Original Research Article

Optimization of chemical fertilizer through Integrated Nutrient Management (INM) approach and its effect on growth and yield of Mustard (*Brassica juncea* L.)

Abstract:

A field experiment to test the optimization of chemical fertilizer use through Integrated Nutrient Management (INM) approach and its effect on growth and yield of Mustard (Brassica*juncea* L.) was carried out at Rampur agricultural field of Doon (P.G) College of Agriculture Science and Technology, Selaqui, Dehradun, Uttarakhand during the rabi season 2021-2022. The experiment comprised of ninetreatmentsof organic and inorganic nutrient combination, laid out in randomized block design with three replications. The results of experiment revealed that with the application of 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + Vermicompost (1 t/ha) + Green Manure (1 t/ha) + Gypsum (10 kg/ha) (T_9), there was anincrease in growth of the plant, followed by T_8: 75% R.D.F (60:45:30 kg/ha) + Vermicompost (1.5t/ha) + Green Manure (1.5 t/ha), 50% R.D.F (40:30:20 kg/ha) + F.Y.M (5t/ha) + Green Manure (2.5 t/ha) + Gypsum (10 kg/ha) (T_5). Moreover, maximum (2240.39 kg/ha) seed yieldwas observed under T_9over control, where no fertilizer application was applied.The present investigation established the fact that integrated use both organic and inorganic fertilizer can be recommended to the farmers as one of the key strategies for enhancing crop response in terms of growth and yield.

Keywords*:* Integrated nutrient management, oil seeds, organic manures, inorganic nutrients

Introduction:

Mustard (*Brassica juncea* (L.)) is considered to be one of the most valuable oilseed crops. It belongs to*Brassicaceae* (*Cruciferae*) family, with around 338 genera and 3709 species scattered worldwide. Mustard seeds are known by several names in different parts of the world, such as sarson, rai or raya, toria or lahi. While sarson and toria (lahi) are commonly referred to as rapeseed, rai, raya, or laha. Afghanistan and neighbouring countries (Central Asia) were the principal sites of origin, whereas central and western China, eastern India, and Asia were subsidiary centres of origin for Brassica**(Vavilov, 1949).**

China is the first largest producer of rapeseed mustard followed by Canada. India is the third largest producer of rapeseed-mustard and contributes to around 11% of the world's total production **(Bareliya, 2023)**. Mustard production has raised by 40% from 91.24 to 128.18 lakh tonnes during last 3 years. The productivity saw 11% increase from 1331 to 1447 kg/ha. The area under rapeseed and mustard enhanced by 29% from 68.56 lakh ha in 2019-20 to 88.58 lakh ha in 2022-23. Timely action by central and state government made this remarkable achievement possible**(PIB, 2023)**

In India, mustard is grown in Rajasthan, Madhya Pradesh, Uttar Pradesh, Uttarakhand, Haryana, Gujarat, Andra Pradesh, Karnataka, and Tamil Nadu. Yellow sarson is grown as a rabi crop in Assam, Bihar, Orissa, and West Bengal, but as a catch crop in Punjab, Haryana, Uttar Pradesh, and Himachal Pradesh. Previously, brown sarson was planted in the majority of the areas; however, its area under cultivation is decreasing and being replaced by Indian mustard.

India is a major importer of edible oils since domestic supply cannot fulfil domestic demand. Imports supply around 56-60% of the edible oils consumed in the nation. Madhya Pradesh comes out on top in total oilseeds output (31%), followed by Rajasthan and Gujarat. The mustard crop is widely grown in northern India. Rajasthan has 46.06 percent mustard farming, followed by Haryana (12.60 percent), Madhya Pradesh (11.38 percent), Uttar Pradesh (10.49 percent), and West Bengal (7.81 percent) **(APEDA,2020).**

Mustard is high in nutrients and its oil content ranges from 25 to 49 percent. Mustard greens are high in Vitamin A, Vitamin B6, Vitamin C, Vitamin E, and beta-carotene. It is mostly composed of folate, oleic, erucic, and linoleic fatty acids.

Consistent application of fertilizers and other chemicals adversely affects soil health in terms of sustainability and productivity. Rapeseed and mustard, being demanding crops that require significant energy, necessitate careful fertilizer management for optimal growth **(Sharma, 1986)**Inadequate fertilization, specifically sub-optimal doses, leads to reduced yields in farmers' fields. Given the development of new Indian mustard varieties, it is crucial to assess their growth characteristics and harness their production potential across varying fertilizer levels. This is essential for enhancing oil quality and overall production.By combining inorganic fertilizers with organic manures and bio-fertilizers, the crop productivity can be sustained as well as soil health can be improved, andnutrient-use efficiency can be accelerated, as emphasized by **(Kakraliya et al., 2017).**

For the growth and development of plants, nitrogen (N) is a critical metabolic component. A strong root system can only develop when phosphorus (P) is present. Potassium (K) significantly raises grain and stover yield. The fundamental elements of plant life also require other nutrients.The core strategy for optimizing nutrient supply to plants and preserving soil nutrient stocks, thereby enhancing soil health and crop production, lies in the integrated nutrient management approach. This approach is based on the premise that chemical fertilizers can be efficiently delivered to plants while simultaneously improving the biological environment of the soil. Different research findings revealed that adoption of integrated nutrient management practices, reduced emissions of greenhouse gases and reactive nitrogen losses are decreased. Lower inputs of fertilizers (chemical), lower environmental as well as human costs were achieved because of INM methods **(Tafreen*et***

***al*., 2023).**Keeping in view the above facts, the investigation was carried out to see the effect of integrated Nutrient Management (INM) on growth and yield of Mustard (*Brassica juncea* L.)

Materials and methods: -

The field experiment was conducted during rabi season 2021-2022 at Rampur experimental farm, Department of Agronomy, Doon (P.G) College of Agriculture Science and Technology, Dehradun, Uttarakhand. The experimental site is situated at a Latitude 30.369117^{o} and Longitude 77.839441^{o} withminimum and maximum temperatures ranging from 8.1 ^{0}C to 24.9 ^{0}C (at sowing) and 14.4 ^{0}C to 34.7 ^{0}C, (at harvest) respectively. The mean relative humidity ranged from 50.8 percent (evening) to 95.5 percent (morning). Before the initiation of the experiment, the composite soil sample was collected at a depth of 0-15 cm for analysis of Physico-chemical parameters of soil. The details of soil properties arepresented in **table no 1**.

Table 1: Soil physico-chemical properties of the experimental site:

Physical properties:

Properties	**Values**	**Method employed**
Sand (%)	58.69	Bouycos Hydrometer method (Black, 1965)
Silt (%)	27.76	
Clay (%)	13.55	
Texture class	Sandy-loam	USDA Textural Triangle
Soil pH (1:2.5)	7.59	Glass electrode digital meter. (Jackson 1973)
Electrical conductivity (dS m^{-1}) at 25^{o}C (1:2.5)	0.39	EC meter(Bower and Wilcox 1965)
Organic carbon (%)	0.38	Walkley and Black's rapid titration method (1965)
Available Nitrogen (kg/ha)	228.6	Alkaline permanganate method (Subbiah and Asija, 1956)
Available Phosphorus(kg P_2O_5/ha)	36.34	Olsen's extraction method **(Olsen *et al.*, 1954)**
Available Potassium (kg K_2O /ha)	192.0	Neutral 1 N NH_4OAc extraction method **(Hanway and Hiedel, 1952)**

The soil of experimental field was sandy loam in texture having a pH of 7.59, EC 0.39dSm^{-1} and having a low soil organic carbon (0.38%).The experimental soil contained228.6, 36.34, 192.0

and 15.64 kg ha^{-1} of N,P, K and S, respectively. The experiment was conducted in randomized block design (RBD) having three replications. The mustard cultivar used during this study was DRMR 1165-40. It was sown under different doses of nutrient or fertilizer regime viz. T_1- Control (No Fertilizer), T_2- Recommended Dose of Fertilizer (80:60:40 kg/ha), T_3- 100 % vermicompost (6.0 t/ha), T_4- 75% F.Y.M (15.0 t/ha) + 25% R.D.F (20:15:10 kg/ha), T_5- 50% R.D.F (40:30:20 kg/ha) + F.Y.M (5.0 t/ha) + green manure (2.5 t/ha) + gypsum (10.0 kg/ha), T_6-50% R.D.F (40:30:20 kg/ha) + vermicompost (3.0 t/ha)+ gypsum (5.0 kg/ha), T_7- 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5t/ha), T_8- 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5t/ha) + green manure (1.5t/ha), T_9- 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1 t/ha) + gypsum (10.0 kg/ha).The observations were recorded from five randomly selected plants from each plot in each replication.

Statistical analysis:

All data related to pre- and post-harvest study of the crop were collected and statistically analyzed by using the analysis of variance technique (ANOVA) (Fisher, 1958). Data so computed was subjected to Fisher's analysis of variance for judging the effect of various treatments. The statistical analysis was carried out by OPSTAT-HAU and STPR3.

Results and Discussion

Growth parameters

Plant Height (cm):

Data pertaining to plant height of mustard at 25, 45, 75, 100 DAS is depicted in table 2 It was be observed that different nutrient combinations showed significant effect on plant height at 25 DAS. However , maximum (14.69 cm) plant height at 25 DAS was observed under T_9 (75% R.D.F (60:45:30 kg/ha) + F.Y.M @1.5 t/ha + vermicompost @1 t/ha + G.M @1 t/ha + Gypsum @10 kg/ha) followed by T_8(75% R.D.F (60:45:30 kg/ha) + vermicompost @1.5 t/ha + G.M @1.5 t/ha) and T_7(75% R.D.F (60:45:30 kg/ha) + vermicompost @ 2.5 t/ha), respectively.

Further maximum plant height (22.96, 110.59 and 158.63 cm) was reported under treatment T_9, and lowest plant height was observed at T_4(75% F.Y.M (15t/ha) +25% R.D.F(20:15:10 kg/ha)) and ultimate lowest (15.23, 86.95 and 112.41)cm was reported under treatment T_1(Control) at 45, 75 and 100 DAS, respectively.

The combination use of chemical fertilizers and organic manure, which met the crop's immediate nutrient needs and improved soil conditions, may have contributed to the observed positive outcomes, similar findings were reported by **Tripathi *et al.* (2010).**This could be attributed

to the use of organic fertilizers containing Bio-NPK, which resulted in increased photosynthetic activity, chlorophyll formation, nutrient metabolism, and hormonal content in the plants. This, in turn, elevated metabolic activity by supplying essential macro and micronutirents. Similar outcomes were observed in studies conducted by **Jethava*et al*. 2023, Kumar *et al.* 2017, Parmar *et al*. 2019, and Singh *et al*. 2015 and Kumar *et al.* 2021**and **Waskel*et al*. 2019**.

Table 2: Plant height (cm) and Number of Leavesof mustard as influenced by different uses of fertilizer

Treatments		**Plant height (cm)**				**Number of Leaves**			
		25 DAS	**45DAS**	**75DAS**	**100 DAS**	**25 DAS**	**45DAS**	**75DAS**	**100 DAS**
T_1	Control (No Fertilizer)	8.82	15.23	86.95	112.41	4.48	5.96	14.50	8.27
T_2	Recommended Dose of Fertilizer (80:60:40 kg/ha)	11.76	19.89	109.81	122.73	5.47	7.03	19.31	10.73
T_3	100 % vermicompost (6.0 t/ha)	12.36	20.69	97.00	129.53	5.17	6.15	19.84	11.50
T_4	75% F.Y.M (15.0 t/ha) +25% R.D.F(20:15:10 kg/ha)	9.56	16.56	101.75	127.04	4.68	7.03	19.01	11.93
T_5	50% R.D.F (40:30:20 kg/ha) + F.Y.M (5.0 t/ha) + green manure (2.5 t/ha) + gypsum (10.0 kg/ha)	11.09	21.69	95.67	141.98	5.27	7.23	19.84	12.87
T_6	50% R.D.F(40:30:20 kg/ha) + vermicompost(3t/ha)+ gypsum (5 kg/ha)	10.76	18.49	96.78	138.58	5.76	6.93	19.46	11.47
T_7	75% R.D.F (60:45:30 kg/ha) + vermicompost(2.5t/ha)	13.69	21.16	88.38	129.57	5.17	6.64	18.26	12.87
T_8	75% R.D.F (60:45:30 kg/ha) + vermicompost(1.5t/ha) + green manure(1.5	13.76	21.76	97.66	141.43	5.27	7.42	19.08	12.07

	t/ha)								
T_9	75% R.D.F (60:45:30 kg/ha) +F.Y.M (1.5t/ha) + vermicompost(1.0 t/ha) + green manure(1.0 t/ha)+ gypsum (10.0 kg/ha)	14.69	22.96	110.59	158.63	5.86	7.62	21.11	16.60
Sem ±		**0.67**	**1.35**	**5.01**	**7.76**	**0.26**	**0.32**	**1.11**	**0.48**
CD at 5%		**2.00**	**4.05**	**15.02**	**23.25**	**0.78**	**0.96**	**3.33**	**1.45**

Number of Leaves per Plant:

Table 2 contains data regarding the number of mustard plant leaves observed at 25, 45, 75, and 100 DAS. At 25 DAS, plant leaves varying in size from 4.48 cm to 5.86 cm were seen to be significantly affected by a variety of treatments. However, maximum (5.86 cm) plant leaf at 25 DAS was observed under T_9, where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1 t/ha) + gypsum (10 kg/ha) followed by T_2i.e., R.D.F (80:60:40 kg/ha), T_3 i.e., 100 % Vermicompost (6 t/ha), T_5 i.e., 50% R.D.F (40:30:20 kg/ha) + F.Y.M (5t/ha) + Green Manure (2.5 t/ha) + Gypsum (10.0 kg/ha), T_6 i.e., 50% R.D.F (40:30:20 kg/ha) + vermicompost (3.0 t/ha)+ gypsum (5.0 kg/ha), T_8i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T_7 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5 t/ha) respectively and these treatments were found to be significantly at par with T_9 i.e., 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) . However, very less number of plant leaves was observed at T_3 and lowest in T_1 (Control) where no fertilizer application was done.

Further maximum plant leaves (7.62, 21.11 and 16.60) cm was reported under treatment T_9, and lowest plant leaves at T_3, $T_7$and T_2 and ultimate lowest (5.96, 14.50 and 8.27) cm was reported under treatment T_1 at 45, 75 and 100 DAS, respectively.

Application of N directly influences the vegetative growth of the plant. FYM improves the soil's physio-chemical condition, creating a favourable environment which promotes the absorption of nutrients and boosts macro as well as micronutrients uptake which eventually enhances the overall growth of the plants. Similar results were found by Jeet *et al.* (2012) who reported that increasing nitrogen availability in the soil through the use of FYM improved the number of leaves per plant in rapeseed.

Number of branches per plant:

Data pertaining to number of branches per plant were recorded at 45, 75 and 100 DAS and presented in Table. 3.. It can be observed that various treatments showed significant effect on number of plant branches at 45 DAS varied from 1.80 to 3.60. However , maximum (3.60) plant branches at 45 DAS was observed under T_9 , where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) followed by T_8 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T_7 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5 t/ha) respectively and these treatments were found to be significantly at par with T_9 i.e., 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) . However, the lowest plant height was observed at T_2 and ultimate lowest in T_1 (Control) where no fertilizer application was done.

Further maximum number of plant branches (7.53 and 7.73) were reported under treatment T_9, where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) and lowest plant branches at T_4, T_2 and ultimate lowest (3.79 and 3.89) was reported under treatment T_1 (Control) at 75 and 100 DAS, respectively.

The combination use of chemical fertilizers and organic manure, which met the crop's immediate nutrient needs and improved soil conditions, may have contributed to the observed positive outcomes.A similar result was given by **Kalita *et al.* (2019).** Improving soil fertility using Inorganic and organic fertilizer may have contributed to the enhanced plant growth seen in the present study.

Table 3.: Number of branches and Dry matter accumulation plant^{-1}of mustard as influenced by different uses of fertilizer.

Treatments		Number of branches			Dry matter accumulation			
		45DAS	75DAS	100DAS	25DAS	45DAS	75DAS	100DAS
T_1	Control (No Fertilizer)	1.80	3.79	3.89	1.38	13.85	35.59	64.64
T_2	Recommended Dose of Fertilizer (80:60:40 kg/ha)	2.40	5.36	5.39	1.58	14.80	38.10	69.01
T_3	100 % vermicompost (6.0 t/ha)	2.50	6.06	6.66	1.72	14.85	38.28	68.65
T_4	75% F.Y.M (15 t/ha) + 25% R.D.F (20:15:10 kg/ha)	2.60	4.99	5.46	1.75	14.90	37.99	67.58
T_5	50% R.D.F (40:30:20 kg/ha) + F.Y.M (5.0 t/ha)	3.20	6.59	6.79	1.78	17.55	41.44	82.24

	+ green manure (2.5 t/ha) + gypsum (10.0 kg/ha)							
T_6	50% R.D.F (40:30:20 kg/ha) + vermicompost(3.0 t/ha)+ gypsum (5.0 kg/ha)	3.00	6.39	6.79	1.77	16.25	39.39	74.09
T_7	75% R.D.F (60:45:30 kg/ha) + vermicompost(2.5t/ha)	3.07	6.33	6.79	1.58	16.45	42.51	75.16
T_8	75% R.D.F (60:45:30 kg/ha) + vermicompost(2.5t/ha) + green manure (2.5 t/ha)	3.13	6.39	6.79	1.92	17.15	43.63	82.36
T_9	75% R.D.F (60:45:30 kg/ha) + F.Y.M (2.5 t/ha) + vermicompost(2.0 t/ha) + green manure (2.0 t/ha) + gypsum (10.0 kg/ha)	3.60	7.53	7.73	2.23	17.90	43.64	85.20
Sem ±		**0.20**	**0.31**	**0.31**	**0.13**	**0.81**	**1.75**	**3.45**
CD at 5%		**0.60**	**0.94**	**0.92**	**0.38**	**2.42**	**5.25**	**10.33**

Dry matter accumulation per plant(gm):

Dry matter accumulation per plant(gm) of mustard is influenced by different uses of fertilizer. It can be observed that various treatments showed significant effect on plant dry matter weight at 25 DAS, varied from 1.38 to 2.23 gm. However, maximum (2.23 gm) dry weight at 25 DAS was observed under T_9,where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha). However less dry matter accumulation was observed at T_2 and lowest was observed in T_1 (Control) where no fertilizer application was done.

Plant dry matter at 45 DAS varied from 13.85 to 17.90 gm during the study. However, maximum (17.90 gm) plant dry matter at 45 DAS was observed under T_9 , followed by T_5 ,$T_6$and T_7 respectively and these treatments were found to be significantly at par with T_9 i.e., 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum

(10.0 kg/ha) . However, very less plant dry matter was found under T_2treatment and ultimate lowest observed in T_1 (Control) where no fertilizer applied.

Further maximum amount plant dry matter (43.64 and 85.20) was reported under treatment T_9, and lowest plant dry mater observed at T_4 and least (35.59 and 64.64) was reported under treatment T_1 at 75 and 100 DAS, respectively.

When organic manures are combined with inorganic fertilisers and incorporated into soil, they boost root growth, thereby increasing the total surface area of the roots that can absorb water. Taller plants have more possibilities to make and store photosynthates, therefore they produce more dry matter, which leads to increased dry weight. It was also discovered that the use of chemical fertilisers in conjunction with FYM, Zn and seed treatment had a good effect on the height and dry matter content of mustard plants **(Singh and Pal, 2011 and Tripathi *et al.* 2010).**

B. Yield contributing characters:

Number of siliquaper plant:

Table 4 contains information on the number of mustard siliquaper plants at 75 and 100 DAS. It can be observed that various treatments showed significant effect on number of siliquaper plantat 75 DAS varied from 17.40 to 26.30. However, maximum (26.30) number of siliqua per plantat 75 DAS was observed under T_9, where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) followed by T_8 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T_5 i.e., 50% R.D.F (40:30:20 kg/ha) + F.Y.M (5.0 t/ha) + green manure (2.5 t/ha) + Gypsum (10.0 kg/ha) respectively and these treatments were found to be significantly at par with T_9 i.e., 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) . However, the lowest number of siliquaper plant was observed at T_3 and ultimate lowest in T_1 (Control) where no fertilizer application was done.

Further maximum number of siliquaper plant (107.78) was reported under treatment T_9, and lowest plant (46.88) was reported at T_3 and ultimate lowest under treatment T_1 at 100 DAS, respectively followed by T_8.

FYM application with chemical fertilisers and organic fertilizer improved mustard's growth characteristics, yield components, and final yield. All improved as a result of enhanced delivery of key nutrients. These results are in line with what was observed by **(Tripathi *et al*. 2010).**

Table 4:Number of siliqua plant^{-1},Seed siliqua^{-1}, Siliqua length, Test weight of mustard as influenced by different uses of fertilizer

Treatments		Number of siliqua plant^{-1}		Siliqua Length(cm)	No of seed siliqua^{-1}	Test weight (gm)
		75 DAS	100 DAS			
T_1	Control (No Fertilizer)	17.40	46.88	5.34	10.16	4.00
T_2	Recommended Dose of Fertilizer (80:60:40 kg/ha)	19.57	85.28	6.41	10.66	4.20
T_3	100 % Vermicompost (6 t/ha)	18.40	78.81	6.48	11.99	4.30
T_4	75% F.Y.M (15 t/ha) + 25% R.D.F (20:15:10 kg/ha)	19.20	79.28	5.84	11.99	4.46
T_5	50% R.D.F (40:30:20 kg/ha) + F.Y.M (5t/ha) + Green Manure (2.5 t/ha) + Gypsum (10 kg/ha)	22.40	93.31	5.97	14.32	5.46
T_6	50% R.D.F (40:30:20 kg/ha) + vermicompost (3 t/ha)+ Gypsum (5 kg/ha)	19.10	80.65	5.81	11.66	4.70
T_7	75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5t/ha)	21.33	82.81	5.81	13.66	5.00
T_8	75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5t/ha) + G.M (1.5 t/ha)	23.47	97.81	5.78	14.32	5.30
T_9	75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1 t/ha) + G.M (1 t/ha) + Gypsum (10 kg/ha)	26.30	107.78	6.59	14.99	5.86
Sem ±		**1.33**	**4.81**	**0.25**	**0.59**	**0.25**
CD at 5%		**3.98**	**14.42**	**0.75**	**1.77**	**0.74**

Length of siliqua:

Data recorded for length of siliqua of mustard is shown in table 4. It can be observed that various treatments showed significant effect of length of siliqua varied from 5.81 to 6.59. However, maximum (6.59) length of siliqua was observed under T_9 followed by T_3, and T_2. However, the lengthof siliqua was very low observed in T_4 and lowest in T_1 (Control) where no fertilizer

application was done.Nitrogen and phosphorus fertilizers increased glucose, protein, and reproductive organ accumulation, which boosted mustard yield. Organic fertilizers supplemented mustard higher nitrogen and phosphorus needs and gave a physiological benefit by creating phytohormones that improved yield.

Number of seed per siliqua:

Table 4 contains information on the number of mustard seed per siliqua. It can be observed that various treatments showed significant effect on number of seedper siliquaat harvest varied from 10.16 to 14.99. However, maximum (14.99) number of seedper siliquaat harvest was observed under T_9, where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) followed by T_7 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5 t/ha), T_8 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T_5 i.e., 50% R.D.F (40:30:20 kg/ha) + F.Y.M (5.0 t/ha) + green manure (2.5 t/ha) + gypsum (10.0 kg/ha) respectively and these treatments were found to be significantly at par with T_9 i.e., 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) . However, very less number of seedper siliqua was observed in T_2 and ultimate lowest in T_1 (Control) where no fertilizer was used.

The quantity of seeds per siliqua increased can be attributed to the fact that the treatments improved cell division and tissue development. Increased seeds per siliqua also increased due to higher growth and more photosynthesis as a result of enough nutrients in the crop. Similar findings were reported by **Mandal and Sinha (2002).**

Test weight (1000 seed weight):

Data recorded for test weight (1000 seed weight)of mustard at harvest in table 4. It can be observed that various treatments showed significant effect on test weight (1000 seed weight) varied from 4.00 to 5.86gm. However, maximum (5.86 gm) test weight was observed under T_9 , where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (2.5 t/ha) + vermicompost (2.0 t/ha) + green manure (2.0 t/ha) + gypsum (10.0 kg/ha) followed by T_8 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure(1.5 t/ha) and T_5 i.e., 50% R.D.F (40:30:20 kg/ha) + vermicompost (3.0 t/ha) + gypsum (5.0 kg/ha) respectively and these treatments were found to be significantly at par with T_9 . However, very less test weight was observed at T_2 and ultimate lowest in T_1 (Control) where no fertilizer application was done. The findings were in close proximity with the investigation of **Parmar *et al*. 2019** and **Singh *et al*. 2015**

Yield

Seed yield (kg/ha):

Data recorded for seed yield (kg/ha)of mustard at harvestis there in table 4. It can be observed that various treatments showed significant effect on seed yield (kg/ha)varied from 822.05 to 2240.39 kg/ha. However, maximum (2240.39 kg/ha) seed yieldwas observed under T_9, where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha). However, the lowest seed yieldwas observed at T_1 (Control) then followed by T_2.

The highest seed production was attained as a result of the combined effects of FYM, chemical fertilisers, and organic fertilisers. Over time, more effective uptake takes place and there is less nitrogen loss since FYM releases its nutrients gradually.Plant height, primary and secondary branches, siliqua quantity, siliqua length, seeds per siliqua, and seed weight were among the growth and yield characteristics that improved with improved nutrient utilisation. Similar trends in results were reported by the investigation of **Chauhan *et al.* 1995; Mukherjee *et al*.2020** and **Thaneshwar*et al.* 2017.**

Table 5: Seed yield, Stover yield (kg/ha)of mustard as influenced by different uses of fertilizer

Treatments		Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest Index (%)
T_1	Control (No Fertilizer)	822.05	3534.62	18.88
T_2	Recommended Dose of Fertilizer (80:60:40 kg/ha)	1546.38	4331.59	26.36
T_3	100 % Vermicompost (6.0 t/ha)	1650.72	4035.23	29.03
T_4	75% F.Y.M (15.0 t/ha) + 25% R.D.F (20:15:10 kg/ha)	1634.72	3973.57	29.08
T_5	50% R.D.F (40:30:20 kg/ha) + F.Y.M (5.0 t/ha) + green manure (2.5 t/ha) + gypsum (10.0 kg/ha)	1820.72	4230.93	30.14
T_6	50% R.D.F (40:30:20 kg/ha) + vermicompost(3.0 t/ha) + gypsum (5.0 kg/ha)	1738.38	4236.76	28.96
T_7	75% R.D.F (60:45:30 kg/ha) + vermicompost(2.5t/ha)	1809.72	4483.11	28.68
T_8	75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5t/ha) + green manure (1.5 t/ha)	1891.05	4635.05	28.90
T_9	75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10 kg/ha)	2240.39	4899.78	31.49
Sem ±		**110.84**	**199.45**	**1.42**

CD at 5%	**332.30**	**597.96**	**NS**

Stover yield (kg/ha):

Data was recorded for stover yield (kg/ha)of mustard at harvestpresented in table.4. It could be observed that various treatments showed significant effect on stover yield (kg/ha)and range varied from 3534.62 to 4899.78 kg/ha. However, maximum (4899.78 kg/ha) stover yieldwas observed under T_9 , where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + Gypsum (10 kg/ha) followed by T_7 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5 t/ha), T_8 i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + G.M (1.5 t/ha) and T_2 i.e., recommended Dose of Fertilizer (80:60:40 kg/ha) respectively and these treatments were found to be significantly at par with T_9 . However, the low stover yieldwas observed at T_4 and lowest in T_1 (Control) where no fertilizer application was done.This could be attributed to an augmented provision of essential plant nutrients, particularly nitrogen, which accelerates both the growth and reproductive phases. Additionally, the increased nutrient supply facilitates protein synthesis, ultimately promoting the yield of mustard.

Higher fertility enhanced plant height, leaf area and dry matter per plant, which boosted stover output and it was in accordance with **Singh and Pal (2011).** When nitrogen was increased by fertilizer N alone or in conjunction with organic fertilizers, yield characteristics and yield increased more than growth parameters. Which eventually lead to higher stover yield. Similar findings were done by **Das, *et al*.(2002), and Saha *et al.* (2010) .**

Harvest Index (%):

Data of harvest index (%) was recordedat the time ofharvest in table 4. It was observed that various treatments showedsignificant effect on harvest index (%)varied from 18.88% to 31.49 %. However, maximum (31.49%) harvest indexwas observed under T_9, where 75% R.D.F (60:45:30 kg/ha) along with F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + Gypsum (10 kg/ha)followed by T_5. Very low harvest indexwas observed in T_2 and lowest was T_1 (Control) where no fertilizer application was done.

Conclusion:

In every experiment treatment 9^{th} showed magnificent result, so we could finally conclude that application of 75% R.D.F (60:45:30 kg/ha) + F.Y.M (1.5 t/ha) + vermicompost (1.0 t/ha) + green manure (1.0 t/ha) + gypsum (10.0 kg/ha) not only produce the maximum quantity of mustard but also maintain the quality and oil content of mustard.Positive outcomes were observed from the interaction between chemical and organic fertilizers. Specifically, the application of treatment 9

enabled a 25% reduction in the use of chemical fertilizers. This presents a promising alternative to solely relying on chemical fertilizers, thereby alleviating pressure on the soil.

Future Scope:

The findings of this study can be utilised as a precedent for further integrated nutrition management research studies. This strategy shows to be a workable substitute for dealing with problems brought on by the overuse of chemical fertilisers in India's trans-Gangetic plains. The ultimate goal is to increase profitability and production while upholding environmental and human welfare. Other organic nutrient sources, such as green manures, green leaf manures, oil cakes, etc., and the application of various nutrients through foliar spray were not studied in this experiment, but they should be before conclusive recommendations can be made to farmers to maximise profits while minimising chemical use in soil.

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