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Study on the influence of organics and micronutrients fertilizer for increasing sesame production and sustainable soil fertility in coastal sandy soil

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Abstract

The light texture coastal sandy soils are also well known for the deficiency of both macro and micronutrients. In sesame production and improving the yield and quality, the Zn and Mn plays a vital role. A field experiment was conducted to find out the effect of organics and micronutrients on the yield, nutrient uptake by sesame and soil fertility in coastal sandy soil. The experiment was carried out in a farmer's field at Ponnanthittu coastal village in Cuddalore district, Tamil Nadu during January –April 2015. The initial fertility status of experimental soil was pH – 8.41, EC- 1.65 dS m^{-1}, organic carbon 2.30 g kg^{-1} and represented low status of micronutrients. The available NPK, were low, low and medium status, respectively. The various treatments included were, T_1-100% NPK (Farmer's Practice), T_2 -125% NPK, T_3 -150% NPK, T_4-125% NPK + CCP @ 12.5 t ha^{-1}, T_5 -125% NPK + FYM @ 12.5 t ha^{-1}, T_6 -150% NPK + CCP @ 12.5 t ha^{-1}, T_7 -150% NPK + FYM @ 12.5 t ha^{-1}, T_8 -125% NPK+CCP @12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}, T_9 -125% NPK+FYM @12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5kg ha^{-1}, T_{10}-150% NPK+CCP @12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1}+ $MnSO_4$ @ 5 kg ha^{-1}, T_{11}-150% NPK+FYM@12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1}+ $MnSO_4$ @ 5 kg ha^{-1}. The above treatments were arranged 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 125% NPK along with composted coirpith @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} and $MnSO_4$ @ 5 kg ha^{-1} (T_8) significantly increased nutrients availability, enzyme activity, microbial population and yield of sesame. The increased seed and stover yield recorded was 766 and 1706 kg ha^{-1} as compared to control.

Keywords: Coastal sandy soil, NPK level, organics, zinc, manganese, soil nutrient availability, enzyme activity, microbial population, sesame, yield.

Introduction

Coarse textured sandy 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. Sesame (*Sesamum indicum* L.) is one of the important crops grown in coastal sandy soil. The low productivity of sesame in coastal sandy soil has been attributed to the imbalanced nutritional status of plant, particularly, the inadequate availability of nutrients especially micronutrients. The poor retention and leaching of nutrients in sandy soil necessitates the increased rate of nutrients application especially NPK in such soil as compared to normal soils. Among the micronutrients, Zn and Mn are more common by deficient in coastal sandy soil. The micronutrients play a vital role in sesame production and improving the quality (Jain *et al.*, 2000 and Elayaraja, 2008) [3]. Micronutrients are recognized as a key element for protein synthesis and it plays an important role in various enzymatic activities and in the development of plant growth and synthesis of oil in sesame crop (Singaravel *et al.*, 2001) [12]. Hence, the present study was undertaken to study the influence of micronutrients and NPK levels along with organics on the nutrient availability, microbial population, enzymatic activity and yield of sesame in coastal sandy soil.

Materials and Methods

A field experiment was conducted in coastal sandy soil at Ponnanthittu village, to find out the response of sesame to NPK levels and micronutrients along with organics on the yield, nutrient availability and biological properties in coastal sandy soil. Texturally, the experimental soil was sandy with pH- 8.41 and EC- 1.65 dS m^{-1}. The soil registered 134.12 kg ha^{-1} of alkaline $KMnO_4$ - N; 9.32 kg ha^{-1} of Olsen –P, 153.45 kg ha^{-1} of NH_4OAc-K, 0.70 mg kg^{-1} of Zn and 0.96 mg kg^{-1} of Mn, respectively. The treatments imposed like, T_1-100% NPK (Farmer's Practice), T_2 -125% NPK, T_3 -150% NPK, T_4-125% NPK + CCP @ 12.5 t ha^{-1}, T_5 -125% NPK + FYM @ 12.5 t ha^{-1}, T_6 -150% NPK + CCP @ 12.5 t ha^{-1}, T_7 -150% NPK + FYM @ 12.5 t ha^{-1}, T_8 -125% NPK+CCP @ 12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}, T_9 -125% NPK+FYM @12.5 t ha^{-1} +$ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5kg ha^{-1}, T_{10}-150% NPK+CCP @12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1}+ $MnSO_4$ @ 5 kg ha^{-1}, T_{11}-150% NPK+FYM@12.5 t ha^{-1}+$ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}. The experiment was laid out in a Randomized Block Design (RBD) with three replications, using sesame var. TMV 7. A fertilizer dose of 35:23:23 kg N: P_2O_5: K_2O ha^{-1} was followed. Required quantities of different organics and NPK and micronutrients like $ZnSO_4$ and $MnSO_4$ fertilizers as per the treatments schedule were incorporated. Soil samples were collected at critical stages of sesame viz., flowering, capsule formation and at harvest stages and analysed for available N, P, K, Zn and Mn, as per the standard procedure of Jackson (1973). Soil enzyme activity like urease and Alkaline phosphatase (Tabatabai and Bremner 1972,) [14] and dehydrogenase (Casida *et al.*, 1964) [1] and microbial population analysed standard plate techniques (Subba Rao, 1995) was also analysed. At harvest pod and haulm yield were separately recorded.

Results and Discussion

Yield of sesame (Table 1)

The significant influence of zinc + manganese along with organics in increasing the seed and stalk yield of sesame was well evidenced in the present study. Among the various treatments, the highest seed yield (784 kg ha^{-1}) and stalk yield (1722 kg ha^{-1}) was recorded with combined application of 150 per cent NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} + CCP @ 12.5 t ha^{-1} (T_{10}). This was on par with application of 125 per cent NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} + CCP @ 12.5 t ha^{-1} (T_8). This was followed by the treatment, 150 per cent NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} + FYM @ 12.5 t ha^{-1} (T_{11}) it was found to be on par with 125 per cent NPK + $ZnSO_4$ + $MnSO_4$ along with FYM (T_9). The treatment (T_6), application of 150% NPK along with CCP alone without micronutrients significantly increased the seed and stalk yield to 663 and 1492 kg ha^{-1} respectively and application of 125% NPK along with CCP (T_4) registered a comparable seed and stalk yield to the tune of 648 and 1464 kg ha^{-1} respectively as compared to NPK applied treatments (T_3 and T_2).

The increased sesame yield with the application of Zn and Mn along with NPK might be attributed to the rapid mineralization of N, P and K from inorganic fertilizers and steady supply of these nutrients to the crop at the critical stages as opined by Narkhede *et al.*, (2001) [8]. In addition, Zn and Mn through activation of various enzymes and increased 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 Chaurasia *et al.*, (2009) [2].

Available Major Nutrients (Table 1)

The available nutrients status in coastal soils are very low due to poor organic matter or crop residue and microbial activity and leaching losses of nutrients associated with poor structure. In the present investigation, the available NPK status in the soil was significantly increased due to the application of organics along with micronutrients. The application of 150 per cent NPK + CCP @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (T_{10}) registered the highest alkaline $KMnO_4$, Olsen-P and NH_4OAc-K content of 156.36, 12.56 and 162.96 kg ha^{-1} at the harvest stages, respectively. However, it was found to be on par with the treatment T_8, the application of 125 per cent NPK + CCP @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}. This treatment was followed by T_{11}, application of 150 per cent NPK + FYM @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} recorded the significant amount of NH_4OAc-K content at all the stages of sesame growth. This was found to be comparable with the treatment T_9, the application of 125 per cent NPK + FYM @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} +$MnSO_4$ @ 5 kg ha^{-1}. These two treatments registered a comparable NPK availability of soil. A similar trend was also observed with the treatments T_6 (150% NPK + CCP @ 12.5 t ha^{-1}) and T_4 (125 % NPK + CCP @ 12.5 t ha^{-1}). This was followed by the treatments T_7 (150 % NPK + FYM @ 12.5 t ha^{-1}) and T_5 (125 % NPK + FYM @ 12.5 t ha^{-1}) which recorded a comparable NPK availability of soil at all stages, respectively. The control treatment (100% NPK) recorded the lowest soil NPK availability at all the critical stages of sesame. The availability of NPK increased in the soil due to the application of NPK, zinc, manganese along with organic manures. This may be attributed to the addition of nutrients from both organics and inorganics 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 Narkhede *et al.*, (2001) [8].

Table 1: Effect of organics and micronutrients on the sesame yield and nutrients availability in coastal sandy soil

Treatments	Yield (kg ha^{-1})		Alkaline $KMnO_4$-N			Olsen-P			NH_4OAc-K		
	Seed	Stalk	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS
T_1	487	1155	132.42	125.29	112.98	11.20	9.41	7.25	137.61	122.77	113.13
T_2	536	1247	141.33	134.57	120.78	12.46	10.42	8.28	146.80	132.24	122.78
T_3	550	1265	153.28	136.52	122.99	12.68	10.72	8.48	148.72	134.35	124.03
T_4	648	1464	159.73	153.50	138.76	14.78	12.87	10.50	167.59	152.90	141.78
T_5	589	1351	150.80	144.31	132.07	13.52	11.64	9.46	157.17	142.67	131.94
T_6	663	1492	161.62	155.51	140.50	14.99	13.18	10.67	169.73	155.26	144.09
T_7	606	1363	152.95	146.62	133.21	13.77	11.86	9.69	159.53	144.75	133.98
T_8	766	1706	177.33	170.10	153.40	16.93	15.35	12.42	188.88	172.75	160.86

T_9	712	1590	168.63	161.95	146.51	15.90	14.14	11.49	178.51	163.14	151.59
T_{10}	784	1722	179.45	172.94	156.36	17.15	15.53	12.56	191.13	174.71	162.96
T_{11}	724	1611	170.47	163.58	148.54	16.05	14.43	11.67	180.57	165.22	153.54
SE_D	18.02	39.13	3.52	3.37	3.06	0.37	0.36	0.29	3.78	3.53	3.33
CD(p=0.05)	37.55	81.45	7.34	7.01	6.37	0.78	0.75	0.61	7.88	7.36	6.94

Avalable Micronutrients (Table 2)

DTPA-Zn

The application of $ZnSO_4$ and $MnSO_4$ either with composted coirpith or FYM significantly increased the available DTPA-Zn content of the soil. The highest available zinc status at flowering (2.34 mg kg^{-1}), capsule formation (1.89 mg kg^{-1}) and 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_5 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[1] (T_9). However, this was found to be on par with treatment (T_3). 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_4. This was followed by the treatment T_2. The control treatment registered the lowest DTPA-Zn availability of 0.65 mg kg^{-1} at harvest stage. The increased use efficiency of applied micronutrient fertilizer and their availability with the addition of micronutrients along with increasing dose of NPK in organic humus complexing and mobilizing property might have increased the DTPA-Zinc content of the soil. Earlier report of Patnaik *et al.* (2012) [9] support the present findings.

Table 2: Effect of organics and micronutrients on the microbial population and enzymatic activity in coastal sandy soil

Treatments	Zinc			Manganese		
	FS	CFS	HS	FS	CFS	HS
T_1	1.72	1.36	487	1.86	1.53	0.87
T_2	1.72	1.36	536	1.85	1.54	0.87
T_3	1.73	1.37	550	2.14	1.85	1.14
T_4	1.99	1.60	648	2.01	1.72	1.02
T_5	1.87	1.45	589	2.17	1.88	1.17
T_6	2.04	1.63	663	2.03	1.74	1.04
T_7	1.90	1.49	606	2.45	2.11	1.40
T_8	2.27	1.86	766	2.31	1.98	1.29
T_9	2.14	1.72	712	2.47	2.14	1.43
T_{10}	2.33	1.89	784	2.35	2.02	1.31
T_{11}	2.18	1.77	724	0.039	0.036	0.034
SE_D	0.034	0.031	18.02	0.082	0.075	0.071
CD(p=0.05)	0.071	0.065	37.55	1.86	1.52	0.86

DTPA- Mn

The highest 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_{11}) which recorded a DTPA-Mn content of 2.39, 2.05 and 1.24 mg kg^{-1} at FS, CFS and at the harvest stages, respectively. However, it was found to be equally efficacious with the treatment T_5. 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} 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_9. This was closely onpar with treatment T_3. This was followed by the treatments arranged in the descending order as $T_2 > T_8 > T_7$ and T_6. These treatments are not statistically significant. The increased zinc and manganese availability might be attributed to the direct addition of these nutrients by 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 findings are accordance with Javia *et al.* (2010) [5].

Soil Microbial Population (Table 3)

Microbial populations of soil microorganisms *viz.*, bacteria, fungi and actinomycetes was significantly increased with micronutrients along with organics. An increase in the microbial population upto capsule formation stage and a decline thereafter was noticed at harvest stage. Among the various treatments, the combined application of 150 per cent NPK + CCP @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (T_{10}) recorded the higher population of bacteria (25.17 x 10^{-6}), fungi (18.05 x 10^{-5}) and actinomycetes (11.37 x 10^{-4}) at capsule formation stage. However, it was found to be comparable with the treatment T_8, the application of 125 per cent NPK + CCP @ 12.5 t ha^{-1} +$ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} which registered a comparable population of bacteria (24.22 × 10^{-6}), fungi (17.83 x 10^{-5}) and actinomycetes (11.27 x 10^{-4}) at capsule formation stage, respectively. This was followed by the treatment T_{11}. This was equally efficient with treatment T_9. Among the organics evaluated, CCP application @ 12.5 t ha^{-1} along with 150 per cent NPK (T_6) significantly improved the population viz., bacteria, fungi and actinomycetes of soil at all the growth stages. This treatment was closely on par with application of 125 per cent along with CCP @ 12.5 t ha^{-1} (T_4). This was followed by FYM applied treatments (T_7 and T_5). The lowest microbial populations of soil was noticed with control.

Soil microbial population plays a vital role in providing soil nutrient cycling and organic matter turnover in coastal saline soil. The enhancement of soil microbial population is known to influence the crop productivity and nutrient cycling (Kodeeswaran, 2015) [6]. The growth and colonization of soil microorganisms can be influenced by physical, chemical and biological properties of the soil. The availability of macro and micronutrients can limit microbial population growth in a coastal saline soil ecosystem. Essential nutrients for plant growth, such as nitrogen, phosphorus, potassium, sulphur and micronutrients influences the microbial population as these nutrient elements are also needed for microbial growth and activity of soil (Naher *et al.*, 2009) [7].

Table 3: Effect of organics and micronutrients on the microbial population in coastal sandy soil

Treatments	Bacteria (x 10^6 / g soil)			Fungi (x 10^5/ g soil)			Actinomycetes (x 10^4 / g soil)		
	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS
T_1	12.84	16.82	15.10	6.19	11.22	9.34	3.77	6.09	4.33
T_2	12.60	16.03	15.05	6.21	11.40	9.41	3.86	6.10	4.45
T_3	13.49	16.87	15.12	6.39	11.51	9.40	3.85	6.07	4.43
T_4	18.38	19.87	19.18	10.50	14.67	12.67	6.66	9.37	7.36
T_5	15.46	18.02	17.26	8.95	13.15	11.31	5.97	8.04	6.07
T_6	19.30	20.61	19.44	10.79	14.97	12.88	6.71	9.55	7.54
T_7	16.33	18.58	17.61	9.09	13.30	11.36	6.03	8.32	6.10
T_8	22.47	24.22	22.95	13.52	17.83	15.43	7.81	11.27	9.63
T_9	21.27	21.46	21.28	12.41	16.16	14.20	7.32	10.41	8.60
T_{10}	22.54	25.17	23.40	13.63	18.05	15.74	7.89	11.37	9.70
T_{11}	21.32	22.25	21.43	12.63	16.35	14.38	7.36	10.56	8.75
SE_D	0.49	0.51	0.50	0.29	0.40	0.33	0.10	0.19	0.11
CD (p=0.05)	1.03	1.07	1.04	0.61	0.85	0.70	0.21	0.40	0.24

Soil Enzyme Activities (Table 4)

The enzymatic activity of the soil was significantly influenced by the application of organics along with micronutrients fertilizer. The maximum urease, alkaline phosphatase and dehydrogenase activity was observed at capsule formation stage. Among the various treatments, the combined application of 150 per cent NPK + CCP @ 12.5 t ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1} (T_{10}) recorded the highest amount of urease, alkaline phosphatase and dehydrogenase activity at all the stages of sesame crop growth. However, it was found to be comparable with the treatment T_8, the application of 125 per cent NPK + CCP @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}. This was followed by the treatment T_{11} (150% NPK + FYM @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 kg ha^{-1}). This was equally efficient with treatment T_9 (125% NPK + FYM + $ZnSO_4$ + $MnSO_4$). Among the various organics evaluated, CCP application @ 12.5 t ha^{-1} along with 150 per cent NPK (T_6) significantly improved the enzymatic activity like urease, phosphatase and dehydrogenase activity of soil at all the growth stages. This treatment was closely on par with application of 125 per cent along with CCP @ 12.5 t ha^{-1} (T_4). This was followed by FYM applied treatments (T_7 and T_5). The lowest enzyme activity of soil was noticed with application of NPK alone treatments as compared to organics along with micronutrients treatments.

Soil enzyme activity is a key feature of plant nutrition and cycling process and therefore measurement of specific enzyme activities may be useful in determining the soil biological activity, which might be used as an indicator of soil fertility. Further, increased the enzyme activities *viz.*, urease, phosphatase and dehydrogenase were significantly and positively increased as the results of addition of various organic wastes. All the enzyme activities estimated in the experiment showed an increment upto peg formation stage of sesame growth and the trend slightly decreased towards the harvest stage of crop (Elayaraja, 2008) [3].

Table 4: Effect of organics and micronutrients on the enzymatic activity in coastal sandy soil

Treatments	Urease (μg NH_4-N/g soil/24 hr)			Phosphatase (μg *p*-nitrophenol/g soil/hr)			Dehydrogenase (μg TTF/g soil/24 hr)		
	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS
T_1	10.14	23.14	16.94	7.79	10.01	8.04	51.31	67.62	60.25
T_2	12.10	25.82	18.56	8.37	11.25	9.51	54.20	70.65	63.30
T_3	12.32	26.13	19.05	8.51	11.43	9.62	54.27	71.28	63.93
T_4	15.34	30.13	23.10	9.91	13.69	11.59	60.43	77.34	69.60
T_5	13.73	28.01	20.81	9.06	12.33	10.43	56.98	74.04	66.38
T_6	15.67	30.57	23.52	10.02	13.94	11.82	61.63	78.17	70.52
T_7	13.97	28.62	21.58	9.20	12.59	10.58	57.87	74.59	66.74
T_8	20.54	34.54	28.08	11.46	16.07	13.82	68.42	85.00	75.91
T_9	16.95	32.25	25.48	10.63	14.99	12.66	64.49	81.09	73.00
T_{10}	21.46	35.31	28.57	11.58	16.28	14.02	69.31	85.74	76.20
T_{11}	17.69	32.98	26.39	10.78	15.14	12.84	65.51	82.12	73.56
SE_D	0.50	0.57	0.63	0.21	0.34	0.30	1.13	1.15	1.00
CD (p=0.05)	1.05	1.20	1.32	0.45	0.71	0.63	2.37	2.41	2.08

References

1. Casida LE, Klein DA, Thomas Santoro. Soil dehydrogenase activity. Soil Sci. 1964; 98:371-376.
2. Chaurasia SK, Neetha J, Narmata J. Effect of integrated use of fertilizers, organic manures and micronutrients and productivity of sesame (*Sesamum indicum*). *Ann. Agrl. Res. New Series.* 2009; 30:91-94.
3. Elayaraja D. Recycling organic wastes for sustainable groundnut production in coastal sandy soil. *Ph.D. Thesis*, Dept. of Soil Science and Agrl. Chem., Faculty of Agriculture, Annamalai University, Annamalainagar, 2008.
4. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1973.
5. Javia RM, Vora VD, Sutacia GS, Akbari KN, Padmani DR. Effect of nutrient management on productivity of sesame and soil fertility of sandy lam soils under rainfed condition. Asian J Soil Sci. 2010; 5:80-82.
6. Kodeeswaran J. Integrated nutrient management on the soil properties and yield of rice-blackgram cropping sequence in coastal saline soil. *M.Sc. (Ag.) Thesis,* Dept. Soil Sci. & Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalainagar, 2015.
7. Naher UA, Radziah O, Halieni MS, Sham Suddin ZH, Mohd Razi I. Influence of root exudates carbon compound of three rice genotypes on Rhizosphere and endophytic Diazotrophs. J Trop. Agri. 2009; 32:209-223.
8. Narkhede TN, Wadile SC, Attarde DR, Suryawanshi RT, Deshmukh AS. Response of macro and micronutrients in combination with organic matter (FYM) on yield of sesame (*Sesamum indicum* L.). J Soils and Crops. 2001; 11:203-205.
9. Patnaik M, Chandini Raju, Sreenivasa Raj, Bhupal G. Zinc requirement of hybrid rice – bhendi and its influence on zinc fraction in an alfisols of Andhra Pradesh. J Indian Soc. Soil Sci. 2012; 59:368-375.
10. Prasad V. Restoration of soil fertility and productivity of degraded coastal soil for sustainable rice production. *Ph.D. Thesis*, Dept. of Soil Science and Agrl. Chem., Faculty of Agriculture, Annamalai University, Annamalainagar, 2008.
11. Ravankar HN, Deore RS, Deshmukh PW. Effect of nutrient management through organic and inorganic sources on soybean yield and soil fertility. PKV Res. J. 1999; 23:47-50.
12. Singaravel R, Imayavaramban Y, Dhanunathan K, Shanmughapriya N. Response of sesame (*Sesamum indicum* L.) to manganese and zinc nutrition. J Oilseeds Res. 2001; 18:136-138.
13. Subha Rao NS. Soil microorganisms and plant growth (3rd edition) Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi, 1995, 57-62.
14. Tabatabai MA, Bremner JM. Assay of urease activity in soil. *Soil Biol. Biochem.* 1972; 4:479-487.