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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF GARDEN PEA (*Pisum sativum var. hortense L.*) UNDER THE GIRD ZONE OF MADHYA PRADESH

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ABSTRACT--
An experiment on INM effect on growth, yield, quality, nutrient uptake, and economics of garden pea (Pisum sativum var. hortense L.), cv. Arkel, was carried out in the rabi season of 2025-26 at the Research Farm of SAM Global University, Raisen, MP. The experiment was based on Randomized Block Design with 10 treatments and 3 replications. The treatments comprised various combinations of RDF, FYM, Rhizobium, PSB, and foliar NPK spray. No significant differences in plant population were observed due to INM treatments, suggesting that the crops were established uniformly. On the other hand, plant height, days to 50% flowering, yield characteristics, yield, nutrient uptake, protein content and economics were significantly affected by the treatment combinations. The use of 75% RDF+ 2.5 t/ha FYM (Treatment No.4) resulted in the highest value in plant height (58.17 cm), seeds/pod (8.20), pods/plant (32.98), seed index (14.33 g), biological yield (6928 kg/ha), grain yield (2286 kg/ha), harvest index (33.0%), protein content (20.77%) and protein yield (475.2 kg/ha). Similarly, the treatment combination T4 also showed maximum values in nitrogen, phosphorus and potassium uptake along with the highest net returns (Rs. 90957/ha) having benefit cost ratio 3.25. The results suggest that substitution of chemical fertilizer partially with FYM is highly beneficial in terms of increasing productivity and grain quality along with its economic profitability of garden peas.
KEYWORDS*: Garden Pea, Integrated Nutrient Management, FYM, Rhizobium, PSB, Protein Yield, Nutrient Uptake, Economics*--

1. INTRODUCTION

Garden pea (Pisum sativum var. hortense L.) is an important cool-season vegetable legume cultivated for its tender green pods and nutritionally rich seeds. The crop is valued as a source of plant protein, carbohydrates, vitamins, minerals and dietary fibre, and it also contributes to soil fertility through symbiotic nitrogen fixation. In central India and particularly in Madhya Pradesh, garden pea is commonly cultivated during the rabi season under irrigated or partially irrigated conditions, where cool weather favours vegetative growth, flowering and pod development.

Despite its economic and nutritional importance, the productivity of garden pea often remains below its potential. One major reason is imbalanced nutrient management. Continuous use of chemical fertilizers without adequate organic inputs can reduce soil organic matter, disturb soil biological activity and create nutrient imbalance. At the same time, exclusive reliance on organic manures may not supply readily available nutrients in sufficient quantity during peak crop demand. Therefore, a balanced approach that combines organic, inorganic and biological nutrient sources is required for stable productivity and long-term soil fertility.

Integrated nutrient management is a holistic nutrient-supply strategy that combines chemical fertilizers with organic manures and biofertilizers. Farmyard manure improves soil structure, water-holding capacity, cation exchange capacity and microbial activity, whereas chemical fertilizers provide readily available nutrients. Biofertilizers such as Rhizobium and phosphate-solubilizing bacteria enhance nitrogen fixation and phosphorus availability in the rhizosphere. Such integration is especially relevant in legumes, where root development, nodulation, photosynthesis and reproductive growth are strongly influenced by balanced nutrient availability.

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The present investigation was planned to evaluate the effect of different INM practices on growth, yield attributes, yield, quality, nutrient uptake, soil nutrient balance and economics of garden pea under the Gird zone of Madhya Pradesh. The specific objectives were to study the effect of INM on growth, yield and quality of pea; to assess its effect on soil fertility and nutrient uptake; and to work out the economics of different treatments.

2. MATERIALS AND METHODS

2.1 Experimental site and climate

The field experiment was conducted during the rabi season of 2025-26 at the Research Farm, Faculty of Agriculture Science, SAM Global University, Raisen, Madhya Pradesh. The experimental site lies in the Gird zone of Madhya Pradesh and has a semi-arid to sub-humid climate with cool, dry winter conditions favourable for pea cultivation. During the crop season, maximum temperature ranged from 13.5 to 33.9 deg C and minimum temperature ranged from 2.3 to 15.3 deg C. Rainfall was intermittent, with the highest weekly rainfall of 40.4 mm during the third standard meteorological week.

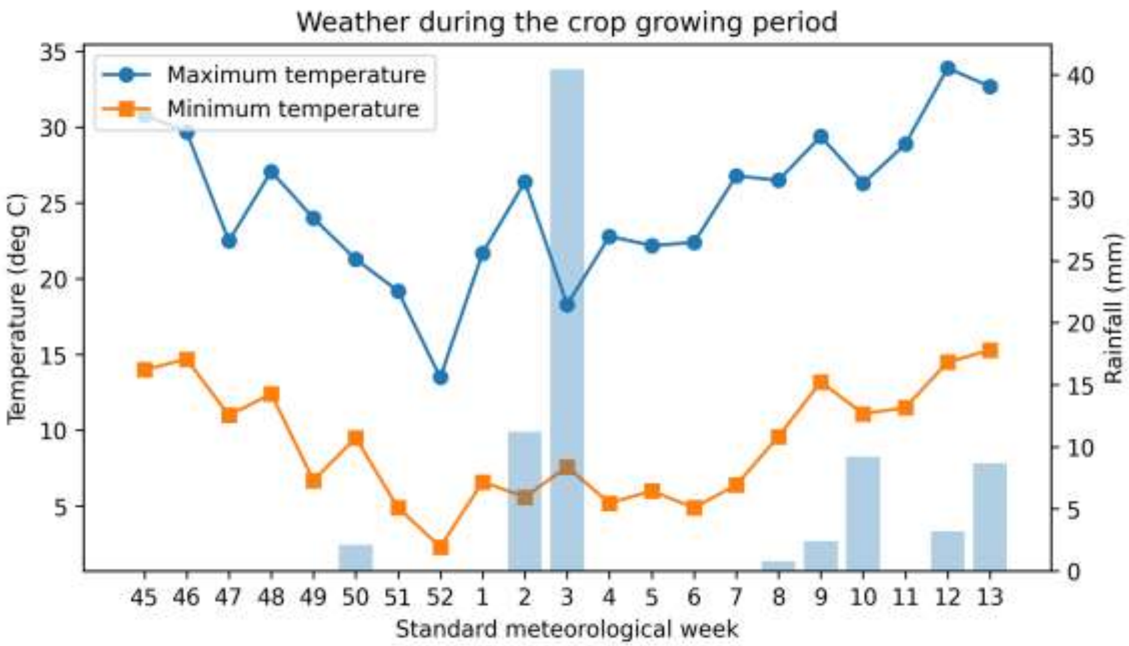

Fig. 1. Weekly weather pattern during the crop growing period.

2.2 Soil Characteristics

The experimental soil was sandy clay loam in texture with 58.50% sand, 18.00% silt and 22.00% clay. The soil was slightly alkaline and non-saline. Initial soil analysis showed low organic carbon and available nitrogen, medium available phosphorus, and adequate available potassium, making the site suitable for evaluating the response of pea to integrated nutrient management.

Table 1. Initial soil characteristics of the experimental site.

Soil property	Value	Method
Texture	Sandy clay loam	International pipette method
pH	7.50	Glass electrode pH meter
Electrical conductivity	0.40 dS/m	Solubridge method
Organic carbon	0.40%	Walkley and Black method
Available nitrogen	210.40 kg/ha	Alkaline permanganate method
Available phosphorus	14.40 kg/ha	Olsen method
Available potassium	240.40 kg/ha	Flame photometer method

2.3 Experimental design and treatments

The experiment was laid out in a randomized block design with ten treatments and three replications. The garden pea variety Arkel was sown at a seed rate of 80 kg/ha with a spacing of 30 cm between rows and 10 cm between plants.

The recommended fertilizer dose was 20:60:20 kg N:P2O5:K2O per hectare. Seeds in relevant treatments were inoculated with Rhizobium and PSB at 20 g/kg seed. The full dose of fertilizers and FYM was applied as basal, while foliar NPK sprays were applied as per treatment schedule.

Table 2. Treatment details used in the experiment.

Treatment	Nutrient management practice
T1	100% RDF
T2	125% RDF
T3	100% RDF + 1% NPK spray at pod formation
T4	75% RDF + 2.5 t/ha FYM
T5	75% RDF + Rhizobium + PSB
T6	75% RDF + 1% NPK spray at flower initiation and pod formation
T7	50% RDF + 2.5 t/ha FYM
T8	50% RDF + Rhizobium + PSB
T9	50% RDF + 1% NPK spray at flower initiation and pod formation
T10	Control

2.4 Crop management and observations

The field was ploughed, harrowed and levelled to obtain a fine seedbed. Fertilizers, FYM and biofertilizers were applied as per treatments. The crop was irrigated as required, and two life-saving irrigations were applied at approximately 30 and 55 days after sowing. Intercultural operations were performed to maintain proper aeration and weed control. Observations were recorded on plant population, plant height, days to 50% flowering, number of seeds per pod, pods per plant, seed index, grain yield, stover yield, biological yield, harvest index, protein content, protein yield, NPK content, nutrient uptake and economics. Data were statistically analysed by analysis of variance for randomized block design, and critical difference at 5% probability was used to compare treatment means.

3. RESULTS

3.1 Growth parameters

Integrated nutrient management did not significantly affect plant population, confirming that crop establishment was uniform. In contrast, plant height differed significantly among treatments at all growth stages. The tallest plants were recorded under T4 (75% RDF + 2.5 t/ha FYM), followed by T5 (75% RDF + Rhizobium + PSB). The control treatment recorded the lowest plant height at harvest. Better plant growth under FYM- and biofertilizer-based treatments may be related to improved nutrient release, microbial activity and root growth.

Table 3. Effect of INM on plant height (cm) and days to 50% flowering.

T	Treatment	30 DAS	60 DAS	Harvest	50% flowering
T1	100% RDF	15.00	39.98	52.47	67.67
T2	125% RDF	15.20	41.87	54.97	68.67
T3	100% RDF + NPK spray	15.00	42.87	56.10	69.33
T4	75% RDF + FYM	15.73	44.97	58.17	70.67
T5	75% RDF + Rhizobium + PSB	15.67	44.60	57.43	70.33
T6	75% RDF + NPK spray	14.93	42.70	56.03	70.00
T7	50% RDF + FYM	15.07	40.97	53.23	68.33
T8	50% RDF + Rhizobium + PSB	14.90	37.73	49.40	65.00
T9	50% RDF + NPK spray	13.47	38.90	50.73	67.33
T10	Control	12.60	37.07	48.07	63.00
SEm +/-		0.562	0.274	0.361	0.723
CD (5%)		1.669	0.813	1.072	2.147

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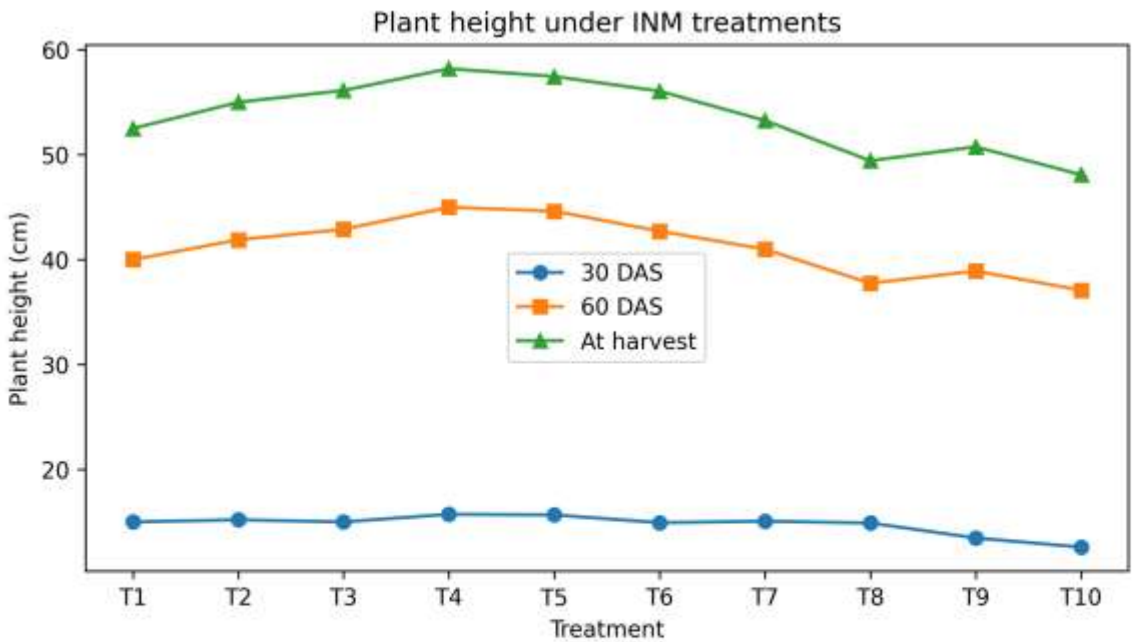

Fig. 2. Plant height of garden pea under different INM treatments.

3.2 Yield-attributing characters

All yield-attributing characters responded significantly to nutrient management. Treatment T4 recorded the highest seeds per pod (8.20), pods per plant (32.98) and seed index (14.33 g), followed closely by T5. The control recorded the lowest values for these traits. The improvement in yield attributes under integrated treatments indicates better assimilate production, improved nutrient availability during reproductive growth and superior seed filling.

Table 4. Effect of INM on yield-attributing characters of garden pea.

T	Treatment	Seeds/pod	Pods/plant	Seed index (g)
T1	100% RDF	6.58	30.15	11.80
T2	125% RDF	7.20	31.12	12.30
T3	100% RDF + NPK spray	7.71	31.33	13.77
T4	75% RDF + FYM	8.20	32.98	14.33
T5	75% RDF + Rhizobium + PSB	8.07	32.43	14.13
T6	75% RDF + NPK spray	7.67	31.18	13.13
T7	50% RDF + FYM	6.93	31.02	12.13
T8	50% RDF + Rhizobium + PSB	6.34	29.03	11.27
T9	50% RDF + NPK spray	6.47	29.47	11.57
T10	Control	6.11	28.92	10.90
SEm +/-		0.244	0.704	0.570
CD (5%)		0.726	2.090	1.692

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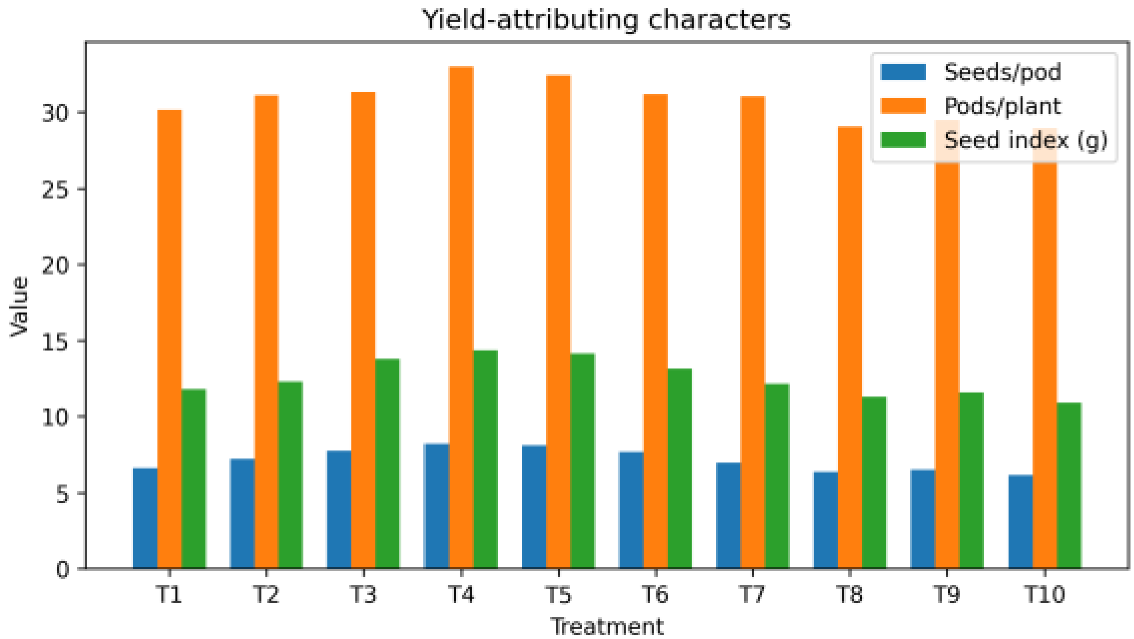

Fig. 3. Effect of INM practices on yield-attributing characters.

3.3 Yield and harvest index

Biological yield, grain yield, stover yield and harvest index were significantly influenced by nutrient management. The highest biological yield (6928 kg/ha) and grain yield (2286 kg/ha) were obtained with T4, while stover yield was highest under T5 (4645 kg/ha) and nearly equal under T4 (4642 kg/ha). The control produced the lowest grain yield (1571 kg/ha). Treatment T4 also recorded the highest harvest index (33.0%), indicating efficient partitioning of dry matter into economic yield.

Table 5. Effect of INM on yield and harvest index of garden pea.

T	Treatment	Biological yield	Grain yield	Stover yield	HI (%)
T1	100% RDF	4831	1775	3056	30.7
T2	125% RDF	5503	1947	3556	31.4
T3	100% RDF + NPK spray	6587	2150	4437	32.6
T4	75% RDF + FYM	6928	2286	4642	33.0
T5	75% RDF + Rhizobium + PSB	6778	2167	4645	32.9
T6	75% RDF + NPK spray	5990	2033	3957	31.9
T7	50% RDF + FYM	5227	1810	3417	31.2
T8	50% RDF + Rhizobium + PSB	4276	1637	2749	29.3
T9	50% RDF + NPK spray	4736	1708	3028	30.0
T10	Control	3743	1571	2529	28.9
SEm +/-		90.1	40.3	51.6	0.87
CD (5%)		267.8	119.8	153.3	2.60

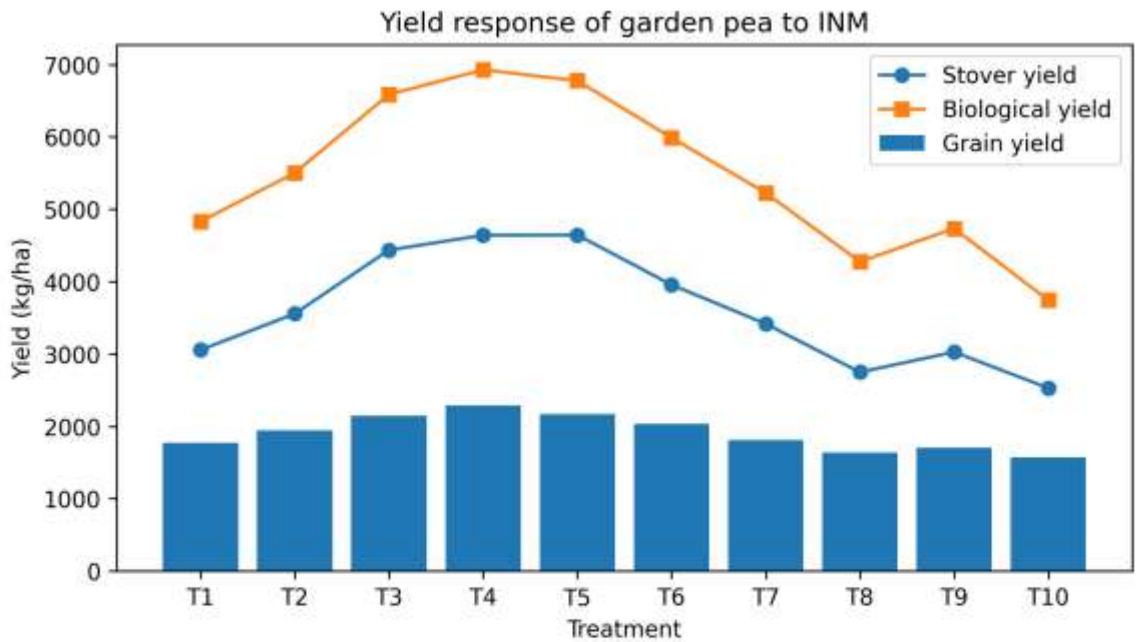

Fig. 4. Grain, stover and biological yield under different INM treatments.

3.4 Nutrient content, uptake and nutrient balance

N, P and K content of pea grain differed significantly across nutrient management practices. Treatment T4 recorded the highest N (3.24%), P (0.67%) and K (1.03%) content, followed by T5. The same treatment also recorded the highest uptake of N, P and K and the maximum positive nutrient balance. The unfertilized control recorded the lowest nutrient content and uptake, and showed depletion trends for P and K balance. These results show the role of FYM and biological inputs in improving nutrient availability and nutrient-use efficiency.

Table 6. Effect of INM on N, P and K content of pea grain.

T	Treatment	N (%)	P (%)	K (%)
T1	100% RDF	3.01	0.59	0.85
T2	125% RDF	3.04	0.61	0.93
T3	100% RDF + NPK spray	3.16	0.62	0.98
T4	75% RDF + FYM	3.24	0.67	1.03
T5	75% RDF + Rhizobium + PSB	3.21	0.63	1.00
T6	75% RDF + NPK spray	3.10	0.61	0.97
T7	50% RDF + FYM	3.02	0.60	0.91
T8	50% RDF + Rhizobium + PSB	2.59	0.57	0.82
T9	50% RDF + NPK spray	2.68	0.58	0.84
T10	Control	1.98	0.53	0.77
SEm +/-		0.165	0.026	0.047
CD (5%)		0.491	0.077	0.139

Table 7. Crop nutrient uptake and net nutrient gain/loss (kg/ha).

T	Treatment	N uptake	P uptake	K uptake	Net N	Net P	Net K
T1	100% RDF	116.27	10.36	49.81	64.67	-0.30	-0.54
T2	125% RDF	126.63	10.67	51.12	69.77	0.32	0.92
T3	100% RDF + NPK spray	134.41	11.52	53.81	81.79	2.78	8.35
T4	75% RDF + FYM	168.85	14.15	66.21	114.72	5.44	17.71
T5	75% RDF + Rhizobium + PSB	163.23	13.68	64.53	93.38	3.25	11.41
T6	75% RDF + NPK spray	130.24	11.12	53.61	74.53	0.55	0.87

T7	50% RDF + FYM	121.05	10.51	50.51	69.41	0.65	0.38
T8	50% RDF + Rhizobium + PSB	104.85	9.15	44.51	57.05	0.25	0.32
T9	50% RDF + NPK spray	112.32	9.96	46.61	60.25	2.01	2.41
T10	Control	68.92	6.07	29.50	22.98	-1.56	-10.60

3.5 Quality parameters

Protein content and protein yield increased significantly under INM treatments compared with the control. Treatment T4 produced the highest protein content (20.77%) and protein yield (475.2 kg/ha), followed by T5 and T3. Improved protein content is mainly associated with better nitrogen availability and greater nitrogen uptake, which enhance amino acid and protein synthesis in the seed.

Table 8. Effect of INM on protein content and protein yield of garden pea.

T	Treatment	Protein content (%)	Protein yield (kg/ha)
T1	100% RDF	18.33	325.4
T2	125% RDF	19.43	378.2
T3	100% RDF + NPK spray	20.45	424.4
T4	75% RDF + FYM	20.77	475.2
T5	75% RDF + Rhizobium + PSB	20.53	443.2
T6	75% RDF + NPK spray	19.73	417.8
T7	50% RDF + FYM	18.82	340.8
T8	50% RDF + Rhizobium + PSB	17.80	291.6
T9	50% RDF + NPK spray	18.23	311.4
T10	Control	17.33	220.2
SEm +/-		0.287	11.77
CD (5%)		0.852	34.97

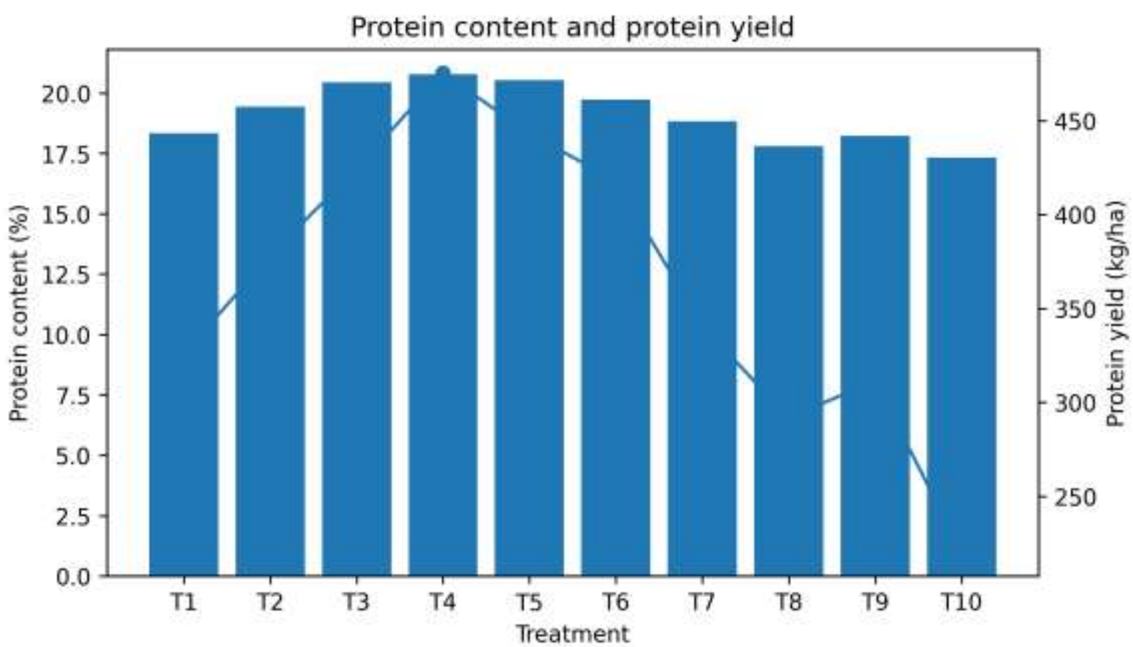

Fig. 5. Protein content and protein yield under INM treatments.

3.6 Economics

The economic analysis showed that all INM treatments were more profitable than the control. The maximum gross income (Rs. 118,942/ha), net return (Rs. 90,957/ha) and benefit:cost ratio (3.25) were recorded under T4. Treatment T5 was the next best treatment with net return of Rs. 85,876/ha and B:C ratio of 3.17. Although FYM-based treatment involved input cost, the yield improvement compensated for this cost and resulted in greater profitability.

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Table 9. Economics of garden pea under different INM treatments.

T	Treatment	Cost (Rs/ha)	Gross income (Rs/ha)	Net return (Rs/ha)	B:C ratio
T1	100% RDF	27,756	91,806	64,050	2.31
T2	125% RDF	28,628	100,906	72,278	2.52
T3	100% RDF + NPK spray	30,756	111,937	81,181	2.64
T4	75% RDF + FYM	27,985	118,942	90,957	3.25
T5	75% RDF + Rhizobium + PSB	27,085	112,961	85,876	3.17
T6	75% RDF + NPK spray	29,885	105,607	75,722	2.53
T7	50% RDF + FYM	27,113	93,917	66,804	2.46
T8	50% RDF + Rhizobium + PSB	26,213	84,489	58,276	2.22
T9	50% RDF + NPK spray	29,013	88,428	59,415	2.05
T10	Control	24,270	66,022	41,752	1.72

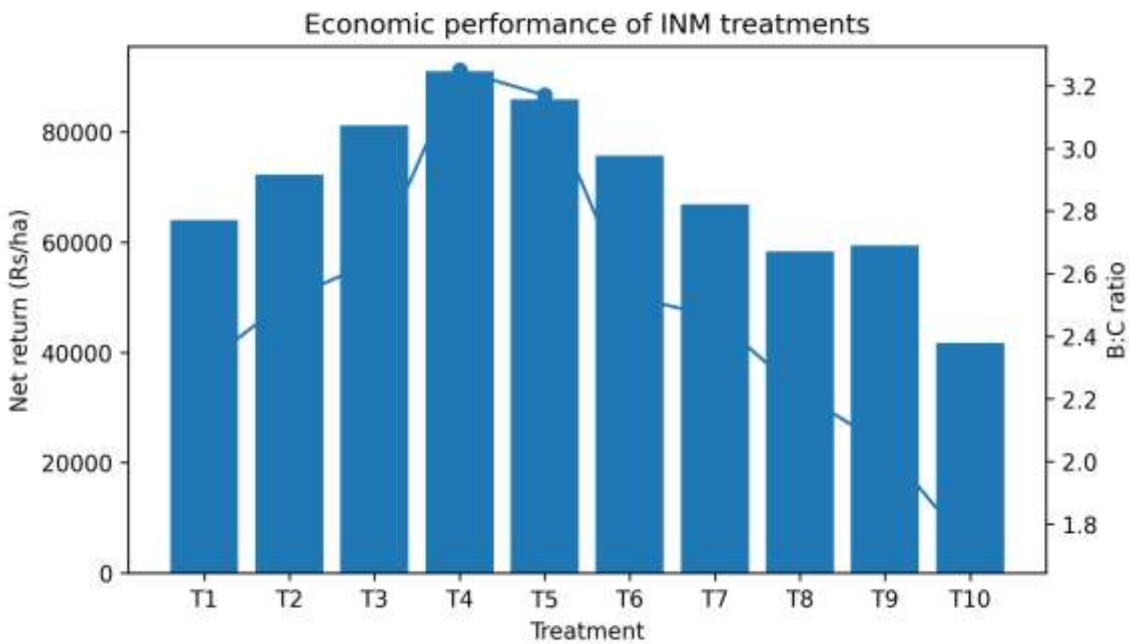

Fig. 6. Net return and benefit:cost ratio under different INM treatments.

4. DISCUSSION

The results clearly demonstrate that integrated use of inorganic fertilizers, FYM and biofertilizers produced better crop performance than unfertilized control and most sole or reduced fertilizer treatments. The superiority of T4 (75% RDF + 2.5 t/ha FYM) may be attributed to a complementary nutrient-supply mechanism. Chemical fertilizers supplied readily available nutrients during early growth, while FYM gradually released nutrients and improved the soil physical environment throughout the crop period. This combination likely maintained nutrient availability during vegetative as well as reproductive growth stages.

Improvement in plant height under FYM-based and biofertilizer-based treatments may be explained by greater root proliferation, higher microbial activity and better nutrient mobilization. Organic matter improves soil aggregation, aeration and moisture retention, which creates a favourable rhizosphere. In legumes, good root development is especially important because it supports nodulation and biological nitrogen fixation. Rhizobium inoculation contributes to atmospheric nitrogen fixation, while PSB enhances phosphorus solubilization, thereby improving nutrient availability and plant metabolism.

The higher number of pods per plant, seeds per pod and seed index under T4 and T5 indicates that balanced nutrition improved the reproductive efficiency of garden pea. Adequate nitrogen enhances leaf area and chlorophyll formation, phosphorus supports root growth, energy transfer and flowering, and potassium regulates enzyme activity and assimilate translocation. A balanced supply of these nutrients improves photosynthesis and translocation of assimilates from source organs to developing pods and seeds. Consequently, better pod formation and seed filling resulted in higher grain yield and harvest index.

The highest protein content and protein yield under T4 also reflected the improved nitrogen nutrition of the crop. Protein formation in seeds is strongly associated with nitrogen uptake and assimilation. The increased nutrient content and uptake observed in the present study indicate that integrated nutrient management enhanced nutrient-use efficiency. Positive nutrient balance under FYM-based treatments suggests that INM can reduce nutrient mining and contribute to long-term soil fertility, whereas the control treatment showed nutrient depletion.

Economic results further support the agronomic findings. Higher net return and B:C ratio under T4 show that the use of FYM with reduced RDF is not only productive but also profitable. The treatment T5 also performed well, indicating the potential of biofertilizers to reduce dependence on higher levels of chemical fertilizers. These findings support the concept that nutrient management in vegetable legumes should be evaluated not only on yield, but also on quality, soil fertility and profitability.

5. CONCLUSION

The study concluded that integrated nutrient management significantly improves growth, yield attributes, yield, grain quality, nutrient uptake and profitability of garden pea under the Gird zone of Madhya Pradesh. Among the treatments, 75% RDF + 2.5 t/ha FYM was the most effective and economically viable practice. This treatment recorded the highest plant height, yield attributes, grain yield, protein content, nutrient uptake, net return and benefit:cost ratio. It is therefore recommended that garden pea growers adopt 75% RDF along with 2.5 t/ha FYM for higher productivity, improved quality and better economic returns. The integration of biofertilizers such as Rhizobium and PSB with reduced fertilizer doses may also be promoted as a sustainable nutrient-management option. Long-term studies are suggested to evaluate the cumulative effects of INM on soil organic carbon, microbial activity and productivity of pea-based cropping systems.

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