



Assessing the Role of Organic and Chemical Fertilizers on Growth, Yield and Nutrient Uptake of Indian Mustard in Central India

Neetu Choudhary^{1*}, SK Trivedi¹, Preeti Sharma², Pardeep Phogat²,
Kiran Dhaka³, Kajal Kumawat³ and Monika¹

¹Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

²Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

³Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

*Corresponding author's E-mail: neetuchoudhary871999@gmail.com

Abstract

A field study was carried out during the Rabi season of 2022–2023 at the Research Farm, Department of Soil Science, College of Agriculture, RVSKVV, Gwalior (M.P.), to assess the impact of organic and inorganic nutrient sources on growth performance, yield parameters, nutrient assimilation, and quality traits of Indian mustard under Central Indian conditions. The experiment consisted of eight nutrient management treatments arranged in a randomized block design (RBD) with three replications. Findings indicated that growth parameters such as plant height, number of siliquae per plant, and plant population at harvest exhibited significant improvement under different nutrient management strategies. The maximum values of these growth indicators were recorded with the treatment comprising 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB (seed treatment) (T4), outperforming the remaining treatments. Likewise, the same treatment (T4) produced the highest seed yield (2411 kg ha⁻¹) and straw yield (5532 kg ha⁻¹), followed closely by T1 and proved superior to the other nutrient combinations. Nutrient analysis revealed that T4 also recorded the greatest nitrogen, phosphorus, potassium, and sulphur concentrations and their uptake in both seed and stover, which was statistically at par with T1. The study emphasizes that integrating organic amendments with chemical fertilizers, rather than relying solely on chemical inputs, can substantially improve crop growth, nutrient use efficiency, and sustainable mustard production.

Keywords: Farmyard manure, Mustard, Nutrient content, PSB, Yield attributes

Introduction

Mustard (*Brassica juncea* L.), a crucial Rabi season oilseed crop, belongs to the Cruciferae (Brassicaceae) family. On a global scale, mustard is cultivated over approximately 36.54 million hectares, producing about 72.80 million tonnes of mustard seed and 16-18 million tonnes of oil. India plays a significant role in the global mustard sector, accounting for around 28.3% of the total area under cultivation and 12% of the overall production. Following soybean and groundnut, mustard ranks as the third most vital oilseed crop in India, contributing 27.8% to the country's oilseed output (Sahoo *et al.*, 2018, Gupta *et al.*, 2023 and Singh *et al.*, 2024). The leading mustard-growing states include Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat.

Remarkably, mustard supplies nearly one-third of India's total edible oil, reinforcing its strategic importance in the agricultural economy.

During the 2021-22 agricultural year, Madhya Pradesh emerged as the second-largest mustard-producing state, contributing 14.36% to the national output. The state recorded an area of 1.23 million hectares, yielding 1.69 million tonnes of mustard with an average productivity of 1376 kg ha⁻¹ (DES, 2021-22). In terms of nutrient management, the use of farmyard manure (FYM), rich in organic matter, is recommended alongside chemical fertilizers (NPK). Though FYM tends to be more expensive per unit of nutrient compared to chemical alternatives, its positive effects on soil health and crop productivity can justify the cost. Vermicompost, another valuable

organic input, has been widely promoted for use in integrated nutrient management (INM) due to its balanced status of macro- and micronutrients (Shroff and Devesthali, 1992). Farmers are increasingly adopting vermicomposting practices. The integrated application of organic and inorganic fertilizers plays a vital role in sustaining crop productivity while simultaneously enriching soil fertility and improving nutrient-use efficiency (Verma *et al.*, 2005). The present study was therefore undertaken to evaluate the impact of integrated nutrient management practices on the yield, oil content, and quality characteristics of Indian mustard.

The low productivity of mustard is largely attributed to inadequate fertilizer application and its cultivation on marginal, rainfed lands. Practices such as intensive cropping, unbalanced fertilizer use, and minimal incorporation of organic manures have led to nutrient depletion and deterioration of soil health, thereby reducing the crop's response to the recommended NPK fertilizer doses in many regions. To ensure that soils remain well-nourished with all essential nutrients and to maintain overall soil health, the incorporation of organic amendments, such as farmyard manure (FYM), vermicompost, neem cake, and poultry manure, is highly recommended. These organic inputs not only supply vital nutrients but also contribute to better crop quality. Vermicompost, in particular, is rich in both macro and micronutrients, and it also contains growth-promoting substances like enzymes, vitamins, antibiotics, and beneficial microorganisms. Combining FYM with chemical fertilizers has been shown to effectively provide both macro- and micronutrients while simultaneously enhancing soil health (Arbad and Ismail, 2011). Organic manures serve as an excellent source of organic matter, significantly contributing to soil fertility improvement. For instance, poultry manure, known for its high nitrogen and phosphorus content, has demonstrated effectiveness in increasing mustard seed yield (Zamil *et al.*, 2004).

The combination of chemical fertilizers with organic manures is essential for improving and sustaining soil health (Prasad *et al.*, 2010). Under continuous cultivation systems, relying solely on either chemical fertilizers or organic sources is

insufficient to maintain desired crop productivity levels. Therefore, Integrated Nutrient Management (INM) plays a pivotal role in sustaining agricultural productivity. It ensures stable crop yields across seasons (Verma *et al.*, 2010), enhances soil health, and contributes to environmental conservation (Vijaya Sankar Babu *et al.*, 2007). The application of nutrients through INM rejuvenates soil fertility and helps maintain consistent production over time (Pal and Pathak, 2016).

Adopting integrated strategies for nutrient management is vital for improving soil quality, enhancing nutrient-use efficiency, and ensuring sustainable crop productivity, all of which are critical for achieving food and nutritional security in India (Swarup, 2010). The combined use of organic and inorganic nutrient sources is now seen as essential for maintaining long-term soil productivity. Among organic inputs, FYM and vermicompost are particularly important, as they supply necessary macronutrients, fulfill micronutrient needs, and boost beneficial microbial activity in the soil (Kumar *et al.*, 2014). In regions where organic farming has been given policy priority, it is especially important to assess the combined impact of organic amendments and chemical fertilizers on soil properties and crop performance. In mustard crops apart from N and P, the need for secondary nutrients especially sulphur, is frequently felt, as deficiency of these nutrients has a deleterious effect on plant productivity. Gypsum is the cheapest and best source of sulphur, which plays a key role in improving the yield and quality of this oilseed crop. Sulphur is a constituent of protein and plays vital role in oil synthesis. As, mustard crop is rich in oil, the requirement for sulphur for this crop is substantial. Sulphur plays vital role in chlorophyll formation. It ranks in importance with N as a constituent of the amino acids *viz.* cysteine, cystine and methionine in protein that accounts for 90% of S in plants. In general, a plant contains as much S as P, the critical limit from 0.2 to 0.5 per cent on a dry weight basis. Therefore, keeping this view, a study on "Impact of organic and chemical fertilizers on growth attributes, yield and nutrient uptake of Indian mustard (*Brassica juncea* L.)" was conducted in Rabi 2023-24 at Research Farm of CoA, RVSKVV, Gwalior.

Table 1. Details of various nutrient management treatments

T ₁	100% RDF (Urea+ SSP+ MOP)
T ₂	75% RDF + FYM @ 4 Mg ha ⁻¹
T ₃	75% RDF + vermicompost @ 1 Mg ha ⁻¹
T ₄	75% RDF + FYM @ 4 Mg ha ⁻¹ + vermicompost @ 1 Mg ha ⁻¹ + PSB (seed treatment)
T ₅	50% RDF + FYM @ 8 Mg ha ⁻¹
T ₆	50% RDF + Vermicompost @ 2 Mg ha ⁻¹
T ₇	50% RDF + FYM @ 4 Mg ha ⁻¹ + vermicompost @ 1 Mg ha ⁻¹ + PSB (seed treatment)
T ₈	FYM @ 8 Mg ha ⁻¹ + vermicompost @ 2 Mg ha ⁻¹ + PSB (seed treatment)

*RDF = Recommended dose of fertilizer, *FYM = Farmyard Manure

Material and Methods

Study location and treatment details

The field study was conducted at the research farm of the Department of Soil Science, CoA, Rajmata Vijayaraje Scindia Krishi Vidhyalaya, Gwalior. Geographically, it is situated in Grid zone of Madhya Pradesh at latitude 26°13'N and longitude 76°10'E with an altitude of 197 meters from mean sea level (MSL). The research was conducted on 621 m² area at maintained plots having uniform topography with gentle slope and adequate drainage. The experimental site was characterized by a semi-arid, sub-tropical climate, receiving an average annual rainfall of 730 mm. The maximum temperature during summer reached 45 °C, whereas the minimum temperature during winter dropped to 1–2 °C. The soil at the site was classified as sandy clay loam, with an initial pH of 7.40, electrical conductivity (EC) of 0.29 dS m⁻¹, and soil organic carbon (SOC) content of 0.45%. The available nutrient status of the soil included nitrogen, phosphorus, potassium, and sulphur at 206.0, 10.04, 239.0, and 8.9 kg ha⁻¹, respectively.

Details of treatments are given in Table 1. Recommended dose of fertilizers (N, P and K) for mustard crop was applied through inorganic (Urea, DAP and MOP) and organic [FYM, vermicompost and PSB (seed treatment)] sources. The FYM and vermicompost were applied (dry weight basis) before sowing of mustard crop. Urea was applied as N source (two equal split doses) in all the treatments. After field preparation, Indian mustard variety RVM-2 was sown in *Rabi* season of 2023-24, and the package of practices recommended by the university were adopted for the cultivation of the crop. Composition of N, P

Table 2. Composition of N, P & K in FYM and Vermi compost used in the experiment

S. No.	Particulars	N (%)	P (%)	K (%)
1	FYM	0.5	0.25	0.5
2	Vermicompost	2	1	1.5

and K in FYM and vermicompost used is shown in Table 2.

Sample collection, preparation and analysis

Crop parameters

Five plants were randomly selected, and various observations were taken during different growth stages of the crop. Data were collected on key parameters such as plant height, number of siliquae per plant, and plant population. Following the shelling of the mustard pods, the yield per hectare and grain yield per net plot were determined. The seed yield per plot was multiplied by the appropriate conversion factor to get the seed yield per hectare. Grain yield was subtracted from the biological yield of all the products to determine the straw yield per net plot area.

Nutrient content and uptake (N, P, K and S)

Representative samples of seed and stover were collected from each treatment plot. These samples were first air-dried and then oven-dried at a temperature of 60±2°C. For N analysis, 0.5 g of dried plant material was digested using a concentrated acid mixture of sulphuric acid and perchloric acid in a 4:1 ratio (H₂SO₄ : HClO₃). The digested extract was analyzed for nitrogen content using the colorimetric method with Nessler's reagent. Specifically, 0.2 ml of the digested solution was transferred into a volumetric

flask, followed by the addition of 1 ml each of 10% sodium hydroxide (NaOH) and 10% sodium silicate. Afterward, 2 ml of Nessler's reagent was added, and the final volume was brought up using distilled water. The resulting orange color was measured at 440 nm using a visible spectrophotometer.

For the estimation of P, K, and S content, 0.5 g of the plant sample was digested with a nitric and perchloric acid mixture in a 4:1 proportion ($\text{HNO}_3 : \text{HClO}_4$). From the resulting clear digest, a 10 ml aliquot was taken for phosphorus analysis. This aliquot was transferred into a 25 ml volumetric flask, followed by the addition of 5 ml of ammonium molybdate vanadate reagent. The volume was then made up to 25 ml using distilled water. After thorough mixing, the solution was kept undisturbed for 30 minutes, and the yellow color intensity was recorded at 470 nm with a spectrophotometer, as per the procedure described by Jackson (1973).

For potassium estimation, a 10 ml portion of the same digest was diluted to 100 ml with distilled water in a volumetric flask, and the potassium concentration was quantified using a flame photometer, following the method of Black (1965). The sulphur content was determined by employing the turbidimetric technique outlined by Chesnin and Yien (1950).

The nutrient uptake was computed using the formula given below and the results were expressed in kg ha^{-1} .

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Yield (grain or straw kg ha}^{-1}\text{)}}{100}$$

Statistical analysis

The data recorded for different observations were statistically analyzed following the procedure outlined by Cochran and Cox (1963).

Results and Discussion

Crop parameters

Plant height

The plant height data of mustard at harvest are presented in Table 3. The results revealed that

plant height was significantly influenced by the application of various doses of organic and inorganic fertilizers. The maximum plant height (124.92 cm) was observed under treatment T4 - 75% RDF + FYM @ 4 Mg ha^{-1} + vermicompost @ 1 Mg ha^{-1} + PSB (seed treatment) - which was significantly higher than most other treatments except T1. In contrast, the minimum plant height (104.65 cm) was recorded under T8 - FYM @ 8 Mg ha^{-1} + vermicompost @ 2 Mg ha^{-1} + PSB (seed treatment) - which was significantly lower than other treatments except T5 and T6. The enhanced plant height under combined application of chemical fertilizers with FYM, vermicompost, and biofertilizer may be attributed to their synergistic effect on plant growth and vigor, as reported by Gaind *et al.* (2006) and Wabela *et al.* (2024). The increased availability of metabolites likely contributed to a significant improvement in dry matter accumulation with higher fertilizer application.

Siliqua/plant

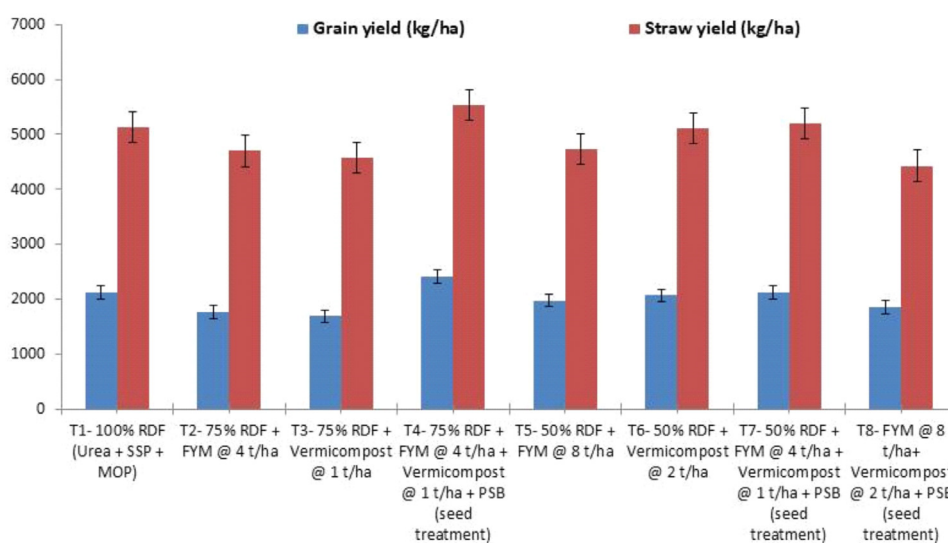
The results shown in Table 3 revealed that the number of siliquae per plant of mustard increased significantly under different combinations of organic and inorganic fertilizers. All treatments demonstrated a significant improvement in siliquae per plant compared to FYM @ 8 Mg ha^{-1} + vermicompost @ 2 Mg ha^{-1} + PSB (seed treatment) (T8). The highest number of siliquae per plant (265.66) was observed under treatment T4 - 75% RDF + FYM @ 4 Mg ha^{-1} + vermicompost @ 1 Mg ha^{-1} + PSB (seed treatment) - which was significantly superior to the other treatments and statistically comparable to T1 - 100% RDF (243.33).

Number of plant/ m^2

The experimental findings presented in (Table 3) indicated that the number of plant/ m^2 of mustard were increased significantly with different treatments of organic and chemical fertilizer. The significantly highest number of plants (22.66) were recorded in treatment T4-75% RDF + FYM @ 4 Mg ha^{-1} + vermicompost @ 1 Mg ha^{-1} + PSB (seed treatment) which was found significantly superior to other treatments and being at par with T1-100% RDF (22.33). However, significantly lowest value

Table 3. Effect of organic and chemical fertilizer application on plant height, siliqua/plant and number of plant/m² at harvest of mustard

Treatments	Plant height at harvest (cm)	Siliqua per plant	Number of plant/m ²
100% RDF (Urea+ SSP+ MOP)	123.23	243.33	22.33
75% RDF + FYM @ 4 Mg ha ⁻¹	114.32	218.33	20
75% RDF + vermicompost @ 1 Mg ha ⁻¹	113.92	220.33	20.66
75% RDF + FYM @ 4 Mg ha ⁻¹ + Vermicompost @ 1 Mg ha ⁻¹ + PSB	124.92	265.66	22.66
50% RDF + FYM @ 8 Mg ha ⁻¹	109.12	210.66	18.66
50% RDF + Vermicompost @ 2 Mg ha ⁻¹	111.62	212.33	19.33
50% RDF + FYM @ 4 Mg ha ⁻¹ + Vermicompost @ 1 Mg ha ⁻¹ + PSB	113.45	215.66	19.66
FYM @ 8 Mg ha ⁻¹ + vermicompost @ 2 Mg ha ⁻¹ + PSB	104.65	183.66	17.33
S.Em+	3.17	8.57	0.54
CD (5%)	9.01	25.98	1.63

**Fig. 1** Effect of organic and chemical fertilizer application on grain and straw yield of mustard

of number of plants of mustard (17.33) was obtained in T8- FYM @ 8 Mg ha⁻¹ + Vermicompost @ 2 Mg ha⁻¹ + PSB over other treatments. The results of the present study are in close conformity with the findings of Reddy and Singh (2018), Yadav *et al.* (2018), Chauhan *et al.* (2020) and Mahmood *et al.* (2020) in mustard crop.

Grain and straw yield

The grain yield data of mustard are presented in Fig. 1. The results indicated that the grain yield increased significantly with the application of various combinations of organic and inorganic fertilizers. The maximum grain yield (2411 kg ha⁻¹) and straw yield (5532 kg ha⁻¹) were recorded under the treatment comprising 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB

(seed treatment), which was significantly higher than most other treatments and statistically comparable to 100% RDF (T1). In contrast, the lowest grain yield (1860 kg ha⁻¹) was observed under T8 — FYM @ 8 Mg ha⁻¹ + vermicompost @ 2 Mg ha⁻¹ + PSB. These findings are consistent with earlier reports by Brar *et al.* (2016), Bijarnia *et al.* (2017), Dhruw *et al.* (2017), Kumar *et al.* (2017a), Saini *et al.* (2017), Bisht *et al.* (2018), Kumar *et al.* (2018a), Murali *et al.* (2018), and Reddy and Singh (2018).

N content and uptake

The nitrogen content and uptake of mustard are presented in Tables 4 and 5. The highest nitrogen content and uptake in grain were recorded under T4 — 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB (seed treatment)

— with values of 3.22% and 71.24 kg ha⁻¹, respectively, which were significantly higher than most other treatments and statistically comparable to T1 (100% RDF), which recorded 3.14% and 66.71 kg ha⁻¹, respectively. The nitrogen content and uptake in straw followed a similar pattern to that observed in the grain. The observed enhancement in nitrogen content and uptake may be attributed to increased nutrient availability in the soil through fertilizer application, enhanced microbial nitrogen fixation, improved soil physical properties, better root development, and higher moisture retention, resulting in greater absorption of water and nutrients. These findings are in close agreement with the reports of Shukla *et al.* (2002) and Tripathi *et al.* (2010).

P content and uptake

The phosphorus content and uptake in mustard grain are presented in Tables 4 and 5. Phosphorus content and uptake in grain were significantly higher under all treatments, except for T8. The maximum phosphorus content and uptake in grain (0.59% and 13.04 kg ha⁻¹, respectively) were observed under T4 - 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB (seed treatment) - which was statistically comparable to T1 (100% RDF) with values of 0.57% and 12.15 kg ha⁻¹, respectively. The lowest phosphorus content and uptake in grain (0.47% and 8.76 kg ha⁻¹, respectively) were recorded under T8 - FYM @ 8 Mg ha⁻¹ + vermicompost @ 2 Mg ha⁻¹ + PSB

(seed treatment). A similar trend was observed in straw, where the highest phosphorus content and uptake (0.18% and 9.60 kg ha⁻¹, respectively) were recorded under T4, which was significantly higher than most other treatments, except T1.

K content and uptake

The results indicated that potassium content and uptake in both grain and straw of mustard increased significantly under different combinations of organic and inorganic fertilizers (Tables 4 and 5). The highest potassium content and uptake in grain (0.64% and 14.22 kg ha⁻¹, respectively) and straw (1.16% and 61.69 kg ha⁻¹, respectively) were observed under T4 - 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB (seed treatment) - which was significantly superior to most other treatments and statistically comparable to T1 (100% RDF), which recorded 0.63% and 13.30 kg ha⁻¹, respectively.

S content and uptake

The sulphur content and uptake in mustard grain are presented in Tables 4 and 5. Sulphur content and uptake in grain were significantly higher under all treatments, except T8. The maximum sulphur content and uptake in grain (0.85% and 18.79 kg ha⁻¹, respectively) and in straw (0.41% and 21.70 kg ha⁻¹, respectively) were recorded under T4 — 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB (seed treatment). These findings are in close agreement with the

Table 4. Effect of organic and chemical fertilizer application on nutrient content in grain and straw of mustard

Treatments	N content (%)		P content (%)		K content (%)		S content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T ₁ - 100% RDF (Urea + SSP + MOP)	3.15	0.64	0.57	0.18	0.63	1.13	0.84	0.40
T ₂ - 75% RDF + FYM @ 4 Mg ha ⁻¹	2.98	0.61	0.54	0.16	0.54	1.03	0.79	0.37
T ₃ - 75% RDF + vermicompost @ 1 Mg ha ⁻¹	3.03	0.62	0.54	0.17	0.56	1.05	0.79	0.38
T ₄ - 75% RDF + FYM @ 4 Mg ha ⁻¹ + vermicompost @ 1 Mg ha ⁻¹ + PSB	3.22	0.67	0.59	0.18	0.64	1.16	0.85	0.41
T ₅ - 50% RDF + FYM @ 8 Mg ha ⁻¹	2.91	0.62	0.50	0.14	0.51	1.10	0.71	0.34
T ₆ - 50% RDF + vermicompost @ 2 Mg ha ⁻¹	2.94	0.63	0.51	0.15	0.52	1.14	0.72	0.35
T ₇ - 50% RDF + FYM @ 4 Mg ha ⁻¹ + vermicompost @ 1 Mg ha ⁻¹ + PSB	2.96	0.64	0.52	0.15	0.53	1.14	0.73	0.36
T ₈ - FYM @ 8 Mg ha ⁻¹ + Vermicompost @ 2 Mg ha ⁻¹ + PSB	2.75	0.58	0.47	0.13	0.48	1.06	0.67	0.30
S.Em+	0.061	0.013	0.011	0.003	0.013	0.023	0.016	0.005
CD (5%)	0.187	0.039	0.035	0.01	0.039	0.071	0.048	0.016

Table 5. Effect of organic and chemical fertilizer application on nutrient uptake by grain and straw of mustard

Treatments	N uptake (kg ha ⁻¹)		P uptake (kg ha ⁻¹)		K uptake (kg ha ⁻¹)		S uptake (kg ha ⁻¹)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T ₁ - 100% RDF (Urea + SSP + MOP)	66.71	32.97	12.15	8.97	13.30	58.10	17.75	20.56
T ₂ - 75% RDF + FYM @ 4 Mg ha ⁻¹	61.31	30.49	11.03	8.00	11.19	51.58	16.22	18.44
T ₃ - 75% RDF + vermicompost @ 1 Mg ha ⁻¹	54.15	31.50	9.72	8.38	10.08	53.25	14.16	19.05
T ₄ - 75% RDF + FYM @ 4 Mg ha ⁻¹ + vermicompost @ 1 Mg ha ⁻¹ + PSB	71.24	35.56	13.04	9.60	14.22	61.69	18.79	21.70
T ₅ - 50% RDF + FYM @ 8 Mg ha ⁻¹	57.47	29.24	9.89	6.73	10.07	52.13	14.02	16.21
T ₆ - 50% RDF + vermicompost @ 2 Mg ha ⁻¹	60.81	32.00	10.57	7.60	10.75	58.03	14.90	17.97
T ₇ - 50% RDF + FYM @ 4 Mg ha ⁻¹ + vermicompost @ 1 Mg ha ⁻¹ + PSB	63.03	32.99	11.12	7.90	11.31	59.23	15.57	18.86
T ₈ - FYM @ 8 Mg ha ⁻¹ + Vermicompost @ 2 Mg ha ⁻¹ + PSB	51.06	25.73	8.76	5.80	8.84	46.73	12.37	13.15
S.Em+	1.51	0.88	0.32	0.21	0.32	1.21	0.35	0.40
CD (5%)	4.59	2.62	0.96	0.65	0.98	3.63	1.07	1.20

observations of Shukla *et al.* (2002) and Tripathi *et al.* (2010).

Conclusions

The productivity and quality of mustard in sandy clay loam soils can be improved through appropriate nutrient management practices. The findings of this study demonstrate that growth, yield, quality, and nutrient uptake of mustard were significantly enhanced by applying various combinations of organic and inorganic fertilizers. The maximum plant height, number of plants, seed and straw yield, as well as the content and uptake of nitrogen, phosphorus, potassium, and sulphur in both seed and straw, were recorded under the treatment comprising 75% RDF + FYM @ 4 Mg ha⁻¹ + vermicompost @ 1 Mg ha⁻¹ + PSB seed treatment. These results highlight that, rather than relying solely on chemical fertilizers, integrating organic and inorganic nutrient sources is more effective for improving soil health and maintaining sustainable crop productivity.

Acknowledgment

Authors are gratefully acknowledge the College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vidhyalaya, Gwalior (M.P.) for its support in carrying out this study.

References

- Agricultural Statistics at a Glance (2021) Government of India Ministry of Agriculture & Farmers Welfare Department of Agriculture & Farmers Welfare.
- Arbad BK and Syed I (2011) Effect of integrated nutrient management on soybean (*Glycine max*)-safflower (*Carthamus tinctorius*) cropping system. *Indian Journal of Agronomy* **56(4)**: 340–345.
- Bijarnia AL, Yadav RS, Rathore PS, Singh SP, Saharan and Choudhary R (2017) Effect of integrated nutrient management and weed control measures on growth and yield attributes of mustard (*Brassica juncea* L.). *Journal of Pharmacognosy and Phytochemistry* **6(4)**: 483-488.
- Bisht S, Saxena AK and Singh S (2018) Effect of integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) cultivar T-9 under Dehradun region (Uttarakhand). *International Journal of Chemical Studies* **6(4)**: 1856-1859.
- Brar AS, Sidhu PS and Dhillon GS (2016) Response of brown sarson (*Brassica campestris* var. brown sarson) to integrated nutrient management in mid hill conditions of Himachal Pradesh. *International Journal Agriculture Science* **12(2)**: 319-325.
- Chauhan ZY, Patel DK and Bhabhor K (2020) Effect of nitrogen, phosphorus and sulphur on yield, nutrient uptake and soil fertility after harvest of Mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Science* **9(6)**: 3506-3512.
- Chesnin L and Yien CH (1950) Turbidimetric determination of available sulphur. *Proceedings of American Society of Soil Science* **15**: 149-151.
- Cochran WG (1963) Sampling Technique. 2nd Edition, John Wiley and Sons Inc., New York.
- Dhruw SS, Swaroop N, Swamy A, Upadhyay Y (2017) Effects of Different Levels of NPK and Sulphur on Growth and Yield Attributes of Mustard (*Brassica juncea* L.) Cv. Varuna. *International Journal of Current Microbiology and Applied Sciences* **6(8)**: 1089-1098.
- Gaind S and Lata N (2007) Chemical and biological properties of wheat soil in response to paddy straw

- incorporation and its biodegradation by fungal inoculants. *Biodegradation* **18**: 495–503.
- Jackson ML (1973) *Soil Chemical Analysis*. Prentice Hall of Englewood cliffs, New Jersey, USA.
- Kumar A, Bharati AK, Yadav S, Pandey HC and Kumar V (2017) Influence of biofertilizer and farm yard manure on growth, yield and seed quality of Mustard (*Brassica juncea* L.) in rainfed condition. *International Journal of Agricultural Science and Research* **7(2)**:197-202.
- Kumar R, Singh MP and Kumar S (2014) Effect of salinity on germination, growth, yield and yield attributes of wheat. *International Journal of Scientific & Technology Research* **1(6)**: 19-23.
- Mahmood M, Tian MY, Qingxia M, Ahmed W, Mehmood S, Hui X and Zhaohui W (2020) Changes in phosphorus fractions and its availability status in relation to long term P fertilization in loess Plateau of China. *Agronomy* **10**: 180-189.
- Murali M, Umrao R and Kumar H (2018) Effect of different levels of organic manure on the growth and yield of mustard (*Brassica juncea* L.) under Jatropa (*Jatropha curcas* L.) based agroforestry system. *Journal of Pharmacognosy and Phytochemistry* **7(4)**: 955-958.
- Pal RL and Pathak J. (2016) The effect of integrated nutrient management on yield and economics of mustard. *International Journal of Science and Nature* **2**: 255-261.
- Prasad JV, Korwar GR, Rao KV, Mandal UK, Rao CA, Rao GR, Ramakrishna YS, Venkateswarlu B, Rao SN, Kulkarni HD, Rao MR (2010) Tree row spacing affected agronomic and economic performance of Eucalyptus-based agroforestry in Andhra Pradesh, Southern India. *Agroforestry Systems*. **78(3)**: 253-67.
- Reddy GK and Singh R (2018) Effect of integrated nitrogen management on the growth and yield of mustard [*Brassica juncea* (L.) Czern. & Coss]. *Journal of Pharmacognosy and Phytochemistry* **7(3)**: 617-619.
- Sahoo RC, Purohit HS, Prajapat OP (2018) Integrated nutrient management in mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Sciences* **7**: 3545-3549.
- Saini LB, George PJ and Bhadana SS. (2017) Effect of nitrogen management and biofertilizers on growth and yield of rapeseed (*Brassica campestris* var. toria). *International Journal of Current Microbiology and Applied Sciences* **6(8)**: 2652-2658.
- Shroff VN and Devasthali S (1992) Earthworm forming-scope and limitations. Proc. Natl. Sem. Natural Farming, LL Somani KL Totwat and BL Baser (Eds.), pp. 126-42.
- Shukla RK, Kumar A, Mahapatra BS and Basanth K (2002) Integrated nutrient management practices in relation to morphological and physiological determination of seed yield in Indian mustard [*Brassica juncea* (L.)]. *Indian Journal of Agricultural Sciences* **72**: 670-672.
- Singh SP and Pal MS (2011) Effect of integrated nutrient management on productivity, quality, nutrient uptake and economics of mustard (*Brassica juncea*). *Indian Journal of Agronomy* **56**: 381-387.
- Singh A, Singh N, Kalhapure AH, Singh SB, Gupta AK, Gupta D, Gupta S and Gupta D (2024) Effect of nutrient management on physico-chemical properties of soil in Indian mustard. *International Journal of Plant & Soil Science* **36(7)**: 610-17.
- Singh RK, Kumar P, Singh SK, Singh SB and Singh RN (2018) Effect of integrated nutrient management on yield and economics of mustard (*Brassica juncea* L.) *International Journal of Current Microbiology and Applied Sciences* **7**: 5261-5269I.
- Swarup A (2010) Integrated plant nutrient supply and management strategies for enhancing soil quality, input use efficiency and crop productivity. *Journal of the Indian Society of Soil Science* **58**: 25-31.
- Tripathi MK, Chaturvedi S, Shukla DK and Mahapatra BS (2010) Yield performance and quality in Indian mustard (*Brassica juncea*) as affected by integrated nutrient management. *Indian Journal of Agronomy* **55(2)**:138-142.
- Verma A, Nepalia V and Kanthaliya PC (2005) Effect of continuous cropping and fertilization on crop yields and nutrient status of a Typic Haplustept. *Journal of the Indian Society of Soil Science* **53**: 365-368.
- Verma G, Mathur A, Bhandari S and Kanthaliya PC (2010) Long-term Effect of Integrated Nutrient Management on Properties of a Typic Haplustept under Maize-Wheat Cropping System. *Journal of the Indian Society of Soil Science* **3**: 299-302.
- Vijay Shankar Babu M, Reddy MC, Subramanyana A and Balaguravaiah D (2007) Effect of integrated use of organic and inorganic fertilizers on soil properties and yield of Sugarcane. *Journal of Indian Society of Soil Science* **55**: 161-166.
- Wabela R, Abera G, Lemma B and Gobena A (2024) Effects of integrated fertilizer application on selected soil properties and yield attributes of common bean (*Phaseolus vulgaris* L.) on different soil types. *Heliyon* **10(19)**: e38163.
- Yadav KM, Chaudhry S, Kumar H, Singh R and Yadav R. (2018) Effect of integrated nutrient management on growth and yield in mustard [*Brassica juncea* (L.) Czern & Cosson]. *International Journal of Chemical Studies* **6(2)**: 3571-3573.
- Zamil SS, Quadir FQ, Choudhary MAH and Al-Adnan W (2004) Effect of different animal manures on yield, quality, and nutrient uptake by mustard. *CV Agrani. BRAC University Journal* **1(2)**: 59-66.