Original Research Article

Crop Growth Indices as influenced by FYM, Vermicompost and fertility levels of Indian Mustard (*Brassica juncea* L.)

ABSTRACT

The field experiments were carried out during *Rabi* seasons of 2021-22 at Student's Instructional Farm (SIF), Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, to study the Effect of FYM, Vermicompost and Fertility levels on growth and yield of Indian Mustard (*Brassica juncea* L.). The results revealed that at 30, 60, 90 & 120 DAS the treatment (T_{14}) 100% RDF+ 50% N through Vermicompost recorded significantly higher plant height, Leaf Area Index, Crop Growth Rate and Relative Growth Rate followed by 100% RDF + 50% N through FYM (T_{10}) in both year and pooled also. The highest Grain Yield (24.63 q. ha^{-1}) with highest Harvest Index (28.40 %) was recorded over treatment (T_{14}) 100% RDF + 50% N through Vermicompost of mustard followed by Grain Yield (23.70 q. ha^{-1}) with Harvest Index (27.70 %) of 100% RDF + 50% N through FYM (T_{10}) in both year and pooled also.

Keywords:FYM (Farm Yard Manure), Vermicompost, Harvest Index

Introduction

Comment [U1]: Explain the perpose of the experiment at the end of the introduction

Indian mustard (*Brassica juncea* L.) is the third most important source of edible oils in the world after soybeans and oil palms. There is a great deal of variation in Brassica sedge species in Central Asia- the Himalayas, with migration into India and China taking place **(Singh, 2023).** The Indian mustard crop is one of the world's largest producers. Around 18% of India's oilseed production comes from rapeseed and mustard. India is one of the major oilseed's grower and importer of edible oils after the United States, China, and Brazil, India has the fourth largest vegetable oil economy in the world. The oilseed accounts for 13% of the Gross Cropped Area, 3% of the Gross National Product and 10% value of all agricultural commodities **(Annual report 2021-22, DAC&FW).**

Indian mustard (*Brassica juncea* L.) is a major oilseed crop belonging to Cruciferae family. Mustard contains 37-49 % oil, 25-32% protein, 7% ash, 1.45%phosphorus, 0.6%

calcium,0.6% magnesium, 0.05% manganese and best source of vitamins like thiamine (g/g)5.2, niacin (g/g) 160, riboflavin (mg/g) 3.7, pantothenic acid (mg/g) 9.2, folic acid (mg/g) 2.3, chlorine (mg/g) 6.7. The cake contains 42% crude protein and 7 % ash **(Damodaram and hedge, 2010).** Indian Mustard seed contains 37 to 49 per cent oil. The oil cake is used as cattle feed and manure, which contains about 4.9 per cent nitrogen, 2.5 percent phosphorus and 1.5 per cent potash **(Mahesh *et. al.*, 2021).**

Farm Yard Manure helps in increasing microbes' population and their activities, which play an important role in easily availability of complex nutrients to the plants. Farm yard manure (FYM) improves the soil physio- chemical properties along with direct release of macro as well as micronutrient; ultimately the crop yields increase **(Lakkineni and Abrol, 1994).**

Application of FYM at 10 tones ha^{-1} significantly increased the LAI, CGR and dry matter accumulation per plant at almost all the stages. Maximum dry matter accumulation per plant and seed yield were recorded with highest levels of FYM (20 tonnes ha^{-1}), Seed yield was strongly associated with LAI and dry matter accumulation per plant at all the stages **(Patel *et al.*, 1996).**

Vermicompost application has been known to improve physical, chemical and biological properties of soil **(Nagavallemma *et al*, 2004).** The material excreted through the anus of the earthworms in the form of manure is known as vermicompost. The earthworms act as natural bio ideal breeding home for aerobic bacteria which can multiply very fast and compete on aerobic bacteria and fungi.

Agronomic practices, such as fertilizer management, irrigation, and pest control, can also influence grain quality by affecting the availability of nutrients and other resources for crop growth and development. Adequate and balanced fertilization is essential for ensuring optimal grain quality, as nutrient deficiencies or imbalances can lead to reduced growth, altered nutrient composition, or increased susceptibility to pests and diseases. **(Sachan *et.al.*, 2023)**

The Indian mustard productivity is managed only through the selection of appropriate varieties and management of fertility in addition to irrigation **(Bhat *et al*., 2006)**. Among nutrients nitrogen, phosphorus, potassium and Sulphur (N, P, K and S) are essential to increase productivity of cultivars. Sulphur promotes oil synthesis, besides being an important constituent of seed protein, amino acid, enzymes, glucosinolate and chlorophyll **(Singh, 2018).** In terms of agronomic efficiency, each kilogram of S increases the yield of mustard by

7.7 kg (**Katyal *et al.*, 1997**).Rapeseed (*Brassica compestris* and *Brassica rapa* L.) has been observed to require 3-10 times more S than barley (**Bole and Pitman 1984**).

Materials and Methods:

Comment [U2]: Explain the variable investigated and the statistical analysis.

Experimental Site

The experiment was conducted at 'Student's Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The experimental field had an even topography and good drainage facility. Geographically, experimental site falls under the sub-tropical and semi- arid tract of North India of Indo- Gangetic plains and lies on the right bank of holy river Ganga. It is located on 260 28'36" N latitude, 800 18' 26" E longitude and at an altitude of 126 meters above mean sea level.

Edaphic condition

Soil samples were collected from different locations of the field before sowing and analysed some physio-chemical characteristics in the Laboratory, C.S. Azad University of Agriculture and Technology, Kanpur. The soil of the experimental field was clayey in texture and slightly alkaline in pH (8.12). The electrical conductivity (EC) of the soil was 0.39 (d S m^{-1}) estimated by Digital EC Meter. Organic carbon in the soil was 0.42% which was estimated by rapid titration method given by **Walkley and Black, 1934**. The available Nitrogen in soil was 189.12 kg ha^{-1}, which was estimated by the Alkaline permanganate method given by **Subbiah and Asija, 1956**. The available Phosphorus was 14.60 kg ha^{-1} estimated by Olsen's method given by **Jackson, 1967**. The available K was 167.31 kg ha^{-1} which was estimated by the Flame photometer method given by **Jackson, 1967.** The available S was 18.50 kg ha^{-1} which was estimated by the calcium extraction method given by **William and Steinberg, 1959.**

Treatment details

The experiment was laid out in Randomized Block Design with three replications. There were fourteen treatment combinations (T1) Control (No fertilizer and no organic source), (T2) 100% RDF (120:60:60:30 NPKS kg ha^{-1}), (T3) 75% RDF, (T4) 125% RDF, (T5) FYM alone (100% N through FYM), (T6) Vermicompost alone (100% N through Vermicompost), (T7) 75% RDF + 25% N through FYM, (T8) 100% RDF + 25% N through FYM, (T9) 75% RDF + 50% N through FYM, (T10) 100% RDF + 50% N through FYM, (T11) 75% RDF + 25% N through Vermicompost, (T12) 100% RDF + 25% N through Vermicompost, (T13)

Comment [U3]: What is this abbreviation?

75% RDF + 50% N through Vermicompost and, (T14) 100% RDF + 50% N through Vermicompost.

Seed Sowing and Spacing

The field was ploughed with a tractor drawn cultivator and after with the rotavator to obtain a fine tilth. The seed was sown at the spacing of 45 cm between rows and 15 cm between plant. The Mustard Variety **Azad Mahak** was sown and the applied seed rate was 5 kg ha^{-1}. Thinning and gap filling was after 15 days after sowing wherever it was required for maintaining optimum plant population.

Land preparation

Land preparation was started after harvesting of kharif crop with an object of optimum moisture condition. For proper germination of seed, a pre-sowing irrigation (palewa) was applied in the experimentation field. One ploughing was done by disc plough followed by two ploughing by tractor drawn cultivator and each ploughing followed by planking so that the soil was well pulverized and levelled. Layout was done carefully after land preparation.

Comment [U4]: Explain in international term

Application of FYM and Vermicompost

In the experimental field, well decomposed FYM and Vermicompost was applied by broadcasting method in individual plot and mixed with soil by hand plough according to required quantity of the particular treatment at the time of sowing after preparation of layout.

Application of nutrients or fertilizers

In main plot, the crop was fertilized with Urea, DAP, MOP and Zinc Sulphate with different doses of RDF viz. 75%, 100%, 125%, (recommended dose 120:60:60:30 kg ha^{-1} NPKS). These doses are applied according to treatment wise.

Results and Discussion

Effect of treatments on Plant height

The data pertaining to Plant height(cm) of Mustard crop was recorded at 30 DAS, 60 DAS and 120 DASpresented in Table-1. Plant height is a crucial parameter in assessing crop growth, and this study revealed that treatments with vermicompost consistently promoted taller plants. The application of treatment 100% RDF and 50% N through vermicompost (T14) consistently outperformed other treatments in promoting taller plants at various stages

Comment [U5]: Explain in matarials and methods

of growth during both the year and pooled also. This outcome underscores the positive influence of vermicompost in enhancing plant height, likely due to its rich organic matter content and nutrient availability. **Rundala *et al*. (2013)** observed that integrated nutrient management with FYM led to maximum plant height.

At 30 DAS table-1 showed that highest plant height (31.30 cm) was influenced significantly under the different treatment. table indicated that highest plant height (29.800 cm) was recorded with application of 100% RDF + 50 % N through Vermicompost(T14) which was significantly superior over the Control (T1) while at par with remaining of the treatment in both the year and pooled also. It is also clear from the table that application of increasing dose of fertility levels along with FYM and Vermicompost increase the plant height of mustard crop. The increase of plant height by a margin of (11.20 cm) or (37.58 %), (0.63 cm) or (2.16 %), (0.53 cm) or (1.98 %), (0.23 cm) or (0.78 %), (1.53 cm) or (5.41 %), (1.30 cm) or (4.57 %), (1.133 cm) or (3.96 %), (0.27 cm) or (0.91 %), (0.80 cm) or (2.76 %), (0.03 cm) or (0.10 %), (0.90 cm) 0r (3.11%), (0.20 cm) 0r (0.68 %), (0.63 cm) or (2.16 %) as compared to Control (T1), 100% RDF (120:60:60:30 NPKS kg ha-1) (T2), 75% RDF(T3), 125% RDF(T4), FYM alone (100% N through FYM) (T5), Vermicompost alone (100% N through Vermicompost) (T6), 75% RDF + 25 % N through FYM (T7), 100% RDF + 25 % N through FYM (T8), 75% RDF + 50 % N through FYM (T9), 100% RDF + 50 % N through FYM (T10), 75% RDF + 25 % N through Vermicompost (T11), 100% RDF + 25 % N through Vermicompost (T12), 75% RDF + 50 % N through Vermicompost(T13). It is also indicated that increasing dose of fertility levels with FYM and Vermicompost increase the plant height (cm) of mustard crop. The lowest plant height (18.10 cm) was recorded with control (T1).

The data pertaining to Plant height(cm) of Mustard crop was recorded at 120 DASpresented in table-1 and the results indicated that highest plant height (208.50 cm) was recorded with application of 100% RDF + 50 % N through Vermicompost(T14) which was significantly superior under the Control (T1) while at par with remaining of the treatment in both the year and pooled also. It is also clear from the table that application of increasing dose of fertility levels along with FYM and Vermicompost increase the plant height of mustard crop. The lowest plant height (117.50 cm) was recorded with control (T1).

Table-1: Plant Height(cm)

Treatments	**Plant height (cm) at 30 DAS**	**Plant height (cm) at 60 DAS**	**Plant height (cm) at 120 DAS**

Comment [U6]: Explain bellow the table

	2021-2022	2022-2023	Pooled	2021-2022	2022-2023	Pooled	2021-2022	2022-2023	Pooled
T1	18	19.233	18.6	69.133	71.167	70.167	117.033	118	117.5
T2	28.2	30.1	29.167	105.4	108.733	107.067	197.7	199.433	198.567
T3	26.5	27	26.767	97.133	100.3	98.7	189.133	191.2	190.2
T4	28.8	30.3	29.567	107	110.433	108.7	200.9	203.1	202
T5	27.1	29.4	28.267	99.133	102.267	100.7	190.167	192.2	191.167
T6	27.4	29.6	28.5	100.267	103.333	101.8	190.7	192.5	191.6
T7	27.6	29.7	28.667	101.267	104.3	102.767	191.067	193.533	192.3
T8	28.767	30.3	29.533	107.033	110.5	108.767	201.067	203.3	202.2
T9	28.033	30	29	103.133	106.467	104.8	192.467	194.667	193.567
T10	29.1	30.4	29.767	108.033	111.567	109.8	205.2	207.567	206.4
T11	27.9	29.9	28.9	102.233	105.3	103.767	191.467	193.933	192.7
T12	28.9	30.3	29.6	107.9	111.067	109.467	203.367	205.233	204.3
T13	28.2	30.1	29.167	104.2	107.5	105.867	195.7	197.6	196.667
T14	29.233	30.433	29.8	108.133	111.867	110	207.2	209.267	208.2
SE(m)±	1.082	1.082	1.057	3.81	3.992	3.869	7.272	7.357	7.219
CD at 5%	3.161	3.161	3.089	11.137	11.669	11.31	21.256	21.505	21.1

Effect of treatments on Leaf Area Index (LAI), Crop Growth Rate (CGR) and Relative Growth Rate (RGR)

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The data pertaining to Leaf area index of Mustard crop was recorded at 30, 60 and 90 DAS is presented in table-2. At 30 DAS table showed that highest Leaf area index of Mustard crop (0.733) was recorded with application of 100% RDF + 50 % N through Vermicompost (T14) which was significantly superior over the Control (T1), 75% RDF (T3), FYM alone (100% N through FYM (T5), Vermicompost alone (100% N through Vermicompost (T6), 75% RDF + 25 % N through FYM (T7), 75% RDF + 50 % N through FYM (T9), 75% RDF + 25 % N through Vermicompost (T11), 75% RDF + 50 % N through Vermicompost (T13) while at par with 100% RDF (120:60:60:30 NPKS kg ha^{-1}) (T2), 125% RDF (T4), 100% RDF + 25 % N through FYM (T8), 100% RDF + 50 % N through FYM (T10), 100% RDF + 25 % N through Vermicompost (T12) of the treatment in both the year and pooled also. It is also clear from the table that application of increasing dose of fertility levels along with FYM and Vermicompost increase the plant height of mustard crop. The lowest Leaf area index of Mustard crop (0.30) was recorded with control (T1).

At 90 DAS table-2 showed that highest Leaf area indexof Mustard crop (0.63) was recorded with application of 100% RDF + 50 % N through Vermicompost(T14) which was significantly superior under the Control (T1), 75% RDF (T3), FYM alone (100% N through FYM (T5), Vermicompost alone (100% N through Vermicompost (T6), 75% RDF + 25 % N through FYM (T7), 75% RDF + 50 % N through FYM (T9), 75% RDF + 25 % N through Vermicompost (T11) while at par with 100% RDF (120:60:60:30 NPKS kg ha-1) (T2), 125% RDF (T4), 100% RDF + 25 % N through FYM (T8), 100% RDF + 50 % N through FYM (T10), 100% RDF + 25 % N through Vermicompost (T12), 75% RDF + 50 % N through Vermicompost (T13)of the treatment in both the year and pooled also. The lowest Leaf area indexof Mustard crop (0.30) was recorded with control (T1).

It is also clear from the table that application of increasing dose of fertility levels along with FYM and Vermicompost increase the plant height of mustard crop.

Table- 2: Leaf Area Index

Treatments	Leaf area index at 30 DAS			Leaf area index at 60 DAS			Leaf area index at 90 DAS		
	2021-	2022-	Poole	2021-	2022-	Poole	2021-	2022-	Poole

Comment [U7]: Explain bellow the table

	2022	2023	d	2022	2023	d	2022	2023	d
T1	0.3	0.31	0.3	0.733	0.734	0.733	0.233	0.433	0.3
T2	0.6	0.7	0.667	1.467	1.567	1.533	0.5	0.6	0.567
T3	0.5	0.567	0.533	1.3	1.4	1.367	0.4	0.5	0.467
T4	0.633	0.733	0.667	1.5	1.6	1.567	0.533	0.633	0.567
T5	0.533	0.567	0.567	1.367	1.433	1.4	0.433	0.5	0.5
T6	0.567	0.567	0.567	1.4	1.467	1.433	0.467	0.5	0.5
T7	0.567	0.6	0.6	1.4	1.5	1.467	0.5	0.533	0.5
T8	0.667	0.733	0.7	1.5	1.6	1.567	0.567	0.633	0.6
T9	0.567	0.633	0.6	1.4	1.567	1.5	0.5	0.567	0.533
T10	0.667	0.767	0.733	1.567	1.667	1.6	0.567	0.667	0.633
T11	0.6	0.6	0.6	1.433	1.5	1.467	0.5	0.567	0.533
T12	0.667	0.767	0.733	1.533	1.633	1.6	0.567	0.633	0.6
T13	0.6	0.667	0.633	1.467	1.567	1.533	0.533	0.567	0.567
T14	0.667	0.767	0.733	1.6	1.7	1.667	0.6	0.667	0.633
SE(m)±	0.032	0.028	0.027	0.062	0.064	0.05	0.026	0.028	0.025
CD at 5%	0.092	0.083	0.079	0.182	0.188	0.145	0.075	0.083	0.072

Leaf area index is indicative of the crop's photosynthetic potential. The study showed that treatments involving vermicompost consistently resulted in higher LAI values compared to the control. Specifically, 100% RDF with 50% N through vermicompost (T14) exhibited the highest LAI values at multiple stages of growth followed by 100% RDF and 50% N through FYM (T10) in both the year and pooled also. Whereas the lowest Leaf area index was recorded over Control (No fertilizer and no organic source) T1. This suggests that vermicompost supplementation enhanced the crop's ability to capture sunlight, which can lead to improved photosynthesis and ultimately higher yields**. Singh *et al.*, (2011)** reported that combining FYM with recommended doses of fertilizers significantly increased plant height, total dry matter accumulation, leaf area index, and seed yield compared to fertilizer application alone.

Table-3. Crop growth rate (g m^{-2} day^{-1})

Treatments	Crop growth rate (g m^{-2} day^{-1}) at 0-30 DAS	Crop growth rate (g m-2 day - 1) at 30-60 DAS	Crop growth rate (g m-2 day - 1) at 60-90 DAS

	2021-2022	2022-2023	Pooled	2021-2022	2022-2023	Pooled	2021-2022	2022-2023	Pooled
T1	0.4	0.5	0.467	3.4	3.9	3.667	8	9.333	8.667
T2	1.2	1.467	1.333	9.9	11.3	10.6	23.867	27.2	25.533
T3	1.033	1.233	1.133	9.167	10.1	9.633	22.433	24.9	23.667
T4	1.133	1.433	1.3	10.433	12.2	11.3	24.5	28.167	26.3
T5	1.1	1.3	1.2	9.267	10.3	9.8	22.767	25.333	24.067
T6	1.1	1.333	1.233	9.367	10.6	10	22.967	25.733	24.367
T7	1.133	1.333	1.233	9.4	10.8	10.1	23.167	26.2	24.667
T8	1.233	1.5	1.367	10.433	12.2	11.3	24.567	28.733	26.667
T9	1.133	1.4	1.3	9.8	11.033	10.4	23.667	26.767	25.233
T10	1.233	1.5	1.4	11.3	13.5	12.4	26.4	31.467	28.9
T11	1.133	1.4	1.267	9.667	10.867	10.3	23.467	26.267	24.9
T12	1.233	1.5	1.4	10.967	12.933	11.967	26.2	30.967	28.6
T13	1.133	1.4	1.3	9.9	11.3	10.6	23.867	27.233	25.567
T14	1.233	1.533	1.4	11.5	13.767	12.633	26.6	31.767	29.167
SE(m)±	0.029	0.057	0.046	0.374	0.433	0.403	0.889	1.03	0.955
CD at 5%	0.085	0.168	0.134	1.092	1.266	1.177	2.599	3.011	2.79

The data pertaining to Crop Growth Rate and Relative Growth Rate of Mustard crop was recorded at 30, 60 and 90 DAS is presented in table-3 and table-4, respectively. CGR and RGR are critical indicators of crop growth and vigour. The results revealed that 100% RDF with 50% N through vermicompost (T14) consistently had the highest CGR values at various

growth stages. This indicates that the combination of 100% RDF and 50% N through vermicompost (T14) significantly stimulated crop growth rate. The results revealed that 100% RDF with 50% N through vermicompost (T14) consistently had the highest RGR values at various growth stages. This indicates that the combination of 100% RDF and 50% N through vermicompost (T14) significantly stimulated Relative Growth Rate. The positive influence of vermicompost on nutrient availability and soil health likely contributed to these results. **Patel *et al.*, (1996)** found that FYM application increased leaf area index (LAI), crop growth rate (CGR), and dry matter accumulation per plant during different growth phases.

Table-4. Relative Growth Rate (g g^{-1} day^{-1})

Treatments	**Relative growth rate (g g-1 day -1) at 0-30DAS 0-30 DAS**			**Relative growth rate (g g-1 day -1) at 30-60 DAS**			**Relative growth rate (g g-1 day -1) at 60-90 DAS**		
	2021-2022	**2022-2023**	**Pooled**	**2021-2022**	**2022-2023**	**Pooled**	**2021-2022**	**2022-2023**	**Pooled**
T1	0.01	0.044	0.027	0.04	0.046	0.043	0.044	0.051	0.047
T2	0.06	0.063	0.061	0.061	0.065	0.063	0.063	0.067	0.065
T3	0.035	0.07	0.052	0.068	0.072	0.07	0.07	0.074	0.072
T4	0.087	0.082	0.084	0.08	0.067	0.073	0.082	0.086	0.084
T5	0.04	0.063	0.051	0.058	0.053	0.055	0.063	0.069	0.066
T6	0.05	0.065	0.057	0.063	0.084	0.073	0.065	0.069	0.067
T7	0.052	0.051	0.051	0.049	0.073	0.061	0.051	0.055	0.053
T8	0.088	0.082	0.085	0.08	0.085	0.082	0.065	0.069	0.067
T9	0.057	0.071	0.064	0.069	0.086	0.077	0.051	0.055	0.053
T10	0.09	0.063	0.076	0.064	0.046	0.055	0.082	0.086	0.084
T11	0.055	0.058	0.056	0.061	0.065	0.063	0.071	0.075	0.073
T12	0.089	0.067	0.078	0.068	0.072	0.07	0.083	0.087	0.085
T13	0.058	0.071	0.064	0.08	0.084	0.082	0.082	0.086	0.084
T14	0.092	0.084	0.088	0.051	0.054	0.052	0.053	0.055	0.054
SE(m)±	0.014	0.016	0.015	0.015	0.014	0.014	0.014	0.014	0.014
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Summary and Conclusions:

The study showed that treatments involving vermicompost consistently resulted in higher LAI values compared to the control. It is also suggested that vermicompost supplementation enhanced the crop's ability to capture sunlight, which can lead to improved photosynthesis and ultimately higher yields. CGR are critical indicators of crop growth and vigour. The results revealed that 100% RDF and 50% N through vermicompost gave best CGR value. It is also suggested that vermicompost supplementation enhanced the crop's ability to capture sunlight, which can lead to improved CGR. The whole study revealed that the combination of 100% RDF with 50% N through vermicompost emerged as the most promising nutrient management approach for good mustard growth.

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