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Optimizing mustard crop productivity through combined application of organic and inorganic nutrients in Chitrakoot (MP)

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Abstract
The present investigation trough field experiment at Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) during Rabi season of 2022-23 to assessed the optimizing mustard crop productivity through combined application of organic and inorganic nutrients on Pusa Mahak variety mustard in Chitrakoot (MP). Crop with different nine treatments combinations and three replicated in RBD (Randomized block design). The results indicated that all growth and yield parameters significantly improved with increasing levels of nutrient application through inorganic fertilizers and integrated nutrient management (IPNS). Among the treatments, T6 (40:20:10 NPK + FYM @ 5 t ha^{-1}) consistently produced superior results. Maximum plant height at 30, 60 and 90 DAS, highest number of branches per plant (7.36), siliqua per plant (176.9), and 1000-seed weight (4.75 g) were recorded under this treatment. Similarly, the highest seed yield (2.334 kg $plot^{-1}$) and Stover yield (6.148 kg $plot^{-1}$) were also achieved with T6, followed by T3 and T5. In contrast, the untreated control recorded the lowest values for all attributes. The enhanced performance under IPNS may be attributed to the balanced supply of nutrients, improved soil structure, better nutrient retention and sustained nutrient availability throughout crop growth. The study concludes that integrated application of NPK fertilizers along with FYM is an effective strategy for improving growth, yield attributes and productivity of mustard crop.

Keywords: Optimizing mustard productivity, integrated nutrient management, organic and inorganic nutrients, NPK fertilizers, farmyard manure (FYM), mustard (*brassica juncea*), yield attributes, Chitrakoot (Madhya Pradesh)

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 tonnes, 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 was conducted during Rabi 2022-23 at the Rajaula Agricultural Farm, MGCGV, Chitrakoot, Satna (M.P.), India, located at 25.148° N and 80.855° E. The soil of the experimental site was sandy loam, low in organic carbon, available N, P, and medium available K, soil analyzed using standard methods (Walkley & Black, Kjeldahl, Olsen, and flame

photometry). The study was laid out in a Randomized Block Design with nine nutrient management treatments (Table-1) and three replications. Treatments included varying levels of inorganic NPK fertilizers, integrated nutrient management (NPK + FYM), and FYM alone. Mustard (*Pusa Mahak*) was sown at 30 cm × 10 cm spacing with a seed rate of 6 kg ha^{-1}.FYM and fertilizers were applied as per treatment. The crop was grown under irrigated conditions, with standard agronomic practices for weeding and thinning and other activity. Observations on plant height (30, 60, 90 DAS), branches per plant, siliqua per plant, 1000-seed weight, seed yield, and Stover yield were recorded from tagged plants. Stastical data were analyzed using ANOVA for RBD, and treatment means were compared using CD at 5% along with SEm±.

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

3. Result and Discussion

3.1 Plant Height (cm)

A significant improvement in plant height was recorded under different nutrient management practices at all growth stages (30, 60 and 90 DAS). Plant height consistently increased with higher levels of nutrient application through both inorganic fertilizers and IPNS treatments. At 30 DAS, plant height ranged from 19.55 cm (T_9) to 29.06 cm (T_6) by 60 DAS, the tallest plants were observed in T_6 (157.94 cm) followed by T_5 (150.23 cm) and T_3 (148.14 cm), whereas the minimum height occurred in the control (T_9: 104.28 cm) at 90 DAS, the maximum height (176.47 cm) was again recorded with T6, while the shortest plants (124.48 cm) were observed in the control. The overall trend showed that integrated nutrient management (NPK + FYM) and higher inorganic NPK levels significantly enhanced vegetative growth. The improvement with IPNS may be attributed to the combined effect of readily available nutrients and slow-release organic sources improving soil structure and nutrient retention.

Table 2: Effect of different treatment combination on plant height (cm) at 30, 60, 90 DAS.

Treatment	Treatment Combination	30 DAS	60 DAS	90 DAS
T_1	NPK (30:20:10) kg ha^{-1}	25.52	127.37	148.56
T_2	NPK (60:30:15) kg ha^{-1}	26.76	140.00	161.2
T_3	NPK (80:40:20) kg ha^{-1}	28.15	148.14	169.34
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)	26.98	130.54	151.74
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)	28.83	150.23	171.43
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)	29.06	157.94	176.47
T_7	FYM @ 5 t ha^{-1}	22.27	111.06	131.26
T_8	FYM @ 7.5 t ha^{-1}	24.37	123.85	144.05
T_9	Control	19.55	104.28	124.48
S. Em ±		0.73	1.9	1.8
C.D.at 5%		2.20	5.6	5.4

3.2 Number of branches per plant

Branching exhibited significant variation among treatments, reflecting the role of balanced nutrition in promoting canopy development.

The highest number of branches (7.36 branches plant^{-1}) was observed under T_6 (40:20:10 NPK + FYM @ 5 t ha^{-1}), followed closely by T_3 (7.09).

The lowest value (3.99 branches plant^{-1}) was recorded in the control. Higher nutrient availability, especially in T_5 and T_6, supported better meristematic activity and lateral branching, which ultimately contributed to improved yield attributes.

Table 3: Effect of different treatment combination on number of branches per plant.

Treatment	Treatment Combination	Branches plant^{-1}
T_1	NPK (30:20:10) kg ha^{-1}	5.19
T_2	NPK (60:30:15) kg ha^{-1}	6.24
T_3	NPK (80:40:20) kg ha^{-1}	7.09
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)	5.35
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)	6.44
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)	7.36
T_7	FYM @ 5 t ha^{-1}	4.30
T_8	FYM @ 7.5 t ha^{-1}	4.69
T_9	Control	3.99
S. Em ±		0.07
C.D.at 5%		0.20

3.3 Number of Siliqua per plant

Siliqua formation responded positively to nutrient application. The maximum number of siliqua (176.9) was registered in T_6, being statistically superior to all lower nutrient doses. This was followed by T_3 (173.6) and T_5 (157.6). The lowest siliqua count (78.9) was recorded in the control (T_9). Increased siliqua formation under IPNS and higher NPK levels indicates better nutrient uptake, photosynthetic translocation and reproductive efficiency.

Table 4: Effect of different treatment combination on number of siliqua per plant.

Treatment	Treatment Combination	No. of siliqua plant^{-1}
T_1	NPK (30:20:10) kg ha^{-1}	139.5
T_2	NPK (60:30:15) kg ha^{-1}	148.0
T_3	NPK (80:40:20) kg ha^{-1}	173.6
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)	150.2
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)	157.6
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)	176.9
T_7	FYM @ 5 t ha^{-1}	96.6
T_8	FYM @ 7.5 t ha^{-1}	116.1
T_9	Control	78.9
S. Em ±		3.9
C.D.at 5%		11.8

3.4 1000-Seed weight (g)

Seed weight improved with nutrient enhancement, with the highest value (4.75 g) recorded in T6, followed by T_3 (4.56 g) and T_5 (4.47 g).

The lowest seed weight (3.51 g) occurred in the control. Organic manure in IPNS likely improved soil physical condition and micronutrient availability, helping in better seed filling.

Table 5: Effect of different treatment combination on 1000-Seed weight (g).

Treatment	Treatment Combination	1000-Seed weight (g)
T_1	NPK (30:20:10) kg ha^{-1}	4.07
T_2	NPK (60:30:15) kg ha^{-1}	4.35
T_3	NPK (80:40:20) kg ha^{-1}	4.56
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)	4.09
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)	4.47
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)	4.75
T_7	FYM @ 5 t ha^{-1}	3.69
T_8	FYM @ 7.5 t ha^{-1}	4.17
T_9	Control	3.51
S. Em ±		0.21
C.D.at 5%		0.63

3.5 Seed yield (kg /ha)

A marked increase in seed yield was recorded with nutrient management treatments. The highest seed yield (1555.8 kg /ha) was obtained in T_6, which was significantly higher than all other treatments. Treatments T_3 (1419.42 kg/ha) and T_5 (1418.38 kg/ha) also produced substantially higher yields. The lowest seed yield (715.09 kg/ha) was observed in the control. The superior performance of T_6 clearly shows the synergistic effect of chemical fertilizers and FYM, ensuring sustained nutrient availability throughout the growing season.

Table 6: Effect of different treatment combination on Seed yield (kg /ha).

Treatment	Treatment Combination	Seed yield (kg/ ha)
T_1	NPK (30:20:10) kg ha^{-1}	1181.87
T_2	NPK (60:30:15) kg ha^{-1}	1323.76
T_3	NPK (80:40:20) kg ha^{-1}	1419.42
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)	1267.43
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)	1418.38
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)	1555.80
T_7	FYM @ 5 t ha^{-1}	945.78
T_8	FYM @ 7.5 t ha^{-1}	1094.78
T_9	Control	715.09
S. Em ±		56.80
C.D.at 5%		170.30

3.6 Stover yield (kg /ha)

Stover yield followed a trend similar to seed yield. The maximum Stover yield (4221.17 kg/ha) was produced by T_3, followed by T_6 (4098.96 kg/ha) and T_2 (3424.37 kg/ha). The minimum Stover yield (2030.50 kg/ha) was observed in the untreated control. Higher biomass accumulation under IPNS treatments is linked with better root growth, water retention, and continuous nutrient supply.

Table 6: Effect of different treatment combination on Stover yield.

Treatment	Treatment Combination	Stover yield (kg/ ha)
T_1	NPK (30:20:10) kg ha^{-1}	2784.88
T_2	NPK (60:30:15) kg ha^{-1}	3424.37
T_3	NPK (80:40:20) kg ha^{-1}	4221.17
T_4	IPNS (NPK + FYM) (15:10:5 + 5 t FYM)	2575.86
T_5	IPNS (NPK + FYM) (30:15:7.5+ 5 t FYM)	3128.02
T_6	IPNS (NPK + FYM) (40:20:10 + 5 t FYM)	4098.96
T_7	FYM @ 5 t ha^{-1}	2487.16
T_8	FYM @ 7.5 t ha^{-1}	2977.00
T_9	Control	2030.50
S. Em ±		96.28
C.D.at 5%		288.60

4. Conclusion

The study revealed that mustard responded strongly to different nutrient management practices, with significant improvements in growth, yield attributes and overall productivity. Among all treatments, the integrated nutrient management approach IPNS (40:20:10 NPK + 5 t FYM ha^{-1}) emerged as the most effective, producing the highest plant height, number of branches, siliqua formation, seed weight, seed yield. This treatment consistently outperformed both lower fertilizer doses and the sole application of organic manure. The results clearly demonstrate that combining chemical fertilizers with FYM ensures a balanced and continuous nutrient supply, enhances soil physical properties and ultimately leads to superior crop performance. In contrast, the control and low-nutrient treatments recorded the lowest values for all parameters, emphasizing the importance of adequate nutrient application. Overall, the findings suggest that integrated use of fertilizers and FYM is a sustainable and efficient nutrient management strategy for maximizing mustard productivity under the given agro-climatic conditions.

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