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Impact of Integrated Nutrient Management on Yield and Economic Returns in Mustard (*Brassica juncea* L.)

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ABSTRACT

A field experiment was conducted during the Rabi seasons of 2021-2022 and 2022-2023 to evaluate the economic feasibility of Integrated Nutrient Management (INM) on the yield and economic returns of mustard (*Brassica juncea* L.). The experiment included fourteen treatments and was replicated three times in a randomized block design (RBD). In the 2021-2022 season, the highest seed yield of 21.46 q/ha was recorded in treatment T_{10} (50% NPK + vermicompost @ 5 t/ha + $ZnSO_4$ @ 40 kg + Azotobacter), while the lowest seed yield of 9.11 q/ha was observed in T_1 (Farmer's practice). Similarly, in the 2022-2023 season, T_{10} again recorded the highest seed yield of 21.86 q/ha, whereas T_1 showed the lowest yield of 9.35 q/ha. The stover yield followed a similar trend, with T_{10} exhibiting the highest yields of 51.36 q/ha in 2021-2022 and 52.06 q/ha in 2022-2023. In contrast, T_1 had the lowest stover yields, recording 27.41 q/ha and 27.85 q/ha in the respective years. From an economic perspective, in the 2021-2022 season, the T_9 treatment (75% NPK + vermicompost @ 2.5 t/ha + $ZnSO_4$ @ 40 kg/ha + Azotobacter) proved to be the most economically feasible. It incurred a cultivation cost of Rs. 33,810, yielding a gross income of Rs. 105,798 and a net income of Rs. 71,988 per hectare. This was closely followed by T_{10} (50% NPK + vermicompost @ 5 t/ha + $ZnSO_4$ @ 40 kg/ha + Azotobacter), with a cultivation cost of Rs. 40,060, a gross income of Rs. 110,064, and a net income of Rs. 70,004 per hectare. In the 2022-2023 season, the T_9 treatment continued to show favourable economic results, with a cultivation cost of Rs. 33,810, a gross income of Rs. 116,624, and a net income of Rs. 82,814 per hectare. Similarly, T_{10} recorded a cultivation cost of Rs. 40,060, generating a gross income of Rs. 120,827 and a net income of Rs. 80,767 per hectare. The benefit-cost (B-C) ratio further highlighted the economic viability of the treatments. In 2021-2022, T_9 had a B-C ratio of 2.13, while T10 recorded a ratio of 1.75. In the 2022-2023 season, the B-C ratio for T_9 increased to 2.44, and for T10, it rose to 2.02. Overall, these results indicate that the T_9 treatment (75% NPK + vermicompost @ 2.5 t/ha + $ZnSO_4$ @ 40 kg/ha + Azotobacter) was the most economically viable option for mustard cultivation across both years, offering higher net returns and a superior B-C ratio.

Key words: *Azotobacter, B:C ratio, Cost of cultivation, FYM, Gross & Net Income, Mustard, Poultry Manure, Vermicompost.*

Introduction

In terms of acreage, production, and economic value, oilseeds rank second only to food grains in India. The cultivation and production of oilseeds are primarily concentrated in the central and southern regions, notably in Madhya Pradesh (28.45%), Rajasthan (18.01%), Maharashtra (16.39%), Gujarat, Karnataka, and Uttar Pradesh (Agricultural Statistics at a Glance 2022, Government of India, Ministry of Agriculture & Farmers Welfare). During the 2020-21 season, mustard was cultivated over 6.7 million hectares, producing 10.21 million tonnes (1). Madhya Pradesh, as one of the leading mustard-

producing states, significantly contributes to the country's overall oilseed production, with 1.31 million tonnes, including a substantial output from the Gwalior district (Department of Agriculture and Farmers Welfare, 2022). The Central Organization for Oil Industry and Trade (COOIT) estimated mustard seed production in India during the 2021-22 Rabi season at 8.95 million tonnes, a 19% increase from the 7.5 million tonnes recorded in the previous year. Despite this growth, India still faces a gap between domestic edible oil availability and actual consumption, necessitating imports.

Organic manures are increasingly being used in mustard cultivation, as rapeseed-mustard serves as a significant income source, particularly for marginal and small farmers (Chaurasiya *et al*., 2024). The use of organic manures, especially in combination with inorganic fertilizers, has shown to improve mustard yield compared to conventional nutrient applications. Organic manures play a vital role in enhancing production efficiency and promoting sustainable farming practices (Singh, *et al*., 2024).

Materials and Methods

The study was conducted at the CRC-III, ITM University, Gwalior, Madhya Pradesh, situated at an elevation of 196 meters, with geographic coordinates of 26°21' N latitude and 78°17' E longitude. The region experiences temperatures ranging from 14.4 °C to 37.3 °C and receives an annual rainfall between 127.4 mm and 128.8 mm during the crop growth period. The soil, representative of the Indo-Gangetic plain, is well-suited for mustard cultivation. The experiment followed a Randomized Block Design (RBD) with 14 treatments and 3 replications, covering a total of 42 plots. The mustard variety GIRIRAJ (DRMR IJ-31) was sown during the Rabi seasons of 2021-22 and 2022-23.

Treatments included various combination T_1 : Absolute control T_2 : 100% RDF (80:60:40:40 Kg/ha) NPKS T_3 : 75% NPK + FYM@ 5 t/ha + $ZnSO_4$ @ 40 Kg T_4 : 50% NPK + FYM@ 10 t/ha + $ZnSO_4$ @ 40 Kg T_5 : 75% NPK + FYM @ 5 t/ha + $ZnSO_4$@ 40 Kg + Azotobacter T_6 : 50% NPK + FYM@ 10 t/ha + $ZnSO_4$ @ 40 Kg + Azotobacter T_7 : 75% NPK +Vermicompost@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg T_8 : 50% NPK +Vermicompost@ 5 t/ha + $ZnSO_4$ @ 40 Kg T_9 : 75% NPK +Vermicompost@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg + Azotobacter T_{10} : 50% NPK +Vermicompost@ 5 t/ha + $ZnSO_4$ @ 40 Kg + Azotobacter T_{11}: 75% NPK + Poultry manure@ 1t/ha + $ZnSO_4$ @ 40 Kg T_{12} : 50% NPK + Poultry manure@2 t/ha + $ZnSO_4$ @ 40 Kg T_{13} : 75% NPK + Poultry manure@1t/ha + $ZnSO_4$ @ 40 Kg + Azotobacter T_{14} : 50% NPK + Poultry manure@2t/ha + $ZnSO_4$ @ 40 Kg + Azotobacter.

The experimental plots measured 5.0 x 3.6 m², with a net plot size of 4.0 x 2.4 m². Seeds were sown at a rate of 3 kg ha^{-1}, with row spacing of 45 cm and plant spacing of 15 cm. Irrigation was applied at both the sowing and flowering stages. Key yield components, including the number of siliquae per plant, seeds per silique, and siliqua length, were recorded. After harvest, seed yield, stover yield, and biological yield were measured, followed by an economic analysis of the treatments. Data were analysed using ANOVA to identify significant differences among treatments, with the standard error of the mean and critical differences calculated at the 5% significance level to determine treatment effects.

Common cost of cultivation as well as treatment wise cost of cultivations on hectare basis were worked at the rates prevailed during the year 2020-2021 and 2022-23. The per hectare yield of the mustard crop was converted into gross returns on the basis of current price of the produce. The net returns were worked out by using following formula for both the years.

$$Net\ Return(Rs.) = Gross\ Return\ (Rs.) - Cost\ of\ Cultivation\ (Rs.)$$

The benefit cost ratio (BCR) was worked out on the basis of net return (Rs.) per unit cost of cultivation (Rs.).

$$Benefit\ cost\ ratio = \frac{Net\ Return}{Cost\ of\ Cultivation}$$

Results and Discussion

As evident from the data presented in the Table 1 and 2, the effect of different nutrient management practices on the seed yield, stover yield, cost of cultivation, gross returns, net returns, and benefit-cost ratio varied significantly across all treatments. The use of integrated nutrient management involving both organic and inorganic fertilizers had a notable impact on the economic performance of mustard cultivation (Tripathy, *et al.*, 2024). Use of 75% NPK +Vermicompost@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg + Azotobacter in treatment T_9 found most significant effect or integrated nutrient management practice over other treatments.

The seed yield in 2021-22, the maximumseed

yield of 21.46 q/ha was observed in T_{10} and the minimum seed yield of 9.11 q/ha was observed in T_1. Similarly, in were 2022-23, the maximum seed yield of 21.86 q/ha was observed in T_{10} and the minimum seed yield of 9.35 q/ha was observed in T_1. The stover yield followed a similar trend, with T_{10}exhibiting the highest yields of 51.36 q/ha in 2021-2022 and 52.06 q/ha in 2022-2023. In contrast, T_1 had the lowest stover yields, recording 27.41 q/ha and 27.85 q/ha in the respective years.

The highest cost of cultivation was observed in treatment T_{10}, with costs amounting to 40,060 per hectare. In contrast, the lowest cost of cultivation was recorded in T_1, which incurred 25,500 per hectare. But the gross returns were highest in treatment T_9 with 105,798 and 116,624 in the 2021-22 and 2022-23 seasons, respectively. This was followed closely by T_{10}, of 110,064 and 120,827 in gross returns for the respective years. The lowest gross returns were observed in T_1(Farmer Practice), amounting to 47,835 and 52,790 in 2021-22 and 2022-23, respectively.

Net returns followed a similar trend, with the highest net returns recorded in T_9, amounting to 71,988 in 2021-22 and 82,814 in 2022-23. Treatments involving a combination of reduced NPK with vermicompost and Azotobacter (T_9 and T_{10}) consistently outperformed other treatments in terms of profitability. The lowest net returns were recorded in T_1 (Farmer Practice), with values of 22,335 and 27,290 across the two years. This indicates that traditional practices, while less costly in terms of cultivation, result in significantly lower economic gains compared to integrated nutrient management.

The benefit-cost ratio further emphasizes the economic efficiency of organic and biofertilizer-based treatments. T_9 achieved the highest B-C ratio of 2.13 in 2021-22 and 2.44 in 2022-23, indicating its superior profitability. In contrast, T_1 (Farmer Practice) recorded the lowest B-C ratio (0.88 in 2021-22 and 1.07 in 2022-23), suggesting limited economic returns from conventional methods.

Overall, the results indicate that treatments involving reduced NPK levels combined with organic manures such as vermicompost or poultry manure, supplemented with Azotobacter, significantly enhance both yield and profitability (Gopal, *et al.*, 2004). Treatment T_9, which integrated 75% NPK with vermicompost and Azotobacter, emerged as the most profitable option, with the highest returns and economic efficiency. Additionally, T_{10} and T_8, which involved higher levels of organic inputs, also proved to be economically viable, though with slightly increased costs of cultivation.

These findings align with previous studies, including those by Jadhav *et al.* (2023) and Kanika *et al.* (2024), which reported the enhanced yield and economic benefits of integrating organic and inorganic fertilizers in mustard cultivation. The results clearly suggest that adopting sustainable nutrient management practices, including the use of biofertilizers and organic manures, can significantly improve both the yield and economic returns of mustard crops, particularly for small and marginal farmers (Sudadi, 2024).

Table 1.

CHARACTER	Seed yield (q/ha)		Stover yield (q/ha)	
EXP. YEAR:	2021-22	2021-22	2021-22	2022-23
Treatments				
T_1 (Farmer Practice)	9.11	9.35	27.41	27.85
T_2 (100% RDF (80:60:40:40 Kg/ha) NPKS)	13.32	13.75	36.32	36.95
T_3 (75% NPK + FYM@ 5 t/ha + $ZnSO_4$ @ 40 Kg)	11.08	11.35	31.08	31.55
T_4 (50% NPK + FYM@ 10 t/ha + $ZnSO_4$ @ 40 Kg)	14.22	14.54	38.12	38.55
T_5 (75% NPK + FYM @ 5 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	16.26	16.50	42.46	43.00
T_6 (50% NPK + FYM@ 10 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	15.09	15.44	40.09	40.44
T_7 (75% NPK + VC@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg)	17.66	17.86	44.66	45.06
T_8 (50% NPK + VC@ 5 t/ha + $ZnSO_4$ @ 40 Kg)	19.23	19.54	47.53	48.04
T_9 (75% NPK + VC@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	20.66	21.14	48.76	49.34
T_{10} (50% NPK + VC@ 5 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	21.46	21.86	51.36	52.06
T_{11} (75% NPK + PM@ 1t/ha + $ZnSO_4$ @ 40 Kg)	15.98	16.17	41.48	41.97
T_{12} (50% NPK + PM@ 2 t/ha + $ZnSO_4$ @ 40 Kg)	16.92	17.10	43.42	43.80
T_{13} (75% NPK + PM@ 1t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	18.14	18.31	45.84	46.11
T_{14} (50% NPK + PM@ 2t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	18.75	18.96	46.75	47.16

Table 2.

CHARACTER	Cost of cultivation (Rs/ha)		Gross Returns (Rs/ha)		Net returns (Rs/ha)		B:C ratio	
EXP. YEAR:	2021-22	2022-23	2021-22	2022-23	2021-22	2021-22	2021-22	2021-22
Treatments								
T_1 (Farmer Practice)	25500	25500	47835	52790	22335	27290	0.88	1.07
T_2 (100% RDF (80:60:40:40 Kg/ha) NPKS)	28300	28300	69202	76802	40902	48502	1.45	1.71
T_3 (75% NPK + FYM@ 5 t/ha + $ZnSO_4$ @ 40 Kg)	31300	31300	57745	63629	26445	32329	0.84	1.03
T_4 (50% NPK + FYM@ 10 t/ha + $ZnSO_4$ @ 40 Kg)	35050	35050	73742	81138	38692	46088	1.10	1.31
T_5 (75% NPK + FYM @ 5 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	31310	31310	84101	91934	52791	60624	1.69	1.94
T_6 (50% NPK + FYM@ 10 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	35060	35060	78205	86060	43145	51000	1.23	1.45
T_7 (75% NPK + VC@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg)	33800	33800	91042	99218	57242	65418	1.69	1.94
T_8 (50% NPK + VC@ 5 t/ha + $ZnSO_4$ @ 40 Kg)	40050	40050	98932	108290	58882	68240	1.47	1.70
T_9 (75% NPK + VC@ 2.5 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	33810	33810	105798	116624	71988	82814	2.13	2.44
T_{10} (50% NPK + VC@ 5 t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	40060	40060	110064	120827	70004	80767	1.75	2.02
T_{11} (75% NPK + PM@ 1t/ha + $ZnSO_4$ @ 40 Kg)	31300	31300	82589	90067	51289	58767	1.64	1.88
T_{12} (50% NPK + PM@ 2 t/ha + $ZnSO_4$ @ 40 Kg)	35050	35050	87347	95135	52297	60085	1.49	1.71
T_{13} (75% NPK + PM@ 1t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	31310	31310	93523	101691	62213	70381	1.99	2.25
T_{14} (50% NPK + PM@ 2t/ha + $ZnSO_4$ @ 40 Kg + Azoto.)	35060	35060	96558	105157	61498	70097	1.75	2.00

Conclusion

Based on the field experiment conducted to evaluate the Integrated Nutrient Management on Yield and Economic Returns in Mustard (*Brassica Juncea* L.), It can be concluded that the treatment T_9 (75% NPK + vermicompost @ 2.5 t/ha + ZnSO @ 40 kg/ha + Azotobacter) was superior in terms of yield among the different integrated nutrient management treatments. However, the highest economic feasibility was observed in treatment T_9, making it the most viable option for mustard cultivation in terms of both productivity and profitability. The combination of reduced NPK with vermicompost and biofertilizer proved to be the most effective strategy for maximizing economic returns.

Conflict of Interest - None

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