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Studies on Screening of Rice Genotypes for High Zinc Use Efficiency

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ABSTRACT

A pot experiment was conducted during Kharif 2011 in glass house at Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University to studies on screening of rice genotypes for high zinc use efficiency. The experimental soil belonged to Kondal series (Typic Haplusterts). The experiment was conducted in FCRD with ten rice genotypes (ADT 36, ADT 37, ADT 45, ADT 38, CO 45, ADT 43, ADT 46, ADT 39, CO 43, ADT 48) and two Zn levels(0 and 5 ppm) with 3 replications in zinc deficient Vertisol.Genotypes differed significantly in grain and straw yield due to zinc addition. The percent increase in grain yield ranged from 4.2 to 13.5 among rice genotypes on addition of 5 ppm Zn over control. Overall there was 5.75% increase in grain yield when 5 ppm Zn was applied. Similar effect was also noticed with respect to Straw. Accordingly in the present study, genotypes ADT 48, CO 43, ADT 39, ADT 45, ADT 36 and ADT 46 were considered zinc inefficient while genotypes ADT 37, ADT 36, CO 45 and ADT 43 were considered Zn efficient.Among rice genotypes, ADT 48 recorded the highest zinc use efficiency except apparent zinc recovery where ADT 43 recorded the highest value.

KEYWORDS:zinc, rice yield, genotypes

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INTRODUCTION

The world's population is essential to increase from 6 billion to about 10 billion by 2050. To meet the food demand of the growing world population, a large increase in food production is required. It has been estimated that to supply enough food for world population in 2020, annual cereal production needs to increase by 40 per cent from 1773 billion tonnes in 1993 to nearly 2500 billion tonnes by 2020[1]. About 85 per cent of the increase in total cereal demand will occur in developing countries. Rice is the staple food for about 50 per cent of the world's population (72.7 billion) that resides in Asia where 90 per cent of the world's rice is grown and consumed. It is an important staple food that provides 66 to 70 per cent body calorie intake of the consumers[2]. Zinc deficiency is the most widespread micronutrient deficiency in the world and in India. Plant available Zn concentration is as low as 50 percent of arable soils in the world and zinc deficiency is the most prevalent in rice growing area[3]. Rice is the main dietary source for 5% of the human population in the world [4]. Developing rice cultivars with high zinc efficiency depends on the capacity of a genotype to grow and yield well on low Zn levels and offers a sustainable and cost effective way to overcome zinc deficiency problem [5]. Variation in Zn efficiency is mainly related to variation in Zn uptake rather than to differences in the internal Zn efficiency [6]. In most soils, total Zn is much larger than the amount of removed by a crop[7] but the ability to absorb sufficient Zn from soil is a concern. High costs of Zn fertilizers and its repeated and relatively low- efficient application may be sufficient justification for use of efficient rice genotypes that can grow well on soils with loe amount of available Zn [5]. Productivity of rice depends upon balance application of nutrients. Farmer's of state having the apathy to use micronutrients in their farming system resulting into poor micronutrients soils[8].Biofertication of staple food crops is a feasible, sustainable and economical approach to defeat zinc malnutrition in the population depending on the origin of plant in the diet. Realizing the importance of zinc efficient genotypes and biofertication to increases the zinc density in plant grain and at the same time seriousness of its deficiency in soils and plants, the present study was undertaken.

MATERIALS AND METHODS

A pot experiment was conducted in glass house of experimental farm of Annamalai University to study the response of rice genotypes to zinc application. The experimental soil belonged to Kondal series (Typic Haplusterts). The physicochemical characterization of the soil was clay loam with pH- 8.02 , EC-0.72 dSm^{-1} , organic carbon- 6.74 g kg^{-1}, $CaCO_3$- 2.27% , $KMnO_4$-N- 283 kg ha^{-1} , Olsen P- 26 kg ha^{-1} , NH_4OAc- K- 320 kg ha^{-1} and DTPA Zn- 0.70 mg kg^{-1}. The experimental soil was deficient in Zn[9] (critical limit of Zn – 0.84 mg kg^{-1}). The treatments consisted of ten rice genotypes (ADT 36, ADT 37, ADT 45, ADT38, CO 45,ADT 43, ADT 46, ADT 39, CO

43, ADT 48) and two Zn levels(0 and 5 ppm) applied through zinc sulfate. Each pot was filled with 10 kg of processed soil sample. All the pots received uniform dose of 100: 50:50 kg N, P_2O_5 and K_2O applied through urea, superphosphate and muriate of potash respectively. The experiment was conducted in FCRD with three replications. To determine grain, straw yield crops were harvested at maturity. The soil and plant samples were analyzed at harvest stages for Zn content. Respective nutrient (Zn) uptake was computed. Based on yield and zinc uptake, various zinc use efficiency parameters were worked out.

RESULTS AND DISCUSSION

Rice yield

Grain and straw yield of rice responded significantly to zinc application (Table 1). The rice genotypes produced significantly (p= .0.05) different grain and straw yield. The grain yield ranged from 29.87 g/pot) to 82.10 g/pot and straw yield ranged from 50.89 g/pot to 107.6 g/pot due to zinc application. The highest grain yield (82.10 g/pot) and straw yield (107.6 g/pot) was noticed with genotype ADT 43 and the minimum grain yield (29.87 g/pot) and straw yield (50.89 g/pot) was observed with ADT 48. The grain yield response varied from 2.10 g/pot to 3.80 g/pot among rice genotypes due to application of 5 ppm. Zn The per cent increase in grain yield due to zinc application among rice genotypes varied from 4.2 to 13.5 over control, while in straw yield percent increase among rice genotypes ranged from 1.8 to 11.33 .On an average 5 ppm Zn caused 5.75% and 4.69% increase in grain and straw yield respectively over control. The increase in grain and straw yield with application of zinc was attributed to adequate supply of zinc that might have increased the availability and uptake of other essential nutrients resulting in improvement in metabolic activities [10] and also due to the effect of zinc on the proliferation of roots so that uptake rate from soil was increased and supplying it to the aerial part of the plant. This was confirmed by the positive significant linear relationship between grain Zn uptake and grain yield (Fig 1) and also by significant positive linear relationship between grain yield and Zn recovery efficiency (Fig.2).Reported similar results[11]. reported poor grains could be produced in zinc deficient plants[12].The variation in the potential grain yield among rice genotypes demonstrates that genotype is an important contributor to overall variability and has to be considered in Zn fertilization management [13]. Differences in growth among cultivars have been related to the absorption, translocation, shoot demand, DMP potential per unit of nutrient absorbed [14]. Large genotypic variation in response to Zn deficiency have been reported among rice [10] .

zinc use efficiency

The analysis of variance on various zinc use efficiency parameters furnished in Table 2 showed that there existed significant differences among rice genotypes with respect to zinc use efficiency on application of zinc. The various zinc use efficiency parameters studied include agronomic efficiency, physiological efficiency, agrophysiological efficiency, apparent zinc recovery and zinc utilization efficiency. The range in values for different zinc use efficiency parameters among rice genotypes were agronomic efficiency (42 to 76 µg µg^{-1}),physiologicalefficiency(3878to 13991 µg µg^{-1}), agrophysiological efficiency (1494 to 5031 µg µg^{-1}), apparent zinc recovery (0.54 to 1.86%) and Zn utilization efficiency (43.1 to 75.6 µg µg^{-1}). In all the zinc use efficiency parameters, except apparent zinc recovery, genotype ADT 48 registered the highest value while ADT 43 recorded the highest apparent zinc recovery (1.86%). With respect to agronomic efficiency, ADT 38 registered the highest value which was comparable with ADT 37. ADT 37 and CO 45, ADT 36, ADT 46, ADT 39 and CO 43, ADT 45 and ADT 43 were comparable. With regard to physiological efficiency, the least value was noticed with ADT 43 which was comparable with CO 45, while rest of the genotypes was significant. The lowest value with respect to agrophysioloigcal efficiency was observed with CO 45 which was comparable with ADT 43, ADT 45 and ADT 39 was on par and rest of the genotypes were significant. With respect to apparent zinc recovery, ADT 48 registered the least value (0.54%). ADT 36 and ADT 45, ADT 39 and ADT 45, ADT 37, ADT 39 and ADT 37, ADT 38 and CO 43 were on par. Regarding zinc utilization efficiency, least value was noticed with ADT 37 (43.1 µg µg^{-1}) which was on par with CO 45, ADT 45 and ADT 43, ADT 26, CO 43, ADT 39 and ADT 46 were on par.Nutrient use efficiency can be defined as the relative ability of plants to produce maximal amounts of DMP or yield per each increment of nutrient accumulation [15] or the capacity of a genotype to grow and yield well in soils with low nutrient availability [16,17].

Rice cultivars showed marked variation in zinc use efficiency parameters *viz.*, agronomic efficiency, physiological efficiency, agrophysiological efficiency, apparent zinc recovery and zinc utilization efficiency. Among rice genotypes, ADT 48 recorded the highest zinc use efficiency except apparent zinc recovery where ADT 43 recorded the highest value. While other genotypes showed intermediate values. Under the same cultivation condition, crop varieties present different behaviour for nutritional characteristics, providing different growth and productivity responses. Such behaviour may be due to differences in nutrient use among varieties.

Genotypic difference in zinc efficiency have been related to various mechanism operating in the rhizosphere and within a plant system which include seed Zn content, uptake of zinc from zinc deficient soil, translocation of zinc from root to shoot, shoot zinc concentration and biochemical zinc utilization[7]. There was significant positive linear relationship between zinc uptake and apparent Zn recovery (Fig. 3) indicatedthat the increase in zinc efficiency caused enhanced zinc uptake. Further, it showed that not only enhanced zinc uptake but also enhanced internal utilization of zinc played an important role in expression of zinc efficiency. Zinc uptake is the major mechanism contributing to zinc efficiency in plants [18]. Enhancement in the zinc uptake rate by roots and zinc utilization at cellular level indicate high zinc efficiency [19]. In the present study, ADT 43 had the highest zinc uptake both under zinc stress and adequate condition and was found to be zinc efficient. Utilization efficiency may be linked to differences in the ability of a genotype to maintain an optimum activity of the important zinc regulating enzymes *viz*., superoxide dismutase (SOD) and carbonic anhydrase (CA)[20]. Difference in internal utilization or mobility of zinc has been known to be involved in expression of zinc efficiency [21].Lowland rice genotype having difference in zinc use has been reported earlier [22]. Characterized zinc use efficiency in varieties of Arabica coffee and found existence of differences in zinc use efficiency.

Table 1. Effect of zinc fertilization on grain and straw yield (g pot^{-1}) in rice genotypes

Rice genotypes	**Grain yield**			**Straw yield**		
	Zinc levels (mg kg^{-1})					
	Zn$_0$	**Zn$_{5.0}$**	**Mean**	**Zn$_0$**	**Zn$_{5.0}$**	**Mean**
ADT 36	53.23	56.31	54.77	69.55	73.88	71.72
ADT 37	50.90	53.06	51.98	66.06	6844	67.25
ADT 45	50.34	53.83	52.08	67.49	70.32	68.90
ADT 38	50.15	52.25	51.20	67.00	69.01	68.01
CO 45	54.78	57.06	55.92	71.43	74.63	73.03
ADT 43	80.30	83.90	82.10	106.65	108.58	107.61
ADT 46	60.56	63.73	62.14	81.09	84.13	82.61
ADT 39	47.32	50.45	48.88	64.40	68.31	66.36
CO 43	44.49	47.61	46.05	62.60	66.22	64.41
ADT 48	27.97	31.77	29.87	48.16	53.62	50.89
Mean	52.00	54.99		70.44	73.71	
	Zn	G	Zn x G	Zn	G	Zn x G
SEd	0.28	0.62	0.88	0.28	0.62	0.88
CD (p=0.05)	0.56	1.26	1.78	0.56	1.27	1.79

Table 2. Effect of zinc fertilization on zinc use efficiency in rice genotypes

Rice genotypes	**Agronomic efficiency (µg µg^{-1})**	**Physiological efficiency (µg µg^{-1})**	**Agro physiological efficiency (µg µg^{-1})**	**Apparent Zn recovery (%)**	**Utilization efficiency (µg µg^{-1})**
ADT 36	61.6	5771	3086	1.07	61.6
ADT 37	43.2	4397	1675	0.98	43.1
ADT 45	69.8	6683	2665	1.04	69.5
ADT 38	42.0	5307	1880	0.79	52.5
CO 45	45.6	4043	1494	1.13	45.7
ADT 43	72.0	3879	1502	1.86	72.1
ADT 46	63.4	4694	1758	1.36	63.8
ADT 39	62.6	6238	2655	1.00	62.4
CO 43	62.4	7385	3261	0.85	62.8
ADT 48	76.0	13991	5031	0.54	75.6
SEd	1.69	87.2	24.75	0.03	1.68
CD (p=0.05)	3.42	176.2	50.0	0.06	3.41

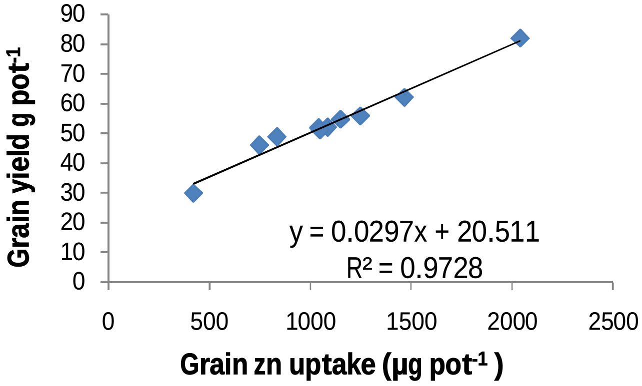

Fig. 1. Linear Relationship Between Grain Yield And Grain Zn Uptak

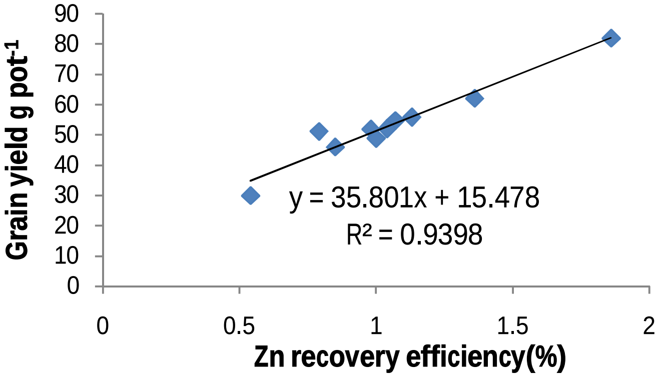

Fig. 2. Linear Relationship Between Grain Yield And Zn Recovery Fficiency

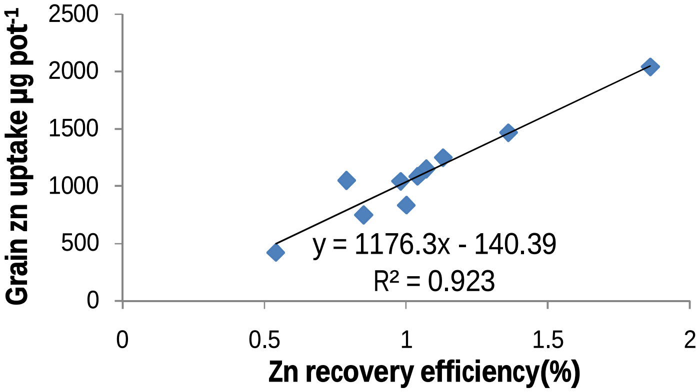

Fig. 3. Linear Relationship Between Grain Zn Uptake And Zn Recovery Efficiency

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