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INFLUENCE OF DIFFERENT SOURCES AND LEVELS OF MANGANESE ON THE QUALITY OF COTTON AND UPTAKE OF MACRO AND MICRONUTRIENT IN SALINE-SODIC SOIL

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Abstract

The pot experiment was conducted to evaluate different source and levels of Mn quality of cotton and uptake of nutrient under saline-sodic conditions. Three sources namely, manganese sulphate, manganese-EDTA and manganese humate were used in this study. The experiment was carried out with three replications in Factorial completely Randomised Design. Treatments comprise of four levels (0, 1.25, 2.5 and 5.0 mg kg^{-1}) of Mn were applied to the cotton. The results revealed that application of graded level of Mn from 0 to 5.0 mg kg^{-1} increased the seed index and lint yield up to 2.5 mg kg^{-1} thereafter decreased. Application of 2.5 mg Mn kg^{-1} as manganese humate recorded the maximum seed index and lint index of 8.70 and 4.15. This was on par with application of 1.25 mg Mn kg^{-1}as manganese humate (S_3L_2) and it recorded the seed and lint index of 8.52 and 4.11. Irrespective of the sources, increase in the levels of Mn from 0 to 5.0 mg kg^{-1} consistently decreased the NPK availability in the soil. The available (DTPA extractable) Zn, Fe, Cu and B (Hot water soluble) content in post-harvest soil was not influenced favourably by the application of different sources and levels of Mn to cotton in a saline sodic soil.

Key words: Cotton, Mn-humate, uptake of macro and micronutrients, Seed index and Lint index.

Introduction

Cotton (*Gosspium* spp.) is one of the most important fibre crops, and name because the "King of fibres" plays a key role in world economic, political and social status (Gourkhede *et al.,* 2019). Past few decades, due to soil depletion, intensive agriculture, low organic matter application and imbalanced fertilizer use create micronutrients level in soil are critical. Soil salinity and poor micronutrient supply is the major hurdle for higher production in cotton. Manganese deficiency is a widespread disorder affecting plants in many parts of the world. It may be due to high pH, high calcium carbonate ($CaCO_3$) content and high soil phosphorus levels which affects crop growth, development and productivity (Moraghan and Mascani, 1991).

Cotton is well suited in different growing conditions and soils around the world, nutritional disorders induced by Mn deficiency are very common (Mullins and Burmester, 1993; Sawan *et al.,* 1993a; 1993b). Although, the symptoms of Mn deficiency appeared without any visible symptoms during the vegetative growth stage will significantly reduce the yield of cotton seeds (Mullins and Burmester, 1993; Sawan *et al.,* 1993b). In severe condition, symptoms of Mn deficiency are interveinal chlorosis, of the younger leaves and middle-aged leaves tissues may rapidly become necrotic (Mengel *et al.,* 2001). The seed number and yield is low because of low pollen fertility and shortage of carbohydrates (Marschner, 1995; Mengel *et al.,* 2001; Sharma *et al.,* 1991).

It is widely accepted that flowering and fruiting organs are particularly sensitive to Mn deficiency owing to a limited supply of phloem and xylem (Marschner, 1995). Manganese deficit causes low pollen productivity and lack of carbohydrate supplies for seed set and fruit production (Sharma *et al.,* 1991). In addition, there is very few literature documented regarding Mn application on the reproductive requirements, flowering, seed set, lint yield and quality, fruit retention and seed development and seed quality of cotton. Elayan, (2008) reported that manganese application with iron significantly influences the plant height, number of sympodial branches, number

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of bolls/plant and fibre uniformity ratio. Dordas (2009) found that manganese application increased the chlorophyll content and number of bolls per plant compared with the control treatment. Abdallah and Mohamed (2013) studied the foliar application of a combined of each of iron, manganese and zinc significantly varied in plant height, number of sympodial branches per plant.

After green revolution in India, cotton may often grow in coastal saline soil which requires more Mn during vegetative and reproductive stage of the crop. In the light of the above, the present study has been planned to assess the influence of different sources and levels of Mn on the quality of cotton and uptake of macro and micronutrients.

Materials and Methods

During 2014, a pot experiment was conducted at the pot culture yard, Faculty of Agriculture, Annamalai University to study the effect of different levels and sources of manganese on cotton (*Gossypium hirsutum* L.) yield and growth under saline sodic condition. The experimental soil was sandy loam texture with pH 8.7 and EC1.23 dSm^{-1}. The soil fertility status was found to be low in nitrogen (228 kg ha^{-1}) and phosphorous (9.12 kg ha^{-1}) and medium in potassium (290 kg ha^{-1}). The experiment was carried out with three replications in Factorial completely Randomised Design. Treatments included four levels of Mn (0, 1.25, 2.5 and 5.0 mg kg^{-1}) from three different sources, namely Mn sulphate, Mn-EDTA and Mn humate. All treatment pots were treated with 20 : 40 : 40g kg^{-1} soil test based NPK dose. The crop was harvested manually at maturity; seed index and lint index were measured and expressed in percent. Using the standard procedure outlined by Jackson (1973), mature plant samples were analysed for Fe, Mn, Cu and B content. The crop's uptake of the individual nutrient was calculated by multiplying the respective nutrient content by DMP. Post-harvest soil samples were collected pot wise and analysed for available nitrogen, phosphorus, potassium, DTPA extractable Fe, Mn, Zn, Cu and hot water soluble B by adopting the procedure (Jackson, 1973).

Results and Discussion

Seed index and Lint index

Addition of manganese to cotton through different sources significantly influenced the seed index and lint index of cotton in a saline sodic soil table 1. Addition of graded level of Mn from 0 to 5.0 mg kg^{-1} increased the seed index and lint yield up to 2.5 mg kg^{-1} thereafter decreased. The application of 2.5 mg Mn kg^{-1} significantly registered the maximum mean seed index and lint index of 8.21 and 3.90. Among the three sources the lowest mean seed index and lint index of 7.43 and 3.47 was recorded with application of manganese sulphate. Mn-EDTA recorded seed index and lint index of 7.77 and 3.67 which is significantly higher than $MnSO_4$. Application of Mn- humate was significantly superior to two other two sources in increasing seed index (8.11) and lint index (3.84) of cotton. Application of 2.5 mg Mn kg^{-1}as manganese humate (S_3L_3) recorded the maximum seed index and lint index of 8.70 and 4.15. This was on par with application of 1.25 mg Mn kg^{-1}as manganese humate (S_3L_2) and it recorded the seed and lint index of 8.52 and 4.11. This was followed by the treatments S_2L_3 (seed index and lint index of 8.15 and 3.90), S_2L_2 and S_3L_4. The lowest seed index and lint index of 7.10 and 3.32 was noticed under control (S_1L_1). The increased in seed cotton and lint yield due to Mn

Table 1: Effect of soil application of different Mn sources and levels on seed index and lint index of cotton in sodic soil.

	Seed index					Lint index				
	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
S_1	7.10	7.55	7.78	7.29	7.43	3.32	3.54	3.65	3.37	3.47
S_2	7.10	8.10	8.25	7.72	7.79	3.32	3.83	3.90	3.62	3.67
S_3	7.10	8.52	8.70	8.12	8.11	3.32	4.02	4.10	3.81	3.81
Mean	7.10	8.06	8.24	7.71		3.32	3.80	3.88	3.60	
	SED		CD($P \leq 0.05$)			SED		CD($P \leq 0.05$)		
L	0.096		0.20			0.053		0.11		
S	0.150		0.32			0.048		0.15		
LXS	0.207		NS			0.096		NS		

2S_1 – Mn sulphate, S_2- Mn EDTA S_3- Mn humate, L_1- 0 mg kg^{-1} of Mn, L_2 -1.25 mg kg^{-1} of Mn , L_3- 2.5 mg kg^{-1} of Mn and L_4- 5.0 mg g^{-1} of Mn.

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

Levels	Zn uptake (mg pot^{-1})					Fe uptake (mg pot^{-1})				
Sources	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
S_1	6.24	6.97	7.34	6.93	6.87	9.60	11.62	12.25	11.55	11.26
S_2	6.24	7.85	8.05	7.48	7.41	9.60	13.09	13.44	12.46	12.15
S_3	6.24	8.61	8.73	8.19	7.94	9.60	14.35	14.56	13.65	13.04
Mean	6.24	7.81	8.04	7.53		9.60	13.02	13.42	12.55	
	SE_D		CD(P=0.05)			SE_D		CD(P=0.05)		
S	0.06		0.13			0.10		0.22		
L	0.11		0.23			0.20		0.42		
LXS	0.14		0.31			0.24		0.51		

S_1–Mn-sulphate, S_2- Mn-EDTA, S_3- Mn humate, L_1- 0 mg Mn kg^{-1} of soil, L_2- 1.25 mg Mn kg^{-1} of soil , L_3- 2.50 mg Mn kg^{-1} of soil and L_4- 5.0 mg Mn kg^{-1} of soil.

application might be the reason for the increased seed index and lint index. These results are in agreement with Ismail *et al.,* (1998). Abd El-Gawad *et al.,* (1985) found that combined application of Fe and Mn recorded the highest lint percentage.

Zn, Fe, Cu and B uptake

The uptakes of micronutrients were significantly and positively influenced by the application of different manganese sources and levels in a saline sodic soil table 2 and 3. Among the different levels of manganese application, addition 2.50 mg.

Mn kg^{-1} (L_3) significantly registered the highest mean Zn, Fe, Cu and B uptake of 8.04, 13.42, 1.73 and 8.62 mg pot^{-1}, respectively. Among the three sources of manganese tried, the lowest mean Zn, Fe, Cu and B uptake of 6.87, 11.26, 1.50 and 7.21 mg pot^{-1} and 31.04 mg pot^{-1}, respectively was recorded with Mn sulphate. Addition of Mn-EDTA recorded the higher mean Zn, Fe, Cu and B uptake of 7.41, 12.15, 1.61 and 7.79 mg pot^{-1}, respectively as compared to $MnSO_4$. Application of Mn as Mn-humate was significantly superior to Mn EDTA and $MnSO_4$ in respect of improving Zn. Fe, Cu and B uptake by cotton and recorded the increasing mean Zn, Fe, Cu and B uptake of 7.94, 13.04, 1.73 and 8.36 mg pot^{-1}, respectively. The interaction effect between levels and sources of manganese favourably improved the Zn. Fe, Cu and B uptake by cotton. Application of 2.50 mg Zn kg^{-1} (S_3L_3) as Mn-humate recorded the highest Zn, Fe, Cu and B uptake of 8.73, 14.56, 1.87 and 9.35 mg pot^{-1}, respectively. This was on par with application of 1.25 mg Mn kg^{-1} as manganese humate (S_3L_2) which recorded Zn, Fe, Cu and B uptake of 8.6, 14.3.5, 1.85 and 9.24 mg pot^{-1}, respectively. This was followed by application of 2.50 mg Zn kg^{-1} as Mn-EDTA (S_2L_3) by registering the Zn, Fe, Cu and B uptake of 8.05 13.44, 1.73 and 8.63 mg pot^{-1}, respectively. This may be due to positive influence of Mn on dry matter production that leads to higher uptake of Zn, Fe, Mn, Cu and B by cotton.

Table 3: Effect of different sources and levels of Mn 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	1.44	1.49	1.58	1.49	1.50	6.08	7.48	7.87	7.43	7.21
S_2	1.44	1.68	1.73	1.60	1.61	6.08	8.43	8.63	8.01	7.79
S_3	1.44	1.85	1.87	1.76	1.73	6.08	9.24	9.35	8.78	8.36
Mean	1.44	1.68	1.73	1.61		6.08	8.38	8.62	8.07	
	SE_D		CD(P=0.05)			SE_D		CD(P=0.05)		
S	0.02		0.05			0.06		0.14		
L	0.02		0.06			0.11		0.24		
LXS	0.04		0.09			0.14		0.31		

S_1–Mn-sulphate, S_2- Mn-EDTA, S_3- Mn humate, L_1- 0 mg Mn kg^{-1} of soil, L_2- 1.25 mg Mn kg^{-1} of soil , L_3- 2.

Available NPK content in post-harvest soil

The available NPK content in post-harvest soil was not significantly influenced by the application Mn to cotton in a saline sodic soil table 4. Irrespective of the sources, increase in the levels of Mn from 0 to 5.0 mg kg^{-1} consistently decreased the NPK availability in the soil. However the decrease was not statistically significant. A decreasing trend in NPK availability in post-harvest soil to control was noticed in all the three sources of Mn tried. However the decrease was very low with $MnSO_4$ and it recorded the mean available NPK status of 115.67 mg kg^{-1} of alkaline $KMnO_4$-N, 6.09 mg kg^{-1} of Olsen-P and 142.27 mg kg^{-1} of NH_4OAc-K. This was followed by Mn-EDTA and Mn-humate. The interaction between levels and sources of Mn on post-harvest NPK status of soil was not significant.

Available DTPA extractable Zn, Fe, Cu and hot water soluble B content

Table 4: Effect of different sources and levels of Mn on available NPK of post-harvest soil.

Levels / Sources	Available N ($KmnO_4$-N) (mg kg^{-1})					Available P (Olsen-P) (mg kg^{-1})					Available K (NH_4OAc-K) (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
S_1	117.12	114.66	114.56	116.34	115.67	6.16	6.03	6.03	6.12	6.09	144.06	141.03	140.91	143.10	142.27
S_2	117.12	113.70	112.57	114.77	114.54	6.16	5.98	5.92	6.04	6.03	144.06	139.85	138.46	141.17	140.88
S_3	117.12	111.46	110.65	113.85	113.27	6.16	5.87	5.82	5.99	5.96	144.06	137.10	136.10	140.04	139.32
Mean	117.12	113.27	112.59	114.99		6.16	5.96	5.93	6.05		144.06	139.33	138.49	141.43	
	SE_D		CD(P=0.05)			SE_D		CD(P=0.05)			SE_D		CD(P=0.05)		
L	1.50		NS			0.08		NS			2.08		NS		
S	1.55		NS			0.06		NS			1.93		NS		
LXS	1.64		NS			0.07		NS			2.03		NS		

S_1-Mn-sulphate, S_2- Mn-EDTA, S_3-Mn humate, L_1-0 mg Mn kg^{-1} of soil, L_2- 1.25 mg Mn kg^{-1} of soil, L_3-2.50 mg Mn kg^{-1} of soil and L_4-5.0 mg Mn kg^{-1} of soil.

The available (DTPA extractable) Zn, Fe, Cu and B (Hot water soluble) content in post-harvest soil was not influenced favourably by the application of different sources and levels of Mn to cotton in a saline sodic soil table 5. Application of increasing level of Mn decreased the DTPA extractable Zn, Fe, Cu and hot water soluble B. However the decrease was not statistically significant. All the three sources of Mn tried, decreased the availability of Zn, Fe, Cu and B in post-harvest soil. Among the three sources of manganese, addition of Mn through Mn-humate recorded the lower mean DTPA extractable Zn, Fe, Cu, and hot water soluble B of 0.57, 10.41, 0.58 and 0.27 mg kg^{-1}. The interaction effect due to level and sources of Mn on DTPA extractable Fe, Cu, Zn and hot water soluble B was non-significant. This may be due to application of Mn through different Mn sources at increasing levels. Moreover, Mn-EDTA and Mn-humate could have reduced the fixation and improved the Mn availability. Application of Mn thorough various sources and levels did not show any significant effect on available (DTPA extractable) Zn, Fe, Cu and hot water soluble B in post-harvest soil.

Table 5: Effect of different sources and levels of Mn on available Zn, Fe, Cu (DTPA extractable) and hot water soluble boron content (mg kg^{-1}) in post-harvest soil.

Levels	Zinc (mg kg^{-1})					Iron (mg kg^{-1})					Copper (mg kg^{-1})					Hot water soluble B (mg kg^{-1})				
Sources	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	0.59	0.6	0.59	0.58	0.59	10.90	10.31	10.08	10.55	10.57	0.56	0.57	0.57	0.58	0.57	0.26	0.27	0.28	0.29	0.28
S_2	0.59	0.6	0.59	0.59	0.58	10.94	10.25	10.71	10.82	10.55	0.56	0.57	0.58	0.59	0.58	0.26	0.28	0.29	0.30	0.28
S_3	0.57	0.57	0.57	0.57	0.57	10.82	10.12	10.20	10.51	10.41	0.56	0.58	0.59	0.60	0.58	0.26	0.28	0.29	0.25	0.27
Mean	0.58	0.59	0.58	0.58		10.89	10.23	10.33	10.63		0.56	0.58	0.58	0.59		0.26	0.28	0.29	0.28	
	SE_D		CD(P=0.05)			SE_D		CD(P=0.05)			SE_D		CD(P=0.05)			SE_D		CD(P=0.05)		
L	0.07		NS			0.04		NS			0.07		NS			0.005		NS		
S	0.09		NS			0.04		NS			0.05		NS			0.075		NS		
LXS	0.01		NS			0.08		NS			0.12		NS			0.010		NS		

S_1-Mn-sulphate, S_2-Mn-EDTA, S_3-Mn humate, L_1-0 mg Mn kg^{-1} of soil, L_2-1.25 mg Mn kg^{-1} of soil, L_3-2.50 mg Mn kg^{-1} of soil and L_4-5.0 mg Mn kg^{-1} of soil.

Conclusion

It could be inferred that addition of manganese to cotton through different sources significantly influenced the seed index and lint index of cotton and uptake of NPK, and other micronutrient in a saline sodic soil. Application of 2.5 mg Mn kg^{-1}as manganese humate recorded the maximum seed index and lint index. The uptakes of macro and micronutrients were significantly and positively influenced by the application of different manganese sources and levels in a saline sodic soil. But the available NPK content and the available (DTPA extractable) Zn, Fe, Cu and B (Hot water soluble) content in post-harvest soil was not significantly influenced by the application Mn to cotton.

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