

## 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 (*Brassicajuncea* L.) was carried out at Rampur agricultural field of Doon (P.G) College of Agricultural 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<sub>9</sub>), there was an increase in growth of the plant, followed by T<sub>8</sub>: 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<sub>5</sub>). Moreover, maximum (2240.39 kg/ha) seed yield was observed under T<sub>9</sub> over 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 oil-seed 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)

**Comment [EA1]:** Briefly describe the methods you adopted to carry out your experiment and actions taken here before your result.

**Comment [EA2]:** Describe what fertilizers and its proportion in your methodology. We need the brief here.

**Comment [EA3]:** You need to specify the type of crops you are recommending such for. You tested on just one crop or did you try many crops? You can recommend this for your particular crop or related crops. Please correct this.

**Comment [EA4]:** Reference not acceptable. Also, if you did not just copy these statements, kindly provide references accordingly.

In India, mustard is grown in Rajasthan, Madhya Pradesh, Uttar Pradesh, Uttarakhand, Haryana, Gujarat, Andhra 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.

**Comment [EA5]:** Add references accordingly.

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.

**Comment [EA6]:** Add references

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, and nutrient-use efficiency can be accelerated, as emphasized by (Kakraliya et al., 2017).

**Comment [EA7]:** Said by who? You? Or are you reporting this? Use the right tense or add reference if any.

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 (Tafreenet

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.)

Comment [EA8]: Add sufficient references

#### 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 Agricultural Science and Technology, Dehradun, Uttarakhand. The experimental site is situated at a Latitude 30.369117° and Longitude 77.839441° with minimum and maximum temperatures ranging from 8.1 °C to 24.9 °C (at sowing) and 14.4 °C to 34.7 °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.

Comment [EA9]: Done where and with which instrument?

The details of soil properties are represented 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 <sup>-1</sup> ) at 25°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 <sub>2</sub> O <sub>5</sub> /ha)	36.34	Olsen's extraction method (Olsen <i>et al.</i> , 1954)
Available Potassium (kg K <sub>2</sub> O /ha)	192.0	Neutral 1 N NH <sub>4</sub> OAc extraction method (Hanway and Hiedel, 1952)

Comment [EA10]: Use standard table format. Remove border line and all vertical lines

The soil of experimental field was sandy loam in texture having a pH of 7.59, EC 0.39 dSm<sup>-1</sup> and having a low soil organic carbon (0.38%). The experimental soil contained 228.6, 36.34, 192.0

and 15.64 kg ha<sup>-1</sup> 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<sub>1</sub>- Control (No Fertilizer), T<sub>2</sub>- Recommended Dose of Fertilizer (80:60:40 kg/ha), T<sub>3</sub>- 100 % vermicompost (6.0 t/ha), T<sub>4</sub>- 75% F.Y.M (15.0 t/ha) + 25% R.D.F (20:15:10 kg/ha), T<sub>5</sub>- 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<sub>6</sub>-50% R.D.F (40:30:20 kg/ha) + vermicompost (3.0 t/ha)+ gypsum (5.0 kg/ha), T<sub>7</sub>- 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5t/ha), T<sub>8</sub>- 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5t/ha) + green manure (1.5t/ha), T<sub>9</sub>- 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.

**Comment [EA11]:** By who? You can just write the proportion as in the bracket.

### 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 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<sub>9</sub> (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<sub>8</sub> (75% R.D.F (60:45:30 kg/ha) + vermicompost @1.5 t/ha + G.M @1.5 t/ha) and T<sub>7</sub> (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<sub>9</sub>, and lowest plant height was observed at T<sub>4</sub>(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<sub>1</sub>(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 micronutrients. 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 Waskelet *et al.* 2019.**

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

Treatments		Plant height (cm)				Number of Leaves			
		25 DAS	45DA S	75DA S	100 DAS	25 DA S	45DA S	75DA S	100 DAS
T <sub>1</sub>	Control (No Fertilizer)	8.82	15.23	86.95	112.4 1	4.48	5.96	14.50	8.27
T <sub>2</sub>	Recommended Dose of Fertilizer (80:60:40 kg/ha)	11.7 6	19.89	109.81	122.7 3	5.47	7.03	19.31	10.73
T <sub>3</sub>	100 % vermicompost (6.0 t/ha)	12.3 6	20.69	97.00	129.5 3	5.17	6.15	19.84	11.50
T <sub>4</sub>	75% F.Y.M (15.0 t/ha) +25% R.D.F(20:15:10 kg/ha)	9.56	16.56	101.75	127.0 4	4.68	7.03	19.01	11.93
T <sub>5</sub>	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)	11.0 9	21.69	95.67	141.9 8	5.27	7.23	19.84	12.87
T <sub>6</sub>	50% R.D.F(40:30:20 kg/ha) + vermicompost(3t/ha)+ gypsum (5 kg/ha)	10.7 6	18.49	96.78	138.5 8	5.76	6.93	19.46	11.47
T <sub>7</sub>	75% R.D.F (60:45:30 kg/ha) + vermicompost(2.5t/ha )	13.6 9	21.16	88.38	129.5 7	5.17	6.64	18.26	12.87

<b>T<sub>8</sub></b>	75% R.D.F (60:45:30 kg/ha) + vermicompost(1.5t/ha) + green manure(1.5 t/ha)	13.7 6	21.76	97.66	141.4 3	5.27	7.42	19.08	12.07
<b>T<sub>9</sub></b>	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)	14.6 9	22.96	110.59	158.6 3	5.86	7.62	21.11	16.60
Sem ±		<b>0.67</b>	<b>1.35</b>	<b>5.01</b>	<b>7.76</b>	<b>0.26</b>	<b>0.32</b>	<b>1.11</b>	<b>0.48</b>
CD at 5%		<b>2.00</b>	<b>4.05</b>	<b>15.02</b>	<b>23.25</b>	<b>0.78</b>	<b>0.96</b>	<b>3.33</b>	<b>1.45</b>

Comment [EA12]: Use Standard table format or follow journal format

#### 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<sub>9</sub>, 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<sub>2</sub> i.e., R.D.F (80:60:40 kg/ha), T<sub>3</sub> i.e., 100 % Vermicompost (6 t/ha), T<sub>5</sub> 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<sub>6</sub> i.e., 50% R.D.F (40:30:20 kg/ha) + vermicompost (3.0 t/ha)+ gypsum (5.0 kg/ha), T<sub>8</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T<sub>7</sub> 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<sub>9</sub> 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<sub>3</sub> and lowest in T<sub>1</sub> (Control) where no fertilizer application was done.

Further maximum plant leaves (7.62, 21.11 and 16.60) cm was reported under treatment T<sub>9</sub>, and lowest plant leaves at T<sub>3</sub>, T<sub>7</sub> and T<sub>2</sub> and ultimate lowest (5.96, 14.50 and 8.27) cm was reported under treatment T<sub>1</sub> 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<sub>9</sub> , 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<sub>8</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T<sub>7</sub> 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<sub>9</sub> 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<sub>2</sub> and ultimate lowest in T<sub>1</sub> (Control) where no fertilizer application was done.

Further maximum number of plant branches (7.53 and 7.73) were reported under treatment T<sub>9</sub>, 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<sub>4</sub>, T<sub>2</sub> and ultimate lowest (3.79 and 3.89) was reported under treatment T<sub>1</sub> (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<sup>-1</sup> of mustard as influenced by different uses of fertilizer.

Treatments		Number of branches			Dry matter accumulation			
		45DAS	75DAS	100DAS	25DAS	45DAS	75DAS	100DAS
T <sub>1</sub>	Control (No Fertilizer)	1.80	3.79	3.89	1.38	13.85	35.59	64.64
T <sub>2</sub>	Recommended Dose of Fertilizer (80:60:40 kg/ha)	2.40	5.36	5.39	1.58	14.80	38.10	69.01
T <sub>3</sub>	100 % vermicompost (6.0 t/ha)	2.50	6.06	6.66	1.72	14.85	38.28	68.65
T <sub>4</sub>	75% F.Y.M (15 t/ha) +	2.60	4.99	5.46	1.75	14.90	37.99	67.58

	25% R.D.F (20:15:10 kg/ha)							
<b>T<sub>5</sub></b>	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)	3.20	6.59	6.79	1.78	17.55	41.44	82.24
<b>T<sub>6</sub></b>	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
<b>T<sub>7</sub></b>	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
<b>T<sub>8</sub></b>	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
<b>T<sub>9</sub></b>	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 ±	<b>0.20</b>	<b>0.31</b>	<b>0.31</b>	<b>0.13</b>	<b>0.81</b>	<b>1.75</b>	<b>3.45</b>
	CD at 5%	<b>0.60</b>	<b>0.94</b>	<b>0.92</b>	<b>0.38</b>	<b>2.42</b>	<b>5.25</b>	<b>10.33</b>

Comment [EA13]: Follow standard table format

#### 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<sub>9</sub>, 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<sub>2</sub> and lowest was observed in T<sub>1</sub> (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<sub>9</sub>, followed by T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> respectively and these treatments were found to be significantly at par with T<sub>9</sub> 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<sub>2</sub> treatment and ultimate lowest observed in T<sub>1</sub> (Control) where no fertilizer applied.

Further maximum amount plant dry matter (43.64 and 85.20) was reported under treatment T<sub>9</sub>, and lowest plant dry matter observed at T<sub>4</sub> and least (35.59 and 64.64) was reported under treatment T<sub>1</sub> 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 siliqua per plant:**

Table 4 contains information on the number of mustard siliqua per plants at 75 and 100 DAS. It can be observed that various treatments showed significant effect on number of siliqua per plant at 75 DAS varied from 17.40 to 26.30. However, maximum (26.30) number of siliqua per plant at 75 DAS was observed under T<sub>9</sub>, 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<sub>8</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T<sub>5</sub> 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<sub>9</sub> 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 siliqua per plant was observed at T<sub>3</sub> and ultimate lowest in T<sub>1</sub> (Control) where no fertilizer application was done.

Further maximum number of siliqua per plant (107.78) was reported under treatment T<sub>9</sub>, and lowest plant (46.88) was reported at T<sub>3</sub> and ultimate lowest under treatment T<sub>1</sub> at 100 DAS, respectively followed by T<sub>8</sub>.

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<sup>-1</sup>, Seed siliqua<sup>-1</sup>, Siliqua length, Test weight of mustard as influenced by different uses of fertilizer**

Treatments		Number of siliqua		Siliqua Length(cm)	No of seed siliqua <sup>-1</sup>	Test weight (gm)
		plant <sup>-1</sup>				
		75 DAS	100 DAS			
<b>T<sub>1</sub></b>	Control (No Fertilizer)	17.40	46.88	5.34	10.16	4.00
<b>T<sub>2</sub></b>	Recommended Dose of Fertilizer (80:60:40 kg/ha)	19.57	85.28	6.41	10.66	4.20
<b>T<sub>3</sub></b>	100 % Vermicompost (6 t/ha)	18.40	78.81	6.48	11.99	4.30
<b>T<sub>4</sub></b>	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
<b>T<sub>5</sub></b>	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
<b>T<sub>6</sub></b>	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
<b>T<sub>7</sub></b>	75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5t/ha)	21.33	82.81	5.81	13.66	5.00
<b>T<sub>8</sub></b>	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
<b>T<sub>9</sub></b>	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

Comment [EA14]: u

Comment [EA15]: Use standard table format

### **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<sub>9</sub> followed by T<sub>3</sub>, and T<sub>2</sub>. However, the length of siliqua was very low observed in T<sub>4</sub> and lowest in T<sub>1</sub> (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 seed per siliqua at harvest varied from 10.16 to 14.99. However, maximum (14.99) number of seed per siliqua at harvest was observed under T<sub>9</sub>, 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<sub>7</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5 t/ha), T<sub>8</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T<sub>5</sub> 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<sub>9</sub> 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 seed per siliqua was observed in T<sub>2</sub> and ultimate lowest in T<sub>1</sub> (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 5.86 gm. However, maximum (5.86 gm) test weight was observed under T<sub>9</sub>, 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<sub>8</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + green manure (1.5 t/ha) and T<sub>5</sub> 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<sub>9</sub>. However, very less test weight was observed at T<sub>2</sub> and ultimate lowest in T<sub>1</sub> (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 harvest is 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 yield was observed under T<sub>9</sub>, 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 yield was observed at T<sub>1</sub> (Control) then followed by T<sub>2</sub>.

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 **Thaneshware *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 <sub>1</sub>	Control (No Fertilizer)	822.05	3534.62	18.88
T <sub>2</sub>	Recommended Dose of Fertilizer (80:60:40 kg/ha)	1546.38	4331.59	26.36
T <sub>3</sub>	100 % Vermicompost (6.0 t/ha)	1650.72	4035.23	29.03
T <sub>4</sub>	75% F.Y.M (15.0 t/ha) + 25% R.D.F (20:15:10 kg/ha)	1634.72	3973.57	29.08
T <sub>5</sub>	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 <sub>6</sub>	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 <sub>7</sub>	75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5t/ha)	1809.72	4483.11	28.68

<b>T<sub>8</sub></b>	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
<b>T<sub>9</sub></b>	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 ±		<b>110.84</b>	<b>199.45</b>	<b>1.42</b>
CD at 5%		<b>332.30</b>	<b>597.96</b>	<b>NS</b>

#### Stover yield (kg/ha):

Data was recorded for stover yield (kg/ha) of mustard at harvest presented 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 yield was observed under T<sub>9</sub>, 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<sub>7</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (2.5 t/ha), T<sub>8</sub> i.e., 75% R.D.F (60:45:30 kg/ha) + vermicompost (1.5 t/ha) + G.M (1.5 t/ha) and T<sub>2</sub> i.e., recommended Dose of Fertilizer (80:60:40 kg/ha) respectively and these treatments were found to be significantly at par with T<sub>9</sub>. However, the low stover yield was observed at T<sub>4</sub> and lowest in T<sub>1</sub> (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 recorded at the time of harvest in table 4. It was observed that various treatments showed significant effect on harvest index (%) varied from 18.88% to 31.49%. However, maximum (31.49%) harvest index was observed under T<sub>9</sub>, 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<sub>5</sub>. Very low harvest index was observed in T<sub>2</sub> and lowest was T<sub>1</sub> (Control) where no fertilizer application was done.

#### Conclusion:

In every experiment treatment 9<sup>th</sup> 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.

#### **References:-**

**APEDA, 2020.** Agricultural and Processed Food Products Export Development. <https://apeda.gov.in/apedawebsite>

**Bareliya , R. S. 2023** Determinants productivity of mustard in gird agro-climatic region of Madhya Pradesh, Ph.D. agricultural economics, thesis, agriculture faculty, MGCGV, Chitrakoot Satna (M.P.)

**Black, C.A. (1965).** Methods of Soil Analysis. Amer. Soc. of Agro. Inc. Publ. Madison, Wisconsin, USA.

**Bower, C.A. and Wilcox, L.A. (1965).** Method of soil analysis, Part 2, ASA, Inc. Madison, Wisconsin, USA.

**Chauhan, D. R., Paroda, S., Kataria, O. P. and Singh, K. P. (1995).** Response of Indian mustard (*Brassica juncea* L.) to biofertilizers and nitrogen. *Indian J. Agron.*, 40(1): 86-90.

**Das, P.K., Sarangi, D., Jena, M.K. and Mohanty, S. 2002.** Response of green gram (*Vigna radiata* (L.) to integrated application of vermicompost and chemical fertilizers in acid lateritic soil. *Indian Agriculture*, 46: 79-87.

**Hanway, J.J. and Hiedal, H. (1952).** Soil analysis method used in Iowa State Soil Testing Laboratory, *Iowa Agriculture*, 57: 1-37.

**Jackson, M.L. 1967.** Soil chemical analysis. Prentice Hall of India. Pvt. Ltd., New Delhi. 498p.

**Jethava, B.A., Patel, K.M., Rathva, V.D. and Macwan, S.J. 2023.** Effect of integrated nutrient management and micronutrients on growth, yield and economics of tomato cv. GAT-5. *The Pharma Innovation Journal*. 12(3): 4462-4466

**Kakraliya, S. K., Kumar, N., Dahiya, S., Kumar, S., Yadav, D. D., andamp; Singh, M. (2017).** Effect of integrated nutrient management on growth dynamics and productivity trend of wheat (*Triticum aestivum* L.) under irrigated cropping system. *Journal of Plant Development Sciences*, 9(1), 11-15.

**Kalita, N., Bhuyan, S., Maibangsa, S., and Saud, R. K. (2019).** Effect of Biofertilizer seed treatment on Growth, yield and economics of toria (*Brassica campestris* L.) under rainfed condition in hill zone of Assam. *Current Agriculture Research Journal*, 7(3), 332.

**Kumar, R., Batra, V.K., Kumar, V., Kumar, A. 2017.** Response of tomato (*Lycopersicon esculentum* Mill.) to integrated nutrient management. *International Journal of Pure Applied Bioscience*. 5(5):217-221.

**Kumar, S.N., Vidhya, M.T.V. and Rathika, K. 2021.** Effect of integrated nutrient management on growth, yield attributes and economics of spiny brinjal (*Solanummelongina* L.) Var. VRM (Br)-1. *Int. J Envi. and Climate Change*. 1(10):1-6. 8.

**Mandal, K. G., and Sinha, A. C. (2002).** Effect of integrated nutrient management on growth, yield, oil content and nutrient uptake of Indian mustard (*Brassica juncea* L.) in foothills soils of eastern India. *Indian J. Agron.*, 47(1): 109-113.

**Mukherjee, D.** Effect of cultivars and fertility levels on growth, nutrient uptake and quality of mustard (*Brassica juncea* (L.) Czern and Coss.) grown in rice fallow in gangetic plains. *New Series Volume 41 December 2020 Number 4*, 382.

**Olsen, S.R., Cok, C.B., Watanboble, P.C. and Dean L.A. (1954).** Estimation of phosphorus in soil by extraction with sodium carbonate, U.S.D.A. circular, 34, 1-19.

**Parmar, U.T.D., Das, M.P. and Pradhan, J. 2019.** Effect of integrated nutrient management on growth development and yield traits of tomato (*Solanumlycopersicon* L.). *J. Pharmacogn. Phytochem*. 8(3):2764-2768.

**Press Information buerua,2023.**National Conference on Agriculture for Kharif Campaign. <https://pib.gov.in/PressReleseDetailm.aspx?PRID=1921735#:~:text=Mustard%20production%20has%20jumped%20by%2040%25%20from%2091.24,in%202019-20%20to%2088.58%20lakh%20ha%20in%202022-23>.

**Saha, P. K., Malik, G. C., Bhattacharyya, P., and Banerjee, M. (2015).** Integrated Nutrient Management on Growth and Productivity of Rapeseed-mustard Cultivars. *International Journal of Bio-resource and Stress Management*, 6(2), 192-197.

**Singh, A., Jain, P.K., Sharma, H.L. and Singh, Y. 2015.** Effect of planting date and integrated nutrient management on the production potential of tomato (*Solanum lycopersicon* Mill.) under polyhouse condition. *J. Crop and Weed*. 11:28-33.

**Singh, S. P., and Pal, M. S. (2011).** Effect of integrated nutrient management on productivity, quality, nutrient uptake and economics of mustard (*Brassica juncea*). *Indian Journal of Agronomy*, 56(4): 381-387.

**Subbiah, B.V. and Asija, G.L. 1956.** A rapid procedure for assessment of available nitrogen in rice plots. *Curr. Sci.*, 31: 196-200.

**Tarfeen, N., Nisa, K.U-I., Hassan, S., Manzoor, A., Humaira and Sultan, Z. 2023.** Integrated nutrient management strategies for improving crop yield. *Sustainable Plant Nutrition. Academic Press*. 283-297. <https://doi.org/10.1016/B978-0-443-18675-2.00003-1>.

**Thaneshwar, Singh V, Prakash J, Kumar M, Kumar S and Singh RK. 2017.** Effect of integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) in irrigated condition of upper gangetic plain zone of India. *International Journal of Current Microbiology and Applied Sciences* 6(1): 922-932

**Tripathi MK, Chaturvedi S, Shukla DK and Saini SK. 2010.** Influence of integrated nutrient management on growth, yield and quality of Indian mustard (*Brassica juncea* L.) in tarai region of northern India. *Journal of Crop and Weed* 7(2): 104-107.

**Vavilov, N.I. 1949.** The origin, variation, immunity and breeding of cultivated plants. *Chron Bot.* 13: 1- 364.

**Waskel, S., Jatav, S.K, Singh, S.S. 2019.** Effect of Integrated Nutrient Management on Growth and Yield attributes of Brinjal. *Int. J Curr. Microbiol. App. Sci.* 8(11):1849-1853.