National Research Journal of Business Economics
Volume No: 12, Issue No: 2, Year: 2025 (July-December)
PP: 145-151
ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

ANALYSIS OF BIOFERTILIZERS FOR SUSTAINABLE AGRICULTURE IN INDIA

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ABSTRACT:

The cornerstone of the Indian economy is farming, which is the most popular occupation in the nation. Fertilizers are crucial for agricultural production and healthy crop growth. Recently, farmers have been using chemical fertilizers to speed up the entire procedure and enhance yield. However, these fertilizers threaten the survival of people and animals as well as habitats, soil, and plants. However, in addition to having a larger yield, natural Biofertilizer [BF] are also safe for human consumption. As sustainable agriculture gains momentum, BFs are emerging as a promising substitute for hazardous chemical fertilizers. Both crop productivity and maintaining long-term soil fertility depend on BFs. In order to meet the world's food demand, BFs are essential for crop development and the preservation of soil fertility over the long term. Microbes and crop plants might communicate to enhance the plants' growth, development, and immunity. Nitrogen, phosphorous, potassium, zinc, and silica serve as vital elements for plant growth. However, these nutrients are naturally insoluble or complicated. Some bacteria make them soluble and available to plants. This review addresses the potential of microorganisms, their mechanism of action, and their effects on crops. BFs are a wonderful alternative to expensive and hazardous chemical fertilizers since they are economical, non-toxic, and beneficial to the environment. This review's insights can aid in our comprehension of the importance and processes of microbial development as BFs for agriculture's sustainable crop production.

Key words: Biofertilizers, microbes, sustainable, solubilizers, environment.

1. INTRODUCTION:

By 2050, there will be approximately 9.7 billion people on the planet, reflecting today's pattern of expanding populations [1]. This rapid growth is intrinsically related to intensive industrialization, urbanization, and agricultural production. Traditional agriculture is crucial for meeting the world's food demand, which is projected to exceed 321 million tons by 2020. It further assists countries strengthen their food production self-sufficiency [2, 3]. But the traditional agricultural practices focus mostly on the extensive use of plant-based foods and synthetic fertilizers and pesticides to address diseases [4]. There is no refuting the benefits of using these chemical inputs sparingly for the improvement of crops as well as for farmers' profits. Unfortunately, the growing consumption of artificial resources can put the ecosystem at severe danger from toxins in the air, water, and soil. Due to their careless use and reluctance to biodegrade, agrochemicals accumulate below ground, changing the structure, fertility, and water-holding capacity of the soil in a detrimental way [5]. The high cost of mineral nitrogen and phosphorus fertilizer means that agronomic techniques should be employed to enhance plant nutrient uptake by using microbial vaccinations. For improved soil health, sustainable crops are crucial to the prudent application of pesticides and herbicides in conjunction with organic manures. Due to persistent crop production from soil, the latter gradually loses nitrogen and other nutrients. In an average crop, ordinary nitrogen (N) is extracted from an acre. Therefore, the cultivation must replenish the soil with elements that are eliminated throughout the year. Concern over sustainable soil productivity and

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ecological stability in the use of chemical fertilizers, as well as the current spike in fertilizer costs, have also become important issues. Additionally, farmers with huge hectares tend to reap advantages economically from a high reliance on chemical fertilizers. BFs and organic manures like farmyard manure, compost, and green manures are experiencing popularity again as a result of these factors.

2. BIOFERTILIZERS AND THEIR ROLES

BFs can convert nutritionally significant components into useable forms. Microorganisms in soil need organic materials to flourish and contribute nutrients to plants. BFs employ microorganisms to repair soil nutrient cycles and increase organic matter. BFs promote healthy plant growth while also improving soil health and sustainability. In order to improve soil and/or crop production, BF refers to a product that contains carrier-based (solid or liquid) living microorganisms that are beneficial to agriculture in terms of phosphorus solubilisation, nitrogen fixation, or nutrient mobilisation. There are now just nitrogen and phosphorus BFs available, but research is being done to find organisms that can mobilise or solubilise other minerals or nutrients [6]. Recently, Zn- and K-BFs have also been created, but they have not yet been put on the market. Additionally, BFs are live or biologically active products or microbial inoculants of bacteria, algae, and fungi (either independently or in combination) that can enrich the soil with organic matter, phosphorus, nitrogen, and other elements. Using microorganisms that form symbiotic connections with the plants, BFs function as a substance that improves the soil's nutrient quality [7].

2.1 Working of Biofertilizers

Microbial inoculants, sometimes referred to as bio-fertilizers, are a crucial part of the Integrated Plant Nutrient System (IPNS) and have enormous promise as an additional, sustainable, and eco-friendly source of plant nutrients. BFs fix atmospheric nitrogen in the soil and root nodules of legume crops, making it available to the plants. They convert insoluble forms of phosphate, including tricalcium, iron, and aluminium phosphates, into usable forms. They remove phosphates from the soil layers. They create hormones and anti-metabolites that support root growth. They help to mineralise soil by decomposing organic materials. BFs can raise output by 10% to 20% by increasing nutrient availability without harming the soil or ecosystem [8].

2.2 Benefits of using Biofertilizers

BFs are live microorganisms that can be applied to seeds, roots, or soil to increase nutrient availability and improve soil health. This benefits crops. BFs are intended to increase soil fertility in N and P. They include growth-promoting chemicals.

- **Increasing harvest yields**: Crop yields have increased by 20 to 37 percent on average. Algae-based fertilisers increase rice yields by 10- 45%.
- **Improving soil structure:** Utilising microbial BFs enhances the structure of the soil by affecting how the soil particles aggregate.
- **Better water relation:** By maintaining stomatal function and transpiration, enhancing root length and development, and improving leaf water and turgor potential, arbuscular mycorrhizal colonisation helps plants become drought tolerant.
- **Lowering production costs:** Made with easily accessible organic materials such as rice husks, earth, bamboo, and vegetables. Reduce input costs by replacing chemical fertilisers.

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- **Providing protection against drought and some soil-borne diseases:** Aquatic cyanobacteria contribute natural growth hormones, proteins, vitamins, and minerals to the soil. Azotobacter infuse the soil with antibiotic pesticides, preventing the spread of infections such as Pythium and Phytophthora.
- **Suppressing the incidence of insect pests and plant diseases:** BFs enhance soil quality, protect water sources, and promote plant development without negative side effects [9].

2.3 Advantages of Biofertilizers:

There are many advantages of BFs

- **Soil enrichment:** Creating nutrient-rich soil can increase agricultural yields.
- **Suitable alternatives to synthetic fertilisers**: Chemical fertilisers alter the soil's natural nutritional makeup, whereas BFs keep it constant.
- **Plant-safe:** BFs, which contain natural substances, can help to speed plant development.
- **Helpful for soil microorganisms:** The soil can continue to host helpful microorganisms that are necessary for plant development.
- **Economic:** Farmers can simply generate and harvest BFs, which are much less expensive.
- **Eco-friendly:** They respect the environment and protect it from contamination.
- **Sustainability:** Most BFs are derived from microbial and plant sources. Algae and biogas production both generate considerable amounts of biological material that can be used to make BF.
- **Better soil:** The bacteria in BFs provide air nitrogen directly to your plants.
- **Enhanced plant development and harvest:** BFs allow our crops to acquire more nutrients from the soil.
- **Generally straightforward to apply:** Some BFs require special tools to be applied, while others are incredibly simple to use [10].

2.4 Disadvantages of Biofertilizers

There are many disadvantages of BFs

- **Increasing crop production slightly:** Most organic farmers continue to use synthetic fertilisers to boost their crop yield, but in smaller amounts.
- **Light-sensitive microbes:** If exposed to sunlight for an extended period of time, BFs begin to disappear.
- **Do not replace chemical fertilisers:** Synthetic fertilisers remain the best alternative for farmers when it comes to providing plants with immediate nutrients.
- **Odour:** The majority of BFs have a strong, recognizable odour.
- **Poor efficiency in too-hot or too-dry soils:** Microbial fertilisers require moisture and warmth to act properly. When these circumstances are present, microbial fertiliser may be ineffective at increasing soil fertility.

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- **The soil's qualities influence the efficiency of microbial fertilisers:** Other factors such as outdoor temperature and moisture may have an impact on effectiveness. The efficiency of the soil is determined by its pH, organic content, and the microorganisms that currently exist.
- **Limited shelf life:** Because BFs are living, they require special management when stored for lengthy periods of time. They have a six-month shelf life when stored at room temperature, therefore we must use them before then. If you keep them in a cool place, you'll have two years to use them [10].

2.5 Microbes used as Biofertilizers

The most popular types of microorganisms employed as BFs include:

i. Rhizobia: Rhizobia are bacteria that dwell in nodules on legume roots. They transform atmospheric nitrogen into a form that plants can use, increasing soil fertility and decreasing the demand for synthetic nitrogen fertilisers.

1. **Azotobacter:** It is a type of bacteria that fixes nitrogen and can be found in soil, water, and plant surfaces. It can supply nitrogen to non-legume crops and produce plant growth-promoting chemicals.
2. **Azospirillum:** It is a bacterium that stimulates plant growth by fixing atmospheric nitrogen and stimulating root development. It is frequently combined with other BFs to enhance soil fertility.
3. **Mycorrhizae:** It is a symbiotic relationship between fungi and plant roots that promotes nutrition and water uptake. It also improves soil structure, suppresses plant diseases, and promotes plant growth.
4. **Bacillus subtilis:** It is a soil bacterium that produces antibiotics and growth-promoting chemicals, thereby improving soil structure, suppressing plant illnesses, and increasing plant development.
5. **Pseudomonas fluorescens:** It is a bacterium that produces antibiotics and growth-promoting chemicals such as hormones and vitamins, which can help plants thrive and prevent illnesses.
6. **Trichoderma:** It is a soil fungus that produces antibiotics and releases nutrients, thereby suppressing plant diseases, improving soil fertility, and stimulating plant growth [11].

3. PRODUCTION OF BIOFERTILIZERS IN INDIA

One of the twelve countries in the world with the greatest biodiversity is India. Despite making up only 2.5 percent of the geographical area, it already has 7–8% of the world's known species.

Both liquid and carrier-based BFs are produced in India. The majority of India's BFs are produced in the western and northern regions, respectively. Gujarat is the western state with the largest production capability. Because of the move from carrier-based to liquid formulations, the inclusion of microbial consortia in the Fertiliser Control Order (FCO), and the rise in effective strains, the BF business has experienced a boom in output. The below Table-1 shows the zone wise production of BF in India and Table-2 shows the total production of BF both in carrier based and liquid based . The total production of carrier-based BFs in 2019-20, 2020-21, 2021-22, 2022-23 and 2023-24 years corresponds to 79446.61,

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192329.2896, 169379.04, 325582.282 and 256208 Metric tons respectively. The total production of liquid-based BFs in 2019-20, 2020-21, 2021-22, 2022-23 and 2023-24 years corresponds to 30105.94, 42239.9351, 232934.29, 556979.045 and 106262 Kilo litres respectively. The Graph-1 depicts the comparison of BFs production (Both carrier based and liquid based) in India from 2019-2024. The Indian fertiliser industry is predicted by IMARC [International Market Analysis Research and Consulting] Group to develop at a compound annual growth rate (CAGR) of 4.2% from 2024 to 2032, reaching US$ 16.58 billion (Rs. 1.38 lakh crore) by that time. Due to deliberate government interventions and rising agricultural demands, the market was valued at US$11.32 billion (Rs. 94,210 crore) in 2023. Fertiliser production in FY24 reached 45.2 million tonnes, demonstrating the effectiveness of the measures [12-16].

Table-1 : Biofertilizers production in various zones of India from 2019-2024

Zone	2019-20		2020-21		2021-22		2022-23	
	Carrier Based (MT)	Liquid based (KL)	Carrier Based (MT)	Liquid based (KL)	Carrier Based (MT)	Liquid based (KL)	Carrier Based (MT)	Liquid based (KL)
SOUTH	17195.25	8394.05	90932.99	4167.63	2372.127	3311.13	139582.279	8145.1175
WEST	17655.49	10186.42	57846.67	26276.45	38943.91	97014.65	93384.438	539440.64
NORTH	17973.72	7850.28	22856.74	7351.21	106775.45	109774.84	88302.622	4797.605
EAST	3029.35	3619	19929.82	895.25	20616.626	213.298	2498.083	951.522
NORTH-EAST	1013.74	56.15	763.07	3549.4	670.93	22620.37	1814.86	3644.06
MT- Metric ton KL-Kilo litres								
Source: National Centre of Organic Farming; Annual reports 2019-20,2020-21,2021-22,2022-23, 2023-24								

Table-2 : Total production of Biofertilizers in India from 2019-2024

Year	Biofertilisers production in India	
	Carrier based (MT)	Liquid based (KL)
2019-20	79446.61	30105.94
2020-21	192329.2896	42239.9351
2021-22	169379.04	232934.29
2022-23	325582.282	556979.045
2023-24	256208	106262
MT- Metric tons, KL-Kilo litres		
Source: National Centre of Organic Farming; Annual reports 2019-20,2020-21,2021-22,2022-23, 2023-24		

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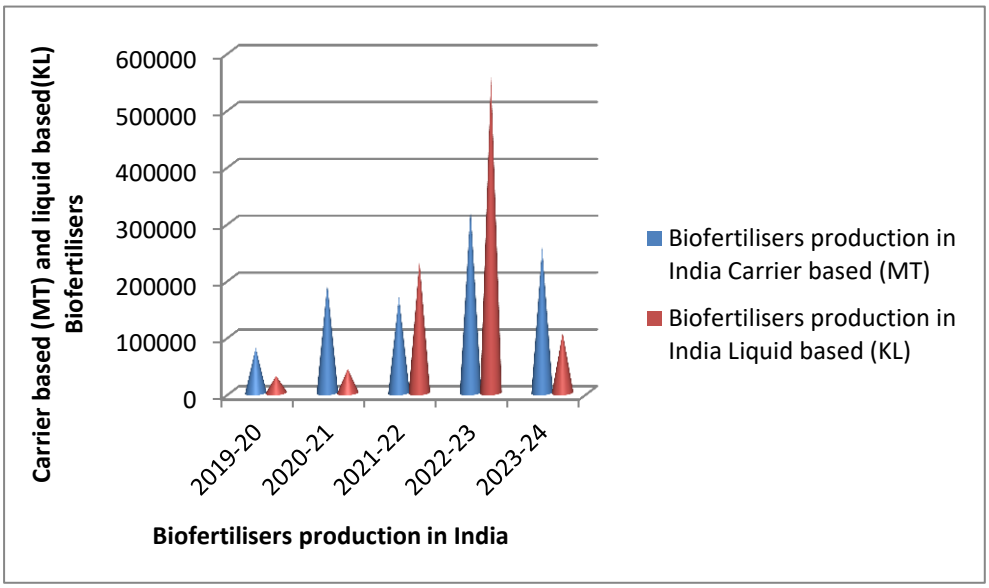

Graph-1: Comparison of Biofertilizers production (Both carrier based and liquid based) in India from 2019-2024.

4. CONCLUSION:

BFs are cost-effective, organic, and environmentally friendly, but cannot fully replace chemical fertilisers. BFs are necessary for Integrated Nutrient Management and organic farming practices. Sustainable agriculture involves environmentally friendly farming practices that promote crop and livestock growth without harming humans or natural systems. Sustainable agriculture aims to provide human needs while safeguarding the environment, benefiting both present and future generations. These technologies are becoming increasingly significant in contemporary agricultural practices. BFs will become more important in the future due to changing farming practices and environmental problems linked with chemical fertilisers.

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