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INFLUENCE OF ZINC AND ORGANICS ON RICE YIELD AND ZINC USE EFFICIENCY IN ZINC STRESS SOIL

Muthukumararaja T.* and M.V. Sriramachandrasekharan
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture
Annamalai University, Annamalainagar-608002, Tamilnadu, India.
Email:saradhakirankumar@gmail.com

Abstract

A field experiments were conducted in a zinc deficient soil belonging to Vertisol (Typic Haplusterts) and Entisol (Typic Ustifluvents) during Rabi 2011-2012. To study response of rice to the integrated use of zinc and organics.The treatments consists of four levels of zinc viz., 0, 2.5, 5.0 and 7.5 mg kg^{-1} and organic sources viz., no organics, FYM @ 12.5 t ha^{-1}, green manure @ 6.5 t ha^{-1}, poultry manure @ 10 t ha^{-1} and vermicompost @ 5 t ha^{-1}. The test crop was rice var.ADT 36. The results revealed that grain and straw yield was significantly enhanced on addition of zinc or organics or both over control in both soils. The rice yield increased with zinc doses and maximum yields was noticed with 5 mg Zn kg^{-1} and declined at 7.5 mg Zn kg^{-1}. While addition of poultry manure recorded the maximum rice yields and was on par with vermicompost. However the highest grain yield (6103, 6344 kg ha^{-1}) and straw yield (8369, 8459 kg ha^{-1}) was recorded with application of 5 mg Zn kg^{-1} and poultry manure @ 10 t ha^{-1} in Vertisol and Entisol respectively. Zinc use efficiency (agronomic efficiency and apparent zinc recovery) was highest at 2.5 mg Zn kg^{-1} and declined with loading of zinc. Zinc use efficiency increased further in the presence of organics and the maximum ZnUE was noticed with 2.5 mg Zn kg^{-1} and poultry manure and was comparable with vermicompost.

***Keyword*:** Zinc, organics, rice, yield, ZnUE.

Introduction

Rice is grown in diverse soil and water regimes, consequently depletion and toxicity of micronutrients is encountered in many parts of India. Zinc deficiency is prevalent worldwide in temperate and tropical climate (Fageria *et al.*, 2003). Zinc is a major component and activator of several enzymes involved in metabolic activities (Klug and Rhodes, 1987). Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country (Chaudhary *et al.,* 2007). Zinc deficiency in soil is influenced by many factors which includes pH, concentration of Zn, Fe, Mn and P in soil solution, $CaCO_3$ (Brar and Sekhon, 1976). Zinc deficiency is usually corrected by application of zinc sulfate and response of rice to zinc under flooded condition has been reported by many workers (Naik and Das, 2007. Fageria *et al.*, 2011). Integrated use of organics and zinc have been found to more effective in maintaining higher productivity and stability through correction of deficiency of zinc in the course of mineralization on one hand and favourable physical soil condition on other hand. Organic manuring improves rice yield and ZnUE when applied in conjunction with Zn fertilizer. Mirza *et al.* (2010) reported higher rice yield when organics was applied with $ZnSO_4$ compared to Zn alone. Keeping in view of the importance of zinc nutrition and its use efficiency in rice and use of organics in maintaining soil fertility, field experiments were conducted in two soils deficient in zinc to study the effect of zinc and organics in lowland rice.

Materials and Methods

Field experiments were conducted during Rabi 2011-2012 in Vertisol (Typic Haplusterts) and Entisol (Typic Ustifluvents). Before imposition of treatments, the soil used in the experiment had the following properties viz., pH-8.2, EC-0.49 dSm^{-1}, organic carbon-4.65 g kg^{-1}, CEC-42.1 c mol(p$^+$) kg^{-1},$CaCO_3$- 3.38%, $KMnO_4$-N- 329 kg ha^{-1}, Olsen-P- 31.2 kg ha^{-1}, NH_4OAc-K- 330.8 kg ha^{-1} and DTPA-Zn-0.73 mgkg^{-1}(Vertisol). Similarly soils of Entisol had pH-7.5, EC-0.73 dSm^{-1}, organic carbon-5.36 g kg^{-1}, $CaCO_3$- 1.37%, CEC- 21.2 c mol(p$^+$) kg^{-1}, $KMnO_4$-N- 296.3 kg ha^{-1}, Olsen-P- 16.0 kg ha^{-1}, NH_4OAc-K- 299 kg ha^{-1} and DTPA-Zn-0.0.59 mgkg^{-1}. The treatments consisted of four levels of zinc viz., 0,2.5,5.0 and 7.5 mg kg^{-1} applied through $ZnSO_4$ and organics viz., no organics, FYM- 12.5 t ha^{-1}, green manure- 6.5 t ha^{-1}, poultry manure–10 t ha^{-1} and vermicompost- 5 t ha^{-1}. The design was FRBD with three replications. Twenty seven days old rice seedling var ADT 36 was transplanted in the main field. All the plots received uniform dose of 150 kg N ha^{-1}, 50 kg P_2O_5 ha $^{-1}$ and 50 kg K_2O ha^{-1} applied through urea, SSP and muriate of potash respectively. Grain and straw yield was recorded at harvest and expressed as kg ha^{-1}. The plant samples were analyzed for zinc following standard procedure and uptake was computed. Soil was analyzed for DTPA zinc (Lindsay and Norwell, 1978). Zinc use efficiency was calculated following the formula proposed by Fageria (2009).

Results and Discussion

Rice yield

Analysis of variance (p=0.05) on rice yield showed that application of graded dose of zinc or organics or both significantly enhanced the grain and straw yield over control (Table 1). Addition of 5 mg Zn kg^{-1} registered the maximum grain yield (5600, 5910 kg ha^{-1}) and straw yield (7783, 7893 kg ha^{-1}) which was about (15.6, 14.3%) and (20.7, 20.9%) greater than control (no zinc) in Vertisol and Entisol respectively. The rice yield declined at 7.5 mg Zn kg^{-1}. The higher rice yield due to zinc is attributed to its involvement in many metallic enzymes system, regulatory function and auxin production (Hacisalihoglu *eta*l., 2002), enhanced synthesis of carbohydrates and their transport to the site of grain production (Pedda Babu *et al.*, 2007). Slaton *et al.* (2005) observed 12 to 180% and Fageria *et al.* (2011) reported 97% increase in rice yield due to zinc fertilization. The argument on the enhanced rice yield by zinc addition was ably supported by the significant positive correlation observed in the present study between grain yield and DTPA-

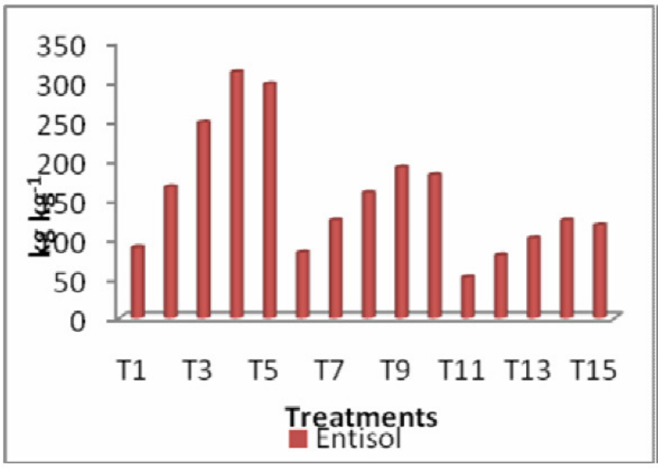
Zn (r =0.94**). Response of lowland rice to zinc addition has been reported widely (Fageria *et al.,* 2011. Khan *et al*., 2012). Among organics, addition of poultry manure@ 10 t ha^{-1} reported the highest grain yield (5742, 6039 kg ha^{-1}) and straw yield (7951, 8084 kg ha^{-1}) in Vertisol and Entisol respectively and was comparable with vermicompost. The percent increase due to poultry manure on grain yield (23.1, 22.0) and straw yield (22.2, 21.9) was noticed over control in Vertisol and Entisol respectively. This could be due to supply of nutrients especially macro and micronutrients which induce cell division, expansion of cell wall, meristamatic activity, photosynthetic efficiency, regulation of water into cells, conducive physical environment leading to better aeration, root activity and nutrient absorption resulting in higher rice yield(Singh *et al.,* 2001). In the present study, poultry manure contained higher nutrient content compared to other organics which caused higher rice yield. Higher grain yield due to poultry manure was reported by (Saidu Adami *et al.,* 2012, Sangeeta *et al*., 2013). Interaction between zinc and organics was significant. The highest grain yield (6103, 6344 kg ha^{-1}) and straw yield (8369, 8439 kg ha^{-1}) was observed on addition of 5 mg Znkg^{-1} and poultry manure @ 10 t ha^{-1}. It caused (18.2, 16.3%) and (25.1, 20.0%) increase in grain and straw yield over control. This is due to the fact that zinc availability was expected to enhance through complexation or chelation thereby prevent fixation in soil (Latha *et al*., 2001).

Zinc use efficiency

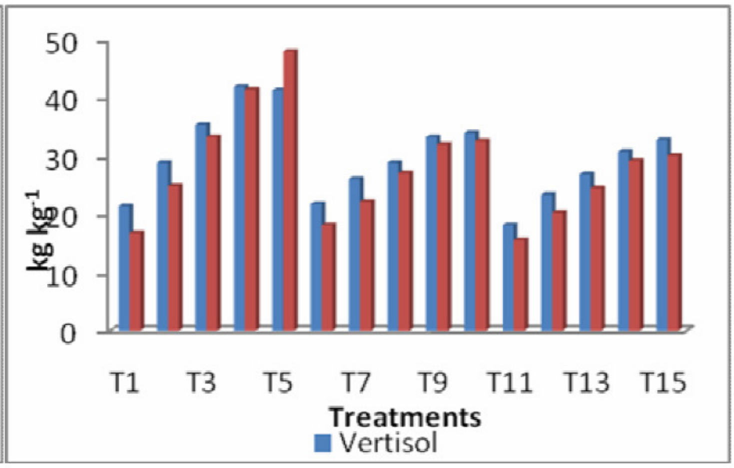
Zinc use efficiency (ZnUE) was significantly influenced by addition of zinc and organics (Fig.1). Agronomic efficiency, physiological efficiency, agro physiological efficiency, apparent zinc recovery and zinc utilization efficiency was highest at 2.5 mg Zn kg^{-1} and declined with Zn loading. It was due to inverse relationship observed between utilization and rate of application and also due to progressive decline in grain yield at highest level of zinc applied. (Fageria, 1992) Higher ZnUE at lower level of Zn in rice was reported by Fageria *et al*. (2011). Apparent zinc recovery was very low due to poor distribution from low rates applied and fertilizer reaction with soil to form insoluble products (Mortvedt, 1994). Brijesh Yadav *et al.* (2013) reported higher recovery of zinc at lower level of zinc applied. Addition of organics also improved ZnUE over no organics and the maximum value was noticed with poultry manure and was comparable with vermicompost. Zinc use efficiency increased further when zinc was applied in the presence of organics compared to their absence and the highest ZnUE was noticed with 2.5 mg Zn kg^{-1} + poultry manure compared to other combinations. Zinc enriched organic manures improves the availability of zinc in soils by preventing their fixation and precipitation thereby enhances the use efficiency of applied zinc (Sathynarayana *et al*., 2002)

Table 1 : Effect of zinc and organics on grain and straw yield (kg ha^{-1})

Organic sources	Grain yield					Straw yield				
	Zinc levels (mg kg^{-1})									
	0	2.5	5.0	7.5	Mean	0	2.5	5.0	7.5	Mean
	Vertisol									
O_1 - Control	4107	4536	4930	4806	4595	5824	6451	6874	6865	6504
O_2 – FYM @ 12.5 t ha^{-1}	4506	4871	5295	5200	4968	6315	6929	7484	7419	7037
O_3-GM @ 6.25 t ha^{-1}	4855	5270	5596	5502	5306	6753	7385	7940	7881	7490
O_4 –PM @ 10 t ha^{-1}	5149	5678	6103	6058	5747	7299	7813	8369	8324	7951
O_5-VC @ 5 t ha^{-1}	5074	5623	6077	5818	5648	7151	7811	8246	8204	7853
Mean	4738	5196	5600	5477		6668	7277	7783	7739	
		O	**Zn**	**O xZn**		**O**	**Zn**	**O xZn**		
SEd		58.05	66.85	116.11		50.48	54.06	120.88		
CD(p=0.05)		116.69	134.37	233.39		101.48	108.66	242.97		
	Entisol									
O_1 - Control	4432	4880	5265	5210	4948	6559	6559	7013	6966	6633
O_2 – FYM @ 12.5 t ha^{-1}	4785	5263	5675	5631	5338	6604	7106	7542	7510	7190
O_3-GM @ 6.25 t ha^{-1}	5198	5670	6020	5955	5711	7044	7543	8020	7962	7642
O_4 –PM @ 10 t ha^{-1}	5527	5990	6344	6297	6039	7474	8000	8459	8403	8084
O_5-VC @ 5 t ha^{-1}	5457	5915	6246	6195	5953	7342	7931	8433	8385	8023
Mean	5080	5544	5910	5808		6891	7428	7893		
		O	**Zn**	**O xZn**		**O**	**Zn**	**O xZn**		
SEd		50.40	56.02	123.69		55.03	59.35	128.42		
CD(p=0.05)		101.31	112.61	248.62		110.63	119.31	258.13		



(A)



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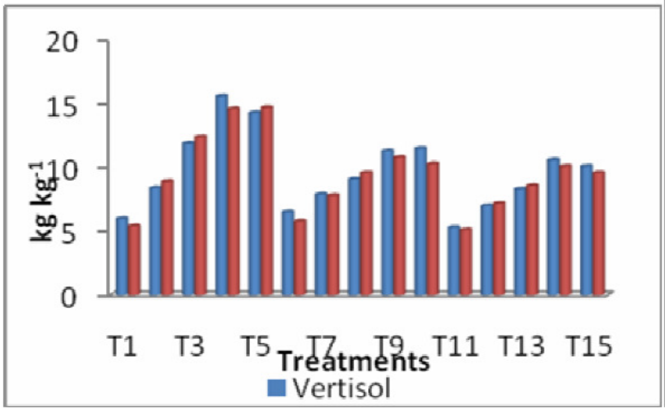

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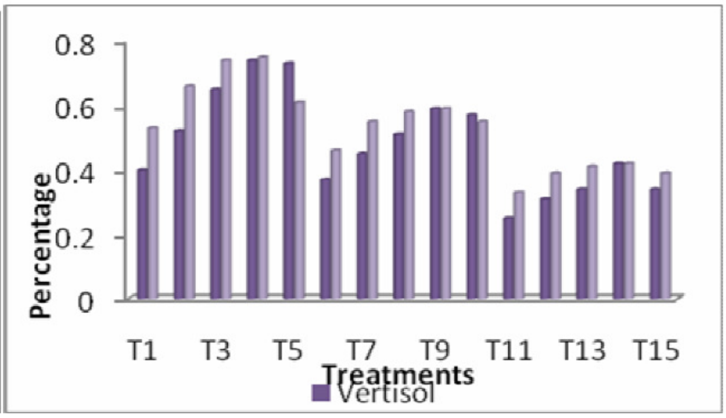

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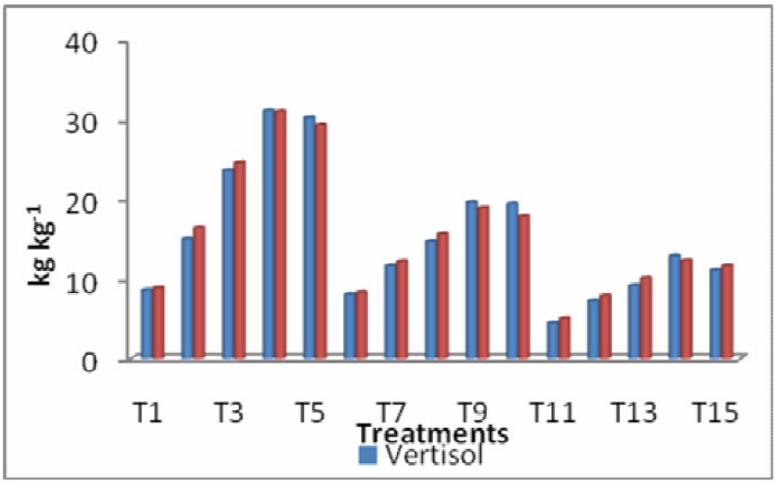

(E)

Fig. 1 : Effect of zinc and organics on zinc use efficiency.

A) Agronomic efficiency, B) physiological efficiency, C) Agro physiological efficiency, D) Apparent zinc recovery, E) Zinc utilization efficiency.

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