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Effect of different levels of zinc on growth and uptake ability in rice zinc contrast lines (*Oryza Sativa* L.)

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ABSTRACT

Rice (Oryza sativa) is the worlds' most important cereal and potentially an important source of zinc (Zn) for people who eat mainly rice. Zinc deficiency being a major constraint to reduce the potential yield of rice. To improve Zn delivery by rice, plant Zn uptake and internal allocation need to be better investigated. Field experiments were carried out to find out the effect of three different levels of zinc on rice zinc contrasting lines, high zinc groups and low zinc groups. The experiments revealed that increased Zn supply induced increased plant Zn uptake rate throughout the crop development in both high zinc groups and low zinc groups. The highest effect was observed when treated with 30kg $ZnSO_4$ /ha irrespective of zinc groups. However, high zinc groups showed better uptake ability in zinc content and overall performance in growth characteristics. This studies could help in identifying for genotypes with high zinc uptake ability in zinc content for further breeding programs.

Key words: Zinc uptake, zinc contrasting lines, Zinc allocation, *Oryza sativa* L.

INTRODUCTION

Zinc (Zn) deficiencies constitute a major public health problem in many countries, especially in regions where people rely on monotonous diets of cereal-based food [1,2], as the Zinc level or content (mg Zn kg/dry matter) in the grains of staple crops, such as cereals and legumes, is generally low. Increasing the Zn content in the grains of these crops is considered a sustainable way to alleviate human Zn deficiency [3, 2, 4, 5, 6, 7].

Zinc deficiency has been reported in various parts of the world [8]. About 30% of the world's soils are also Zn deficient [9]. It is particularly acute in puddled soils. In the Indian context, more than 50 per cent of the agricultural soils are Zn deficient. Zinc deficiency being an important nutrient constraint, any approach to improve Zn uptake and its transport to grains has significant practical relevance. Plant breeding strategy appears to be the most sustainable and cost effective approach useful in improving Zn status of plants and also its concentrations in grains.

However, for improving Zn acquisition, one of the primary prerequisites is significant genetic variability in this trait. Such genotypic variations can be exploited in breeding programs to produce genotypes with higher zinc efficiency. This research work was to assess the effect of different levels of zinc on growth and zinc uptake ability in some selected rice zinc contrasting lines.

MATERIALS AND METHODS

Field experiment was conducted to study the effect in differences in uptake ability of zinc in some rice varieties. The experiment was carried out at the Department of Crop Physiology Research Station, University of Agricultural Sciences, Bangalore. The soil of the experimental field was red sandy loam in texture and belongs to taxonomical order of Kandic paleustalfs.. The soil physio-chemical properties of the experimental site were studied from soil samples collected at 20 cm – 30 cm depth randomly from the experimental plots. And this was analyzed by DTPA methods[10]. The results of some selected soil physio-chemical properties are presented in Table 1.

Table1. Selected Physio-chemical of the soil on the experimental site

Characteristics	Values range
pH	5.5 - 5.96
EC (ds/m)	0.08 - 0.12
Organic carbon (%)	0.21 - 0.46
CEC (c.mol(P^+)/kg)	12.20 -3.63
DTPA-extractable Zinc (mg/kg)	1.37 -2.34
DTPA extractable Iron (mg/kg)	6.38 - 13.21

Three high zinc groups and three low zinc types rice genotypes were sown in the field at the rate 20kg/ha and transplanting of seedling (3-4 seedlings/ hill) were done 25 days after sowing, with a spacing of 30 cm x 15 cm. Seeds were sown in field in a randomized complete block design (RCBD) with three treatments (zero $ZnSO_4$, 20kg/ha $ZnSO_4$, 30kg/ha $ZnSO_4$) and three replications. Required agronomic management practices were followed as per recommended package. Zinc was estimated in the grains, stem and leaf samples using Inductively Coupled Plasma – Optical Emission Spectrometry (ICP – OES).

The experiments were conducted under irrigated shallow low / medium land situation, medium in fertility with good drainage facility

The results of the experiment were statistically evaluated in the form of Analysis of Variance (ANOVA), and Duncan's New Multiple Range Test (DMRT) was used for mean separation.

RESULTS AND DISCUSSION

Effects of different levels of zinc on some growth characteristics.

Plant height, Number of effective tiller, and SPAD values

Besides Zn as nutrient, genotypes with high seed Zn has phenomenal relevance in human nutrition. The average plant height, number of effective tiller, straw dry weight, leaf dry weight and SPAD, as affected by different levels of Zinc are presented in Table 2. The results are significant at 5% level

In case of plant height, our data showed that the plant height significantly increased at 20kg $ZnSO_4$ /ha and 30kg $ZnSO_4$ /ha across genotypes under study in both groups (high and low zinc). From our data however, the highest plant height was at 30kg $ZnSO_4$ /ha in IR73898 and Thanu for high and low zinc groups respectively.

Number of effective tillers data indicated that there is very little difference between zero zinc and 20kg $ZnSO_4$ /ha but at 30kg $ZnSO_4$ /ha, BPT5204 and IR73898 differ significantly from the zero zinc and the number of effective tillers was the lowest at zero zinc for high zinc groups. A similar scenario was also indicated for the low zinc groups with Thanu and IET17913 differ significantly from zero zinc treatment.

Application of Zn resulted in relatively large and a significant increase in the uptake of Zn from the soil irrespective of soil pH, was also investigated by [11]. Similar results were also reported by [12, 13]. Application of Zn was found to have significant positive influence on growth of rice compared to zero zinc control (Table 2). The yield increase as a result of Zn fertilization was also reported by many authors([11,13]

Table 2. Effect of different levels treatment of Zn on some growth characteristics.

Treatments	Zinc groups	Plant height (cm)			No of effective tiller			SPAD		
		IR20	**BPT5204**	**IR73898**	**IR20**	**BPT5204**	**IR73898**	**IR20**	**BPT5204**	**IR73898**
zero zinc	High Zn groups	104.33c	85.67c	111.33c	14.67a	16.67b	15.00b	45.21b	50.99a	48.68b
20kg ZnSO4/ha		115.00b	121.33b	127.67b	18.00a	22.00a	19.00b	53.08a	52.88a	52.26ab
30kg ZnSO4/ha		125.00a	129.00a	145.00a	19.33a	25.67a	28.00a	57.81a	54.47a	54.92a
		Thanu	**IET17913**	**IR59656**	**Thanu**	**IET17913**	**IR59656**	**Thanu**	**IET17913**	**IR59656**
zero zinc	Low Zn groups	93.00c	68.00c	114.33c	15.67b	11.67b	14.00a	45.2b	40.12c	45.60a
20kg ZnSO4/ha		122.00b	78.00b	120.67b	18.33ab	15.00ab	15.33a	54.71a	54.75a	48.80a
30kg ZnSO4/ha		138.00a	125.50a	133.00a	23.00a	20.00a	19.67a	48.99b	47.20b	45.09a

The means followed by the same letters in a column are not statistically different at 5% level of significance

The data for SPAD chlorophyll reading for the high zinc groups showed that the chlorophyll level was higher and significantly increased at 20kg $ZnSO_4$ /ha and 30kg $ZnSO_4$ /ha compared with the zero zinc, which is having the lower chlorophyll content. In the case of the low zinc groups, the data also showed a significant difference between the zero zinc and 20kg $ZnSO_4$ /ha and 30kg $ZnSO_4$ /ha but 20kg $ZnSO_4$ /ha treatment resulted with chlorophyll content for the low zinc groups genotypes.

Grewal *et al.* [14] reported that the application of zinc increased the chlorophyll content i.e., chlorophyll a, b as compared to control. The high zinc types with the application of zinc maintained higher chlorophyll content and higher seed zinc in the present investigation. Zinc application in general increased chlorophyll content in pigeon pea, particularly in high zinc types. However, the seed zinc content differed between the genotypes of high type groups.

Effects of different levels of zinc on dry matter production.

Straw and leaf dry matter

The average straw and leaf dry matter production of rice as affected by different levels of Zn are represented in Table 3. The dry matter productions obtained with different treatments of Zn were significant at 5% level for straw and leaf in the both zinc groups in all rice genotypes. The data indicated that there is no significant difference between zero zinc and 30kg $ZnSO_4$ /ha in both straw and leaf dry matter for the two zinc groups classification. The dry matter production was highest at 30kg $ZnSO_4$ /ha.

Kumar *et al.*[15] reported that application of 10 µg Zn/g soil along with 200 µg N/g soil increased the dry matter yield of pearl millet. They further reported that application of heavy doses of Zn (20 µg Zn/g soil) might decrease the N concentration which in addition deteriorate the yield and quality of grains and fodder in pearl millet. Similar increases due to Zn application in dry matter and grain yields in different crops have also been reported by [15]. Similar study was also reported by [16] on genetic variation in zinc acquisition and transport in diverse rice germplasm lines.

Table 3. Effect of different levels treatment of zinc on dry matter production

Treatments	Zinc groups	Straw dry weight (g)			leaf dry weight (g)		
		IR20	**BPT5204**	**IR73898**	**IR20**	**BPT5204**	**IR73898**
zero zinc	High Zn groups	22.35b	24.95b	17.20b	13.25b	11.63c	11.85b
20kg ZnSO4/ha		36.67a	31.00a	19.85b	21.15a	17.95b	16.97b
30kg ZnSO4/ha		41.00a	34.70a	55.40a	22.4a	28.43a	35.77a
		Thanu	**IET17913**	**IR59656**	**Thanu**	**IET17913**	**IR59656**
zero zinc	Low Zn groups	21.83c	17.67c	16.83c	13.12b	3.28c	9.47b
20kg ZnSO4/ha		29.00b	20.35b	26.50b	14.73b	9.93b	11.33ab
30kg ZnSO4/ha		41.25a	30.95a	33.53a	35.33a	16.17a	13.33a

The means followed by the same letters in a column are not statistically different at 5% level of significance

Effect of different levels of Zinc treatments on Zn uptake ability in two contrasting genotypes.

Straw, leaf and seed zinc content (mg/100g)

Straw, leaf and seed samples were analyzed for zinc content at maturity using ICP-OES and the results indicated that high zinc groups accumulated more zinc content in leaf and seed (Fig. 1). There was a significant difference in straw zinc content of the both contrasting groups, with a higher zinc content in 30kg $ZnSO_4$ /ha treatment compared to zero zinc. In case of leaf zinc content, both 20kg $ZnSO_4$ /ha and 30kg $ZnSO_4$ /ha showed a significant increase in leaf zinc content of the both contrast groups compared to zero zinc. Also seed zinc content showed a higher response in zinc content when treated with 20kg $ZnSO_4$ /ha and 30kg $ZnSO_4$ /ha in both contrasting groups. Nevertheless, 30kg $ZnSO_4$ /ha treatment showed a slight increase in zinc content when compared with 20kg $ZnSO_4$ /ha among the treated genotypes.

Carmak [8] also reported that depending on plant species, soil application of zinc can increase zinc concentration in plants by as much as 2 to 3 folds. Zinc in seeds of high zinc types increased nearly by 1 to 2 folds and in low type by 1.16 folds. Thus, agronomic practice of external zinc application had a positive effect of increasing zinc content in straw, leaf and seed of rice contrasting genotypes investigated. Therefore, identification of genotypes with high zinc uptake efficiency and zinc content is crucial in breeding program for high zinc content rice genotypes.

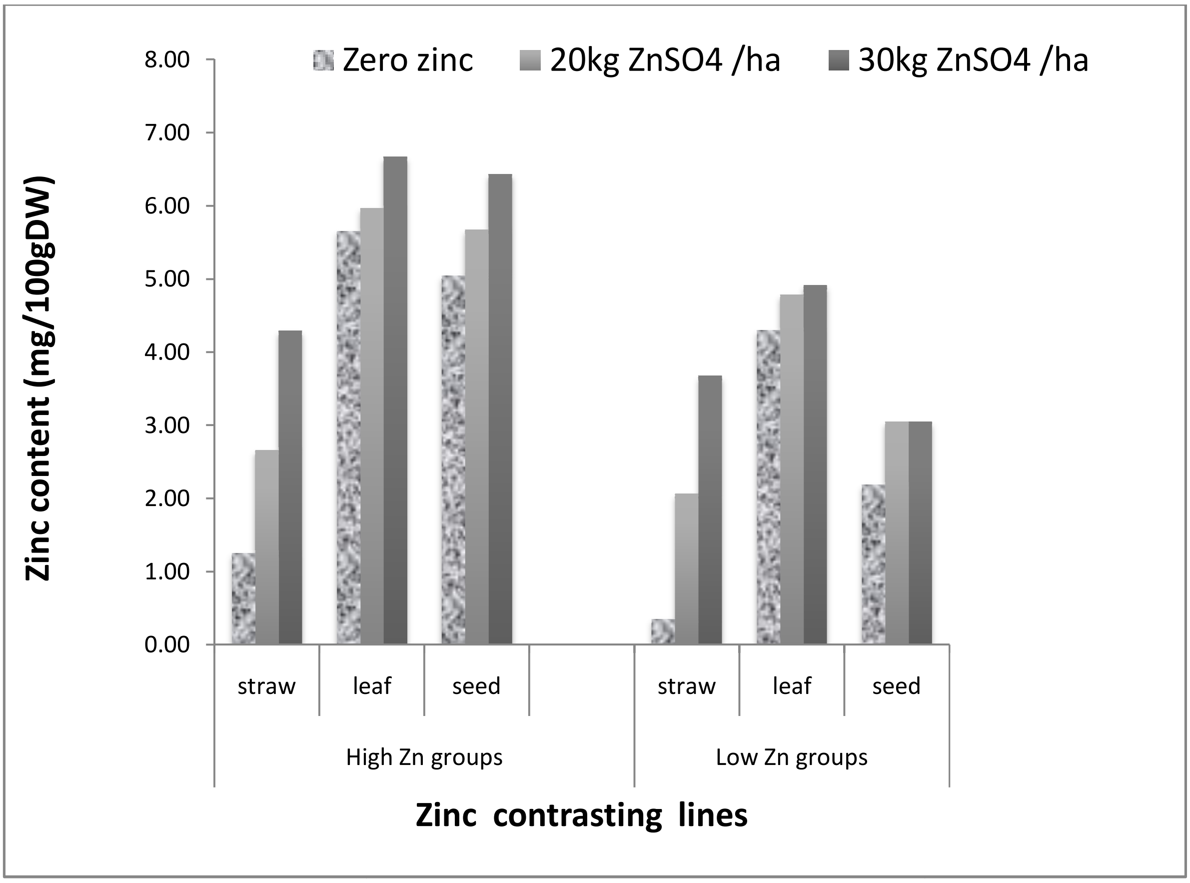

Fig. 1 Effect of different levels of Zinc treatments on rice straw, leaf and stem zinc contents.

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