Growth and Yield Response of Indian Mustard (*Brassica juncea* L.) to Integrated Nutrient Management in Dehradun, Uttarakhand

Abstract

A crucial Rabi oilseed crop in India, Indian mustard (Brassica juncea L.) is still not producing as much as it could because of nutrient imbalances and an over dependence on chemical fertilizers. A sustainable strategy to enhance soil health, nutrient use efficiency, and productivity is integrated nutrient management (INM), which combines inorganic fertilizers with organic manures and biofertilizers. The "Growth and Yield Response of Indian Mustard (Brassica juncea L.) to Integrated Nutrient Management in Dehradun, Uttarakhand" field experiment was carried out at Jigyasa University's Agronomy Research Farm in Dehradun during the Rabi season of 2023–2024. The soil was a sandy loam with a high K content, medium levels of accessible N and P, and a slight alkalinity. Nine nutrient management treatments, comprising combinations of recommended dose fertilizers (RDF), vermicompost, and biofertilizers (Azotobacter + PSB), were duplicated three times in this research, which was set up in a Randomized Block Design. The findings showed that the growth and yield characteristics of the various treatments varied significantly. The highest plant height (194.74 cm), fresh weight (275.41 g), dry matter accumulation (127.26 g), siliqua length (6.65 cm), seeds per siliqua (14.90), and test weight (4.64 g) were all recorded by T_4 (80% RDF + Vermicompost + Biofertilizers). Additionally, this treatment yielded the highest harvest index (27.34%), stover yield (58.38 q/ha), biological output (80.35 q/ha), and seed yield (21.97 q/ha). On the other hand, T_9 (biofertilizers alone) showed the poorest performance. The superiority of T_4 emphasizes how mixing organic and inorganic sources can have a synergistic effect, improving soil biological activity, ensuring a consistent and balanced nutrient supply, and improving assimilate partitioning towards reproductive structures. The study concludes that using vermicompost and biofertilizers in place of some chemical fertilizers improved growth and output while lowering reliance on chemical inputs alone, which in turn promoted environmentally friendly and sustainable mustard farming. In the Shivalik region of Uttarakhand and other agro-ecologies, adopting INM—in particular, 80% RDF with vermicompost and biofertilizers—can therefore be a farmer-friendly nutrient management method.

Keywords: Indian mustard, integrated nutrient management, growth, yield, vermicompost, biofertilizers, sustainability.

Introduction

Next only to groundnuts in the country's oilseed economy, Indian mustard (Brassica juncea L.), a well-known member of the Brassicaceae family, is one of the most significant Rabi oilseed crops in India. Valued for its edible oil, use as a condiment, and as a source of protein-rich oilcake for animal feed, it is grown in a variety of agroclimatic zones (Bhindani et al., 2020; Sarker et al., 2021). Despite its versatility, rainfed farming, unequal nutrient utilization, and poor management techniques are the key reasons why productivity levels are still below their potential on a worldwide scale (Lal et al., 2015).

In order to maximize mustard's yield potential, nutrient management is essential. For early establishment, rapid vegetative growth, and seed development, a balanced supply of nitrogen, phosphorus, potassium, and sulfur is essential. However, nutritional imbalances and a halt in crop increase have resulted from an ongoing reliance on chemical fertilizers (Meena et al., 2016). An efficient method for increasing nutrient availability, enhancing physiological processes, and optimizing yield attributes like plant height, siliqua formation, and seed weight is integrated nutrient management (INM), which blends chemical fertilizers, organic manures, and biofertilizers (Prasad et al., 2017; Tomar et al., 2017).

Research has demonstrated that INM enhances mustard grain yield and oil content by promoting nutrient uptake, root growth, and overall biomass accumulation (Hadiyal et al., 2017; Selim, 2018). The crop's vital significance in livelihood support, food security, and the edible oil sector makes it an agronomic priority to maximize growth and output through effective nutrient management. Therefore, the current study assesses how integrated nutrient management techniques affect mustard growth and yield performance under various treatment combinations.

2. Review of Literature

A balanced supply of nutrients from chemical fertilizers, organics, and biofertilizers is ensured by integrated nutrient management (INM), which has been widely documented to enhance mustard's development and yield characteristics. While Bharati et al. (2022) reported superior plant height under 100% RDF across consecutive phases in Bihar, Kaur et al. (2022) observed that 100% RDF in combination with FYM, vermicompost, $ZnSO_4$, and Azotobacter greatly boosted plant height, branching, and dry matter accumulation. In a similar vein, Bhanuwanti et al. (2022) discovered that 50% RDF combined with vermicompost, Azotobacter, and PSB resulted in taller plants (210.47 cm) with higher biomass, whereas Kashive et al. (2022) observed that 100% RDF + vermicompost in Madhya Pradesh produced plants as tall as 180.98 cm. Additionally, 75% NPK combined with 25% FYM, sulfur, and mulching increased plant height (191.19 cm) and branching (24.53) at harvest, according to Diwakar et al. (2021). Bisht et al. (2018) in Dehradun, where 75% RDF + FYM considerably improved plant growth parameters, while Mahanta et al. (2019) under 50% RDN from fertilizers + 50% FYM in late-sown toria also observed positive results.

In addition to growth, INM methods have a positive effect on mustard yield and yield-attributing characteristics. While Kaur and Verma (2023) noted the highest siliquae per plant (225.6) and yield under 75% RDF with FYM in Punjab, Tiwari et al. (2023) showed that vermicompost containing S, Fe, and Zn increased siliquae per plant and seed production.

Improved siliquae per plant (314.47) and test weight (6.80 g) with PSB, VAM, and phosphorus were reported by Rohith and Umesha (2023). Similarly, Gora et al. (2022) found that 100% RDF + vermicompost + Azotobacter produced the highest siliquae per plant, seed yield (1.83 t/ha), and biological yield (5.50 t/ha), while Goyal et al. (2023) noted that 75% RDF combined with FYM, vermicompost, and Azotobacter produced the highest seed yield (2803.9 kg/ha). 50% RDF with FYM, vermicompost, biofertilizers, and $ZnSO_4$ greatly increased oil yield and protein content in Kanpur, according to Dubey et al. (2021). While Halder et al. (2020) indicated that RDF with FYM and sulfur boosted both yield and oil content in rapeseed, Singh et al. (2021) also showed that 75% RDF combined with vermicompost, sulfur, Azotobacter, and PSB produced the maximum grain yield (1.79 t/ha) with oil content of 40.86%. When taken as a whole, these studies demonstrate that INM is a sustainable substitute for chemical fertilizers since it not only improves plant growth parameters but also yield qualities, oil content, and mustard farming profitability.

3. Materials and Methods

At Jigyasa University (formerly Himgiri Zee University), Dehradun, Uttarakhand, during the Rabi season of 2023–2024, a field study titled "Effects of Integrated Nutrient Management on Growth and Production of Indian Mustard (Brassica juncea L.) in Dehradun, Uttarakhand" was carried out. Situated at 31°21′50″ N latitude and 78°18′27″ E longitude, the experimental farm lies 650 meters above mean sea level in the Shivalik range of the lower Himalayas. The area has a humid subtropical climate with moderate springs, cool winters, and 2,070 mm of annual rainfall on average, most of which falls during the monsoon season.

The experimental soil was classified as sandy loam, slightly alkaline in reaction (pH 7.47), with an electrical conductivity of 1.37 µS/cm, medium in available nitrogen and phosphorus, high in available potassium, and containing 0.75% organic carbon.

The trial was laid out in a Randomized Block Design (RBD) comprising nine nutrient management treatments replicated thrice, resulting in 27 experimental plots. The treatments consisted of different combinations of inorganic fertilizers, vermicompost, and biofertilizers, described as follows:

T_1: Control (no nutrient application); **T_2**: 100% RDF (80:60:40 kg $N:P_2O_5:K_2O$/ha); **T_3**: 75% RDF + Vermicompost @ 5 t/ha; **T_4**: 75% RDF + Biofertilizers (Azotobacter + PSB); **T_5**: 50% RDF + Vermicompost @ 5 t/ha + Biofertilizers; **T_6**: 100% RDF + Vermicompost @ 2.5 t/ha; **T_7**: 100% RDF + Biofertilizers (Azotobacter + PSB); **T_8**: Vermicompost @ 5 t/ha (sole application);**T_9**: Biofertilizers (Azotobacter + PSB) alone.

The net plot size for recording observations was 2.4 m × 1.6 m, whereas the gross plot size was 3 m × 2 m. The HY-805 mustard variety was harvested on March 5, 2024, after being sowed on October 20, 2023, at a 45 cm × 10 cm spacing. A third of the nitrogen and the entire amount of potassium and phosphorus were administered basally, and the remaining nitrogen was top-dressed 30 days after sowing (DAS). Fertilizers were applied in accordance with treatment allocation. At the time of seeding, biofertilizers and vermicompost were used. There was uniform adoption of standard agronomic methods, such as weeding, thinning, two irrigations, and plant protection measures.

From each plot, five plants were chosen at random and tagged in order to document observations regarding yield and growth characteristics. Plant population, height, and accumulation of dry matter were considered growth characteristics, whereas the number of siliquae per plant, siliqua length, number of seeds per siliqua, 1000-seed weight, seed yield, stover yield, biological yield, and harvest index were considered yield attributes. Analysis of variance (ANOVA) was used to statistically analyze the experimental data in accordance with the methodology outlined by Gomez and Gomez (1984). The crucial difference (CD) was employed for mean separation, and the significance of treatment effects was examined at the 5% probability level.

Results & Discussions

4.1 Effect of Integrated Nutrient Management under Different Treatments on Growth of Mustard

4.1.1 Plant Population and Plant Height (cm)

Following thinning, there were notable differences in the plant populations across treatments (Table 1). T7 (60% RDF + Vermicompost + Biofertilizer) had the largest population (128 plants), while T1 (100% RDF) had the smallest (86.67 plants). The favorable soil environment produced by the combined application of inorganic fertilizers, vermicompost, and biofertilizers may be the reason for the increased plant population under T7. This environment most likely enhanced seedling vigor, germination, and survival. On the other hand, T1's comparatively smaller plant population raises the possibility that integrated approaches, as opposed to merely using chemical fertilizers, may offer a higher degree of microbial activity and soil conditioning. These findings are consistent with reports by Pal et al. (2008) and Jat et al. (2014), who emphasized that INM enhances soil structure and microbial activity, leading to better crop establishment and higher plant stand.

Table 1 shows that the plant height of Indian mustard at various growth stages (30, 60, 90 DAS, and harvest) was significantly impacted by integrated nutrient management (INM) approaches. Plant height varied between treatments at 30 DAS, ranging from 47.75 cm to 58.58 cm. T4 (80% RDF + Vermicompost + Biofertilizer) had the highest plants (58.58 cm), whereas T9 (100% Biofertilizer) had the shortest plants (47.75 cm). This early growth response suggests that, in comparison to applying biofertilizer alone, partially replacing inorganic fertilizer with organic sources improved nutrient availability and supported faster initial growth. At 60 DAS, plant height varied between 91.26 cm and 140.10 cm. The maximum height (140.10 cm) was recorded in T7 (60% RDF + Vermicompost + Biofertilizer), whereas the minimum (91.26 cm) was again observed in T9 (100% Biofertilizer). Likewise, plant height varied between 146.70 cm and 166.29 cm at 90 DAS, with T7 still performing better than all other treatments. Plant heights ranged from 150.88 cm to 194.74 cm by harvest. T7 (60% RDF + Vermicompost + Biofertilizer) had the tallest plants, whereas T9 (100% Biofertilizer) had the shortest. According to these findings, using 60% RDF, vermicompost, and biofertilizers together improved nutrient synchronization and promoted continuous development, which led to the highest plant height at maturity.

These results are consistent with Rajput et al. (2018), who found that better soil fertility and increased nitrogen uptake under integrated nutrient management led to a considerable increase in mustard plant height. In a similar vein, Pal et al. (2008) discovered that plants with complete INM packages and 100% RDF grew noticeably taller than those with lower fertilizer dosages.

In order to improve mustard development, the current study emphasizes the value of balanced nutrient management and shows that the combined impacts of inorganic, organic, and biofertilizer inputs are more successful than their individual application.

4.1.2. Dry Matter Accumulation at Harvest

The data presented in Table.1 revealed a significant influence of different Integrated Nutrient Management (INM) treatments on dry matter accumulation at harvest.

4.1.2.1 Fresh Weight (g) Across treatments, the fresh weight of mustard plants varied from 158.15 g to 275.41 g. T4 (80% RDF + Vermicompost + Biofertilizer) had the largest fresh weight (275.41 g), whereas T9 (100% Biofertilizer only) had the smallest (158.15 g). The benefit of combining organic and inorganic nutrition sources is evident from treatment T4's 74.2% higher fresh weight than treatment T9. Because chemical fertilizers, organic manures, and biofertilizers worked in concert to maintain a sufficient supply of nutrients throughout the crop cycle, T4 had a greater fresh weight. Vermicompost provided micronutrients and organic matter, and biofertilizers improved nitrogen fixation and nutrient mobilization, which led to increased biomass formation. In contrast, the sole use of biofertilizers (T9) was insufficient to meet the complete nutrient requirement, leading to reduced fresh weight.

These findings are in agreement with Pal et al. (2008) and Gour et al. (2017), who reported that integrating organic and inorganic nutrient sources enhances growth and fresh biomass of mustard through improved nutrient uptake and soil health.

4.1.3.2 Dry Weight (g) The dry weight of mustard after various treatments ranged from 73.73 g to 127.26 g. T4 (80% RDF + Vermicompost + Biofertilizer) had the highest dry weight (127.26 g), whereas T9 (100% Biofertilizer only) had the lowest (73.73 g). The dry weight of treatment T4 was 72.6% more than that of treatment T9. The noticeably higher dry matter accumulation under T4 suggests that using vermicompost and biofertilizers in place of some chemical fertilizers not only guaranteed a consistent supply of macronutrients but also improved soil structure and microbial activity, which allowed for sustained nutrient availability during later growth stages. On the other hand, T9 was unable to provide enough nutrients to support increased dry matter formation when it was only using biofertilizers.

These results are corroborated by the findings of Singh et al. (2014) and Sahoo et al. (2018), who emphasized that combining organic and inorganic nutrient sources increases mustard dry matter production by improving nutrient-use efficiency and sustaining crop growth.

4.2. Impact of INM on Yield and Yield Attributes of Mustard

The data presented in Table 2 reveal that integrated nutrient management (INM) significantly influenced yield attributes of mustard, including siliqua length, number of seeds per siliqua, test weight, and number of siliquae per plant.

4.2.1. Length of Siliqua (cm) At harvest, silica lengths varied from 3.50 to 6.65 cm. T4 (80% RDF + Vermicompost + Biofertilizer) had the longest length (6.65 cm), whereas T9 (100% Biofertilizer) had the shortest (3.50 cm). The synergistic effect of chemical fertilizers and organic manures in maintaining a balanced nutrient supply during the crop's reproductive phase may be the reason for T4's improved performance. Kumar et al. (2018) reported similar results.

4.2.2. Number of Seeds per Siliqua There was a range of 8.79 to 14.90 seeds per siliqua. T4 had the greatest number of seeds (14.90), while T9 had the lowest (8.79). Better nutrient availability and assimilate translocation may be the cause of the increase in seed number with T4, which would boost reproductive efficiency.

4.2.3. Test Weight (1000-Seed Weight, g) T4 recorded the greatest test weight (4.64 g) and T9 the lowest (3.05 g), with the test weight ranging from 3.05 to 4.64 g. Higher test weight was probably the result of better seed filling and size due to the balanced nutrition supply under T4. The results of Singh et al. (2006) and Tripathi et al. (2011), who highlighted the importance of integrated nutrition delivery in increasing seed weight, are consistent with this tendency. Additionally, Singh et al. (2011) found that yield qualities significantly improve when there is a consistent supply of nutrients, especially nitrogen, during the active growth stages.

4.2.4. Number of Siliquae per Plant Each plant had between 131.59 and 225.95 siliquae. In contrast to T9, which recorded the lowest number of siliquae per plant (131.59), treatment T4 recorded the highest number (225.95). The combined effect of inorganic and organic nutrition sources may have boosted crop growth and branching, leading to better reproductive development and a greater siliqua count under T4.

4.3. Impact of INM on Yield of Mustard

The results presented in Table 3 and Fig.1, show that different fertility levels, involving chemical fertilizers, organics, and biofertilizers, significantly influenced seed yield, stover yield, biological yield, and harvest index of mustard.

4.3.1. Seed Yield (q/ha) Across treatments, seed yield varied from 15.07 to 21.97 q/ha. T4 (80% RDF + Vermicompost + Biofertilizer) had the highest seed production (21.97 q/ha), whereas T9 (100% Biofertilizer) had the lowest (15.07 q/ha). The synergistic effect of artificial fertilizers and organic manures, which guaranteed a balanced nutrient supply throughout the crop's life cycle and improved seed development, may be responsible for the higher seed production under T4.

4.3.2. Stover Yield (q/ha) The range of the steady state yield was 48.40 to 58.38 q/ha. T4 recorded the highest (58.38 q/ha), while T9 recorded the lowest (48.40 q/ha). The increased vegetative development brought on by an adequate supply of nitrogen and organic matter may be the cause of the improvement in stover production under T4.

4.3.3. Biological Yield (q/ha) T4 had the highest biological yield (80.35 q/ha) while T9 had the lowest (63.49 q/ha). The biological yield ranged from 63.49 to 80.35 q/ha. The promotion of both vegetative and reproductive growth through balanced nutrition administration explains the rise in biological yield under T4. A sufficient supply of NPK promotes meristematic activity, cell differentiation, and efficient assimilate translocation, all of which increase yield (Singh et al., 2011; Bhindani et al., 2020).

4.3.4. Harvest Index (%) Table.3 shows that the harvest index ranged from 22.74% to 27.34%. T4 showed the highest HI (27.34%), whilst T9 showed the lowest (22.74%). An increased harvest index under T4 denotes effective assimilation partitioning for seed production. These results are consistent with those of Babar and Dongale (2013), who found that using inorganic fertilizers in conjunction with organic manures, like FYM, improved harvest index more than using inorganic fertilizers alone.

Summary

The findings showed that integrated nutrition management (INM) has a major impact on mustard's development and production characteristics. The highest values for plant height, branches per plant, siliquae per plant, test weight, and dry matter accumulation were consistently obtained by T4 (80% RDF + Vermicompost @ 9 kg + Biofertilizer [Azotobacter + PSB]) out of all the treatments. Additionally, this treatment produced the highest harvest index (27.34%), stover yield (58.38 q/ha), biological output (80.35 q/ha), and seed yield (21.97 q/ha). Conversely, T9 (biofertilizer alone) produced the lowest yields. The findings demonstrate how inorganic fertilizers, organic manures, and biofertilizers work in concert to provide a steady and balanced supply of nutrients that supported vegetative growth, reproductive development, and effective assimilate partitioning.

Conclusion

It is possible to draw the conclusion that applying chemical fertilizers in combination with organic manures and biofertilizers enhances mustard yield and growth more successfully than using either source alone. A sustainable and farmer-friendly nutrient management technique, the application of 80% RDF in conjunction with vermicompost and biofertilizers maintained excellent productivity while reducing reliance on chemical fertilizers.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

References

Babar, P. B., & Dongale, J. H. (2013). Effect of integrated nutrient management on productivity, nutrient uptake and economics of mustard (*Brassica juncea* L.). International Journal of Agricultural Sciences, 9(1), 264–267.

Bhanuwanti, B., Meena, H. M., & Singh, J. P. (2022). Response of mustard (*Brassica juncea* L.) to integrated nutrient management practices in Madhya Pradesh. *Indian Journal of Fertilisers, 18*(7), 634–639.

Bharati, R. C., Kumar, S., Kumar, A., & Singh, R. (2022). Effect of fertility levels and sowing dates on growth and productivity of mustard (*Brassica juncea* L.) under rainfed conditions. *Journal of Oilseeds Research, 39*(1), 45–49.

Bhindani, A., Kumar, R., Singh, J., & Singh, K. (2020). Mustard: An important oilseed crop of India. *Journal of Oilseed Research, 37*(2), 91–96.

Bhindani, A., Singh, R., Meena, R. S., & Lal, R. (2020). Integrated nutrient management for enhancing crop productivity and soil fertility in oilseed-based cropping systems. Journal of Oilseed Brassica, 11(2), 81–89.

Bisht, A., Singh, S., & Sharma, P. (2018). Effect of integrated nutrient management on growth and productivity of mustard in Dehradun valley. *International Journal of Chemical Studies, 6*(2), 1012–1016.

Diwakar, R., Singh, R., & Yadav, P. K. (2021). Productivity and profitability of Indian mustard (*Brassica juncea* L.) as influenced by integrated nutrient management and mulching. *Journal of Pharmacognosy and Phytochemistry, 10*(3), 1155–1160.

Dubey, R. K., Singh, D., & Yadav, V. (2021). Effect of integrated nutrient management on yield and quality of mustard (*Brassica juncea* L.) under Kanpur conditions. *Annals of Plant and Soil Research, 23*(2), 213–217.

Gill, K. K., Singh, J., & Singh, R. (2021). Rapeseed-mustard production in India: Status, challenges, and opportunities. *Indian Journal of Agronomy, 66*(3), 275–283.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). Wiley.

Gora, R. K., Meena, R. S., & Singh, V. (2022). Effect of integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) under irrigated conditions. *International Journal of Current Microbiology and Applied Sciences, 11*(2), 254–262.

Gour, A. K., Sharma, J. K., & Sharma, S. K. (2017). Effect of integrated nutrient management on growth, yield and economics of Indian mustard (*Brassica juncea* L.). International Journal of Agricultural Sciences, 9(11), 4011–4015.

Goyal, M., Singh, S., & Kaur, J. (2023). Influence of integrated nutrient management on growth, yield and economics of Indian mustard (*Brassica juncea* L.) under irrigated conditions. *Legume Research, 46*(7), 815–820.

Hadiyal, D. S., Patel, R. H., & Gohil, B. S. (2017). Effect of nutrient management on growth, yield attributes and yield of mustard. *International Journal of Current Microbiology and Applied Sciences, 6*(6), 1258–1264.

Halder, P., Singh, K., & Das, A. (2020). Effect of organic manures and fertilizers on growth, yield and quality of rapeseed-mustard. *International Journal of Bioresource and Stress Management, 11*(5), 449–454.

Kashive, P., Meena, S., & Sharma, R. (2022). Productivity and profitability of mustard (*Brassica juncea* L.) under integrated nutrient management practices. *Journal of Pharmacognosy and Phytochemistry, 11*(1), 1926–1930.

Kaur, H., & Verma, A. (2023). Effect of nutrient management practices on growth, yield and economics of Indian mustard (*Brassica juncea* L.) under Punjab conditions. *Journal of Oilseeds Research, 40*(1), 65–70.

Kaur, M., Singh, G., & Thakur, P. (2022). Growth and yield of mustard as influenced by integrated nutrient management. *Indian Journal of Agricultural Research, 56*(4), 568–574.

Kumar, A., Singh, S., & Sharma, R. K. (2018). Response of mustard (*Brassica juncea* L.) to integrated nutrient management in alluvial soils of eastern Uttar Pradesh. Journal of Pharmacognosy and Phytochemistry, 7(5), 234–238.

Lal, R., Singh, S., & Meena, R. K. (2015). Constraints and strategies for increasing productivity of oilseed crops in rainfed areas of India. *Agricultural Reviews, 36*(2), 120–127.

Mahanta, S., Bora, P., & Dutta, D. (2019). Effect of integrated nutrient management on productivity of late sown toria (*Brassica rapa* L. var. toria) in Assam. *Journal of Oilseeds Research, 36*(2), 124–129.

Meena, V. S., Maurya, B. R., & Verma, J. P. (2016). Does a rhizospheric microorganism enhance K+ availability in agricultural soils? *Microbiological Research, 183*, 18–26.

Pal, M., Singh, J. P., & Singh, D. (2008). Effect of integrated nutrient management on productivity and quality of Indian mustard (*Brassica juncea* L.). Journal of Oilseeds Research, 25(1), 45–47.

Prasad, D., Singh, R. P., & Sharma, S. K. (2017). Effect of integrated nutrient management on productivity and quality of Indian mustard (*Brassica juncea* L.). *Journal of Oilseed Research, 34*(1), 14–18.

Rajput, A., Singh, V., & Kumar, P. (2018). Response of mustard (*Brassica juncea* L.) to integrated nutrient management practices. Journal of Pharmacognosy and Phytochemistry, 7(5), 1701–1704.

Rohith, K., & Umesha, C. (2023). Effect of integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) under southern dry zone of Karnataka. *Crop Research, 58*(3), 154–159.

Sahoo, T. R., Sahoo, A., & Dash, R. N. (2018). Effect of integrated nutrient management on growth, yield, economics and soil fertility of Indian mustard (*Brassica juncea* L.). International Journal of Chemical Studies, 6(1), 1188–1191.

Sarker, U., Hossain, M. M., & Islam, T. (2021). Genetic variability and traits association of mustard (*Brassica juncea* L.) genotypes for seed yield. *Plant Breeding and Biotechnology, 9*(3), 243–253.

Singh, A., Meena, M. C., & Gautam, R. C. (2006). Effect of nutrient management on growth, yield and quality of Indian mustard (*Brassica juncea* L.). Indian Journal of Agronomy, 51(1), 83–85.

Singh, R., Singh, D., & Kumar, P. (2011). Effect of integrated nutrient management on productivity and economics of mustard (*Brassica juncea* L.) under limited irrigation conditions. Annals of Agricultural Research, 32(3), 107–112.

Singh, R., Singh, M., & Yadav, R. (2014). Effect of integrated nutrient management on growth, yield and quality of Indian mustard (*Brassica juncea* L.) and soil fertility in western Uttar Pradesh. Annals of Agricultural Research, 35(1), 42–46.

Singh, R., Yadav, P. K., & Meena, R. H. (2021). Integrated nutrient management practices for enhancing yield and quality of mustard (*Brassica juncea* L.) in eastern Rajasthan. *Annals of Plant and Soil Research, 23*(4), 426–430.

Tiwari, S., Sharma, S., & Patel, R. (2023). Influence of integrated nutrient management on yield and oil content of mustard (*Brassica juncea* L.) under irrigated conditions of Madhya Pradesh. *Legume Research, 46*(6), 701–707.

Tomar, S. S., Singh, R. K., & Yadav, P. (2017). Integrated nutrient management for enhancing productivity and profitability of mustard in semi-arid conditions. *Annals of Plant and Soil Research, 19*(4), 403–407.

Tripathi, M. K., Yadav, R. A., & Singh, R. P. (2011). Effect of fertility levels and biofertilizers on productivity, nutrient uptake and economics of Indian mustard (*Brassica juncea* L.). Journal of Oilseeds Research, 28(1), 31–34.

Table.1. Influence of treatments on plant population, plant height and dry matter accumulation

Treatments	**Plant Population**	**Plant Height (cm)**				**Dry Matter Accumulation (g)**	
		30 DAS	**60 DAS**	**90 DAS**	**At Harvest**	**Fresh Weight**	**Dry Weight**
T1 – 100% RDF (N:83.58g, P:75.12g, K:47.4g)	86.67	54.83	127.91	161.36	185.44	248.94	112.55
T2 – 80% RDF + Vermicompost @9kg	93.67	53.87	119.15	158.30	182.23	218.39	100.40
T3 – 80% RDF + Biofertilizer (Azotobacter + PSB @ 500 ml/kg seed)	103.67	51.94	109.76	154.83	174.25	215.07	91.46
T4 – 80% RDF + Vermicompost @9kg + Biofertilizer	87.00	58.58	134.71	163.48	190.85	275.41	127.26
T5 – 60% RDF + Vermicompost @10.8kg	97.67	53.52	111.61	156.26	178.61	217.64	97.90
T6 – 60% RDF + Biofertilizer	116.67	49.88	103.38	153.43	167.46	189.34	85.57
T7 – 60% RDF + Vermicompost	128.00	57.84	140.10	166.29	194.74	262.74	116.78

@10.8kg + Biofertilizer							
T8 – 100% Vermicompost @20kg	99.00	48.71	98.64	151.27	163.76	181.67	80.44
T9 – 100% Biofertilizer	106.67	47.75	91.26	146.70	150.88	158.15	73.73
C.D. (P=0.05)	N/A	1.42	6.96	3.14	2.50	9.28	4.09
SE(m)	9.21	0.47	2.30	1.04	0.83	3.07	1.35
SE(d)	13.03	0.67	3.25	1.47	1.17	4.34	1.92
C.V. (%)	15.62	1.54	3.46	1.15	0.81	2.43	2.38

Table.2 Effect of Treatments on Yield Components

Treatments	**Length of Siliqua (cm)**	**No. of Seeds/Siliqua**	**Test Weight (g)**	**No. of Siliqua/Plant**
T1 (100% RDF @N:83.58g, P:75.12g, K:47.4g)	5.62	13.32	4.48	175.30
T2 (80% RDF @N:69.65g, P:62.60g, K:32g + Vermicompost @9kg)	5.45	12.67	4.15	164.98
T3 (80% RDF @N:69.65g, P:62.60g, K:32g + Biofertilizer @500 ml/kg seed)	4.43	10.84	3.44	155.02
T4 (80% RDF @N:69.65g, P:62.60g, K:32g + Vermicompost @9kg + Biofertilizer @500 ml/kg seed)	6.65	14.90	4.64	225.95
T5 (60% RDF @N:52.24g, P:46.95g, K:24g + Vermicompost @10.8kg)	4.81	11.42	3.72	161.31
T6 (60% RDF @N:52.24g, P:46.95g, K:24g + Biofertilizer @500 ml/kg seed)	3.87	9.60	3.30	145.18
T7 (60% RDF @N:52.24g, P:46.95g, K:24g +	5.96	14.03	4.44	203.26

Vermicompost @10.8kg + Biofertilizer @500 ml/kg seed)				
T8 (100% Vermicompost @20kg)	3.75	9.27	3.09	141.06
T9 (100% Biofertilizer @500 ml/kg seed)	3.50	8.79	3.05	131.59
C.D.	0.18	0.74	0.37	9.13
SE(m)	0.06	0.25	0.12	3.02
SE(d)	0.08	0.35	0.17	4.27
C.V. (%)	2.06	3.65	5.53	3.13

Table.3 Impact on yield and harvest index under Different Treatments

Treatment	**Description**	**Seed Yield (q/ha)**	**Stover Yield (q/ha)**	**Biological Yield (q/ha)**	**Harvest Index (%)**
T1	100% RDF @ N:83.58g, P:75.12g, K:47.4g	16.50	55.28	71.78	22.98
T2	80% RDF @ N:69.65g, P:62.60g, K:32g + Vermicompost @9kg	18.47	53.81	72.28	25.54
T3	80% RDF @ N:69.65g, P:62.60g, K:32g + Biofertilizer (Azotobacter + PSB @500 ml/kg seed)	15.63	53.13	68.78	22.74
T4	80% RDF + Vermicompost @9kg + Biofertilizer (Azotobacter + PSB @500 ml/kg seed)	21.97	58.38	80.35	27.34
T5	60% RDF @ N:52.24g, P:46.95g, K:24g + Vermicompost @10.8kg	16.37	53.45	69.81	23.43
T6	60% RDF @ N:52.24g, P:46.95g, K:24g +	15.23	50.84	66.06	23.04

	Biofertilizer (Azotobacter + PSB @500 ml/kg seed)				
T7	60% RDF + Vermicompost @10.8kg + Biofertilizer (Azotobacter + PSB @500 ml/kg seed)	19.60	57.50	77.08	25.41
T8	100% Vermicompost @20kg	15.23	49.80	65.01	23.39
T9	100% Biofertilizer (Azotobacter + PSB @500 ml/kg seed)	15.07	48.40	63.49	23.76
CD (P=0.05)	-	0.59	0.71	0.60	0.83
SE(m)	-	0.19	0.23	0.20	0.28
SE(d)	-	0.27	0.33	0.28	0.39
CV (%)	-	1.96	0.76	0.49	1.97

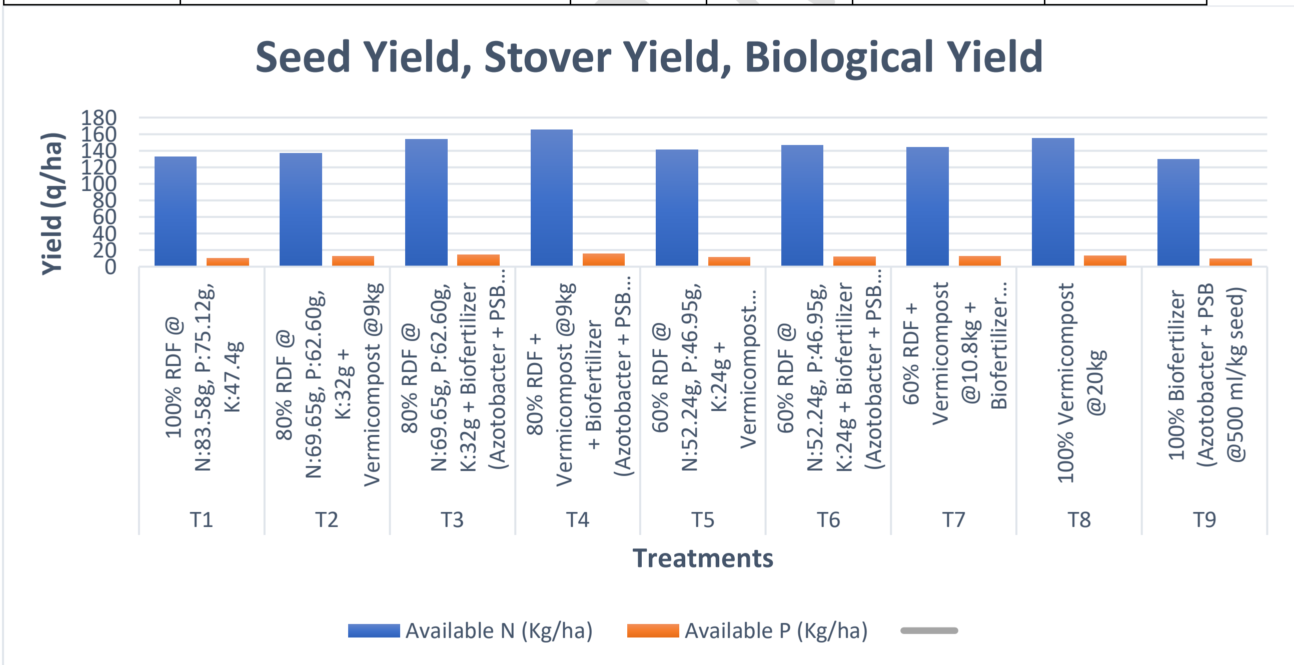

Fig.1. Influence of Integrated nutrient management on seed, stover and biological yield of Mustard