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Response of inorganic and organic sources of nutrients on growth, yield and quality of Mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during the Rabi season of 2022-2023 at Sardar Patel University, Balaghat (M.P.), to evaluate the effects of inorganic and organic nutrient sources on the growth, yield, and quality of mustard (*Brassica juncea* L.). The study aimed to assess individual and interactive effects of nutrient sources, and their economic viability. Results indicated that the application of 100:80:60 kg NPK/ha, particularly in combination with 5 t/ha of vermicompost, significantly enhanced growth parameters, yield attributes, and overall yield of mustard. This combination led to the highest seed yield (17.92 q/ha), oil content (386.7%), gross monetary returns (₹100841.56/ha), net monetary returns (₹68439.48/ha), and a favourable B:C ratio (2.11). The findings suggest that integrating inorganic fertilizers with organic sources like vermicompost can optimize mustard production and economic returns, though further validation from multi-year trials is recommended.

Keywords: Mustard, *Brassica juncea*, inorganic fertilizers, organic sources

Introduction
Oilseeds are a vital agricultural commodity in India, contributing significantly to the agricultural economy, accounting for 14% of the gross cultivated area and 1.5% of the gross domestic output. Mustard (Brassica junacea L.) ranks as the third most important oilseed crop globally, after soybean and palm oil. It is a versatile crop, with its oil utilized in various products, including cooking, pickles, hair oil, soaps, and even tanning. Mustard seeds are rich in calories, carbohydrates, protein, fat, dietary fiber, and essential minerals like manganese, magnesium, phosphorus, and calcium, making them highly favoured for cooking oil. The crop's young leaves also serve as a valuable source of sulfur, essential minerals, and vitamins (A, D, E, K, and C) for human and livestock consumption.

Agronomic management, especially nutrient application, is crucial for mustard growth. Inorganic fertilizers (nitrogen, phosphorus, and potassium) are essential for soil fertility and influence soil properties, impacting soil health and productivity. Studies have shown that increasing fertility levels enhance plant height, branching, leaf count, dry matter accumulation, and chlorophyll content in mustard. Integrating organic manure with inorganic fertilizers boosts crop yield and promotes diverse soil microbial populations.

Nitrogen is critical for mustard development, increasing protein and mineral content, and facilitating the uptake of potassium and phosphorus. Phosphorus promotes root and shoot growth, accelerates seed maturity, and enhances seed filling and oil concentration. Organic resources, such as farmyard manure (FYM), vermicompost, compost, and poultry manure, are vital for maintaining soil health and nutrient supply. FYM, containing NPK (0.5, 0.25, and 0.5% respectively), improves soil fertility and physical, chemical, and biological attributes, creating an optimal environment for crop growth. Organic leftovers are a cost-effective, environmentally friendly alternative to chemical fertilizers, supplementing nutrient supply in agricultural systems. Combining organic and inorganic fertilizers significantly improves crop yields.

Given the importance of both inorganic and organic nutrient sources in augmenting mustard yield and oil content, this experiment was designed with the following objectives:

- To assess the effect of inorganic sources of nutrients on the growth, yield, and quality of Mustard.
- To ascertain the effect of organic sources of nutrients on the growth, yield, and quality of Mustard.
- To work out the interaction effect of inorganic and organic sources of nutrients on growth, yield, and quality of Mustard.
- To work out the economic viability of treatments.

Review of literature

The review of literature indicates that integrated nutrient management significantly impacts mustard growth, yield attributes, and economics.

- **Growth Parameters:** Studies consistently show improved growth parameters with combined organic and inorganic nutrient applications. Hadiyal *et al*. (2017) [12] observed enhanced plant height and branching with FYM application. Kumar *et al*. (2018) reported maximum plant height, branches per plant, dry matter accumulation, and leaf area index with 50% RDF + FYM + Vermicompost + bio-fertilizer. Similarly, Chaudhary *et al*. (2021) and Reddy and Mehera (2022) found higher plant height and branching with organic manure and micronutrient combinations.
- **Yield Attributes and Yield:** Integrated nutrient management has also shown positive effects on yield attributes and overall yield. Hadiyal *et al*. (2017) [12] noted higher siliquae per plant, seeds per siliqua, and ultimately increased seed and stover yield with FYM. Kumar *et al*. (2018) reported maximum siliqua length, siliquae per plant, seeds per siliqua, and test weight with a combination of 50% RDF + FYM + Vermicompost. Dhaked *et al*. (2020) [6] highlighted significantly higher seed and stover yields with 100% RDF + FYM. Choudhary and Rai (2021) [4] observed enhanced yield attributes and seed yield with FYM + Vermicompost + 100% N:P:K.
- **Economics:** The economic benefits of integrated nutrient management are also well-documented. Sharma *et al*. (2023) found the highest gross monetary return, net monetary return, and B:C ratio with FYM and vermiwash application

Materials and Methods

The field experiment titled "Response of inorganic and organic sources of nutrients on growth, yield and quality of Mustard (*Brassica juncea* L.)" was conducted at the Research Farm of the Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.), during the Rabi season of 2022-2023.

*** Soil Properties**

Physicochemical properties of soil.

S. No.	Soil constituents	Value	Method of determination
1.	**Mechanical composition**		
	(i) Sand (%)	29.47	International pipette method (Piper,
	(ii) Silt (%)	39.91	1966)
	(iii) Clay (%)	30.65	
2.	**Chemical components**		
	(i) Soil pH (1:2 soil- water ratio)	7.4	Method No. 21 (b), USDA Hand Book No. (Richards, 1968)
	(ii)Electrical conductivity (ds/m)	0.17	Method No. 4, USDA Hand Book No. 60 (Richards, 1968)
	(iii)Organic carbon	0.44	Walkley and Black rapid titration method (Jackson, 1973) [13]
	(iv) Available nitrogen (kg/ha)	177.6	Alkaline permanganate method (Subbiah and Asija, 1956)
	(v) Available phosphorous (kg/ha)	12.4	Olsen"s method (Olsen *et al*., 1954)
	(vi) Available potassium	201.0	Flame photometer method (Jackson,1973) [13]

*Meteorological Data:

Date		Met. Week	Temp. C		R.H.%		Total Rainfall (mm)	No. of Rainy days	Evaporation (mm)
			Max.	Min.	Morn.	Even.			
08-14	Nov,22	45	31.4	19.0	76	60	0.0	0	3.5
15-21		46	31.7	19.2	78	62	0.0	0	3.7
22-28		47	31.5	18.2	81	63	5.2	1	2.9
29-05		48	29.5	16.4	78	59	0.0	0	3.2
06-12	Dec,22	49	29.6	15.6	74	56	0.0	0	2.5
13-19		50	28.6	14.5	79	61	0.0	0	2.4
20-26		51	27.3	11.3	79	61	0.0	0	2.3
27-02		52	27.3	14.1	80	61	0.0	0	1.9
03-09	Jan,23	1	30.3	14.1	81	56	0.0	0	1.8
10-16		2	30.3	14.1	82	58	0.0	0	1.8
17-23		3	31.3	14.1	72	45	0.0	0	1.6
24-30		4	31.3	14.1	61	44	0.0	0	3.3
31-06		5	30.3	12.1	65	39	0.0	0	3.4
06-13	Feb,23	6	27.3	12.1	60	32	0.0	0	4.4
14-20		7	32.3	15.1	57	37	1.4	0	4.9
21-27		8	33.3	15.3	49	28	2.4	0	5.3
28-06		9	36.5	19.1	36	22	0.0	0	6.4
07-13	Mar,23	10	38.7	21.1	32	18	0.0	0	7.3
14-20		11	39.8	22.2	31	17	0.0	0	7.4
21-27		12	39.9	22.7	30	17	0.0	0	7.5

*Cropping History: Cropping history of the experimental field

Year	Crop season		
	Kharif	**Rabi**	**Summer**
2020-21	Soybean	Linseed	--
2021-22	Maize	Gram	--
2022-23	Green gram	*Mustard	--

*Experimental Design

Layout plan of the experiment

Location	Research farm of Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.).
Crop	Mustard (*Brassica juncea* L.)
Year	2022-2023
Design	Randomized Block Design (with Factorial concept)
Replication	3
Treatments combination	4 x 3 = 12
Gross Plot size	5.0 m x 3.0 m
Net Plot size	4.5 m x 2.1 m
Total No of plot	36
Spacing	45 cm x 15 cm
eplication Gap	1.0 m
Gross Area	801.0 m2
Net Area	340.2 m2
Variety	Pusa Jay Kisan
Seed rate	5 kg/ha

*Treatment Combinations

Treatments	Notation	Treatment combination
T_1	F0M1	00:00:00Kg/ha (N:P: K) + FYM 5 ton per ha
T_2	F0M2	00:00:00Kg/ha (N:P: K) + Vermicompost 5 ton per ha
T_3	F0M3	00:00:00Kg/ha (N:P: K) + Compost 5 ton per ha
T_4	F1M1	60:40:20 Kg/ha (N:P: K) + FYM 5 ton per ha
T_5	F1M2	60:40:20 Kg/ha (N:P: K) + Vermicompost 5 ton per ha
T_6	F1M3	60:40:20 Kg/ha (N:P: K) + Compost 5 ton per ha
T_7	F2M1	80:60:40 Kg/ha (N:P: K) + FYM 5 ton per ha
T_8	F2M2	80:60:40 Kg/ha (N:P: K) + Vermicompost 5 ton per ha
T_9	F2M3	80:60:40 Kg/ha (N:P: K) + Compost 5 ton per ha
T_{10}	F3M1	100:80:60 Kg/ha (N:P: K) + FYM 5 ton per ha
T_{11}	F3M2	100:80:60 Kg/ha (N:P: K) + Vermicompost 5 ton per ha
T_{12}	F3M3	100:80:60 Kg/ha (N:P: K) + Compost 5 ton per ha

*Cultural Operations: Calendar of Cultural Operations

S. No.	Operations	Date	Remark
A.	**Pre-sowing operations**		
1.	Ploughing	26/10/2022	By tractor-drawn disc harrow planking
2.	Layout Execution	01/11/2022	By manual labour
3.	Basal application of fertilizers	02/11/2022	By manual labour
B.	**Sowing Operations**		
1.	Determination of plots preparation of furrow and seed sowing	02/11/2022	By manual labour.
C.	**Post sowing operations**		
1.	Tagging	20/11/2022	self (five plants in each plot)
2.	Thinning	22/11/2022	self
3.	Weeding	27/11/2022	By manual labour
4.	Spray of Acetamiprid for plant protection	27/11/2022	By manual labour
D.	**Harvesting**		
1.	Collection of tagged plants from each plot	10/03/2023	By manual labour
2.	Harvesting	11/03/2023	By manual labour
3.	Threshing	13/03/2023	By manual labour

This included light irrigation 2 days after sowing, and subsequent irrigations at 30 days after sowing, flowering stage, and siliqua formation stage. No plant protection measures were adopted as the crop was not affected by pests or diseases. Harvesting was done manually at complete maturity.

Observations Recorded

- **Growth Parameters:** Plant height, number of leaves per plant, number of branches per plant. Root length was measured at 60 DAS.
- **Yield Attributes:** Number of siliquae per plant, number of seeds per siliqua, 1000-grain weight (test weight).
- **Yield:** Seed yield per plant, seed yield per plot, grain yield per hectare, stover yield per hectare, and harvest index.
- **Quality Parameters:** Oil content.
- **Economics:** Gross monetary return, net monetary return, and B:C ratio.

Experimental Findings (Results)

The experimental findings demonstrated significant impacts of inorganic and organic nutrient sources on various parameters of mustard.

Growth Parameters

- **Plant Height:** The application of higher nutrient levels significantly improved plant height. The combination of 100:80:60 kg NPK/ha with 5 t/ha vermicompost resulted in the highest plant height.
- **Number of Leaves and Branches per Plant:** Similar to plant height, the number of leaves and branches per plant also showed significant improvement with higher nutrient levels and combined applications.

Yield Attributes

Number of Siliquae per Plant, Seeds per Siliqua, and 1000-Grain Weight: The highest number of siliquae per plant, grains per siliqua, and test weight were obtained with the combination of 100:80:60 kg NPK/ha and 5 t/ha vermicompost.

Yield

- **Seed Yield:** A significantly greater seed yield of 17.92 q/ha was obtained with the treatment of 100:80:60 kg NPK/ha. The application of 5 t/ha of vermicompost yielded 16.27 q/ha of seed.
- **Stover Yield:** A significantly greater stover yield of 30.35 q/ha was obtained with the treatment of 100:80:60 kg NPK/ha. The application of 5 t/ha of vermicompost yielded 29.61 q/ha, comparable to 5 t/ha of compost.
- **Harvest Index:** The application of 100:80:60 kg NPK/ha resulted in a significantly higher harvest index of 37.11%. Vermicompost at 5 t/ha yielded a harvest index of 35.34%, comparable to compost.

Quality

Oil Content: The oil content was highest with 100:80:60 kg NPK/ha (386.7%), comparable to 80:60:40 kg NPK/ha. Similarly, 5 t/ha of vermicompost generated an oil content of 37.07%, comparable to 5 t/ha of compost.

Economics

- **Gross Monetary Return:** A notable gross monetary yield of ₹100841.56/ha was achieved by applying 100:80:60 kg NPK/ha. The application of 5 t/ha of vermicompost yielded a greater gross monetary return of ₹91685.88/ha, comparable to compost.
- **Net Monetary Return:** At ₹68439.48/ha, the application of 100:80:60 kg NPK/ha yielded a notable net monetary return. Similarly, 5 t/ha of vermicompost yielded a greater net monetary return of ₹61417.92/ha, comparable to compost.

B:C Ratio: The B:C ratio was much greater (2.11) with the application of 100:80:60 kg NPK/ha compared to 80:60:40 kg NPK/ha. The B:C ratio was also greater (2.03) when compost was applied at 5 t/ha, comparable to vermicompost

Discussion

The findings of this experiment align with previous research demonstrating the positive impact of balanced nutrient management on mustard. The enhanced growth parameters (plant height, leaves, and branches) observed with higher nutrient levels and particularly with the combination of inorganic NPK and vermicompost can be attributed to increased nutrient availability and improved soil conditions. Optimal nutrient application promotes early root growth and cell multiplication, facilitating greater nutrient absorption and a higher crop growth rate.

The significant improvement in yield-contributing traits, such as the number of siliquae per plant, grains per siliqua, and test weight, under the 100:80:60 kg NPK/ha + 5 t/ha vermicompost treatment, is likely due to the beneficial effects of elevated growth parameters and efficient translocation of photosynthetic products. The sustained mineralization and availability of nutrients throughout the growth stages further contributed to these observed higher values.

Both individual and combined applications of inorganic and organic nutrient sources significantly influenced mustard grain yield. The highest grain yield achieved with 100:80:60 kg NPK/ha and vermicompost highlights the effectiveness of integrated nutrient management in optimizing production.

Economically, the application of 100:80:60 kg NPK/ha combined with 5 t/ha vermicompost proved to be the most financially rewarding approach. The higher net monetary returns and favorable B:C ratio are primarily attributed to the increased grain and straw yields under these higher nutrient concentrations, coupled with relatively lower additional costs compared to other treatments. These results are consistent with findings by other researchers (Arya *et al*., 2022; Choudhary and Rai, 2021) [3, 4].

Conclusion

The experiment demonstrated that applying 100:80:60 kg NPK/ha in conjunction with 5 t/ha of vermicompost significantly improved mustard's seed production, oil content, gross and net monetary returns, and B:C ratio. This integrated nutrient management strategy is recommended as a compensation plan to ensure optimal output and financial gain in mustard cultivation. However, as these results are based on a single-year trial, further validation through multi-year experiments is advisable.

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