➔DOI : 10.15740/HAS/AJBS/12.2/165-184
e ISSN-0976-8343 | ■ Visit us : *www.researchjournal.co.in*
ASIAN JOURNAL OF BIO SCIENCE
Volume **12** | Issue 2 | Oct., 2017 | 165-184

RESEARCH **P**APER

Influence of vermicompost and different nutrients on performance of Indian mustard [*Brassica juncea* (L.) Czern and Coss] in Typic Haplustepts

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Article Info : Received : 08.05.2017; Revised : 14.08.2017; Accepted : 11.09.2017

The experiment was laid out according to Randomized Block Design with three replications. The treatments consisting of three levels of vermicompost (control, 2.5 and 5t ha^{-1}) and five levels of different nutrients (control, S @ 40kg/ha^{-1}, S @ 40kg/ha^{-1} + iron @ 9.5kg/ha^{-1}, S @ 40kg/ha^{-1} + zinc @ 5kg/ha^{-1}, S @ 40kg/ha^{-1} + iron @ 9.5kg/ha^{-1} + zinc @ 5kg/ha^{-1}) were applied to the mustard var. Bio-902 as soil application with uniform application of nitrogen, phosphorus and potassium as per recommended doses. The main findings of investigation are summarized as:- (i) The increasing levels of vermicompost application increased the plant height, number of siliquae per plant, number of seeds per siliqua, test weight, seed and stover yield as well as content and uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron in seed and stover, oil content in seed, net returns and B:C ratio as compared to control. The pH and EC of soil decreased whereas, organic carbon and available N, P_2O_5, K_2O, S, Zn, Fe, Mn and Cu content of soil at harvest stage of crop were increased significantly with increasing levels of vermicompost. (ii) the application of different nutrients increased significantly the plant height, number of siliquae per plant, number of seeds per siliqua, test weight, seed yield, stover yield, content and uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron in seed and stover, oil content in seed and net returns and B:C ratio as compared to control. The application of different nutrients significantly enhanced the available N, P_2O_5, K_2O, S, Zn, Fe, Mn and Cu content of soil whereas, the effect on pH, EC and organic carbon were found non-significant at harvest stage of crop. (iii) The combined application of vermicompost and different nutrients was more beneficial for increasing seed, stover yield, and zinc and iron uptake by seed and net returns of mustard as compared to their individual application. The higher seed yield, Zn uptake by seed, Fe uptake by seed and net returns (2099.02 kg ha^{-1}, 894.60, 3563.69 g ha^{-1} and 53773 Rs. ha^{-1}) were obtained under the combined application of vermicompost @ 5 t ha^{-1} + different nutrients (S @ 40kg/ha^{-1} + iron @ 9.5kg/ha^{-1} + zinc @ 5kg/ha^{-1}), respectively.

Key words : RDF, NPK, Vermicompost, Stover, Mustard

How to cite this paper : Gour, Manisha Kumari, Choudhary, Ramesh and Jat, Bhanwar Lal (2017). Influence of vermicompost and different nutrients on performance of Indian mustard [*Brassica juncea* (L.) Czern and Coss] in Typic Haplustepts. *Asian J. Bio. Sci.*, **12** (2) : 165-184.**DOI : 10.15740/HAS/AJBS/12.2/165-184.**

INTRODUCTION

Rapeseed and mustard are important oilseed crops of the family Cruciferae and occupy prominent place among oilseed crops being next to soybean. India is second in rapeseed and mustard production to China and first in area. It occupies 5.3 million ha area with 7.4 million tonnes of production. In Rajasthan, rapeseed and mustard occupy prime place amongst all the oilseed crops grown in the state, occupying 2.63 million ha area and 3.51 million tonnes production (Anonymous, 2013 and 2014).

Rajasthan ranks first both in area and production of rapeseed and mustard in the country. Although it is a major oilseed crop but its productivity in the state (1334kg/ha) is much lower than its realizable yield potential of 2200 to 2400kg/ha. There is a great scope for increasing the production of mustard by bringing more area under cultivation and increasing its productivity by applying organic manures (vermicompost) with balanced fertilization and maintaining soil fertility status. The vermicomposting is an eco-friendly and effective way to recycle agricultural and kitchen wastes. 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. The biological recycling is process of transformation of organic waste into more elaborate products which are relatively richer in humic substances. The application of vermicompost not only adds plant nutrients (macro and micro) and growth regulators to one but also increases soil water retention, microbial population and humic substances of the soil, mineralization and release of nutrients. Besides these, vermicompost also improves soil aeration, reduction of soil erosion, reduces of evaporation losses of water, accelerates the process of humification, stimulates the microbial activity, deodourification of obnoxious smell, destruction of pathogens, detoxification of pollutant in soil etc. Recently, sulphur deficiency has aggravated in the soils due to continuous crop removal because of intensive cropping system and use of sulphur free high analysis NPK fertilizers. Leaching and erosion losses also contribute to sulphur deficiencies in soils. Farmers of the region apply nitrogen and phosphatic fertilizers but sulphur and micronutrients are still not used in the optimum quantity. The soils of this region are coarse textured and deficient in sulphur, zinc and iron. Their deficiency has been reported in the soils of Jaipur, Jodhpur and Udaipur districts. Sulphur which has now emerged as the third important plant nutrient to oilseed crops and plays a multiple role in nutrition. Sulphur is involved in the synthesis of oil and is a constituent of proteins, vitamins (biotin, thiamine) and sulphur containing amino acids *i.e.* cysteine, cystine and methionine. It is also a constituent of glycoside "Sinigrin" ($C_{10}H_{16}O_9NS_2K$) which imparts the specific pungency to mustard oil. Sulphur deficiency can reduce crop yield upto 35 per cent even without appearance of visible symptoms on plants. Micronutrients are equally important in plant nutrition as the major nutrients; they simply occur in plants and soils in much smaller concentrations. Plants grown on micronutrients deficient soils can exhibit similar reductions in plant growth and yield as major nutrients. Zinc is one of the essential micronutrient and plays important role in various enzymatic and physiological activities of the plant. It is also essential for photosynthesis and N-metabolism and important for the stability of cytoplasmic ribosome's, cell division, dehydrogenase, proteinase, peptidase enzymes and in the synthesis of tryptophan, a component of some proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid. Reduced growth hormone production in Zn-deficient plants causes the shorting of inter-nodes and smaller leaves. Therefore, if the soil is in short supply with respect to zinc, crop yields are further adversely affected. Hence, it becomes necessary to pay serious attention to the use of zinc. Iron is a structural component of porphyrin molecules, cytochromes, heams, hematin, ferrichrome and leghaemoglobin. These substances are involved in oxidation-reduction reactions in respiration and photosynthesis. It is also an important part of the enzyme nitrogenase, which is essential for nitrogen fixation. Iron in chloroplasts reflects the presence of cytochromes for performing various photosynthetic reduction processes and ferrodoxin as an electron acceptor. The ferrodoxins are Fe-S proteins and are the first stable redox compound of the photosynthetic electron transport chain. The efficiency of native micronutrients is further improved when these are used in conjunction with organic manures especially when the soils are low in organic carbon with low moisture retention and microbial activity. Improvement in available nutrient status of the soil with the incorporation of vermicompost alone or integration with chemical fertilizer could be attributed to the slow decomposition of organic manure producing acids and enhancing soil biological activity. These in turn provides congenial physical condition, conserves soil nitrogen and increases the availability of other nutrients. The mineralization of nutrients in the rhizosphere improves crop growth and provides a better source-sink relationship by enhancing synthesis and allocation of metabolites to reproductive organs. Keeping the above facts in view, it is considered appropriate to carry out an investigation on influence of vermicompost and different nutrients on performance of Indian mustard [*Brassica juncea* (L.) Czern and Coss] in typic haplustepts with the following

objectives: To study the effect of different nutrient management practices on growth, yield and economics of mustard, to investigate the effect of different nutrient management on content and uptake of nutrients in mustard and to evaluate the effect of different nutrient management on soil properties.

RESEARCH METHODOLOGY

The details of experimental techniques adopted, criteria used for treatment evaluation and methods followed during entire course of investigation are presented in this chapter.

Location of experimental site:

The experiment was conducted during *Rabi* season of 2015-16 at the Bhagwant Farm Ajmer situated at an altitude of 480 meters above mean sea level and at 26.44^0N latitude and 74.63^0E longitude. The region falls under agro-climatic zone- IV a "Sub- humid Southern Plain and Aravalli Hills" of Rajasthan.

Climate and weather conditions:

This zone possesses typical sub-tropical climatic conditions characterized by mild winters and moderate summers associated with high relative humidity during the months of July to September. The mean annual rainfall of the region is 637mm, most of which is contributed by south west monsoon from July to September.

Soil of the experimental field:

In order to ascertain the physico-chemical characteristics of the soil, soil samples were collected from different spots of the experimental field randomly from 0-15cm soil depths and representative composite sample were subjected to physical and chemical analysis separately.

Composition of vermicompost:

The chemical composition of vermicompost used in field experiment is presented in Table A.

Experimental details:

Treatments:

Treatments consisted of three levels of vermicompost and five levels of different nutrients application to mustard. The different treatments and their symbols used are given in Table B.

Table A : Chemical composition of vermicompost

Content	Value
N (%)	1.60
P (%)	2.01
K (%)	0.78
S (%)	4.78
Zn (ppm)	5.71
Fe (ppm)	7.65

Table B : Treatments and their symbols

Treatments	Symbols
Vermicompost (t ha^{-1})	
No vermicompost (control)	VC_0
2.5	VC_1
5.0	VC_2
Different nutrients (kg ha^{-1})	
Recommended dose of NPK (Control)	N_0
RDF + Sulphur @ 40kg/ha^{-1}	N_1
RDF + Sulphur @ 40kg/ha^{-1} + Iron @ 9.5kg/ha^{-1}	N_2
RDF + Sulphur @ 40kg/ha^{-1} + Zinc @ 5kg/ha^{-1}	N_3
RDF + Sulphur @ 40kg/ha^{-1} +Iron @ 9.5kg/ha^{-1} +Zinc @ 5kg/ha^{-1}	N_4

Details of crop rising:

The schedule of pre and post sowing operations carried out in the field during the crop season and details of the crop raising are described as under:

Treatment application :

Vermicompost application:

The vermicompost was applied in the field as per treatments and was thoroughly mixed at the time of sowing.

Different nutrients application:

The recommended dose of nitrogen (60kg/ha^{-1}) was applied in two equal splits, the half as basal and the remaining half was top dressed at the time of first irrigation. The whole quantity of phosphorus (40kg/ha^{-1}) through diammonium phosphate, potassium (30kg/ha^{-1}) through muriate of potash, zinc through $ZnSO_4.7H_2O$ and iron through $FeSo_4.7H_2O$ was drilled as basal at 8-10cm depth along with half nitrogen prior to sowing. Sulphur was applied @ 40kg/ha^{-1} through gypsum at the time of sowing. The quantity of sulphur supplied through $ZnSO_4.7H_2O$ and $FeSo_4.7H_2O$ was equated @ 40kg S

ha^{-1} in respective treatments.

Thinning, hoeing and weeding :

One hoeing cum weeding was done at 30 DAS with the help of 'Kassi'. The extra plants were also thinned out at this stage, maintaining a plant to plant distance of about 10cm.

Harvesting, threshing and winnowing:

The crop was harvested from a net plot size of 3.0m x 1.8m ($5.4m^2$) separately, tied in bundles, tagged and sun dried. After complete drying, bundles were weighed to record biological yields. Thereafter, threshing was done by beating the plants with sticks.

Treatment evaluation:

Plant studies :

In order to evaluate the treatment effects on plant characteristics, the observations on yield attributes and yield of mustard were recorded at harvest.

Plant height at harvest (*cm*):

Plant height of five randomly selected plants was recorded in each plot at harvest of the crop and expressed as average height per plant in cm.

Number of siliquae per plant:

The numbers of siliquae of the five randomly selected plants were counted and their mean was computed to express as number of siliquae per plant.

Number of seeds per siliqua:

Seeds per siliqua were recorded at harvest by counting the number of seeds of ten randomly selected siliquae from five tagged plants of each plot and average was worked out.

Test weight:

One thousand seeds were counted from each sample drawn from the finally winnowed and cleaned produce of each plot and their weight was recorded as test weight (g).

Seed yield:

After threshing and winnowing, the clean seeds obtained from the produce of individual plot were weighed and weight was recorded as seed yield kg/plot.

Stover yield:

Stover yield was calculated by subtracting the seed yield from the biological yield of the respective net plot and it was expressed as kg ha^{-1}.

Nutrient content and quality parameters :

The plant samples collected at harvest were air dried. The dried samples were powdered in a grinder having stainless steel blades to avoid contamination of micronutrients and estimation of N, P, K, S, Zn and Fe content in seed and stover.

Nitrogen content:

Nitrogen content in seed and stover was estimated by colorimetric method (Snell and Snell, 1949).

Phosphorus content:

Phosphorus content in seed and stover was determined by 'Vanadomolybdo' phosphoric acid yellow colour method. Digestion of grinded samples of grain and straw was done by tri-acid mixture and the intensity of colour was measured by spectrophotometer.

Potassium content:

Potassium content in seed and stover was determined by using flame photometry method given by Jackson (1967).

Sulphur content:

Sulphur was estimated by turbid metric method. Plant samples were digested with tri-acid mixture (nitric acid, perchloric acid and hydrochloric acid) using barium chloride solution for development of turbidity. The turbidity was measured by colorimeter and the concentration was expressed as percentage on dry weight basis.

Zinc and iron content:

Digestion of samples was done by tri-acid mixture using double distilled water. the zinc and iron content in seed and stover was estimated with atomic absorption spectrophotometer (AAS) by Lindsay and Norvell (1978) method.

Nutrient uptake:

The uptake of nitrogen, phosphorus, potassium and sulphur at harvest in seed and stover was estimated by using the following formula:

$$\text{Total uptake (kg /ha}^{-1}) = \frac{\text{Nutrient content (\%) in seed} \times \text{Seed yield (kg/ha}^{-1}) + \text{Nutrient content (\%) in stover} \times \text{Stover yield (kg/ha}^{-1})}{100}$$

The uptake of Zn and Fe at harvest in seed and stover was estimated by using the following formula:

$$\text{Total uptake (g /ha}^{-1}) = \frac{\text{Nutrient content in seed (ppm)} \times \text{Seed yield (kg/ha}^{-1}) + \text{Nutrient content in stover (ppm)} \times \text{Stover yield (kg/ha}^{-1})}{1000}$$

Oil content:

Oil content in mustard seed was determined by Soxhlet's ether extraction method.

Soil studies:

Soil chemical determination:

The pH, EC, per cent organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, iron, manganese and copper were determined at harvest stage of crop from surface (0-15cm depth) layer.

Economics:

The economics of a treatment is the most important consideration before making any recommendation to the farmer for its adoption. In order to determine the effectiveness and economics of the treatment, the additional costs involved due to application of vermicompost, N, P, K, S, Zn and Fe were taken into account. The net returns from each treatment were calculated so as to decide the most effective and remunerative treatment.

RESEARCH FINDINGS AND ANALYSIS

The data recorded for important characters have also been presented graphically for elucidation of the important trends wherever, necessary. The experimental findings are presented under the following appropriate sub heads: Quality, yield attributes and yield, nutrient content and uptake, soil properties and economics.

Quality, yield attributes and yield:

The effect of vermicompost and different nutrients on plant height, number of siliquae per plant, numbers of seeds per siliqua and test weight (g) are presented in Table 1 and Fig. 1.

Plant height:

Effect of rock phosphate:

The critical examination of data in Table 1 revealed that plant height increased significantly with increasing levels of rock phosphate. The increase in plant height was obtained to the extent of 8.17 and 18.43% with the application of vermicompost @ 2.5 and 5t ha^{-1}, respectively as compared to control.

Effect of sulphur :

The perusal of the data given in Table 1 showed that the effect of nutrients on plant height was significant. The treatments N_1, N_2, N_3 and N_4 increased the plant

Table 1: Effect of vermicompost and different nutrients on growth and yield attributes of mustard

Treatments	Plant height (cm)	Number of siliquae per plant	Number of seeds per siliqua	Test weight (g)
Vermicompost levels (t/ha)				
Control (VC_0)	159.99	156.04	11.86	3.64
2.5 t/ha (VC_1)	173.07	188.99	13.20	3.93
5.0 t/ha (VC_2)	189.49	211.18	13.87	4.02
S.E.±	3.55	3.73	0.13	0.05
C.D. (P=0.05)	10.29	10.80	0.36	0.14
Nutrients levels (kg/ha)				
RDF (Control) (N_0)	152.13	154.50	11.66	3.64
RDF + Sulphur @ 40 kg/ha (N_1)	165.97	175.17	12.61	3.86
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	174.09	189.46	13.30	3.86
RDF +Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	185.87	192.74	13.47	3.91
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	192.86	215.15	13.85	4.04
S.E.±	4.59	4.81	0.16	0.06
C.D. (P=0.05)	13.28	13.95	0.47	0.18

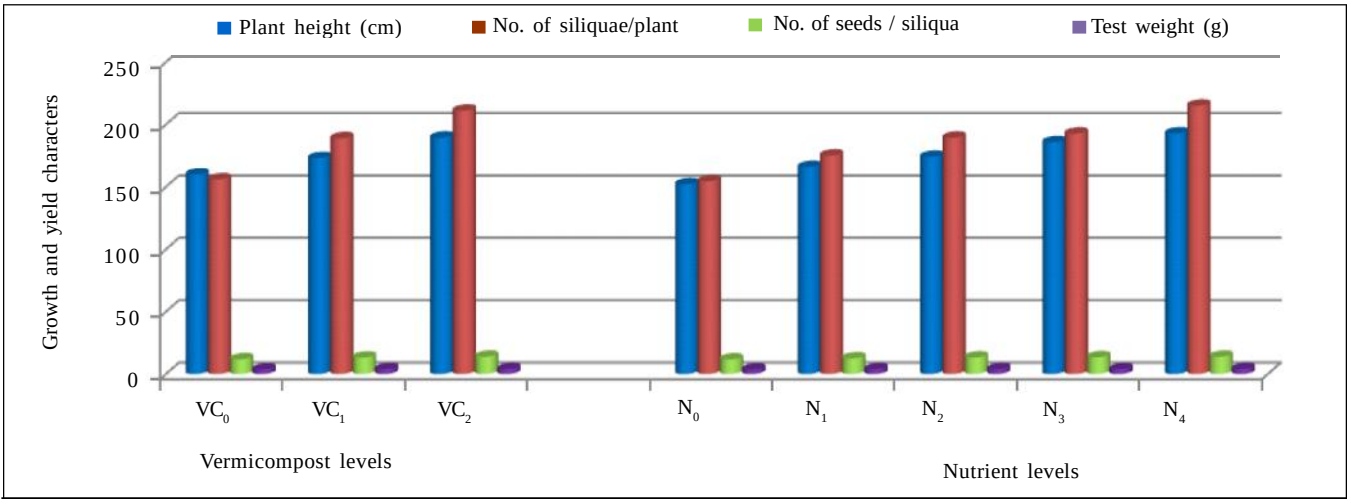

Fig. 1 : Effect of vermicompost and different nutrients on growth and yield attributes of mustard

height to the extent of 9.09, 14.43, 22.17 and 26.77 per cent, respectively over control.

Effect of biofertilizer :

Number of siliquae per plant:

Effect of vermicompost:

The maximum number of siliquae per plant was observed under the treatment VC_2 and the minimum under control. The increase in number of siliquae per plant was obtained to the extent of 21.11 and 35.33 per cent with the application of vermicompost @ 2.5 and 5t ha^{-1}, respectively as compared to control.

Effect of different nutrients :

The data related to number of siliquae per plant presented in Table 1 indicated that the application of nutrients significantly increased the number of siliquae per plant over control. However, treatment N_2 and N_3 were at par. In treatments N_1, N_2, N_3 and N_4 the number of siliquae per plant increased to the extent of 13.37, 22.62, 24.75 and 39.25 per cent, respectively over control.

Number of seeds per siliqua:

Effect of vermicompost:

The critical examination of data in Table 1 revealed that number of seeds per siliqua increased significantly with increasing levels of vermicompost. The increase in number of seeds per siliqua was obtained to the extent of 11.29 and 16.94 per cent with the application of vermicompost @ 2.5 and 5t ha^{-1}, respectively as compared to control.

Effect of different nutrients:

The perusal of the data given in Table 1 showed that the effect of nutrients on number of seeds per siliqua was significant. The treatments N_1, N_2, N_3 and N_4 increased the number of seeds per siliqua to the extent of 8.14, 14.06, 15.52 and 18.78 per cent, respectively as over control.

Test weight :

Effect of vermicompost:

Further reference to data in Table 1 showed that test weight increased significantly with increasing levels of vermicompost. However, VC_1 and VC_2 were at par. The increase in test weight was obtained to the extent of 7.96 and 10.43 per cent with the application of vermicompost @ 2.5 and 5 t ha^{-1}, respectively as compared to control.

Effect of different nutrients:

It is seen from the data in Table 1 that the effect of nutrients on test weight was significant. The treatments N_1, N_2, N_3 and N_4 increased the test weight to the extent of 6.04, 6.04, 7.41 and 10.98 per cent, respectively over control.

Seed yield :

The main and interactive effects of all the treatments are presented in Table 2 and diagrammatically shown in Fig. 2 and 3.

Effect of vermicompost :

The data presented in Table 2 revealed that seed yield increased significantly with increasing levels of vermicompost. The increase in seed yield was obtained to the extent of 29.40 and 47.24 per cent with the application of vermicompost @ 2.5 and 5t ha^{-1}, respectively as compared to control.

Effect of different nutrients:

The data related to seed yield presented in Table 2 indicated that the application of nutrients significantly increased the seed yield over control. However, treatment N_2 and N_3 were at par. The treatments N_1, N_2, N_3 and N_4 increased the seed yield to the extent of 22.29, 35.84, 41.19 and 57.29 per cent, respectively as compared to control. The maximum seed yield of mustard was recorded under treatment N_4.

Interactive effect of vermicompost and different nutrients :

Interactive effect of treatments showed that increase in vermicompost level in conjunction with

Table 2 : Effect of vermicompost and different nutrients on seed and stover yield (kg ha^{-1}) of mustard

Treatments	Seed yield	Stover yield
Vermicompost levels (t/ha)		
Control (VC_0)	1144.38	2941.20
2.5 t/ha (VC_1)	1480.88	3713.20
5.0 t/ha (VC_2)	1684.99	4158.47
S.E.±	29.09	88.84
C.D. (P=0.05)	84.29	257.36
Nutrients levels (kg/ha)		
RDF (Control) (N_0)	1094.05	2850.40
RDF + Sulphur @ 40 kg/ha (N_1)	1337.97	3377.39
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	1486.17	3774.18
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	1544.72	3804.93
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	1720.85	4214.55
S.E.±	37.56	114.69
C.D. (P=0.05)	108.81	332.25

Table 3: Effect of vermicompost and different nutrients on nitrogen and phosphorus content (%) in seed and stover of mustard

Treatments	Nitrogen		Phosphorus	
	Seed	Stover	Seed	Stover
Vermicompost levels (t/ha)				
Control (VC_0)	3.071	0.607	0.410	0.254
2.5 t/ha (VC_1)	3.261	0.647	0.444	0.295
5.0 t/ha (VC_2)	3.401	0.671	0.500	0.353
S.E.±	0.021	0.004	0.004	0.002
C.D. (P=0.05)	0.061	0.011	0.010	0.007
Nutrients levels (kg/ha)				
RDF (Control) (N_0)	3.094	0.612	0.350	0.258
RDF + Sulphur @ 40 kg/ha (N_1)	3.194	0.635	0.384	0.275
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	3.256	0.648	0.496	0.306
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	3.299	0.650	0.502	0.310
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	3.380	0.666	0.523	0.352
S.E.±	0.027	0.005	0.005	0.003
C.D. (P=0.05)	0.078	0.015	0.013	0.009

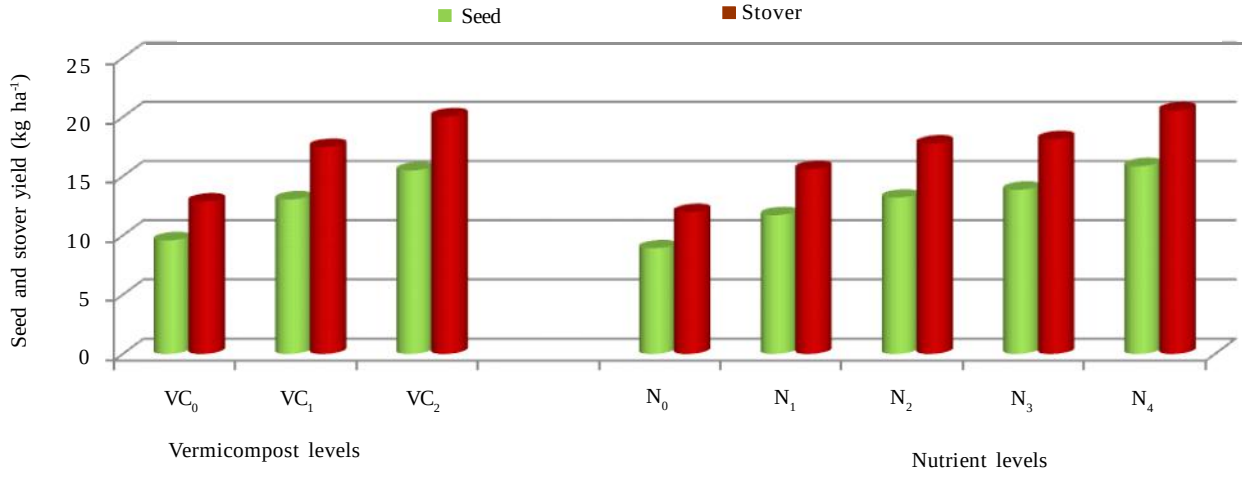

Fig. 2 : Effect of vermicompost and different nutrients on seed and stover yield (kg ha^{-1}) of mustard

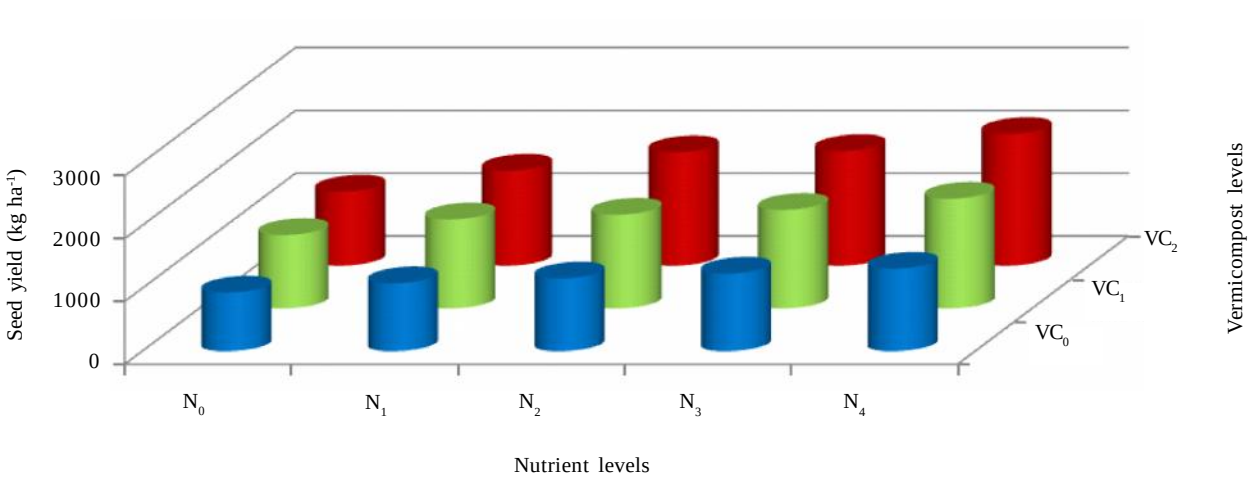

Fig. 3 : Interactive effect of vermicompost and different nutrients on seed yield (kg ha^{-1}) of mustard

nutrients resulted in increased seed yield. The highest value of seed yield was obtained under VC_2 N_4 and the lowest under VC_0N_0 treatment combination. The meticulous observations of the data indicated that the extent of increase in seed yield under all the levels of nutrients was more at VC_2 level of vermicompost.

Stover yield :

The main effects of all the treatments are presented in Table 2.

Effect of vermicompost :

The data given in Table 2 showed that stover yield increased significantly with increasing levels of vermicompost. The increase in stover yield was obtained to the extent of 26.24 and 41.38 per cent with the application of vermicompost @ 2.5 and 5t ha^{-1}, respectively as compared to control.

Effect of different nutrients :

The data related to stover yield presented in Table 2 indicated that the application of nutrients significantly increased the stover yield over control. However, the treatment N_2 and N_3 were at par. The treatments N_1, N_2, N_3 and N_4 increased the stover yield to the extent of 18.48, 32.40, 33.48 and 47.85 per cent, respectively as compared to control.

Nutrient content :

Nitrogen:

Effect of vermicompost:

The data presented in Table 3 showed that nitrogen content in seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the nitrogen content of seed and stover to the extent of 6.18 and 6.58 and 10.74 and 10.54 per cent, respectively as compared to control.

Effect of different nutrients:

Further reference to data in Table 3 revealed that the effect of nutrients on N content in seed and stover was found significant. Application of nutrients N_1, N_2, N_3 and N_4 increased the N content of seed and stover to the extent of 3.23 and 3.75, 5.23 and 5.88, 6.62 and 6.20 and 8.46 and 8.82 per cent, respectively as compared to control. The increasing trend in N content of seed and stover due to nutrients was:- $N_0 < N_1 \leq N_2 \leq N_3 < N_4$.

Table 4: Effect of vermicompost and different nutrients on potassium and sulphur content (%) in seed and stover of mustard

Treatments	Potassium		Sulphur	
	Seed	Stover	Seed	Stover
Vermicompost levels (t/ha)				
Control (VC_0)	0.654	1.223	0.833	0.434
2.5 t/ha (VC_1)	0.744	1.323	0.875	0.468
5.0 t/ha (VC_2)	0.852	1.674	0.912	0.479
S.E.±	0.007	0.012	0.005	0.003
C.D. (P=0.05)	0.021	0.035	0.016	0.008
Nutrients levels (kg/ha)				
RDF (Control) (N_0)	0.632	1.076	0.811	0.416
RDF + Sulphur @ 40 kg/ha (N_1)	0.693	1.360	0.870	0.459
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	0.765	1.470	0.881	0.468
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	0.786	1.518	0.892	0.473
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	0.876	1.609	0.914	0.485
S.E.±	0.009	0.015	0.007	0.003
C.D. (P=0.05)	0.027	0.045	0.020	0.010

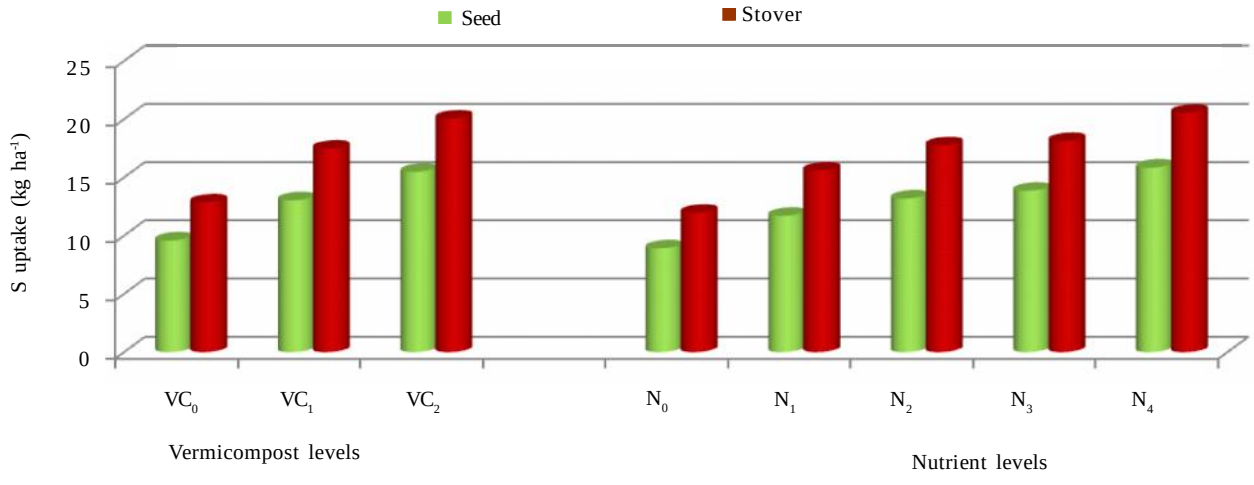

Fig. 4 : Effect of vermicompost and different nutrients on sulphur uptake (kg ha^{-1}) by seed and stover of mustard

Phosphorus:

Effect of vermicompost:

It is apparent from the data in Table 3 that P content in seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the phosphorus content in seed and stover to the extent of 8.29 and 16.14 and 21.95 and 38.97 per cent, respectively as compared to control.

Effect of different nutrients:

On going through the data in Table 3 showed that the effect of nutrients on P content in seed and stover was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the P content of seed and stover to the extent of 9.71 and 6.58, 41.71 and 18.60, 43.42 and 20.15 and 49.42 and 36.43 per cent, respectively as compared to control.

Potassium:

Effect of vermicompost:

The data presented in Table 4 showed that potassium content in seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the potassium

Table 5 : Effect of vermicompost and different nutrients on zinc and iron content (mg/kg^{-1}) in seed and stover of mustard

Treatments	Zinc		Iron	
	Seed	Stover	Seed	Stover
Vermicompost levels (t/ha)				
Control (VC_0)	35.67	14.36	151.34	159.75
2.5 t/ha (VC_1)	37.36	15.10	157.28	163.70
5.0 t/ha (VC_2)	38.98	15.69	162.09	167.32
S.E.±	0.19	0.11	0.88	0.56
C.D. (P=0.05)	0.57	0.31	2.54	1.63
Nutrients levels (kg/ha)				
RDF (Control) (N_0)	34.61	14.02	149.08	157.96
RDF + Sulphur @ 40 kg/ha (N_1)	35.63	14.70	152.50	160.50
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	37.81	15.15	153.80	161.30
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	38.59	15.56	162.90	167.90
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	40.06	15.83	166.22	170.30
S.E.±	0.25	0.14	1.13	0.73
C.D. (P=0.05)	0.74	0.39	3.28	2.11

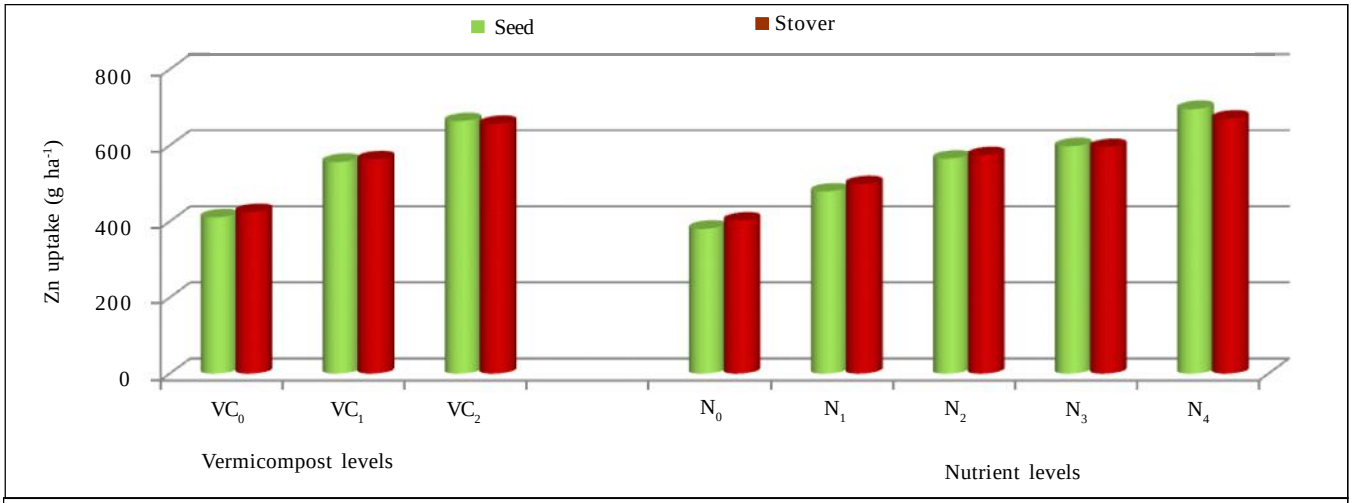

Fig. 5 : Interactive effect of vermicompost and different nutrients on zinc uptake (g ha^{-1}) by seed of mustard

content of seed and stover to the extent of 13.76 and 8.17 and 30.27 and 36.87 per cent, respectively as compared to control.

Effect of different nutrients:

Further reference to data in Table 4 revealed that the effect of nutrients on K content in seed and stover was found significant. Application of nutrients N_1, N_2, N_3 and N_4 increased the K content of seed and stover to the extent of 9.65 and 26.39, 21.04 and 36.61, 24.36 and 41.07 and 38.60 and 49.53 per cent, respectively as compared to control. The increasing trend in K content of seed and stover due to nutrients was: $-N_0 < N_1 < N_2 \leq N_3 < N_4$

Sulphur:

Effect of vermicompost:

The critical examination of data in Table 4 showed that S content in seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the sulphur content of seed and stover to the extent of 5.04 and 7.83 and 9.48 and 10.36 per cent, respectively as compared to control.

Effect of different nutrients :

The perusal of the data given in Table 4 showed that the effect of nutrients on S content in seed and stover was found significant. The maximum value of S content was recorded under N_4 while minimum under N_0. Application of nutrients N_1, N_2, N_3 and N_4 increased the S content of seed and stover to the extent of 7.27 and 10.33, 8.63 and 12.50, 9.98 and 13.70 and 12.70 and 16.58 per cent, respectively as compared to control. The increasing trend in S content of seed and stover due to nutrients was: $N_0 < N_1 \leq N_2 \leq N_3 < N_4$.

Zinc:

Effect of vermicompost :

It is evident from the data in Table 5 that Zn content in seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the Zn content of seed and stover to the extent of 4.73 and 5.15 and 9.27 and 9.26 per cent, respectively as compared to control.

Effect of different nutrients:

A perusal of the data given in Table 5 showed that the effect of nutrients on Zn content in seed and stover was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the Zn content of seed and stover to the extent of 2.94 and 4.85, 9.24 and 8.05, 11.49 and 10.98 and 15.75 and 12.91 per cent, respectively as compared to control.

Iron:

Effect of vermicompost:

It is apparent from the data in Table 5 that Fe content in seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the iron content in seed and stover to the extent of 3.92 and 2.47 and 7.10 and 4.73

Table 6 : Effect of vermicompost and different nutrients on nitrogen and phosphorus uptake (kg/ha^{-1}) by seed and stover of mustard

Treatments	Nitrogen		Total N uptake	Phosphorus		Total P uptake
	Seed	Stover		Seed	Stover	
Vermicompost levels (t/ha)						
Control (VC_0)	35.27	17.94	53.21	4.77	7.58	12.35
2.5 t/ha (VC_1)	48.50	24.12	72.62	6.69	11.08	17.77
5.0 t/ha (VC_2)	57.62	28.02	85.64	8.64	14.84	23.48
S.E.±	1.06	0.62	1.46	0.14	0.30	0.39
C.D. (P=0.05)	3.08	1.78	4.23	0.40	0.88	1.13
Nutrients levels (kg/ha)						
RDF (Control) (N_0)	34.08	17.57	51.65	3.87	7.54	11.41
RDF + Sulphur @ 40 kg/ha (N_1)	42.99	21.56	64.55	5.19	9.46	14.65
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	48.65	24.56	73.21	7.46	11.71	19.17
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	51.32	24.88	76.20	7.84	12.06	19.90
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	58.61	28.21	86.82	9.14	15.07	24.21
S.E.±	1.37	0.79	1.89	0.18	0.39	0.50
C.D. (P=0.05)	3.98	2.30	5.46	0.52	1.14	1.46

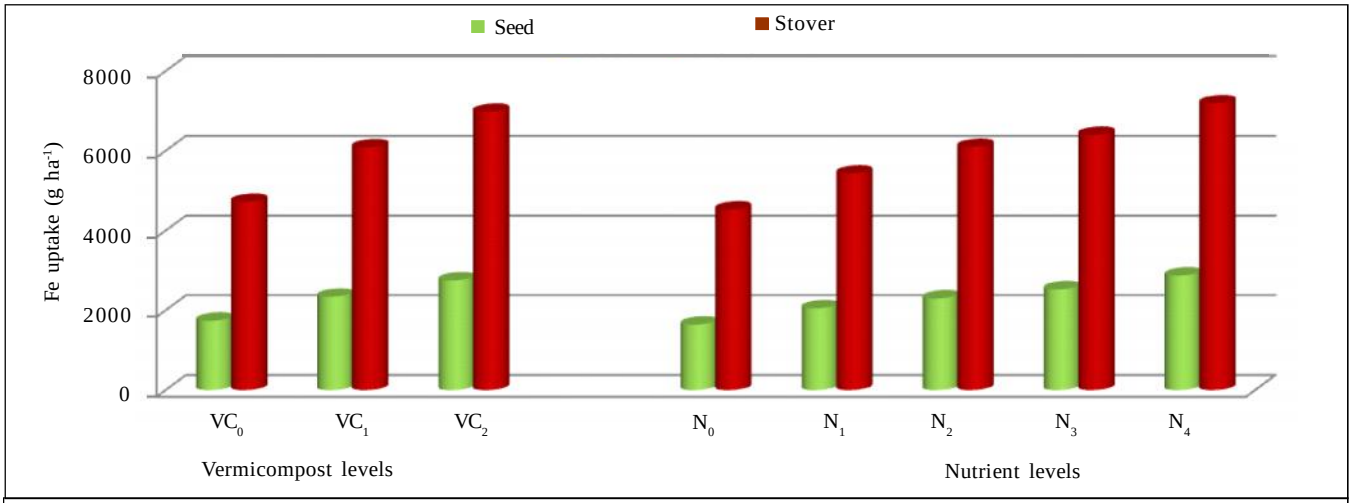

Fig. 6 : Interactive effect of vermicompost and different nutrients on zinc uptake (g ha^{-1}) by seed of mustard

per cent, respectively as compared to control.

Effect of different nutrients:

On going through the data in Table 5 showed that the effect of nutrients on Fe content in seed and stover was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the Fe content of seed and stover to the extent of 2.29 and 1.60, 3.16 and 2.11, 9.27 and 6.29 and 11.49 and 7.81 per cent, respectively as compared to control.

Nutrient uptake:

Uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron by mustard crop as influenced by varying levels of vermicompost and nutrients were found significant and are presented in Table 6, 7 and 8.

Nitrogen:

Effect of vermicompost :

It is obvious from the data in Table 6 that N uptake by seed and stover of mustard increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the N uptake by seed and stover to the extent of 37.51 and 34.44 and 63.36 and 56.18 per cent, respectively as compared to control. The relative

Table 7: Effect of vermicompost and different nutrients on potassium and sulphur uptake (kg/ha^{-1}) by seed and stover of mustard

Treatments	Potassium		Total K uptake	Sulphur		Total S uptake
	Seed	Stover		Seed	Stover	
Vermicompost levels (t/ha)						
Control (VC_0)	7.56	36.37	43.93	9.58	12.86	22.44
2.5 t/ha (VC_1)	11.18	49.83	61.01	13.03	17.47	30.50
5.0 t/ha (VC_2)	14.71	71.21	85.92	15.48	20.05	35.53
S.E.±	0.25	1.44	1.55	0.27	0.44	0.63
C.D. (P=0.05)	0.72	4.16	4.48	0.79	1.28	1.83
Nutrients levels (kg/ha)						
RDF (Control) (N_0)	6.99	30.95	37.94	8.91	11.96	20.87
RDF + Sulphur @ 40 kg/ha (N_1)	9.36	46.25	55.61	11.70	15.59	27.29
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	11.65	56.54	68.19	13.18	17.75	30.93
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	12.38	59.34	71.72	13.85	18.12	31.97
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	15.38	69.28	84.66	15.84	20.55	36.39
S.E.±	0.32	1.85	1.99	0.35	0.57	0.81
C.D. (P=0.05)	0.93	5.37	5.78	1.02	1.65	2.36

order of increase in total uptake of nitrogen by mustard with increasing application of vermicompost was: $VC_0 < VC_1 < VC_2$.

Effect of different nutrients:

An examination of data in Table 6 revealed that application of nutrients significantly increased N uptake by seed and stover of mustard as compared to control. Application of nutrients N_1, N_2, N_3 and N_4 increased N uptake by seed and stover to the extent of 26.14 and 22.70, 42.75 and 39.78, 50.58 and 41.60 and 71.97 and 60.55 per cent, respectively as compared to control. The maximum value of N uptake was recorded under N_4 followed by N_3, N_2, N_1 and N_0.

Phosphorus:

Effect of vermicompost:

It is evident from the data presented in Table 6 that phosphorus uptake by seed and stover of mustard increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the P uptake by seed and stover of mustard to the extent of 40.25 and 46.17 and 81.13 and 95.77 per cent, respectively as compared to control. The relative order of increase in total uptake of phosphorus by mustard with increasing application of vermicompost was: $VC_0 < VC_1 < VC_2$.

Effect of different nutrients:

The perusal of data in Table 6 showed that application of nutrients significantly increased P uptake by seed and stover of mustard over control. The maximum value of P uptake was recorded under N_4 followed by N_3, N_2, N_1 and N_0. Application of nutrients N_1, N_2, N_3 and N_4 increased the P uptake by seed and stover to the extent of 34.10 and 25.46, 92.76 and 55.30, 102.5 and 59.94 and 136.17 and 99.86 per cent, respectively as compared to control.

Potassium:

Effect of vermicompost:

It is obvious from the data in Table 7 that K uptake by seed and stover of mustard increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the K uptake by seed and stover to the extent of 47.88 and 37.00 and 94.57 and 95.79 per cent, respectively as compared to control. The relative order of increase in total uptake of potassium by mustard with increasing application of vermicompost was: $VC_0 < VC_1 < VC_2$.

Effect of different nutrients :

An examination of data in Table 7 revealed that application of nutrients significantly increased K uptake by seed and stover of mustard as compared to control. Application of nutrients N_1, N_2, N_3 and N_4 increased K uptake by seed and stover to the extent of 33.90 and 49.43, 66.66 and 82.68, 77.11 and 91.72 and 120.02 and 123.84 per cent, respectively as compared to control. The maximum value of K uptake was recorded under

Table 8: Effect of vermicompost and different nutrients on zinc and iron uptake (g ha^{-1}) by seed and stover of mustard

Treatments	Zinc		Total Zn uptake	Iron		Total Fe uptake
	Seed	Stover		Seed	Stover	
Vermicompost levels (t/ha)						
Control (VC_0)	410.82	425.02	835.84	1740.65	4720.35	6461.00
2.5 t/ha (VC_1)	556.70	563.53	1120.23	2341.11	6088.53	8429.64
5.0 t/ha (VC_2)	664.06	656.39	1320.45	2749.43	6978.40	9727.83
S.E.±	11.90	14.58	23.08	50.08	144.49	169.89
C.D. (P=0.05)	34.48	42.23	66.85	145.08	418.57	492.18
Nutrients levels (kg/ha)						
RDF (Control) (N_0)	380.98	402.57	783.55	1639.66	4525.21	6164.87
RDF + Sulphur @ 40 kg/ha (N_1)	479.15	498.33	977.48	2048.86	5429.87	7478.73
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	565.29	574.43	1139.72	2298.12	6098.80	8396.92
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	598.03	595.74	1193.77	2527.22	6401.86	8929.08
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	695.86	670.49	1366.35	2871.45	7189.74	10061.19
S.E.±	15.36	18.82	29.79	64.65	186.53	219.34
C.D. (P=0.05)	44.51	54.52	86.30	187.29	540.37	635.39

N_4 followed by N_3, N_2, N_1 and N_0.

Sulphur:

Effect of vermicompost:

It is evident from the data presented in Table 7 and Fig. 4 that sulphur uptake by seed and stover of mustard increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the S uptake by seed and stover of mustard to the extent of 36.01 and 35.84 and 61.58 and 55.90 per cent, respectively as compared to control. The relative order of increase in total uptake of sulphur by mustard with increasing application of vermicompost was: $VC_0 < VC_1 < VC_2$.

Effect of different nutrients:

The perusal of data in Table 7 showed that application of nutrients significantly increased S uptake by seed and stover of mustard over control. The maximum value of S uptake was recorded under N_4 followed by N_3, N_2, N_1 and N_0. Application of nutrients N_1, N_2, N_3 and N_4 increased the S uptake by seed and stover to the extent of 31.31 and 30.35, 47.92 and 48.41, 55.44 and 51.50 and 77.77 and 71.82 per cent, respectively as compared to control.

Zinc:

Effect of vermicompost:

It is obvious from the data in Table 8 that Zn uptake by seed and stover of mustard increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the Zn uptake by seed and stover of mustard to the extent of 35.50 and 32.58 and 61.64 and 54.43 per cent, respectively as compared to control. The relative order of increase in total uptake of zinc by mustard with increasing application of vermicompost was: $VC_0 < VC_1 < VC_2$.

Effect of different nutrients:

It is apparent from the data in Table 8 that application of nutrients significantly increased the Zn uptake by seed and stover of mustard as compared to control. The maximum value of Zn uptake was recorded under N_4 followed by N_3, N_2, N_1 and N_0. Application of nutrients N_1, N_2, N_3 and N_4 increased the Zn uptake of seed and stover to the extent of 25.76 and 23.78, 48.35 and 42.69, 56.97 and 47.98 and 82.65 and 66.55 per cent, respectively as compared to control.

Interactive effect of vermicompost and different nutrients :

The data (Fig. 5) revealed that the interactive effect of vermicompost and nutrients on Zn uptake by seed was found significant. The Zn uptake by seed increased with increasing number of nutrients under all the levels of vermicompost except VC_2 over VC_1 under N_0 and N_1 levels of nutrients. The maximum value was recorded under VC_2N_4, while the minimum under VC_0N_0 treatment combination.

Table 9 : Effect of vermicompost and different nutrients on oil content (%) in seed of mustard

Treatments	Oil content
Vermicompost levels (t/ha)	
Control (VC_0)	37.37
2.5 t/ha (VC_1)	38.57
5.0 t/ha (VC_2)	39.13
S.E.±	0.38
C.D. (P=0.05)	1.09
Nutrients levels (kg/ha)	
RDF (Control) (N_0)	36.75
RDF + Sulphur @ 40 kg/ha (N_1)	38.22
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	38.41
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	38.47
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	39.93
S.E.±	0.49
C.D. (P=0.05)	1.40

Iron:

Effect of vermicompost:

On going through the data in Table 8 it showed that Fe uptake by seed and stover increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the Fe uptake by seed and stover to the extent of 34.49 and 28.98 and 59.95 and 47.83 per cent, respectively as compared to control. The relative order of increase in total uptake of iron by mustard with increasing application of vermicompost was: $VC_0 < VC_1 < VC_2$.

Effect of different nutrients:

The data in Table 8 revealed that application of nutrients significantly increased the Fe uptake by seed and stover of mustard over control. The maximum value of Fe uptake was found under N_4 followed by N_3, N_2, N_1 and N_0. Application of nutrients N_1, N_2, N_3 and N_4 treatments increased the Fe uptake by seed and stover to the extent of 24.95 and 19.97, 40.15 and 34.77, 54.13 and 41.47 and 75.12 and 58.88 per cent, respectively as compared to control.

Interactive effect of vermicompost and different nutrients :

The data (Fig. 6) revealed that the interactive effect of vermicompost and nutrients on Fe uptake by seed was found significant. The Fe uptake by seed increased with

Table 10 : Effect of vermicompost and different nutrients on pH, EC (dSm^{-1}) and organic carbon (%) in soil at harvest

Treatments	pH	EC	Organic carbon
Vermicompost levels (t/ha)			
Control (VC_0)	8.25	0.66	0.65
2.5 t/ha (VC_1)	8.17	0.61	0.74
5.0 t/ha (VC_2)	8.13	0.54	0.85
S.E.±	0.02	0.01	0.02
C.D. (P=0.05)	0.07	0.04	0.05
Nutrients levels (kg/ha)			
RDF (Control) (N_0)	8.24	0.56	0.69
RDF + Sulphur @ 40 kg/ha (N_1)	8.21	0.60	0.74
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	8.19	0.61	0.76
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	8.15	0.63	0.77
RDF+ Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	8.13	0.63	0.78
S.E.±	0.03	0.02	0.02
C.D. (P=0.05)	NS	NS	NS

NS = Non-significant

Table 11: Effect of vermicompost and different nutrients on available N (kg/ha^{-1}), P_2O_5 (kg/ha^{-1}), K_2O (kg/ha^{-1}) and S (mg/kg^{-1}) in soil at harvest

Treatments	Available N	Available P_2O_5	Available K_2O	Available S
Vermicompost levels (t/ha)				
Control (VC_0)	297.04	17.63	382.53	8.16
2.5 t/ha (VC_1)	322.74	21.64	403.66	9.45
5.0 t/ha (VC_2)	367.52	25.64	459.94	11.32
S.E.±	3.10	0.21	4.63	0.15
C.D. (P=0.05)	8.97	0.62	13.42	0.44
Nutrients levels (kg/ha)				
RDF (Control) (N_0)	276.18	18.02	378.80	7.12
RDF + Sulphur @ 40 kg/ha (N_1)	328.44	20.00	399.31	8.45
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	337.06	22.29	416.21	10.55
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	346.05	22.78	432.07	10.62
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	357.78	25.09	450.50	11.48
S.E.±	4.00	0.27	5.98	0.19
C.D. (P=0.05)	11.60	0.79	17.32	0.56

increasing levels of nutrients under all the levels of vermicompost except VC_2 over VC_1 under N_0 and N_1 levels of nutrients. The maximum value of Fe uptake was recorded under VC_2 N_4, while minimum under VC_0 N_0 treatment combination.

Quality:

The data regarding effect of vermicompost and different nutrients on oil content of mustard seed are being summarized in Table 9.

Oil content:

Effect of vermicompost:

A critical examination of data in Table 9 revealed that increasing levels of vermicompost significantly increased the oil content of mustard seed. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the oil content of seed to the extent of 3.21 and 4.70 per cent, respectively as compared to control.

Effect of different nutrients:

The perusal of data given in Table 9 showed that

Table 12: Effect of vermicompost and different nutrients on available Zn (mg/kg^{-1}), Fe (mg/kg^{-1}), Mn (mg/kg^{-1}) and Cu (mg/kg^{-1}) content in soil at harvest

Treatments	Available Zn	Available Fe	Available Mn	Available Cu
Vermicompost levels (t/ha)				
Control (VC_0)	0.78	4.43	5.45	1.97
2.5 t/ha (VC_1)	1.66	5.07	6.29	2.47
5.0 t/ha (VC_2)	2.09	6.09	6.78	2.78
S.E.±	0.004	0.059	0.052	0.044
C.D. (P=0.05)	0.011	0.171	0.149	0.128
Nutrients levels (kg/ha)				
RDF (Control) (N_0)	0.79	4.44	5.44	1.99
RDF + Sulphur @ 40 kg/ha (N_1)	1.26	5.49	6.12	2.34
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	1.59	5.86	6.24	2.44
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	1.81	5.65	6.36	2.57
RDF + Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	2.15	6.22	6.71	2.72
S.E.±	0.005	0.076	0.067	0.057
C.D. (P=0.05)	0.014	0.221	0.193	0.166

Table 13: Effect of vermicompost and different nutrients on net returns (Rs./ha^{-1}) and B:C of mustard

Treatments	Net returns	B:C
Vermicompost levels (t/ha)		
Control (VC_0)	23725	1.29
2.5 t/ha (VC_1)	33963	1.67
5.0 t/ha (VC_2)	39357	1.76
S.E.±	1034	0.05
C.D. (P=0.05)	2995	0.15
Nutrients levels (kg/ha)		
RDF (Control) (N_0)	20405	1.03
RDF + Sulphur @ 40 kg/ha (N_1)	28902	1.42
RDF + Sulphur @ 40 + Iron @ 9.5 kg/ha (N_2)	34030	1.64
RDF + Sulphur @ 40 + Zinc @ 5 kg/ha (N_3)	36162	1.76
RDF +Sulphur @ 40+Iron @ 9.5+Zinc @ 5 kg/ha (N_4)	42243	2.02
S.E.±	1335	0.07
C.D. (P=0.05)	3866	0.19

the effect of nutrients on oil content was found significant. Application of nutrients N_1, N_2, N_3 and N_4 increased the oil content by seed to the extent of 4.00, 4.51, 4.68 and 8.65 per cent, respectively as compared to control.

Soil properties:

The data regarding effect of vermicompost and different nutrients on pH, EC, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, iron, manganese and copper in soil at harvest stage of mustard crop have been presented in Table 10, 11 and 12.

pH :

Effect of vermicompost :

The data given in Table 10 showed that pH of the soil at harvest stage of the mustard crop decreased significantly with increasing levels of vermicompost. The maximum pH was obtained under the control which decreased by 0.08 and 0.12 under application of VC_1 and VC_2 levels of vermicompost, respectively.

Effect of different nutrients:

The critical appraisal of data presented in Table 10 revealed that the effect of nutrients on pH of the soil at harvest stage of mustard crop was found non-significant.

Electrical conductivity (EC):

Effect of vermicompost :

The data given in Table 10 showed that electrical conductivity of the soil at harvest stage of the mustard crop decreased significantly with increasing levels of vermicompost. The maximum electrical conductivity was obtained under the control which decreased by 0.05 and 0.12 dS m^{-3} under application of VC_1 and VC_2 levels of vermicompost, respectively.

Effect of different nutrients:

The perusal of the data given in Table 10 showed that application of nutrients on electrical conductivity of the soil at harvest stage of mustard crop was found non-significant.

Organic carbon:

Effect of vermicompost:

The data presented in Table 10 showed that organic carbon status of the soil at harvest stage of the crop increased significantly with increasing levels of application of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the status of organic carbon of soil to the extent of 13.85 and 30.77 per cent, respectively as compared to control.

Effect of different nutrients:

A critical look of data in Table 10 indicated that the application of nutrients had non-significant effect on the organic carbon content of the soil at harvest stage of mustard crop.

Available nitrogen:

Effect of vermicompost:

A perusal of the data in Table 11 showed that available N content of soil increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available nitrogen content of soil to the extent of 8.65 and 23.72 per cent, respectively as compared to control.

Effect of different nutrients:

Further reference to data in Table 11 revealed that the effect of nutrients on available N content of soil was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the available N content of soil to the extent of 18.92, 22.04, 25.29 and 29.54 per cent, respectively as compared to control.

Available phosphorus:

Effect of vermicompost :

It is evident from data in Table 11 that available P_2O_5 content of soil increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available P_2O_5 content of soil to the extent of 22.75 and 45.43 per cent, respectively as compared to control.

Effect of different nutrients:

The application of nutrients increased the available P_2O_5 content of soil significantly as compared to control (Table 11). The application of nutrients N_1, N_2, N_3 and N_4 increased the available P_2O_5 content of soil to the extent of 10.99, 23.70, 26.42 and 39.23 per cent, respectively as compared to control.

Available potassium:

Effect of vermicompost :

An examination of data in Table 11 indicated that

available K_2O content of soil increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available K_2O content of soil to the extent of 5.52 and 20.24 per cent, respectively as compared to control.

Effect of different nutrients:

The critical examination of data in Table 11 revealed that the effect of nutrients on available K_2O content of soil was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the available K_2O content of soil to the extent of 5.41, 9.88, 14.06 and 18.93 per cent, respectively as compared to control.

Available sulphur:

Effect of vermicompost :

It is evident from data in Table 11 that available S content of soil increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available S content of soil to the extent of 15.81 and 38.73 per cent, respectively as compared to control.

Effect of different nutrients :

The application of nutrients increased the available S content of soil significantly as compared to control in Table 11. The application of nutrients N_1, N_2, N_3 and N_4 increased the available S content of soil to the extent of 18.68, 48.17, 49.16 and 61.24 per cent, respectively as compared to control.

Available zinc:

Effect of vermicompost :

An examination of data in Table 12 indicated that available Zn content of soil increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available Zn content of soil to the extent of 112.8 and 167.9 per cent, respectively as compared to control.

Effect of different nutrients:

The critical examination of data in Table 12 revealed that the effect of nutrients on available Zn content of soil was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the available Zn content of soil to the extent of 59.49, 101.2, 129.1 and 172.1 per cent, respectively as compared to control.

Available iron:

Effect of vermicompost :

It is obvious from the data presented in Table 12 that increasing levels of vermicompost significantly increased available Fe content of soil. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available Fe content of soil to the extent of 14.44 and 37.47 per cent, respectively as compared to control.

Effect of different nutrients:

Further reference to data in Table 12 showed that the effect of nutrients on available Fe content of soil was significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the available Fe content of soil to the extent of 23.64, 31.98, 27.25 and 40.09 per cent, respectively as compared to control.

Available manganese:

Effect of vermicompost :

An examination of data in Table 12 indicated that available Mn content of soil increased significantly with increasing levels of vermicompost. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available Mn content of soil to the extent of 15.41 and 24.40 per cent, respectively as compared to control.

Effect of different nutrients:

The critical examination of data in Table 12 revealed that the effect of nutrients on available Mn content of soil was found significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the available Mn content of soil to the extent of 12.50, 14.70, 16.69 and 23.34 per cent, respectively as compared to control.

Available copper :

Effect of vermicompost:

It is obvious from the data presented in Table 12 that increasing levels of vermicompost significantly increased available Cu content of soil. The application of vermicompost @ 2.5 and 5t ha^{-1} increased the available Cu content of soil to the extent of 25.38 and 41.11 per cent, respectively as compared to control.

Effect of different nutrients:

Further reference to data in Table 12 showed that the effect of nutrients on available Cu content of soil was significant. The application of nutrients N_1, N_2, N_3 and N_4 increased the available Cu content of soil to the

extent of 17.58, 22.61, 29.14 and 36.68 per cent, respectively as compared to control.

Economics:

The data regarding effect of vermicompost and nutrients on net returns and B:C ratio of crop is being summarized in Table 13. The interactive effect of vermicompost and different nutrients on net returns of mustard crop was found significant.

Net returns:

Effect of vermicompost :

The perusal of data in Table 13 revealed that net returns increased significantly with increasing levels of vermicompost. The increase in net returns was obtained to the extent of 43.15 and 65.88 per cent with the application of vermicompost @ 2.5 and 5t ha^{-1}, respectively as compared to control.

Effect of different nutrients:

A critical examination of data in Table 13 revealed that the effect of nutrients on net returns was found significant. The treatment N_1, N_2, N_3 and N_4 increased the net returns to the extent of 41.64, 66.77, 77.22 and 107.02 per cent, respectively as compared to control.

B:C ratio :

Effect of vermicompost :

It is evident from data in Table 13 that B:C ratio increased significantly with increasing levels of vermicompost. The increase in B:C ratio was obtained to the extent of 29.05 and 36.01 per cent with the application of vermicompost @ 2.5 and 5 t ha^{-1}, respectively as compared to control.

Effect of different nutrients:

Further reference to data in Table 13 showed that the effect of nutrients on B:C ratio ratio was found significant. The treatment N_1, N_2, N_3 and N_4 increased the B:C ratio to the extent of 37.86, 59.22, 70.87 and 96.11 per cent, respectively as compared to control.

Interactive effect of vermicompost and different nutrients:

The reference to data regarding interactive effect of vermicompost and nutrients on net returns of mustard crop. The net returns of mustard increased with increasing levels of nutrients under all the levels of vermicompost except VC_2 over VC_1 under N_0 and N_1 levels of nutrients. The maximum value of net returns was recorded under treatment VC_2N_4 while minimum under VC_0N_0 treatment combination. Similar work related to the present investigation was also carried out by Badiyala and Chopra (2011) on productivity and nutrient availability in maize-linseed cropping system, Bameri *et al.* (2012) on wheat, Kansotia *et al*. (2013 and 2015); Kumar (2014) and Singh *et al*. (2014) on Indian mustard.

Conclusion:

Based on one year experimentation it may be concluded that both vermicompost and nutrients application brought an additive effect in increasing growth and parameter yield attributes *viz.*, plant height, number of siliquae per plant, number of seeds per siliqua, test weight, yields, net returns and B:C ratio of mustard crop. the highest seed yield (2099.02kg/ha^{-1}) and net returns (53773Rs./ha^{-1}) was obtained under the combined application of vermicompost @ 5 t ha^{-1} and different nutrients (sulphur @ 40kg ha^{-1} + iron @ 9.5kg/ha^{-1} + zinc @ 5kg/ha^{-1}) along with the recommend dose of fertilizers. These results are only indicative and require further experimentation to derive credible conclusion.

LITERATURE CITED

Anonymous (2013). *Agricultural statistics at a glance*, Directorate of Economics and Statistics, Department of Agriculture and Cooperation. Govt. of India.

Anonymous (2014). *Status paper on oilseed* (Oilseed Division). Department of Agriculture and Cooperation Publication, Ministry of Agriculture, Govt. of India, Krishi Bhawan, New Delhi, pp. 43-52.

Badiyala, D. and Chopra, P. (2011). Effect of zinc and FYM on productivity and nutrient availability in maize (*Zea mays)* - linseed (*Linum usitatissimum)* cropping sequence. *Indian J. Agron.,* **56**: 88-91.

Bameri, M., Abdolshahi, R., Mohamadi, N.G., Yousefi, K. and Abatabaie, S.M. (2012). Effect of different microelement treatments on wheat (*Triticum aestivum*) growth and yield. *Internat. Res. J. Appl. & Basic Sci.*, **3** (1):219-223.

Jackson, M.L.(1967). *Soil chemical analysis,* Prentice Hall of India Pvt. Ltd., New Delhi, India p.205.

Kansotia, B.C., Meena, R. and Meena, V. (2013). Effect of vermicompost and inorganic fertilizers on Indian mustard (*Brassica juncea* L.). *Asian J. Soil Sci.,* **8**(1):

136-139.

Kansotia, B.C., Sharma, Y. and Meena, R.S. (2015). Effect of vermicompost and inorganic fertilizers on soil properties and yield of Indian mustard (*Brassica juncea* L.). *J. Oilseed Brassica*, **6** (1): 198-201.

Kumar, A., Kumar, S., Kumar, P., Kumar, A., Kumar, S., Arya, S. and Kumar, S. (2014). Effect of zinc and iron application on yield and acquisition of nutrient on mustard crop (*Brassica juncea* L.). *Internat. J. Agric. Sci.*, **10** (2): 797-800.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. America J.*, **42**: 421–428.

Singh, V., Verma, S., Srivastava, V. K., Mohd, A.K. and Aslam, T. (2014). Studies on integrated nutrient management in mustard [*Brassica juncea* (L.) Czern & Cosson]. *Internat. J. Agric. Sci.*, **10**(2) : 667-670.

Snell, F. D. and Snell, C. T. (1949). *Colorimetrie methods of analysis*, 3rd Ed., D. Van Nostrand Co., Inc., New York, 950 p.