Influence of Organic Manures and Micronutrients Fertilization on the Soil Properties and Yield of Sesame (*Sesamum indicum* L.) in Coastal Saline Soil

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**ABSTRACT**

The light texture coastal saline soils are well known for the deficiency of both macro and micronutrients especially zinc, boron, iron and manganese, etc. The zinc (Zn) and manganese (Mn) plays an important role in improving the growth, yield and quality of sesame. A field experiment was conducted to find out the influence of organics and micronutrients fertilization on the soil properties and yield of sesame in coastal saline soil. The experiment was carried out in a farmer’s field at Ponnanthittu coastal village, near Chidambaram Taluk, Cuddalore district, Tamil Nadu. The Physico-chemical properties and nutrient status of initial soil were: pH- 8.43, EC- 4.25 ds m⁻¹, organic carbon- 2.30 g kg⁻¹ and DTPA Zn – 0.70 mg kg⁻¹ and Mn- 0.96 mg kg⁻¹, respectively. The treatments included were T₁ - Control (Recommended dose of NPK), T₂ -125% NPK + Composted coirpith (CCP) @ 12.5 t ha⁻¹, T₃ - T₄ + ZnSO₄ @ 25 kg ha⁻¹ soil application (SA), T₅ - T₆ + MnSO₄ @ 5 kg ha⁻¹ (SA), T₇ - T₈ + (ZnSO₄ + MnSO₄) SA. T₉ - T₁₀ + ZnSO₄ @ 0.5 % foliar application (FA), T₁₁ - T₁₂ + ZnSO₄ (FA), T₁₃ - T₁₄ + MnSO₄ (FA), T₁₅ - T₁₆ + ZnSO₄ (SA) + MnSO₄ (FA), T₁₇ - T₁₈ + MnSO₄ (SA) + MnSO₄ (FA) and T₁₉ - T₂₀ + (ZnSO₄ + MnSO₄) SA + (ZnSO₄ + MnSO₄) FA. The experiment was laid out in a Randomized Block Design (RBD) with three replications, using sesame variety TMV 7. The results of the study indicated that the combined application of 125 per cent NPK + composted coirpith (CCP) @ 12.5 t ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ through soil application along with foliar application of ZnSO₄ @ 0.5% + MnSO₄ twice at 0.5 per cent significantly increased the soil nutrient availability, microbial population, enzyme activity and yield of sesame in coastal sandy soil. This treatment recorded the highest sesame seed yield of 815 kg ha⁻¹ and stalk yield of 1805 kg ha⁻¹ as compared 100% recommended NPK alone 421 and 944 kg ha⁻¹ of seed and stalk yield, respectively.

**Key words**: Coastal sandy soil, Micronutrients fertilization, Organics, Sesame yield, Soil properties.

**INTRODUCTION**

The Indian agricultural scenario becomes grimmer due to unabated depletion of nutrients, pollution and degradation of land and water resources. To ensure food security for ever increasing population, India needs to produce large quantities of food grains and oil seeds. Out of total 329 M ha land, 147 M ha (about 47%) are degraded due to various causes (Maji et al., 2004). Of which 7.0 M ha of land are reported to be saline affected and less productive (Nancy Jasmin et al., 2017). In Tamil Nadu alone, 40,000 ha of lands are salt affected (Dhanushkodi and Subrahmaniyam, 2012). These salt affected lands may be saline or alkali and are present along the coastal belt or in inland. 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 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 Tamilnadu (Velayutham et al., 1999). Almost the entire coastal tracts suffer from soil salinity, sodicity and seawater intrusion which resulted in the low productivity of crops (Laxminarayana and Archana, 2016). 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.

Coarse textured coastal salt affected soils have several soil related constraints 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 coastal region. Even the applied nutrients are leached to the lower layers due to poor physical properties, poor nutrient retention and low organic carbon content, which further aggravates the problem of nutrient deficiency. The coastal farmers are cultivating the lands by adopting traditional management practices means improper/imbalanced nutrient application particularly N
fertilizer alone or combined with sub-optimal rates or total omission of other nutrients is the primary cause and realizing very low yield of sesame as compared to other regions. Further, coastal salt affected soils are most commonly present 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 (Jadav et al., 2010 and Vani et al., 2017). It is now established that micronutrient deficiency is the prime factor responsible for increasing productivity of sesame in coastal areas. Hence, inclusion of micronutrient fertilizer in the fertilizer programme becomes an imperative need to improve the yield of sesame. Therefore, the present investigation was carried out to study the influence of organic manure along with micronutrients fertilization on the yield of sesame and soil properties in coastal saline soil.

**MATERIALS AND METHODS**

A field experiment was carried out in a farmer's field during February- May, 2017 at Ponnantithu coastal village, to find out the influence of organics and micronutrients fertilization on the soil properties and yield of sesame in coastal saline soil. The various treatments included were, T1-Control (Recommended dose of NPK), T2-125% NPK + Composted coirpith (CCP) @ 12.5 t ha⁻¹, T3-T2 + ZnSO₄ @ 25 kg ha⁻¹ soil application (SA), T4-T2 + MnSO₄ @ 5 kg ha⁻¹ (SA), T5-T2 + (ZnSO₄ + MnSO₄) SA, T6-T2 + ZnSO₄ @ 0.5 % foliar application (FA), T7-T2 + MnSO₄ (FA), T8-T2 + (ZnSO₄ + MnSO₄) FA, T9-T2 + MnSO₄ (SA) + ZnSO₄ (FA), T10-T2 + MnSO₄ (SA) + MnSO₄ (FA) and T11-T2 + (ZnSO₄ + MnSO₄) SA + (ZnSO₄ + MnSO₄) FA. The above treatments were arranged in a Randomized Block Design (RBD) and replicated thrice, using sesame variety TMV 7. The experimental soil had sandy texture with pH- 8.43; EC- 4.25 dSm⁻¹; organic carbon- 2.30 g kg⁻¹; Zinc 0.70 mg kg⁻¹ and Manganese status of 0.96 mg kg⁻¹. The alkaline KMnO₄-N; Olsen-P and NH₄OAc-K, were low, low and medium status, respectively. Calculated amount of inorganic fertilizer doses of nitrogen (35 kg N ha⁻¹), phosphorus (23 kg P₂O₅ ha⁻¹) and potassium (23 kg K₂O ha⁻¹) were applied through urea, single super phosphate and muriate of potash, respectively. Half of the N and entire P₂O₅ and K₂O were applied as basal and the remaining half dose of N was applied in two splits at flowering and capsule formation stage. Composted coirpith (CCP) @ 12.5 t ha⁻¹ were applied basally and well incorporated into the soil as per the treatment schedule. Required quantities of ZnSO₄ and MnSO₄ were applied either through soil or foliar spray and or both as per the treatment schedule. Foliar application of ZnSO₄ and MnSO₄ @ 0.5 per cent in each at Pre Flowering Stage (PFS) and at Flowering Stage (FS) was applied as per the treatment. The biofertilizer Azospirillum @ 2 kg ha⁻¹ was applied to all the experimental plots. The soil samples were collected at harvest stages and analyzed for various soil properties like major (N, P and K) and micronutrients (Zn and Mn), microbial populations (bacteria, fungi and actinomycetes) and enzymatic activity (urease, phosphatase and dehydrogenase) in soil (Jackson, 1973). At harvest stage, seed and stalk yield were also recorded.

**RESULTS AND DISCUSSION**

Physical properties of soil

The effect of organics along with different methods of micronutrients (zinc and manganese) application in altering the physical properties viz., bulk density, particle density and water holding capacity of the soil at different critical stages of sesame were not vary significantly. But, the treatment T₅, combined application of 125% NPK + CCP

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**Table 1:** Effect of organics and micronutrients fertilization on the physical, physico-chemical properties and macronutrients availability of soil (Mean of three replications).

| Treatments | Physical properties | Physico-chemical properties | Macro Nutrients availability (kg ha⁻¹) |
|------------|---------------------|----------------------------|-------------------------------------|
|            | Bulk density (Mg m⁻³) | Particle density (Mg m⁻³) | Water Holding Capacity (%) | pH (dS m⁻¹) | EC (g kg⁻¹) | OC | N | P | K |
| T₁        | 1.54                | 2.53                        | 28.06                        | 8.30          | 1.26              | 2.41          | 96.14 | 6.40 | 93.26 |
| T₂        | 1.43                | 2.40                        | 30.98                        | 8.13          | 1.13              | 2.84          | 101.85 | 6.97 | 100.31 |
| T₃        | 1.41                | 2.42                        | 31.01                        | 8.14          | 1.15              | 2.80          | 116.01 | 8.47 | 116.91 |
| T₄        | 1.43                | 2.41                        | 30.95                        | 8.16          | 1.15              | 2.80          | 120.80 | 9.00 | 121.42 |
| T₅        | 1.43                | 2.42                        | 30.91                        | 8.15          | 1.12              | 2.76          | 132.31 | 10.24 | 131.12 |
| T₆        | 1.40                | 2.40                        | 30.97                        | 8.15          | 1.14              | 2.85          | 106.88 | 7.46 | 106.54 |
| T₇        | 1.41                | 2.40                        | 30.95                        | 8.14          | 1.13              | 2.74          | 115.50 | 7.97 | 112.44 |
| T₈        | 1.42                | 2.39                        | 30.89                        | 8.15          | 1.16              | 2.73          | 125.61 | 9.61 | 126.49 |
| T₉        | 1.43                | 2.41                        | 30.99                        | 8.16          | 1.14              | 2.79          | 138.76 | 10.83 | 135.47 |
| T₁₀       | 1.43                | 2.41                        | 31.00                        | 8.18          | 1.14              | 2.83          | 145.35 | 11.46 | 139.87 |
| T₁₁       | 1.41                | 2.41                        | 30.89                        | 8.15          | 1.15              | 2.78          | 152.45 | 12.06 | 144.19 |
| SE₀       | 0.031               | 0.045                       | 0.61                         | 0.13          | 0.013             | 0.09          | 2.07    | 0.23 | 2.02   |
| CD (p=0.05) | NS                  | NS                          | NS                          | NS            | NS                | NS            | 4.32    | 0.48 | 4.21   |
12.5 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\(_{11}\)); slightly decreased the soil bulk density (1.41 Mg m\(^{-3}\)) and particle density (2.41 Mg m\(^{-3}\)) and slightly increased the water holding capacity (30.89\%) of post harvest soil as compared to initial status of soil due to addition of composted coirpith.

**Physico-chemical properties of Soil**

The influence of micronutrients fertilization along with organic manures and recommended dose of NPK fertilizer in altering the pH, EC and organic carbon content of the soil at different critical stages of sesame were did not vary significantly. Among the various treatments, the application of 125% NPK + CCP @ 12.5 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\(_{11}\)), slightly decreased the soil pH (8.15) and EC(1.15 d Sm\(^{-1}\)) and slightly increased the soil organic carbon (2.78 g kg\(^{-1}\)) status as compared to initial status of soil in the treatments applied with composted coirpith.

**Available major nutrients**

The influence of different methods of micronutrients fertilization along with organics and NPK treatments in altering the available major nutrients status in coastal sandy soil was statistically significant.

Among the various treatments, the highest amount of soil available nitrogen (152.45 kg ha\(^{-1}\)), phosphorus (12.06 kg ha\(^{-1}\)) and potassium content (144.19 kg ha\(^{-1}\)) at harvest stage was recorded with the combined application of 125% NPK + CCP @ 12.5 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\(_{11}\)). This was followed by treatments T\(_{10}\), 125 per cent NPK + CCP @ 12.5 t ha\(^{-1}\) + MnSO\(_4\) @ 5 kg ha\(^{-1}\) through soil + MnSO\(_4\) @ 0.5 per cent foliar spray and treatment T\(_{1p}\), 125 per cent NPK + CCP @ 12.5 t ha\(^{-1}\) + ZnSO\(_4\) @ 25 kg ha\(^{-1}\) through soil + ZnSO\(_4\) @ 0.5 per cent foliar spray which recorded an available nitrogen (145.35 and 138.76 kg ha\(^{-1}\)), phosphorus (11.46 and 10.83 kg ha\(^{-1}\)) and potassium content (139.87 and 135.47 kg ha\(^{-1}\)) at harvest stage, respectively. This was followed by the treatments significantly arranged in the descending order as T\(_{10}\)>T\(_{1p}\)>T\(_{11}\)>T\(_{1p}\)>T\(_{10}\). These treatments were also statistically significant. Application of 100 per cent NPK alone (T\(_{1}\)) recorded a comparatively lower available N (96.14 kg ha\(^{-1}\)), P (6.40 kg ha\(^{-1}\)) and K (93.26 kg ha\(^{-1}\)) content at harvest stage as compared to application of 125% NPK along with CCP (T\(_{1p}\)) which recorded available N (101.85 kg ha\(^{-1}\)), P (6.97 kg ha\(^{-1}\)) and K (100.31 kg ha\(^{-1}\)) content at harvest stage, respectively.

The availability of N increased in the soil due to the application of zinc along with organic manures. This may be attributed to the addition of nutrients from both organics and inorganic sources. Inorganic sources sustain the crop demand in initial stage while organic source owing to their slow release contribute at the later stage. Similar results were reported by Sahu et al. (2017). Further the improved soil physico-chemical properties and microbial activity might have resulted in higher mineralization releasing more available N in soil. This corroborates the earlier report of and Elayaraja (2016). The availability of phosphorus in soil due to the application of ZnSO\(_4\) and organics was not significantly altered. Many workers have shown that the application of zinc had no effect on the available P content in soil. With control, there was an increase in availability of K in the soil due to the application of ZnSO\(_4\) along with organics. The treatment NPK + ZnSO\(_4\) @ 35 kg ha\(^{-1}\) and NPK + ZnSO\(_4\) @ 30 kg ha\(^{-1}\) along with composted coirpith ranked on par in increasing the K availability. The increased availability of K with ZnSO\(_4\) application might be due to enhanced efficiency of fertilizer K in Zn deficient soil. The result obtained was in accordance with the similar findings of Ghosh et al. (2013). The higher content of K, O in organics and also, enhanced activity of beneficial microorganisms increased the K availability in the soil. The earlier reports of Singaravel et al. (2016) corroborate the present findings.

**Available micronutrients**

**DTPA-Zinc**: The positive influence of micronutrients fertilization either through soil or foliar and or both along with composted coirpith and recommended dose of NPK was also significantly increasing the availability of DTPA-zinc was well evidenced in the present study.

The highest available zinc status at harvest stage (1.07 mg kg\(^{-1}\)) was recorded with the combined application of 125% recommended dose of NPK + ZnSO\(_4\) @ 25 kg ha\(^{-1}\) + MnSO\(_4\) @ 5 kg ha\(^{-1}\) (SA) through soil and foliar (ZnSO\(_4\) and MnSO\(_4\) @ 0.5 per cent at twice) spray along with CCP @ 5 t ha\(^{-1}\) (T\(_{11}\)). This was equally efficient with T\(_{10}\) which received 125% NPK + CCP along with soil application of ZnSO\(_4\) @ 25 kg ha\(^{-1}\) and MnSO\(_4\) @ 5 kg ha\(^{-1}\). This was followed by application of 125% recommended dose of NPK + CCP along with soil application of ZnSO\(_4\) @ 25 kg ha\(^{-1}\) and foliar application of ZnSO\(_4\) @ 0.5 per cent (T\(_{1p}\)). However, this was found to be on par with treatment (T\(_{1p}\)) which received 125% recommended NPK + CCP along with ZnSO\(_4\) @ 25 kg ha\(^{-1}\) through soil and recorded a comparable available DTPA-Zinc content of 1.01 and 0.99 mg kg\(^{-1}\) at harvest stage, respectively. This was followed by the treatment T\(_{10}\), application of 125% NPK + CCP @ 12.5 t ha\(^{-1}\) along with MnSO\(_4\) @ 5 kg ha\(^{-1}\) through soil as well as foliar application of MnSO\(_4\) @ 0.5% and it recorded 0.92 mg kg\(^{-1}\) of available DTPA-Zinc content of soil at harvest stage and, this could be comparable with treatment T\(_{1p}\) (the application of 125% NPK + MnSO\(_4\) @ 5 kg ha\(^{-1}\) (SA) through soil along with composted coirpith application) which recorded 0.89 mg kg\(^{-1}\) of available DTPA-Zinc content of soil at harvest stage. This was followed by the treatment T\(_{1p}\). The control treatment (without micronutrients and organics) registered the lowest DTPA-Zn availability of 0.65 mg kg\(^{-1}\) at harvest stage.

The highest DTPA-Zn content was recorded with the treatment ZnSO\(_4\) + MnSO\(_4\) + RDF along with vermicompost application. The increased use efficiency of applied
micronutrient fertilizer and their availability with the addition of micronutrients along with organics in complexing and mobilizing property might have increased the DTPA-Zinc content of the soil. Earlier reports of Venkatakrishnan and Dhanasekaran (2012), Sahu et al. (2017) and Singaravel et al. (2016) support the present findings.

**DTPA-Manganese:** The highest DTPA-Mn was registered with 125% recommended dose of fertilizer (RDF) + ZnSO$_4$ @ 25 kg ha$^{-1}$ + MnSO$_4$ @ 5 kg ha$^{-1}$ SA + ZnSO$_4$ and MnSO$_4$ (FA) @ 0.5% foliar spray along with CCP @ 12.5 t ha$^{-1}$ (T$_{4}$) which recorded a Mn content of 1.24 mg kg$^{-1}$ at the harvest stage. However, it was found to be equally efficacious with the treatment T$_{6}$ (125% RDF + CCP @ 12.5 t ha$^{-1}$ + ZnSO$_4$ @ 25 kg ha$^{-1}$ + MnSO$_4$ @ 5 kg ha$^{-1}$ through soil alone). The treatment T$_{6}$ registered a DTPA-Mn content of 1.22 mg kg$^{-1}$ at harvest stage of sesame. This was followed by the treatments T$_{10}$, application of NPK + CCP @ 12.5 t ha$^{-1}$ + MnSO$_4$ @ 5 kg ha$^{-1}$ + MnSO$_4$ @ 0.5 per cent through soil as well as foliar spray and T$_{4}$, application of 125% recommended dose of NPK + MnSO$_4$ @ 5 kg ha$^{-1}$ through soil along with composted coirpith @ 12.5 t ha$^{-1}$ (T$_{1}$), which recorded a comparable DTPA-Mn content of 1.13 and 1.10 mg kg$^{-1}$ at harvest stage, respectively. This was followed by the treatment T$_{12}$ (125% NPK+CCP+ ZnSO$_4$ @ 25 kg ha$^{-1}$ through soil and foliar). This was closely onpar with treatment T$_{15}$ (125% NPK+CCP+ ZnSO$_4$ @ 25 kg ha$^{-1}$ through soil alone). The treatment T$_{15}$ was followed by the treatments arranged in the descending order as T$_{10}$ > T$_{1}$ > T$_{2}$ and T$_{4}$. These treatments are not statistically significant. The lowest DTPA-Mn was recorded with T$_{1}$, the control treatment (RDF alone) that did not received organics, zinc and manganese.

The increased Zn and Mn availability might be attributed to the direct addition of these nutrients by added fertilizer and organic manures, which maintain maximum available Zn and Mn status in post harvest soil. Further the complexation of micronutrients with applied organics might have mobilized and increased the availability of Zn and Mn in soil. These similar findings are accordance with Bharathi et al. (2014).

**Biological properties of soil**

**Microbial population in soil:** Among the various treatments, the integrated application of ZnSO$_4$ @ 25 kg ha$^{-1}$ + MnSO$_4$ @ 5 kg ha$^{-1}$ through soil application + foliar spray of ZnSO$_4$ + MnSO$_4$ @ 0.5% twice at pre flowering and flowering stage along with 125% recommended dose of NPK and composted coirpith @ 12.5 t ha$^{-1}$ (T$_{1}$) recorded the highest microbial population of bacteria (25.17 × 10$^{9}$), fungi (18.09 × 10$^{9}$) and actinomycetes (11.37 × 10$^{9}$). However, it was found to be comparable with the treatment T$_{5}$ (125% NPK + CCP @ 12.5 t ha$^{-1}$ + ZnSO$_4$ @ 25 kg ha$^{-1}$ + MnSO$_4$ @ 5 kg ha$^{-1}$ through soil application) which registered a comparable microbial population count of bacteria (24.46 × 10$^{9}$), fungi (17.68 × 10$^{9}$) and actinomycetes (11.23 × 10$^{9}$) at harvest stage, respectively. This was followed by the treatment T$_{10}$ (125% NPK + CCP + ZnSO$_4$ @ 5 kg ha$^{-1}$ + MnSO$_4$ @ 0.5% through soil and foliar application). This was equally efficient with treatment T$_{6}$ (125% NPK + CCP + MnSO$_4$ @ 5 kg ha$^{-1}$ SA). This was followed by the treatment T$_{15}$ (125% NPK + CCP + + ZnSO$_4$ @ 25 kg ha$^{-1}$ SA + MnSO$_4$ @ 0.5% FA). However, it was found to be equally efficacious with the treatment T$_{5}$ (125% NPK + CCP + ZnSO$_4$ @ 25 kg ha$^{-1}$ SA).
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This was followed by the treatment T6, which received 125% recommended dose of NPK along with composted coirpith (without micronutrients). The lowest microbial population count was noticed in control.

The increased microbial counts in soil microorganisms with application of organics along with micronutrients may be due to better soil biological environment of coastal saline soil (Aminunmahar et al., 2013). Further, the availability of readily mineralized C and N and improvement in the physico-chemical properties of the soil due to the application of organics might have increased the microbial population load of the soil. These results are in parity with the results reported by Abdullahi et al. (2013) and Sahu et al. (2017).

**Enzymatic activity of soil:** The application of 125 per cent NPK + CCP @ 12.5 t ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ through soil as well as foliar spray of ZnSO₄ + MnSO₄ @ 0.5% (T₁) registered the highest urease, phosphatase and dehydrogenase activity of the soil. This was comparable with the treatment T₅, the application of 125% NPK + CCP @ 12.5 t ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ (SA) through soil application alone which recorded a urease activity of 26.40 mg NH₄-N/g soil/24 hr at harvest stage of sesame. The similar trend was also observed with phosphatase and dehydrogenase activity of soil. This treatment was followed by T₄, application of 125 per cent NPK + CCP @ 12.5 t ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ (SA) + MnSO₄ @ 0.5% (FA) through soil and foliar spray which recorded the significant amount of enzymatic activity content of post harvest soil. This was found to be comparable with the treatment T₅ (125 per cent NPK + CCP @ 12.5 t ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ through soil alone). A similar trend was also observed with the treatments T₆ (125 % NPK + CCP @ 12.5 t ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹ by SA + FA) and T₃ (125 % NPK + CCP @ 12.5 t ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹ by SA alone). This was followed by the treatment T₇ which received 125 % NPK + CCP @ 12.5 t ha⁻¹ (without micronutrients). Regarding the treatments, application of 125 per cent recommended NPK along with organics and micronutrients through only foliar applied treatments like, T₈ (125% NPK+ CCP + ZnSO₄ + MnSO₄ FA), T₉ (125% NPK + CCP + MnSO₄ FA alone) and T₁₀ (125% NPK + CCP + ZnSO₄ FA alone) recorded the lowest enzymatic activity as compared to micronutrient through soil and combined mode of application. The control (100% NPK alone) recorded the lowest urease activity of the soil at all the three critical stages of sesame.

The increased rate of nitrogen application and various biomaterials added to the soil as well as the root exudates promoted the nitrogenase substances which have induced the urease activity. The results of the present findings are agreeable with the results obtained by Ramamoorthy et al. (2018). The increase in the soil phosphatase activity with the addition of organics could have been due to the soil substrate enrichment caused by the addition of mineral fertilizers. The phosphates added through organics and fertilizer improved the phosphatase activity, which may be ascribed to the stabilized extra cellular fraction of enzyme (Biswas and Narayanasamy, 2006). The increased dehydrogenase activity might be due to the incorporation of organics, owing to increase in microbial activity of the soil. Similar results were reported by Liang et al. (2005) and Elayaraja and Singaravel (2011).

**Yield of sesame:** The yield realized under the nutrient mixed coastal sandy soil, the highest seed yield (815 kg ha⁻¹) and stalk yield (1805 kg ha⁻¹) was recorded with combined application of 125 per cent recommended dose of NPK fertilizer + ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ through soil as well as folar spray of ZnSO₄ @ 0.5% + MnSO₄ @ 0.5 per cent twice at pre flowering and flowering stage along with CCP @ 12.5 t ha⁻¹ (T₁). This was followed by the treatments arranged in a descending order like T₁₀ > T₉ > T₈ > T₇ > T₆ > T₅ and T₂. Among the various treatments, the treatment (T₉), 125% recommended dose of NPK + composted coirpith along with micronutrients through soil (ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹) and foliar (ZnSO₄ @ 0.5% + MnSO₄ @ 0.5 per cent) application recorded a seed and stalk yield of 815 and 1805 kg ha⁻¹ which was 48.34 and 47.70 per cent increase over control or 100 per cent NPK alone (without micronutrients and organics). The control recorded a lower seed (421 kg ha⁻¹) and stalk (944 kg ha⁻¹) yield of sesame, respectively.

The sesame yield increased with the application of recommended dose of NPK fertilizer + ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ (SA) through soil as well as foliar spray of ZnSO₄ @ 0.5% + MnSO₄ @ 0.5 per cent twice at pre flowering and flowering stage along with CCP @ 12.5 t ha⁻¹. Application of micronutrients and organic manures helped in the slow and steady rate of nutrient release into soil solution to match the absorption pattern of sesame thereby increased the yield. Further, the favourable effect of Zn and Mn on seed and stalk yield was also could be attributed to their effect in maintaining soil available nutrients in balanced proportions for better growth of sesame. The pronounced effect of micronutrients foliar spray might have helped in enhancing the enzyme and photosynthetic activities, accumulation of photosynthesates thereby higher seed yield. This corroborates the earlier report of Choudhary et al. (2017) and Ahirwar et al. (2017).

**CONCLUSION**

From the above investigations, it can be concluded that the beneficial effect of organics namely composted coirpith and micronutrients (Zn and Mn) fertilization for increasing sesame production in coastal sandy soil. Application of 125 per cent recommended dose of NPK + composted coirpith @ 12.5 t ha⁻¹ along with ZnSO₄ @ 25 kg ha⁻¹ + MnSO₄ @ 5 kg ha⁻¹ through soil and folar spray of both the micronutrients (ZnSO₄ + MnSO₄) @ 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 and to sustain soil health in coastal saline sandy soil.
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