EFFECT OF VERMICOMPOST AND MICRONUTRIENTS FERTILIZATION ON THE PRODUCTIVITY OF SESAME IN COASTAL SALINE SANDY SOIL

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ABSTRACT : In the coastal areas of Tamilnadu, the deficiency of micronutrients especially zinc and manganese are the most common in coarse textured sandy soils. To study the effect of vermicompost and micronutrients fertilization on the productivity of sesame in coastal saline sandy soil. A field experiment was conducted in a farmer's field at Maanampaadi coastal village, near Chidambaram during February- May, 2016. The experimental soil was sandy in texture and taxonomically classified as *Typic Usticpsaments*. The initial soil had the following 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. The available zinc (0.69 mg kg^{-1}) and manganese content (0.94 mg kg^{-1}) of soil is below the critical level, respectively. The various treatments evaluated were T_1–Control (RDF alone/Farmers practice), 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 with three replications were studied under Randomized Block Design (RBD) using sesame var. TMV 7. The results revealed that, the combined application of recommended dose of NPK + vermicompost @ 5 t ha^{-1} along with 50 per cent recommended dose of $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil and foliar spray of both the micronutrients ($ZnSO_4$ + $MnSO_4$) @ 0.5 per cent twice at critical stages *viz.*, pre flowering and flowering stage was (T_{10}) was significantly superior in increasing the yield, quality, nutrient uptake and economics of sesame.

Key words: Vermicompost, Micronutrients Fertilization, Sesame, Yield, Quality, Uptake, Economics, Coastal Saline Sandy Soil.

INTRODUCTION

Around the world, nearly one billion people live along the 3,12,000 km long coastline. The Indian coastal region stretching over a length of 8,129 km long over the eastern and western border are severely degraded and pose serious problems for agricultural production (Dhanushkodi and Subrahmaniyan, 2012). Tamil Nadu occupies 6,80,622 ha of coastal area constituting 26.8 per cent of the total area of the coastal districts. Coarse textured sandy or sandy loam soil dominates majority of the coastal region. Coastal soils have specific soil constraints *viz.,* light texture, poor exchange property, nutrient and water retention capacity, low status of organic carbon and multinutrient deficiencies. These problems severely affect the productivity of crops in this region. The most part of nutrients applied through fertilizers are also lost through leaching due to poor physical properties associated with poor exchange and low organic carbon status. This has led to low use efficiency of applied fertilizers. The coastal area farmers are cultivating these lands by exploiting traditional management practices and realizing very low yield in most of the crops as compared to other regions. Therefore, it is an imperative need to develop a technology to make the cropping pattern in coastal soil a profitable one. Exploitation of these stressed ecosystems for oilseed cropping will increase the oilseed production to meet out demand due to increasing population arises.

Further, coarse textured coastal sandy soils having the low status of organic matter coupled with poor texture and structure reduces the nutrient holding capacity and the availability of nutrients. The poor retention and also leaching of nutrients in sandy soil necessitates for the increased rate of nutrients application especially NPK in such soil in comparison to other soils. Among the micronutrients, the deficiency of Zn and Mn are common feature of coastal saline soil especially in sesame production. Organic matter helps in increasing adsorptive power of soil for cations, anions and micronutrients. These adsorbed ions are released slowly for the benefit of crop during entire growth period. Organic manures improve the organic carbon status, available primary and secondary nutrients and also supply sufficient amount of micronutrients in available forms (Swati and Dhok, 2013). Realising the key role played, by Zn and Mn in various growth promoting and enzyme activities of crop, the present study was undertaken to find out the influence of vermicompost and zinc and manganese fertilization on the yield, quality, nutrient uptake and economics of sesame in coastal saline sandy soil.

MATERIALS AND METHODS

A field experiment was conducted in the farmer's field during February-May 2016, to study the effect of vermicompost and micronutrients fertilization on the productivity of sesame in coastal saline sandy soil. The various treatments included were T_1–Control (RDF alone/Farmers practice), 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 .The experiment was carried out in a Randomized Block Design (RBD) with three replications and tested with sesame var. TMV 7 as test crop. 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 0.70 mg kg^{-1} and 0.96 mg kg^{-1}, respectively. Calculated amount of inorganic fertilizer doses of Nitrogen (35 kg N ha^{-1}), Phosphorus (23 kg P_2O_5 ha^{-1}) and Potassium (23 kg K_2O ha^{-1}) were applied through urea, super phosphate and muriate of potash, respectively. 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. The plant samples were collected at different critical stages of crop growth and analyzed for major (N, P and K) and micronutrients (Zn and Mn) contents and also analysed oil and protein content of seeds using the procedure as out lined by Jackson (1973). The total uptake of individual nutrients was computed by multiplying the respective nutrient content with DMP. At the harvest stage, the seed and stalk yield were recorded and analysed for the above nutrients and uptake were calculated. The economics were also worked out with economic yield of sesame.

RESULTS AND DISCUSSION

YIELD CHARACTERS OF SESAME

The application of zinc and manganese either through soil or foliage along with recommended dose fertilizer (RDF) and organics (VC) significantly and 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. 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). This was followed by the treatments which received RDF + VC + $ZnSO_4$ + $MnSO_4$ through foliar spray (T_7), RDF + $ZnSO_4$ + $MnSO_4$ (SA + FA) by both soil and foliar application (T_5), RDF + micronutrients ($ZnSO_4$ and $MnSO_4$) through soil (T_3) and foliar alone (T_4). 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.

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. 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 OF SESAME

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). This was on par with application of RDF + 50% $ZnSO_4$ + 50% $MnSO_4$ (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 on par with each other. This was followed by the treatment T_7, (RDF+ VC + $ZnSO_4$ + $MnSO_4$ through foliar application). 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 per cent) 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 on 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 or RDF alone (without micronutrients and organics).

Moreover, the benefits effect of the combined use of organics along with micronutrients might be attributed to the positive impact of availability of all the plant nutrients from manure which facilitated better crop growth. Further the rapid mineralization of N, P and K from recommended dose of inorganic fertilizers and steady supply of these nutrients from vermicompost might have met the nutrient requirement of crop at the different critical stages of crop growth. In addition, the beneficial influence of micronutrients *viz.,* Zn and Mn through activation of various enzymes and basic metabolic rate in plants, facilitated the synthesis of nucleic acids and hormones, which in turn enhanced the seed yield due to greater availability of nutrients and photosynthates. These results are in agreement with those of Swati and Dhok, (2013) and Elayaraja (2016).

QUALITY CHARACTERS OF SESAME

Oil and Protein content

The influence of different methods of micronutrients (zinc and manganese) fertilization along with vermicompost and NPK treatments in altering the quality parameters *viz*., oil and protein content of sesame seeds was not statistically significant.

Oil and Protein yield

The micronutrient fertilization through soil + foliar application of zinc + manganese along with organics and recommended dose of NPK exerted a significant influence on protein and oil yield of sesame. Among the treatments, the application of recommended dose of NPK fertilizer + VC @ 5 t ha^{-1} along with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} and foliar application of $ZnSO_4$ @ 0.5% + $MnSO_4$ @ 0.5 per cent twice (T_8) registered a significantly higher oil (399.66 kg ha^{-1}) and protein yield (213.96 kg ha^{-1}) of sesame seed. This was comparable with treatment which received RDF + VC along with $ZnSO_4$ + $MnSO_4$ 50% (SA) through soil and $ZnSO_4$ + $MnSO_4$ @ 0.5% foliar spray (T_{10}) it recorded the protein and oil yield of 390.29 and 210.67 kg ha^{-1}, respectively. This was followed by the application of RDF + VC @ 5 t ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1} and $MnSO_4$ @ 5 kg ha^{-1} (SA) through soil application (T_6) recorded the highest oil and protein yield of sesame seed. However, it was found to be comparable with the treatment T_9, (RDF + VC @ 5 t ha^{-1} + 50% $ZnSO_4$ @ 12.5 kg ha^{-1} + $MnSO_4$ @ 2.5 kg ha^{-1} through soil application). These two treatments registered a comparable oil (364.44 and 360.24 kg ha^{-1}) and protein (188.12 and 188.63 kg ha^{-1}) yield of sesame seed. This was followed by the treatments arranged in the descending order like $T_7 > T_5 > T_3 > T_4$ and T_2. The lowest quality parameters *viz*., oil (210.74 kg ha^{-1}) and protein yield (111.75 kg ha^{-1}) was recorded in the control or RDF alone (without micronutrient and organics) as compared to all other treatments.

The improvement in quality of sesame seeds with the application of inorganic nutrients both macro and micronutrients along with organics increased the seed yield and nutrient availability which resulted in better accumulation of N and hence the protein content in seeds (Thiruppathi *et al*., 2001). Besides the addition of zinc as $ZnSO_4$, manganese as $MnSO_4$ promoted better quality through synthesis of oil, protein and amino acids through its effect on protein and lipid metabolism in plants. Similar results were earlier made by Salwa *et al.* (2010) and Tripathy and Bastia (2012). The impact of NPK addition play a vital role in enhancing the glycoside content in seed, which upon hydrolysis and estrifications resulted in higher oil yield of sesame seeds. In line with the present study Mahajan *et al.* (2016) also reported similar results.

MAJOR NUTRIENTS UPTAKE (NPK)

The NPK uptake of sesame at all the critical stages of crop growth and in seed and stalk was significantly increased with the micronutrient fertilization. Application of NPK and organics (VC) along with zinc as $ZnSO_4$ and manganese as $MnSO_4$ either through soil or foliage and or both significantly increased the uptake of major nutrients by sesame.

Among the treatments evaluated, the combined application of $ZnSO_4$ + $MnSO_4$ through soil and foliar spray along with organics and NPK recorded the highest NPK uptake at different stages of crop growth as compared to with or without micronutrients and organics.

The treatment T_8 (recommended dose of fertilizer (RDF) + VC @ 5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (SA) through soil and foliar spray of $ZnSO_4$ and $MnSO_4$ @ 0.5 per cent) registered the highest N (39.25 and 35.48 kg ha^{-1}), P (6.24 and 8.84 kg ha^{-1}) and K uptake (17.20 and 40.20 kg ha^{-1}) by seed and stalk, respectively. However, it was found to be equally good with RDF + 50% $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} (SA) through soil + $ZnSO_4$ and $MnSO_4$ (FA) through foliar spray @ 0.5% along with VC @ 5 t ha^{-1} (T_{10}) which recorded a comparable N (38.20 and 34.59 kg ha^{-1}), P (6.13 and 8.65 kg ha^{-1}) and K (16.94 and 39.29 kg ha^{-1}) by seed and stalk, respectively. This was followed by T_6, application of RDF + VC @ 5 t ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (SA) and T_9, application of recommended dose of NPK + VC @ 5 t ha^{-1} along with $ZnSO_4$ and $MnSO_4$ @ 50% though soil application registered the comparable NPK uptake by seed and stalk, respectively. This was followed by treatments $T_7 > T_5 > T_3 > T_4$ and T_2. The lowest nitrogen uptake was registered in control (RDF alone).

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 Grzebisz *et al.* (2010) and Chesti *et al*. (2015).

MICRONUTRIENTS UPTAKE

Zinc and Manganese uptake

The effect due to the different methods of micronutrient (zinc + manganese) application along with NPK and vermicompost had significant influence on Zn and Mn uptake by sesame. Among the various treatments, the highest Zn (241.72 g ha^{-1} and 168.53 g ha^{-1}) and Mn uptake (275.15 g ha^{-1} and 172.47 g ha^{-1}) by seed and stalk, respectively was recorded with the application of

RDF + VC @ 5 t ha^{-1} along with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} and foliar spray ($ZnSO_4$ + $MnSO_4$) @ 0.5 per cent twice (T_8). This was equally efficient with T_{10} which received RDF + VC along with soil application of 50% $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} and foliar application of $ZnSO_4$ + $MnSO_4$ @ 0.5 per cent. This was followed by application of RDF + VC along with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (T_6). However, this was found to be on par with treatment (T_9). This was followed by the treatments 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.

The increased Zn and Mn uptake by sesame with application of organics along with 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) and Elayaraja and Singaravel (2012). Further, the addition of organic manures resulted in higher micronutrient availability due to mineralization according to Swati and Dhok (2013).

ECONOMICS OF THE SESAME PRODUCTION

The benefit cost ratio was worked out to realize beneficial influence of different methods of micronutrients (Zn and Mn) fertilization along with recommended dose of NPK and vermicompost application in increasing the net profit over the conventional methods of sesame production and/or farmers practice. The net income per ha (gross income-cost of cultivation) and the benefit cost ratio (return per rupee invested) was greatly increased with the Zn and Mn application through soil + foliage along with NPK and VC. Among the various treatments, the highest net income (Rs. 27,344 ha^{-1}) and benefit cost ratio (Rs. 2.35) were obtained with the soil application of 50 per cent $ZnSO_4$ @ 12.5 kg ha^{-1} and $MnSO_4$ @ 2.5 kg ha^{-1} + foliar application of $ZnSO_4$ and $MnSO_4$ @ 0.5 per cent twice at pre flowering stage (PFS) and flowering stage (FS) along with recommended dose of NPK and VC (T_{10}). This was followed by application of $ZnSO_4$ @ 25 kg ha^{-1} and $MnSO_4$ @ 5 kg ha^{-1} through soil as well as foliar application of $ZnSO_4$ + $MnSO_4$ @ 0.5 per cent along with NPK and VC (T_8). The lowest net income (Rs. 8,107 ha^{-1}) and benefit cost ratio (Rs. 1.45) was observed in the control treatment (without micronutrients and organics).

The highest net income (Rs. 27, 344) and B:C ratio (2.35) was recorded with the combined application of 100 per cent recommended dose of NPK + 50% recommended $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% recommended $MnSO_4$ @ 2.5 kg ha^{-1} through soil + foliar spray twice @ 0.5% ($ZnSO_4$ and $MnSO_4$) along with vermicompost @ 5 t ha^{-1} as compared to all other treatments. The increase in the economic yields of sesame and hence the economic values of the yield support the cost of cultivation and ultimately resulted in higher net return and also the benefit: cost ratio. The earlier reports of Kumawat *et al.*(2012) and Mahajan *et al.* (2016) also support the present findings.

CONCLUSION

The present investigation clearly concluded the beneficial effect of organics and micronutrients fertilization for increasing sesame production in coastal saline soil. Application of recommended dose of NPK + vermicompost @ 5 t ha^{-1} along with 50 per cent recommended dose of $ZnSO_4$ @ 12.5 kg ha^{-1} + 50% $MnSO_4$ @ 2.5 kg ha^{-1} through soil and foliar spray of both the micronutrients ($ZnSO_4$ + $MnSO_4$) @ 0.5 per cent twice at critical stages *viz.*, pre flowering and flowering stage was identified as best treatment combination can be recommend to the farmer's of coastal areas to realize the maximum profit in sesame yield.

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Table 1. Effect of vermicompost and micronutrients fertilization on the yield characters, yield and quality of sesame

Treatments	Yield characters			Yield (kg ha^{-1})		Quality characters			
	Number of capsules plant^{-1}	Number of seeds capsule^{-1}	1000 seed weight (g)	Seed	Stalk	Oil content (%)	Protein content (%)	Oil yield (kg ha^{-1})	Protein yield (kg ha^{-1})
T_1	34.25	34.60	2.10	980	1506	40.45	11.64	396.41	114.07
T_2	37.59	37.93	2.39	1132	1716	40.57	11.60	459.25	131.31
T_3	40.82	44.07	2.61	1243	1909	40.76	11.62	506.44	144.43
T_4	32.59	41.08	2.44	1458	2279	41.26	11.91	601.57	173.64
T_5	43.81	47.43	2.76	1375	2088	41.05	11.71	557.04	158.90
T_6	49.99	54.68	3.15	1675	2763	41.75	12.28	699.31	205.69
T_7	46.44	50.54	2.90	1557	2534	41.53	12.14	646.62	189.01
T_8	53.11	58.74	3.35	1816	3020	42.13	12.45	765.08	226.09
T_9	48.98	53.62	3.07	1783	2971	42.04	12.37	755.45	222.28
T_{10}	52.21	57.72	3.31	1911	3218	42.44	12.60	811.02	204.78
SE_D	0.98	1.22	0.06	46.07	80.16	0.82	0.22	18.33	4.43
CD (p=0.05)	2.07	2.57	0.13	96.76	168.34	NS	NS	38.50	9.31

Table 2. 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
SE_D	0.53	0.79	0.88	0.78	0.05	0.12	0.14	0.17	0.72	1.05	0.39	1.00
CD (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

Table 3. 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
SE_D	6.45	8.14	5.79	4.00	5.80	6.43	6.24	3.77
CD (p=0.05)	13.54	17.10	12.15	8.41	12.17	13.51	13.10	7.91

Table 4. Effect of vermicompost and micronutrients fertilization on the economic analysis of sesame

Treatments	Cost of cultivation (Rs.)	Gross income (Rs.)	Net return (Rs.)	Benefit cost ratio (Rs.)
T_1	18129	34300	16171	1.89
T_2	19473	39620	20147	2.03
T_3	19919	43505	23586	2.18
T_4	20807	51030	30223	2.45
T_5	20009	47495	27486	2.37
T_6	20427	58625	38198	2.86
T_7	20045	54495	34450	2.71
T_8	21298	63560	42262	2.98
T_9	20133	62405	42272	3.09
T_{10}	21511	66885	45374	3.11