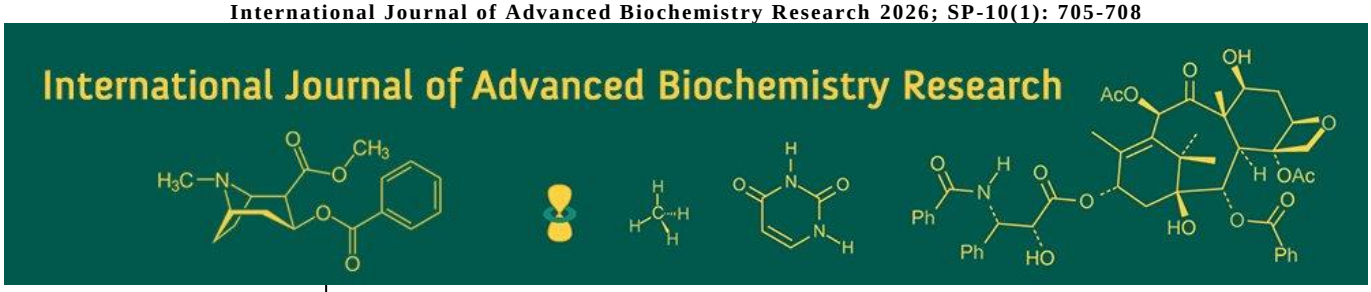

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Effect of integrated nutrient management on mustard under Kymore Plateau conditions

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Abstract
Indian mustard (*Brassica* spp.) is a major Rabi oilseed crop of India, and its productivity is strongly influenced by balanced nutrient management. A field experiment was conducted during the Rabi season of 2022-23 at the Rajoula Agricultural Farm, MGCGV, Chitrakoot, Satna (Madhya Pradesh), to evaluate the effect of integrated nutrient management on mustard under Kymore Plateau conditions on yield, quality, and nutrient uptake of mustard (Pusa Mahak variety). The experiment was laid out in a randomized block design with nine treatments comprising different levels of NPK fertilizers, farmyard manure (FYM), and their combinations, replicated three times. Results revealed significant variations in seed yield, Stover yield, oil content, oil yield, and nutrient uptake due to different nutrient management practices. Seed yield ranged from 715.09 to 1555.80 kg ha^{-1}, with the highest yield recorded under IPNS treatment T_6 (40:20:10 NPK + 5 t FYM ha^{-1}), which was significantly superior to all other treatments. The same treatment also registered maximum oil content (36.48%), oil yield (567.94 kg ha^{-1}), and the highest uptake of nitrogen, phosphorus, and potassium in seed, Stover, and total biomass. Integrated nutrient treatments consistently outperformed sole application of inorganic fertilizers or FYM, while the control recorded the lowest values for all parameters. The enhanced performance under INM was attributed to improved nutrient availability, better nutrient-use efficiency, and improved soil health. The study concludes that application of IPNS (40:20:10 NPK + 5 t FYM ha^{-1}) is the most effective and sustainable nutrient management strategy for improving productivity, quality, and nutrient uptake of mustard under Kymore Plateau agro-climatic conditions.

Keywords: Indian mustard, *Brassica* spp., integrated nutrient management, IPNS, farmyard manure

1. Introduction
Indian mustard (*Brassica* spp.) is a leading Rabi season oilseed crop and plays a vital role in meeting India's edible oil demand. During the 2023-24 season, the area under rapeseed-mustard expanded to around 100.39 lakh hectares, with national production estimated at nearly 12.0 million tones, reflecting a steady increase in its importance. The crop is predominantly cultivated in Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana and Gujarat. Mustard seeds are widely used for oil extraction, condiments and several industrial products, while the residual oil cake serves as a nutrient-rich organic manure and valuable livestock feed. However, continuous reliance on chemical fertilizers has raised concerns regarding soil fertility depletion and long-term sustainability of production. Organic sources such as farmyard manure, others contribute to the improvement of soil physical properties, microbial activity, nutrient availability and nutrient use efficiency. Integration of organic manures with inorganic fertilizers enhances nutrient uptake, minimizes nutrient losses and promotes sustainable soil health. Thus, integrated nutrient management emerges as an effective, economical and environmentally sound strategy for sustaining mustard productivity under diverse agro-climatic conditions.

2. Materials and Methods
A field experiment entitled "Effect of Integrated Nutrient Management on Mustard under Kymore Plateau Conditions" was conducted during the Rabi season of 2022-23 at the Rajoula Agricultural Farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (Madhya Pradesh), India. The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments and three replications, comprising 27 plots Treatments included different levels of NPK fertilizers, FYM, and integrated plant nutrient system (IPNS) combinations.

Table 1: Experimental treatment details.

Treatment	Treatment Combination
T_1	NPK (30:20:10) kg ha^{-1}
T_2	NPK (60:30:15) kg ha^{-1}
T_3	NPK (80:40:20) kg ha^{-1}
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)
T_7	FYM @ 5 t ha^{-1}
T_8	FYM @ 7.5 t ha^{-1}
T_9	Control

Data on growth, yield and quality parameters were subjected to Analysis of Variance (ANOVA) following the procedure of Fisher (1947) [2] and Panse & Sukhatme (1967) [4]. Treatment differences were evaluated at the 5% probability level. The Standard Error of Mean (SEm±) and Critical Difference (CD at 5%) were computed for comparison of treatment means.

3. Result and Discussion

3.1. Seed and Stover Yield

The results of the field experiment revealed that different nutrient management practices exerted a significant effect on the growth and productivity of mustard. Seed yield varied markedly among the treatments, ranging from 715.09 to 1555.80 kg ha^{-1}, whereas Stover yield ranged from 2030.55 to 4098.97 kg ha^{-1}. The maximum seed yield (1555.80 kg ha^{-1}) was recorded under T_6 (IPNS: 40:20:10 NPK + 5 t FYM), which was significantly superior to all other treatments. This was followed by T_3 (80:40:20 NPK), which produced 1419.43 kg ha^{-1}.

Among integrated nutrient treatments, $T_6 > T_5 > T_4$, and among inorganic fertilizer treatments $T_3 > T_2 > T_1$, indicating that higher fertilizer doses and addition of FYM markedly improved yield. The lowest seed yield (715.09 kg ha^{-1}) and Stover yield (2030.55 kg ha^{-1}) were recorded in T_9 (control). A similar trend was evident for Stover yield, with the highest value (4098.97 kg ha^{-1}) observed in T_6, while T_3 produced 4221.17 kg ha^{-1}, which was significantly higher than lower nutrient doses.

3.2. Oil Content and Oil Yield

Oil content in mustard seed showed significant variation due to nutrient management treatments. Oil percentage ranged from 31.28 to 36.48%, with T_6 registering the maximum (36.48%) followed by T_3 (35.86%) and T_5 (34.78%). The lowest oil percentage (31.28%) was found under the control.

Oil yield showed a more pronounced response to nutrient application. It varied from 223.53 to 567.94 kg ha^{-1}, and the highest oil yield was obtained with T_6, followed by T_3 and T_2. The improvement in oil yield under T_6 was mainly attributed to higher seed yield as well as enhanced oil accumulation.

Table 2: Effect of INM on mustard Seed yield, Stover Yield, Oil Content (%), and Oil Yield.

Treatments	Seed Yield (Kg/h)	Stover Yield (Kg/h)	Oil (%)	Oil (Kg/ha)
T_1	1181.87	2784.88	33.73	399.43
T_2	1323.76	3424.37	34.32	454.1
T_3	1419.42	4221.17	35.86	508.97
T_4	1267.43	2575.86	34.4	436.34
T_5	1418.38	3128.02	34.78	493.3
T_6	1555.8	4098.96	36.48	567.93
T_7	945.78	2487.16	32.16	304.02
T_8	1094.78	2977	34.39	376.95
T_9	715.09	2030.55	31.28	223.53
S. Em ±	56.81	96.28	0.678	22.62
C.D.at 5%	170.31	288.62	2.033	67.809

3.3. Nutrient Content in Seed

Nitrogen content in seed ranged from 2.77 to 3.22%. The maximum value was observed in T_6 (3.22%), followed by T_3 (3.14%) and T_2 (3.07%), while the minimum was recorded in the control (2.77%). Seed phosphorus content varied from 0.656 to 0.717%, with the highest in T_6 (0.717%) and the lowest in the control. Integrated nutrient management consistently enhanced P concentration over sole FYM or lower fertilizer rates. Potassium content ranged from 0.55 to 0.615%, being highest under T_6 (0.615%), followed by T_3 (0.605%) and T_2 (0.596%). Control had the lowest K content.

Table 3: Effect of INM on nutrient content (Nitrogen, Phosphorus and Potassium) in Mustard seed.

Treatment	Nitrogen content in seed (%)	Phosphorus content in Seed (%)	Potassium content in Seed (%)
T_1	2.78	0.67	0.57
T_2	3.06	0.69	0.59
T_3	3.14	0.7	0.6
T_4	2.76	0.68	0.58
T_5	3.02	0.7	0.6
T_6	3.22	0.71	0.61
T_7	2.78	0.66	0.57
T_8	2.96	0.68	0.59
T_9	2.77	0.65	0.55
S. Em ±	0.082	0.0030	0.004
C.D.at 5%	0.247	0.0100	0.013

3.4. Nutrient Content in Stover

Stover nitrogen content ranged from 0.403 to 0.477%, with T_6 again recording the highest value. Stover phosphorus concentration varied widely between 0.10 and 0.23%. The highest was found in T_6 (0.231%), followed by T_5 (0.203%), indicating improved P availability under integrated nutrient management. Stover potassium content ranged from 1.29 to 1.75%. Among all treatments, T_4 (1.76%) and T_7 (1.70%) showed higher K accumulation in Stover, indicating a positive effect of FYM on potassium mobilization.

Table 4; Effect of INM on nutrient content (Nitrogen, Phosphorus and Potassium) in Mustard Stover.

Treatment	Nitrogen content in Stover (%)	Phosphorus content in Stover (%)	Potassium content in Stover (%)
T_1	0.41	0.15	1.39
T_2	0.44	0.17	1.35
T_3	0.45	0.18	1.29
T_4	0.44	0.13	1.75
T_5	0.46	0.2	1.5
T_6	0.47	0.23	1.43
T_7	0.42	0.1	1.7
T_8	0.45	0.13	1.6
T_9	0.4	0.11	1.68
S. Em ±	0.0040	0.018	0.068
C.D.at5%	0.0130	0.055	0.206

3.5 Nutrient Uptake in Seed

N uptake by seed was significantly enhanced by INM and higher fertilizer levels. Uptake ranged from 20.07 to 50.64 kg ha^{-1}, with T_6 (50.64 kg ha^{-1}) showing the highest value, followed by T_5 (43.44 kg ha^{-1}) and T_3 (45.16 kg ha^{-1}). Phosphorus uptake in seed ranged from 4.73 to 11.22 kg ha^{-1}. The highest P uptake was noted in T_6, while control recorded the lowest. Potassium uptake varied from 4.39 to 10.20 kg ha^{-1}, with T_6 again achieving the highest K uptake, followed by T_5 and T_3. This corresponded with improved nutrient content and higher seed yield.

Table 5: Effect of INM on nutrient uptake (Nitrogen, Phosphorus and Potassium) in Mustard seed (Kg/ha).

Treatment	Nitrogen Uptake in Seed (Kg/ha)	Phosphorus Uptake in Seed (Kg/ha)	Potassium Uptake in Seed (Kg/ha)
T_1	33.64	7.99	7.25
T_2	40.92	9.28	8.43
T_3	45.16	10.13	9.14
T_4	35.28	8.75	7.93
T_5	43.43	10.1	9.13
T_6	50.63	11.22	10.2
T_7	26.65	6.37	5.92
T_8	32.87	7.6	6.93
T_9	20.07	4.72	4.39
S. Em ±	1.42	0.39	0.35
C.D.at 5%	4.27	1.19	1.06

3.6 Nutrient Uptake in Stover

Stover N uptake ranged from 8.20 to 19.56 kg ha^{-1}, with the highest in T_6, followed by T_3 (19.33 kg ha^{-1}) and T_2 (15.10 kg ha^{-1}). Stover P uptake varied between 2.33 and 9.49 kg ha^{-1}, peaking in T_6. FYM-based treatments (T_4 and T_7) also improved P uptake over control. Potassium uptake by Stover ranged from 34.31 to 59.00 kg ha^{-1}. The highest K uptake occurred in T_6 (59.00 kg ha^{-1}), followed by T_3 and T_2.

Table 6: Effect of INM on nutrient uptake (Nitrogen, Phosphorus and Potassium) in Mustard Stover (Kg/ha).

Treatment	Nitrogen Uptake in Stover (Kg/ha)	Phosphorus Uptake in Stover (Kg/ha)	Potassium Uptake in Stover (Kg/ha)
T_1	11.48	4.35	38.86
T_2	15.09	5.98	45.98
T_3	19.32	7.96	54.78
T_4	11.5	3.4	45.19
T_5	14.53	6.4	47.32
T_6	19.56	9.49	59
T_7	10.66	2.59	42.44
T_8	13.41	3.91	47.92
T_9	8.19	2.32	34.31
S. Em ±	0.46	0.55	2.49
C.D.at 5%	1.39	1.66	7.46

3.7 Total Nutrient Uptake (Seed + Stover)

Combined nutrient uptake showed a clear superiority of integrated nutrient management. Total nitrogen uptake ranged from 28.27 to 70.20 kg ha^{-1}, maximum under T_6. Total phosphorus uptake varied from 7.05 to 20.72 kg ha^{-1}, again highest in T_6. Total potassium uptake ranged between 38.71 and 69.20 kg ha^{-1}, with T_6 registering the highest value. Across all nutrients, T_6 consistently recorded the maximum uptake, followed by T_5 and T_3. Control recorded the minimum uptake values.

Table 7: Effect of INM on total uptake of Nitrogen, Phosphorus and Potassium by Mustard crop (Kg/ha).

Treatment	Total Uptake Nitrogen (Kg/ha)	Total Uptake Phosphorus (Kg/ha)	Total Uptake Potassium (Kg/ha)
T_1	45.13	12.34	46.111
T_2	56.02	15.27	54.41
T_3	64.48	18.09	63.92
T_4	46.79	12.16	53.12
T_5	57.97	16.50	56.45
T_6	70.20	20.71	69.20
T_7	37.32	8.97	48.36
T_8	46.28	11.51	54.85
T_9	28.27	7.051	38.71
S. Em +	1.595	0.630	2.64
C.D.at 5%	4.783	1.88	7.92

4. Conclusion

The effect of integrated nutrient management on mustard under Kymore Plateau conditions demonstrated that integrated nutrient management (INM) and graded levels of NPK significantly improved growth, yield, and nutrient uptake of mustard. Statistical analysis showed that seed yield, Stover yield, oil content, and oil yield responded strongly and significantly (CD at 5%) to various nutrient treatments, confirming a high sensitivity of mustard to balanced nutrient supply.

Among all treatments, T6 - IPNS (40:20:10 NPK + 5 t FYM ha^{-1}) consistently produced the highest seed yield (1555.8 kg ha^{-1}), Stover yield, oil percentage (36.48%), and oil yield (567.94 kg ha^{-1}). This treatment also recorded the maximum uptake of N, P and K in seed, Stover, and total biomass, indicating improved nutrient absorption and enhanced fertilizer-use efficiency.

Overall, the results confirm that integrated nutrient management, particularly higher-level IPNS (40:20:10 NPK + FYM), is the most effective nutrient strategy for achieving

higher productivity, better quality, and enhanced nutrient-use efficiency in mustard. Adoption of INM practices can therefore contribute to sustainable yield improvement and long-term soil health in mustard-based cropping systems.

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