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Studies on the effect of different zinc sources and levels on the quality and micro- nutrient uptake of cotton

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Abstract
The present study was aimed to study the effects of different zinc levels and sources on n the quality and micro- nutrient uptake of cotton in saline sodic soil. A pot experiment was conducted in Factorial Completely Randomized Design with three replications. The treatments consisted of three different sources of zinc namely zinc sulphate, zinc –EDTA and zinc humate and four levels of Zn (0, 1.25, 2.5 and 5.0 mg kg-1) and the variety MCU-7 was grown as test crop. The uptake of NPK was recorded at harvest. The results of the study indicated that soil application of Zn significantly increased the seed index and lint index and micro- nutrient uptake of cotton. Application of 2.5 mg Zn kg-1 of soil recorded superior seed index and lint index of 9.03 and 4.50, respectively. This was on par with application of 5.0 mg Zn kg^{-1}. Similar trend was observed in micronutrient uptake of cotton. The present study concluded that 2.5 mg kg-1of Zn through zinc humate is the optimum dose for highest seed and lint index and maximum micronutrient uptake.

Keywords: Cotton, Zinc humate, Seed and Lint index, Uptake of micronutrient, Available micronutrient content

Introduction
Cotton, a crop of prosperity is an industrial commodity of worldwide importance has a profound influence, on men and matter. Cotton cultivation in India encompasses total diversity in vastness, spread, agro-climate, farming methods, cropping system and planting seasons, varieties, duration, yield, quality, costs and returns. Despite the recent setbacks, cotton continues to remain the backbone of the rural economy, particularly in the dry land areas. Besides being a money spinner, it is also an employment generator as its cultivation provides 200 men day's ha-1. About 60 million people in the world earn their livelihood through its cultivation processing and trade.

Application of high analysis fertilizer without organic manures as a source of nutrients to heavy nutrient feeding crops like cotton in intensive cropping system resulted in rapid depletion of the available micronutrient status of soil. The deficiencies of micronutrients are generally more prevalent in the crops grown in soils with coarse texture, high pH, low organic matter content and high CaCO3 besides field irrigated with poor quality irrigation water.

It is estimated that a quarter of the world's soils currently suffer from micronutrient stress, known to cause greater production loss than any other factor (Hassan, 2007) [12]. In India nearly 47 percent of the soils are deficient in zinc and 33 per cent in boron and 5 per cent in manganese. In Tamilnadu, zinc, manganese and boron deficiencies are about 58.4, 6.0 and 21.0 percent, respectively. The deficiencies are more common in salt affected, coarse textured, high pH soils wherein organic matter content is low. These soils require micronZinc is one of the important essential plant nutrients, which is deficient in most of the Indian soils. Moreover, its availability to plant is affected by different soil factors like high pH, adsorption by the negatively charged clay colloids, presence of other competitive cations like Fe3+, Cu2+, Ca2+ etc., anions like PO43-, SO42- etc., low pCO2 value, adsorption on the surface of precipitated CaCO3 concretions etc. (Dipankar Kar *et al*., 2007) [11]. Widespread deficiency of zinc in the cotton growing area manifested the development of technologies for its efficient correction. The loss in the yield due to Zn deficiency could be resorted to marginal with the application of required quantities of Zn from appropriate sources nutrient fertilization to achieve sustainable productivity. Hence, the present study was planned to assess the impact of different zinc sources and levels on the quality and micro- nutrient uptake of cotton

Materials and Methods
A pot experiment was conducted at pot culture yard, faculty of Agriculture, Annamalai University during 2012 to study the effect of various level and source of zinc on yield and

growth of cotton (*Gossypium hirsutum* L.) in saline sodic soil. The experimental soil was sandy loam in texture (Typic haplustalf) having pH 8.7 and EC1.23 dSm^{-1}. The fertility status of the soil was found low nitrogen (228 kg ha^{-1}) and phosphorus (9.12 kg ha^{-1}) and medium in potassium (290 kg ha^{-1}). The micronutrient Zn status of the soil was 0.72mg kg^{-1} of soil. The experiment was laid out in Factorial Completely Randomised Design with three replications. The treatments included four levels of Zn (0, 1.25, 2.5 and 5.0 mg kg^{-1}) supplied through three different sources namely zinc sulphate, zinc-EDTA and zinc humate. All treatmental pots were applied with soil test based NPK dose of 20 : 40 : 40 g kg^{-1}. The Znhumate used in this study was prepared by adding excess of saturated zinc sulphate solution into Na-humate at pH 5.5. The complex precipitated were first washed with dil. HCl and later with distilled water to remove the hydroxide, if any. The Zn-humate complexes were then dried at 550C. Zinc content of the Zn-humate was estimated by using atomic adsorption spectrometer.

At maturity, the crop was harvested manually; seed index and lint index were calculated and expressed in per cent. Plant samples collected were collected at maturity and analysed for Fe, Mn, Cu and B content using standard procedure outlined by Jackson (1973) [13]. The total uptake of the individual nutrient by the crop was computed by multiplying the respective nutrient content with DMP.

Post-harvest soil samples were collected pot wise. The soil samples were air dried, powdered, processed and analysed for available nitrogen, phosphorus, potassium, DTPA extractable Fe, Mn, Zn, Cu and hot water soluble B by adopting the procedure (Jackson, 1973) [13].

Results and Discussion

The results of this investigation and the relevant discussion were summarised in the following headings:

Seed index and lint index

Application of Zn through different zinc sources significantly increased the seed and lint index of cotton in a saline sodic soil (Table 1). Addition of graded levels of zinc from 0 to 5.0 mg kg-1 consistently increased the seed and lint index and it ranged from 7.08 to 9.27 and 3.56 to 4.59. Among the different levels of zinc, addition of 5.0 mg Zn kg^{-1}(L_4) significantly registered the highest mean seed index and lint index of 9.27 and 4.59. Application of 2.5 mg Zn kg-1(L_3) of soil recorded mean seed index and lint index of 9.03 and 4.50, respectively. However, this was on par with application of 5.0 mg Zn kg^{-1}. The control (L_1) registered the lowest mean seed and lint index of 7.08 and 3.56, respectively. Among the three sources of zinc tested, application of Zn-humate (S_3) recorded the highest mean seed index and lint index of 8.77 and 4.37. This was followed by Zn-EDTA (seed index and lint index of 8.39 and 4.16) and ZnSO4 (seed index and lint index of 7.98 and 4.03).

Table 1: Effect of different sources and levels of Zn on seed index and lint index of cotton in a saline sodic soil

Levels / Sources	Seed index					Lint index				
	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
S_1	7.08	7.78	8.38	8.68	7.98	3.56	3.95	4.25	4.34	4.03
S_2	7.08	8.20	9.00	9.28	8.39	3.56	4.10	4.43	4.56	4.16
S_3	7.08	8.42	9.73	9.86	8.77	3.56	4.22	4.82	4.89	4.37
Mean	7.08	8.13	9.03	9.27		3.56	4.09	4.50	4.59	
	S.ED		CD(*P* = 0.05)			S.ED		CD(*P* = 0.05)		
S	0.07		0.20			0.04		0.10		
L	0.12		0.25			0.07		0.15		
L X S	0.19		0.40			0.11		0.24		

*S_1 - Zinc sulphate, S_2- Zn EDTA S_3- Zn-humate, L_1- 0 mg Zn $Kg^{-1}$of soil, L_2- 1.25 Zn $Kg^{-1}$of soil L_3- 2.5 mg Zn $Kg^{-1}$of soil and L_4- 5.0 mg Zn $Kg^{-1}$of soil.

The interaction effect due to levels and sources of Zn on seed index and lint index was significant. Supply of 5.0 mg Zn kg^{-1} as Zn-humate recorded the highest seed index and lint index of 9.86 and 4.89. This was on par with application of 2.5 mg Zn kg^{-1} (S_3L_3) as Zn-humate, which registered seed index and lint index of 9.73 and 4.82. Application of 5.0 mg Zn kg^{-1} as Zn-EDTA(S_2L_4) recorded the seed index and lint index of 9.28 and 4.56, respectively which was followed by application of 2.5 mg Zn kg^{-1} (S_2L_3) as Zn-EDTA and registered the seed and lint index of 9.00 and 4.43. The lowest seed and lint index of 7.08 and 3.56 was noticed in control. This result was accordance with the observation of Ahmed *et al*., (2010) [1]. This may be due to application of zinc through different sources, improved the overall growth and development of cotton plants and thereby enhanced the translocation of photosynthates from vegetative plant parts to reproductive organs, resulting in greater number of boll retention with a concurrent increase in seed and lint index (Welch, 1995) [14]. Moreover the humate ions released in soil during the dissociation of Zn humate might have also helped to mobilize nutrients from the soil as well as improved the growth and development of the plant directly (Trevisan *et al*., 2010) [2].

Uptake of Fe, Mn, Cu and B

The uptake of Fe, Mn, Cu and B were significantly and positively influenced by the application of different zinc levels applied through three different sources in a saline sodic soil (Table 2 and 3). Among the different levels of zinc, application of 5.0 mg Zn kg^{-1} significantly registered the highest mean Fe, Mn, Cu and B uptake of 13.47, 5.83, 1.81 and 9.05 mg pot^{-1}, respectively. Addition of 2.5 mg Zn kg^{-1} of soil recorded the mean Fe, Mn, Cu and B uptake of 13.33, 5.77, 1.79 and 8.96 mg pot^{-1}, respectively and this was at par with the application of 5.0 mg Zn kg^{-1}. The zinc level L_1 registered the lowest mean Fe, Mn, Cu and B uptake of 10.38, 3.98, 1.56 and 6.57 mg pot^{-1}, respectively.

Table 2: Effect of different sources and levels of Zn on Zn, Fe and Mn uptake by cotton in a saline sodic soil

Levels / Sources	Fe uptake(mg pot^{-1})					Mn uptake(mg pot^{-1})				
	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
S_1	10.38	11.99	12.60	12.80	11.94	3.98	5.19	5.45	5.54	5.04
S_2	10.38	12.73	13.33	13.47	12.48	3.98	5.51	5.77	5.83	5.27
S_3	10.38	13.07	14.07	14.14	12.91	3.98	5.66	6.09	6.12	5.46
Mean	10.38	12.60	13.33	13.47		3.98	5.45	5.77	5.83	

	Fe S.E$_D$	Fe CD(P = 0.05)	Mn S.E$_D$	Mn CD(P = 0.05)
S	0.09	0.20	0.04	0.10
L	0.14	0.31	0.08	0.18
L X S	0.20	0.42	0.12	0.25

*S_1 - Zinc sulphate, S_2- Zn EDTA S_3- Zn-humate, L_1- 0 mg Zn Kg^{-1} of soil, L_2- 1.25 Zn Kg^{-1} of soil L_3- 2.5 mg Zn Kg^{-1} of soil and L_4- 5.0 mg Zn Kg^{-1} of soil.

Table 3: Effect of different sources and levels of Zn on Cu and B uptake by cotton in a saline sodic soil

Levels / Sources	Cu uptake(mg pot^{-1})					B uptake(mg pot^{-1})				
	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
S_1	1.56	1.61	1.69	1.72	1.64	6.57	8.06	8.46	8.60	7.92
S_2	1.56	1.71	1.79	1.81	1.72	6.57	8.55	8.96	9.05	8.28
S_3	1.56	1.76	1.89	1.90	1.78	6.57	8.78	9.45	9.50	8.57
Mean	1.56	1.69	1.79	1.81		6.57	8.46	8.96	9.05	

	Cu S.Ed	Cu CD(P = 0.05)	B SED	B CD(P = 0.05)
S	0.02	0.05	0.07	0.15
L	0.04	0.09	0.11	0.24
L X S	0.06	0.14	0.15	0.32

*S_1 - Zinc sulphate, S_2- Zn EDTA S_3- Zn-humate, L_1- 0 mg Zn Kg^{-1} of soil, L_2- 1.25 Zn Kg^{-1} of soil L_3- 2.5 mg Zn Kg^{-1} of soil and L_4- 5.0 mg Zn Kg^{-1} of soil

Among the three sources of zinc tried, the lowest mean Fe, Mn, Cu and B uptake of 11.94, 5.04, 1.64 and 7.92 mg pot^{-1}, respectively was recorded with zinc sulphate. Addition of Zn-EDTA recorded the higher mean Fe, Mn, Cu and B uptake of 12.48, 5.27, 1.72 and 8.28 mg pot^{-1}, respectively as compared to $ZnSO_4$. Application of Zn-humate was significantly superior in increasing mean Fe, Mn, Cu and B uptake to 12.91, 5.46, 1.78 and 8.57 36.10 mg pot^{-1}, respectively as compared with other two sources. The interaction effect between levels and sources of zinc favourably improved the NPK by uptake by cotton. Application of 5.0 mg Zn kg^{-1} (S_3L_4) as Zn-humate recorded the highest Fe, Mn, Cu and B uptake of 14.14, 6.12, 1.90 and 9.50 mg pot-1, respectively. This was on par with application of 2.5 mg Zn kg-1 as Zn-humate (S_3L_3), and it recorded Fe, Mn, Cu and B uptake of 14.07, 6.09, 1.89 and 9.45 mg pot^{-1}, respectively. This was followed by application of 5.0 mg Zn kg-1 as Zn-EDTA (S_2L_4) which registered the Fe, Mn, Cu and B uptake of 13.47, 5.83, 1.81 and 9.05 mg pot-1, respectively.

The increased Mn uptake may be due to the role of applied zinc in activating the enzymatic system which helped the transloaction of manganese to other plant parts (Yadav *et al.* 1991) [3]. The effect of zinc on Fe uptake by cotton was non-significant. Cu also does not have a statistically significant effect with application of Zn. These findings are in accordance with earlier reports of Tandon, (1992) [5]. In the present study, addition of Zn has improved the B uptake by cotton. The higher B uptake might be attributed to the better availability of B in the soil applied with Zn, which resulted in the better accumulation of B by the cotton. The results are in the conformity with Ganeshappa (2000) [6]. Humic substances have been shown to improve plant growth through several mechanisms. In addition to their positive effects on solubility and uptake of micronutrients, humic substances are also involved in uptake of other nutrients, and can increase root and shoot growth as well as induce the plant resistance to different stresses (Quaggiotti *et al.* 2004) [10]. This could also be the reason for the better performance of Zn humate applied plants in respect of growth, yield attributes, yield as well as nutrient uptake by cotton

DTPA extractable Fe, Mn, and Cu and hot water soluble B in post-harvest soil

The available Fe, Mn, Cu and B content in post-harvest soil was not positively influenced by the application of different zinc levels applied through three different sources of cotton in a saline sodic soil (Table 4). Application of increasing level of Zn decreased the DTPA extractable Fe, Mn, Cu and hot water soluble B. However the decrease was not significant. All the three sources of Zn showed a decreasing trend on the availability of Fe, Cu, Mn and B in post-harvest soil. Addition of Zn through Zn-humate recorded the lower mean DTPA extractable Fe, Mn, Cu and hot water soluble B of 10.73, 1.64, 0.615, and 0.28 mg kg^{-1}, respectively. The interaction effect due to level and sources of Zn on DTPA extractable Fe, Cu, Zn and hot water soluble B was non-significant.

Table 4: Effect of different sources and levels of Zn on DTPA extractable Mn, Fe, Cu and hot water soluble boron content in post-harvest soil

Levels / Sources	Iron (mg kg^{-1})					Manganese (mg kg^{-1})					Copper (mg kg^{-1})					Hot water soluble B (mg kg^{-1})				
	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
S_1	11.53	10.8	10.7	10.62	10.84	1.72	1.66	1.68	1.63	1.68	0.583	0.593	0.603	0.613	0.598	0.30	0.30	0.31	0.31	0.30
S_2	11.32	10.75	10.56	10.4	10.74	1.68	1.72	1.68	1.63	1.66	0.583	0.618	0.625	0.633	0.615	0.29	0.31	0.30	0.29	0.29
S_3	11.28	10.61	10.52	10.5	10.73	1.70	1.69	1.67	1.51	1.64	0.583	0.616	0.611	0.610	0.614	0.29	0.31	0.28	0.28	0.28
Mean	11.38	10.72	10.59	10.51		1.70	1.69	1.68	1.59		0.583	0.614	0.623	0.632		0.29	0.30	0.33	0.29	

	Iron S.Ed	Iron CD(P = 0.05)	Manganese S.Ed	Manganese CD(P = 0.05)	Copper S.Ed	Copper CD(P = 0.05)	B S.Ed	B CD(P = 0.05)
S	0.57	NS	0.03	NS	0.07	NS	0.002	NS
L	0.67	NS	0.03	NS	0.01	NS	0.002	NS
L X S	0.98	NS	0.07	NS	0.01	NS	0.008	NS

*S_1 - Zinc sulphate, S_2- Zn EDTA S_3- Zn-humate, L_1- 0 mg Zn Kg^{-1} of soil, L_2- 1.25 Zn Kg^{-1} of soil L_3- 2.5 mg Zn Kg^{-1} of soil and L_4- 5.0 mg Zn Kg^{-1} of soil

Conclusion

From this investigation, it tend to be concluded that the application of 2.5 mg kg-1 of Zn as zinc humate could be the optimal dose to increase seed index and lint index of the cotton in salt - affected soil.

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