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IMPACT OF ZINC DRESSING ON ZINC NUTRIENT IN RICE (*ORYZA SATIVA* L.)

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Abstract

The experiment was conducted during kharif seasons of April-July in the year 2011 to study the impact of zinc dressing on zinc nutrient in rice in to two soil (Typic Haplusterts) and Typic Ustifluvents). The treatment consist with two factors *viz.*, Factor A – Zinc levels (mg kg^{-1}) Zn_0 – 0, Zn_1- 2.5, Zn_2- 5.0 and Zn_3- 7.5 and Factor B- Zinc sources S_1- Zinc sulfate (Zn – 21%), S_2- Zn-EDTA (Zn-12%),S_3 – Zn humate (Zn- 9%). The result of experiment revealed that addition of 7.5 mg Zn kg^{-1} recorded the highest zinc content in grain; 56.07, 58.42 mg kg^{-1} in straw with per cent increase in zinc content due to addition of 7.5 mg Zn kg^{-1} over control was 51.4, 50.5 in grain and 19.8, 22.9 in straw in Vertisol and Entisol respectively. It was comparable with 5.0 mg Zn kg^{-1} but superior to 2.5 mg Zn kg^{-1} and no zinc (control). With respect to Zn sources, addition of Zn through Zn-EDTA recorded the highest Zn content but was comparable with $ZnSO_4$ but superior to Zn-humate. Similarly zinc uptake in grain and straw was highest with increasing rate of higher zinc levels.

Key words : Rice, Zn-EDTA, Zn-Humate, zinc content, Zinc uptake.

Introduction

Zinc deficiency is the most common nutrient disorder constraining rice productivity worldwide and is effectively controlled by field application of zinc sulphate. Plant root absorbs zinc as ion (Zn^{++}) and as component of synthetic and natural molecular complexes can enter the plant system directly through leaves. Zinc is closely involved in the diversity of enzymatic and N metabolism of plant in zinc deficient plant protein. Synthesis and level are markedly reduced and amino acid and amides are accumulated. Zinc is the essential mineral for IAA synthesis. Zinc deficiency is closely related to the inhibition of RNA synthesis reduces root and shoot growth and chlorophyll concentration in leaves. The available zinc in Indian soils ranges between 0.08–20.5 ppm. Application of zinc has been found to boost growth and yield of crops to a greater extent. Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country (Muthukumararaja and Sriramachandrasekharan, 2012) and causes poor tillering leading to decreased productivity of crop.Increases in the level of zinc increase the Zn content of roots more than that of shoots (Mehdi *et al.,* 1990). It has been reported that P and Zn application significantly increased root CEC which in turn increased nutrient uptake (Julan *et al.,* 1990; Tiwari *et al.,* 1975). Fe and Zn either alone or in combination significantly influenced uptake of each other (Hussain, 1973). Combined application of NPK, organic manures (GM or FYM) and Zn significantly increased the Zn, N and K contents while lowered the P content of paddy and straw (Yaseen *et al.,* 1999). Since zinc is a co-factor carbonic anhydrase and aldosase. Therefore it may adversely affect enzyme activities and carried corresponding metabolic reactions when zinc is deficient in soil. It is also involved in synthesis of protein and tryptophane. It is indicated that zinc is an essential structural components for normal functioning of super oxide dismutase enzyme. Aiming the above mentioned views, the present study "impact of zinc dressing on zinc nutrient in rice (*Oryza sativa* L.).

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Materials and Methods

Two field experiments were conducted in zinc deficient soil belonging to two soil series: Kondal series (Typic Haplusterts) and Padugai series(Typic Ustifluvents) at the farmer's holding during the karife season of year 2011. Before imposition of treatments, the soil used in the experiment had the following properties *viz.*, pH-8.50, EC-0.92 dSm^{-1}, organic carbon-5.41g kg^{-1}, CEC-43.2 c mol (p^{+}) kg^{-1}, $CaCO_3$- 4.31%, $KMnO_4$-N-302 kg ha^{-1}, Olsen-P- 19.0 kg ha^{-1}, NH_4OAc-K- 603 kg ha^{-1} and DTPA-Zn-0.60 $mgkg^{-1}$ (Vertisol). Similarly soils of Entisol had pH-7.80, EC-0.89 dSm^{-1}, organic carbon-6.3 g kg^{-1}, $CaCO_3$- 1.56%, CEC- 24.2 c mol(p^{+}) kg $^{-1}$, $KMnO_4$-N- 276 kg ha^{-1}, Olsen-P- 18.0 kg ha^{-1}, NH_4OAc-K- 293 kg ha^{-1} and DTPA-Zn-0.57 $mgkg^{-1}$. The treatment consists of two factors *viz.*, Factor A-Zinc levels (mg kg^{-1}) Zn_0-0, Zn_1- 2.5, Zn_2- 5.0 and Zn_3-7.5 and Factor B- Zinc sources S_1- Zinc sulfate (Zn - 21%), S_2 - Zn-EDTA (Zn-12%), S_3-Zn humate (Zn-9%). The design was FRBD with three replications. Twenty seven days old rice seedling var ADT 43 was transplanted in the main field. All the plots received uniform dose of 120 kg N ha^{-1}, 40 kg P_2O_5 ha $^{-1}$ and 40 kg K_2O ha^{-1} applied through urea, SSP and muriate of potash respectively. Plant samples were collected at harvest stage of crop growth and analysed zinc content and calculated the zinc uptake with expressed mg kg^{-1}.

Results

Zinc content

Analysis of variance on zinc content furnished in table 1 showed zinc content in grain and straw was significantly influenced by graded dose of zinc applied through different zinc sources in Vertisol and Entisol. Zinc content decreased with advancement of crop growth. Addition of successive increment of Zn dose increased zinc content and addition of 7.5 mg Zn kg^{-1} recorded the highest zinc content 25.26, 27.65 mg kg^{-1} in grain; 56.07, 58.42 mg kg^{-1} in straw in Vertisol and Entisol respectively. It was comparable with 5.0 mg Zn kg^{-1} but superior to 2.5 mg Zn kg^{-1} and no zinc (control). Per cent increase in zinc content due to addition of 7.5 mg Zn kg^{-1} over control was 51.4, 50.5 in grain and 19.8, 22.9 in straw in Vertisol and Entisol respectively. With respect to Zn sources, addition of Zn through Zn-EDTA recorded the highest Zn content but was comparable with $ZnSO_4$ but superior to

Table 1: Effect of zinc sources and levels on zinc content and uptake in grain and straw.

Zinc sources	Zinc content (mg kg^{-1})										Zinc uptake (g ha^{-1})									
	Grain					Straw					Grain					Straw				
	Zn levels (mg kg^{-1})																			
	0	2.5	5.0	7.5	Mean	0	2.5	5.0	7.5	Mean	0	2.5	5.0	7.5	Mean	0	2.5	5.0	7.5	Mean
Vertisol																				
Zinc sulfate	17.38	24.00	25.03	25.81	23.05	46.84	53.02	54.21	55.97	52.51	76.68	122.62	138.97	139.56	119.45	267.56	337.53	378.22	378.58	340.47
Zn-EDTA	18.65	24.27	25.94	26.83	23.92	48.42	54.54	56.68	58.10	54.43	85.96	128.30	148.74	150.49	128.37	282.39	361.11	410.08	411.29	366.21
Zn-Humate	14.03	19.66	22.84	23.14	19.91	45.12	51.57	52.58	54.15	50.85	59.27	96.80	123.05	120.87	99.99	247.72	318.40	361.60	360.80	322.13
Mean	16.68	22.64	24.59	25.26		46.79	53.04	54.15	56.07		73.97	115.90	136.90	136.97		265.89	339.01	383.30	383.55	
		S	L	SxL			S	L	SxL			S	L	SxL			S	L	SxL	
SE_d		0.48	0.52	0.61			0.96	1.23	1.37			2.39	2.28	3.56			4.58	4.98	8.96	
CD (p=0.05)		1.00	1.08	1.28			2.00	2.56	2.85			4.96	4.73	7.38			9.50	10.32	18.56	
Entisol																				
Zinc sulfate	19.26	25.26	27.07	28.02	24.90	48.31	54.18	57.00	58.86	54.58	92.14	135.94	155.66	157.62	135.34	293.11	367.19	407.90	413.67	370.46
Zn-EDTA	19.88	26.11	28.36	29.25	25.90	50.86	56.83	59.61	61.42	57.18	96.42	145.21	168.69	170.68	145.25	319.06	393.04	435.33	439.95	396.84
Zn-Humate	15.98	21.85	24.23	25.69	21.93	43.35	50.24	53.11	55.00	50.42	73.25	114.43	136.19	141.07	116.43	255.09	328.68	366.73	371.20	330.42
Mean	18.37	24.40	26.55	27.65		47.50	53.75	56.57	58.42		87.27	131.86	153.51	156.72		289.08	362.97	403.32	408.27	
		S	L	SxL			S	L	SxL			S	L	SxL			S	L	SxL	
SE_d		0.61	0.64	0.70			1.30	1.33	1.44			2.57	2.71	4.08			4.98	5.87	10.55	
CD (p=0.05)		1.28	1.33	1.45			2.70	2.76	3.00			5.34	5.63	8.40			10.31	12.16	21.85	

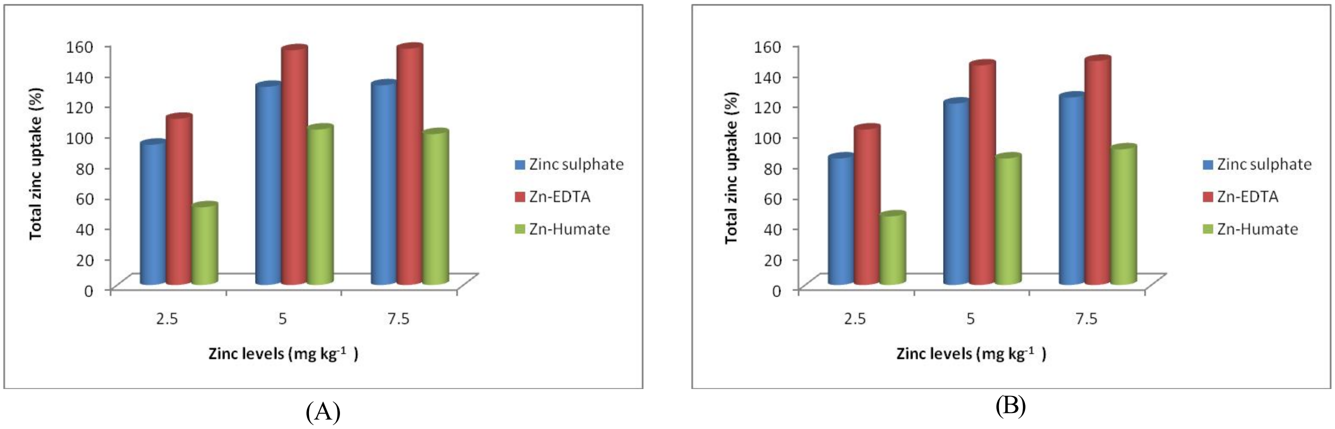

Fig. 1: Percentage increase in total Zn uptake A) Vertisol B) Entisol.

Zn-humate. Interaction effect between Zn levels and sources was significant. At all levels of zinc, zinc content was highest with Zn-EDTA and was comparable with $ZnSO_4$ but superior to Zn-humate. Similarly, irrespective of zinc sources, zinc content was highest with 7.5 mg Zn kg^{-1} but was comparable with 5.0 mg Zn kg^{-1} but superior to 2.5 mg Zn kg^{-1} and no zinc (control).

Zinc uptake

On close examination of data on zinc uptake furnished in table 1 showed significant enhancement in zinc uptake due to addition of different Zn rates through different zinc sources over control in grain and straw in both soils. Zinc uptake increased with advancement of crop growth. Addition of successive increment of Zn level increased zinc uptake and the highest zinc uptake was noticed with 7.5 mg Zn kg^{-1} 136.97, 156.72 g ha^{-1} in grain and 383.55, 408.27 g ha^{-1} in straw in Vertisol and Entisol respectively. It was comparable with 5.0 mg Zn kg^{-1} but superior to 2.5 mg Zn kg^{-1} and no zinc (control). The per cent increase in Zn uptake due to 7.5 mg Zn kg^{-1} over control was 85.2, 79.6 in grain and 44.3, 41.2 in straw in Vertisol and Entisol respectively. With respect to zinc sources, addition of Zn through Zn-EDTA recorded the highest Zn uptake 128.37, 145.25 g ha^{-1} in grain and 366.21, 396.84 g ha^{-1} in straw in Vertisol and Entisol respectively. It was superior to $ZnSO_4$ and Zn-humate. Interaction effect between zinc sources and levels was significant. Irrespective of Zn levels and grain and straw, the highest Zn uptake was noticed with application of 7.5 mg Zn kg^{-1} through Zn-EDTA. Similarly, irrespective of zinc sources the highest Zn uptake was noticed with 7.5 mg Zn kg^{-1} and was comparable with 5.0 mg Zn kg^{-1}. Overall, the zinc uptake due to various treatment was observed high in Entisol than Vertisol.

Discussion

Graded dose of zinc increased zinc concentration and uptake and the highest value was noticed with 7.5 mg Zn kg^{-1} in both soils. Per cent increase in Zn uptake due to 7.5 mg Zn kg^{-1} over control was 85.2, 79.6 in grain and 44.3, 41.2 in straw in Vertisol and Entisol respectively (Fig. 1). Zinc content of plant or uptake is controlled by many factors such as amount of soil DTPA-Zn, transfer of zinc to root surfaces and the interaction between Zn and other nutrients in the soil or within the plant (Robson, 1993). This was confirmed by the significant positive correlation between zinc uptake with available N (r=0.98** (TS), r=0.98** (PI), r=0.99** (grain), r=0.98** (straw), available P (r=0.90**) (TS), r=0.86** (PI), r=0.93** (grain), r=0.90** (straw) and available K (r=0.98** (TS), r=0.99** (PI), r=0.97** (grain), r=0.95** (straw). Kirk and Bajata (1995) reported importance of root induced changes in plant Zn uptake. It seems that zinc is solubilized by root induced acidification resulting for the excess of cations (NH_4^+) over anions and concomitant release of H^+ from the roots (Neue *et al.,* 1998). Shehu and Jamala (2010) reported that application of Zn at 5.0, 7.5 and 10.0 kg ha^{-1} had uptake advantage of 113, 131 and 172 per cent over control.

Increase in zinc content and uptake in different parts of rice plant might be due to the presence of increased amount of DTPA-Zn in soil solution by the application of zinc that facilitated greater absorption (Fageria *et al.,* 2011). The zinc content was higher in grain than in straw. Similar result was reported by Naik and Das (2008). Sharp increase in zinc uptake at greater Zn level might be related to greater increase in zinc concentration in soil solution at this zinc level. The above result was confirmed by significant positive correlation between DTPA-Zn with Zn uptake (r=0.95** (TS), r=0.96** (PI), r=0.99** (grain), r=0.96** (straw). Further, water soluble Zn had significant positive correlation in Zn uptake (r=0.96** (grain), r=0.94** (straw). Similarly, exchangeable Zn had significant positive correlation with zinc uptake (r=0.87** (grain), r=0.86** (straw). Veerendra Dixit *et al*. (2012) reported increase in Zn uptake on addition of 10 kg Zn ha^{-1}.

With respect to Zn sources, addition of Zn as Zn-EDTA recorded maximum zinc content and uptake at all stages of crop growth compared to zinc sulfate and zinc humate. Increase in zinc content in different parts of rice plant might be due to the presence of increased amount of Zn in soil solution by the application of chelated Zn that facilitated greater absorption of zinc compared to $ZnSO_4$. The greater influence of Zn-EDTA over other sources of Zn might be due to less retention and greater transport and movement of chelated Zn to plant roots (Ortiz and Gavare, 1998). Ugurluoglu and Kacar (1996) studied the efficiency of $ZnSO_4$ and Zn-EDTA on rice and reported that application of Zn @ 8 mg kg^{-1} as Zn-EDTA was found most effective in the enhancement of Zn content and uptake. Higher efficiency of Zn-EDTA over $ZnSO_4$ in improving Zn content and uptake in rice was reported earlier by Naik and Das (2008).

Conclusion

The present study find out addition of 5.0 mg kg^{-1} (Zn EDTA) registered with the highest nutrient content and uptake of zinc in both the soil. However response of rice to graded dose of zinc through various sources was more prominent in Entisol than Vertisol.

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