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EFFECT OF SECONDARY AND MICRONUTRIENTS FERTILIZATION WITH ORGANIC MANURE ON THE GROWTH, YIELD, QUALITY AND ECONOMICS OF SUNFLOWER IN COASTAL SALINE SOIL

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Abstract

Coarse texture coastal saline soils are common for the deficiency of all sorts of nutrients and organic carbon status. In determining the yield and quality of sunflower, the role of sulphur, Zn and B is much pronounced. Restricted availability of these nutrients in sandy soil greatly impairs the yield of sunflower production due to salinity stress. A field experiment was conducted in a farmer's field at Mandabam coastal village, near Chidambaram during June–September 2016, to find out the effect of organics along with secondary (S) and micronutrients (Zn and B) fertilization on the growth, yield quality and economics of sunflower in coastal saline soil. The experimental soil was sandy loam in texture and taxonomically classified as *Typic Ustifluvent*. The initial soil had the following characteristics (0-15 cm layer) of the experimental site were, pH–8.34 and EC–2.41 dS m^{-1}. The soil registered low organic carbon status of 2.30 g kg^{-1}, 156.32 kg ha^{-1} of alkaline $KMnO_4$ – N; 9.35 kg ha^{-1} of Olsen–P, 173.74 kg ha^{-1} of NH_4OAc-K, 6.15 mg kg^{-1} of 0.15% $CaCl_2$-S, 0.71mg kg^{-1} of DTPA-Zn and 0.08 mg kg^{-1} of hot water boron, respectively. 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 above treatments were arranged in a Randomized Block Design (RBD) with three replications and tested with sunflower var. Sunbred-hybrid. The results of the study 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 was significantly superior in increasing the growth, yield quality and economics of sunflower.

Key words: Coastal saline soil, organics, gypsum, $ZnSO_4$, borax, yield, nutrient uptake, sunflower.

Introduction

In sunflower production and improving the quality, the zinc and boron plays a vital role. Zinc is recognized as a key element for protein synthesis, biological nitrogen fixation and also plays an important role in various enzymatic activities in the development of plant growth and increase of oil content in sunflower crop. Boron plays a significant role in promoting growth, quality of seeds and yield of sunflower. It also arrest flower drop/poor seeds formation, and plays a pivotal role in cell division in the process of enlarged size of flower capitulum formation besides its involvement in carbohydrate and fat synthesis. Several earlier works has emphasized the need for application of these nutrients for increasing the growth, yield and quality of sunflower crop (Kalaiyarasan and Vaiyapuri, 2008 and Rasool *et al.,* 2013). Whereas sulphur is also increasingly being recognized as the fourth major plant nutrient next to nitrogen, phosphorus and potassium (Tendon and Messick, 2002). It helps in the synthesis of cystein, methionine, chlorophyll, vitamins-B like biotin and thiamine, metabolism of carbohydrates increasing oil and protein content as well as associated with growth and metabolism, especially affecting the protolytic enzymes (Najar *et al*., 2011). In addition, there is a strong consensus among scientists that incorporation of organic manure is essential to sustain soil health and crop production. Utilization of organic manures in coastal soils have multidimensional effect in improving all the soil related constraints. Hence, in the present study was

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undertaken to find out the influence of sulphur, zinc and boron fertilization along with organics on sunflower, growth, yield, quality and economics of sunflower 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 effect of secondary and micronutrients on the growth, yield, quality and economics of sunflower in coastal saline soil. The treatments involving like 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 d Sm^{-1} and organic carbon- 2.30 g kg^{-1}. The available zinc content of 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 biofertilizer namely *Azospirillum* @ 2 kg ha^{-1} was applied to all the experimental plots. Growth character like plant height and DMP were recorded at critical stages of sunflower viz., flowering, capitulum formation and at harvest stages and analyzed for the quality parameters like protein and oil content were estimated using the standard procedure as outlined by Jackson (1973) and computing the protein and oil yield of sunflower seeds. At harvest seed and stalk yield were recorded as separately and economics was also worked out.

Results and Discussion

Growth Characters

The application of secondary and micronutrient fertilization along with organics and recommended dose of NPK fertilizers was significantly increased the plant height and dry matter production of sunflower. Of all the treatments, the application of sulphur @ 200 kg ha^{-1} through gypsum + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} (SA) through soil application + foliar spray of $ZnSO_4$ @ 0.5% + borax @ 0.5 per cent along with CCP @ 12.5 t ha^{-1} and recommended dose of NPK fertilizer (T_{10}), recorded a plant height of 142.50cm and DMP of 4947 kg ha^{-1} at the harvest stage. This treatment was followed by $T_{8,}$ which received the application of RDF + gypsum @ 200 kg ha^{-1} along with CCP @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} (SA) through soil alone recorded a significant plant height (134.95 cm) and dry matter production of 4646 kg ha^{-1} at harvest stages, respectively. However, it was found to be equally efficacious with T_9 This was followed by treatments in descending order $T_6 > T_7 > T_4 > T_5 > T_3$ and T_2. These treatments were also statistically significant. The treatment T_1, application of recommended dose of NPK alone (without secondary, micronutrient and organics) recorded a lowest dry matter production of 2325 kg ha^{-1} at harvest.

The increased growth characters of sunflower, the addition of recommended NPK+ S + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{--1} through soil and foliar spray @ 0.5% along with CCP @ 12.5 t ha^{--1} recorded the highest plant height and dry matter production. This might be due to the increased nutrient supply with the addition of secondary and micronutrients fertilizer and organics. Further, micronutrients might had direct effect of plant growth like auxin activity (Suresh *et al.,* 2013) contributing to increase in plant height, leaf area index and DMP. Further, Zinc improved dry matter production though the cell wall formation and N fixation which enhanced root growth by activation of several enzyme systems and auxins. Whereas, boron influenced the nitrogen and carbohydrate metabolism of plants which might have contributed for the better plant growth of sunflower (Mekki, 2015). In addition, foliar application of $ZnSO_4$ and borax might have improved the fundamental cell processes like photosynthesis and respiration. The presence of micronutrients in chloroplasts, cell organells was considered for the possible causes of increased growth characters of plants. Further, this was led to an increase in various plant metabolites responsible for cell division and elongation (Kalayarasan and Vaiyapuri, 2008).

Yield of Sunflower

The significant influence of sulphur, zinc + boron in increasing the seed and stalk yield of sunflower was well evidenced in the present study. 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. This was followed by treatments in descending order like $T_6 > T_7 > T_4 > T_5 > T_3 > T_2$ and T_1. These treatments were also statistically significant.

The improved growth and yield characters, the sunflower yield also increased with the application of recommended dose of NPK + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} through soil application (SA) + $ZnSO_4$ and borax @ 0.5 per cent through foliar application (FA) along with composted coirpith @ 12.5 t ha^{-1}. This might be due to the application of micronutrients and organic manures helped in the slow and steady rate of nutrient release into soil solution to match the required absorption pattern of sunflower thereby increased the yield. This corroborates the earlier report of Eslami *et al*. (2014). Further the rapid mineralization of N, P, K and S from recommended dose of inorganic fertilizers and steady supply of these nutrients from composted coirpith, might have met the nutrient requirement of crop at the critical stages. In addition, the beneficial influence of micronutrients *viz.,* Zn and B 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 Wabekwa *et al*. (2014) and Ramesh, (2015).

Quality Characters of Sunflower

Oil and protein content

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

Oil and Protein yield

The micronutrient fertilization through soil + foliar application of zinc + boron along with organics, recommended dose of NPK and sulphur exerted a significant influence on protein and oil yield of sunflower seeds. Among the treatments, the application of recommended dose of NPK fertilizer + sulphur @ 200 kg ha^{-1} (gypsum)+ CCP @ 12.5 t ha^{-1} along with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} and foliar application of $ZnSO_4$ @ 0.5% + borax @ 0.5 per cent twice (T_{10}) registered a significantly higher oil (811.02 kg ha^{-1}) and protein yield (204.78 kg ha^{-1}) of sunflower seed. This was followed by the soil application of RDF + S + composted coirpith @ 12.5 t ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1} and borax @ 10 kg ha^{-1} (SA) (T_8). However, it was found to be comparable with the treatment T_9, (RDF + S + CCP @ 12.5 t ha^{-1} + $ZnSO_4$ @ 0.5% + borax @ 0.5 per cent through foliar application). These two treatments registered a comparable oil (765.08 and 755.45 kg ha^{-1}) and protein (226.09 and 222.28 kg ha^{-1}) yield of sunflower seed. The lowest oil (396.41 kg ha^{-1}) and protein yield (114.07 kg ha^{-1}) was recorded in the control or RDF alone (without secondary, micronutrient and organics) as compared to all other treatments.

Application of recommended dose of NPK + $ZnSO_4$ and borax through soil and foliar spray along with composted coir pith accounted for a highly significant improvement in the protein and oil yield of sunflower seeds. The improvement in the protein and oil yield of sunflower with the application of micronutrients and organics was earlier reported by Khan *et al.* (2009). In the over all improvement in quality characters *viz.,* protein and oil yield, the combined application of 100 per cent recommended dose of NPK + sulphur + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} through soil + foliar spray of $ZnSO_4$ + borax @ 0.5% along with CCP @ 12.5 t ha^{-1} recorded the highest protein and oil yields could mainly be due to cumulative effect of higher seed yield in these treatments. Similar results were also observed by Reddy Bheemanna (2015). Higher nutrient availability resulted in greater accumulation of N in the capitulum and hence crude protein content of the seed was increased due to higher nutrient content through mineral fertilizer and organic amendments application (Nandhagopal *et al.,* 2003). The application of organics through decomposition supplied adequate sulphur and promoted the synthesis of fatty acids resulting in increased oil content (Khatik and Dikshit, 2001).

Further, 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 content and hence the protein content in seeds (Shaker and Doori, 2012). Besides the addition of zinc as $ZnSO_4$, boron as borax might be improved the

Table 1: Effect of secondary and micronutrients fertilization with organic manure on the growth, yield and quality of sunflower.

Treatments	Plant height (cm)			Dry matter production (kg ha^{-1})			Yield		Quality characters			
	FS	CFS	HS	FS	CFS	HS	Seed	Stalk	Oil cont -ent (%)	Protein content(%)	Oil yield (kg ha^{-1})	Protein yield(kg ha^{-1})
T_1	28.44	53.14	75.01	443	1635	2325	980	1506	40.45	11.64	396.41	114.07
T_2	33.85	65.83	84.35	501	1919	2673	1132	1716	40.57	11.60	459.25	131.31
T_3	38.07	75.75	92.46	549	2184	3037	1243	1909	40.76	11.62	506.44	144.43
T_4	45.80	88.65	108.95	627	2671	3700	1458	2279	41.26	11.91	601.57	173.64
T_5	42.04	81.92	100.64	591	2443	3382	1375	2088	41.05	11.71	557.04	158.90
T_6	55.12	101.57	124.90	698	3115	4308	1675	2763	41.75	12.28	699.31	205.69
T_7	50.69	95.20	116.99	665	2905	3999	1557	2534	41.53	12.14	646.62	189.01
T_8	60.12	108.97	134.95	745	3333	4646	1816	3020	42.13	12.45	765.08	226.09
T_9	59.00	107.66	132.73	733	3310	4597	1783	2971	42.04	12.37	755.45	222.28
T_{10}	64.31	115.27	142.50	778	3531	4947	1911	3218	42.44	12.60	811.02	204.78
SE_D	1.54	2.76	3.44	14.44	85.61	121.96	46.07	80.16	0.82	0.22	18.33	4.43
CD (p=0.05)	3.25	5.81	7.24	30.34	179.80	256.13	96.76	168.34	NS	NS	38.50	9.31

better quality through synthesis of oil, protein and amino acids through its effect on protein and lipid metabolism in plants. Similar result was earlier made by Salwai *et al.* (2010).

Economics of Sunflower Production

The benefit cost ratio was worked out for the cultivation of sunflower in the coastal saline soil revealed the beneficial influence of different methods of micronutrients (Zn and B) fertilization along with recommended dose of NPK, sulphur and composted coirpith application in increasing the net profit over the conventional methods of sunflower 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 as $ZnSO_4$ and B as borax application through soil as well as foliar along with NPK, sulphur as gypsum and composted coirpith. Among the various treatments, the highest net income

(Rs. 45,374 ha^{-1}) and benefit cost ratio (Rs. 3.11) were obtained with the soil application of $ZnSO_4$ @ 25 kg ha^{-1} and borax @ 10 kg ha^{-1} + foliar application of $ZnSO_4$ and borax @ 0.5 per cent twice at pre flowering stage (PFS) and flowering stage (FS) along with recommended dose of NPK + sulphur as gypsum @ 200 kg ha^{-1} and CCP @ 12.5 t ha^{-1} (T_{10}). The lowest net income (Rs. 16,171 ha^{-1}) and benefit cost ratio (Rs. 1.89) was observed with T_1, the control treatment (RDF alone) that did not receive organics, sulphur, zinc and boron.

The increase in the economic yields of sunflower like seed and stalk and hence the economic values of the yield support the cost of cultivation and ultimately resulted in higher net income and also the benefit : cost ratio. Further the higher return in this treatment than the remaining treatments might be due to the cost effectiveness of these secondary and micronutrients along with organic source which are locally available in abundant and also due to the higher yield obtained when compared to other treatments. The earlier findings of Beema (2015) and Reddy Bhemanna (2015) also support the present investigation.

Conclusion

The results of the present investigation clearly concluded that for increasing the growth, yield, quality and economics of sunflower, the combined application of recommended dose of NPK + sulphur as gypsum @ 200 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} through soil + foliar spray twice @ 0.5% ($ZnSO_4$ and Borax) along with composted coirpith @ 12.5 t ha^{-1} would be beneficial.

Table 2: Economic analysis of sunflower.

Treat-ments	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

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