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Effect of liquid biofertilizer consortia and micronutrient on growth, quality and yield of *kharif* soybean (*Glycine max* L.)

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Abstract
A field experiment was conducted during the *kharif* season of 2024 at the Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule, to evaluate the impact of liquid biofertilizer consortia and micronutrients on the growth, quality and yield of *kharif* soybean (*Glycine max* L.). The study included ten treatments arranged in a randomized block design with three replications. The treatments involved the application of 100% and 75% recommended doses of fertilizers (RDF) (50:75:45 kg ha^{-1} N, P_2O_5, K_2O), seed treatment with Rhizobium + PSB at 25 g kg^{-1} seed, and liquid biofertilizer consortia at 25 ml kg^{-1} seed, along with two foliar sprays of Phule Micronutrient GR-II at 1% concentration applied at 30 and 45 days after sowing (DAS). The results demonstrated that the combination of 100% RDF, seed treatment with liquid biofertilizer consortia, and two foliar sprays of Phule Micronutrient GR-II significantly improved growth parameters, including plant height (97.18 cm), number of branches per plant (15.40), dry matter accumulation (40.11 g), protein yield (1015.5 Kg ha^{-1}), oil yield (511.34 Kg ha^{-1}), grain yield (26.00 q ha^{-1}) and straw yield (37.00 q ha^{-1}) compared to the other treatments.

Keywords: Soybean, consortia, liquid biofertilizer, Phule micro nutrient GR II, growth and quality

Introduction
Soybean has played a pivotal role in India's "Yellow Revolution," contributing around 28% to the country's domestic vegetable oil output among nine oilseed crops. It is the third most significant oilseed crop in India after rapeseed, mustard, and groundnut and ranks first globally for edible oil production. Globally, soybean accounts for approximately 40% of edible vegetable oil (Hildebrand *et al.*, 1986) [1]. In Maharashtra, soybean is largely cultivated as a rainfed crop between June and November, particularly in districts like Solapur, Osmanabad, Nandurbar, Nashik, Satara, Sangli, and Kolhapur. There exists substantial potential for yield improvement through the application of organic, inorganic, and biological fertilizers (Sharma *et al.*, 2024) [9]. Biofertilizer application enhances soil fertility and crop output (Yadav and Sarkar, 2019) [9]. Liquid biofertilizers can reduce the dependence on chemical fertilizers by 15-40% and are known for their longer shelf life, cost-effectiveness, and ease of use. Biofertilizer consortia improve both soil organic matter and microbial diversity (Mishra *et al.*, 2021) [4]. An adequate nutrient supply not only boosts yield but also enhances seed quality by increasing protein and oil contents (Fageria *et al.*, 2011) [2].

Material and Methods
A field experiment was conducted during the *kharif* season of 2024 at the Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule, to evaluate the impact of liquid biofertilizer consortia and micronutrients on the growth, quality and yield of *kharif* soybean (*Glycine max* L.). Ten treatments were evaluated: The treatments consist of an Absolute control (T_1), 100% RDF (50;75;45, N, P_2O_5 and K2O kg ha^{-1}) (T_2), 100% RDF + (seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed) (T_3), 75% RDF + (seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed) (T_4), 100% RDF + seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed (T_5), 75% RDF + seed treatment with

liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed (T_6), 100% RDF + seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed +Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS. (T_7), 75% RDF + seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS (T_8), 100% RDF + Seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS (T_9) and 75% RDF
+ seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS (T_{10}). All treatments, except the control (T_1), received a uniform application of 10 tons ha^{-1} of FYM. The soybean variety 'Phule Sangam' was sown on July 29, 2024, using a spacing of 45 x 5 cm. The biofertilizer consortia included *Rhizobium*, PSB, and PMB strains.

Results and Discussion Growth attributing characters

The application of combination of 100% RDF + seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS (T_9) recorded significantly tallest plant height (97.18 cm), maximum number of branches per plant (15.40), highest dry matter accumulation plant-1 (g) (40.11 gm) at harvest than all other treatments. The lowest plant height, number of branches per plant, dry matter accumulation plant-1 (g) was observed in the untreated control (T_1), aligning with the findings of Bhosale *et al.*, (2024) [5], Meher *et al.*, (2024) [7], Pawar *et al.*, (2024) [8] and Sharma *et al.*, (2024) [9]. The i ncreased plant height, number of branches per plant, dry matter accumulation with foliar application of Phule Micro nutrient GR II observed due to most favourable availability of micro nutrients as Phule Micro nutrient GR II contains optimum amount of Zn, Fe, Cu, Mn, B and Mo. Along with that it was also coupled with 10 tonnes of FYM ha^{-1} which also increase the nutrient availability. The RDF provides major nutrients which facilitated the luxurious growth of soybean crop. Iron increases metabolism of chlorophyll while zinc is involved in carbohydrate metabolism, copper increases nodulation and helps in nitrogen fixation. The addition of 100% RDF along with seed treatment with liquid biofertilizer consortia and foliar spray of Phule Micro nutrient GR II increased the availability of all nutrients to the crop and enhanced meristematic activity of cells resulting in superior growth contributing characters.

Table 1: Plant height, Number of branches plant-1, Dry matter accumulation plant-1, quality parameters, grain and straw yield as influenced periodically by different treatment.

Treatment Details		Plant height (cm)	Number of branches plant-1	Dry matter Accumulation plant-1 (g)	Quality parameters				Grain yield (qt ha^{-1})	Straw yield (qt ha^{-1})
		At Harvest	At Harvest	At Harvest	Protein content	Protein yield (Kg ha^{-1})	Oil content	Oil yield (Kg ha^{-1})		
T_1	Absolute control (No fertilizer, No liquid bio fertilizer consortia, No Micronutrient)	53.11	8.20	25.39	38.81	410.99	18.40	184.22	10.59	17.26
T_2	100% RDF (50;75;45, N, P_2O_5 and K2O Kg ha^{-1})	72.33	10.60	30.13	38.87	777.40	18.26	365.18	20.00	29.10
T_3	100% RDF + (Seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed)	78.90	11.80	32.51	39.00	832.26	18.20	388.28	21.34	30.56
T_4	75% RDF + (Seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed)	68.99	9.800	27.74	38.75	674.63	18.00	313.33	17.41	25.40
T_5	100% RDF + Seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed	91.66	13.80	37.11	38.93	912.90	18.00	445.52	23.45	32.50
T_6	75% RDF + seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed	73.00	10.00	30.18	38.75	767.25	18.25	361.28	19.80	27.03
T_7	100% RDF + Seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed+Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS.	91.00	13.80	37.21	38.87	936.76	18.05	456.66	24.10	33.00
T_8	75% RDF + Seed treatment with Rhizobium + PSB @ 25 g each Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS	83.47	12.00	34.80	38.87	868.47	18.40	404.76	22.00	30.15
T_9	100% RDF + Seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS	97.18	15.40	40.11	39.06	1015.5	18.07	511.34	26.00	37.00
T_{10}	75% RDF + Seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS	91.00	13.90	37.63	38.93	953.78	18.40	465.46	24.50	34.40
SE (m.)±		1.56	0.43	0.74	0.18	19.29	0.19	12.18	0.40	0.55
C. D. @ 5%		4.64	1.28	2.20	NS	57.32	NS	36.19	1.17	1.64
General mean		80.06	12.93	35.61	38.88	815.00	18.23	389.60	10.59	17.26

Quality parameters

Protein yield and oil yield (Kg ha^{-1})

The application of combination of 100% RDF + seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + Two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 DAS and 45 DAS (T_9) recorded highest protein and oil yield (1015.5 Kg ha^{-1} and 511.34 Kg ha^{-1}) which is found significantly superior over all other treatment. The lowest protein and oil yield (410.99 qt ha^{-1} and 184.22 qt ha^{-1}) was recorded under the absolute control. The addition of 100% RDF along with seed treatment with liquid biofertilizer consortia and foliar spray of Phule Micro nutrient GR II increased the availability of all nutrients to the crop which influenced the highest protein content and oil content which subsequently resulted in highest protein yield and oil yield. Similar results were in agreement with Chandapure, *et al.*, (2024) [6] and Pawar *et al.*, (2024) [8].

Grain yield and Straw yield (Kg ha^{-1})

The data presented in Table 1 in respect to grain and straw yield of soybean show significant difference due to various nutrient management treatments. The grain and straw yield of soybean (qt ha^{-1}) were significantly highest (26.00 and 37.00 q ha^{-1}, respectively) in 100% RDF + seed treatment with liquid bio fertilizer consortia @ 25 ml Kg^{-1} seed + two foliar sprays of Phule Micronutrient GR-II @ 1% at 30 and 45 DAS (T_9) compared to the application of carrier-based bio fertilizer. These practices created favourable conditions for soil moisture absorption, nutrient content, and sunlight penetration during the crop period. The continuous availability of the micronutrients from soil and foliar spray increases the growth characters and zinc and iron increases the translocation of photosynthates from source to sink ultimately leads to higher grain and straw yields. The lowest grain yield and straw yield was recorded in the untreated control (T_1), aligning with the findings of Bhosale *et al.*, (2024) [5], Meher *et al.*, (2024) [7], Pawar *et al.*, (2024) [8] and Sharma *et al.*, (2024) [9].

Conclusion

Based on the findings of this study, it can be concluded that the combined application of 100% RDF, seed treatment with liquid biofertilizer consortia at 25 ml/kg of seed, and two foliar sprays of Phule Micronutrient GR-II at 1% concentration applied at 30 and 45 DAS was most effective in enhancing growth traits, improving quality parameters and improving yield in soybean. This integrated approach outperformed all other treatments in terms of growth, quality and yield.

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