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RESEARCH ARTICLE

Influence of Zinc sulphate and Zinc EDTA on Grain zinc, Growth and Yield Parameters, of Rice Genotypes

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ABSTRACT

A field experiment was conducted at the Department of Rice, Tamil Nadu Agricultural University, Coimbatore-3 during Kharif season, 2017. The objective of the experiment was to study the influence of Zinc nutrition on growth, physiology, ZUE, yield and grain Zn content of rice genotypes at two stages of crop. The experiment was laid out in a factorial randomized block design with three replications. The results of the field study revealed the maximum total tillers per plant were observed in the rice genotype IR93354:19-B-12-21-9-1RGA-2RGA-1-B under 0.5% ZnSO4 condition at the grain filling stage. However the higher total dry matter production recorded in the genotype IR15M1266 under 0.5% ZnSO4 treatment. Regarding zinc use efficiency indices, the maximum zinc use efficiency (42.2%) was observed in the foliar application of 0.5% ZnSO4 in rice genotype IR14M117 followed by BPT5204 (39.0%). The higher spikelet fertility was observed in BPT5204 (98.2%) under foliar application of 0.5% ZnSO4 was followed by Kalanamak (97.3%) on par with Chittmutyalu (97.2%) was under 0.5% ZnSO4 application. The treatment 0.5% ZnSO4 had recorded higher grain yield (8870.0 kg/ha) in IR95097:3-B-16-11-4-GBS which was on par with IR14M124 (8800 kg/ha). To conclude, when foliar sprayed with zinc sources such as 0.5% ZnSO4 and 0.5 % Zn EDTA at boot leaf and grain filling stage in rice genotypes like IR15M1003, IR95097:3-B-16-11-4-GBS, IR95040:12-B-3-10-GBS, IR15M1341 and IR95097:4-B-2-18-8-GBS showed significant changes in growth, physiology and zinc grain content.

Keywords: *Rice, Zinc sulphate, foliar application, zinc EDTA, grain filling stage*

INTRODUCTION

Rice (*Oryza sativa* L.) is being the staple food for almost two-thirds of the population plays a pivotal role in the Indian economy. Currently, increasing Zn concentration of cereal grains is a big global challenge. Zinc (Zn) biofortification of rice grains, which aims at increasing Zn concentration and bioavailability of food crop, appears to be the most feasible, sustainable and economical approach among the different interventions to address human Zn deficiency (Salunke *et al.,* 2011). Over the last decade, several efforts have been made to biofortify food crops with micronutrients, which led to a significant understanding of the physiological, genetic, and molecular basis of high Zn accumulation in grains and also the influence of agronomic management, physiological interventions and environmental factors on Zn uptake, translocation and loading into grains (Impa and Johnson-Beebout, 2012).

Zinc is one of the most important micronutrients essential for plant growth especially for rice grown under submerged condition. Zinc is essential for several biochemical processes in the rice plant, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation, and membrane integrity. A Genetic and agronomical/physiological bio-fortifications are two important agricultural tools to Zn concentration in rice grain. However, yield factor, interactions between genotype and environment, lack of sufficient genetic diversity in current cultivars for a breeding program, consumer resistance and safety of genetically modified crops are the main bottlenecks of genetic bio-fortification. An adequate amount of plant available Zn in the soil is essential for Zn bio-fortified rice genotypes to accumulate Zn in grains. Most of the rice growing area is Zn deficit and also Zn availability in irrigated rice ecosystems is very low due to formation of less soluble Zn complexes under anaerobic conditions (Imba *et al*., 2012). An estimation of soil Zn status and application of Zn fertilizer to Zn deficit soil is important for Zn bio-fortification.

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Foliar application can avoid the problems of Zn binding in the soil, but the timing of Zn foliar application should be around flowering for increased grain Zn concentration (Pandey *et al*., 2013). It is also important to note that various fertilization methods, used to boost rice grain content of Zn, are supplemental to breeding strategies for bio-fortifying rice grain. For foliar application, a number of Zn sources, such as $ZnSO_4$, Zn (NO_3) and Zn-EDTA, have been used on many crops. The foliar of $ZnSO_4$ has been proved an effective technique to increase grain Zn concentration and to overcome Zn deficiency (Stomph *et al*., 2011). With this background the study was conducted to assess the effect of two sources of Zn in relation to physiology, ZUE and grain Zn content of rice genotypes through a foliar application at two stages of crop.

MATERIAL AND METHODS

Field experiments were conducted during 2017 at Department of Rice, Tamil Nadu Agricultural University, Coimbatore. The seeds of twenty three rice genotypes were sown on 4thAugust of 2017 in raised seed bed. Foliar spray of $ZnSO_4$ (0.5%) and Zn EDTA (0.5%) was given at boot leaf stage and grain filling stage of rice crop. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications and three treatments. The net plot size of 4 m^2 and gross plot size was 40 m^2 maintained. Planting Spacing of 20 cm × 20 cm was. The crops were foliar applied with the various zinc sources *viz.,* T_1- Control, T_2- $ZnSO_4$ (0.5%), T_3- Zn EDTA (0.5%) at boot leaf and grain filling stages. Observations were made on growth and physiological parameters, zinc content in plants and grains and yield parameters at boot leaf and grain filling stages. The zinc content in dry matter of rice grains and straw is determined by Prasad *et al.* (2006) using Atomic Absorption Spectrophotometer (AAS).

Zinc Use Efficiency (ZUE) = The total biomass or grain yield produced per unit of Applied zinc

Statistical analysis of all the data collected is carried out following the analysis of variance technique for randomized block design (RBD) as outlined by Panse and Sakhtme (1985).

RESULTS AND DISCUSSION

Experimental results showed that the spraying

Table 1. Effect of $ZnSO_4$ and Zn EDTA on total number of tillers, total dry matter production, Specific leaf area (cm2/g) of different rice genotypes at grain filling stage

Rice genotypes	Total number of tillers			Total drymatter production (g/plant)			Specific leaf area (cm^2/g)		
	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%
IR15M1298	23.0	29.1	26.5	50.6	58.2	55.7	128.3	147.5	141.1
IR15M1319	28.0	35.4	32.2	43.3	49.8	47.6	118.9	136.7	130.8
IR15M1328	21.0	26.6	24.2	43.0	49.5	47.3	175.3	201.6	192.8
IR15M1341	21.0	26.6	24.2	35.8	41.2	39.4	160.7	184.8	176.8
IR10M210	26.0	32.9	29.9	38.9	44.7	42.8	174.1	200.2	191.5
IR95097:4-B-2-18-8-GBS	19.0	24.0	21.9	23.1	26.6	25.4	121.9	140.2	134.1
IR95040:12-B-3-10-GBS	22.0	27.8	25.3	33.6	38.6	37.0	123.4	141.9	135.7
IR15M1178	19.0	24.0	21.9	34.4	39.6	37.8	148.3	170.5	163.1
IR93354:19-B-12-21-9-1RGA-2RGA-1-B	28.0	38.4	32.2	35.1	40.4	38.6	112.5	129.4	123.8
IR15M1266	26.0	32.9	29.9	45.8	52.7	50.4	181.4	208.6	199.5
IR95097:3-B-16-11-4-GBS	28.0	35.1	31.9	28.0	32.2	30.8	187.3	255.4	206.0
IR95041:9-B-7-5-17-GBS	24.0	32.9	29 .9	34.4	39.6	37.8	152.0	174.8	167.2
IR14M117	21.0	26.6	24.2	18.2	20.9	20.0	128.3	147.5	141.1
IR14M121	18.0	22.8	20.7	42.4	48.8	46.6	177.8	204.5	195.6
IR14M124	23.0	29.1	26.5	51.6	59.3	56.8	185.2	213.0	203.7
IR15M1003	21.0	26.6	24.2	32.9	37.8	36.2	146.6	168.6	161.3
IR15M1284	19.0	24.0	21.9	25.3	29.1	27.8	102.5	117.9	112.8
IR15M1337	24.0	30.4	27.6	48.8	56.1	53.7	120.2	138.2	132.2
Chittmutyalu	23.0	29.1	26.5	34.6	39.8	38.1	146.8	168.8	161.5
DRR Dhan45	21.0	26.6	24.2	36.8	42.3	40.5	151.2	173.9	166.3
BPT 5204	30.0	38.0	34.5	27.7	31.9	30.5	140.7	161.8	154.8
Kalanamak	23.0	29.1	26.5	47.4	54.5	52.1	151.2	173.9	166.3
CO-51	22.0	27.8	25.3	24.2	29.8	27.1	193.7	222.8	213.1
Mean	23.0	29.1	26.5	36.3	41.8	40.0	149.1	171.4	164.0
	T	G	TxG	T	G	TxG	T	G	TXG
SEd	0.10	0.27	0.48	0.17	0.46	0.80**	0.64	1.63	3.16
CD(0.05%)	0.19**	0.55**	NS	0.33	0.92	1.58**	1.33	3.69	6.40**

of Zinc sources such as $ZnSO_4$ and Zn EDTA had significant effect on a total number of tillers, total dry matter production, specific leaf area, total zinc content in plants and brown rice, zinc use efficiency and yield components.

The increase in the number of tillers per plant could be ascribed to the adequate supply of zinc sources. The highest number of tillers per plant (38.4) was recorded in the rice genotype IR93354:19-B-12-21-9-1RGA-2RGA-1-B at grain filling stage (Table 1).

Table 2. Effect of $ZnSO_4$ and ZnEDTA on total zinc content, zinc content in brown rice, zinc use efficiency of different rice genotypes at physiological maturity stage

Rice genotypes	Total zinc content in plant (g/g)			Zinc content in brown rice (g/g)			Zinc use efficiency (%)		
	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%
IR15M1298	95.3	114.2	109.2	15.1	22.7	16.6	23.8	27.4	25.3
IR15M1319	88.0	101.2	96.8	13.8	20.7	15.2	21.6	24.8	23.7
IR15M1328	94.1	108.2	103.5	19.9	29.9	21.9	24.8	27.2	27.7
IR15M1341	102.3	117.6	112.5	18.1	27.2	19.9	21.2	21.9	21.5
IR10M210	86.4	99.4	95.0	15.2	22.8	16.7	36.7	42.2	40.3
IR95097:4-B-2-18-8-GBS	109.3	125.7	120.2	15.1	22.7	16.6	21.7	24.9	23.8
IR95040:12-B-3-10-GBS	98.0	112.7	107.8	13.8	20.7	15.2	23.8	27.4	25.6
IR15M1178	96.4	110.9	106.0	22.2	33.3	24.4	20.9	24.0	23.0
IR93354:19-B-12-21-9-1RGA-2RGA-1-B	92.3	106.1	101.5	18.1	27.2	19.9	20.2	23.3	22.3
IR15M1266	94.3	108.4	103.7	16.1	24.2	17.7	24.8	28.5	27.2
IR95097:3-B-16-11-4-GBS	88.3	101.5	97.1	14.1	21.2	15.5	26.9	30.9	29.5
IR95041:9-B-7-5-17-GBS	82.6	95.0	90.9	18.4	27.6	20.2	17.6	20.3	19.4
IR14M117	101.1	116.3	111.2	16.9	25.4	18.6	36.7	42.2	40.3
IR14M121	92.4	106.3	101.6	18.2	27.3	20.0	16.9	19.4	18.6
IR14M124	93.8	107.9	103.2	19.6	29.4	21.6	26.7	30.7	29.3
IR15M1003	84.0	96.6	92.4	29.8	44.7	32.8	29.8	34.2	32.7
IR15M1284	92.6	106.5	101.9	18.4	27.6	20.2	24.8	28.5	27.2
IR15M1337	95.8	110.2	105.4	16.6	24.9	18.3	19.0	21.9	21.0
Chittmutyalu	89.2	102.6	98.1	25.1	37.7	27.6	15.5	17.8	17.0
DRR Dhan45	91.8	105.6	101.0	17.6	26.4	19.4	17.6	20.3	19.4
BPT 5204	87.3	100.4	96.0	23.1	34.7	25.4	34.0	39.0	37.3
Kalanamak	92.9	106.8	102.2	18.7	28.1	20.6	19.8	22.7	21.7
CO-51	83.5	96.0	91.9	29.3	44.0	32.2	20.0	21.8	21.8
Mean	92.7	106.8	102.1	18.8	28.3	20.7	92.7	106.8	102.1
	T	G	TXG	T	G	TXG	T	G	TXG
SEd	0.12	0.32	0.52	0.13	0.38	0.58	0.12	0.32	0.52
CD (0.05%)	0.26	0.64	1.02**	0.27	0.78	1.19**	0.26	0.64	1.02**

In the present study also the application of zinc significantly increased the number of tillers and this could be attributed to the improved enzymatic activity and auxin metabolism in plants (Hung *et al.,* 1990). The higher dry matter production (70.3 g plant^{-1}) was recorded in IR15M1266 under the foliar application of 0.5% $ZnSO_4$ compared the check DRR Dhan 45 (56.4 g plant^{-1}) at grain filling stage (Table 1). Khanda *et al., (*1997) also observed the significant increase in drymatter accumulation with foliar application of ZnSO4. The highest specific leaf area (255.4 cm^{-2}g^{-1}) was observed in the rice genotype IR95097:3-B-16-11-4-GBS under 0.5% $ZnSO_4$ compared 0.5 % Zn EDTA (206.0 cm^{-2}g^{-1}) at grain filling stage

The data on zinc content in plants and brown rice at physiological maturity stage were summarized in table 2 which showed that there was a significant difference in total zinc content in response to zinc treatments among different genotypes. The higher total zinc content in plants was observed in IR95097:4-B-2-18-8-GBS (125.7µg/g) under 0.5% $ZnSO_4$ treatment compared to 0.5% Zn EDTA treatment in the same genotype which recorded the lower value of 120.2 µg/g compared to control. Among the treatments, the foliar application of 0.5% $ZnSO_4$ was found to show significantly higher zinc content in brown rice (44.4 µg/g) in IR15M1003 which was followed by Co 51 (44.0 µg/g) (Table 2). The increase in Zn concentrations in rice plant might be due to the presence of increased amounts of Zn by the foliar application of $ZnSO_4$ that facilitates greater absorption of Zn compared with that of chelated Zn. Similar findings were also observed by Mandal *et al.* (1985) and Naik *et al.* (2008) in wheat. These results might be due to translocation of Zn from leaf to the grain. Zinc application increased the zinc concentration in brown rice might be due to higher leaf absorption and seed deposition of foliar applied Zn. Similar findings are in confirmation with the results of Mao *et al.* (2014) and Phattarakul *et al*. (2012). Zinc Use Efficiency (ZUE)correlated with enhanced expression and activity of zinc-requiring enzymes. Compared to all treatments, 13% increase in zinc use efficiency was observed in the foliar application of 0.5% $ZnSO_4$ in rice genotype IR14M117 compared with control. Similar findings were reported by (Mandal *et al*., 2000)

Table 3. Effect of $ZnSO_4$ and ZnEDTA on yield components of different rice genotypes at physiological maturity stage

Rice genotypes	Spikelet fertility (%)			Straw yield (kg/ha)			Grain yield (kg/ha)		
	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%	Control	$ZnSO_4$ 0.5%	ZnEDTA 0.5%
IR15M1298	84.0	86.5	85.7	28.3	42.7	40.8	7333.3	7630.0	7416.6
IR15M1319	80.6	87.7	87.6	16.2	18.7	17.9	6128.0	6927.5	6625.5
IR15M1328	92.5	94.3	92.7	28.2	32.5	31.1	7877.7	8374.1	8017.0
IR15M1341	86.3	90.4	89.7	29.1	33.4	32.0	6251.3	6613.9	6323.8
IR10M210	80.1	88.8	84.6	21.0	24.2	23.1	7024.3	7425.5	7104.5
IR95097:4-B-2-18-8-GBS	85.3	87.1	87.0	24.7	28.4	27.2	6583.3	6962.5	6659.1
IR95040:12-B-3-10-GBS	83.7	93.8	91.0	22.6	26.0	24.9	7328.3	7744.7	7411.6
IR15M1178	83.2	89.3	88.3	19.9	22.9	21.9	4624.7	4905.9	4680.9
IR93354:19-B-12-21-9-1RGA-2RGA-1-B	85.9	87.6	86.9	25.3	29.1	27.8	6083.3	6437.5	6154.1
IR15M1266	85.4	86.5	91.0	33.0	37.9	36.3	7666.7	8100.0	7753.4
IR95097:3-B-16-11-4-GBS	86.6	90.7	89.3	25.2	29.0	27.8	8400.0	8870.0	8494.0
IR95041:9-B-7-5-17-GBS	83.5	85.0	84.2	38.4	44.1	42.2	4729.7	5016.2	4787.0
IR14M117	87.0	89.7	88.4	26.9	30.9	29.6	7122.3	7528.4	7203.5
IR14M121	84.8	86.7	85.9	20.5	23.5	22.5	4916.7	5212.5	4975.9
IR14M124	89.3	91.3	89.9	27.0	31.0	29.6	8333.3	8800.0	8426.6
IR15M1003	88.2	96.3	90.0	39.8	45.8	43.8	6524.7	6900.9	6599.9
IR15M1284	82.2	92.0	90.4	30.4	34.9	33.4	7666.7	8100.0	7753.4
IR15M1337	86.0	91.7	94.6	23.6	27.2	26.0	5666.7	6000.0	5733.4
Chittmutyalu	87.6	97.2	96.3	32.0	36.8	35.2	4416.7	4687.5	4470.9
DRR Dhan45	84.1	94.4	90.3	28.6	32.9	31.4	5166.7	5475.0	5228.4
BPT 5204	85.4	98.2	94.0	35.1	40.4	38.6	7024.3	7425.5	7104.5
Kalanamak	86.8	97.3	95.5	25.7	29.6	28.3	5916.7	6262.5	5985.9
CO-51	91.7	95.3	94.4	16.3	38.8	17.9	6578.0	7431.0	7154.0
Mean	85.7	91.2	89.9	27.2	31.3	30.0	6514.6	6910.9	6611.5
	T	G	TXG	T	G	TXG	T	G	TXG
SEd	0.39	1.09	1.89	0.12	0.35	0.60	51.59	142.85	247.83
CD (0.05%)	0.78	2.16	3.74**	0.25	0.69	1.203**	102.03	282.51	489.32**

In spikelet fertility, grain yield and straw yield. The variation observed in rice genotypes due to zinc treatment was showed in table 3. The highest mean spikelet fertility was observed in BPT5204 (98.2) with foliar application of 0.5% $ZnSO_4$. Grain yield was significantly influenced by different zinc treatment on rice genotypes is presented in table 3. The treatment 0.5% $ZnSO_4$ had recorded higher grain yield (8870.0 kg/ha) in IR95097:3-B-16-11-4-GBS which was on par with IR14M124 (8800 kg/ha), however the genotype IR95097:3-B-16-11-4-GBS had recorded grain yield of 8494.0 kg/ha due to 0.5% Zn EDTA treatment (Table 3). Higher grain yield with zinc fertilizer application might be due to the fact that zinc plays an important role in the biosynthesis of IAA and initiation of primordial for the reproductive part which have favored the metabolic reaction within the plant. Similar findings were also observed by Muthukumararaja *et al.* (2012) and Keram *et al*. (2012) in rice. The treatment 0.5% $ZnSO_4$ recorded the highest straw yield per plant (24727.0 kg/ha) in the genotype IR95097:3-B-16-11-4-GBS and the lowest straw yield per plant (10500.0 kg/ha) was recorded in CO51 under control condition. Stalin *et al*.(2011) observed that the supply of micronutrient zinc through foliar spray resulted in better absorption and thereby helping in photosynthetic activity and effective translocation to storage organs, thus, contributed to the increased straw yield.

CONCLUSION

To conclude, when foliar sprayed with zinc sources such as 0.5% $ZnSO_4$ and 0.5 % Zn EDTA at boot leaf and grain filling stage in rice genotypes like IR15M1003, IR95097:3-B-16-11-4-GBS, IR95040:12-B-3-10-GBS, IR15M1341 and IR95097:4-B-2-18-8-GBS showed significant changes in growth, physiology, zinc use efficiency, zinc grain content and yield attributes. This study helps us to know the response of Zn sources such as $ZnSO_4$ and Zn EDTA through a foliar application at two reproductive growth stages of rice crop for higher grain zinc content. Thus, the extreme genotypes identified in this study will be useful for selecting and breeding lines with enriched micronutrient status of rice.

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