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## Screening of rice genotypes to zinc stress alluvial soils of Odisha

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### Abstract

Zinc deficiency to crop yield results in low concentration of zinc in grain for which malnutrition of human being occurs and it is major nutritional problem in rice consuming countries. Growing zinc efficient cultivars represent long term solution for sustainable approach to crop production. Twenty diverse rice genotypes were tested in a field experiment of alluvial soils of Odisha, at three levels of Zn (0, 20 kg ha<sup>-1</sup> and 20 kg ha<sup>-1</sup> + 0.5% ZnSO<sub>4</sub> sprayed twice at pre-flowering and booting stage) with the objective of developing a screening technique to evaluate the rice genotypes for zinc use efficiency. Genotypes differed significantly in grain yield. Grain yield efficiency Index is the best tools to categorize the genotypes into efficient and non-efficient groups. The relative grain yield i.e. Zn efficiency index from 98.0 to 54.0 percent and relative grain Zn uptake i.e. Zn efficiency from 77.0 to 34.0% were found among the genotypes. On the basis of grain yield and Zn efficiency, genotypes are classified on efficient and responsive (Daya, Gajapati, Udaya, Pusa 44, Kharbela, IR64, 1009, IR36 and Surendra), efficient and non-responsive (Jajati, MTU1010 and Monoswani), Inefficient and responsive (Lalata and Pratiskha), Inefficient and non-responsive (Satabdi, Tapaswani, Sebati, samba masuri, Jaiphula and Leelabati). From practical point of view, genotypes that produce high grain yield at low level of Zn and responsive well to Zn addition are most desirable because they able to express their high potential in a wide range of Zn availability.

**Keywords:** Zinc, rice, genotypes, grain yield, efficiency

### Introduction

Zinc deficiency in crops has been recognized as world wise nutritional constraint in food production. Short supply of zinc to the crop, yield often reduce (Gao *et al.* 2006) <sup>[3]</sup> and Zn mass concentration in the grains are often low (Jiang *et al.* 2007) <sup>[7]</sup> which resulted Zn malnutrition of human beings who depend on rice based diet. Rice is the main diet source for 3% of human population in world (Liang *et al.* 2007) <sup>[9]</sup>. Zinc deficiency in soils of Odisha ranges from 0 to 76 percent with a mean of 19 percent (Jena *et al.* 2008) <sup>[5]</sup>. Under submerged condition of rice cultivation, zinc (either native or applied) is changed into amorphous sesquioxide precipitates or franklinite, ZnFe<sub>2</sub>O<sub>4</sub> (Sajwan and Lindsay, 1988) <sup>[13]</sup>. Crop products constitute the primary source of all the micronutrients for humans especially in developing countries. High consumption of cereals based food with low levels of available micronutrient may cause malnutrition in humans (San, 2006) <sup>[12]</sup>. However, the Zn concentration in cereals may be enhanced by applying Zn fertilizer directly to the soil or plant (Broadley *et al.*, 2007) <sup>[1]</sup>. Zinc deficiency in the field crops is emerging nutritional problem and effect crop growth as well as yield. Therefore, an attempt were made to screen out the rice genotypes on zinc efficient and non efficient basis, and develop an alternative technology for improving sustainable solution to the problem.

### Materials and Method

A field experiment was conducted during kharif at Research Farm, Ranital, OUAT, Balasore, Odisha. The soil of the experimental field was loamy alluvial soils having pH 7.53, organic carbon 7.3 g kg<sup>-1</sup> soil and DTPA<sup>1</sup> extractable Zn was 0.58 mg kg<sup>-1</sup> and Boron was 0.76 mg kg<sup>-1</sup>. The experiment was conducted in a strip plot design with three replications. Twenty diverse rice genotypes of 21 days old seedling was transplanted. Rice received uniform dose of

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<sup>1</sup> Di-ethylenetriamine pentaacetic acid

N- P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O respectively through DAP<sup>2</sup>, Urea and MOP<sup>3</sup>. The treatment consist of three levels of Zn viz. T<sub>0</sub>-low (no fertilizer Zn), T<sub>1</sub>-20kg Zn and T<sub>2</sub>-20kg Zn ha<sup>-1</sup> + two sprays of 0.5% ZnSO<sub>4</sub> at pre-flowering and booting stage. Crop was harvested at maturity and grain yield was recorded. Zn content in grains were determined by drying the grain in an oven at 70 °C, then grind. Ground material was digested with diacid 2:1 mixture of nitric acid and perchloric acid for chemical analysis. Zinc content in grain was analyzed by Atomic absorption spectrophotometer (Lindsay and Norvel, 1978) [10] and the following parameter was calculated (Graham, 1984) [4].

Zinc efficiency index = (Grain yield at control Zn / Grain yield at Zn treatment) x 100

Zinc efficiency = (Grain Zn uptake at control / Grain Zn uptake at Zn treatment) x 100

## Result and Discussion

The grain yield of rice genotypes (Table-1) varied widely from 12 qha<sup>-1</sup> for genotype Leelabati to 38.7 qha-1 for Jajati with an average of 26.4 qha-1(T<sub>0</sub>). The grain yield varied from 22.9 qha-1 to 41.7 qha-1 with an average of 33.2 qha-1 at the application of Zn @ 20kg/ha-1 with two spray of ZnSO<sub>4</sub> @ 0.5% (T<sub>2</sub>). The genotype Jajati produced higher mean grain yield of 40.2qha-1. On an average, Zn application increased grain yield at high Zn application along with two spray of ZnSO<sub>4</sub> might be due to partitioning of nutrients and photosynthetic between vegetative and reproductive parts in efficient genotypes. The different response of rice plants grown under Zn deficiency might be due to genotypic variation in some of the zinc affected processes as reported by Jiang (2008) [6] in aerobic rice, Similar findings made by Kumar *et al.* (2018) [8] and Pal *et al.* (2020) [11] on rice under Zn stress condition. Different genotypes varied widely in their zinc content as well as response to zinc application (Table-2). The data revealed that a mean increase of Zn content in rice grain 35.9 percent over no Zn application in rice grain of twenty diverse genotypes. Highest Zn content in grain was recorded in udaya followed by Jajati while a lowest Zn content was noted in IR 64. The data showed that the application of higher dose of Zn increased Zn concentration as well as uptake by rice grain compared to control (no Zn application).

The pertaining to grain yield, Zn content and uptake at control, 20kg Zn and 20kg Zn ha<sup>-1</sup> + two sprays of 0.5% ZnSO<sub>4</sub> did not give a clear view of Zn efficiency of the genotypes. The desired genotypes should have higher grain yield and Zn uptake to applied Zn, keeping this in view Zn efficiency index and Zn efficiency were calculated (Table-3). Zn efficiency index varied from 54.0 to 98.0% with eight genotypes having Zn efficiency index >90%. Zn efficiency also varied widely among genotypes ranging from 34.0 to 77.0%. Thus genotypes with high Zn efficiency are desired as they will be efficient scavengers of Zn under low Zn supply.

To screen Zn efficient genotypes, the genotypes were classified into four groups. Fageria and Baliger (1993) [2] suggested this type of classification for the nutrient use efficiency of crop genotypes using nutrient efficiency and average yield of genotypes at low Zn supply. The first group comprise of the efficient and responsive genotypes that produced more than average yield of 20 genotypes under Zn

deficiency and their Zn efficiency was also higher than average Zn efficiency. Genotypes like Daya, Gajapati, Udaya, Pusa 44, Kharbela, IR64, 1009, IR36 and Surendra fall in this group. The second group of efficient and non-responsive genotypes produced more than average yield of 20 genotypes at low Zn level, but response to Zn application was lower than the average. These genotypes included Jajati, MTU1010 and Monoswani. The third group is inefficient and responsive genotypes produced less than average grain yield, but their response to Zn application was above the average. The genotypes that fall into this groups were Lalata and Pratiksha. The fourth group of genotypes produced less than average yield at low Zn level and less than average response to applied zinc. These genotypes were classified as inefficient and non-responsive. The genotypes fall into this groups were Satabdi, Tapaswani, Sebati, samba masuri, Jaiphula and Leelabati.

**Table 1:** Effect of zinc application on grain yield (q/ha) of diverse rice genotypes

Rice Variety	Grain Yield(q/ha)			
	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	Mean
Daya	27.2	27.6	31.0	28.6
Gajapati	28.7	30.2	33.5	30.8
Jajati	38.7	40.1	41.7	40.2
Udaya	33.0	33.4	33.8	33.4
Pusa 44	37.0	38.7	41.6	39.1
Kharbela	30.0	33.0	33.0	32.0
IR 64	31.5	35.8	37.3	34.9
1009	33.0	34.4	35.8	34.4
IR 36	31.5	34.4	35.8	33.9
Surendra	23.6	27.2	27.5	26.1
Lalata	27.2	33.0	33.0	31.1
Monoswani	31.5	35.0	40.2	35.6
Satabdi	28.5	32.9	38.5	33.3
Tapaswani	15.2	25.2	31.5	24.0
Pratiksha	21.0	22.9	28.5	24.1
Sebati	22.0	26.1	31.5	26.5
MTU1010	25.0	27.2	33.0	28.4
Sambamasuri	16.1	27.2	27.2	23.5
Jaiphula	15.6	16.4	27.2	19.7
Leelabati	11.5	18.6	22.9	17.7
Mean	26.4	29.9	33.5	
CD(p=0.05)	Zn-1.56;V-2.95;Zn xV-5.1			

**Table 2:** Effect of zinc application on grain Zinc concentration (mgkg-1) and uptake (gha-1) on rice genotypes

Rice variety	Concentration(mgkg-1) uptake (gha-1)			
	T <sub>0</sub>	T <sub>2</sub>	T <sub>0</sub>	T <sub>2</sub>
Daya	20.53	24.33	55.43	75.42
Gajapati	19.53	26.80	56.64	91.12
Jajati	19.00	32.17	74.10	135.11
Udaya	25.33	34.37	83.59	116.86
Pusa 44	20.70	26.03	76.59	109.33
Kharbela	18.97	22.37	56.91	73.82
IR 64	16.53	20.40	52.89	75.48
1009	17.60	27.23	58.08	98.03
IR 36	18.00	21.87	57.60	78.73
Surendra	20.03	24.37	48.07	68.24
Lalata	15.60	25.50	42.12	84.15
Monoswani	18.20	27.80	58.24	111.20
Satabdi	15.33	21.07	44.46	82.17
Tapaswani	18.20	25.57	27.30	81.82
Pratiksha	18.23	23.10	38.28	66.99
Sebati	15.33	21.07	33.73	67.42
MTU1010	18.20	27.30	45.50	90.09
Sambamasuri	18.63	26.13	29.81	70.55
Jaiphula	19.50	24.90	31.20	67.23
Leelabati	22.40	28.63	26.88	65.85
Mean	18.79	25.55	49.57	85.10

<sup>2</sup> Diammonium phosphate

<sup>3</sup> Muriate of Potash

**Table 3:** Mean Zinc index efficiency and Zinc efficiency (%) of rice genotype

Rice variety	Zinc efficiency Index (%)	Zinc efficiency (%)
Daya	93.0	74.0
Gajapati	90.0	62.0
Jajati	95.0	55.0
Udaya	98.0	72.0
Pusa 44	92.0	70.0
Kharbela	91.0	77.0
IR 64	86.0	68.0
1009	94.0	60.0
IR 36	90.0	72.0
Surendra	86.0	71.0
Lalata	82.0	50.0
Monoswani	84.0	51.0
Satabdi	80.0	54.0
Tapaswani	54.0	34.0
Pratiskha	83.0	58.0
Sebati	77.0	51.0
MTU1010	84.0	51.0
Sambamasuri	59.0	42.0
Jaiphula	76.0	45.0
Leelabati	56.0	39.0
Mean	82.5	57.8

### Conclusion

From practical point of view, the efficient and responsive group of genotypes that produce high grain yield at low level of Zn and responsive well to Zn addition are most desirable because they able to express their high potential in a wide range of Zn availability. The second most desirable group is efficient and non-responsive that can be planted under low Zn level and procured more than average yield. The inefficient and responsive genotypes can used in breeding programme for their Zn responsive characteristics. The most undesirable genotypes are the inefficient and non-responsive.

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