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Yield, Zinc Uptake and Grain Fortification of Rice as Affected by Soil and Foliar Application of Zinc

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ABSTRACT

Field experiment conducted at the agricultural college farm, Bapatla during *kharif* season of 2011-12 revealed that highest grain yield and straw yield were recorded with soil application @ 50 kg $ZnSO_4$ ha^{-1} +foliar application of 0.5% $ZnSO_4$ at MT+ PI+ flowering stages which proved significantly superior to rest of the treatments. Similarly, highest Zinc content in grain was recorded with the same treatment and proved significantly superior to rest of the treatments, which remained at a par among themselves. Similar trend was also noticed with respect of Zinc content in brown rice as well as in polished rice as that was observed with Zinc content in grain.

Key words : Foliar application, Soil application,Yield, Zinc and Grain fortification, Zinc uptake.

Introduction of high yielding varieties of cereals and their continuous cultivation caused the deficiency of secondary and micronutrients, especially Zn and Fe, in time and space, which resulted in yield stagnation (Gill and Singh, 2009).Rice grain is a poor source of Zinc and Iron in addition to many essential mineral nutrients.

Increase the Zn content in cereals can be achieved by biofortification of food grains either by developing crop cultivars with high concentration of Zn in grains or by adequate Zn fertilization of crops grown on Zn-deficient soils (Rajendra Prasad, 2010). The new thinking in the area of zinc nutrition is that neither uptake nor translocation contributes much to the zinc efficiency. Therefore, zinc content of rice grain should be dramatically improved.

Hence, it is proposed to explore the possibility of ferti-fortification for enhancing the nutrient content of rice grain either by adding fertilizer to soil or by applying zinc fertilizer to the crop foliage at an appropriate time during its growth.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* season of 2011 at the Agricultural college farm, Bapatla. The soil was clay loam (sand 28 %, silt 24 %, clay 48 %) with pH 7.9,Organic carbon 0.4% and 210, 20, 362 kg ha^{-1} and 0.6 ppm available N, P_2O_5, K_2O and Zn, respectively. The soil was deficient in available zinc. Thirty five days old seedlings of BPT-2270 (Bhavapuri sannalu) were transplanted with a spacing of 20 cm ×15 cm in each plot of 8.0 m × 6.0 m. The experiment was laid out in Randomized Block Design with three replications. A total rainfall of 651.6 mm was received in 31 number of rainy days during the period of crop growth .The experiment was consisted of nine treatments viz., Soil application @ 50 kg $ZnSO_4$ ha^{-1} (T_1), T_1 + foliar application @ 0.5% $ZnSO_4$ at maximum tillering (MT) stage (T_2), T_1 + foliar application @ 0.5% $ZnSO_4$ at panicle intiation (PI) stage (T_3), T_1 + foliar application @ 0.5% $ZnSO_4$ at flowering stage (T_4), T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + flowering stages (T_5), T_1 + foliar application @ 0.5% $ZnSO_4$ at PI + flowering stages (T_6), T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + PI stages (T_7), T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages (T_8), Control *i.e.*, no zinc (T_9).Recommended dose of 160 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} was applied through urea, single superphosphate and muriate of potash respectively. Entire quantity of phosphorus and half of potassium and one third of the N were applied at the time of final land preparation just before transplanting. The remaining nitrogen was applied in two equal splits at active tillering and panicle initiation stages. The remaining half of K was applied at PI stage. Zinc sulphate @ 50 kg ha^{-1} was applied to soil 3 days after N, P and K application as per the treatments. For foliar application of Zn, sprays of $ZnSO_4$ (0.5 %) were given (500 L ha^{-1}) with hand sprayer during morning hours between 8 A.M. and 9 A.M. However, no measurable foliar burning or precipitation was recorded within 24 hours of foliar treatments imposed. Zinc content in the grain samples and its uptake by plant was determined by Atomic Absorption Spectrophotometer method (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Effect on yield

Foliar spraying of zinc along with soil application influenced yield components which in turn increased the yield of crop (Table 1). Among the various treatments, soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages (T_8) resulted in the highest number of panicles m^{-2} (249), and found significantly superior to T_1, T_2 and T_3 treatments only.. This increase in no.of panicles due to foliar application of zinc might be due to increased photosynthetic rate, excessive accumulation of sucrose, glucose and fructose in leaves, which might have increased the physiological parameters of the plant. Similar findings were also reported by Sharma *et al*. (1999). The maximum number of total grains $panicle^{-1}$ (221) was registered with soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages (T_8). Similar trend was also noticed in respect of filled grains $panicle^{-1}$ as that was observed with total grains $panicle^{-1}$. Test weight was not significantly influenced by the different zinc treatments.

The highest grain yield (5961 kg ha^{-1}) and straw yield (7604 kg ha^{-1}) was recorded with soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages (T_8) which was on a par with T_5, T_6 followed by T_7 but proved significantly superior to rest of the treatments (Table 1). All the treatments resulted in significantly higher grain yield over control. The increased yield with Zn foliar spray might be attributed to enhanced yield components viz., number of panicles and number of filled grains $panicle^{-1}$. Similar results were also reported by Ram *et al*. (1995). The significant increase in straw yield in rest of the treatments over T_9 (No zinc) was as a result of better supply of Zn, which plays specific role in various metabolic activities.

Effect on Zn uptake and its content in grain

The highest zinc content in grain (40.0 ppm) was recorded with the treatment that received soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages (T_8) which was on a par with T_7 (37.7), T_6 (37.2) followed by T_5 (36.1) but proved significantly superior to rest of the treatments, and all these treatments remained at a par among themselves (Table 2). Similar trend was also noticed in respect of zinc content in brown rice and in polished rice as that was observed with Zn content in grain. The increased zinc content in whole grain might be due to direct application of zinc at critical growth stages, which might have helped in increased absorption in the grain during ripening and also due to its direct absorption in plant tissue resulted in increased grain content of zinc. Similar findings were also reported by Dhaliwal *et al*., 2010.

The treatments which received soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages (T_8), soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + flowering stages (T_5), soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at PI + flowering stages (T_6) and soil application @ 50 kg $ZnSO_4$ ha^{-1} + foliar application @ 0.5% $ZnSO_4$ at MT + PI stages (T_7) were equally effective in increasing the zinc uptake and found superior to rest of the treatments which, in turn, also remained statistically on a par with each other. Das *et al*. (2004) reported that the increase in Zn uptake by the crop might be due to easy availability and rapid rate of absorption caused by greater mobility of zinc when applied as foliar spray.

From the above results, it can be concluded that foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages along with soil application @ 50 kg $ZnSO_4$ ha^{-1} was found to be effective in increasing the yield and zinc content in rice grain.

Table 1. Yield attributes and yield of rice as influenced by different zinc treatments.

Treatment	No.of panicles m^{-2}	Totalgrains $panicle^{-1}$	No.of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 :Soil application @ 50 kg $ZnSO_4$ ha^{-1}	224	187	143	19.1	5251	5945
T_2 : T_1 + foliar application @ 0.5% $ZnSO_4$ at maximum tillering (MT) stage	230	191	147	19.2	5276	6306
T_3 :T_1 + foliar application @ 0.5% $ZnSO_4$ at panicle intiation (PI) stage	228	195	149	19.2	5290	6363
T_4 :T_1 + foliar application @ 0.5% $ZnSO_4$ at flowering stage	231	196	153	19.4	5356	6616
T_5 :T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + flowering stages	239	204	160	19.6	5486	7013
T_6 :T_1 + foliar application @ 0.5% $ZnSO_4$ at PI + flowering stages	242	207	161	19.8	5666	7197
T_7 :T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + PI stages	246	213	167	20.0	5771	7471
T_8 : T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages	249	221	176	20.1	5961	7604
T_9 : Control (No Zinc)	204	154	117	18.9	4232	5501
SEm±	5.9	6.0	5.3	0.3	176	213
CD (P= 0.05)	17.6	17.0	15.8	NS	529	637
CV (%)	6.9	6.2	5.9	3.5	7.8	6.9

Table 2. Zinc content (ppm) in rice grain and its uptake as influenced by different zinc treatments.

Treatment	Zinc content (ppm)			Zinc uptake (kg ha^{-1})
	Brown rice	Polished rice	Whole rice	
T_1 :Soil application @ 50 kg $ZnSO_4$ ha^{-1}	31.9	24.6	29.0	0.87
T_2 : T_1 + foliar application @ 0.5% $ZnSO_4$ at maximum tillering (MT) stage	34.0	26.0	31.2	0.91
T_3 :T_1 + foliar application @ 0.5% $ZnSO_4$ at panicle intiation (PI) stage	34.5	26.4	32.6	0.95
T_4 :T_1 + foliar application @ 0.5% $ZnSO_4$ at flowering stage	37.0	27.6	33.2	0.97
T_5 :T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + flowering stages	39.7	29.9	36.1	1.01
T_6 :T_1 + foliar application @ 0.5% $ZnSO_4$ at PI + flowering stages	40.4	30.6	37.2	1.10
T_7 :T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + PI stages	41.3	32.6	37.7	1.18
T_8 : T_1 + foliar application @ 0.5% $ZnSO_4$ at MT + PI + flowering stages	42.7	34.4	40.0	1.34
T_9 : Control (No Zinc)	26.8	14.4	22.8	0.63
SEm±	1.4	1.6	1.4	0.09
CD (P= 0.05)	4.0	4.7	4.1	0.27
CV (%)	6.4	9.8	6.2	10.11

LITERATURE CITED

Das D K, Karak T and Maiti D 2004 Effect of foliar application of different sources of Zn on the changes in Zn content, uptake and yield of rice (*Oryza sativa* L.). *Annals of agricultural Research New Series*, 25(2): 253-256.

Dhaliwal S S, Sadana U S, Khurana M P S, Dhadli H S and Manchanda S 2010 Effect of foliar application of Zn and Fe on rice yield. *Indian Journal of Fertilizers*, 6 (7): 28-35.

Gill M S and Singh V K 2009 Productivity enhancement of cereals through secondary and micronutrients application. *Indian Journal of Fertilizers*, 5 (4): pp.59-66, 69-76, 79-80 &106.

Lindsay W L and Norvell W A 1978 developments of DTPA soil test for zinc, iron, managanese and copper. *Soil Science Society of American Journal,*421-428.

Rajendra Prasad. 2010 Zinc biofortification of food grains in relation to food security and alleviation of zinc malnutrition. *Current Science*, 98(10):1300-1304.

Ram S, Chauhan R P S and Singh B B 1995 Response of rice (*Oryza sativa*) to zinc application in sodic soil of Uttar Pradesh. *Indian Journal of Agricultural Sciences*, 65(7): 525-527.

Sharma S K, Bhunia S R and Pathan A R K 1999 Effect of zinc fertilization on transplanted rice in Ghaggar flood plains of North-West Rajasthan. *Crop Research*, 20(2): 245-247.

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