



Growth and Yield of Indian Mustard as Affected by Integrated Nutrient Management under Doon Valley Condition of Uttarakhand, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/ijpss/2024/v36i115146>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/126145>

Original Research Article

Received: 05/09/2024

Accepted: 08/11/2024

Published: 20/11/2024

ABSTRACT

Aims: To study the effects of integrated nutrient management practices on growth, and yield of Indian mustard.

Study Design: Randomized Block Design.

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Cite as: Nandan, Yash, R. K. Sharma, Saurabh Suman, and R. G. Upadhyay. 2024. "Growth and Yield of Indian Mustard As Affected by Integrated Nutrient Management under Doon Valley Condition of Uttarakhand, India". *International Journal of Plant & Soil Science* 36 (11):311-18. <https://doi.org/10.9734/ijpss/2024/v36i115146>.

Place and Duration of Study: Agricultural Research Farm Doon (P.G.) College of Agricultural Science and Technology, Selaqui, Dehradun during rabi season (2023-2024).

Methodology: The experiment was laid out with three replication and ten treatments. The plot size was 4.5 m × 3m with high yielding variety 'NRCHB 101' was taken for the study.

Results: Significantly the highest growth parameters at harvest viz. plant height(199.33cm), number of primary and secondary branches(10.00 and 15.66), leaf area index(3.64), dry matter (68.233 g plant⁻¹), yield attributing characters i.e. length of siliquae (6.433cm), number of siliquae plant⁻¹(323.667), number of seeds siliquae⁻¹(13.333), test weight(5.57g), grain yield(21.813q ha⁻¹), stover yield(71.343q ha⁻¹), biological yield(93.157q ha⁻¹), harvest index (23.407) were observed in T₁₀ (75% RDF + FYM + Vermicompost + *Azotobacter*) and the lowest were observed in the in the T₁.

Conclusion: The significantly higher grain yield was observed in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + *Azotobacter*).

Keywords: *Azotobacter*; fertility; FYM; growth; RDF; vermicompost.

1. INTRODUCTION

"By 2050, India needs to produce 17.84 mt of vegetable oils for its nutritional fat requirement of projected 1685 million populations. This target is difficult to achieve at current status of technology and resources management in Indian agriculture" (Hegde, 2012). "Thus, enhancing the productivity of oilseeds is imperative for self-reliance. India holds 11.3 % of world's arable land and only 4% of the water resources to feed 16% of human population and 18% of animal population of the world. India oilseed scenario recently presented a picture of virtual stagnation. The technology mission on oilseed launched by government of India in 1986 has impacted to overall production of oilseed significantly. The transformation in mustard scenario is commonly known as "Yellow–Revolution" the quantum jump in production of mustard is to be attributed to the development of improved technology" (Manohar et al., 2009).

The oilseeds have an important place in Indian agriculture next to cereals crops. The rapeseed-mustard group broadly includes Indian mustard, yellow sarson, brown sarson, raya, and toria crops. Indian mustard (*Brassica juncea* (L.) Czern & Coss) is predominantly cultivated in Rajasthan, UP, Haryana, Madhya Pradesh, and Gujarat. It is also grown under some non traditional areas of South India including Karnataka, Tamil Nadu, and Andhra Pradesh. The crop can be raised well under both irrigated and rainfed conditions.

India grows oilseeds on 12–15% of the world's total area, but its production accounts for less than 6–7% of global output, which is insufficient to feed roughly 16% of the world's population. In India, oilseeds are the second most important agricultural product after cereals, accounting for

10% of the value of all agricultural commodities and 13% of the gross cropped area. They also contribute close to 5% of the nation's GDP.

"India's rapeseed-mustard acreage for 2022–2023 is estimated at 95.77 lakh hectares, which is lower than the Ministry of Agriculture's projection of 98.02 lakh hectares, based on the primary survey of nine major states (West Bengal, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Madhya Pradesh, Rajasthan, Uttar Pradesh) and secondary survey of the remaining states," stated SEA. It has been anticipated that the average productivity for 2022–2023 will be 1,203 kg/ha. Rajasthan is the highest producer of mustard and rapeseed (4.22 million tons) in India, followed by Haryana (1.15 million tons) and Uttar Pradesh (0.96 million tons)" (GOI, 2020). "Rapeseed and mustard seed is considered a rich source of oil and protein. The seeds contain oil (46-48%), 43.6 percent protein, and low glucosinolate content. Also, the seed residues are used as an ingredient for cattle and poultry feed in India" (Mandal & Sinha, 2004; Manohar et al. 2009).

"Mustard is cultivated mostly under temperate climates. It is also grown in certain tropical and subtropical regions as a cold weather crop. Rapeseed-mustard follows C₃ pathway for carbon assimilation. Therefore, it has efficient photosynthetic response at 15–20°C temperature. At this temperature the plant achieves the maximum CO₂ exchange range which declines thereafter. Rai is mostly grown as a rainfed crop, moderately tolerant to soil acidity, preferring a pH from 5.5 to 6.8, thrives in areas with hot days and cool night and can fairly sustain drought. Mustard requires well-drained sandy loam soil. Rapeseed-mustard has a low water requirement (240–400 mm) which fits well in the rainfed cropping systems. Nearly 20% area

under these crops is rain fed. Identification of the critical inputs to enhance the mustard production is need of hour. Apart from improved varieties and judicious irrigation, use of balanced fertilizers is critical for realizing higher yield. Indian soils are becoming deficient in N, P, and K along with S due to intensive cultivation and use of high analysis fertilizers, under such situation organic manures can be exploited to boost the soil health condition vis-à-vis production of crops and to improve fertilizer use efficiency. Nitrogen is the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and oil yield. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen. It promotes flowering, setting of siliquae and increase the size of siliquae and yield" (Singh & Meena, 2004). "The judicious use of nutrients is very important as our country is importing most of the fertilizers from abroad. Under present situation, focus on nutrient management on mustard needs to be changed by integration with other option. The use of total organic or inorganic nutrient sources has some limitations. Combine use of chemical and organic sources of nutrients proved superior result generally to the use of each unit separately. Sustainable oilseed production requires the efficient use of inputs by balanced fertilization, which include biofertilizer, organic manures, secondary and micronutrients, and site-specific nutrient management so that there is no wastage and harness positive interactions of nutrients and growth factors" (Hegde & Sudhakara, 2009). So, for attaining higher production as well as quality oilseeds the use of integration of nutrients for oilseed production is required. The oil content increased from 2 to 7% due to the use of fertilizers either singly or in combination with major, secondary, and micronutrients (Hegde & Sudhakara, 2004).

Through integrated nutrient management, extra mining of nutrients will have to be checked to maintain soil health. Thus, both organic and inorganic sources of plant nutrients and biofertilizer not only manage long-term fertility and productivity of the soil but also take care of environmental pollution (Antil & Narwal, 2007)

2. MATERIALS AND METHODS

The present study was carried out during the *rabi* season of 2023-2024 at Agricultural Research Farm, Doon (P.G.) College of Agricultural Science and Technology, Selaqui, Dehradun under Doon Valley on the foothills of the

Himalayas nestled between Song River, a tributary of Ganga on the east and the Asan river, a tributary of Yamuna on the west. Geographically, the experimental site is situated at 30.36° N latitude, 78.85° E longitude at an elevation of about 538 metres above the sea level. The meteorological data showed that the maximum and minimum temperature during the crop period varied from 21.2-33.9°C and 0.4-10.9°C respectively. Initially the available nitrogen was 212.5 kg/ha, available phosphorus was 26.32 kg/ha, available potassium was 202.30 kg/ha, organic carbon (%) was 0.41, pH was 7.32.

The experiment was laid out in randomized block design with three replication and ten treatments-comprising of T₁-Control, T₂-100% RDF of NPK, T₃-100% RDF + FYM @10 ton/ ha, T₄-100% RDF + Vermicompost @5 ton/ ha, T₅-100% RDF + *Azotobacter* @ 10 g/kg seed, T₆-FYM @10 ton/ ha , T₇-Vermicompost @ 5Ton/ha, T₈-Vermicompost @ 5 ton/ha + FYM @ 10 ton/ha + *Azotobacter* @ 10 g/kg seed, T₉-75% RDF + Vermicompost @ 5 ton/ha + FYM @ 10 ton/ha, T₁₀-75% RDF + Vermicompost @ 5 ton/ha + FYM @ 10 ton/ha + *Azotobacter* @ 10 g/kg seed. The plot size maintained was 4.5m × 3m. High Yielding Variety 'NRCHB 101' was taken for the study. *Azotobacter* was applied as seed inoculation at the time of sowing whereas FYM and vermicompost was applied before sowing.

The growth parameters viz. plant height, leaf area index, dry matter accumulation and yield attributes i.e. number of primary and secondary branches, length of siliquae, numbers of siliquae plant⁻¹, numbers of seeds siliqua⁻¹, test weight, grain yield, stover yield, biological yield, harvest index of Indian mustard and were observed by adopting the standard scientific methods. The analysis of variance (ANOVA), the standard error of means (SEm±) and critical difference (CD) at 5% probability level of significance was analysed through MS Excel and OP Stat.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

As compared to control significantly highest plant height was observed in T₁₀ (75% RDF + Vermicompost @ (5 ton/ ha + FYM @ (10 ton/ ha + *Azotobacter*) at 30 Days after sowing (31.933 cm), 60 DAS (136.333 cm), 90 DAS (194.5 cm), and at harvest (199.33 cm). The Fig. 1 showed that at harvest the treatment T₉ was observed at

par with T₁₀ and there was no significant variation. Significantly highest number of primary branches plant⁻¹ was observed in the same treatment T₁₀ (75% RDF + Vermicompost @ (5 ton/ ha + FYM @ (10 ton/ ha + Azotobacter) at 60 DAS, 90 DAS and at harvest (10) and at 60 DAS, the treatment T₉ was observed at par with T₁₀ as well as at 90 DAS the treatment T₇ and T₉ were observed at par with T₁₀ and at harvest the treatment T₇ and T₉ were observed at par. Significantly the highest number of secondary branches plant⁻¹ was observed in T₁₀ (75% RDF

+ Vermicompost @ (5 ton/ ha + FYM @ (10 ton/ ha + Azotobacter) at 60 DAS, 90 DAS and at harvest (15.667) while lowest number of secondary branches plant⁻¹ was observed in T₁. The treatments T₄, T₅, T₆, T₈ and T₉ were found at par with T₁₀ at 60 DAS. The significantly highest dry matter (g plant⁻¹) was observed in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) at 30 DAS (2.3 g plant⁻¹), 60 DAS (16.067 g plant⁻¹), 90 DAS (38.2 g plant⁻¹) and at harvest (68.233g plant⁻¹) as well as lowest dry matter was observed in T₁.

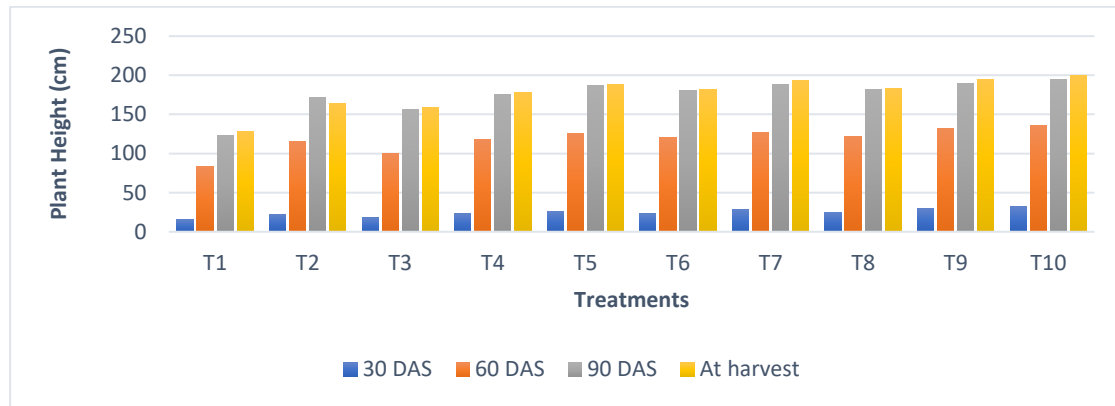


Fig. 1. Effect of integrated nutrient management on plant height

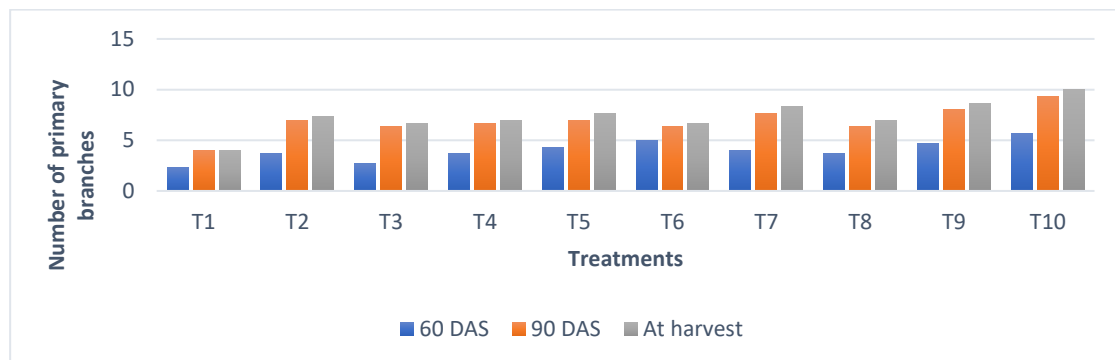


Fig. 2. Effect of integrated nutrient management on primary branches⁻¹ of mustard

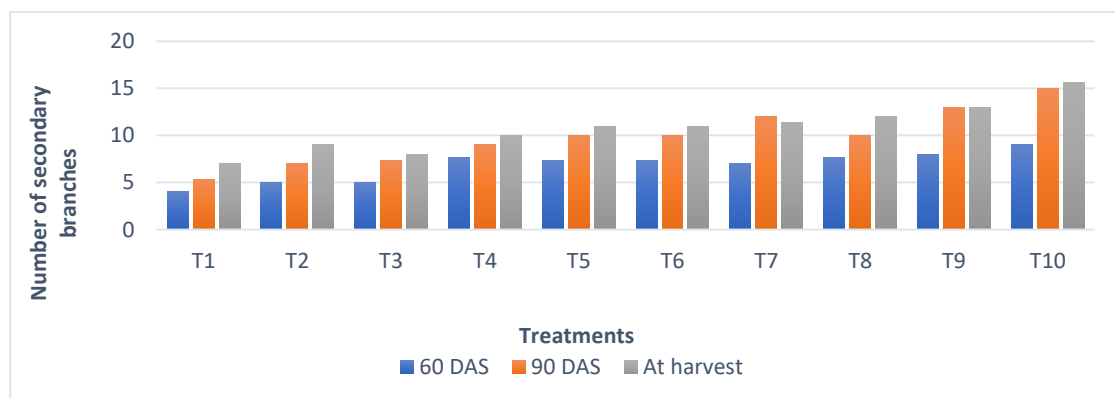


Fig. 3. Effect of integrated nutrient management on secondary branches⁻¹ of mustard

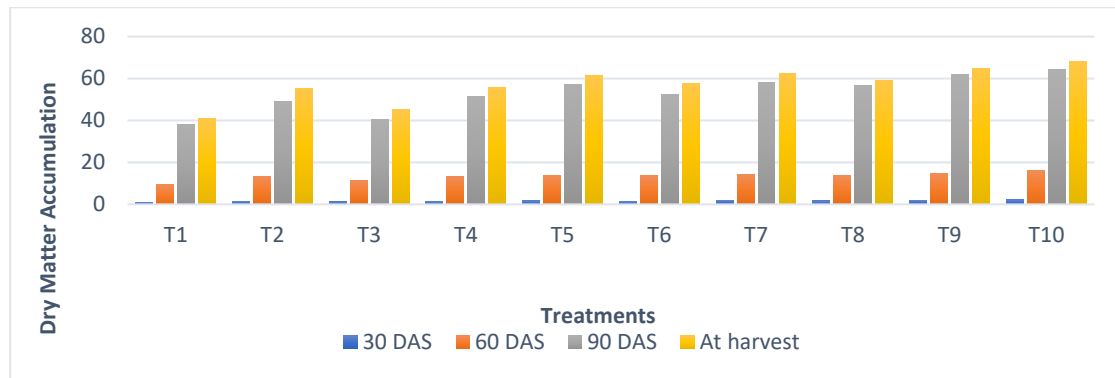


Fig. 4. Effect of integrated nutrient management on dry matter (gplant⁻¹) of mustard

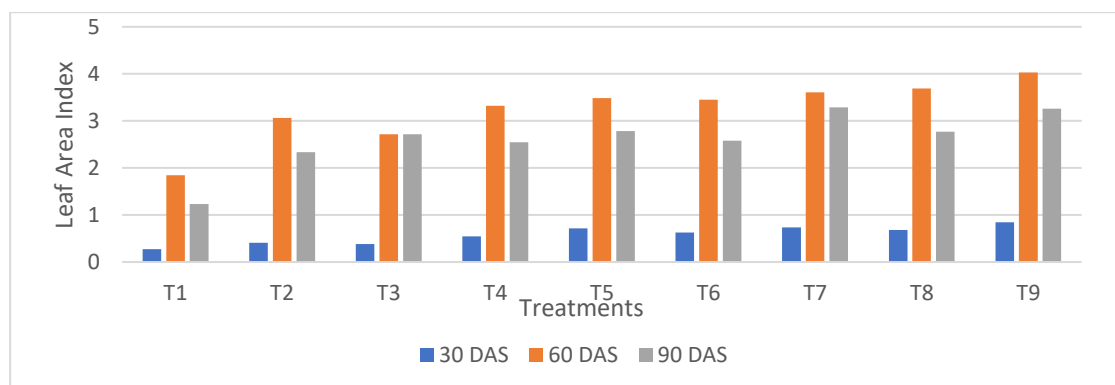


Fig. 5. Effect of integrated nutrient management on leaf area index

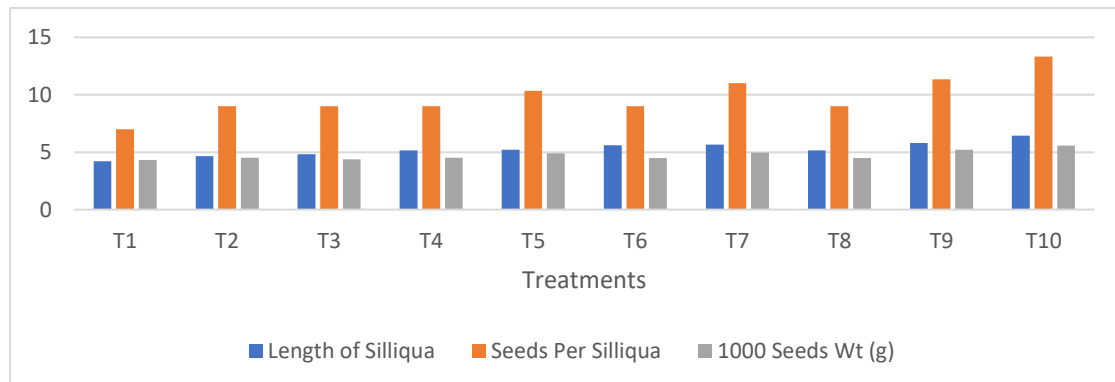


Fig. 6. Effect of integrated nutrient management on length of siliquae(cm), seeds siliquae⁻¹ and test weight (g) of mustard

The leaf area index was observed at various growth stages and found that significantly the highest leaf area index was observed in T₁₀ (75% RDF + Vermicompost @ (5 ton/ ha + FYM @ (10 ton/ ha + Azotobacter) at 30, 60, 90 DAS while lowest leaf area index was observed in T₁. At 60 days after sowing treatment T₉ was observed at par with other treatments.

The significantly highest plant height, number of primary and secondary branches were observed

in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) due to the combined application of NPK, FYM, vermicompost and seed inoculation with Azotobacter because (azotobacter) promotes plant growth by producing biologically active substances, stimulating microbes, and modifying nutrient uptake and vermicompost contains enzymes and hormones like auxins and gibberellins which promotes plant growth and thus increase plant height and number of branches in plants.

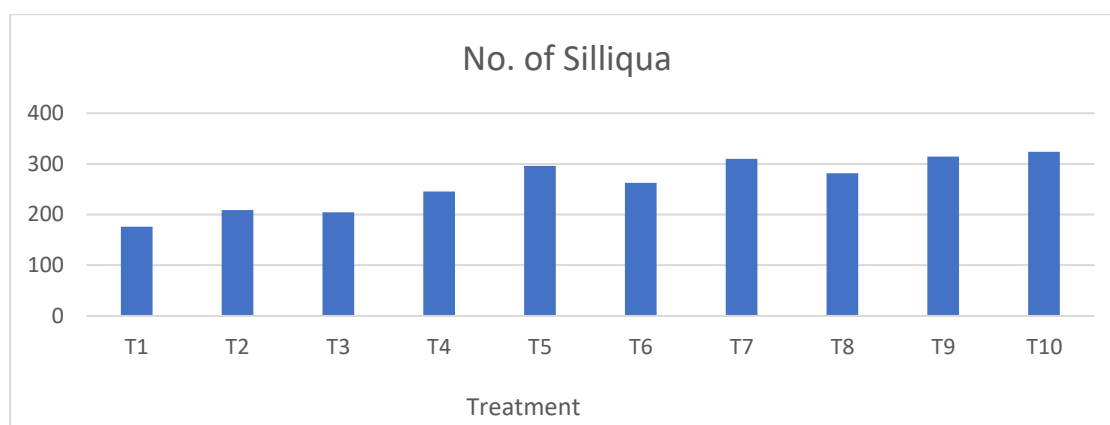


Fig. 7. Effect of integrated nutrient management on number of siliqua plant⁻¹ of mustard

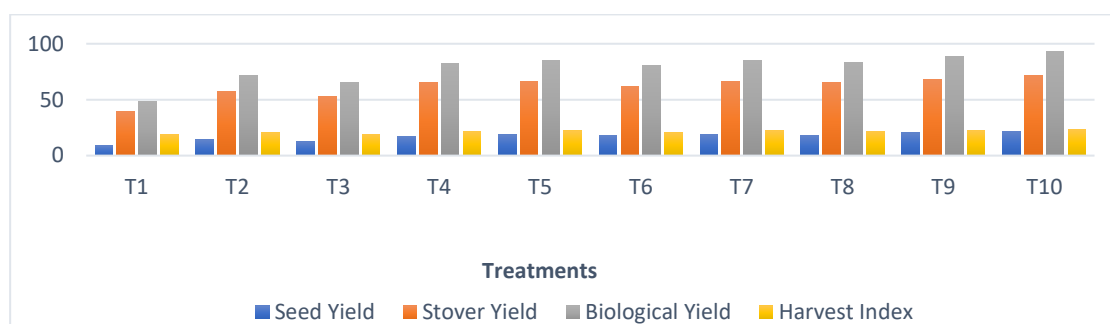


Fig. 8. Effects of integrated nutrient management on grain, stover, biological yield (q ha⁻¹) harvest index of mustard

The significantly highest leaf area index and dry matter (g/plant) were observed in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) due to the slow decomposition rate of vermicompost in soil which enables plants to assimilate their essential nutrients throughout the growth period which results in higher dry matter content and leaf area index.

The Similar results were also observed by Anand et al. (2017), Yadav et al. (2018), Kumar et al. (2021), Vinod et al. (2019).

3.2 Yield Attributing Characters

The significantly highest length of siliqua, number of siliqua per plant, number of seeds siliqua⁻¹, and test weight (g) was observed in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) while the lowest were observed in T₁.

The Table 1 showed that the significantly highest grain yield (21.813 q ha⁻¹) among all the treatment was observed in T₁₀ (75% RDF +

Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) and the lowest grain yield was observed in T₁. Significantly highest stover yield (71.343 q ha⁻¹) and biological yield (93.157 q ha⁻¹) were observed in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) and the lowest were observed in T₁. The significantly highest harvest index (%) was recorded in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) 23.407 and the lowest harvest index (%) was observed in T₁.

Significantly highest length of siliqua(cm), number of siliqua plant⁻¹, number of seeds siliqua⁻¹, test weight, grain yield, stover yield, biological yield, and harvest index were observed in T₁₀ (75% RDF + Vermicompost @ 5 ton/ ha + FYM @ 10 ton/ ha + Azotobacter) due to better nutrient uptake and increased soil microbial activity, enhanced oxygen availability, improved porosity, enhanced infiltration rate.

The similar trends were also observed by Chand (2007), Bisht et al. (2018), Tripathi et al. (2010).

Table 1. Effect of integrated nutrient management on grain, stover, biological yield (q ha⁻¹) and harvest index of mustard

S.No.	Treatments	Grain yield(qha ⁻¹)	Stover yield(qha ⁻¹)	Biological yield (qha ⁻¹)	Harvest Index (%)
T ₁	Control	9.233	39.387	48.753	18.997
T ₂	100% RDF of NPK	14.227	57.67	71.897	20.437
T ₃	100% RDF + FYM (10 ton/ ha)	12.5	53.193	65.693	19.23
T ₄	100% RDF + Vermicompost (5 ton/ ha)	17.483	65.277	82.76	21.507
T ₅	100% RDF + Azotobacter	18.683	66.087	84.77	22.08
T ₆	FYM @ (10 ton/ ha)	18.38	62.173	80.553	20.473
T ₇	Vermicompost @ (5 ton/ha)	19.043	66.223	85.267	22.297
T ₈	Vermicompost @ (5 ton/ha)+ FYM @ (10 ton/ ha + Azotobacter	18.33	65.2	83.507	21.883
T ₉	75% RDF + Vermicompost @ (5 ton/ha)+ FYM@ (10 ton/ ha	20.853	67.77	88.623	22.37
T ₁₀	75% RDF + Vermicompost@ (5 ton/ha) + FYM @ (10 ton/ ha + Azotobacter	21.813	71.343	93.157	23.407
S. Em±		0.265	0.302	0.398	0.197
CD (P= 0.05)		0.792	0.905	1.192	0.591

4. CONCLUSION

Based on the study findings, it can be concluded that the application of only recommended dose of fertilizers is not capable of exploring the potential yield of the *Brassica juncea* L. in sustainable manner. Therefore, application of nutrients through integration of inorganic source, vermicompost, FYM, and *Azotobacter* is essential to get the higher production and productivity. From the current research findings, it can be concluded that application of nutrients through integration of 75% RDF, Vermicompost @ 5 ton ha⁻¹, FYM @ 10 ton ha⁻¹ and seed inoculation with *Azotobacter* could increase growth, yield attributes and yield of Indian mustard.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

ACKNOWLEDGEMENT

The authors are highly thankful to Dr. Sanjay Chaudhary (Director), Dr. Roop Kishore Sharma (Head Department of Agronomy), Doon (P.G.) College of Agriculture Science and Technology, Dehradun for providing all resources to conduct the experiment and lab facilities for biochemical analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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