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# Effect of zinc fertilization on growth and yield of coloured rice [*Oryza sativa* L.]

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## ABSTRACT

A field experiment was carried out during *kharif*, 2023 on a sandy clay loam soil at the Agricultural College Farm, Bapatla to study the effect of zinc fertilization on the growth, yield attributes, yield of coloured rice. The experiment was laid out in split plot design with four coloured rice varieties as main plot treatments and four zinc fertilization at different growth stages as sub plot treatments. The results of the investigation revealed that the highest number of tillers $m^{-2}$, drymatter production (kg $ha^{-1}$), productive tillers $m^{-2}$, number of grains per panicle, grain yield, straw yield and harvest index were realized with $M_4$ (Kujipatalia variety) except the plant height and test weight characters which were recorded highest with Navara variety. Among all Zn fertilization stages, the highest values of all the above parameters were found with application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages. Hence, it was concluded that the Kujipatalia variety combined with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages was found to be superior.

**Key words :** *Coloured rice, Zinc fertilization, Growth and Yield*

Rice serves as the primary food for more than half of the world's population and plays a critical role in meeting over 90% of the world's dietary energy needs especially in the developing nations. India is the world's second largest producer of rice, accounting for 20 percent of world rice production. It is cultivated in an area of 22.9 lakh hectares in Andhra Pradesh with a production of 77.6 lakh metric tons and productivity of 3,392 kilograms per hectare (Ministry of Agriculture & Farmer Welfare, 2022).

Pigmented rice has gained significant interest among rice varieties due to their sensory attributes, high nutritional content, and particularly its advantageous health benefits (Kushwaha, 2016; Ito and Lacerda*.,* 2019). They are comprised of a variety of beneficial substances, such as vital amino acids, functional lipids, anthocyanins, phenolic compounds, ã-oryzanols, tocopherols, tocotrienols, phytosterols, and phytic acid and is also abundant in antioxidants and has the ability to decrease chronic inflammation. Zinc(zn) is an essential plant nutrient required for several biochemical processes in the rice plant, including chlorophyll production and membrane integrity. Thus, zn deficiencies affect the growth and development of plant. Zn limits plant growth when its availability in soil is low and the zinc applied to the soil is associated with complex interactions within the soil and thereby reducing the plant uptake of zn. So, agronomic biofortification of zinc enhances the growth, yield and also zn concentration of rice. With regard to zn application, foliar fertilization offers additional benefits compared to soil treatment, as it requires less quantity and provides a rapid response to crop growth (Liu *et al*., 2019). Therefore, it has been proposed to study the effect of coloured rice varieties on zinc fertilization.

## MATERIAL AND METHODS

A field experiment was carried out during *kharif*, 2023 at the Agricultural College Farm, Bapatla which is geographically situated at an altitude of 5.49 m above mean sea level, 80.30p E longitudes and 15.54p N latitude in the Krishna Agro climatic Zone of Andhra Pradesh. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in nature, medium in organic carbon (0.45) and available nitrogen (235 kg $ha^{-1}$), medium in available phosphorus (32.8 kg $ha^{-1}$) and available potassium (309.1 kg $ha^{-1}$). The mean maximum and minimum temperatures recorded during crop period were

$33.2^0$C and $23.7^0$C, respectively. A total rainfall of 900.8 mm was received in 33 rainy days during the crop period. The experiment was laid out in Split plot design with three replications. The treatments comprised combination of four coloured rice varieties *viz.,* $M_1$: Navara, $M_2$:BPT-2858, $M_3$: BPT-2841 and $M_4$: Kujipatalia and four zinc fertilization at different growth stages ($S_1$: no zinc, $S_2$: application of $ZnSO_4$ @ 0.2% at tillering, $S_3$: application of $ZnSO_4$ @ 0.2% at tillering and panicle initiation stages and $S_4$: application of $ZnSO_4$ @ 0.2% at tillering and panicle initiation and booting stages). Application of nutrients was done as per the treatments in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. Nitrogen was applied in 3 split doses, 1/3rd at basal, 1/3rd at tillering and 1/3rd at panicle initiation stages. The foliar application of zinc was done in all the plots based on the stages of crop except the control plot and also the fertilizer was applied in the evening hours to reduce sterility percent of grains. The final split application of N was coinciding with the flowering stage. Entire quantity of phosphorus and half dose of potassium was applied at the time of transplanting. Remaining dose of potassium was applied at PI stage of the crop. Field operations such as weeding, irrigation and plant protection measures were taken as per requirement. The data on plant height, number of tillers $m^{-2}$, drymatter production (kg $ha^{-1}$), productive tillers $m^{-2}$, number of grains per panicle, grain yield, straw yield and harvest index were recorded as per standard procedures. Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p=0.05)

## RESULTS AND DISCUSSION

### Effect on growth parameters

#### Plant height

Data on plant height at harvest of coloured rice was significantly influenced by varieties and zinc fertilization. Among the varieties, Navara variety (138.8 cm) recorded significantly higher plant height but it was on par with BPT-2858 (128.9 cm) and significantly the lowest plant height was recorded with BPT-2841 variety (123.4 cm). Incase of zinc fertilization, application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages (135.3 cm) recorded significantly the highest plant height followed by application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation (130.6 cm) and also with application of $ZnSO_4$ @ 0.2% at tillering (128.2 cm). Liu *et al.* (2016) presented that the use of adequate amount of Zn improves plant height, because it activates enzymatic activity. Similar findings were reported by Wang *et al.* (2019). Significantly the lowest plant height was recorded with no zinc application (120.5 cm).

#### Number of tillers $m^{-2}$

Results of the data on number of tillers was significantly influenced by coloured rice varieties and zinc fertilization. Incase of varieties, Kujipatalia variety recorded significantly superior number of tillers over the rest of the varieties tested in this experiment and Navara variety recorded significantly the lowest number of tillers. With respect to zinc fertilization, application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages recorded significantly the highest number of tillers followed by application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation stages. Liu *et al.* (2016) reported that the rice tiller growth is mainly facilitated by the CTK plant hormone which is enhanced by Zn application. Similar findings were observed by Wang *et al.* (2019). Significantly the lowest number of tillers were recorded with no zinc application. The interaction effect was found to be significant between the coloured rice varieties and zinc fertilization. The highest number of tillers were recorded with Kujipatalia variety combined with application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages and the lowest were recorded with Navara variety coupled with no zinc application.

#### Drymatter production

Experimental data revealed that the coloured rice varieties and zinc fertilization were significantly influenced on drymatter production of rice. Incase of varieties, significantly the highest drymatter production was observed with Kujipatalia variety followed by BPT-2858 variety and significantly the lowest was recorded with Navara variety. Among the zinc fertilization stages, significantly the highest drymatter production was recorded with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages followed by application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation stages and minimum drymatter production was recorded with no zinc application. Higher drymatter production with Zn

**1. Growth attributes, yield attributes, yield and test weight of rice as influenced by coloured rice varieties and zinc fertilization**

| Treatments | Plant height (cm) | No. of tillers $m^{-2}$ harvest | Drymatter production at harvest (kg $ha^{-1}$) | No. of productive tillers $m^{-2}$ | Total no. of grains $panicle^{-1}$ | Grain yield (kg ha-1) | Straw yield (kg ha-1) | Harvest index (%) | Test weight (g) |
|---|---|---|---|---|---|---|---|---|---|
| **Coloured rice varieties** | | | | | | | | | |
| $M_1$:Navara | 138.8 | 319 | 7334 | 245 | 184 | 3318 | 4116 | 44.5 | 18.5 |
| $M_2$:BPT-2858 | 128.9 | 341 | 9825 | 279 | 244 | 3868 | 4801 | 44.9 | 12.1 |
| $M_3$:BPT-2841 | 123.4 | 352 | 9808 | 312 | 250 | 4312 | 5255 | 44.8 | 13.5 |
| $M_4$:Kujjipatalia | 123.4 | 373 | 9927 | 319 | 255 | 4480 | 5374 | 45.5 | 14.8 |
| SEm (±) | 3.4 | 6.6 | 238 | 6.9 | 3.7 | 100.9 | 94.6 | 0.5 | 0.24 |
| CD (P=0.05) | 11.6 | 23 | 823 | 24 | 13 | 349 | 327 | NS | 0.8 |
| CV (%) | 9 | 8.6 | 8.9 | 8.4 | 9.6 | 8.8 | 8.9 | 3.1 | 5.7 |
| **Foliar application of $ZnSo_4$ @ 0.2%** | | | | | | | | | |
| $S_1$:No zinc | 120.5 | 332 | 8660 | 266 | 221 | 3559 | 4559 | 43.7 | 14.6 |
| $S_2$:Tillering stage | 128.2 | 345 | 8976 | 285 | 227 | 3847 | 4780 | 45.1 | 14.7 |
| $S_3$:Tillering and PI stages | 130.6 | 355 | 9329 | 294 | 236 | 3948 | 4886 | 45.3 | 14.8 |
| $S_4$:Tillering, PI and booting stages | 135.3 | 363 | 9929 | 304 | 249 | 4328 | 5221 | 45.5 | 14.9 |
| SEm (±) | 4.6 | 5.1 | 318.4 | 7.4 | 4 | 103.3 | 98.9 | 0.51 | 0.41 |
| CD (P=0.05) | 13.6 | 14 | 657 | 22 | 11 | 302 | 289 | NS | NS |
| CV (%) | 12.5 | 9.1 | 8.5 | 9 | 10 | 9 | 9.2 | 4 | 9.6 |
| **Interaction** | | | | | | | | | |
| SEm (±) | 7.5 | 8.8 | 551.5 | 12.8 | 7 | 179 | 171.2 | 0.89 | 2.2 |
| CD (P=0.05) | 21.1 | 25 | 1138 | 37 | 20 | 523 | 500 | NS | NS |

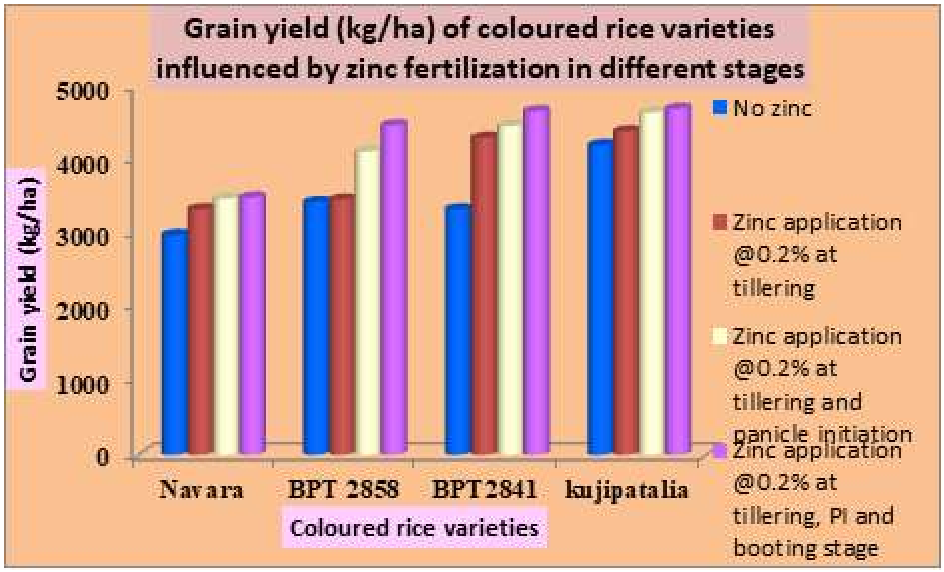


**Fig 1. Grain yield (kg ha$^{-1}$) of coloured rice varieties influenced by zinc fertilization**

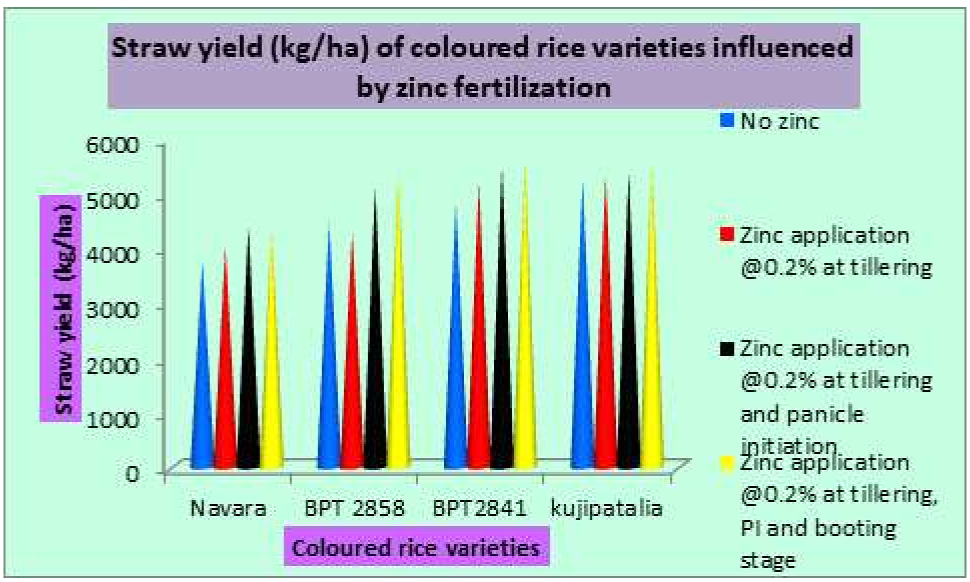


**Fig 2. Straw yield (kg ha$^{-1}$) of coloured rice varieties influenced by zinc fertilization**

application was owing to higher photosynthates and simultaneous translocation of more photosynthates from source to sink. Zinc also helped in increased synthesis of tryptophan and IAA which are two main factors in fresh and dry weight expansion (Tetarwal *et al.,* 2011). These results were in accordance with the studies conducted by Srivastava *et al.* (1999). The interaction among the varieties and zinc fertilization has significant effect on drymatter production of rice. The highest drymatter production was recorded with Kujipatalia variety combined with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages and the lowest was recorded with Navara variety coupled with no zinc application.

**Effect on yield parameters**

**Productive tillers m$^{-2}$**

Experimental data on number of productive tillers of coloured rice was significantly influenced by varieties and zinc fertilization. Significantly the highest number of productive tillers were recorded with Kujipatalia variety which was on par with BPT-2841 variety and showed significant effect with BPT-2858 variety and Navara variety. Among the zinc fertilization at different stages, significantly highest number of productive tillers were recorded with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages followed by application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation stages. Mustafa *et al.* (2011) stated that the increase in number of productive tillers $m^{-2}$ is ascribed to adequate supply of zinc that had increased the uptake and availability of other essential nutrients, which resulted in improvement of plant metabolic process and finally increased the crop growth. These results are in accordance with Naik and Das (2007). Significantly the lower number of productive tillers were recorded with no zinc application. The interaction effect was also found to be significant among the coloured rice varieties and zinc fertilization. The highest number of productive tillers were recorded with Kujipatalia variety coupled with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages and lowest was recorded with Navara variety coupled with no zinc application.

**Total number of grains per panicle**

Data revealed that the total number of grains $panicle^{-1}$ was noticed significantly with coloured rice varieties and zinc fertilization. Data on total number of grains $panicle^{-1}$ indicated that Kujipatalia variety has recorded significantly the maximum number of grains $panicle^{-1}$ which was on par with BPT-2841 variety. Significantly the lowest number of grains were noticed with Navara variety. With difference in zinc fertilization stages of the rice crop, number of grains per panicle increased significantly. The maximum number of grains per panicle were recorded with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages which was significantly superior among the other treatments. Fergany (2018) stated that the zinc foliar application at three times exhibited maximum number of grains $panicle^{-1}$. These results were similar with those conducted by Jaksomsak *et al.* (2018). While, significantly the lowest number of grains $panicle^{-1}$ were recorded with no zinc application. There was significant interaction among the varieties and zinc application on total number of grains per panicle. The highest total number of grains per panicle was recorded with Kujipatalia variety coupled with application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages and the lowest total number of grains per panicle was recorded with Navara variety coupled with no zinc application.

**Effect on grain and straw yield**

The grain and straw yield were significantly influenced by coloured rice varieties and zinc fertilization, and interaction effect was also significantly effected by varieties and zinc fertilization. Data reveals that, Kujipatalia variety recorded significantly the highest grain yield which was on par with BPT-2841 variety while significantly the minimum grain yield was recorded with Navara variety. Experimental data reveals that the various zinc fertilization stages had a significant impact on grain and straw yield. The maximum yield was recorded with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages which was found to be on par with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation. The foliar application of Zn significantly improved grain yield by increasing number of spikelets per spike, filled grain rate and 1000 grain weight stated by Wang *et al.* (2023). The similar findings were noted with those conducted by Xia *et al*. (2018) and Chen *et al*. (2022). Significantly the minimum grain and straw yield was noticed with no zinc application. There was significant interaction among the varieties and zinc application at different stages on grain yield. The highest grain and straw yield were recorded with Kujipatalia variety coupled with application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages and the lowest grain yield was recorded with Navara variety combined with no zinc application.

**Effect on Harvest index**

Data shows that harvest index was observed non-significant on both varieties and zinc fertilization and their interaction was also found to be non-significant.

**Effect on Test weight**

The test weight was significantly influenced with coloured rice varieties but found non-significant with zinc application at different stages and their interaction effect was also non-significant. Among the varieties, Navara variety recorded highest test weight while lowest being recorded with BPT-2858 variety.

**CONCLUSION**

Based on the above results and discussion, it can be concluded that Kujipatalia variety coupled with the application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation stages has recorded significantly higher growth and yield parameters and can be recommended for obtaining highest productivity and profitability.

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