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RESEARCH PAPER

Effect of vermicompost and micronutrients fertilization on the growth, yield and nutrients uptake by sesame (*Sesamum indicum* L.) in coastal saline soil

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Abstract : A field experiment was conducted in the farmer's field during January-April 2015, to study the effect of vermicompost and micronutrients fertilization on the growth, yield and nutrients uptake by sesame in coastal saline soil. Texturally, the experimental soil was sandy and taxonomically classified as *Typic Udipsamments* with initial soil characteristics (0-15 cm layer) of the experimental site were, pH–8.37 and EC–1.58 dS m^{-1}. The soil registered low organic carbon status of 2.31 g kg^{-1}, 134.56 kg ha^{-1} of alkaline $KMnO_4$–N; 9.43 kg ha^{-1} of Olsen–P and 159.31 kg ha^{-1} of NH_4OAc-K, respectively. The DTPA extractable Zn and Mn was 0.69 mg kg^{-1} and 0.94 mg kg^{-1}, respectively. The various treatments imposed in the study included T_1–Control (RDF alone), T_2–RDF + vermicompost (VC) @ 5 t ha^{-1}, T_3–RDF + $ZnSO_4$ @ 25 kg ha^{-1} soil application (SA) + $MnSO_4$ @ 5 kg ha^{-1} (SA), T_4–RDF + $ZnSO_4$ @ 0.5% foliar application (FA) + $MnSO_4$ @ 0.5% (FA), T_5–RDF + ($ZnSO_4$ + $MnSO_4$) SA + ($ZnSO_4$ + $MnSO_4$) FA, T_6–RDF + VC ($ZnSO_4$ + $MnSO_4$) SA, T_7–RDF + VC + ($ZnSO_4$ + $MnSO_4$) FA, T_8– RDF + VC + ($ZnSO_4$ + $MnSO_4$) SA + ($ZnSO_4$ + $MnSO_4$) FA, T_9– RDF+VC + (50% $ZnSO_4$ + 50% $MnSO_4$) SA and T_{10}–RDF + VC + (50% $ZnSO_4$ + 50% $MnSO_4$) SA+($ZnSO_4$ + $MnSO_4$) FA @ 0.5 per cent. The experiment was carried out in a Randomized Block Design (RBD) with three replications and tested with sesame var. TMV 7 as test crop. The results of the study clearly indicated that the combined application of RDF + VC + 50% recommended $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil application along with foliar spray of $ZnSO_4$ + $MnSO_4$ twice @ 0.5 per cent significantly increased the growth, yield and nutrient uptake by sesame. This treatment recorded the highest seed and stalk yield of 792 kg ha^{-1} and 1713 kg ha^{-1} which was 45.32 and 36.77 per cent increased seed and stalk yield, respectively over recommended dose of fertilizer alone (RDF).

Key Words : Coastal saline soil, Vermicompost, RDF, Zinc, Manganese, Soil application, Foliar application, Sesame, Yield, Uptake

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INTRODUCTION

The Indian coastal region stretching over a length of 8129 km long, over the eastern and western border are severely degraded and, pose serious problems for

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agricultural production. Out of 10.78 M ha of land under coastal agro ecosystem in India, there exist 3.1 M ha of coastal saline soil and nearly 2.04 L ha in Tamil Nadu (Dhanushkodi and Subramaniyan, 2012). Almost the entire coastal tracts suffer from soil salinity, sodicity and seawater intrusion which resulted in the low productivity of crops. Nearly one billion people in the world live along the coastline and contribute to the national economy to a significant extent through farming. Soil salinity hampers crop production in the coastal ecosystem to greater extent.

Soil fertility is the most limiting factor for crop production in coastal saline soil. Coarse textured soils have several soil problems *viz.*, light texture, poor exchange property, nutrient and water retention capacity, low status of soil organic carbon and deficiency of both macro and micronutrients. These problems severely affect the productivity of sesame in this region. Even the applied nutrients are leached to the sub surface soil. Coastal salt affected soils are most commonly suffered due to zinc deficiency. Boron, iron, manganese and copper are also deficient in some locations. Zinc and manganese plays an important role in various enzymatic activities in the growth and development of sesame production. It is now established that micronutrient deficiency is the prime factor responsible for that low productivity of sesame in coastal areas. Hence, inclusion of micronutrient fertilizer in the fertilization programme becomes an imperative need to improve the yield of crops. It is more vivid that application of organic manure along with micronutrients fertilization sustain soil health and crop productivity in coastal saline soil. Therefore, the present investigation was carried out to study the effect of vermicompost along with Zn and Mn on the growth yield and nutrient uptake by sesame.

MATERIAL AND METHODS

A field experiment was conducted in the farmer's field at Maanampaadi coastal village, near Chidambaram in Cuddalore district, during January-April, 2015 using sesame variety TMV 7 as test crop. The experimental soil was sandy in texture and taxonomically classified as *Typic Udipsamments* with pH-8.37, EC-1.58 dS m^{-1} and represented low status of organic carbon (2.31 g kg^{-1}). The soil analysed low in alkaline $KMnO_4$–N (134.56 kg ha^{-1}) and Olsen-P (9.43 kg ha^{-1}) and medium in NH_4OAc-K (159.31 kg ha^{-1}). The DTPA extractable Zn and Mn was 0.69 mg kg^{-1} and 0.94 mg kg^{-1}, respectively. The various treatments included were, T_1– Control (RDF alone), T_2–RDF + vermicompost (VC) @ 5 t ha^{-1}, T_3–RDF + $ZnSO_4$ @ 25 kg ha^{-1} soil application (SA) + $MnSO_4$ @ 5 kg ha^{-1} (SA), T_4–RDF + $ZnSO_4$ @ 0.5% foliar application (FA) + $MnSO_4$ @ 0.5% (FA), T_5–RDF + ($ZnSO_4$ + $MnSO_4$) SA + ($ZnSO_4$ + $MnSO_4$) FA, T_6–RDF + VC ($ZnSO_4$ + $MnSO_4$) SA, T_7–RDF + VC + ($ZnSO_4$ + $MnSO_4$) FA, T_8– RDF + VC + ($ZnSO_4$ + $MnSO_4$) SA + ($ZnSO_4$ + $MnSO_4$) FA, T_9– RDF+VC + (50% $ZnSO_4$ + 50% $MnSO_4$) SA and T_{10}–RDF + VC + (50% $ZnSO_4$ + 50% $MnSO_4$) SA + ($ZnSO_4$ + $MnSO_4$) FA @ 0.5 per cent. The experiment was carried out in a Randomized Block Design (RBD) with three replications. A fertilizer recommendation of 35:23:23 kg of N:P_2O_5:K_2O per hectare was applied to all experimental plots uniformly. Half of the N and entire P_2O_5 and K_2O were applied as basal and the remaining half dose of N was applied in two splits at flowering and capsule formation stage. Vermicompost (VC) @ 5 t ha^{-1} were applied basally and well incorporated into the soil as per the treatment schedule. Required quantities of $ZnSO_4$ and $MnSO_4$ were applied either through soil or foliar spray and or both as per the treatment schedule. Foliar application of $ZnSO_4$ and $MnSO_4$ @ 0.5 per cent in each at pre- flowering stage (PFS) and at flowering stage (FS) was applied as per the treatment. Various growth components like plant height, dry matter production (DMP) and number of branches $plant^{-1}$ at different critical stages of crop growth *viz.*, flowering, capsule formation and at harvest and yield components *viz.*, number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$ and 1000 seed weight were recorded at harvest stage. The seed and stalk samples were collected at harvest stage and analysed for the content of N, P, K, Zn and Mn using the standard procedure as outlined by Jakcson (1973) and uptake were calculated. The yield of seeds and stalk yield were recorded separately and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth characters :

The application of micronutrients either through soil or foliage along with organics and recommended dose of fertilizer (RDF) significantly and positively influenced the growth characters *viz.*, plant height, number of

branches per plant and dry matter production at different growth stages of sesame. Among the various treatments, the treatment (T_8), combined application of recommended dose of NPK + vermicompost (VC) @ 5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} through soil application along with foliar application of $ZnSO_4$ @ 0.5% + $MnSO_4$ @ 0.5 per cent twice at pre-flowering stage (PFS) and at flowering stage (FS) recorded the highest plant height (139.65 cm), number of branches $plant^{-1}$ (12.10), dry matter production (2079 kg ha^{-1}) at harvest stage, respectively (Table 1). However, it was found to be at par with RDF + VC + 50% $ZnSO_4$ + 50% $MnSO_4$ through soil application and foliar application of $ZnSO_4$ and $MnSO_4$ @ 0.5% (T_{10}), which recorded the plant height (137.34 cm), number branches $plant^{-1}$ (11.90) and dry matter production (2060 kg ha^{-1}) at harvest stage, respectively. This was followed by T_6, which received the application of RDF + VC + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (soil application). However, this was comparable with RDF + VC + 50% $ZnSO_4$ + 50% $MnSO_4$ through soil application (T_9). This was followed by the treatments significantly arranged in the descending order like $T_7 > T_5 > T_3 > T_4$ and T_2. The control (without micronutrients and organics) produced the shortest plants over all other treatments.

In coastal saline soil, combined application of recommended dose of NPK + vermicompost (VC) @ 5 t ha^{-1} + 50% recommended dose of $ZnSO_4$ @ 12.5 kg ha^{-1} + $MnSO_4$ @ 2.5 kg ha^{-1} through soil application along with foliar application of $ZnSO_4$ + $MnSO_4$ @ 0.5 per cent twice at pre flowering stage (PFS) and at flowering stage (FS) was significantly increasing plant height, number of branches $plant^{-1}$ and dry matter production. This might be due to micronutrient fertilization along with organics which enhanced plant growth, increased plant metabolites and encouraged the growth of micro-organisms as well as organic matter. Further, the presence of organic manure may be tended to supplement nutrients continuously to the growing plants. These results are in conformity with Subramaniyan *et al*. (1999) and Habbasha *et al*. (2007).

In addition, foliar application of $ZnSO_4$ and $MnSO_4$ might have improved the fundamental cell processes like photosynthesis and respiration. The presence of micronutrients in chloroplasts, cell organells was considered for the possible causes of increased growth characters of plants. Further, this was led to an increase in various plant metabolites responsible for cell division and elongation (Imayavaramban *et al*., 2002). The increase in number of branches may be due to higher nutrient use efficiency, N-physiological efficiency and photosynthetic rates (Jayasingh, 2002), whereas, dry matter accumulation increase might be due to increased plant height, number of branches $plant^{-1}$, greater nutrient availability and increase in photosynthetic rate. The result obtained was in accordance with the similar findings of Karthikraja (2012).

Yield characters :

The application of zinc and manganese either through soil or foliage along with recommended dose fertilizer (RDF) and organics (VC) significantly and

Table 1 : Effect of vermicompost and micronutrients fertilization on the growth characters of sesame

Treatments	Plant height (cm)			Number of branches $plant^{-1}$			Dry matter production (kg ha^{-1})		
	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS
T_1	27.74	39.04	75.97	4.44	5.19	6.15	477	815	1127
T_2	32.76	46.99	85.78	4.95	5.81	7.09	538	913	1256
T_3	40.23	60.13	102.55	5.71	6.80	8.67	652	1081	1511
T_4	37.13	53.81	94.10	5.39	6.32	7.99	597	1005	1390
T_5	44.44	65.69	110.96	6.12	7.23	9.56	726	1162	1649
T_6	54.67	78.51	130.08	7.02	8.34	11.25	872	1337	1941
T_7	48.35	71.58	119.74	6.48	7.73	10.40	795	1248	1786
T_8	60.31	85.41	139.65	7.62	8.94	12.10	940	1436	2079
T_9	53.24	76.54	127.62	6.87	8.17	11.07	856	1326	1915
T_{10}	59.19	83.72	137.34	7.50	8.83	11.90	928	1418	2060
S.E.±	1.38	1.96	3.01	0.14	0.18	0.26	23.62	35.00	51.33
C.D. (P=0.05)	2.91	4.12	6.33	0.30	0.39	0.54	49.6	73.5	107.8

positively influenced the yield characters *viz*., number of capsules plant^{-1}, number of seeds capsule^{-1} and 1000 seed weight of sesame. However, the combined addition of organics and micronutrients (Zn + Mn) by both soil and foliage recorded the better response in respect of yield characters than sole application. Among the various treatments, combined application of recommended dose of NPK + vermicompost @ 5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} through soil application as well as foliar spray ($ZnSO_4$ + $MnSO_4$) @ 0.5 per cent twice at flowering and capsule formation stage (T_8) recorded the highest number of capsules plant^{-1} (53.11), number of seeds capsule^{-1} (58.74) and 1000 seed weight (3.35 g), respectively (Table 2). However, it was found to be equally efficacious with application of RDF + 50 per cent $ZnSO_4$ @ 12.5 kg ha^{-1} and $MnSO_4$ @ 2.5 kg ha^{-1} through soil application along with foliar spray @ 0.5 per cent + VC @ 5 t ha^{-1} (T_{10}) which recorded number of capsules plant^{-1} (52.21), number seeds capsule^{-1} (57.72) and 1000 seed weight (3.31 g), respectively. This was followed by the treatment $T_{6,}$ supplied with RDF + VC @ 5 t ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (SA) through soil application recorded number of capsules plant^{-1} of 49.99, number seeds capsule^{-1} of 54.68 and 1000 seed weight of 3.15 g, respectively. This was closely on par with treatment supplied with recommended NPK + VC along with 50% $ZnSO_4$ + 50% $MnSO_4$ (SA) through soil application (T_9). Based on the yield characters of sesame the treatments are significantly arranged in ascending order $T_1 < T_2 < T_4 < T_3 < T_5$ and $T_{7.}$ The lowest number of capsules plant^{-1} (34.25), number of seeds capsule^{-1} (34.60) and 1000 seed weight (2.10g) was recorded in the treatment T_1, (without micronutrients and organics).

The increase in yield attributes of sesame might be due to sustained release of nutrient from conjunctive use of NPK along with micronutrients and organics sources of nutrient (Elayaraja, 2015). In addition, response of sesame to micronutrient application of $ZnSO_4$ and $MnSO_4$ through soil and foliar along with RDF and organics significantly increased the yield attributes may be ascribed to better nutrient availability of soils (Chaurasia *et al*., 2009). Further, the addition of organic manure namely vermicompost in these treatments and their subsequent decomposition in soil released the plant nutrients slowly throughout the crop growth and thus, improved all the yield characters of sesame. Similar findings were also reported by Duhoon *et al*. (2004).

Yield :

The sesame responded well for the micronutrients application. The significant influence of micronutrient fertilization (zinc + manganese) along with recommended NPK and organics in increasing the seed and stalk yield of sesame was well documented in the present study. The yield realised under the nutrient poverished coastal saline soil, the highest seed yield (812 kg ha^{-1}) and stalk yield (1732 kg ha^{-1}) was recorded with combined application of recommended dose of fertilizer (RDF) + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (SA) through soil as well as foliar spray of $ZnSO_4$ @ 0.5% + $MnSO_4$ @ 0.5 per cent twice at pre flowering and flowering stage along with VC @ 5 t ha^{-1} (T_8) (Table 2). This was at par with application of RDF + 50% $ZnSO_4$ + 50%

Table 2: Effect of vermicompost and micronutrients fertilization on the yield characters and yield of sesame

Treatments	Number of capsules plant^{-1}	Number of seeds capsule^{-1}	1000 seed weight (g)	Yield (kg ha^{-1})	
				Seed	Stalk
T_1	34.25	34.60	2.10	433	1083
T_2	37.59	37.93	2.39	491	1182
T_3	40.82	44.07	2.61	581	1348
T_4	32.59	41.08	2.44	532	1266
T_5	43.81	47.43	2.76	626	1431
T_6	49.99	54.68	3.15	743	1630
T_7	46.44	50.54	2.90	683	1523
T_8	53.11	58.74	3.35	812	1732
T_9	48.98	53.62	3.07	734	1608
T_{10}	52.21	57.72	3.31	792	1713
S.E.±	0.98	1.22	0.06	18.40	37.88
C.D. (P=0.05)	2.07	2.57	0.13	38.66	79.54

$MnSO_4$ (SA) through soil application and foliar application of $ZnSO_4$ @ 0.5% + $MnSO_4$ @ 0.5 per cent + VC @ 5 t ha^{-1} (T_{10}). This was followed by the treatments T_6, (RDF + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (SA) + VC @ 5 t ha^{-1}) and T_9 (RDF + 50% $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil application along with VC. The treatments T_6 and T_9 were found to be at par with each other. This was followed by the treatment T_7, (RDF+ VC + $ZnSO_4$ + $MnSO_4$ through foliar application). Application of micronutrients (Zn and Mn) either through soil or foliar alone along with RDF and organics applied treatments significantly increased the yield of sesame as compared to control. Application of recommended dose of NPK along with micronutrients application both soil ($ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}) and foliar ($ZnSO_4$ + $MnSO_4$ @ 0.5%) alone with out organics (T_5) significantly increased the seed and stalk yield to 626 and 1431 kg ha^{-1}, respectively as compared to application of micronutrients either through soil (T_3, RDF + $ZnSO_4$ + $MnSO_4$) or foliar alone (T_4, RDF + $ZnSO_4$ + $MnSO_4$).

Among the various treatments, the treatment (T_8), recommended dose of NPK + vermicompost along with micronutrients through soil ($ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}) and foliar ($ZnSO_4$ @ 0.5% + $MnSO_4$ @ 0.5 %) application recorded a seed and stalk yield of 812 and 1732 kg ha^{-1} which was 46.67 and 37.47 per cent increase over 100 per cent NPK (RDF alone). This treatment was closely at par with the treatment which received RDF + VC + 50% $ZnSO_4$ + 50% $MnSO_4$ through soil as well as foliar spray of $ZnSO_4$ + $MnSO_4$ @ 0.5% (T_{10}). The treatment RDF along with vermicompost and $ZnSO_4$ + $MnSO_4$ both soil and foliar application registered a seed and stalk yield of 792 and 1713 kg ha^{-1} which was 45.32 and 36.77 per cent increase over control.

The overall improvement in yield attributing characters of sesame was obtained with application of zinc + manganese through soil as well as foliar spray along with vermicompost and recommended dose of NPK. Supply of both macro and micronutrients play a major role in physiological activities of sesame. Further, the betterment of yield characters might be ascribed to the effect of Zn and Mn which enhanced the photosynthetic activity resulting in the higher biomass production and accumulation of carbohydrates and essential auxins which enhanced the growth and yield of sesame. Similar results were reported by Yadav *et al.* (2009) and Ravi and Channal (2010). Further, foliar application of micronutrients through Zn and Mn at pre flowering and flowering stages of crop growth were effectively absorbed in the plant system and translocated into sink which resulted in more number of seeds capsule^{-1}. Further, increased in photosynthesis during growth stages might be contributed for greater assimilates supply to the capsules which resulting in better seed setting and also betterment of higher seed yield of sesame. The results are in conformity with those of Prakash *et al.* (2003).

Major nutrients (NPK) uptake :

The uptake of NPK was significantly influenced

Table 3: Effect of vermicompost and micronutrients fertilization on the major nutrients uptake (kg ha^{-1}) by sesame

Treatments	Nitrogen				Phosphorus				Potassium			
	FS	CFS	HS		FS	CFS	HS		FS	CFS	HS	
			Seed	Stalk			Seed	Stalk			Seed	Stalk
T_1	9.85	20.50	18.65	14.76	2.01	3.21	2.87	4.38	13.42	21.65	7.45	16.26
T_2	11.28	23.06	21.90	17.97	2.29	3.66	3.54	5.18	15.77	24.93	8.54	20.27
T_3	14.33	27.32	27.18	23.66	2.69	4.28	4.40	6.23	19.66	30.76	10.67	26.65
T_4	12.64	25.10	24.89	20.98	2.51	3.98	3.99	5.73	17.87	27.95	9.66	24.16
T_5	15.81	29.16	29.36	26.09	3.07	4.69	4.79	7.02	21.80	33.75	12.43	29.86
T_6	20.13	34.19	35.88	32.39	3.58	5.56	5.78	8.19	26.65	40.31	15.93	36.76
T_7	17.56	31.10	32.31	28.80	3.35	5.06	5.23	7.50	23.84	36.56	14.30	32.93
T_8	22.36	37.34	39.25	35.48	3.79	5.96	6.24	8.84	29.45	43.83	17.20	40.20
T_9	19.44	33.23	34.94	31.35	3.56	5.44	5.63	8.08	25.77	39.11	15.63	35.72
T_{10}	21.85	36.24	38.20	34.59	3.76	5.86	6.13	8.65	28.54	42.79	16.99	39.29
S.E.±	0.53	0.79	0.88	0.78	0.05	0.12	0.14	0.17	0.72	1.05	0.39	1.00
C.D. (P=0.05)	1.12	1.65	1.84	1.64	0.10	0.25	0.29	0.36	1.51	2.20	0.82	2.12

by the different methods of micronutrients application and organics at all the critical stages *viz.*, flowering, capsule formation and at harvest stages of sesame. Among the various treatments, the application of RDF + VC @ 5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} SA + $MnSO_4$ @ 5 kg ha^{-1} SA along with $ZnSO_4$ and $MnSO_4$ FA @ 0.5 per cent twice (T_8) registered the highest uptake of NPK at all the growth stages (Table 3). However, this was found to be at par with treatment supplied with RDF + VC + 50% $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil and foliar @ 0.5% (T_{10}). This was followed by the treatments T_6 (RDF + VC + $ZnSO_4$ + $MnSO_4$ SA) and treatment T_9 (RDF + VC + 50%$ZnSO_4$ + 50%$MnSO_4$ SA). The treatments T_6 and T_9 recorded a comparable NPK uptake by seed and stalk, respectively. This was followed by treatments are significantly arranged in a descending order like $T_7 > T_5 > T_3 > T_4$ and T_2. The treatment T_1, application of RDF alone (Control) recorded the lowest NPK uptake by seed (18.65, 2.87 and 7.45 kg ha^{-1}) and stalk (14.78, 4.38 and 16.26 kg ha^{-1}), respectively.

The increased NPK uptake by sesame with application of organics along with micronutrients may be due improvement of the soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrients from larger rhizosphere. Moreover, organic manures, during decomposition release nutrients which became available to the plants and thus, increased NPK concentration. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of micronutrient complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of nutrients by crop plants. These results are in parity with the results reported by Salwa *et al*. (2010) and Chesti *et al*. (2015).

Micronutrients (Zn and Mn) uptake :

The effect due to the different methods of micronutrient (zinc + manganese) application along with NPK and vermicompost had significant influence on zinc and manganese uptake by sesame. As like NPK uptake, the highest Zn and Mn uptake by sesame at all the critical stages was recorded with the application of RDF + vermicompost @ 5 t ha^{-1} + $ZnSO_4$ SA @ 25 kg ha^{-1} + $MnSO_4$ SA @ 5 kg ha^{-1} through soil and foliar spray of $ZnSO_4$ + $MnSO_4$ @ 0.5 % (T_8). It recorded a Mn uptake of 275.15 and 172.47 g ha^{-1} by seed and stalk, respectively. However, it was found to be equally efficacious with the treatment T_{10} (RDF + VC + 50% $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil and foliar) and it registered a Mn uptake of 272.26 and 169.92 g ha^{-1} by seed and stalk, respectively (Table 4). A similar trend was also observed with treatments T_6 and T_9. The treatment, T_6 recorded a Mn uptake of 255.01 and 159.11 g ha^{-1} by seed and stalk and T_9, recorded a comparable Mn uptake of 251.59 and 156.05 g ha^{-1} by seed and stalk, respectively. This was followed by the treatments significantly arranged in the descending order like $T_7 > T_5 > T_3 > T_4$ and T_2. The control treatment recorded the lowest Mn uptake at all the critical stages of sesame.

Table 4 : Effect of vermicompost and micronutrients fertilization on the micronutrients uptake (g ha^{-1}) by sesame

Treatments	Zinc				Manganese			
	FS	CFS	HS		FS	CFS	HS	
			Seed	Stalk			Seed	Stalk
T_1	169.03	165.33	119.78	82.98	104.41	137.33	150.27	90.41
T_2	191.18	186.23	137.72	98.71	123.88	158.77	168.85	103.52
T_3	222.19	232.37	167.68	119.14	154.08	195.09	200.96	125.08
T_4	207.28	205.46	153.46	109.93	140.71	177.10	184.22	116.15
T_5	239.22	256.70	184.70	131.15	169.29	210.05	216.84	134.82
T_6	278.32	304.51	221.99	156.01	207.24	247.21	255.01	159.11
T_7	255.96	275.92	199.96	141.93	188.03	228.15	235.10	146.24
T_8	298.52	331.42	241.72	168.53	225.32	269.39	275.15	172.47
T_9	274.21	299.06	217.37	153.35	204.36	244.00	251.59	156.05
T_{10}	294.72	324.72	237.87	165.45	221.93	264.43	272.26	169.92
S.E.±	6.45	8.14	5.79	4.00	5.80	6.43	6.24	3.77
C.D. (P=0.05)	13.54	17.10	12.15	8.41	12.17	13.51	13.10	7.91

Application of different methods of zinc and manganese fertilization recorded the highest micronutrients (Zn and Mn) uptake. The treatment receiving 50% recommended $ZnSO_4$ @12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil as well as foliar spray of $ZnSO_4$ and $MnSO_4$ @ 0.5% along with RDF and vermicompost @ 5 t ha^{-1} registered the highest Zn and Mn uptake. This might be attributed to increase total dry matter production, growth and yield components of sesame. Further, improvement in the availability and higher absorption by sesame resulted in higher uptake of these nutrients. The increased uptake of micronutrients with the Zn and Mn has been well documented by Ravi and Channal (2010). Further, the addition of organic manures resulted in higher micronutrient availability due to mineralization according to Dhok (2013). Organics application could result in release of more micronutrients in easily available form which was reflected in over all growth of the crop plants. These results are in accordance with the earlier reports of Hanumanthappa and Shivaraj (2003).

REFERENCES

Chaurasia, S.K., Neetha, J. and Narmata, J. (2009). Effect of integrated use of fertilizers, organic manures and micronutrients and productivity of sesame (*Sesamum indicum*). *Ann. Agril. Res. New Series*, **30**(3&4): 91-94.

Chesti, M.H., Kohli, A., Mujtaba, A., Sofi, J.A., Nzir Qadri, T., Peer, R.J.A., Dar, M.A. and Bisati, I.A. (2015). Effect of integrated application of inorganic and organic sources on soil properties, yield and nutrient uptake by rice (*Oryza sativa* L.) in intermediate zone of Jammu and Kashmir. *J. Indian Soc. Soil Sci.*, **63**: 88-92.

Dhanushkodi, V. and Subramaniyan, K. (2012). Soil management to increase rice yield in salt affected coastal soil-A review. *Internat. J. Res. Chem. Environ.*, **2**(4): 1-5.

Dhok, Swati (2013). Role of vermicompost and vermiwash as a indictor for enhancement of soil health in sustainable agriculture. *Internat. J. Agril. Sci.*, **9** (1) : 388-391.

Duhoon, S.S., Jyotishi, A., Deshmukh, M.R. and Singh, N.B. (2004). Optimization of sesame (*Sesamum indicum* L.) production through bionatural inputs proceedings of the 4th International Crop Science Congress, Brisbane, Australia, 26 September to 1st October.

Elayaraja, D. (2015). Response of sesame (*Sesamum indicum* L.) to micronutrients and NPK levels on the growth, yield and nutrients uptake in coastal sandy soil. *J. Oilseeds Res.*, **32**(2): 179-182.

Habbasha, S.F., Abd El Salam, M.S. and Kabesh, M.O. (2007). Response of two sesame varieties (*Sesamum indicum* L.) to partial replacement of chemical fertilizer by bio-organics. *Res. J. Agric. Biol. Sci.*, **3**(6): 563-571.

Hanumanthappa, M. and Shivaraj, B. (2003). Effect of organic manures and fertilizer level on yield, yield components and nutrient uptake of sesamum under rainfed condition. *Mysore J. Agril. Sci.*, **37**(2): 144-151.

Imayavaramban, V., Thanunathan, K., Singaravel, R. and Manickam, G. (2002). Studies on the influence of integrated nutrient management on growth yield parameters and seed yield of sesame (*Sesamum indicum*). *Crop Res. (Hison)*, **24**(2): 309-313.

Jakcson, M.L. (1973). *Soil chemical analysis*. Prentice Hall of India Pvt. Ltd., NEW DELHI, INDIA.

Jayasingh, J. (2002). Studies on the effect of foliar application of N, P, K and chelated micronutrients on growth and yield of sesame (*Sesamum indicum* L.) M.Sc. (Ag.) Thesis, Annamalai University, Annamalaingar, Chidambaram, T.N. (INDIA).

Karthikraja, M. (2012). Effect of nipping, growth, retardants and micronutrients on growth and yield of sesame (*Sesamum indicum* L.) cv. TMV 3, M.Sc. (Ag.) Thesis, Annamalai University, Annamalainagar, Chidambaram, T.N. (INDIA).

Prakash, M., Saravana, K., Sunilkumar, B., Jagadeesan, S. and Ganesan, J. (2003). Effect of plant growth regulators and micronutrients on yield attributes of sesame. *Sesame Safflower Newsl.*, **18**: 58-60.

Ravi, S. and Channal, H.T. (2010). Effect of sulphur, zinc and iron on growth yield and nutrients uptake by safflower. *Asian J. Soil Sci.*, **5**(1): 178-181.

Salwa, A.I., Eisa, M., Mohsen, Abass and Behary, S.S. (2010). Amelioration productivity of sandy soil by using amino acids, sulphur and micronutrients for sesame production. *J. Am. Sci.*, **6** (11) : 250-257.

Subramaniyan, K., Sridhar, P. and Arulmozhi, N. (1999). Response of sesame (*Sesamum indicum*) to sulphur and micronutrients with and without farmyard manure under irrigated condition. *Indian J. Agron.*, **44** (4) : 826-829.

Yadav, R.A., Tripathi, A.K. and Yadav, A.K. (2009). Effect of micronutrients in combinations with organic manures on production and net returns of sesame (*Sesamum indicum*) in Bundelkhand tract of Uttar Pradesh. *Ann. Agril. Res. New Series*, **30**(1&2): 53-58.