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Vermicompost and Fertility Levels on Growth, Yield and Profitability of Indian Mustard (*Brassica juncea* (L.) Czern and Cosson.)

Shivam Verma, Deen Dayal Yadav, Praveen Kumar Yadav, Shikhar Verma, Mausmi Rastogi, Vineet Dheer, Vikash Singh

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ABSTRACT

A field experiment was conducted during rabi season of 2019-20 at the Student Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh entitled "Effect of vermicompost and fertility levels on growth and yield of Mustard (*Brassica juncea* (L.) Czern and Cosson.)". The experiment was laid out randomly in a split plot design with three replications having vermicompost viz., V_1 (Control), V_2 (2 tonnes ha^{-1}), V_3 (4 tonnes ha^{-1}), V_4 (6 tonnes ha^{-1}) were allotted in main plots where, F_1 (Control), F_2 50% RDF (60:30:30 kg ha^{-1} NPK), F_3 75% RDF (90:45:45 kg/ha NPK), F_4 100% RDF (120:60:60 kg ha^{-1} NPK) allotted in sub plots. Thus total sixteen treatment combinations were replicated thrice. The result showed that among the vermicompost application of 6 tonnes ha^{-1} gave significantly higher yield attributes, seed yield (21.88 q ha^{-1}), gross return (108360.67 Rs ha^{-1}) and net return (62264.50 Rs ha^{-1}) in compare to control treatment. Among the different fertility levels application of 100% RDF gave significantly higher, yield attributes, seed yield (23.548 q ha^{-1}), gross return (116374.25 Rs ha^{-1}) and net return (73437.50 Rs ha^{-1}) in compare to control treatment. The combined application of vermicompost 6 tonnes ha^{-1} with 100% RDF resulted significantly higher seed yield (24.87 q ha^{-1}), gross return (122978.00 Rs ha^{-1}) and net return (74045.00 Rs ha^{-1}) of Indian mustard.

Keywords Indian mustard, Vermicompost, Fertilizer, Yield, Economics.

INTRODUCTION

India is one of the world's main oil seed producing countries, accounting for 16% of total land and 10% of total oil seed production. Oilseeds are India's second largest agricultural commodity after cereals, contributing 13.33% of the gross cultivated area and accounting for almost 3.0% of gross national production and 10% of the value of all agricultural

Shivam Verma[1]*, Deen Dayal Yadav[2], Shikhar Verma[4], Vineet Dheer[6]
[2]Professor, [4, 6]PhD Research Scholar,
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208002, Uttar Pradesh, India

Praveen Kumar Yadav[3]
[3]PhD Research Scholar, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208002, Uttar Pradesh, India

Mausmi Rastogi[5]
[5]PhD Research Scholar, Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250110, Uttar Pradesh, India

Vikash Singh[7]
[7]PhD Research Scholar,
Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh 224229, India

Email : svmsc1998@gmail.com
*Corresponding author

commodities. The country primarily cultivates nine oilseed crops: Groundnut, rapeseed and mustard, soyabean, sesame, sunflower, safflower, niger, castor, and linseed. Only seven of these oilseed crops are edible: Groundnut, rapeseed and mustard, soyabean, sesame, sunflower, safflower, niger, and linseed and castor. (Anonymous 2020a). Demand for vegetable oil is rising due to rising population and living standards, increased industrialization, and biofuel diversion. To meet its edible oil requirements, India purchased 15.57 million tonnes of vegetable oils at a cost of Rs 69023 crore. (Anonymous 2020b). The country had a sharp growth in consumption and imports of vegetable oils in the 1980s, prompting the establishment of an oilseed technology mission by the Government of India in 1986 to improve production and expedite self-reliance in vegetable oils. This mission collaborated extensively with all relevant partner agencies to expand oilseed and vegetable oil output, with favorable policy backing. The yellow revolution refers to the significant shift in Indian oilseed output from net importer to self-sufficiency and net importer during the early 1990s. Total oilseed crop area in the country is 25.49 million hectares, and production in 2019-20 is anticipated at 32.26 million tonnes, up 7.01 million tonnes from 2015-16 with oilseed productivity in the country is 1265 kg ha^{-1} (Anonymous 2020b). The per capita consumption of edible oil (including vanaspati), which was approximately 5.0 kg. In 1980-81, has now increased to 19.50 kg per person by 2018-19, and domestic consumption of edible oil has increased significantly over the years, reaching more than 25 million tonnes in 2018-19 and is expected to increase further with increase in per capita income and population. In India, total rapeseed and mustard area has expanded by 0.76 million hectares (1950-51) to 6.65 Mha, with production predicted to increase by 1.23 million tonnes to 9.33 million tonnes (2018-19) with country's average rapeseed and mustard yield 1499 kg ha^{-1} Anonymous (2020b). After Canada and China, India ranks third in rapeseed and mustard production, Rajasthan leads India in both area (26.32 lakh ha) and production (41.08 lakh metric tonnes) with Uttar Pradesh planted on 7.93 lakh ha, with a yield of 11.20 lakh metric tonnes and a productivity of 1412 kg ha^{-1} Anonymous (2020b). Mustard includes 37-49% oil, 25-32% protein, 7% ash, 0.6% calcium, 1.45% phosphorus, 0.6% magnesium, 0.05% manganese, and is a good source of vitamins, minerals, and fiber (mg/g) thiamine 5.2 mg/g niacin, 160 mg/g riboflavin 3.7 (mg/g) pantothenic acid Folic acid (mg/g), 9.5 2.3 (mg/g) chlorine 6.7, as well as tocopherols (mg/g) 1.5. The cake is made up of 42% crude proteins and 7% ash (Damodaram and Hedge 2010). Major constraints responsible for low yield of mustard in India due to lack of high yielding biotic stress resistant varieties, diseases like Alternaria blight and white rust, insects like Aphids, low input response, cultivation under rainfed situation with imbalanced use of nutrient and poor dissemination of transfer of technology. Continuous and sole application of artificial or inorganic fertilizer includes the soil sickness and disturb the soil environment and decrease productivity and unsustainability. Chemical fertilizers also have contributed significantly towards the pollution of water, air and soil. In agro ecosystem, the use of synthetic toxic chemicals and fertilizers affects the soil fertility and growth of cultivated crops (Savci 2012). Continuous application of chemical fertilizers creates acidity resulting phytotoxicity in crops as (Randhawa 1992). On the other hand, organic sources are eco-friendly, improve productivity and sustainability. The current trend is to explore the possibility of supplementing chemical fertilizers with organic ones that are eco-friendly and cost effective. Eco-friendly and environmentally safe biofertilizer, vermicompost became handy to minimize chemical fertilizer use as well as a carbon sink in crop fields. Vermicompost is a good organic source of plant nutrient supplying manure. It is a rich source of nitrogen (1.7-2.5%), phosphorus (0.7-1.0 %), potassium (1.1-1.4%), calcium (0.45%), magnesium (0.15%), sulfur (0.45%), zinc (25 PPM), iron (175.2 PPM), vitamins and growth hormone which enhance plant growth and microbial population. In contrary to the combined application of synthetic fertilizers and vermicompost reduce soil toxicity by buffering action, prevents soil degradation and enhance soil fertility status. (Rajkhowa *et al.*2002) noted that vermicompost is an excellent base for the establishment of beneficial non symbiotic and symbiotic microbes and efficacy of vermicompost was reported manifold. Earthworms consume large quantities of organic matter and excrete it as cast and this cast contains several enzymes and is rich in plant nutrient, which are beneficial for bacteria and mycorrhizae. Application of inorganic fertilizers with combination of organic sources is beneficial because organic source of manures contains few amount of primary, secondary and micronutrients and crop needed more quantity of nutrient, therefore fulfillment of these gap, judicious use of organic and inorganic fertilizers is needed and beneficial to crops. Nitrogen is an important constituent of protein. Higher the nitrogen greater would be the protein and protoplasm which would increase, in turn greater cell size, leaf area index resulting into greater photosynthetic activity. Thus nitrogen help in formation of a larger frame on which more flowers and eventually more pods can develop. In view of higher net oil recovery and quality, application of nitrogen in more than required is not advisable. Phosphorus fertilization improves growth of rapeseed and mustard crops. Besides growth, phosphorus reduces the adverse effects of excess nitrogen fertilization. Phosphorus deficiency restricts growth of roots and aerial part and sometimes it even prevent flowering. The role of patash in rapeseed and mustard is to activate a wide range of enzyme system. It also controls other physiological functions like water economy through regulation of stomatal opening and closing photosynthesis by influencing chloroplast formation, transport of photosynthates carbohydrate and nitrogen metabolism. Sulfur is an important secondary plant nutrient which is essential for proper growth and functioning of the plant. It is observed as divalent sulphate ion. It is metabolized by roots only to the extent that they review it and most of the observed sulphate is translocated unchanged to the shoots. Mustard plant need sulfur in a great amount because of its presence in the sulfur containing amino acid like methionine, cysteine. It also results in a considerable amount of increase in growth and yield of mustard along with an increase in the oil content of mustard varieties. In a view of the facts mentioned, the present investigation was carried out with the following objectives: To find out the effect of vermicompost and fertility levels on growth, yield attributes and yield of mustard, to find out the interaction effect of treatment and to assess the economics of the treatment.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at Student's Instructional Farm (SIF), Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India.

Geographical condition and metrology of crop

The City Kanpur Nagar is situated in the alluvial tract of Gangetic plains in Central part of Uttar Pradesh, India between $25^0 56'$ to $28^0 58'$ North latitude and $79^0 31'$ to $80'$ East longitudes and at an elevation of 125.9 meter from sea level. Total rainfall received during the crop period was 113.2 mm. The maximum rainfall of 65.6 mm was recorded during the week of January 15-21, 2020. And the weekly maximum and minimum temperature recorded during crop period ranged from 12.3 ^{0}C to 31.6 ^{0}C and 3.9 ^{0}C to 16.9 ^{0}C respectively. The maximum temperature (35.0 ^{0}C) was recorded in the month of March, whereas the minimum temperature (3.9 ^{0}C) was observed in the month of January. The weekly maximum relative humidity ranged from 77 to 96 % and weekly minimum relative humidity varied from 37.7 to 81 % during the period of experimentation. The range of wind velocity during the experimentation varied from 1.6 to 6.6 km $hrs.^{-1}$

Experimental details

Considering the nature of factors under study and the convenience of agricultural operation, the experiment was consists of 16 treatment combination and laid out in split plot design assigning four treatments in main plot viz., V_1-Control, V_2-Vermicompost @ 2 tonnes ha^{-1}, V_3- Vermicompost @ 4 tonnes ha^{-1}, F_4- Vermicompost @ 6 tonnes ha^{-1} and four treatment in sub plot viz., F_1-Control, F_2- RDF 50%, F_3- RDF 75%, F_4- RDF 100% with three replications. Each treatment was randomly allocated within them.

Variety

Azad Mahak [KMK (E)15-2] was released by Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP). It is early maturing, suitable for early sown condition, tolerance to high temperature at seed germination stage.

Dose and source of fertilizers

In main plot, the crop was fertilized with different doses of vermicompost @ 2, 4, 6 t ha^{-1} and in sub plot, crop was fertilized with Urea, DAP, and MOP with different doses of RDF viz., 50%, 75%, 100% (recommended dose of 120: 60:60 kg ha^{-1} NPK). These doses were applied according to treatment wise.

Yield attributes

Number of siliquae plant^{-1}

The total siliquae separated from four randomly selected and tagged plant were counted carefully and averaged was recorded as to assess the effect on the number of siliquae plant^{-1}.

Number of seeds siliquae^{-1}

Fifteen siliquae were randomly selected and splits open carefully thus healthy seeds obtained were counted carefully to take the average values of seeds siliquae^{-1}.

Seed weight plant^{-1}

The siliquae were dried 3-4 days in sun light and threshed, winnowed and seeds weighted of all four tagged plants with the help of weighting device, after adding and dividing average weight of seeds plant^{-1} was computed.

Test weight (g)

The test weight computed from 1000 healthy seeds from the representative sample of each plot and weighed with the help of electronic balance to get and record 1000 seed weight in g.

Yield characters

In respect of yield under different treatments following characters were studies.

Biological yield (q ha^{-1})

Before threshing the total sundried produce was weighed and noted with the help of spring balance in kg and there after it was converted in q ha^{-1} to quantify actual weight of each treatment with the help of conversion factor which workout for plot size.

Seed yield (q ha^{-1})

The crop was harvested separately from each plot and produce was sun dried. After sun drying, the crop was threshed and produce was cleaned. The final weight was recorded in kg plot^{-1} and finally converted in to q ha^{-1} by using conversion factor.
(conversion factor- 100/ net plot size in meter ^{2}= N × produce yield in net plot = yield q ha^{-1}).

Stover yield (q ha^{-1})

Stover yield was computed by deducting the seed yield from the total biological yield recorded plot^{-1} and expressed in q ha^{-1} by multiplying with conversion factor.

Harvest index

The economic yield (yield of main produce was described by (Singh and Stoskopf 1971) and later the relationship of economic and biological yield was expressed as harvest index. It was calculated by following formula.
Harvest index (%) = Economic yield (q ha^{-1})/ Biological yield (q ha^{-1}).

Economics (Rs ha^{-1})

Cost of cultivation of various treatments was calculated on the basis of approved market rates for input as fixed by different Government marketing agencies.

Cost of cultivation

Cost of cultivation was worked out on the basis of one ha. Economics of different treatment was worked out by taking into account the cost of cultivation and existing sale price of produce.

Gross income

Gross income was worked out by multiplying seed and stover yield obtained under various treatments with the prevailing market selling price (minimum support price basis, fixed by GOI).

Net income

Net income in (Rs ha^{-1}) was calculated by subtracting the total cost of cultivation from gross income. The gross return and net return as well as the net rupee ha^{-1} invested were worked out as follows for each treatment.

Net income = Gross return (Rs ha^{-1}) - Total cost of cultivation (Rs ha^{-1}).

Benefit: Cost ratio

The benefit: Cost ratio was calculated as follows B: C ratio = Gross return (Rs ha^{-1}) / Cost of cultivation (Rs ha^{-1})

Statistical analysis

The experimental data recorded during the course of investigation were tabulated and analyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by (Gomez and Gomez 1984). The significance of treatments was tested by 'F' test (Variance ratio). Standard error of mean was computed in all cases. The difference in the treatment mean were tested by using Least Significant Difference (LSD) at 5% level of probability where 'F' test showed significant differences among means by the following formula.

$$LSD = \frac{\sqrt{2 \times \textit{Error mean sum of square}}}{N} \times t\ (\textit{error df 5\%})$$

CD at 5% = SE (d) × t at 5% error of freedom

RESULTS AND DISCUSSION

Yield attributes

The average number of total of silique plant^{-1}, number of seed silique^{-1}, seed weight (g) plant^{-1}, test weight (1000 g seed) affected by different levels of vermicompost and fertility that are presented in Table 1 was significantly influenced by different doses of vermicompost. However, number of silique plant^{-1} was recorded maximum with the application of 6 tonnes vermicompost ha^{-1} (V_4) which was significantly higher than other treatment of vermicompost. Number of silique plant^{-1} was influenced significantly due to different levels of fertility. However, maximum number of silique plant^{-1} was observed with the application of 100% RDF (F_4) which was significantly higher than 75% RDF, 50% RDF and control treatments. The interaction effect of different levels of vermicompost and fertility on number of silique plant^{-1} was found non-significant. However, number of seeds silique^{-1} was recorded maximum with the application of 6 tonnes vermicompost ha^{-1} (V_4) which was significantly higher than other treatment of vermicompost. Also number of seeds silique^{-1} were influenced significantly due to different levels of fertility. However, higher number of seeds silique^{-1} was observed with the application of 100% RDF (F_4) which was statistically at par with 75% RDF (F_3) and significantly higher than 50% RDF (F_2) and control treatments. The interaction effect of different levels of vermicompost and fertility on number of seeds silique^{-1} was found non-significant. Further, weight of seeds plant^{-1} was recorded maximum with the application of 6 tonnes vermicompost ha^{-1} (V_4) which was significantly higher than other treatment of vermicompost. Weight of seeds plant^{-1} were influenced significantly due to different levels of fertility. However, maximum weight of seeds plant^{-1} was observed with the application of 100% RDF (F_4) which was significantly higher than 75% RDF (F_3), 50% RDF (F_2) and control treatments. The interaction effect of different levels of vermicompost and fertility on weight of seeds per plant was found non-significant and, highest test weight was recorded with the application of 6 tonnes vermicompost ha^{-1} (V_4) which was significantly higher than other treatment of vermicompost. Test weight was also influenced significantly due to different levels of fertility. However, maximum test weight was observed with the application of 100% RDF (F_4) which was statistically at par with 75% RDF but significantly higher than 50% RDF and control treatments. The interaction effect of different levels of vermicompost and fertility on test weight was found non-significant. Vegetative development produces traits in the plant that are associated with yield attribute. Favorable vermicompost conditions with an appropriate supply of nutrients in the form of RDF during the sowing and vegetative growth

Table 1. Effect of vermicompost and fertility levels on siliqua/plant, seeds/siliqua and seed weight/plant, test weight of mustard.

Treatment	No. of siliqua/plant	No. of seeds/siliqua	Seed weight/plant	Test weight (g)
Vermicompost				
V_1- Control	173.957	11.549	9.947	4.828
V_2- 2 t ha^{-1}	182.557	11.788	11.137	5.172
V_3- 4 t ha^{-1}	187.653	11.925	11.882	5 .270
V_4- 6 t ha^{-1}	201.630	12.058	13.433	5.478
SEm±	2.509	0.028	0.201	0.038
CD (P=0.05)	7.327	0.082	0.587	0.112
Fertility levels				
F_1-Control	146.865	11.384	7.718	4.637
F_2- 50% RDF	183.557	11.855	11.324	6.180
F_3- 75% RDF	200.430	11.990	13.072	5.422
F_4- 100% RDF	214.945	12.090	14.285	5.508
SEm±	2.444	0.032	0.178	0.036
CD (P=0.05)	8.434	0.112	0.614	0.124
V X F	NS	NS	NS	NS

periods lead to enhanced photosynthetic translocation to developing plant parts for improved expression of yield characteristics (Chaturvedi and Kumar 2019) and (Usmani *et al.* 2019).

Yield

The average biological yield, seed yield, stover yield (q ha^{-1}) of mustard, affected by the application of vermicompost and different fertility levels are presented in Table 2 and Fig. 1 were influenced significantly. However, higher biological yield obtained with the application of 6 tonnes vermicompost ha^{-1} (V_4) which is significantly higher than V_3, V_2 and control treatments of vermicompost and also with different fertility levels. However, higher biological yield was found with the application of 100% RDF (F_4) which was significantly higher than F_3, F_2 and control

Table 2. Effect of vermicompost and fertility levels on biological, seed yield, stover yield, and HI. of mustard.

Treatment	Biological yield (q ha^{-1})	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
Vermicompost				
V_1- Control	62.072	16.353	45.720	26.170
V_2- 2 t ha^{-1}	69.781	18.400	51.215	26.377
V_3- 4 t ha^{-1}	76.088	20.230	55.858	26.590
V_4- 6 t ha^{-1}	82.088	21.880	60.763	26.702
SEm±	1.135	0.441	0.878	0.060
CD (P=0.05)	3.314	1.288	2.563	0.207
Fertility levels				
F_1-Control	47.962	12.717	35.237	25.907
F_2- 50% RDF	72.638	18.845	47.812	26.375
F_3- 75% RDF	82.463	21.760	60.703	26.645
F_4- 100% RDF	87.553	23.540	63.935	26.913
SEm±	1.102	0.424	0.857	0.060
CD (P=0.05)	3.802	1.465	2.957	0.207
VXF	NS	NS	NS	NS

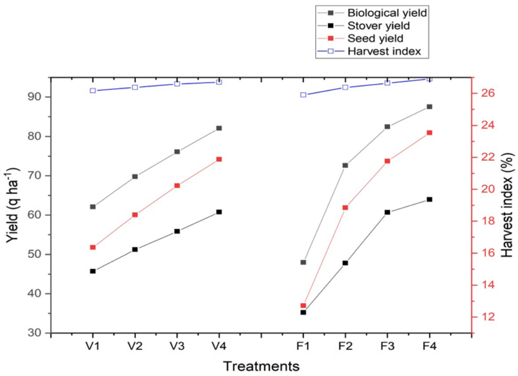

Fig. 1. Effect of vermicompost and fertility levels on yield and harvest index of mustard.

treatments of fertility levels. The interaction effect of vermicompost and fertility levels on biological yield was found non-significant. However, higher seed yield was recorded with the application of 6 tonnes vermicompost $^{-1}$ (V_4) which was significantly higher than V_3, V_2 and control treatments. Seed yield was influenced significantly due to different levels of fertility. However, maximum seed yield was obtained with the application of 100% RDF (F_4) which was significantly higher than F_3, F_2 and control treatments. The interaction effect of different levels of vermicompost and fertility on seed yield was found non-significant. Further, higher stover yield observed with the application of 6 tonnes vermicompost ha^{-1} (V_4) which is significantly higher than V_3, V_2 and control treatments of vermicompost. Stover yield influenced significantly due to different fertility levels. However, higher stover yield was found with the application of 100% RDF (F_4) which was significantly higher than F_3, F_2 and control treatments fertility levels. The interaction effect of different levels of vermicompost and fertility on stover yield was found non-significant and highest harvest index (%) observed with the application of 6 tonnes vermicompost ha^{-1} (V_4) which was statistically at par with application of 4 tonnes vermicompost ha^{-1} (V_3) and significantly higher than V_2 and control treatments of vermicompost. Harvest index (%) influenced significantly due to different fertility levels. However, highest harvest index (%) was found with the application of 100% RDF (F_4) which was significantly higher than 75% RDF (F_3), 50% RDF (F_2) and control treatments of fertility levels. The interaction effect of vermicompost and fertility levels did not have significant effect on harvest index (%). Vermicompost is well known for enhancing the biological and physical characteristics of soil, as well as providing nearly all of the nutrients that plants require to grow and develop. In order to produce new tissues and establish new shoots, a balanced diet in a favorable environment may have been helpful. The positive effect of vermicompost on these parameters may also be attributable to the fact that, thanks to enhanced microbial activity, it contributes to providing additional plant nutrients and enhancing the availability of native soil nutrients. The effective and increased partitioning of metabolites and the proper placement of nutrients to growing plant structures may also be contributing factors. Because of the use of vermicompost, nearly all crop growth and yield showed a considerable improvement. These results are in agreement with those of Sharma *et al. (*2017) Nurhidayati *et al.* (2018) and Haque and Ali (2020)

Economics of treatment

The data pertaining on gross income, net profit (Rs ha^{-1}) of mustard was influenced significantly where benefit: Cost ratio (B:C) were non-significant by application of different levels of vermicompost and fertility are presented in Table 3. Vermicompost treatments were influenced significantly gross re-

Table 3. Effect of vermicompost and fertility levels on gross return, net returns and B:C ratio of mustard.

Treatment	Gross returns (Rs/ha)	Net returns (Rs/ha)	B : C ratio
Vermicompost			
V_1- Control	81113.000	46938.250	1.337
V_2- 2 t ha^{-1}	91218.250	53038.250	1.361
V_3- 4 t ha^{-1}	100202.500	57992.500	1.355
V_4- 6 t ha^{-1}	108360.667	62264.500	1.334
SEm±	370.273	250.156	0.025
CD (P=0.05)	1081.040	730.348	NS
Fertility levels			
F_1-Control	62939.917	26362.500	0.702
F_2- 50% RDF	93694.500	53907.750	1.352
F_3- 75% RDF	107885.750	66525.750	1.609
F_4- 100% RDF	116374.250	73437.500	1.725
SEm±	395.674	247.871	0.025
CD (P=0.05)	1365.613	855.491	0.085
VXF	NS	NS	NS

turn. However, maximum gross return recorded with the application of 6 tonnes vermicompost ha^{-1} (V_4) which is significantly higher than V_3, V_2 and control treatments of vermicompost. Gross return influenced significantly due to different fertility levels. However, maximum gross return was found with the application of 100% RDF (F_4) which was significantly higher than F_3, F_2 and control treatments of fertility levels. However, maximum net returns recorded with the application of 6 tonnes vermicompost ha^{-1} (V_4) which is significantly higher than V_3, V_2 and control treatments of vermicompost. Net returns influenced significantly due to different fertility levels. However, maximum net returns was found with the application of 100% RDF (F_4) which was significantly higher than F_3, F_2 and control treatments of fertility levels. Further highest B:C ratio was recorded with the application of 2 tonnes vermicompost ha^{-1} (V_2) treatment which was non- significant than other vermicompost treatments. Different fertility levels were influenced significant effect on B:C ratio. However, highest B:C ratio was obtained with the application of 100% RDF (F_4) which was significantly higher than F_3, F_2 and control treatments of fertility levels. Similar finds were in collaboration with Sorathiya *et al.* (2014), Todawat and Sharma (2021) and Nayak *et al. (*2022).

CONCLUSION

Based on the findings of the present study, it can be inferred that the application of vermicompost @ 6 tonnes ha^{-1} (V_4) resulted maximum yield attributes which results more biological, seed and stover yield and net returns. Application of 100% RDF (120,60,60 kg ha^{-1} NPK) resulted maximum yield attributes which results more biological, seed and stover yield and net returns. Application of vermicompost @ 6 tonnes ha^{-1} with 100% RDF got maximum growth and yield attributes which resulted more biological, seed yield and stover yield and net returns.

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