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Response of integrated nutrient management on growth and yield of Indian mustard (*Brassica juncea* L.)

Deepa Singh, Ravikesh Kumar Pal, Naveen Kumar Maurya, Shivraj Gupta and Seema Patel

Abstract
A field experiment was conducted during Ravi of 2022- 2023 farm Rama University, Kanpur (U.P.) located in Indo-Gangetic plains of Central Uttar Pradesh to study the Response of Integrated Nutrient Management on growth and yield of Indian Mustard (*Brassica juncea* L.). The trial was laid down in randomized block design (RBD) with three replications and nine treatments *viz* T1 = RDF, T2 =75% RDF + FYM @ 5 t ha^{-1}, T3 =100% RDF + FYM @ 5 t ha^{-1}, T4 = 75% RDF + FYM @ 10 t ha^{-1}, T5 = 100% RDF + FYM @ 10 t ha^{-1}, T6 = 75% RDF + Vermicompost @ 2.5 t ha^{-1}, T7 = 100% RDF + Vermicompost @ 2.5 t ha^{-1}, T8 = 75% RDF + Vermicompost @ 5 t ha^{-1}, T9 = 100% RDF + Vermicompost @ 5 t ha^{-1},. Study results revealed that, there was significant statistical variation on growth and yield parameters. Maximum plant population, plant hight, number of branches, dry matter, leaf area index, number of siliques. seed yield, number of grains per silique and length of silique test weight higher harvest index in T_9 which was statistically at par with T_5 Maximum yield (23.37 q/ha) was recorded in T_9, which was statistically at par with treatment T_5 (22.77 q/ ha). It was evident that RDF with organic Manure is possible to produced more yield without much soil productivity.

Keywords: Integrated nutrient management, growth, yield, Indian mustard, *Brassica juncea* L.

Introduction
Indian mustard (*Brassica juncea* L.) is world's third most important source of edible oil after soybean and oil palm. Central Asia Himalayas are a primary center of diversity for Brassica *juncea*, with migration to China, India and the Caucasus (Hemingway, 1979) [19]. Estimate production rapeseed and mustard are 11.46 million tonnes during 2021-22 (Ministry of Agriculture & Farmer Welfare). Demand for vegetable oil is increasing due to increase in population and standard of living, increase industrialization and diversion of biofuels.
Mustard seeds are known by different names in different places eg. Sarson, Rai or Raya, Toria or Lahi. While sarson and toria (Lahi) are generally termed as rapeseed and rai or laha is termed as mustard. The oil content obtained from the different variety and species show variation in percentage of oil recovery. The oil content varies from 37-49%. The young plants are used as vegetables as they supply enough sulphur and minerals in the diet. The seed and oil are used as condiments in the preparation of pickles and for flavouring curries and vegetables. The oil is used as the main medium for cooking and frying purposes throughout Northern India. It is also used for preparation of hair oils, medicines, soaps and manufacture of lubricants and softening of leather. Oilseed cake is used for cattle feed and manure. Green stems and leaves of young plants are used as fodder for cattle Keerthi *et al.* (2017) [1].
The important rapeseed and mustard growing countries of the world are India, Canada, China, Pakistan, Bangladesh and Sweden. In India, its cultivation is mainly confined to Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, Assam, Bihar, Gujrat and West Bengal and its oil consumption is mainly in these states Singh *et al.* (2011) [2].
Nutrient management is one important agronomic practice to improve crop production. proper integration of organic manures with chemical fertilizers shows great promises in not only sustain the growth and productivity but also in meeting a part of chemical requirement of crop (Khan *et al*., 2019) [16]. Organic manures such as vermicompost and FYM are good source nutrients and organic matter, these sources enhance biodiversity and microbial property of soil (Albiach *et al*., 2000) [15]. Nitrogen is an important constituent of protein. Higher the nitrogen greater would be the protein and protoplasm which would increase, in turn greater cell size, leaf area index resulting into greater photosynthetic activity. Phosphorus fertilization improves growth of rapeseed and mustard crops.

Besides growth, phosphorus reduces the adverse effects of excess nitrogen fertilization. Farm yard manure (FYM) improves the soil physiochemical properties along with direct release of macro as well as micronutrient; ultimately the crop yields. (Singh *et al*., 2014) [17] vermicompost also improves soil aeration, reduction of soil erosion, reduces of evaporation losses of water, accelerates the process of humification, stimulates the microbial activity, destruction of pollutants in soil etc. Here the purpose of study was that up to which level and type of organic manure applying with RDF is maximize the production. Hence an experiment on "Response of Integrated Nutrient Management on growth and yield of Indian Mustard (*Brassica juncea* L.)" was conducted at research farm Rama University, Kanpur (U.P.) located in Indo-Gangetic plains of Central Uttar Pradesh *Rabi* 2022-23.

Material and Method

The field experiment was conducted at research farm Rama University, Kanpur (U.P.) located in Indo-Gangetic plains of Central Uttar Pradesh. The experiment was laid out into Randomized Block Design (RBD) with 3 replication and consisted 9 treatments *viz.* T_1 = RDF, T_2 = 75% RDF + FYM @ 5 t ha^{-1}, T_3 = 100% RDF + FYM @ 5 t ha^{-1}, T_4 = 75% RDF + FYM @ 10 t ha^{-1}, T_5 = 100% RDF + FYM @ 10 t ha^{-1}, T_6 75% RDF + Vermicompost @ 2.5 t ha^{-1}, T_7 100% RDF + Vermicompost @ 2.5 t ha^{-1}, T_8 75% RDF + Vermicompost @ 5 t ha^{-1} T_9 100% RDF + Vermicompost @ 5 t ha^{-1}. (As shown is table 1). The crop was raised at spacing of 45 cm x 15 cm and plot size of 5 x 4m. Standard culture practices recommended for musterd was followed uniformly in all experimental plots.

Table 1: Experimental layout and treatment details

S.N.	Treatment details	Symbols
1	RDF	T1
2	75% RDF + FYM @ 5 t ha^{-1}	T2
3	100% RDF + FYM @ 5 t ha^{-1}	T3
4	75% RDF + FYM @ 10 t ha^{-1}	T4
5	100% RDF + FYM @ 10 t ha^{-1}	T5
6	75% RDF + Vermicompost @ 2.5 t ha^{-1}	T6
7	100% RDF + Vermicompost @ 2.5 t ha^{-1}	T7
8	75% RDF + Vermicompost @ 5 t ha^{-1}	T8
9	100% RDF + Vermicompost @ 5 t ha^{-1}	T9

Biometric Observations

Plant population

The initial plant population per square meter was recorded after thinning (mustard) and final plant population per square meter was counted before harvesting or at maturity stage.

Plant height (cm)

The height of the mustard plant was measured from the base to the top of the plant at final harvesting, with the help of meter scale. The mean of plant height was worked out on the basis of total height of five randomly selected plants in each plot which was divided by the number of plants.

Number of branches per plant

Five plants from each plot were randomly selected and total numbers of primary and secondary branches were counted and mean of branches per plant were computed.

Plant dry matter accumulation (g/plant)

Five plants were randomly uprooted from observation row without damaging the root from each plot at harvest. The samples were air dried and then kept in oven for 24 hours at 700 C, their dry weight was determined and the average dry weight per plant was calculated.

Yield attributes

Number of siliquae/plants

The Number of siliquae from five randomly selected plants was counted and reported on average basis.

Length of siliqua (cm)

Length of 10 randomly selected siliqua from main shoot, primary and secondary branches were measured and average reported as length of siliqua in cm.

Number of seeds/siliquae

The seeds from five randomly selected siliquae per plant were separated, counted and reported on average basis.

Test weight (g)

1000 seeds were randomly selected, counted from sample and weight was recorded in grams.

Seed yield (q/ha)

From the individual plot net plot area was harvested air dried and produce was threshed and cleaned. The final weight was recorded in kg/plot and converted seed yield into q ha^{-1}.

Biological yield (q/ha)

After harvesting, each net plot biomass was bundled and weighted before threshing. The weight, thus recorded was converted into (q/ha), as biological yield

Stover yield (q/ha)

Stover yield of mustard is calculated with subtraction of seed yield from biological yield and reported in (q/ha).

Harvest Index

Harvest index was calculated with the help of formula as suggested by Singh and Stockopf (1971) [18].

$$Harvest\ Index = Economic\ Yield\ (kg/ha)/Biological\ Yiel\ (kg/ha) \times 10$$

Biometrical Analysis

Experimental data was subjected to biometrical analysis as per the standard as procedure given by Gomez and Gomez (1984) [20].

Results and Discussion

Growth parameters

Plant population (plants m^{-2})

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded maximum plant population 30.12 and 19.80 at initial and harvest stage followed by 29.70 and 19.71 in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and lowest population 24.42 and 16.41 was observed in the T_1 (control) treatment. This reason might be due to the application of FYM and VC with RDF in this treatment because these manures supply most nutrient in available form such as nitrates, phosphates, soluble potassium and necessary plant growth substances. Similar result was also given by Sandhu (2015) [4] and Satyajeet. and Nanwal (2007) [5].

Plant height (cm)

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded maximum plant height 150.15 cm at the harvest stage followed by 149.46cm in in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and lowest height 142.47 cm was observed in control treatment. The results were supported by the finding Keerthi *et al.* (2017) [1]

Number of primary and secondary branches $plant^{-1}$

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded maximum primary branches $plant^{-1}$ 22.62 and secondary branches $plant^{-1}$ 28.17 at harvest stage followed by 17.92 and 27.69 in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and lowest 14.22 and 16.65 primary and secondary branches $plant^{-1}$ was observed in control treatment. The results supported by finding of Kumar *et al.* (2017) [6].

Leaf area index

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded maximum Leaf area index of 3.00 at 90 DAS followed by 2.294 in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and lowest Leaf area index 2.65 was observed in control treatment. Similar result was also given by Nath *et al*. (2018) [8].

Fresh weight (g/plant)

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded maximum Fresh weight (g/plant) 83.43 at 110 DAS followed by (81.75 g) in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Fresh weight (60.24 g) was observed in control treatment. Similar result was also given by Nath *et al*. (2018) [8].

Dry weight (g/plant)

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest Dry weight (21.36 g) 110 DAS followed by (20.37 g) in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and lowest Dry weight (g/plant) 14.55 g was observed in control treatment. Similar results was also given by Singh *et al.* (2005) [9] and Singh *et al.* (2009) [10].

Table 2: Response of Integrated Nutrient Management on growth parameters of Indian Mustard

Treatment	Initial plant population m^{-2}	Final plant population m^{-2}	Plant height(cm)	No. of primary branches/plant	No. of secondary branches/plant	LAI	Fresh weight (g/plant)	Dry weight (g/plant)
T1	24.42	16.41	142.47	14.22	16.65	2.65	60.24	14.55
T2	25.14	16.65	143.52	15.66	15.66	2.70	63.39	15.33
T3	28.41	18.33	147.93	20.46	25.47	2.85	78.36	19.86
T4	28.11	17.37	146.55	18.27	21.75	2.76	72.63	17.62
T5	29.70	19.71	149.46	21.36	27.69	2.94	81.75	20.37
T6	26.22	17.61	145.47	16.62	18.93	2.73	67.74	16.53
T7	29.40	18.63	148.71	20.82	26.67	2.91	80.46	20.13
T8	27.63	18.12	147.63	19.65	23.46	2.82	76.53	18.36
T9	30.12	19.80	150.15	22.62	28.17	3.00	83.43	21.36
SEm)±	0.72	0.46	1.27	0.48	0.58	0.07	1.91	0.47
CD at5%	2.17	1.41	3.84	1.47	1.67	0.22	5.79	1.42

Table 3: Response of Integrated Nutrient Management on yield parameters of Indian Mustard

Treatment.	Days to 50% flowering	No. of Silique $plant^{-1}$	No. of Seed $silique^{-1}$	Length of silique (cm)	Test weight (g)	Biological yield q ha^{-1}	Stover yield q ha^{-1}	Grain yield q ha^{-1}	Harvest index (%)	Oil yield q ha^{-1}
T1	52.00	281.22	12.96	5.37	4.50	74.44	55.48	18.96	25.47	7.11
T2	44.10	284.43	12.33	5.53	4.71	73.77	54.25	19.52	26.46	7.50
T3	50.88	296.33	16.65	6.63	5.55	75.73	53.44	22.29	29.43	8.83
T4	44.16	289.53	14.67	5.86	5.22	75.02	54.29	20.73	27.63	8.09
T5	51.45	298.41	17.46	6.93	5.92	74.33	51.56	22.77	30.63	9.16
T6	44.62	288.63	13.71	5.73	5.13	72.19	52.46	19.73	27.33	7.62
T7	49.44	297.62	17.25	6.66	5.76	75.80	53.24	22.56	29.76	9.03
T8	49.82	295.36	15.66	6.12	5.37	75.84	54.18	21.66	28.56	8.51
T9	42.53	306.33	18.12	7.11	6.12	74.26	50.89	23.37	31.47	9.42
SEm)±	1.23	2.04	0.39	0.16	0.13	1.96	1.40	0.55	0.47	0.21
CD at 5%	3.73	4.52	1.20	0.48	0.41	5.71	4.23	1.67	2.23	0.65

Yield attributes

Days to 50% flowering

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded minimum Days to 50% flowering 42.53 which was statistically at par with other treatment and maximum Days to 50% flowering 52.00 was observed in control treatment. Similar result was also given by Nath *et al*. (2018) [8]. Gill *et al*. (2021) [7]

Number silique $plant^{-1}$

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest Number silique $plant^{-1}$ 306.33 at the time of harvesting followed by (298.41) in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and lowest Number silique $plant^{-1}$ 281.22 was observed in control treatment Similar result was also given by Nath *et al*. (2018) [8].

Number of Seed silique^{-1}

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest Number of Seed silique^{-1} 18.12 at the time of harvesting followed by (17.46) in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Number of Seed silique^{-1} 12.96 was observed in control treatment. Similar result was also given by Nath *et al*. (2018) [8].

Length of silique (cm)

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest maximum Length of silique 7.11cm at the time of harvesting followed by (6.93) in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Length of silique 5.37cm was observed in control treatment**.** Similar result was also given by Thaneshwar (2017) [11]

Test weight (g)

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest maximum Test weight 6.12 g after the harvesting of crop followed by (5.92g) in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Test weight 4.50 g was observed in control treatment. Similar result was also given by Nath *et al*. (2018) [8].

Biological yield (q/ha)

Among the all treatment T_8 (75% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest maximum biological yield 75.84 q ha^{-1} after the harvesting of crop followed by74.80 q ha^{-1} in T_6 (100% RDF + Vermicompost @ 2.5 t ha^{-1}) which was statistically at par with other treatment and minimum biological yield 72.19 q ha^{-1} was observed in 75% RDF + Vermicompost @ 2.5 t ha^{-1} treatment. Similar result was also given by Nath *et al*. (2018) [8], Solanki *et al*. (2015) [12]

Stover yield q ha^{-1}

Among the all treatment T_1 (RDF) recorded highest maximum Stover yield 55.48 q ha^{-1} after the harvesting of crop followed by in 51.56 q ha^{-1} in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Stover yield q ha^{-1} 72.19 q ha^{-1} was observed in 100% RDF + Vermicompost @ 5 t ha^{-1} treatment. Similar result was also given by Singh *et al.* (2011) [2]

Grain yield q ha^{-1}

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest maximum Grain yield 23.37 q ha^{-1} after harvesting of crop followed by 22.77 q ha^{-1} in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Grain yield 18.96 q ha^{-1} was observed in control treatment. Similar result was also given by Tripathi *et al.* (2010) [13] and Thaneshwar (2017) [11]

Harvest index (%)

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest Harvest index 31.47 after the harvesting of crop followed by 30.63 in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Harvest index 25.47 was observed in control treatment. Similar result was also given by Hassan and Malhi (2011) Tripathi *et al.* (2010) [13].

Oil yield q ha^{-1}

Among the all treatment T_9 (100% RDF + Vermicompost @ 5 t ha^{-1}) recorded highest Oil yield 9.42 q ha^{-1} in grain after the harvesting of crop followed by 9.16 in T_5 (100% RDF + FYM @ 10 t ha^{-1}.) which was statistically at par with other treatment and minimum Oil yield 7.11 q ha^{-1} in grain was found in control treatment. Similar result was also given by Gill *et al*. (2021) [7] and Nath *et al*. (2018) [8].

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