Annals of Plant and Soil Research 19(1): 17 - 22 (2017)

Effect of vermicompost and nutrients application on soil properties, yield, uptake and quality of Indian mustard (*Brassica juncea*)

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Received: December, 2016; Revised accepted: February, 2017

ABSTRACT

A field experiment was conducted at the Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur, Rajasthan during the rabi season of 2014-15 using randomized block design with three replications to study the effect of applied vermicompost and nutrients on soil properties, yield, uptake and quality of mustard. Treatments consisted of three levels of vermicompost viz., zero (control), 2.5 and 5.0 t ha^{-1} and five levels of nutrients viz., no nutrients, 40 kg S ha^{-1}, 40 kg S + 9.5 kg Fe ha^{-1}, 40 kg S + 5.0 kg Zn ha^{-1}, and 40 kg S + 9.5 kg Fe + 5.0 kg Zn ha^{-1}. Results revealed that vermicompost and nutrients, individually and in combination, significantly increased the seed and stover yield, oil content, nutrient content and uptake of N, S, Zn and Fe in seed and stover over the control. Combined application of vermicompost and nutrients was found to increase Zn and Fe uptake in seed over their individual application. Highest Zn (895 g ha^{-1}) and Fe (3564 g ha^{-1}) uptake in seed was obtained under 5 t vermicompost + 40 kg S + 9.5 kg Fe + 5 kg Zn ha^{-1}. The organic carbon and available N, P, K, S, Zn, Fe, Cu and Mn content in post harvest soil was significantly increased but pH and EC of soil was decreased significantly with increasing levels of vermicompost. The status of these nutrients in soil improved significantly with the supplementation of nutrients (S+Zn+Fe).

Key words: Vermicompost, nutrients, yield, uptake, quality, soil properties, mustard.

INTRODUCTION

Prapeseed-mustard (*Brassica juncea* L.) is the third most important oilseed crops after soybean and groundnut in India occupying 5.3 million hectare acreage, 7.40 million tonnes production and 1185 kg ha^{-1} productivity (Anonymous, 2015-16). The productivity is quite lower than other developed countries mainly due to sub-optimal application of fertilizers and their cultivation on marginal lands under rainfed conditions. The organic manures (vermicompost) being cheaper and eco-friendly, could be the alternatives to fertilizers for improving both crop productivity and sustainability of the systems. The continuous mining of nutrients from soils coupled with inadequate and imbalanced fertilizer use has resulted in emergence of multi-nutrient deficiencies. Sulphur is involved directly or indirectly in different metabolic pathways of plants and also as a constituent of many metabolites. The involvement of S as an important component of several enzymes and metabolic processes in plants is well documented. Activator of several enzymes such as urease, nitrogenase, nitrate reductase and ribonuclease are known to be retarded by deficiency of sulphur. Zinc is one of the first micronutrients recognized as essential for plants. It is a micronutrient most commonly limiting crop yields in Indian soils. Zinc is transported to plant root surface through diffusion. It aids in the synthesis of plant growth substances and enzyme systems and is essential for promoting certain metabolic reactions. It is necessary for production of chlorophyll and carbohydrates. Iron plays an important role in the synthesis of chlorophyll and also helps in the absorption of other nutrients. As a constituent of chlorophyll, it regulates respiration, photosynthesis, reduction of nitrates and sulphates. Thus, the use of organic manure (vermicompost) and supplementation of soil fertility through mineral nutrients is essential not only to harvest higher yields of crops but to maintain the physical, chemical and biological properties of the soil. Therefore, the present study was carried out with objective to study the effect of vermicompost and nutrients on soil properties, yield, uptake and quality of mustard.

MATERIALS AND METHODS

A field experiment was conducted on mustard during the rabi season of 2014-15 at Instructional Farm (Agronomy) of Rajasthan

College of Agriculture, Udaipur (Rajasthan) (24.34^0 N, 73.42^0 E and 579.5 m above mean sea level). The experimental soil was clay loam in texture, alkaline in reaction (pH 8.1) with EC 0.38 dS m^{-1}, organic carbon 5.4 g kg^{-1}, available N 249 kg ha^{-1}, P_2O_5 17 kg ha^{-1}, K_2O 349 kg ha^{-1}, S 7.10 mg kg^{-1}, Zn 0.58 mg kg^{-1} and Fe 4.42 mg kg^{-1}. The experiment was laid out in randomized block design and replicated thrice with three levels of vermicompost [Control (VC_0), 2.5 (VC_1) and 5 (VC_2) t ha^{-1}] and five levels of nutrients (Control 40 kg S ha^{-1} 40 kg S ha^{-1} + 9.5 kg Fe ha^{-1} 40 kg S ha^{-1} + 5 kg Zn ha^{-1} 40 kg S ha^{-1} + 9.5 kg Fe ha^{-1} + 5 kg Zn ha^{-1}). The recommended dose of N, P, and K (60, 40 and 30 kg ha^{-1}) was applied in the field prior to sowing. Whereas, sulphur and vermicompost were applied at the time of sowing of the crop. The quantity of sulphur added through $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$ was equated @ 40 kg S ha^{-1} in respective treatments. The mustard var. Bio-902 was taken as test crop and sown in lines 30 cm apart manually by 'Kera methods'. Usual crop husbandry operations were followed to raise a good crop. Yield from each plot was recorded at maturity. The N, P, K, S, Zn and Fe contents in seed and stover were estimated as per the procedures described by Prasad *et al.* (2006). The uptakes of these nutrients were calculated by multiplication of concentrations with the respective yield (seed and stover) data. After crop harvest the soil samples were analyzed for pH and electrical conductivity, and organic carbon, (Jackson 1973), and available N (Subbiah and Asija 1956) P, K, S (Jackson 1973) and Zn, Fe, Cu and Mn, (Lindsay ans Norvell 1978).

RESULTS AND DISCUSSION

Effect of Vermicompost

Yield

The increasing levels of vermicompost significantly increased the seed and stover yield of mustard (Table 1). The highest values of seed and stover yield (1.68 and 4.16 t ha^{-1}) were recorded in 5 t vermicompost ha^{-1}. Application of 5 t vermicompost ha^{-1} significantly increased the seed and stover yield by 47.4 and 41.5 % as compared to control. It is an established fact that vermicompost improves the physical and biological properties of soil including supply of almost all the essential plant nutrients for the growth and development of plants. Thus, balanced nutrition under favourable environment might have helped in production of new tissues and development of new shoots. The beneficial effect of vermicompost on these parameters might also be due to its contribution in supplying additional plant nutrients and increasing the availability of native soil nutrients due to increased microbial activity. Another reason could be efficient and greater partitioning of metabolites and adequate location of nutrients to developing plant structures. As a result almost all growth and yield of crop resulted into significant improvement due to application of vermicompost. These results are in agreement with those of Kansotia *et al.* (2013) and Singh *et al.* (2014).

Uptake of nutrients

The data (Table 1) revealed that the concentration and uptake of N, S, Zn and Fe in seed and stover and oil content of mustard increased significantly with increasing levels of vermicompost. The highest concentration (3.40 and 0.67 %) and (57.6 and 28.0 kg ha^{-1}), S (0.91 and 0.48 % and 15.4 and 20.0 kg ha^{-1}), Zn (38.9 and 15.69 mg kg^{-1} and 664.0 and 656.3 g ha^{-1}); and Fe (162.0 and 167.3 mg kg^{-1} and 2749.4 and 6978.4 g ha^{-1}) in seed and stover and oil content (39.13 %) was found in 5 t vermicompost ha^{-1}. The positive influence of vermicompost was due to adequate supply of nutrients in root zone and plant system. The increased availability of these nutrients in the root zone coupled with increased metabolic activity at cellular levels might have synthesized more nutrients and their accumulation in various plant parts. Thus crop supplied with higher dose of vermicompost had utilized more nutrients as compared to lower doses resulting in increased nitrogen, phosphorus, potassium and sulphur content in seed and stover. The increased uptake of these nutrients seems to be due to the fact that uptake of nutrient is a product of biomass and nutrient content. These results are in agreement with those of Jat *et al.* (2012) and Kansotia *et al.* (2013). The increase in content of Zn and Fe with application of vermicompost might be due to increased availability of native micronutrient cations. This is due to transformation of their solid phase form to soluble metalo-complexes and the application of micronutrients increased their contents. The results obtained in the present investigation are in close conformity with those of Samant (2015).

Table 1: Effect of vermicompost and nutrients on yield, N, S, Zn and Fe content in seed and stover of mustard

Treatment	Yield (t ha^{-1})		N (%)		S (%)		Zn (mg kg^{-1})		Fe (mg kg^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Vermicompost (t ha^{-1})										
0.0	1.14	2.94	3.07	0.61	0.83	0.43	35.6	14.3	151.3	159.7
2.5	1.48	3.71	3.26	0.65	0.88	0.47	37.3	15.1	157.2	163.7
5.0	1.68	4.16	3.40	0.67	0.91	0.48	38.9	15.6	162.0	167.3
S.Em+	0.03	0.09	0.02	0.004	0.005	0.003	0.19	0.11	0.88	0.56
CD (P=0.05)	0.08	0.26	0.06	0.011	0.016	0.008	0.57	0.31	2.54	1.63
Nutrients (kg ha^{-1})										
Control	1.09	2.85	3.09	0.61	0.81	0.42	34.6	14.0	149.0	157.9
40 kg S ha^{-1}	1.34	3.38	3.19	0.64	0.87	0.46	35.6	14.7	152.5	160.5
40 S+9.5 Fe ha^{-1}	1.49	3.77	3.26	0.65	0.88	0.47	37.8	15.1	153.8	161.3
40kg S+5kg Zn ha^{-1}	1.54	3.80	3.30	0.65	0.89	0.47	38.5	15.5	162.9	167.9
40 S+9.5 Fe+5 Zn ha^{-1}	1.72	4.21	3.38	0.67	0.91	0.49	40.0	15.8	166.2	170.3
S.Em+	0.04	0.11	0.03	0.005	0.007	0.003	0.25	0.13	1.13	0.73
CD (P=0.05)	0.11	0.33	0.08	0.015	0.02	0.01	0.74	0.39	3.28	2.11

Quality

The oil content of mustard seed was significantly higher under application of 5 t vermicompost ha^{-1} over control. It might be due to the unique role of organic matter in improving the nutritional environment of rhizosphere via improvement in nutrient availability. Thus, the balanced nutrient uptake by plant owing to enhanced level of vermicompost probably favoured enzymic activities responsible for oil synthesis. These results are in agreement with those of Kansotia *et al.* (2013) who had reported increased oil content of mustard due to application of 6 t vermicompost ha^{-1}.

Table 2: Effect of vermicompost and nutrients on N, S, (kg ha^{-1}) Zn and Fe (g ha^{-1}) uptake in seed and stover and oil content (%) of mustard

Treatment	Nitrogen		Sulphur		Zinc		Iron		Oil content (%)
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed
Vermicompost (t ha^{-1})									
0.0	35.2	17.9	9.5	12.8	410.8	425.0	1740.6	4720.3	37.37
2.5	48.5	24.1	13.0	17.4	556.7	563.5	2341.1	6088.5	38.57
5.0	57.6	28.0	15.4	20.0	664.0	656.3	2749.4	6978.4	39.13
S.Em+	1.06	0.62	0.27	0.44	11.90	14.58	50.08	144.49	0.38
CD (P=0.05)	3.08	1.78	0.79	1.28	34.46	42.23	145.08	418.57	1.09
Nutrients (kg ha^{-1})									
Control	34.0	17.5	8.9	11.9	380.9	402.5	1639.6	4525.2	36.75
40 kg S ha^{-1}	42.9	21.5	11.7	15.5	479.1	498.3	2048.8	5429.8	38.22
40 S+9.5 Fe ha^{-1}	48.6	24.5	13.1	17.7	565.2	574.4	2298.1	6098.8	38.41
40kg S+5kg Zn ha^{-1}	51.3	24.8	13.8	18.1	598.0	595.7	2527.2	6401.8	38.47
40 S+9.5 Fe+5 Zn ha^{-1}	58.6	28.2	15.8	20.5	695.8	670.4	2871.4	7189.7	39.93
S.Em+	1.37	0.79	0.35	0.57	15.36	18.8	64.6	186.5	0.49
CD (P=0.05)	3.98	2.30	1.02	1.65	44.51	54.5	187.2	540.3	1.40

Soil Properties

The data (Table 3) showed that the pH and electrical conductivity of the post harvest soil decreased significantly with increasing levels of vermicompost. The maximum pH (8.25) and EC (0.66 dS m^{-1}) was obtained under the control while minimum with 5 t vermicompost ha^{-1}. The decrease in pH and EC of soil with the application of vermicompost is due to the fact that production of organic acids on decomposition of organic matter and improvement in soil aggregation might have resulted in to lowering of soil pH and EC. These results are in line with Sharma *et al.* (2013) and Kansotia *et al.* (2015) who also reported decreased pH and EC of soil with the application of vermicompost. A perusal of the data (Table 3) reveals that organic carbon, available N, P, K, S, Zn, Fe, Cu and Mn content of soil increased significantly with increasing levels of vermicompost. The maximum organic carbon (8.5 g kg^{-1}), available N (367.5 kg ha^{-1}), P_2O_5 (25.6 kg ha^{-1}), K_2O (459.9 kg ha^{-1}), S (11.3 mg kg^{-1}), Zn (2.09 mg kg^{-1}), Fe (6.09 mg kg^{-1}) , Mn (6.78 mg kg^{-1}) and Cu (2.78 mg kg^{-1}) were observed under 5 t vermicompost ha^{-1} and the minimum under control. It may be ascribed to the beneficial role of vermicompost in mineralization of native as well as its own nutrient content by creating favourable conditions for microbial as well as chemical activities which enhanced the available nutrient pool of the soil. As a matter of fact all the available nutrients are not taken up by the plant and the rest remains in the soil which improves the available nutrient status of soil after harvest of crop. These results are in agreement with those of Jat *et al.* (2012) and Sharma *et al.* (2013).

Table 3: Effect of vermicompost and nutrients on pH, EC, organic carbon, available N, P_2O_5, K_2O, S, Zn, Fe, Mn, and Cu in soil at harvest

Treatments	pH	EC (dSm^{-1})	Org. carbon (g kg^{-1})	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})	Avail. S (mg kg^{-1})	Avail. Zn (mg kg^{-1})	Avail. Fe (mg kg^{-1})	Avail. Mn (mg kg^{-1})	Avail. Cu (mg kg^{-1})
Vermicompost (t ha^{-1})											
0.0	8.25	0.66	6.50	297.0	17.6	382.5	8.1	0.78	4.43	5.45	1.97
2.5	8.17	0.61	7.40	322.7	21.6	403.6	9.4	1.66	5.07	6.29	2.47
5.0	8.13	0.54	8.50	367.5	25.6	459.9	11.3	2.09	6.09	6.78	2.78
S.Em+	0.02	0.01	0.2	3.10	0.21	4.63	0.15	0.004	0.06	0.05	0.04
CD (P=0.05)	0.07	0.04	0.5	8.97	0.62	13.42	0.44	0.011	0.17	0.15	0.13
Nutrients (kg ha^{-1})											
Control	8.24	0.56	6.90	276.1	18.0	378.8	7.1	0.79	4.44	5.44	1.99
40 kg S ha^{-1}	8.21	0.60	7.40	328.4	20.0	399.3	8.4	1.26	5.49	6.12	2.34
40 S+9.5 Fe ha^{-1}	8.19	0.61	7.60	337.0	22.2	416.2	10.5	1.59	5.86	6.24	2.44
40kg S+5kg Zn ha^{-1}	8.15	0.63	7.70	346.0	22.7	432.0	10.6	1.81	5.65	6.36	2.57
40 S+9.5 Fe+5 Zn ha^{-1}	8.13	0.63	7.80	357.7	25.0	450.5	11.4	2.15	6.22	6.71	2.72
S.Em+	0.03	0.02	0.2	4.0	0.27	5.9	0.19	0.005	0.08	0.07	0.06
CD (P=0.05)	NS	NS	NS	11.6	0.79	17.3	0.56	0.014	0.22	0.19	0.17

Effect of Nutrients

Yield

The data (Table 1) revealed that the seed and stover yield of mustard increased significantly with nutrients. The highest values of seed and stover yield (1.72 t ha^{-1} and 4.21 t ha^{-1}) were recorded 40 kg S ha^{-1} + 9.5 kg Fe ha^{-1} + 5 kg Zn ha^{-1}. This treatment significantly increased seed and stover yield by 57.7 and 47.7 % as compared to control. The application of nutrients alone or in combination increased the yield attributes and yield of mustard, but the response was more when more number of nutrients was applied. This may be due to the fact that applications of fertilizer alone have supplied only one or two nutrients, but conjoint use of macro and micronutrient fertilizers have provided all the essential nutrients in proper amount, required by the plant for its growth and development. Application of more nutrients through fertilizers resulted into more yield attributes and yield of mustard crop. This might be due to the cumulative effect of all the nutrients and also due to low status of respective nutrients in experimental field. Similar, results have also been reported in mustard by Dubey *et al.*, (2013), Kumar *et al.,* (2014) and Solanki and Sharma (2016).

Uptake of nutrients

An examination of data (Table 1 and 2) revealed that application of nutrients significantly increased the concentration and uptake of N, S, Zn and Fe in seed and stover of mustard as compared to control. The highest concentration and uptake of N (3.38 and 0.67 % and 58.6 and 28.2 kg ha^{-1}), S (0.91 and 0.49 % and 15.8 and 20.5 kg ha^{-1}), Zn (40.0 and 15.8 mg kg^{-1} and 695.8 and 670.4 g ha^{-1}); and Fe (166.2 and 170.3 mg kg^{-1} and 2871.4 and 7189.7 g ha^{-1}) in seed and stover was found with 40 kg S ha^{-1} + 9.5 kg Fe ha^{-1} + 5 kg Zn ha^{-1}. Similar, finding was also observed by Kumar *et al.* (2014). The increase in sulphur uptake seemed to be associated with increased its availability with sulphur application. The increase in uptake of micronutrients may be attributed to increased seed and stover yields with the application of different nutrient combinations. Similar findings were also observed by Kumar *et al.* (2014).

Quality

The oil content of mustard seed also increased significantly with application of different nutrients. The maximum value of oil content (39.93%) was recorded with 40 kg S + 9.5 kg Fe + 5 kg Zn ha^{-1}. It might be because sulphur is recognized as integral parts of oil, the increased availability of S due to application of different nutrients in the soil have favourable effect on synthesis of essential metabolites responsible for higher oil content. Similar results have also been reported in mustard by Karthikeyan and Shukla (2008).

Soil properties

A perusal of the data (Table 3) showed that pH, electrical conductivity and organic carbon in soil were not affected significantly with application of nutrients. But, the status of available N, P, K, S, Zn, Fe, Cu and Mn in post harvest soil was also influenced significantly due to nutrients application (Table 3) and maximum values were observed under 40 kg S + 9.5 kg Fe + 5 kg Zn ha^{-1} and the minimum under control. The favourable soil pH and nutrient availability conditions also enhance the microbial activity in the soil which might cause the increased availability of nutrients. Such results were also indicated by Jat *et al.* (2012). The higher sulphur content in soil could be attributed to a greater mineralization of organic sulphur and release of SO_4^{2-} ions on its gradual oxidation. Similar, results were also reported by Badiyala and Chopra (2011). Liberation of acids from applied sulphur and its consequent dissolution effect might be the reasons for increased availability of micronutrients in the soil Jat *et al.* (2012).

Table 4: Interactive effect of vermicompost and nutrients on zinc and iron uptake of mustard

Treatments	Vermicompost (t ha^{-1})					
	0	2.5	5.0	0	2.5	5.0
	Zinc uptake (g ha^{-1})			Iron uptake (g ha^{-1})		
Control	306.4	409.4	427.0	1338.3	1748.2	1832.37
40 kg S ha^{-1}	365.7	510.7	560.9	1586.5	2167.5	2392.52
40 S+9.5 Fe ha^{-1}	416.3	570.6	708.8	1714.4	2301.2	2878.65
40kg S+5kg Zn ha^{-1}	469.9	595.3	728.8	1941.4	2560.3	3079.92
40 S+9.5 Fe+5 Zn ha^{-1}	495.6	697.3	894.6	2122.5	2928.1	3563.69
S.Em$\pm$		26.6			111.9	
CD (P=0.05)		77.0			324.3	

Interaction

The data (Table 4) showed that irrespective the levels of nutrients, the increasing levels of vermicompost enhanced the Zn and Fe uptake in seed significantly. Similarly, irrespective of the levels of vermicompost the nutrients significantly enhanced the Zn and Fe uptake in seed. The combined application of 5 t vermicompost ha^{-1} and 40 kg S ha^{-1} + 9.5 kg Fe ha^{-1} + 5 kg Zn ha^{-1} gave significantly highest Zn uptake in seed (894.6 g ha^{-1}) and Fe uptake in seed (3563.6 g ha^{-1}) as compared to all other combination of vermicompost and nutrients. The combined application of vermicompost and nutrients improved the nutrient uptake mainly due to better growth and seed production. The balanced nutrition also enhanced the synergistic effect on uptake of other plant nutrients.

It may be concluded from the results that, the application of vermicompost significantly improved the physical and chemical properties of soil. However, inorganic fertilizers application could not influence the physical properties and status of organic carbon of soil but had significant effect on residual fertility of soil and yield of crop. The combined application of 5 t vermicompost ha^{-1} and 40 kg S + 9.5 kg Fe + 5 kg Zn ha^{-1} was found to be optimum for Fe and Zn uptake in mustard seed grown in clay loam soils.

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