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# Effect of zinc fertilization on growth, yield and quality of high zinc rice (*Oryza sativa* L.) varieties under alternate wetting and drying condition

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**Abstract**
A field experiment was conducted during *summer* season of 2015 at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). Three high zinc rice varieties and MTU-1010 were fertilized with zinc through different method of application. Variety R-56 and MTU-1010 recorded maximum growth and yield attributes as compared to other varieties. Application of 25 kg $ZnSO_4$ $ha^{-1}$ and foliar spray of 0.2% Zn through $ZnSO_4$ at panicle initiation and flowering stage recorded maximum growth and yield attributes as compared to other zinc fertilization

**Keywords:** Growth, High zinc rice varieties, quality, yield.

## Introduction
Rice is the most important cereal crop in Asia. India is the second largest producer and consumer of rice in the world. Area under rice crop in India is about 43.95 million hectare with production of 103.61 million tonnes and productivity of 2492 kg per hectare during 2015-16 (Anonymous, 2015) [1]. Chhattisgarh is known as "Rice bowl of India" where the total rice grown area is 3.71 million hectares with production of 7.71 million tonnes and productivity of 2050 kg per hectares (Anonymous, 2016) [2]. Zinc deficiency is a well documented problem in food crops, causing decreased crop yields and nutritional quality. In developing countries zinc, iron and vitamin A deficiencies were reported in human population. Increasing the grain Zn concentration in rice may be a sustainable way to alleviate human Zn deficiency in monotonous diet area of India as well as Chhattisgarh. The poor tribals, who cannot afford for different known sources of zinc, the high zinc rice varieties may benefit their health without any additional cost (Black *et al*., 2008) [3]. Despite the importance of high Zn content rice genotypes as constraints, little efforts have been devoted to developing high Zn content rice genotypes through breeding or by fortification as applied Zn fertilizers through basal or foliar application.

## Materials and Methods
Zinc is an essential micronutrient for the normal growth, development and health of plants and human beings. Currently, large areas of agricultural land are now known to be zinc deficient, causing severe reductions in crop productivity and nutritional quality of the food crops. Still in many countries, zinc deficiency is unrecognized or underestimated and untreated. There is, therefore, an urgent need to understand and address zinc deficiency in these countries in order to contribute to both crop production and human health. Zinc is also particularly important for better tolerance of crop plants under various stress factors such as drought, heat and salinity. Applying zinc fertilizers to soil and or into plant leaves offers a simple and highly effective solution to zinc deficiency problems in crop plants and to increasing zinc concentrations of foods. This strategy greatly prevents unnecessary loss of food production and helps to improve in public health. For example, enrichment of rice and wheat grain with zinc may save the lives of up to 48,000 children in India annually (Stein *et al*, 2007) [7]. Considering the importance of micronutrient based malnutrition as major public health, the future demand of high grain Zn rice varieties, may provide the alternative to combat malnutrition. Based on the above facts, three high zinc rice varieties and one most popular variety MTU-1010 were fertilized with zinc through different methods of application under study.

The treatment comprised of four varieties *viz.* MTU-1010, RHZ-2, RHZ-7 and R-56 in main plots and three zinc fertilization *Viz.* Control (no Zn), soil application of 25 kg $ZnSO_4$ ha $^{-1}$ and foliar sprays of 0.2% Zn through $ZnSO_4$ at panicle initiation and flowering stage in sub plots in split plot design replicated thrice. Single rice seedling was transplanted at 20 x 10 cm spacing and fertilized with 120: 60: 40 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ respectively through urea, single super phosphate and muriate of potash. Total concentration of zinc and iron was analyzed by atomic absorption spectroscopy.

**Results and Discussion**

Significant variation was found in plant height, number of effective tillers $plant^{-1}$, filled grains $panicle^{-1}$, grain and straw yield and test weight due to different varieties and zinc fertilization (Table 1). Results revealed maximum plant height, effective tillers $plant^{-1}$, number of filled grains $panicle^{-1}$, test weight, grain and straw yields were recorded with variety R-56 followed by variety MTU-1010 except with respect to number of filled grains $panicle^{-1}$. The minimum growth, yield attributes and yield were recorded with variety RHZ-7.

These results might be due to their genetic behaviour and different growth habits of rice varieties.

In case of zinc fertilization, the plants fertilized with soil application of 25 kg $ZnSO_4$ $ha^{-1}$ recorded maximum all above growth, mentioned yield attributes and yields followed by foliar spray of 0.2% $ZnSO_4$ at panicle initiation and flowering stage. The minimum growth, yield attributes and grain and straw yields were recorded under no zinc fertilization treatment. These results might be due to the adequate supply of soil application of 25 kg $ZnSO_4$ $ha^{-1}$ which contributed to accelerate the enzymatic activity and auxin metabolism in plants, grrater availability of nutrients of plants, more photosynthesis and transport of photosynthates from some to sink. These results are in consonance with the findings of Khan *et al.* (2007) [6] and Ghani *et al.* (1990) [5].

The high zinc rice varieties different significantly in almost all quality parameters except alkali value and head rice recovery per cent (Table 2). Maximum grain length and kernel expansion were recorded with variety R-56 followed by variety MTU-1010. Whereas, minimum grain length and kernel expansion was recorded with variety RHZ-7. The maximum grain breadth was recorded with variety MTU-1010 followed by variety R-56 whereas, the maximum grain L/B ratio was observed with variety R-56 which was statistically at par with variety RHZ-7. The maximum Fe and Zn content in grain were recorded with variety RHZ-7 followed by variety R-56 and RHZ-2. The minimum grain Fe and Zn was recorded with variety MTU-1010.

In case of zinc fertilization, all the quality parameters did not show significant variation due to different method of zinc fertilization except Fe and Zn content in grain. Significantly highest Fe and Zn content in rice grain was recorded with foliar spray of 0.2% $ZnSO_4$ at PI & FL stage and the minimum Fe and Zn content were recorded under control.

These results might be due to the impact of foliar zinc fertilization on bio fortification of zinc in rice grain, since it has the advantages of low application rates and avoiding zinc losses through soil fixation. Furthermore, foliar applied Zn caused greater increases in brown rice Zn concentration than soil application. There is evidence in literature demonstrating that foliar applied Zn can be absorbed by leaf epidermis, and remobilized and transferred into the rice grains through the phloem and several members of the Zn-regulated transporters regulate this process. Similar results have been reported by Chaab *et al.* (2011) [4].

This study can be concluded that among high zinc rice varieties, variety R-56 recorded maximum growth, yield attributes and grain and straw yields followed by variety MTU-1010. Soil application of 25 kg $ZnSO_4$ $ha^{-1}$ recorded the maximum growth, yield attributes and grain and straw yields followed by foliar spray of 0.2% $ZnSO_4$ at panicle initiation and flowering stage. Almost all quality parameters were maximum with variety R-56 and soil application of 25 kg $ZnSO_4$ $ha^{-1}$. Highest Fe and Zn content in grain was recorded with variety RHZ-7 and foliar spray of 0.2% $ZnSO_4$.

**Table 1:** Effect of zinc application on growth, yield attributes and yield of high zinc rice varieties

| Treatments | Plant height (cm) | Effective tillers $plant^{-1}$ | Filled grains $panicle^{-1}$ | Grain yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) | Test weight (g) |
|---|---|---|---|---|---|---|
| **Varieties** | | | | | | |
| MTU-1010 | 72.73 | 11.0 | 147 | 50.02 | 54.11 | 23.5 |
| RHZ-2 | 71.98 | 9.8 | 113 | 47.50 | 52.85 | 22.8 |
| RHZ-7 | 69.50 | 9.7 | 153 | 40.01 | 47.22 | 16.3 |
| R-56 | 74.20 | 11.6 | 151 | 53.84 | 58.38 | 24.2 |
| **SEm±** | 0.10 | 0.16 | 1.28 | 1.42 | 2.05 | 0.23 |
| CD ( P=0.05) | 0.35 | 0.57 | 4.44 | 4.50 | 6.47 | 0.80 |
| Zn fertilization | | | | | | |
| Control (no Zn) | 72.79 | 9.2 | 145 | 45.30 | 48.35 | 21.2 |
| 25 kg $ZnSO_4$ $ha^{-1}$ (Soil application) | 74.09 | 11.4 | 160 | 50.05 | 57.50 | 22.4 |
| Foliar spray of 0.2% $ZnSO_4$ at PI&FL | 73.18 | 10.9 | 153 | 48.18 | 53.57 | 21.5 |
| SEm± | 0.14 | 0.15 | 0.75 | 1.42 | 2.04 | 0.17 |
| CD (P = 0.05) | 0.42 | 0.45 | 2.25 | 4.50 | 6.42 | 0.52 |

PI & FL- Panicle initiation and flowering stage

**Table 2:** Effect of zinc fertilization on quality parameters of high zinc rice varieties

| Treatments | Grain length (mm) | Grain Breadth (mm) | Grain L/B ratio | Kernel expansion | Alkali value | Grain Fe (ppm) | Grain Zn (ppm) | Head rice recovery (%) |
|---|---|---|---|---|---|---|---|---|
| Varieties | | | | | | | | |
| MTU-1010 | 9.14 | 2.73 | 3.34 | 2.01 | 2.31 | 9.60 | 19.07 | 50.21 |
| RHZ-2 | 8.37 | 2.44 | 3.43 | 1.93 | 2.46 | 9.37 | 22.90 | 54.51 |
| RHZ-7 | 8.24 | 2.27 | 3.62 | 1.70 | 2.06 | 17.95 | 23.87 | 55.42 |
| R-56 | 9.24 | 2.48 | 3.72 | 2.23 | 2.30 | 12.55 | 22.29 | 54.19 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SEm± | 0.03 | 0.05 | 0.06 | 0.04 | 0.09 | 0.04 | 0.72 | 2.96 |
| CD ( P=0.05) | 0.12 | 0.17 | 0.24 | 0.15 | NS | 0.14 | 2.50 | NS |
| Zn fertilization | | | | | | | | |
| Control (no Zn) | 8.72 | 2.39 | 3.39 | 1.93 | 2.22 | 11.23 | 18.93 | 49.36 |
| 25 kg $ZnSO_4$ $ha^{-1}$ (Soil application) | 8.78 | 2.60 | 3.65 | 1.99 | 2.38 | 12.72 | 20.92 | 56.25 |
| Foliar spray of 0.2% $ZnSO_4$ at PI&FL | 8.75 | 2.46 | 3.59 | 1.98 | 2.25 | 13.15 | 26.25 | 55.13 |
| SEm± | 0.04 | 0.06 | 0.09 | 0.05 | 0.06 | 0.03 | 0.56 | 2.64 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | 0.09 | 1.70 | NS |

PI & FL- Panicle initiation and flowering stage

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