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Yield and economic response of soybean (*Glycine max* L.) to organic manures and biofertilizer inoculation

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Abstract

A field experiment was carried out during *kharif* 2025 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh, to evaluate the yield and economic response of soybean to organic manures and biofertilizer inoculation. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. The treatments comprised absolute control, 100% recommended dose of fertilizer (RDF), 100% vermicompost, RDF with individual inoculation of *Rhizobium*, phosphate-solubilizing bacteria (PSB) or *Azotobacter*, and two vermicompost-based microbial combinations. The treatment T₈ (50% vermicompost + *Rhizobium* + PSB + *Azotobacter*) recorded the highest pods plant⁻¹ (54.70), seeds pod⁻¹ (2.76), seeds plant⁻¹ (151.00) and 100-seed weight (11.02 g). The same treatment also produced the maximum seed yield (24.80 q ha⁻¹), stover yield (35.40 q ha⁻¹), biological yield (60.20 q ha⁻¹) and harvest index (41.20%). Economic analysis showed the highest gross monetary return (₹1,42,562 ha⁻¹), net monetary return (₹90,562 ha⁻¹) and benefit-cost ratio (2.74) under T₈. The study indicated that integrated use of vermicompost with compatible biofertilizers improved yield, profitability and input-use efficiency of soybean under the agro-climatic conditions of Gwalior.

Keywords: soybean, vermicompost, *Rhizobium*, PSB, *Azotobacter*, seed yield, net return, benefit-cost ratio

Introduction

Soybean (*Glycine max* L.) is an important oilseed and leguminous crop valued for its high seed protein and oil content. The crop has a direct role in edible-oil supply, livestock feed, nutritional security and agro-industrial development. In India, soybean is mainly grown during the *kharif* season, and Madhya Pradesh occupies a prominent position in the national soybean economy. However, productivity in the rainfed soybean belt is often limited by poor soil fertility, imbalanced nutrient use, low organic carbon and inadequate biological activity in the rhizosphere.

Balanced nutrient management is essential for realizing the genetic yield potential of soybean. Although soybean fixes atmospheric nitrogen through symbiotic association with *Rhizobium* or *Bradyrhizobium*, adequate phosphorus availability and favourable soil conditions are required for effective nodulation and nitrogen fixation. Phosphate-solubilizing bacteria improve phosphorus availability, whereas *Azotobacter* can support rhizospheric activity through nonsymbiotic nitrogen fixation and growth-prom substances. Organic sources such as vermicompost improve soil structure, microbial activity and gradual nutrient release, thereby strengthening the effect of microbial inoculants.

Exclusive dependence on inorganic fertilizers may increase crop response in the short term but does not ensure sustained improvement in soil health. Conversely, sole organic sources may not release nutrients rapidly enough to meet crop demand during critical stages. Integrated nutrient management combining organic manure, mineral nutrients and biofertilizers is therefore considered a practical approach for improving yield and profitability. Earlier studies have reported favourable effects of *Rhizobium*, PSB, vermicompost and their integrated use on soybean growth, nodulation, yield and economics (Singh *et al.*, 2007; Sharma *et al.*, 2018; Ulzen *et al.*, 2020) [17, 18]. The present paper focuses on the yield attributes, yield and economic outcomes of the investigation entitled "Influence of Organic Manures and Biofertilizers on Growth and Yield of Soybean (*Glycine max* L.)".

Materials and Methods

The field experiment was conducted during *kharif* 2025 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. Soybean variety JS-2172 was used. The crop was sown at a spacing of 45 cm × 15 cm with a seed rate of 80 kg ha⁻¹. The recommended dose of fertilizer was 20:40:20 kg N:P₂O₅:K₂O ha⁻¹, applied as per treatment requirement.

Observations on yield attributes, namely pods plant⁻¹, seeds pod⁻¹, seeds plant⁻¹ and 100-seed weight, were recorded at harvest. Seed yield, stover yield, biological yield and harvest index were computed on plot and hectare basis. Economic analysis was carried out by calculating cost of cultivation, gross monetary return, net monetary return and benefit-cost ratio for each treatment. The recorded data were statistically analysed as per the Randomized Block Design procedure, and treatment differences were interpreted using SEM±, CD at 5% probability and CV.

Table 1: Treatment details used in the experiment

Treatment symbol	Treatment combination
T ₁	Absolute control
T ₂	100% recommended dose of fertilizer (RDF)
T ₃	100% vermicompost
T ₄	RDF + Rhizobium inoculation
T ₅	RDF + phosphate-solubilizing bacteria (PSB) inoculation
T ₆	RDF + Azotobacter inoculation
T ₇	50% vermicompost + Rhizobium + PSB
T ₈	50% vermicompost + Rhizobium + PSB + Azotobacter

Results and Discussion

Yield attributes

Yield attributes were significantly influenced by organic manure and biofertilizer treatments. The treatment T₈ (50% vermicompost + *Rhizobium* + PSB + *Azotobacter*) recorded the maximum pods plant⁻¹ (54.70), seeds pod⁻¹ (2.76), seeds plant⁻¹ (151.00) and 100-seed weight (11.02 g). This treatment remained statistically at par with T₇ (50% vermicompost + *Rhizobium* + PSB), which recorded 53.10 pods plant⁻¹, 2.72 seeds pod⁻¹, 144.40 seeds plant⁻¹ and

10.92 g 100-seed weight. The absolute control recorded the lowest values for all yield attributes. The improvement under T₈ may be attributed to the combined effect of nutrient release from vermicompost, enhanced nitrogen fixation through *Rhizobium*, better phosphorus solubilization through PSB and additional rhizospheric stimulation through *Azotobacter*. Similar beneficial effects of organic and microbial nutrient sources on soybean yield attributes were reported by Desai *et al.* (2019)^[5], Sharma *et al.* (2018)^[15] and Ulzen *et al.* (2020)^[18].

Table 2: Effect of organic manures and biofertilizers on yield attributes of soybean

Treatment	Treatment details	Pods plant ⁻¹	Seeds pod ⁻¹	Seeds plant ⁻¹	100-seed weight (g)
T ₁	Absolute control	31.80	2.18	69.30	9.48
T ₂	100% recommended dose of fertilizer (RDF)	44.60	2.52	112.40	10.42
T ₃	100% vermicompost	41.90	2.44	102.20	10.16
T ₄	RDF + Rhizobium inoculation	50.80	2.66	135.10	10.78
T ₅	RDF + phosphate-solubilizing bacteria (PSB) inoculation	49.20	2.62	128.90	10.69
T ₆	RDF + Azotobacter inoculation	46.80	2.57	120.30	10.55
T ₇	50% vermicompost + Rhizobium + PSB	53.10	2.72	144.40	10.92
T ₈	50% vermicompost + Rhizobium + PSB + Azotobacter	54.70	2.76	151.00	11.02
SEM±		2.61	0.13	7.23	0.52
CD (P=0.05)		7.92	0.39	21.94	1.56
CV (%)		9.70	8.80	10.40	8.50

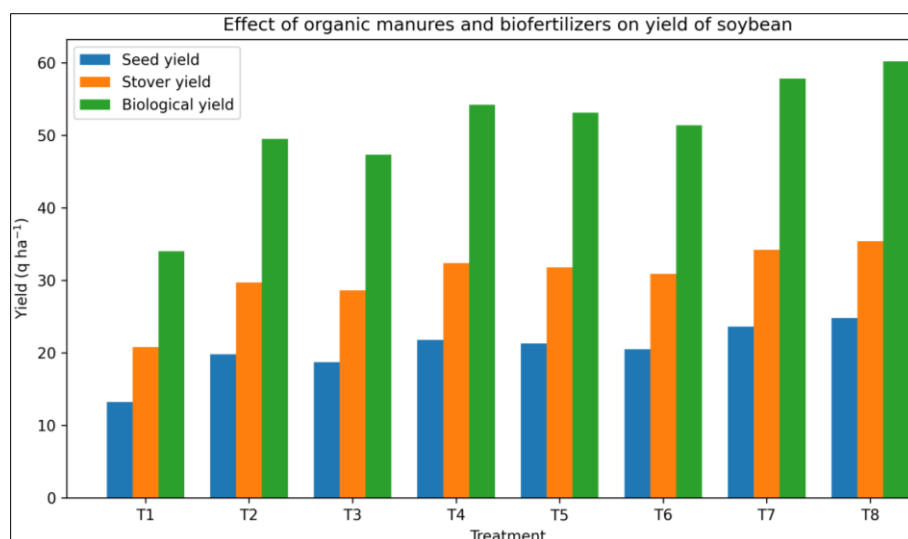
Seed, stover and biological yield

Seed yield, stover yield, biological yield and harvest index followed a similar treatment response. T₈ recorded the highest seed yield (24.80 q ha⁻¹), stover yield (35.40 q ha⁻¹), biological yield (60.20 q ha⁻¹) and harvest index (41.20%). The yield advantage of T₈ over the absolute control was 87.88% for seed yield. T₇ also performed well and remained statistically at par with T₈ for major yield parameters, recording 23.60 q ha⁻¹ seed yield, 34.20 q ha⁻¹ stover yield and 57.80 q ha⁻¹ biological yield. Among single-inoculant treatments, RDF + *Rhizobium* (T₄) produced better values than RDF + PSB (T₅) and RDF + *Azotobacter* (T₆).

The response indicates that soybean productivity was improved most when organic manure and microbial inoculants were combined rather than applied individually. The favourable response may be linked with improved nutrient synchrony, effective nodulation, better phosphorus availability and greater assimilate translocation during pod formation and seed filling. These findings are in agreement with the yield response reported by Singh *et al.* (2007)^[17], Singh *et al.* (2010)^[16], Sharma *et al.* (2018)^[15], Amanullah *et al.* (2025)^[1] and Malviya *et al.* (2025)^[11].

Table 3: Effect of organic manures and biofertilizers on seed, stover and biological yield and harvest index of soybean

Treatment	Treatment details	Seed yield (kg plot ⁻¹)	Seed yield (q ha ⁻¹)	Stover yield (kg plot ⁻¹)	Stover yield (q ha ⁻¹)	Biological yield (kg plot ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
T ₁	Absolute control	0.98	13.20	1.54	20.80	2.52	34.00	38.82
T ₂	100% recommended dose of fertilizer (RDF)	1.47	19.80	2.21	29.70	3.68	49.50	40.00
T ₃	100% vermicompost	1.39	18.70	2.12	28.60	3.51	47.30	39.53
T ₄	RDF + Rhizobium inoculation	1.62	21.80	2.41	32.40	4.02	54.20	40.22
T ₅	RDF + phosphate-solubilizing bacteria (PSB) inoculation	1.58	21.30	2.36	31.80	3.94	53.10	40.11
T ₆	RDF + Azotobacter inoculation	1.52	20.50	2.29	30.90	3.82	51.40	39.88
T ₇	50% vermicompost + Rhizobium + PSB	1.75	23.60	2.54	34.20	4.29	57.80	40.83
T ₈	50% vermicompost + Rhizobium + PSB + Azotobacter	1.84	24.80	2.63	35.40	4.47	60.20	41.20
SEm±		0.08	1.09	0.12	1.57	0.19	2.56	1.94
CD (P=0.05)		0.24	3.30	0.35	4.75	0.58	7.76	5.90
CV (%)		9.20	9.20	8.90	8.90	8.70	8.70	8.40

**Fig 1:** Effect of organic manures and biofertilizers on seed, stover and biological yield of soybean

Economics

Economic analysis clearly showed that the most productive treatment also generated the highest monetary return. The cost of cultivation was highest under T₈ (₹52,000 ha⁻¹), followed by T₃ (₹51,800 ha⁻¹) and T₇ (₹50,500 ha⁻¹), while the lowest cost was recorded under T₁ (₹38,200 ha⁻¹). Despite the higher input cost, T₈ recorded the maximum gross monetary return (₹1,42,562 ha⁻¹), net monetary return (₹90,562 ha⁻¹) and benefit-cost ratio (2.74). The net monetary return under T₈ was 133.08% higher than the absolute control. T₇ was the next best treatment with ₹1,35,971

ha⁻¹ gross return, ₹85,471 ha⁻¹ net return and 2.69 benefit-cost ratio. RDF + *Rhizobium* (T₄) also gave favourable profitability, recording ₹1,26,086 ha⁻¹ gross return, ₹79,086 ha⁻¹ net return and 2.68 benefit-cost ratio. The results demonstrate that added expenditure on vermicompost and compatible biofertilizers was compensated by higher seed and stover yield. Comparable economic advantages of integrated nutrient management in soybean were reported by Gangadhar Eswar Rao *et al.* (2024)^[7] and Malviya *et al.* (2025)^[11].

Table 4: Economics of different organic manure and biofertilizer treatments in soybean

Treatment	Treatment details	Cost of cultivation (₹ ha ⁻¹)	Gross monetary return (₹ ha ⁻¹)	Net monetary return (₹ ha ⁻¹)	B:C ratio
T ₁	Absolute control	38,200	77,054	38,854	2.02
T ₂	100% recommended dose of fertilizer (RDF)	45,500	114,682	69,182	2.52
T ₃	100% vermicompost	51,800	108,640	56,840	2.10
T ₄	RDF + Rhizobium inoculation	47,000	126,086	79,086	2.68
T ₅	RDF + phosphate-solubilizing bacteria (PSB) inoculation	46,800	123,280	76,480	2.63
T ₆	RDF + Azotobacter inoculation	46,900	118,826	71,926	2.53
T ₇	50% vermicompost + Rhizobium + PSB	50,500	135,971	85,471	2.69
T ₈	50% vermicompost + Rhizobium + PSB + Azotobacter	52,000	142,562	90,562	2.74

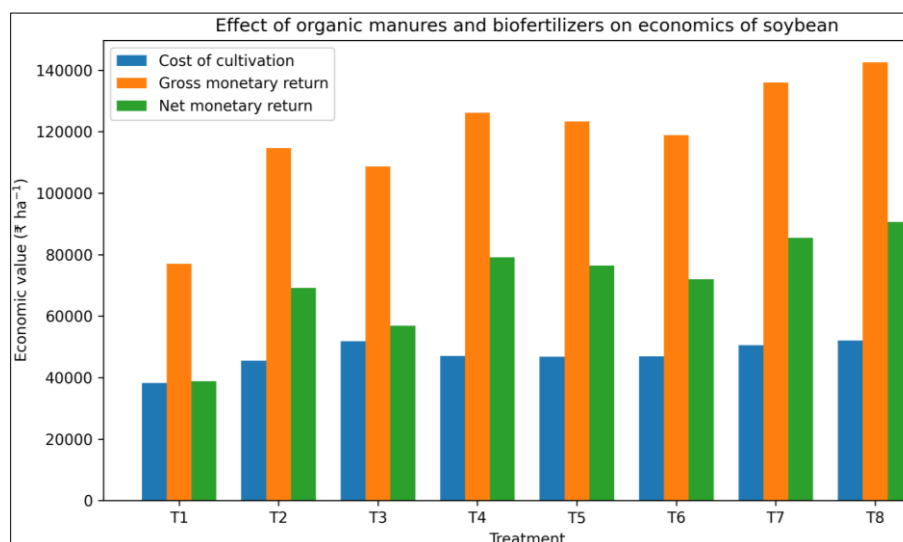


Fig 2: Effect of organic manures and biofertilizers on economic returns of soybean.

Conclusion

On the basis of yield and economics, T₈ (50% vermicompost + *Rhizobium* + PSB + *Azotobacter*) was identified as the most effective treatment for soybean under the experimental conditions. It recorded the highest seed yield, stover yield, biological yield, harvest index, gross monetary return, net monetary return and benefit-cost ratio. T₇ (50% vermicompost + *Rhizobium* + PSB) also gave statistically comparable yield performance and may be considered a practical alternative where *Azotobacter* culture is not easily available. The study confirms that integration of vermicompost with compatible biofertilizers is a profitable nutrient-management approach for improving soybean productivity and farm income under the agro-climatic conditions of Gwalior, Madhya Pradesh.

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