducing sugar (1.72%), total sugar (8.07%), ascorbic acid (177.67 mg/100 g pulp). Whereas, the soil application of 40% RDF through chemical fertilizers + 40% RDN through poultry manure + 10 ml Bio NPK Consortium per tree treatment obtained significantly maximum shelf life (8.17 days) of guava cv. Allahabad Safeda.

Singh *et al.* (2020) concluded that the soil application of 75 % RDF + *Azotobacter* (250 g/tree) + PSB (200 g/tree) + VAM (200 g/tree) were most effective for TSS (9.03°Brix), ascorbic acid (180.36 mg/100 g), total number of fruits (257.33 per tree), fruit yield (58.60 kg/tree), fruit yield (9.16 t/ha) and titratable acidity (0.51%) of guava cv. Allahabad Safeda.

Precautions in the use of biofertilizers

- Biofertilizers should be in good quality which containing minimum 107/gm viable microbial count.
- Preserve the biofertilizers away from sunlight, heat and moisture and store them in cool and dry place at room temperature of 25-28^{0}C.
- Chemical fertilizers and biofertilizers should not be applied together as there is possibilities of the microorganisms being killed by them.
- Use only packets or bottles on which batch no., name of manufacturer and expiry date is mentioned.
- Do not mix biofertilizer in warm or hot water.
- Seed coated with biofertilizers should not be treated with fungicides and pesticides.

Conclusion

From the foregoing details, it can be concluded that use of biofertilizers in fruit crops promotes sustainable agriculture by enhancing nutrient availability, improving plant health and boosting yields. Nitrogen-fixing, phosphorus-solubilizing and potassium-mobilizing biofertilizers reduce the need for chemical fertilizers, supporting healthy soil and long-term fertility. These biofertilizers also improve fruit quality by aiding root development, enhancing nutrient uptake and increasing stress resistance. Additionally, they are environmentally friendly sot effective, helping farmers reduce input costs while minimizing pollution. Overall, biofertilizers are a valuable tool in fruit crop production, contributing to healthier crops and more sustainable farming practices.

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