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INFLUENCE OF SECONDARY AND MICRONUTRIENTS ALONG WITH ORGANICS ON THE NUTRIENTS AVAILABILITY AND YIELD OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN COASTAL SALINE SOIL

D. Elayaraja[1]*, P. Anandan[2] and P. Kamalakannan[1]

[1*]Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalai Nagar- 608 002, Tamilnadu, India.

[2]Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar- 608 002 (T.N.) India.

Abstract

A field experiment was conducted to find out the influence of secondary and micronutrients along with organics on the nutrients availability and yield of sunflower in coastal saline soil. The experiment was carried out in a farmer's field at Mandabam coastal village near Chidambaram in Cuddalore district, Tamil Nadu during June–September 2016. The initial fertility status of experimental soil was sandy loam in texture with pH – 8.34, EC – 2.41 dS m^{-1}, organic carbon 2.30 g kg^{-1} and represented low status of micronutrients. The various treatments included were T_1 - Control (RDF alone), T_2 - RDF + Composted coirpith (CCP) @ 12.5 t ha^{-1}, T_3 - RDF + CCP + Sulphur (S) @ 200 kg ha^{-1} through Gypsum, T_4 - RDF + CCP + S + $ZnSO_4$ soil application (SA) @ 25 kg ha^{-1}, T_5 - RDF + CCP + S + $ZnSO_4$ foliar application (FA) @ 0.5%, T_6 - RDF + CCP + S + Borax (SA) @ 10 kg ha^{-1}, T_7 - RDF + CCP + S + Borax (FA) @ 0.5%, T_8 - RDF + CCP + S + $ZnSO_4$ (SA) + Borax (SA), T_9 - RDF + CCP + S + $ZnSO_4$ (FA) + Borax (FA) and T_{10} - RDF + CCP + S + $ZnSO_4$ (SA) + Borax (SA) + $ZnSO_4$ (FA) + Borax (FA). The experiment was carried out in a Randomized Block Design (RBD) with three replications, using sunflower variety Sunbred-hybrid as test crop. The results of the study clearly indicated that, the combined application of recommended dose of NPK fertilizer along with composted coirpith @12.5 t ha^{-1} + S @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1} through soil along with foliar application @ 0.5% twice (T_{10}) was significantly superior in increasing the nutrients availability and yield of sunflower. This treatment recorded the highest seed yield of 1911 kg ha^{-1} and stalk yield of 3218 kg ha^{-1} which represented 48.71 and 53.20 per cent increased in seed and stalk yield, respectively over 100 per cent NPK application alone.

Key words : Coastal Soil, organics, Sulphur, Zinc, Boron, growth, yield, nutrient availability, sunflower.

Introduction

The coastal agro system in India spreads over a narrow strip of land along the 8,129 km coastline of the country. Out of 10.78 M hectares of land under coastal agro ecosystem in India, about 3.1 m ha of land is saline which poses further aggravates the problems to agriculture (Laxminarayana and Mainaik, 2016). 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 all sorts of nutrient deficiency of major, secondary and micronutrients etc. These problems severely affect the productivity of crops in this region. Even the nutrients are applied, the poor physical properties associated with poor exchange and low organic carbon status of soil leads to leaching of nutrients, further extent of these problem of nutrient deficiency. The coastal farmers are exploiting these lands with unscientific management practices and realizing very low yield of crops as compared to other regions.

Further, Low organic matter, poor nutrient retention and deficiency of micronutrients are common feature of coastal saline sandy soil. S, Zn and B are recognized as key elements in promoting growth, yield and quality of sunflower. Organic matter helps in increasing adsorptive power of soil for cations, anions, secondary and micronutrients. These adsorbed ions are released slowly

***Author for correspondence :** E-mail : md.elayaraja@yahoo.in

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 (Agasimani *et al.,* 2007 and Beema, 2016). Hence, in the present study was undertaken to find out the influence of sulphur, zinc and boron fertilization along with organics on sunflower yield and nutrients availability in coastal saline soil.

Materials and Methods

A field experiment was carried out in a farmer's field during June–September, 2016 at Mandabam coastal village, to find out the influence of secondary and micronutrients along with organics on the nutrients availability and yield of sunflower in coastal saline soil. The various treatments imposed were T_1 - Control (RDF alone), T_2 - RDF + Composted coirpith (CCP) @ 12.5 t ha^{-1}, T_3 - RDF + CCP + Sulphur (S) @ 200 kg ha^{-1} through Gypsum, T_4 - RDF + CCP + S + $ZnSO_4$ soil application (SA) @ 25 kg ha^{-1}, T_5 - RDF + CCP + S + $ZnSO_4$ foliar application (FA) @ 0.5%, T_6 - RDF + CCP + S + Borax (SA) @ 10 kg ha^{-1}, T_7 - RDF + CCP + S + Borax (FA) @ 0.5%, T_8- RDF + CCP + S + $ZnSO_4$ (SA) + Borax (SA), T_9 - RDF + CCP + S + $ZnSO_4$ (FA) + Borax (FA) and T_{10} - RDF + CCP + S + $ZnSO_4$ (SA) + Borax (SA) + $ZnSO_4$ (FA) + Borax (FA). The experiment was carried out in a Randomized Block Design (RBD), with three replications, using sunflower variety Sunbred-hybrid. The experimental soil had sandy loam texture with pH - 8.34; EC-2.41 dS m^{-1}; organic carbon-2.30 g kg^{-1}, Zinc 0.71 mg kg^{-1} and Boron status of 0.08 mg kg^{-1}. The alkaline $KMnO_4$-N; Olsen-P and NH_4OAc-K, were low, low and medium status, respectively. Calculated amount of inorganic fertilizer doses of Nitrogen (60 kg N ha^{-1}), Phosphorus (90 kg P_2O_5 ha^{-1}) and Potassium (60 kg K_2O ha^{-1}) were applied through urea, super phosphate and muriate of potash, respectively. Required quantities of Gypsum, Zinc Sulphate and Borax as per the treatment schedule were incorporated. The periodical soil samples were collected at different critical stages of crop growth and analyzed for available major (N, P, K and S) and micronutrients (Zn and B) contents in soil (Jackson, 1973). At harvest stage, seed and stalk yield were also recorded.

Results and Discussion

Available Major nutrients (NPK) in soil

The available NPK in the soil was significantly increased due to the different methods of micronutrients application (zinc + boron) along with organics at all the critical stages like flowering, capitulum formation and at harvest stages of sunflower. The treatment 100 per cent recommended dose of fertilizer + S as gypsum @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} + CCP @ 12.5 t ha^{-1} through soil and foliar application of $ZnSO_4$ + $MnSO_4$ @ 0.5 per cent twice (T_{10}) recorded the highest available P content of 16.05, 14.33 and 11.57 kg ha^{-1} at FS, CFS and at the harvest stage, respectively. This was equally efficient with T_8 which received RDF + CCP + S along with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}. This was followed by the treatments arranged in the descending order *viz.,* $T_9 > T_6 > T_7$ and T_4. These treatments were also statistically significant with each other. This was followed by treatments T_5, RDF+ S+ $ZnSO_4$ @ 0.5% FA + CCP @ 12.5 t ha^{-1} which recorded an Olsen-P content of 11.79, 10.57 and 8.42 kg ha^{-1} and T_3, RDF + S along with CCP alone (without micronutrients) which recorded a comparable Olsen-P content of 11.68, 10.46 and 8.32 kg ha^{-1} at the above said critical stages, respectively. The control treatment T_1, recorded the lowest Olsen-P content of 6.96 kg ha^{-1} at harvest.

The increased NPK availability, application of recommended dose of NPK + gypsum + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} through soil and foliar spray of $ZnSO_4$ + borax @ 0.5% along with CCP @ 12.5 t ha^{-1} rated best in recording the highest alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K content in the soil. Addition of micronutrients increased the nodulation and atmospheric N fixation by increased nitrogenase activity thereby the availability of N is increased. Further, the addition of organics stimulated the growth and activity of microorganisms, which increased the nutrient release and the effect was further enhanced by the addition of NPK fertilizers. These findings are in conformity with the earlier work of Chalwade *et al.,* (2006); and Elayaraja (2013). The rapid solubilization of native and applied phosphorus as a result of the carbonic acid produced due to higher microbial respiration, protection provided by humic, fulvic and humin substances resulting from the organic carbon recycling might explains the reason for higher P availability. The findings of Balaguravaih *et al.* (2005) and Ed-Haun Chang *et al.* (2007) corroborate the present findings. With the combined application of recommended NPK + S + $ZnSO_4$ + borax through soil along with CCP there was significant increase in NH_4OAc-K content in the soil. This might be due to higher native K in addition to added potassium. These findings are in conformity with Manikandan, (2012) and Gebremedhin *et al.,* (2015).

Available Secondary and Micronutrients in soil

Available Sulphur ($CaCl_2$- s)

The availability of $CaCl_2$-S was significantly increased with the micronutrient fertilization through soil + foliar

application of zinc + boron along with composted coirpith and recommended dose of NPK. The treatment, application of recommended dose of NPK + CCP @ 12.5 t ha^{-1} + sulphur as gypsum @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} through soil and foliar spray of $ZnSO_4$ + borax @ 0.5 per cent twice (T_{10}) by recording 12.90, 12.51 and 10.85 mg kg^{-1} $CaCl_2$-S at FS, CFS and at the harvest stages, respectively ranked best in increasing the S availability. However, it was found to be equally efficacious with the treatment T_8 (RDF + S + $ZnSO_4$ @ 25 mg kg^{-1} + borax @ 10 kg ha^{-1} through soil alone + CCP @ 12.5 t ha^{-1}). The treatment T_8 registered a $CaCl_2$-S content of 12.79, 12.38 and 10.71 mg kg^{-1}, respectively at the above said three critical stages of sunflower. This was followed by the treatment T_9, (RDF+ CCP + S + $ZnSO_4$ + borax foliar spray @ 0.5%). The treatments individual application of borax alone through soil (T_6), application of borax alone through foliar (T_7), application of $ZnSO_4$ alone through soil (T_4) and application of $ZnSO_4$ alone through foliar spray (T_5) along with recommended NPK + sulphur and organics followed the above said treatments. At harvest the $CaCl_2$-S content registered with T_6, T_7, T_4 and T_5 were 9.71, 9.08, 8.39 and 7.67 mg kg^{-1}, respectively. The treatment T_5 was closely on par with treatment T_3, which received RDF + CCP along with sulphur alone (without micronutrients). The lowest $CaCl_2$-S content was recorded with T_1, the control treatment (RDF alone) that did not received organics, sulphur, zinc and boron.

There was a significant improvement in S availability with the treatment received recommended NPK + sulphur as gypsum + $ZnSO_4$ + borax through soil and foliar along with composted coirpith. The release of organic bound S and native S through the mineralization process resulted in the higher availability of S in the soil. Further, the direct addition of S and slow release of these nutrients through, organic manures resulted in increased S availability. These results are in agreement with Singh *et al.,* (2005); Rasool *et al*., (2013) and Reddy Bheemanna (2015).

DTPA-Zinc and Hot water-Boron

The application of zinc and boron either through soil or foliar and or both along with sulphur and composted coirpith significantly increased the Zn and B availability in the soil. The availability of DTPA-Zn and hot water-B in the soil significantly increased at all the stages of sunflower growth with the application of different treatments. The highest available zinc (1.05 mg kg^{-1}) and B status (0.091 mg kg^{-1}) at harvest stage was recorded with the combined application of 100 per cent recommended dose of NPK + S + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} (SA) through soil and foliar spray of $ZnSO_4$ + borax @ 0.5% along with CCP @ 12.5 t ha^{-1} (T_{10}). This was comparable with treatment which received RDF + S + basal application of micronutrients ($ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}) along with composted coirpith @ 12.5 t ha^{-1} (T_8). This treatment was followed by recommended NPK + CCP @ 12.5 t ha^{-1} + S along with $ZnSO_4$ + borax @ 0.5 per cent (FA) through foliar application (T_9) and it recorded (0.97 and 0.087 mg kg^{-1}) of available DTPA-Zinc and Hot water - B content of soil at harvest stage. This was followed by the treatments significantly arranged in the descending order as $T_4 > T_5 > T_6$ and T_7. These treatments were also statistically significant. The treatment T_7 (RDF + CCP + S + borax FA @ 0.5%) and treatment T_3 (RDF + CCP + S) was closely on par. The control treatment (without S, Zn, B and organics) registered the lowest Zn and B availability (0.58 and 0.066 mg kg^{-1}) at harvest stage.

The available zinc and boron content of the coarse textured coastal saline soils are very low. The present

Table 1: Influence of secondary and micronutrients along with organics on the major (NPK) and secondary (S) nutrients (kg ha^{-1}) availability in coastal saline soil.

Treatments	Alkaline $KMnO_4$-N			Olsen-P			NH_4OAc-K			$CaCl_2$ –S (mg kg^{-1})		
	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS
T_1	130.77	125.49	121.75	10.05	9.01	6.96	146.06	137.57	122.84	7.74	6.21	5.16
T_2	138.20	134.08	130.38	10.88	9.76	7.62	153.97	147.88	137.86	8.41	8.18	6.78
T_3	145.67	140.38	136.58	11.68	10.46	8.32	161.52	154.30	145.18	9.17	8.98	7.57
T_4	155.29	148.80	143.82	12.58	11.26	9.00	170.92	162.57	153..26	10.02	9.86	8.39
T_5	147.68	142.60	137.67	11.79	10.57	8.42	162.60	156.22	147.07	9.35	9.13	7.67
T_6	170.08	161.39	156.23	14.19	12.78	10.27	189.67	175.99	165.68	11.41	11.17	9.71
T_7	162.77	155.11	150.15	13.40	11.94	9.64	180.46	168.98	159.53	10.73	10.56	9.08
T_8	180.43	174.34	168.59	15.84	14.20	11.44	206.45	189.91	178.75	12.79	12.38	10.71
T_9	178.27	167.82	162.44	14.9	13.50	10.82	198.33	182.51	172.00	12.06	11.76	10.26
T_{10}	188.47	176.35	170.47	16.05	14.33	11.57	208.75	192.22	181.15	12.90	12.51	10.85
SE_D	3.42	2.91	2.86	0.36	0.30	0.24	3.52	2.96	2.88	0.28	0.25	0.18
CD (p=0.05)	7.20	6.13	6.02	0.76	0.65	0.52	7.40	6.22	6.06	0.60	0.53	0.39

Table 2: Influence of secondary and micronutrients along with organics on the micronutrients (Zn and B) availability and yield of sunflower in coastal saline soil.

Treatments	DTPA-Zinc (mg kg^{-1})			Hot water-boron (mg kg^{-1})			Yield (kg ha^{-1})	
	FS	CFS	HS	FS	CFS	HS	Seed	Stalk
T_1	1.64	1.33	0.58	0.071	0.068	0.066	980	1506
T_2	1.74	1.40	0.65	0.075	0.072	0.071	1132	1716
T_3	1.82	1.49	0.71	0..079	0.077	0.074	1243	1909
T_4	2.11	1.73	0.91	0.092	0.090	0.084	1458	2279
T_5	2.02	1.65	0.85	0.088	0.086	0.081	1375	2088
T_6	1.94	1.58	0.78	0.084	0.082	0.078	1675	2763
T_7	1.85	1.50	0.72	0.080	0.78	0.075	1557	2534
T_8	2.30	1.88	1.04	0.100	0.098	0.090	1816	3020
T_9	2.21	1.80	0.97	0.096	0.094	0.087	1783	2971
T_{10}	2.32	1.89	1.05	0.101	0.099	0.091	1911	3218
SE_D	0.033	0.030	0.023	0.001	0.001	0.001	46.07	80.16
CD (p=0.05)	0.070	0.064	0.050	0.003	0.002	0.002	96.76	168.34

* RDF- Recommended dose of fertilizer; CCP- Composted coirpith; SA-soil application; FA- foliar application

FS- Flowering stage; CFS - Capitulum formation stage; HS- Harvest stage

experimental soil also showed deficiency of zinc and boron. However, the availability of Zn and B in soil as affected by different treatments assumes significance. In the present investigation, the application of $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} through soil application significantly increased the availability of Zn and B in soil. The highest DTPA-Zn and hot water-B content was recorded with the treatment $ZnSO_4$ + borax + RDF along with composted coirpith 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 and hot water-Boron content of the soil. This finding was in accordance with the earlier workers (Elayaraja, 2008 and Reddy Bheemanna, 2015). Further, the increased zinc and boron availability might be attributed to the direct addition of these nutrients by fertilizer and organic manures, which maintain maximum available zinc and boron status in post harvest soil. Further the complexation of micronutrients with applied organics might have mobilized and increased the availability of Zn and B in soil. These results are in line with Beema (2016).

Yield of sunflower

The sunflower responded well for the secondary and micronutrients application. The significant influence of sulphur, zinc + boron along with recommended NPK and organics in increasing the seed and stalk yield of sunflower was well evidenced in the present investigation. The yield realized under the nutrient poverished coastal saline soil, the highest seed yield (1911 kg ha^{-1}) and stalk yield (3218 kg ha^{-1}) was recorded with combined application of recommended dose of NPK fertilizer (RDF) + S @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} (SA) through soil as well as foliar spray of $ZnSO_4$ @ 0.5% + borax @ 0.5 per cent twice at pre flowering and flowering stage along with composted coirpith @ 12.5 t ha^{-1} (T_{10}). This was followed by the treatments T_8 (RDF + S @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} (SA) + CCP @ 12.5 t ha^{-1}) and treatment T_9 (RDF + CCP @ 12.5 t ha^{-1} + S @ 200 kg ha^{-1} + ($ZnSO_4$ + borax) FA @ 0.5 per cent (T_9). The treatments T_8 and T_9 were found to be on par with each other. The next best treatments in increasing yield of sunflower are T_6 (RDF + S + borax @ 10 kg ha^{-1} (SA) +CCP @ 12.5 t ha^{-1}), T_7 (RDF + S + borax @ 0.5% (FA) + CCP @12.5 t ha^{-1}), T_4(RDF + S + $ZnSO_4$ @ 25 kg ha^{-1} (SA) + CCP @ 12.5 t ha^{-1}) and T_5 (RDF + S + $ZnSO_4$ @ 0.5% (FA) through foliar application along with CCP). This was followed by the treatments T_3 (RDF + CCP + sulphur alone/ without micronutrients) and T_2 (RDF + CCP alone/without secondary and micronutrients). The individual application of $ZnSO_4$ and borax alone and mode of application either through soil or foliar alone along with RDF, sulphur and organics applied treatments in significantly increasing the yield of sunflower as compared to control. Of all the treatments, the treatment (T_{10}), recommended dose of NPK + S + composted coirpith along with micronutrients through soil ($ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}) and foliar ($ZnSO_4$ @ 0.5% + borax @ 0.5 per cent) application recorded a seed and stalk yield of 1911 and 3218 kg ha^{-1} which was 48.71 and 53.20 per cent higher over 100 per cent NPK or RDF alone (without sulphur, micronutrients and organics).

The sunflower yield increased with application of recommended dose of NPK fertilizer (RDF) + S @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} (SA) through soil as well as foliar spray of $ZnSO_4$ @ 0.5% + borax @ 0.5 per cent twice along with composted coirpith @ 12.5 t ha^{-1} (T_{10}). This might be due to supply of both macro and micronutrients play a major role in physiological activities of sunflower. Further, the betterment of yield characters might be ascribed to the effect of zinc and boron which enhanced the photosynthetic activity resulting in the higher biomass production and accumulation of carbohydrates and essential auxins which resulted in enhanced the growth and yield of sunflower. These results are in agreement with those of Kalayarasan and Vaiyapuri (2008) and Chandra deo *et al.,* (2013). Foliar application of micronutrients through Zn and B at pre flowering and flowering stages of crop growth were effectively absorbed in the plant system and translocated into sink

which resulted in more number of seeds capitulum^{-1}. Further, increased in photosynthesis during growth stages might be contributed for greater assimilates supply to the maximum capitulum size which resulting in better seed setting and also betterment of higher seed yield of sunflower. The results are in conformity with Farzanian *et al.,* (2010) and Mekki (2015). Application of sulphur as gypsum also had favourable effect on dry matter production and yield components due to proper partitioning of photosynthates from source to sink which lead to increase in seed yield of sunflower. These findings of the present study are in agreement with the report of Poomurugasen (2003) and Meti *et al.,* (2004).

Conclusions

The present investigation clearly concluded the beneficial role of organics along with sulphur and micronutrients fertilization for increasing sunflower production in coastal saline soil. Application of recommended dose of NPK + composted coirpith @ 12.5 t ha^{-1} along with sulphur as gypsum @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10kg ha^{-1} through soil and foliar spray of both the micronutrients ($ZnSO_4$ + borax) @ 0.5 per cent twice at critical stages like, pre flowering and flowering stage was identified as best treatment combination to recommend to the farmer's of coastal areas to realize the maximum net profit in sunflower yield and to sustain soil health in coastal saline soil.

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