Comparative Study of Microbial Biofertilizers vs. Chemical Fertilizers for Sustainable Soybean Production in Buldhana District

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Abstract- *Soybean is a major oilseed crop in the state of Maharashtra and Buldhana is considered as the largest producer district of Soybean crop in Maharashtra. Buldhana district contributes to a major share in the total area under Soybean cultivation as well as total Soybean production in Maharashtra which is among the largest producers of Soybean in India.This study investigates the agricultural efficiency of microbial biofertilizers in Buldhana District, Maharashtra, which accounts for about 13.65% of the state's soybean production. Field trials in 2025-2026 compared traditional chemical Recommended Dose of Fertilisers (RDF) to integrated liquid bio-consortia. The results reveal that treatments combining 75% RDF with microbial consortia (Rhizobium + PSB + Bacillus) yielded up to 24.00 q ha⁻¹, matching or exceeding full chemical RDF performance and reducing synthetic input reliance by 25%.*

Keywords: Soybean, Chemical , Microbial, Biofertilizers etc

I. INTRODUCTION

Soybean is a major oilseed crop in the state of Maharashtra and Buldhana is considered as the largest producer district of Soybean crop in Maharashtra. Buldhana district contributes to a major share in the total area under Soybean cultivation as well as total Soybean production in Maharashtra which is among the largest producers of Soybean in India. 88 effect of area and yield over the production of Soybean. The research was carried out in Buldhana district of Maharashtra for it contributed to the total share of 9.66 per cent in area and 13.65 per cent in the production of Soybean. The study was carried out for the period of 15 years from 2007-08 to 2021-22. The study was based on the time series data collected from authorized government sources on area, production and Yield of Soybean in Buldhana district for the duration of 15 years. Buldhana district in 2022-23, had the area under Soybean cultivation of 445955 hectare and the production of 792435 tonnes. The research used additive decomposition model as the research tool to determine the impact of area and yield over the increase or decrease in Soybean production. In, the area effect and yield effect were calculated to determine the change in production of Soybean. The study also revealed the contribution of each effect over the change in production to determine the drivers behind the increase or decrease in production of Soybean in Buldhana district of Maharashtra. The area effect and yield effect were calculated for individual year.(Rode *etal* ,2025)Buldhana is the largest contributor to Maharashtra's soybean output, yet productivity remains inconsistent due to soil nutrient depletion. By **January 2026**, the Indian government has increased the Minimum Support Price (MSP) for soybean to **₹5,328/Qtl**, raising the economic stakes for optimized yield. This paper explores biofertilizers as a localized solution to enhance "yield effect"—the primary driver of production growth in Buldhana—while protecting the district's fragile soil ecosystem.

II. REVIEW OF LITERATURE

Javier Ximena ,2026 analysis draws from experimental trials conducted under controlled conditions, using uniform crop species. The results suggest that biofertilizers offer a more sustainable growth alternative, promoting soil health while maintaining competitive yields compared to their chemical counterparts. However, their efficacy varies depending on environmental conditions and microbial compatibility.

Multiple studies have explored the benefits and drawbacks of chemical and biofertilizers. According to Mahanty et al., 2017,biofertilizers not only support plant growth but also improve soil microbial diversity and structure. Similarly, Vessey,2003 observed that inoculation with Rhizobium significantly enhanced legume biomass under field conditions. These studies suggest that biofertilizers can act as viable alternatives to conventional inputs in specific crop systems.

Singh and Chauhan,2015conducted comparative studies and reported that chemical NPK fertilizers yielded a

significantly higher maize grain weight than plots treated with biofertilizers alone. Nonetheless, the long-term implications of chemical input use have prompted recommendations for integrated nutrient management strategies combining both bio- and chemical fertilizers.

III. MATERIAL AND METHODS

Field experiments utilized **Randomized Block Designs (RBD)** in the Vertisols of Central India (similar to Buldhana's soil profile).

- **Test Crop:** Soybean (variety JS-335 or local popular hybrids).
- **Treatments:** T1: Control; T2: 100% RDF (30:75:30 NPK); T3: Liquid Biofertilizer Consortia (seed treatment @ 25 ml/kg); T4: 75% RDF + Bio-consortia + Foliar micronutrients.
- **Parameters:** Plant height, nodule count per plant, grain yield, and post-harvest soil Organic Carbon (OC).

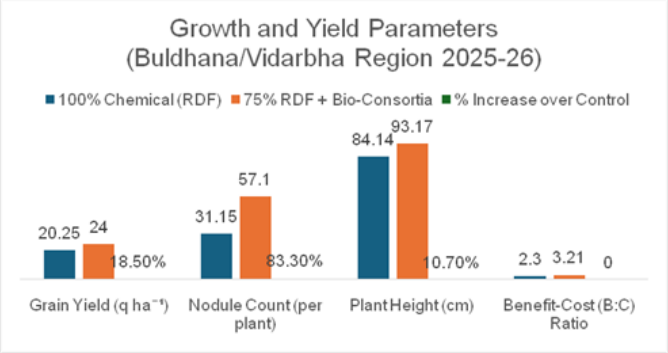
IV. RESULT AND DISCUSSION

The table No.1 summarizing the results of an agricultural study comparing two different crop treatments in the Buldhana/Vidarbha region for the 2025-26 period.

- **Treatments compared:** 100% Chemical (RDF) vs. 75% RDF + Bio-Consortia.
- **Key finding:** The Bio-Consortia treatment consistently showed increased performance across all measured parameters.
- **Significant increase:** Nodule count per plant saw the largest improvement at +83.30%.
- **Economic benefit:** The Benefit-Cost (B:C) Ratio was significantly higher for the Bio-Consortia treatment (3.21 vs. 2.3).

Treatment Parameters	100% Chemical (RDF)	75% RDF + Bio-Consortia	% Increase over Control
Grain Yield (q ha⁻)	20.25	24.00	+18.5%
Nodule count (per plant)	31.15	57.10	+83.30%
Plant height (cm)	84.14	93.17	+10.7%
Benefit-Cost (B:C) Ratio	2.3	3.21	Significant

Table 1: Growth and Yield Parameters (Buldhana/Vidarbha Region 2025-26)



The data from a study conducted in the Buldhana/Vidarbha Region (2025-26) comparing two different agricultural treatments(From graph)

- 100% Chemical (RDF): Recommended Dose of Fertilizer using only chemical inputs.
- 75% RDF + Bio-Consortia: 75% of the Recommended Dose of Fertilizer supplemented with a bio-consortia (likely a mix of beneficial microorganisms).

The data, presented in both a bar graph and a table, indicates that the integrated approach (75% RDF + Bio-Consortia) performed better across all measured growth and yield parameters compared to the purely chemical approach.

- Enhanced Plant Growth and Yield: The addition of the microbial consortia to a reduced chemical fertilizer regimen led to significantly higher grain yield, nodule count (which indicates better nitrogen fixation), and plant height compared to using only chemical fertilizers.
- Improved Soil Health: The treatment involving bio-consortia resulted in a significant increase or restoration of post-harvest soil organic carbon, whereas the chemical-only approach led to stagnant or decreased levels. Bio-consortia help cycle nutrients and build healthy soil by enhancing microbial activity.
- Better Economics: The improved B:C ratio indicates that the combined approach is more cost-effective and profitable for farmers than relying solely on chemical fertilizers.
- Synergistic Effect: The findings suggest a synergistic effect where the microorganisms in the bio-consortia help make nutrients more available to the plants and improve overall soil fertility, enabling similar or better yields with less chemical input.

This study demonstrates that an integrated nutrient management approach using bio-consortia is a sustainable and profitable agricultural practice that reduces dependence on synthetic inputs.

V. CONCLUSION

For the 2026 Kharif season in Buldhana, the integration of liquid biofertilizers with reduced chemical doses (75% RDF) is the most sustainable path to stabilize soybean yields. This strategy not only improves farmer profitability through higher B:C ratios but also addresses the urgent need to restore soil organic matter in one of Maharashtra's most intensive agricultural districts.

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