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Screening of Rice cultivars responding to Zinc fertilization

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A B S T R A C T

Zinc malnutrition affects a large population, particularly women and children fed with cereals having low Zn concentration due to wide spread Zn deficiency in soils. Genetic manipulation and /or agronomic biofortification are the ways to enhance the Zn concentration in grains. (Cakmak, 2008).With this view, an agronomic biofortification strategy was taken to enhance Zn concentration in different in different rice cutivars. A Field experiment was conducted in Inceptisol and Zinc application was made in soil ($20kgha^{-1}$) as well as soil plus two foliar spray (0.5% $ZnSO_4.7H_2O$ solution at pre-flowering and panicle emergence). The treatments were replicated thrice with strip plot design. The results indicated that the grain yield of rice and concentration of zinc in grain were higher at long duration cultivars. Short duration cultivars (115-130 days) could accumulate higher amount of zinc while greater response recorded in cultivars of 130-145 days. The zinc concentration in grain was maximum with two foliar spraying of $ZnSO_4$ along with soil application while grain yield was at par in both soil application and soil plus foliar application.

Keywords: Biofortification, Zinc, Rice, Varieties

A R T I C L E I N F O

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1. Introduction

Micronutrient deficiencies are widespread in developing countries. More than 3 billion people suffer from Fe and Zn nutrition (Graham et.al. 2001). The zinc deficiency in soils of Odisha ranged from 0 to 76 % with state mean of 19 % and crops grown on these soils contain less amount of Zn. About 1 million people of the state are affected from Zn deficiency Agriculture is the primary source of nutrients necessary for a healthy life by improving nutritional quality of food. Cereals mainly rice serve as a staple food for large population of the state. Biofortification is a scientific method to develop plant that have an increased content of bioavailable nutrients in their edible parts.

Plant biofortification appears to be the root-shoot barrier and in cereals- the process of grain filling. Cereals are, however, inherently very low in concentration of Zn and Fe, that are rich in compounds which limit the bioavailability of Zn and Fe to humans (Welch and Graham, 1999). The Zn deficiency problem in cereals grain is aggravated by growing cereal crops on potentially Zn deficient soil. Under Zn deficient soil conditions, plant shows a high susceptibility to environmental stress factors such as drought stress and pathogenic infections, and develop severe symptom such as leaf necrosis and stunted growth. Agronomic biofortification is one of the effective means to enrich seeds with Zn. Zinc content in rice cultivars varied widely owing to their genetic variability (Palmgren et.al.2008) Screening of cultivars containing higher content of Zn with better yield has high priority research to reduce Zn malnutrition in Zn deficient soils.

2. Materials and Methods

A Field experiment was conducted in Inceptisols during 2010 – 11 at Central Research Station Farm, Odisha University of Agriculture and Technology , Bhubaneswar to enhance Zn content in rice grain through agronomic manipulation Twenty cultivars having varied charecteristics particularly variable duration were selected for screening at three Zn levels, i.e. No Zn, Soil application of 20kg Zn ha^{-1} and Soil application of 20 kg Zn ha-1 plus two foliar spray (0.5% ZnSO4.7H2O solution at pre-flowering and panicle initiation stage).The experiment was conducted with standard management practices in strip plot design with three replications. The cultivars used are as follows:

Table 1

Duration(days)	Cultivars
<115	Vanaprava, Suphala, Ghanteswari, Rudra
115-130	IR 64, IR36, Kharbela, Lalata, Birupa
130-145	Swarna, Jajati, Gajapati, Manoswani, Samba masuri, Swarna masuri
>145	Ranidhan,CR1030, Banki, Prachi, Sarada

The soil of the experimental site is sandy loam (Inceptisol) having pH 5.9, and organic carbon 4.1 g/kg. The initial available SO_4-S (0.15 % $CaCl_2$ extractable) status of the soil was 17 ppm and Zn was 0.501 ppm. Rice received uniform dose of 80-40-40 kg/ha of N-P_2O_5-K_2O respectively through D.A.P, urea and M.O.P. The grain and straw samples were harvested, dried and weighed. After proper washing, drying and grinding the samples were then acid digested for the concentration of zinc was measured by using an atomic absorption spectrophotometer Statistical Analysis. The data presented in tables are means with ± standard deviation.

3. Results and Discussion

Effect of Zn fertilization on Grain yield of rice

The rice grain yield varied from 12.0 to 51.67 q/ha (Table 1) depending on crop cultivar, duration and method of Zn application. Highest yield was obtained in the treatment receiving combined application of soil and foliar spray than soil application alone in all the cultivars. Highest grain yield was recorded in cultivars of 130 – 145 days duration cultivars under soil plus foliar spray treatments which was about 24 percent over soil application of Zinc alone. This indicate the effectiveness of Zn by combined application of soil and foliar spray on rice grain yield may be due to varietal variability effect on use efficiency of nutrient.

Table 1: Effect of Soil application and Spray of Zn on grain yield (q/ha) of Rice cultivars

Duration (Days)	Grain Yield(q/ha)		
	Control	Zn Soil Application	Soil + Foliar Spray
<115	12.0-30.33 (19.58)	15.33-34.0 (22.67)	16.0-34.67 (25.42)
115-130	24.33-29.0 (27.27)	26.67-35.67 (29.73)	30.0-44.67 (36.67)
130-145	27.67-35.0 (30.72)	29.83-41.33 (33.64)	35.67-51.67 (41.56)
> 145	22.33-39.33 (30.37)	26-41.0 (33.51)	28.0-47.0 (37.80)
S.D	5.17	5.14	6.95

*Figure in parenthesis indicates mean value

Zinc concentration in Grain and straw

Zinc concentration in rice grain across the treatment and cultivars varied from23.53 mgkg-1 to 38.47 mgkg-1 (Table 2). Zn concentration was found to be directly related to Zn application, highest Zn concentration was noticed in the treatment receiving 20 kg Zn ha-1 as soil application plus two foliar sprays at pre flowering and PI than soil application alone. Highest Zn concentration of 29.13 – 36.80 mgkg-1 was observed in case of long duration cultivars. . Similiarly, Zn concentration in rice straw was varied from 31.1 to 92.3 mgkg-1 irrespective e of duration, treatments and varieties. Highest straw concentration was obtained in the treatment receiving soil application + foliar spray than only soil application of Zinc.

Table 2: Effect of Soil application and Spray of Zn on Zn concentration of Rice cultivars

Duration days	Zn concentration (mgkg-1)					
	Grain			Straw		
	Control	Zn Soil Application	Soil + Foliar Spray	Control	Zn Soil Application	Soil + Foliar Spray
<115	26.83-31.2 (28.91)	27.9-32.27 (30.88)	30.33-33.9 (32.53)	38.5-64.3 (54.88)	60.1-92.33 (66.9)	54.13-84.43 (67.92)
115-130	24.9-31.57 (27.77)	26.0-33.7 (28.66)	27.5-34.17 (30.28)	38.2-59.9 (47.91)	38.7-65.43 (56.76)	34.5-83.9 (57.08)
130-145	23.53-36.33 (27.03)	25.07-30.0 (29.70)	26.7-38.47 (30.09)	36.0-78.27 (52.94)	31.07-77.53 (55.66)	51.77-89.6 (70.49)
> 145	24.97-36.67 (29.35)	27.13-37.67 (31.60)	29.13-36.8 (33.83)	42.53-81.1 (56.61)	40.23-74.53 (53.05)	52.03-65.2 (57.73)
S.D.		1.26	1.81		6.07	6.89

*Figure in parenthesis indicates mean value

Zinc use efficiency (ZnUE), Response and apparent Zn recovery (AZnR)

It was observed that from table 3 that the zinc use efficiency (ZnUE) was higher at soil and foliar spray than soil application of Zn and it was at 130- 145 days duration cultivars (Fig. 1.). However, Zn uptake as well as Zn recovery (AZnR) was maximum at sprays than soil application at 115- 130 days duration rice crop indicating the cultivars could accumulate a higher amount of zinc than others (Fig.2).

Table 3: Effect of Soil application and Foliar Spray of Zn on Response, ZnUE, Zn Recovery

Duration	Soil Application(Days)				Soil+ Foliar Spray(Days)			
	<115	115-130	130-145	>145	<115	115-130	130-145	>145
Response	2.47	2.47	2.92	3.08	7.73	9.40	10.83	5.84
ZnUE	0.15	0.12	0.15	0.17	0.27	0.43	0.49	0.35
Zn Recovery	10.7	4.77	7.27	8.75	11.81	30.26	18.58	17.60

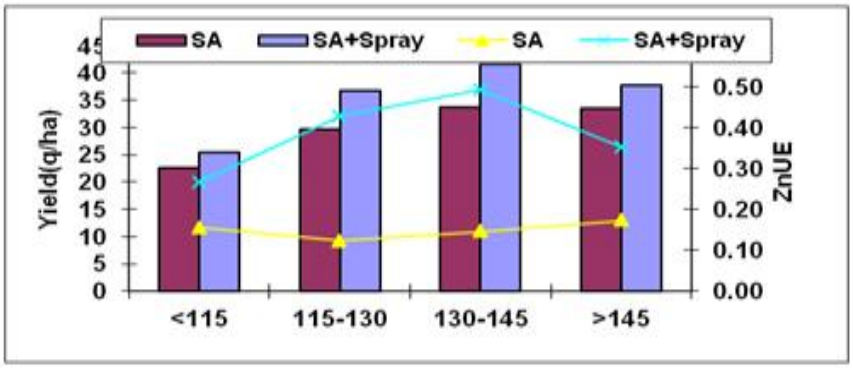

Figure 1: Yield and zinc use efficiency of different rice cultivars

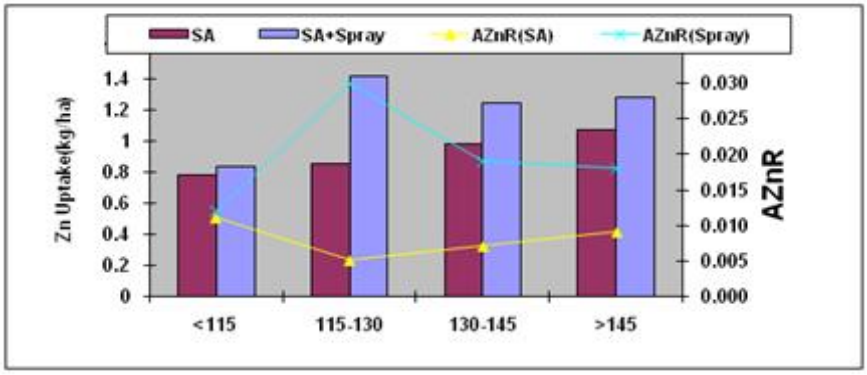

Figure 2: Uptake and recovery of zinc of different rice cultivars

Discussion

Zinc concentration in Grain

The increase in zinc content of long duration cultivars may be due to genotypic variation in grain concentration of micronutrient within plant genome (Peterson et.al. 1986). Similar observations was made under Zn deficient soil conditions, higher concentration of Zn in grain could be obtained by a combined application of soil and foliar application of Zn (Yilmaz et. Al. 1997, jena et.al. 2011).

Zinc use efficiency (ZnUE), Response and Zn recovery (AZnR):

Cultivars in turn resulted maximum yield response may be due to genetical variability of the cultivars and adaptive mechanisms to tolerate zn deficiency stress and are highly efficient due to their fine root length and release of zinc chelating phytosiderophores and more efficient utilization of zn within cell, tissues and organs (Rengel et. al.1998).

4. Conclusion

From this study it may concluded that cultivars of 115-130 days duration could accumulate higher amount of zinc while the response was more in 130-145 days duration cultivars. The zinc concentration in grain was maximum by combined application of soil and two foliar spray of Zn than soil application.

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