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Effect of Organic Manures, Micronutrients and Growth Regulators on Growth and Yield of Sesame (*Sesamum indicum* L.) in Coastal Saline Soil

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A pot experiment was conducted in the Department of Soil Science and Agricultural Chemistry, Annamalai University, Tamil Nadu. The soil used in the study was saline in nature having pH 8.02 and EC 3.16 dS m^{-1} (1:2.5 soil water ratio), low organic C content (0.30 %). The available N, P and K status were low, low and medium respectively and the DTPA extractable Zn and Mn were below the critical limit. The treatments consisted of T_1 (control) – recommended NPK (35: 23: 23 kg N: P_2O_5: K_2O ha^{-1}), T_2 – recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5 % , T_3 – recommended NPK + FYM @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5 %, T_4 – recommended NPK + Vermicompost @ 4 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5 %, T_5 – recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + Humic acid @ 20 kg ha^{-1} + sea weed extract @ 0.5 %. The results of the experiment showed that application of organic manures and micronutrients increased the growth and yield of sesame. Among the treatments, T_5 consisting of recommended NPK + $ZnSO_4$ + $MnSO_4$ + humic acid + foliar application of sea weed extract recorded significantly higher seed (35.7 g pot^{-1}) and haulm yield (67.3 g pot^{-1}) and uptake of NPK and micronutrients by sesame. A significant reduction in the pH and EC and increased availability of nutrients was also recorded with this treatment. Supplementation of the recommended dose of NPK fertilizers with organic manures, micronutrients and growth regulators would therefore be beneficial in improving the growth and yield of sesame as well as improve soil properties in a coastal saline soil.

(***Key words:*** *Coastal saline soil, Growth regulator, Manures, Micronutrients, Sesame*)

Coastal soils are generally salt affected due to hydrological and geographic reasons, and soil salinity is the major factor for poor crop yields. High salinity and poor organic matter reduces the availability of micronutrients especially Zn and Mn (Singh *et al*., 1983). In coastal areas, mostly rainfed farming is being practiced and sesame is one of the major crop cultivated with poor yield realization of around 250-300 kg ha^{-1} as compared to average yield of around 700 kg ha^{-1} in other areas. The major reasons for its poor yield are growing of the crop without much nutrient application and organic manures and well as the physiological problems associated with micronutrient deficiencies that result in hormonal imbalance. Zinc and manganese are the important micronutrients in sesame production. Reduced growth hormone production in Zn deficient plants causes shortening of internodes and short leaves resulting in malformation of fruit and low yield (Havlin, 2005). Mn is essential for photosynthesis reactions, enzyme activation and root growth (Mortvedt *et al*., 1999).

Application of organic materials to nutrient depleted or poorly buffered coastal soil is useful for enhancing the physical, chemical and biological properties of soil. Humic acids are complex organic compounds and play an important role in nutrition of crop plants. It helps in improvement of the soil physical properties making the soil conditions favourable for better plant growth, improves nutrient availability, helps in increasing nutrient absorption (Lobartini *et al*., 1997), has growth promoting action and enhances stress tolerance (Piccolo *et al*., 1992). Sea weed extract obtained from marine algae contains major and micro nutrients, amino acids, vitamins, cytokinins, auxin and absicic acid like growth promoting substances and have been reported to stimulate the growth and yield of plants, develop tolerance to environment stress and increase nutrient uptake from soil (Arioli *et al*., 2015; Verkletij,

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1992). Realizing the beneficial role of micronutrients, organic manures and growth promoters on the yield and fertility improvement, the present study was conducted to evaluate the effect of application of micronutrients and growth promoters along with organic manures and fertilizers on the growth and yield of sesame in a coastal saline soil.

A pot experiment was carried out in the Department of Soil Science and Agricultural Chemistry, Annamalai University, Annamalai Nagar, Tamil Nadu during February to April, 2016. The treatments consisted of T_1 (control) – recommended NPK (35: 23: 23 kg N: P_2O_5: K_2O ha^{-1}), T_2 – recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5 % , T_3 – recommended NPK + FYM @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5 %, T_4 – recommended NPK + Vermicompost @ 4 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5 %, T_5 – recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + Humic acid @ 20 kg ha^{-1} + sea weed extract @ 0.5 %. The experimental design followed was completely randomized design and all treatments were replicated four times. Cements pots of 30.5 cm diameter were filled with a coastal saline soil @ 20 kg per pot which was collected from the farmer's field located at Parangipettai, Chidambaram Taluk, Cuddalore district of Tamil Nadu. The soil was analyzed for initial properties following standard procedures (Jakson, 1973). The soil had a pH 8.02, EC 3.16 dS m^{-1} (both measured in 1:2.5 soil water suspension) and low in organic C content (0.30 per cent). The available N, P and K status were low, low and medium respectively. The DTPA extractable Zn and Mn were below the critical limit. Sesame (Variety TMV-3) was grown in the pots as a test crop. Required quantities of organic manures were applied to pots as per the treatment schedule. Recommended NPK fertilizer schedule of 35:23:23 kg N: P_2O_5: K_2O ha^{-1} was followed. Entire P_2O_5 and K_2O were applied basally and N was applied is 3 splits. Half of N dose was applied basally and the remaining half was applied in two splits at vegetative and flowering stages. Sea weed extract @ 0.5% was applied as foliar spray at the vegetative and flowering stages. Various growth and yield parameters like plant height, LAI, dry matter production, number of capsules, seed yield and haulm yield were recorded. The post harvest soil samples were collected from each treatment and analyzed for pH, EC, organic carbon, available major nutrients *viz*., N, P and K and micro nutrients, Zn and Mn using the standard procedures (Jackson, 1973). The plant and seed samples were collected at harvest and digested using di-acid mixture (H_2SO_4 : $HClO_4$ in 4 : 1 ratio) and estimated for the contents of N, P, K, Zn and Mn using the procedure as described by Jackson (1973). The data was subjected to analysis of variance (ANOVA) and the differences in treatment means were compared by computing the values of critical difference at probability level of 5% (Gomez and Gomez, 1984).

RESULTS AND DISCUSSIONS

Growth parameters

All the growth parameters of sesame were significantly influenced by application of organic manures and micronutrients along with growth regulator (Table 1). The treatments, T_5 comprising application of recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + Humic acid @ 20 kg ha^{-1} + sea weed extract @ 0.5% excelled among all other treatments in increasing the plant height, dry matter production (DMP) and leaf area index (LAI) of sesame. This treatment recorded significantly the highest plant height (85 cm), DMP (53.4 g per pot) and LAI (4.83). This treatment was followed by the treatment T_4 (recommended NPK + Vermicompost @ 4 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + sea weed extract @ 0.5%). The treatment T_2 (NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1}+ sea weed extract @ 0.5%) also significantly recorded higher plant height (64 cm), DMP (38.9 g per pot) and LAI (2.32) while the lowest growth parameters (plant height - 58 cm; DMP - 32.5 g per pot and LAI -1.45) were recorded in the control treatment where only recommended dose of N, P and K was applied (Table 1) to a lower values in control. The increase in growth parameters might be due to the influence of humic substances on improving the physical, chemical and biological properties of soil and favourable influence on plant growth (Nardi *et al*., 2002). Humic substances also have growth promoting effect attributable to the hormone like impact and activation of photosynthesis and improved nutrient uptake (Chen and Aviad, 1990). Besides sea weed extract also contains grown promoting substances and have been reported to stimulate growth in crop plants (Khan *et al*., 2009; Rathore *et al*., 2009).

Table 1. *Influence of micronutrients and growth regulator on the growth and yield of sesame*

Treatments	Plant height (cm)	DMP (g pot^{-1})	LAI	No. of capsules plant^{-1}	Seed yield (g pot^{-1})	Haulm yield (g pot^{-1})
T_1 (control)	58	32.5	1.45	26.5	24.2	40.5
T_2	64	38.9	2.32	35.0	28.5	48.4
T_3	70	43.3	2.96	39.5	30.8	57.2
T_4	78	47.2	3.34	42.5	32.5	63.6
T_5	85	53.4	4.83	47.7	35.7	67.3
S.Ed.	0.87	1.31	0.11	0.93	0.86	1.57
CD (P=0.05)	1.75	2.63	0.22	1.86	1.73	3.15

Yield components and yield

The beneficial role played by micronutrients along with humic acid and sea weed extract including organic manures is highlighted by the fact that significantly higher number of capsules, seed yield and haulm yield as compared to the control was obtained in all the other treatments (Table 1). Significantly the highest number of capsules (47.7 no. plant^{-1}), seed yield (35.7 g pot^{-1}) and haulm yield (67.3 g pot^{-1}) was obtained in the treatment T_5 consisting of recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + Humic acid @ 20 kg ha^{-1} + sea weed extract @ 0.5 %. There was an improvement in seed and haulm yields over control (T_1) by 47.52 and 66.17 % respectively. In coastal saline soil, the response of sesame to micronutrient application, Zn and Mn was well pronounced with the yield realization of 28.5 and 48.4 g pot^{-1} of seed and haulm, respectively (Treatment T_2). Manganese is an essential element of photosynthesis and activator of many enzymes (Mengel and Kirkby, 2001) and Zn also being a component of enzyme is responsible for N metabolism and protein synthesis, helps in chlorophyll formation, synthesis of growth regulating substance and metabolic activity of plants (Bell and Dell, 2008; Mengel and Kirkby, 2001). Application of these micronutrients thereby improved the physiological processes which ultimately led to increase in the growth and yield of sesame crop. In the present study, all the organic manures also contributed to significant increase in yield over control. Organic manure directly added an appreciable amount of major and micro nutrients, improved physical properties for the root development, enhanced nutrient uptake leading to better crop growth and yield (Chaudhary *et al*., 2004). The increase in growth and yield might also be explained by the beneficial role of sea weed extract on root development and mineral absorption, shoot growth and photosynthesis (Khan *et al*., 2009; Pramanick *et al*., 2016).

Soil properties

The soil pH and EC in control was 8.09 and 2.39 dS m^{-1}, respectively, which decreased to a range of 7.62 to 7.90 and 1.94 to 2.17 with organic manure application (Table 2). Application of humic acid was found to be better than other FYM and vermicompost in decreasing the pH (7.62) and salinity (1.94 dS m^{-1}) while increasing organic carbon (0.49 %). The increase in organic carbon may be attributed to addition of organic material and better root growth as reported by Sharma *et al*. (2009). The decrease in soil pH and EC might be associated with the production of organic acids during decomposition of added organic matter and leaching of salts by the improved physical environment of soil (Chaudhary *et al*., 2004). There was also a significant increase in the availability of N, P and K in all the treatments except T_2 which was at par with the control (T_1). Significantly highest available N (113.6 mg kg^{-1}), P (5.9 mg kg^{-1}) and K (112.0 mg kg^{-1}) in the soil was recorded in the treatment T_5 consisting of recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $MnSO_4$ @ 5 Kg ha^{-1} + Humic acid @ 20 kg ha^{-1} + sea weed extract @ 0.5 %. The increase in available N with addition of FYM, vermicompost and humic acid might be attributed to the direct addition of nitrogen through these sources to the available soil pool (Sharma *et al*., 2009). Humic acid by forming phosphor-humus complex reduces the precipitation of P and thereby increases soil P availability (Thangavel and Manickam, 1989). The beneficial effect of organics on available potassium may be ascribed to the reduction in potassium fixation and release of potassium due to interaction of organic matter (Tandon, 1987). Supplementation of NPK with micronutrients alone or with organics significantly increased the availability of Zn and Mn (Table 2) over control (Recommended dose of NPK). Highest Zn (0.98 ppm) and Mn (4.12 ppm) availability was recorded in the treatment T_5, however, it was found to be at par with the treatment T_4

Table 2. *Influence of micro nutrients and growth regulator on the physico-chemical properties and available nutrient status of soil*

Treatments	pH	EC (dS m^{-1})	Org. C (%)	Available N (mg kg^{-1})	Available P (mg kg^{-1})	Available K (mg kg^{-1})	DTPA-Zn (ppm)	DTPA-Mn (ppm)
T_1 (control)	8.09	2.39	0.33	95.2	4.5	95.0	0.73	3.23
T_2	8.08	2.32	0.33	97.3	4.5	96.0	0.81	3.55
T_3	7.90	2.17	0.39	103.4	5.1	103.0	0.87	3.79
T_4	7.82	2.02	0.44	105.3	5.3	105.0	0.89	3.92
T_5	7.62	1.94	0.49	113.6	5.9	112.0	0.98	4.12
S.Ed.	0.04	0.02	0.01	2.27	0.16	3.06	0.02	0.11
CD (P=0.05)	0.08	0.04	0.03	4.56	0.23	6.12	0.04	0.22

Table 3. *Influence of micronutrients and growth regulator on the uptake of nutrients by sesame*

Treatments	N (g pot^{-1})		P (g pot^{-1})		K (g pot^{-1})		Zn (g pot^{-1})		Mn (g pot^{-1})	
	Seed	Shoot	Seed	Shoot	Seed	Shoot	Seed	Shoot	Seed	Shoot
T_1 (control)	1.06	0.33	0.15	0.03	0.22	0.40	1.51	0.98	2.81	7.52
T_2	1.32	0.43	0.21	0.04	0.28	0.30	1.95	1.23	3.70	9.57
T_3	1.63	0.51	0.26	0.05	0.34	0.58	2.54	1.38	5.01	11.24
T_4	1.85	0.58	0.31	0.07	0.43	0.64	2.94	1.53	5.92	12.45
T_5	2.09	0.70	0.39	0.08	0.49	0.76	3.31	1.81	6.67	14.50
S.Ed.	0.09	0.02	0.01	0.001	0.02	0.03	0.13	0.11	0.32	0.45
CD (P=0.05)	0.18	0.05	0.03	0.002	0.04	0.06	0.25	0.23	0.64	0.91

(3.92 ppm) in case of Mn availability. The increase in availability of Zn and Mn may be due to the reduction in pH with the application of organic manures (Singh *et al*., 1983). Further, the organic acids produced during decomposition and also humic acid may have complexed the micronutrient cations and increased their availability (Bell and Dell, 2008).

Nutrient uptake

Recommended dose of fertilizer when applied with micronutrients and organic manure significantly increased the uptake of nutrients by sesame. Among the treatments, T_5 - NPK + $ZnSO_4$ + $MnSO_4$ + Humic acid + sea weed extract ranked best in enhancing the uptake of major and micronutrients. This treatment registered a Zn uptake of 3.31 and 1.81 mg pot^{-1} and Mn uptake of 6.70 and 14.50 mg pot^{-1} by seed and haulm, respectively. This was followed by the treatment T_4 - NPK + $ZnSO_4$ + $MnSO_4$ + Vermicompost + sea weed extract. Humic substances are reported to stimulate root development and enhance N, Cu, Mn, K, Mg, Ca, Zn and Fe uptake in plants (Bidegain *et al*., 2000). The humic substances affect the membrane permeability and may interact with the phospholipid structures of the cell membranes and react as carrier of nutrients through them (Chen and Schnitzer, 1978). Besides, sea weed extract acts as a biostimulant and promotes root growth in plants enhancing better nutrient utilization and uptake from the soil (Khan *et al*., 2009; Rathore *et al*., 2009).

The present study revealed that supplementation of the recommended dose of NPK fertilizers with organic manures, micronutrients and growth regulators would be beneficial in improving the growth and yield of sesame in coastal saline soil. Further the application of organic manures and humic acid will also help in improving the soil properties, reduce soil salinity and increase the fertility of soils.

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