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Oil productivity and economic performance of soybean (*Glycine max* L.) under integrated nutrient management

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ABSTRACT

Profitability, rather than yield alone, determines whether farmers adopt integrated nutrient management (INM). A field experiment was conducted during kharif 2025 on a clayey Vertisol at the College of Agriculture, Latur, Maharashtra, to evaluate seed oil content, oil yield and economics of soybean cv. MAUS-158 under seven nutrient management treatments laid out in a randomized block design with three replications. The treatments comprised control, recommended dose of fertilizers (RDF, 30:60:30 kg N:P₂O₅:K₂O ha⁻¹), and RDF combined with farmyard manure (FYM, 5 t ha⁻¹), neem cake powder (NC, 3 q ha⁻¹) and multi-micronutrient Grade-I (MMN, 25 kg ha⁻¹). Seed oil content (21.98–24.04%, measured by NMR) was not significantly influenced by the treatments. Oil yield, however, increased from 402.9 kg ha⁻¹ in the control to 930.8 kg ha⁻¹ under RDF + FYM + NC + MMN (T₇), which was at par with RDF + FYM + MMN (T₅, 850.9 kg ha⁻¹). T₇ gave the highest gross (₹ 2,00,250 ha⁻¹) and net returns (₹ 1,31,750 ha⁻¹), whereas T₅ recorded the highest benefit:cost ratio (2.96), the lowest cost of production (₹ 16.88 kg⁻¹ seed) and the highest additional net return per rupee of additional investment over RDF (₹ 4.06). Oil yield gains under INM were therefore driven by seed yield rather than oil concentration, and RDF + FYM + MMN emerged as the most cost-efficient option, with RDF + FYM + NC + MMN maximizing absolute returns.

Keywords: Soybean, Integrated nutrient management, Oil content, Oil yield, Economics, Benefit:cost ratio, Vertisol

Introduction

Soybean [*Glycine max* (L.) Merrill] contributes a large part of India's domestic vegetable oil production and supports an export-oriented soy-meal industry. For both farmers and processors, the relevant output is not only seed yield but also oil yield per hectare, the product of seed yield and seed oil concentration. In the Marathwada region of Maharashtra, where soybean is the principal rainfed *kharif* crop, farm incomes from soybean are constrained by low productivity and rising input costs (SOPA, 2025) [1].

Integrated nutrient management (INM) – the combined use of chemical fertilizers, organic manures and micronutrients – is widely advocated to sustain soil fertility and yields (Paramesh et al., 2023) [2]. Organic inputs such as farmyard manure and neem cake, however, add substantially to the cost of cultivation, and their economic justification must be established locally. Earlier studies have shown that the INM combination giving the highest yield does not always give the highest return per rupee invested (Singh et al., 2013; Biswas et al., 2025) [4, 3]. Similarly, effects of INM on seed oil concentration of soybean have been inconsistent across studies (Amanullah et al., 2025; Biswas et al., 2025) [5, 3].

The present study examined how integrating FYM, neem cake and a multi-micronutrient mixture with RDF influences seed oil content, oil yield and the economics of soybean cultivation on a Vertisol of Latur, with the aim of identifying treatments that maximize both absolute and relative profitability.

Materials and Methods

Experimental site, soil and weather

The field experiment was conducted during the *kharif* (rainy) season of 2025 at the Experimental Farm, Department of Agronomy, College of Agriculture, Latur, Maharashtra, India. Latur lies in the semi-arid tropical Marathwada region and receives a mean annual rainfall of about 795 mm. The soil of the experimental field was a medium-deep black Vertisol, clayey in texture (clay 44.21%, silt 29.53% and sand 25.68%), moderately alkaline (pH 7.4) and non-saline (EC 0.24 dS m⁻¹), with 0.58% organic carbon. It was low in available nitrogen (112.9 kg ha⁻¹; alkaline KMnO₄ method, Subbiah and Asija, 1956) [6], contained 7.46 kg ha⁻¹ Olsen-P (Olsen et al., 1954) [7] and was high in available potassium (1145.6 kg ha⁻¹; neutral normal ammonium acetate, flame photometry; Jackson, 1967) [8]. Soybean–chickpea had been the preceding sequence on the field for the previous three years. A total of 1136.2 mm rainfall was received in 30 rainy days

during the crop season (standard meteorological weeks 29–43), and the weather was generally favourable for crop growth.

Treatments and experimental design

The experiment was laid out in a randomized block design (RBD) with seven treatments replicated three times: T₁, control (no fertilizer); T₂, 100% recommended dose of fertilizers (RDF, 30:60:30 kg N:P₂O₅:K₂O ha⁻¹); T₃, RDF + farmyard manure (FYM) @ 5 t ha⁻¹; T₄, RDF + neem cake powder (NC) @ 3 q ha⁻¹; T₅, RDF + FYM @ 5 t ha⁻¹ + multi-micronutrient Grade-I (MMN) @ 25 kg ha⁻¹; T₆, RDF + NC @ 3 q ha⁻¹ + MMN @ 25 kg ha⁻¹; and T₇, RDF + FYM @ 5 t ha⁻¹ + NC @ 3 q ha⁻¹ + MMN @ 25 kg ha⁻¹. The gross and net plot sizes were 5.4 m × 4.5 m and 4.5 m × 3.9 m, respectively. Nitrogen, phosphorus and potassium were supplied through urea (46% N), single superphosphate (16% P₂O₅) and muriate of potash (60% K₂O), respectively, and were applied as basal dose at sowing along with the organic sources and the micronutrient mixture as per treatment.

Crop management

The land was ploughed to 20 cm depth with a tractor-drawn reversible mould-board plough and harrowed twice. Soybean cv. MAUS-158 was sown on 18 July 2025 by dibbling at 45 cm × 5 cm spacing using a seed rate of 65 kg ha⁻¹, after seed treatment with fungicide. Gap filling and thinning were done 10 days after sowing. One hand weeding and one hoeing were given. Insect pests and foliar diseases were managed with need-based sprays of thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, emamectin benzoate 5% SG, tebuconazole 10% + sulphur 65% WG and flubendiamide 20% WG. The crop was harvested at physiological maturity on 27 October 2025 (101 DAS), sun-dried and threshed manually.

Observations

Seed yield was recorded from each net plot and expressed in kg ha⁻¹. Seed oil content (%) was estimated on a composite seed sample from each plot by nuclear magnetic resonance (NMR) spectroscopy at [AICRP on Sunflower, Main Agricultural Research Station, University of Agricultural Sciences, Raichur, Karnataka]. Oil yield (kg ha⁻¹) was computed as oil content (%) × seed yield (kg ha⁻¹)/100. The cost of cultivation of each treatment was worked out from prevailing rates of inputs (seed, fertilizers, FYM, neem cake, micronutrient mixture, plant protection chemicals) and operations (labour and machinery). Gross monetary returns (GMR) were computed from seed yield at the prevailing market price of ₹ 5,000 q⁻¹; straw was not valued. Net monetary returns (NMR) were obtained as GMR minus cost of cultivation, and the benefit:cost (B:C) ratio as GMR/cost of cultivation. Cost of production (₹ kg⁻¹ seed) was calculated as cost of cultivation/seed yield. To evaluate the value of each supplementary input, additional cost, additional NMR and additional NMR per rupee of additional cost were computed for every INM treatment relative to RDF alone.

Statistical analysis

Data were analysed by the analysis of variance technique appropriate to RBD (Panse *et al.*, 1967) [9]. Treatment means were compared using critical difference (CD) at 5% probability wherever the *F*-test was significant.

Results and Discussion

Seed oil content and oil yield

Seed oil content ranged from 21.98% in the control to 24.04% under RDF + FYM (T₃) and did not differ significantly among treatments (Table 1). The lack of response suggests that oil concentration in MAUS-158 was governed mainly by genotype and the seed-filling

environment, which were common to all plots, rather than by nutrient supply. Oil and protein concentrations in soybean seed are negatively related, and improved nitrogen nutrition through better nodulation often raises protein at the expense of oil, which may have offset any positive effect of better nutrition on oil concentration. Non-significant or small effects of INM on soybean oil content have also been reported by Biswas *et al.* (2025) [3].

Oil yield, in contrast, differed significantly and closely followed seed yield. T₇ recorded the highest oil yield (930.8 kg ha⁻¹), which was 131.0% higher than the control and 42.5% higher than RDF, and was at par with T₅ (850.9 kg ha⁻¹). T₆ (802.2 kg ha⁻¹), T₃ and T₄ (764.5–764.6 kg ha⁻¹) were significantly better than RDF (653.0 kg ha⁻¹) and the control (402.9 kg ha⁻¹). Since oil content was stable, practices that increase seed yield are the most effective route to higher oil output per hectare, in line with the findings of Amanullah *et al.* (2025) [5], who reported that INM increased soybean oil yield mainly through higher grain yield.

Table 1. Seed yield, oil content and oil yield of soybean as influenced by integrated nutrient management

Treatment	Seed yield (kg ha ⁻¹)	Oil content (%)	Oil yield (kg ha ⁻¹)
T ₁ : Control	1833	21.98	402.89
T ₂ : RDF	2905	22.48	653.04
T ₃ : RDF + FYM	3180	24.04	764.47
T ₄ : RDF + NC	3435	22.26	764.63
T ₅ : RDF + FYM + MMN	3785	22.48	850.87
T ₆ : RDF + NC + MMN	3625	22.13	802.21
T ₇ : RDF + FYM + NC + MMN	4005	23.24	930.76
SE(m) ±	127	1.23	32.19
CD (<i>P</i> = 0.05)	382	NS	96.86
Mean	3253	22.66	738.41

RDF, recommended dose of fertilizers (30:60:30 kg N:P₂O₅:K₂O ha⁻¹); FYM, farmyard manure @ 5 t ha⁻¹; NC, neem cake powder @ 3 q ha⁻¹; MMN, multi-micronutrient Grade-I @ 25 kg ha⁻¹; DAS, days after sowing; NS, non-significant.

Cost of cultivation, returns and B:C ratio

The cost of cultivation increased from ₹ 48,500 ha⁻¹ in the control to ₹ 55,200 ha⁻¹ with RDF and to ₹ 68,500 ha⁻¹ with RDF + FYM + NC + MMN (Table 2). Despite the higher cost, all INM treatments gave higher net returns than RDF alone, the increase being significant for T₅, T₆ and T₇. T₇ recorded the highest GMR (₹ 2,00,250 ha⁻¹) and NMR (₹ 1,31,750 ha⁻¹); its GMR was at par with T₅ and T₆, and its NMR was at par with T₄, T₅ and T₆. The NMR of T₇ exceeded that of the control by 205% and that of RDF by 46.3%.

The B:C ratio ranked differently from absolute returns. RDF + FYM + MMN (T₅) recorded the highest B:C ratio (2.96), followed by T₇ (2.92), T₄ (2.79) and T₆ (2.78), while the control was lowest (1.89). T₅ also had the lowest cost of producing one kilogram of seed (₹ 16.88 against ₹ 19.00 with RDF and ₹ 26.46 in the control). Thus, adding neem cake to T₅ to make T₇ increased the cost by ₹ 4,600 ha⁻¹ and the NMR by ₹ 6,400 ha⁻¹ – a positive but statistically non-significant gain – so T₅ represents the more efficient use of capital while T₇ maximizes profit per hectare. Similar divergence between the highest-yielding and the most cost-efficient nutrient treatments in soybean was reported by Singh *et al.* (2013) [4], and Narkhede *et al.* (2017) [10] and Biswas *et al.* (2025) [3] found integrated organic–inorganic nutrition to be more profitable than fertilizers alone.

Table 2. Economics of soybean cultivation as influenced by integrated nutrient management

Treatment	Cost of cultivation (₹ ha ⁻¹)	GMR (₹ ha ⁻¹)	NMR (₹ ha ⁻¹)	B:C ratio	Cost of production (₹ kg ⁻¹)
T ₁ : Control	48,500	91,650	43,150	1.89	26.46
T ₂ : RDF	55,200	1,45,250	90,050	2.63	19.00
T ₃ : RDF + FYM	59,800	1,59,000	99,200	2.66	18.81
T ₄ : RDF + NC	61,500	1,71,750	1,10,250	2.79	17.90
T ₅ : RDF + FYM + MMN	63,900	1,89,250	1,25,350	2.96	16.88
T ₆ : RDF + NC + MMN	65,200	1,81,250	1,16,050	2.78	17.99
T ₇ : RDF + FYM + NC + MMN	68,500	2,00,250	1,31,750	2.92	17.10
SE(m) ±	—	7,400	7,400	—	—
CD (P = 0.05)	—	22,400	22,400	—	—
Mean	60,371	1,62,629	1,02,257	2.66	19.16

GMR, gross monetary returns (seed at ₹ 5,000 q⁻¹); NMR, net monetary returns; B:C, GMR/cost of cultivation. RDF, recommended dose of fertilizers (30:60:30 kg N:P₂O₅:K₂O ha⁻¹); FYM, farmyard manure @ 5 t ha⁻¹; NC, neem cake powder @ 3 q ha⁻¹; MMN, multi-micronutrient Grade-I @ 25 kg ha⁻¹; DAS, days after sowing; NS, non-significant.

Returns on additional investment over RDF

Partial budgeting against RDF (Table 3) shows that every rupee spent on supplementary inputs returned more than one rupee of additional net income. The return was lowest for FYM alone (₹ 1.99 per rupee) and highest for FYM + MMN (₹ 4.06 per rupee), followed by neem cake alone (₹ 3.21) and the full combination (₹ 3.14). The micronutrient mixture thus substantially improved the return on organic inputs: adding MMN to RDF + FYM doubled the additional net return per rupee from ₹ 1.99 to ₹ 4.06. Under the conditions of this study, the combined use of FYM and MMN with RDF was the most remunerative way of supplementing the recommended fertilizer dose, while the

full combination is justified where the farmer's goal is maximum net income per hectare and capital is not limiting.

RDF, recommended dose of fertilizers (30:60:30 kg N:P₂O₅:K₂O ha⁻¹); FYM, farmyard manure @ 5 t ha⁻¹; NC, neem cake powder @ 3 q ha⁻¹; MMN, multi-micronutrient Grade-I @ 25 kg ha⁻¹; DAS, days after sowing; NS, non-significant.

Conclusion

Integrated nutrient management did not alter seed oil concentration of soybean but raised oil yield in proportion to seed yield, from 653 kg ha⁻¹ with RDF to 931 kg ha⁻¹ with RDF + FYM + NC + MMN. The latter treatment gave the highest gross and net returns, whereas RDF + FYM (5 t ha⁻¹) + multi-micronutrient Grade-I (25 kg ha⁻¹) gave the highest B:C ratio (2.96), the lowest cost of production and the best return on additional investment, with net returns statistically at par with the full combination. RDF + FYM + MMN can therefore be suggested as the most cost-effective INM option for soybean on Vertisols of Latur, subject to confirmation over more seasons and under varying price scenarios.

Table 3. Partial budget of INM treatments relative to RDF alone (T₂)

Treatment	Additional cost (₹ ha ⁻¹)	Additional seed yield (kg ha ⁻¹)	Additional NMR (₹ ha ⁻¹)	Additional NMR per ₹ of additional cost
T ₃ : RDF + FYM	4,600	275	9,150	1.99
T ₄ : RDF + NC	6,300	530	20,200	3.21
T ₅ : RDF + FYM + MMN	8,700	880	35,300	4.06
T ₆ : RDF + NC + MMN	10,000	720	26,000	2.60
T ₇ : RDF + FYM + NC + MMN	13,300	1,100	41,700	3.14

Conflict of Interest

The authors declare no conflict of interest.

References

- SOPA. Soybean statistics. Indore: The Soybean Processors Association of India; 2025.
- Paramesh V, Mohan Kumar R, Rajanna GA, Gowda S, Nath AJ, Madival Y, Jinger D, Bhat S, Toraskar S. Integrated nutrient management for sustainable crop production and improving soil health: A review. *Frontiers in Sustainable Food Systems*. 2023;7:1173258.
- Biswas S, Nwe LL, Das R, Dutta D. Effect of integrated nutrient management on nodulation, yield, quality, energetics and economics of soybean [*Glycine max* (L.) Merrill.] varieties in Eastern India. *Legume Research*. 2025;48(7):1172–1180.
- Singh R, Sharma HB, Kumar P, Paliwal DK, Kumar P. Effect of integrated nutrient management on growth, yield and nutrient uptake by soybean (*Glycine max*) cultivars. *Indian Journal of Agronomy*. 2013;58(3):379–383.
- Amanullah, Khan JA, Yasir M. Improving soybean yield and oil productivity: an integrated nutrient management approach for sustainable soybean production. *BMC Plant Biology*. 2025;25:293.
- Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. 1956;25:259–260.
- Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA Circular 939*. 1954.
- Jackson ML. *Soil Chemical Analysis*. New Delhi: Prentice Hall of India Pvt. Ltd.; 1967.
- Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers*. New Delhi: ICAR; 1967.

10. Narkhede WN, Khandare RN, Nayak SK, Khazi GS. Effect of organic and inorganic nutrient sources and their integrated nutrient management on productivity, economic efficiency, available N, P, K and microbial population in soybean (*Glycine max*)–onion (*Allium cepa*) cropping sequence. Indian Journal of Agronomy. 2017;62(2):147–154.

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