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RESEARCH PAPER

Effect of different levels and sources of zinc fertilizers on the growth and yield of okra in coastal sandy soil

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Abstract : To find out the effect of different levels and sources of zinc fertilizers on the growth and yield of okra in coastal sandy soil, a pot experiment was carried out in the department of Soil Science and Agricultural Chemistry, Annamalai University during January –April 2014. The texture of the soil was sandy and taxonomically classified as *Typic usticpsamments* with pH-8.32, EC-1.54 dS m^{-1} and represented low status of organic carbon (2.30 g kg^{-1}). The soil had low alkaline $KMnO_4$-N (134.50 kg ha^{-1}), low in Olsen- P (9.48 kg ha^{-1}) and medium in NH_4OAc-K (178.20 kg ha^{-1}). The available Zn (DTPA extractable Zn) content was 0.71 mg kg^{-1} in soil. The sixteen treatments consisted of four levels of zinc *viz.*, 0, 10, 15 and 20 mg kg^{-1} Zn as factor-A and three different sources of zinc fertilizers *viz.*, control, zinc sulphate ($ZnSO_4$), Zn-EDTA and Zn-Humate as factor-B. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications using okra variety MBH-64 as test crop. The results revealed that the combined application of Zn @ 15 mg kg^{-1} through Zn-Humate (A_2B_3) significantly increased the growth, yield characters and yield of okra.

Key Words : $ZnSO_4$, Zn-EDTA and Zn-Humate, Growth, Yield, Okra, Coastal sandy soil

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INTRODUCTION

Coarse textured sandy soil dominates majority of the coastal regions and pose great challenge to sustainable crop production. Soil fertility is the most limiting factor for crop production in coastal sandy soil. Sandy soils have specific soil constraints *viz.*, light texture, poor exchange property, low nutrient and water retention capacity, low status of organic carbon and deficiency of both macro and micronutrients. These problems severely affect the productivity of crops in this region. Even the applied nutrients are leached to the lower layers due to poor physical properties, poor nutrient retention and low organic carbon content, which further aggravates the problem of nutrient deficiency. The coastal farmers are cultivating the lands by adopting traditional management practices and realizing very low yield of crops as compared to other regions.

The poor nutrient retention and leaching of applied nutrients necessitates the application of increased rate of nutrients and bulky organic manures. Deficiency of micronutrients like Zn is more common in coarse textured soil and requires zinc fertilization. The zinc plays

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a vital role to improve production and quality of okra. Zinc is also recognized as a key element for protein synthesis, biological nitrogen fixation and also plays an important role in various enzymatic activities in the growth and development of plants (Asha *et al*., 2012 and Meena *et al*., 2012). Hence, in the present investigation, an attempt has been made to study the effect of different levels and sources of zinc fertilizers on the growth and yield of okra in coastal sandy soil.

MATERIAL AND METHODS

A pot experiment was conducted to find out the effect of different levels and sources of zinc fertilizers on the growth and yield of okra in coastal sandy soil. The pot experiment was carried out in the Department of Soil Science and Agricultural Chemistry, Annamalai University during January- April 2014 using the soil collected at Ponnanthittu coastal village, Cuddalore district, Tamil Nadu. The experimental soil was sandy texture with pH – 8.32 and EC – 1.54 d Sm^{-1}. The status of alkaline $KMnO_4$-N, Olsen-P and NH_4OAC-K were 134.50, 9.48 and 178.20 kg ha^{-1}, respectively. The treatments consisted of different levels of zinc like A_0-control, A_1- 10 mg kg^{-1}, A_2 – 15 mg kg^{-1} and A_3 – 20 mg kg^{-1} as factor-A and different sources of zinc fertilizers *viz.*, B_0-control, B_1- zinc sulphate ($ZnSO_4$), B_2-Zn EDTA and B_3- Zn humate as factor-B. The experiment was conducted in a Factorial Completely Randomized Design (FCRD) with three replications, using okra var. MBH – 64 as test crop. Calculated amount of zinc sulphate ($ZnSO_4$), Zn- EDTA and Zn-Humate as per the treatment schedule was applied just before sowing. A uniform NPK dose of 20:25:15 mg kg^{-1} was supplied through urea, super phosphate and muriate of potash to all pots. The entire dose of N, P_2O_5 and K_2O were applied as basal. Various growth components like plant height, number of branches $plant^{-1}$, dry matter production (DMP) and yield components *viz.*, number of fruits $plant^{-1}$, fruit length and single fruit weight were recorded at harvest stage. The yield of fruits and stover yield were recorded separately and expressed in g pot^{-1}.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth characters :

Application of different levels of Zn through different sources favourably increased the growth characters of okra *viz.*, plant height, number of branches $plant^{-1}$ and dry matter production (Table 1). Irrespective of the sources of Zn, okra responded to Zn application upto 15 mg kg^{-1} in coastal sandy soil. Among the different levels of Zn evaluated, application of Zn @ 20 mg kg^{-1} recorded the maximum plant height (120.77cm), number of branches $plant^{-1}$ (5.78) and dry matter production (906 g pot^{-1}) of okra. However, it was found to be at par with Zn @ 15 mg kg^{-1}, which recorded 119.03 cm plant height, 5.71 number of branches $plant^{-1}$ and 885 g pot^{-1} of dry matter production, respectively. Among the three sources of zinc fertilizers tried, application of zinc through Zn-Humate was found to be superior in increasing the growth characters *viz.*, plant height (123.45cm), number of branches $plant^{-1}$ (5.85) and dry matter production (923 g pot^{-1}), respectively. However, it was found to be equally efficacious with application of zinc through Zn-EDTA. This was followed by the application of zinc through $ZnSO_4$.

Interaction effect due to different levels and sources

Table 1: Effect of different levels and source of zinc fertilizers on the growth characters of okra

A / B	Plant height (cm)					No. of branches $plant^{-1}$					Dry matter production (g pot^{-1})				
	A_0	A_1	A_2	A_3	Mean	A_0	A_1	A_2	A_3	Mean	A_0	A_1	A_2	A_3	Mean
B_0	82.21	95.41	104.98	103.06	96.41	4.44	4.94	5.16	5.27	4.95	695	764	819	834	778
B_1	98.71	108.43	116.32	118.84	110.57	5.07	5.38	5.62	5.69	5.44	738	799	856	883	819
B_2	105.38	117.00	125.64	128.73	119.18	5.46	5.75	5.99	6.04	5.80	811	864	913	935	880
B_3	110.85	121.30	129.21	132.45	123.45	5.43	5.78	6.07	6.15	5.85	861	903	955	973	923
Mean	99.29	110.53	119.03	120.77		5.10	5.46	5.71	5.78		776	832	885	906	
		S.E.±		C.D. (P=0.05)			S.E.±		C.D. (P=0.05)			S.E.±		C.D. (P=0.05)	
A		2.22		4.53			0.06		0.13			19.50		39.80	
B		2.79		5.70			0.08		0.18			20.64		42.12	
A × B		2.95		6.03			0.10		0.21			21.71		44.30	

of Zn fertilizers on the growth characters of okra was significant. Application of Zn @ 20 mg kg^{-1} through Zn-Humate (A_3B_3) registered the highest plant height (132.45 cm), number of branches plant^{-1} (6.15) and dry matter production (973 g pot^{-1}). However, it was found to be at par with Zn-Humate @ 15 mg kg^{-1}. This was followed by (A_3B_2) which received zinc @ 20 mg kg^{-1} through Zn-EDTA. The lowest plant height, number of branches plant^{-1} and dry matter production was noticed in control.

The combined application of Zn-Humate @15 mg kg^{-1} + recommended dose of NPK along with composted coirpith registered highest plant growth characters. This might be due to the reason that zinc is an important constituent of nucleotides, chlorophyll and enzymes involved in various metabolic processes which had a direct impact on vegetative phase of plants. Further, adequate supply of N and P increased root growth through better absorption and utilization of all the plant nutrients, thus resulting in increased height and DMP associated with better growth of plants (Tisdale *et al.*, 1995). Further more, the improvement in growth characters namely plant height as a result of application of Zn-Humate + recommended dose of NPK along with organics might be due to the greater availability of macro and micronutrients in Zn-Humate applied pots which might have enhanced photosynthetic and other metabolic activity. This led to an increase in various plant metabolites responsible for cell division and elongation (Datir *et al.*, 2010). The increase in number of branches may be due to higher nutrient use efficiency, N-physiological efficiency and photosynthetic rates (Naruka *et al.*, 2000), whereas, dry matter accumulation increased due to increase in plant height, number of branches and greater nutrient availability and increase in photosynthetic rate. The result obtained was in accordance with the findings of Abbasi *et al.* (2010).

Yield characters:

Yield components such as number of fruits plant^{-1}, fruit length and single fruit weight were significantly increased due to different levels and source of zinc fertilizers. Among the different levels of Zn studied, the application of Zn @ 20 mg kg^{-1} recorded the highest mean number of fruits plant^{-1} (19.30), fruit length (22.38 cm) and single fruit weight (25.19 g) of okra (Table 2). However, it was found to be equally efficacious with application of Zn @ 15 mg kg^{-1}, which recorded 18.56 number of fruits plant^{-1}, with fruit length of 21.18 cm and single fruit weight of 24.50 g. Among the three different sources of zinc fertilizer, Zn-Humate excelled the other two sources in improving the yield components of okra. The interaction effect between levels and sources of Zn on yield characters of okra was significant. The treatment (A_3B_3), which received Zn @ 20 mg kg^{-1} through Zn-Humate, recorded a highest number of fruits plant^{-1} (21.19), fruit length (24.52 cm) and fruit weight (27.65 g). However, it was found to be at par with Zn-Humate @ 15 mg kg^{-1}(A_2B_3). This was fallowed by the application of zinc @ 20 mg kg^{-1} through Zn-EDTA and $ZnSO_4$.

A significant increase in the yield characters like number of fruits plant^{-1}, fruit length and single fruit weight of okra due to the application of Zn-Humate was observed in the present investigation. All the yield characters increased with the increased level of application of zinc upto a level of 15 mg kg^{-1}.The increased yield characters might be due to the involvement of Zn in producing growth promoting substances (Naruka *et al.*, 2000). The over all

Table 2 : Effect of different levels and source of zinc fertilizers on the yield characters of okra

A / B	No. of fruits plant^{-1}					Fruit length (cm)					Single fruit weight (g)				
	A_0	A_1	A_2	A_3	Mean	A_0	A_1	A_2	A_3	Mean	A_0	A_1	A_2	A_3	Mean
B_0	13.21	15.25	16.41	16.99	15.46	14.35	17.29	19.07	19.75	17.61	15.73	18.25	21.10	21.74	19.20
B_1	15.64	16.81	18.01	18.78	17.31	17.39	19.24	20.93	21.64	19.80	20.89	22.40	24.05	24.75	23.02
B_2	17.18	18.36	19.50	20.24	18.82	20.08	21.63	23.01	23.64	22.09	22.79	24.44	25.96	26.64	24.95
B_3	17.98	19.15	20.34	21.19	19.66	20.53	22.22	23.74	24.52	22.78	23.50	25.01	26.90	27.65	25.76
Mean	16.00	17.39	18.56	19.30		18.08	20.09	21.18	22.38		20.72	22.52	24.50	25.19	
		S.E.±		C.D. (P=0.05)			S.E.±		C.D. (P=0.05)			S.E.±		C.D. (P=0.05)	
A		0.47		0.97			0.54		1.12			0.56		1.15	
B		0.50		1.03			0.57		1.18			0.68		1.40	
A × B		0.55		1.13			0.63		1.30			0.72		1.48	

improvement in yield attributing characters of okra was obtained when the Zn through Zn- Humate was applied with NPK. Addition of 100 per cent recommended dose of NPK + Zn-Humate @ 30 mg kg^{-1} out performed all other treatments in increasing number of fruits $plant^{-1}$, fruit length and single fruit weight of okra. The betterment in yield characters might be ascribed to the effect of Zn which enhanced the photosynthetic activity resulting in the production and accumulation of carbohydrates and essential auxins which enhanced the growth and yield of okra. Similar results were reported by Anburani and Manivannan (2002).

Moreover, the humic substances released during the dissociation of Zn humate forms complex with other nutrients and benefit the crop during entire growth period and improve the nutrient availability in soil. The humic acid released during the dissociation might have also entered into the plant system and behaved with a growth promoter and improved the growth and yield of okra. Zn-EDTA was found to be equally best with Zn-humate application, in respect of yield. However, Zn EDTA is costlier than Zn-humate, therefore, it is not affordable to farmers and increase the cost of production. $ZnSO_4$ is most common and widely used source of Zn fertilizer by the farmers, the reasons being, easy water solubility and high Zn content (20-25%). Moreover, it is easily leachable in soil and some part of water soluble Zn may be converted to insoluble $ZnCO_3$ and Zn $(OH)_2$. The result of the study clearly brought out the beneficial effect of Zn-humate application to okra. These results are in conformity with Yadav *et al.* (2007) and Sangeetha and Singaram (2007).

Yield of okra :

The crop responded well for the different levels and sources of zinc fertilizer application. The effect was very clearly reflected in fruit and stover yield of okra. The effect of different levels of zinc in increasing the okra yield was well evidenced in the present study. Increase in the level of Zn from 0 to 20 mg kg^{-1} in increased the fruit and stover yield from 855 to 1008 g pot^{-1} and 728 to 846 g pot^{-1}, respectively (Table 3). Among the various levels of zinc, application of Zn @ 20 mg kg^{-1} was excelled the other two levels. Application of Zn @ 20 mg kg^{-1} (A_3) registered a fruit and stover yield of 1008 and 846 g pot^{-1}, respectively which was at par with application of Zn @ 15 mg kg^{-1} (A_2) by registering 984 and 823 g pot^{-1} of fruit and stover yield of okra, respectively. Among the different sources of zinc fertilizers, the application of zinc through Zn-Humate (B_3) recorded the highest mean fruit (1022 g pot^{-1}) and stover yield (853 g pot^{-1}) of okra. However, it was found to be comparable with the treatment B_2 (application of Zn-EDTA). This was followed by the application of $ZnSO_4$.

The interaction effect due to levels and sources of zinc significantly increased the fruit and stover yield of okra. Application of Zn through Zn-Humate @ 20 mg kg^{-1} (A_3B_3) recorded the highest fruit and stover yield of 1086 g pot^{-1} and 909 g pot^{-1} which was 43.27 and 39.20 per cent increase over control (without Zn application or recommended dose of NPK alone). This treatment was closely at par with the treatment which received Zn-Humate @15 mg kg^{-1} (A_2B_3). Application of Zn-Humate @ 15 mg kg^{-1} registered a fruit and stover yield of 1060 and 881 g pot^{-1} which was 39.84 and 34.91 per cent increase over control (without zinc application).

The yield improvement in fruit and stover yield of okra due to application of Zn-humate @ 15 mg kg^{-1} was positive. This could be attributed to the fact that the nutrients in the Zn-humate are released gradually through the process of mineralization, maintaining optimal soil Zn

Table 3 : Effect of different levels and source of zinc fertilizers on the yield (g pot^{-1}) of okra

A / B	Fruit yield					Stover yield				
	A_0	A_1	A_2	A_3	Mean	A_0	A_1	A_2	A_3	Mean
B_0	758	836	894	916	851	653	712	751	777	548
B_1	827	898	967	985	919	710	765	810	828	778
B_2	894	952	1015	1047	978	763	805	851	872	822
B_3	943	1002	1060	1086	1022	788	836	881	909	853
Mean	855	923	984	1008		728	779	823	846	
		S.E.±		C.D. (P=0.05)			S.E.±		C.D. (P=0.05)	
A		20.78		42.41			19.50		39.80	
B		23.87		48.71			20.64		42.12	
A × B		25.25		51.53			21.71		44.30	

A- Zn levels: A_0 – Control; A_1 – 10 mg kg^{-1}; A_2 – 15 mg $kg^{-1}$and A_3 – 20 mg kg^{-1}, B- Zn sources: B_0 – Control; B_1 – $ZnSO_4$; B_2 – Zn EDTA; B_3 – Zn Humate levels over prolonged periods of crop growth. Some of the humic substances are released during mineralization and may act as a chelate which helps in increasing the absorption of zinc and other essential nutrients. The earlier report of Patel and Singh (2010) and Suge *et al*. (2011) support the present findings. Further, the Zn-humate derived from humic acids are known form chelates with zinc (micronutrients) and thus it improves translocation of the nutrient cations within the plant system and may improve the nutrient use efficiency by providing more balanced supply of nutrients (Rady, 2011) to okra. The increased okra yield due to the application of different forms of humic substance and NPK fertilizer have already been well documented by Sangeetha and Singaram (2005); Balamurugan (2006) and Vetriselvan (2011).

Conclusion :

The results of the present investigation clearly indicated that for increasing the growth, yield attributes and yield of okra, the treatment application of Zn-Humate @ 15 mg kg^{-1} would be beneficial.

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