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# Nutrient Uptake of Rice as Influenced by Agronomic Biofortification of Zn and Fe under Methods of Rice Cultivation

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**ABSTRACT**

*An experiment was conducted on nutrient uptake of rice as influenced by methods of cultivation and micronutrient management practices during kharif 2014. SRI method recorded the higher Nitrogen(N), Phosphorus (P) uptake in grain (116.96 kg ha$^{-1}$ and 6.98 kg ha$^{-1}$ respectively) and straw (102.52 and 4.05 kg ha$^{-1}$ respectively) and also total uptake of N and P. Potassium uptake in grain (12.17 kg ha$^{-1}$), straw (81.48 kg ha$^{-1}$) and total (93.64 kg ha$^{-1}$) with the aerobic method. The treatment $S_4$ (Seed treatment combined with foliar spray of $ZnSO_4$ and $FeSO_4$ at 0.5% each at boot leaf stage and panicle inititation stage) recorded significantly higher N uptake (125.37kg ha$^{-1}$) and total N and P uptake in grain. However, soil application of $ZnSO_4$ at 20 kg ha$^{-1}$ and $FeSO_4$ at 10 kg ha$^{-1}$ recorded significantly higher K uptake in grain (71.38 kg ha$^{-1}$). It also recorded significantly higher N and P uptake in straw. Zn uptake in grain (40g ha$^{-1}$) was recorded high in Conventional method and Zn uptake in straw and total Zn uptake (252.50g ha$^{-1}$ and 290g ha$^{-1}$ respectively) with SRI method. Fe uptake in straw, grain and total was 792.92, 3465 and 4185.41g ha$^{-1}$ respectively with the Conventional method. Seed treatment combined with foliar spray of $ZnSO_4$ and $FeSO_4$ at 0.5 percent each at boot leaf stage and panicle inititation stage recorded significantly higher grain Zn and Fe uptake (41.66 and 1075g ha$^{-1}$, repectively). Also the experiment revealed that there was a higher uptake of straw Zn and Fe (440 and 4315.00g ha$^{-1}$, respectively) and Total uptake of Zn and Fe.*

***Key words:*** *Aerobic rice, Seed treatment, Nutrient uptake, Foliar nutrition.*

## INTRODUCTION

Rice (*Oryza sativa* L.) is the major staple food for almost half the world's population[3]. The UN General Assembly declared 2004 as the "International Year of Rice" which reflects the importance of rice in global concern regarding food security, poverty alleviation, preserving cultural heritage and sustainable development. Rice is known as the grain of life and is synonymous with food for Asians as it supplies majority of starch, protein and micronutrient requirements. Rice has become a common dietary in the world, particularly in developing countries.

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Rice is the only cereal crop cooked and consumed mainly as whole grain and the quality considerations are much more important than for any other food crop[9]. However, rice is a poor source of many essential minerals and organic substances, especially iron (Fe), zinc (Zn) and lysine (Lys) and other essential amino acids for human nutrition. Currently, malnutrition of Fe and Zn afflicts more than 50% of the world's population [12, 14]. This weakens immune function and impairs growth and development [13] and continuous heavy consumption of rice with low concentration of Fe and Zn has been considered a major contributor[15] and Zn deficiency is currently listed as a major risk factor for human health and causes of death globally. Fertilization is the key point of nutrient-integrated management in agronomic approaches to enhance crop quality and yield, so that fertilization could be one of the sustainable and low cost strategies to improve Fe and Zn density in edible portions of staple food crops[10]. Further it is also reported that enhancement of the Zn and Fe content in the consumable portions of the crop can be achieved through optimization of the rates, sources, method and time of application of micronutrients, integrated use of mineral fertilizers and organics, use of crop rotations, and intercropping which is referred as agronomic biofortification.

## MATERIAL AND METHODS

### Experimental site

A field experiment was conducted at College of Agriculture, V. C. Farm, Mandya during kharif, 2014. It falls under the Region III and agro climatic zone VI (Southern Dry Zone) of Karnataka. Geographically the experimental site is located at 12º 45' and 30º 57' North latitude and 76º 45' and 78º 24' East longitude at an altitude of 695 meters above mean sea level (MSL). The experimental soil is Red sandy loam in texture. The soil reaction was alkaline in nature (pH 8.4), organic carbon content was medium (0.57 %) with the electrical conductivity of 0.25 $dSm^{-1}$. The soil was low in available nitrogen (156.8 kg $ha^{-1}$) and medium in available phosphorus (44.30 kg $ha^{-1}$) and potassium (198.36 kg $ha^{-1}$) respectively and medium in zinc (0.6 ppm) and iron (3.5ppm).

### Experimental detail

The experiment was laid out in the split plot design with three replications with three main plot as methods of rice cultivation viz., SRI method, Conventional method and Aerobic method and four subplots with micronutrient management practices viz., control without Zn and Fe , soil application of $ZnSO_4$ at 20kg/ha and $FeSO_4$ at 10kg/ha, seed treatment with $ZnSO_4$ at 0.2% and $FeSO_4$ at 0.1% and seed treatment combined with the Foilar spray of $ZnSO_4$ and $FeSO_4$ at 0.5% each at boot leaf stage and panicle initiation stage.

### Fertilizer application

Fertilizers were applied as per the treatments *viz.*, urea, single super phosphate (SSP), muriate of potash (MOP), Zinc sulphate ($ZnSO_4$) and iron sulphate ($FeSO_4$) to supply N, P, K, Zn and Fe, respectively for the experiment. The fertilizers at 120:60:60 kg NPK per ha were applied as 50 per cent N, full dose of P and K as basal dose at the time of sowing /transplanting. The remaining 50 per cent N was applied in two equal splits at 30 DAT and at panicle initiation. Zinc and iron fertilizers were applied either to soil or seed treatment or as foliar spray as per the treatment.

### Weed management

Five days after sowing or planting in case of aerobic, SRI and conventional transplanting plots, pyrozosulfuron (10 % WP) at 20 g a. i. $ha^{-1}$ was sprayed in moist soil of aerobic rice and on thin film of water in SRI and Conventional methods, followed by three hand weedings and passing of cono-weeder at 20, 40 and 60 DAS was carried out in aerobic method, two hand weedings and passing of cono-weeder at 20 and 40 DAP (days after planting) for SRI and transplanting methods. Weed biomass was generally mixed with the soil by passing conoweeder, which enhanced organic matter content in the soil.

### Observation

At maturity the grain and straw samples were collected from each plot after recording their yields. The collected samples were dried at

70˚C, pulverized and digested using digested in triacid mixture (360 ml conc. $HNO_3$ + 40 ml Con.$H_2SO_4$ + 160 ml of 70 per cent perchloric acid)[8] and Zinc and Iron concentration was determined by the method [1]. Total nitrogen of plant samples was estimated by Kjeldhal's method and digesting the plant samples with triacid mixture, Total phosphorus and potassium concentration in the digest were determined by vanadomolybdate yellow colour method and flame photo meter method, respectively[5]. The uptake of these nutrients was computed with the following formulae *viz.*

**For primary and secondary nutrients**

**Nutrient uptake (kg ha$^{-1}$)** = Nutrient concentration in percentage × Dry matter yield (kg ha$^{-1}$) /100

**For micronutrients**

**Uptake (g ha$^{-1}$)** = Nutrient content (ppm)× Dry matter yield (kg ha$^{-1}$) × 1/100

**Statistical analysis**

The data collected on different parameters during the course, of investigation were subjected to Fishers method of analysis of variance technique (ANOVA)[4]. The level of significance used in "F" and "t" test was P = 0.05. Critical difference (CD) values were calculated for the P = 0.05, whenever "F" test was found significant.

## RESULTS AND DISCUSSION

Among the micronutrient management practices, total Nitrogen uptake (205.49 kg ha$^{-1}$), P (9.88 kg ha$^{-1}$) and K (79.16 kg ha$^{-1}$) uptake was significantly higher in the soil application of $ZnSO_4$ at 20 kg per ha and $FeSO_4$ at 10 kg per ha. Higher Zn (481.66 g ha$^{-1}$) and Fe (4972.77 g ha$^{-1}$) was found in seed treatment of $ZnSO_4$ at 0.2% and $FeSO_4$ at 0.1% combined with the foliar spray of $ZnSO_4$ and $FeSO_4$ at 0.5 % each at boot leaf stage and panicle initiation stage ($S_4$) in Table 1. This might be due to positive interaction of micronutrients with other nutrients. Absorption of Zn and Fe by roots also play an important role in uptake of the nutrients[6,7,10]. SRI method recorded higher nutrient uptake due to larger root volume and higher grain and straw yields compared to aerobic and conventional methods[2].

**Table 1: Nutrient uptake (kg ha$^{-1}$) of rice as influenced by Zn and Fe under different methods of cultivation**

| | N(kg /ha) | | | P(kg/ha) | | | K(kg/ha) | | | Zn(kg/ha) | | | Fe(kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **Grain** | **Straw** | **Total** | **Grain** | **Straw** | **Total** | **Grain** | **Straw** | **Total** | **Grain** | **Straw** | **Total** | **Grain** | **Straw** | **Total** |
| **Methods of cultivation** | | | | | | | | | | | | | | | |
| **$M_1$** | 116.96 | 102.52 | 219.49 | 6.98 | 4.05 | 11.14 | 9.80 | 58.90 | 68.71 | 37.5 | 252.5 | 290 | 792.9 | 3465.0 | 4185.4 |
| **$M_2$** | 101.49 | 66.57 | 168.06 | 6.95 | 2.87 | 9.80 | 9.26 | 40.42 | 49.68 | 40 | 190 | 230 | 933.8 | 4495.0 | 5427.9 |
| **$M_3$** | 90.38 | 37.32 | 127.70 | 5.42 | 1.98 | 7.40 | 12.17 | 81.48 | 93.64 | 32.5 | 135 | 167 | 795.8 | 2845.0 | 3978.8 |
| **S.Em±** | 5.35 | 3.88 | 4.51 | 0.17 | 0.08 | 0.28 | 0.49 | 2.17 | 1.77 | 1.67 | 26.31 | 25.10 | 29.6 | 352.8 | 80.2 |
| **C.D (P=0.05)** | 21.00 | 15.24 | 17.72 | 0.68 | 0.33 | 1.11 | 1.91 | 8.51 | 6.93 | 6.54 | 103.32 | 98.57 | 116.3 | 1385.9 | 314.7 |
| **Micronutrient management practices** | | | | | | | | | | | | | | | |
| **$S_1$** | 78.38 | 51.82 | 130.20 | 6.22 | 3.16 | 8.99 | 8.83 | 48.42 | 57.25 | 33.3 | 76.7 | 110 | 601.7 | 2481.7 | 3083.4 |
| **$S_2$** | 109.44 | 96.05 | 205.49 | 6.26 | 3.22 | 9.88 | 11.13 | 68.05 | 79.16 | 35.00 | 81.7 | 116.7 | 809.4 | 4300 | 5109.4 |
| **$S_3$** | 98.59 | 61.50 | 160.09 | 6.5 | 2.35 | 9.17 | 10.54 | 61.97 | 72.51 | 36.7 | 171.7 | 208.3 | 876.67 | 3310 | 4186.7 |
| **$S_4$** | 125.37 | 65.85 | 191.22 | 6.82 | 3.14 | 9.75 | 11.15 | 62.63 | 73.78 | 41.7 | 440 | 481.6 | 1075.56 | 4315.0 | 4972.7 |
| **S.Em±** | 2.94 | 6.14 | 6.82 | 0.31 | 0.16 | 0.25 | 0.53 | 3.28 | 3.47 | 2 | 58.52 | 57.97 | 49.68 | 368.5 | 180.0 |
| **C.D (P=0.05)** | 8.74 | 18.25 | 20.25 | NS | 0.47 | 0.75 | 1.58 | 9.74 | 10.32 | 5.9 | 173.88 | 172.23 | 147.62 | 1094.92 | 534.9 |
| **Interaction (M×S)** | | | | | | | | | | | | | | | |
| **S.Em±** | 6.93 | 10 | 11.19 | 0.5 | 0.25 | 0.47 | 0.93 | 5.38 | 5.50 | 3.44 | 91.52 | 90.50 | 80.20 | 655.77 | 281.69 |
| **C.D(P=0.05)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Note: NS= Not significant

## CONCLUSION

The present experiment revealed that among the micronutrient management practices, soil application of $ZnSO_4$ and $FeSO_4$ increases the total uptake of nitrogen, phosphorus and potassium. Seed treatment combined with the foliar application of $ZnSO_4$ and $FeSO_4$ recorded higher total uptake of iron and zinc. SRI method shows higher uptake of nutrient compared to the conventional and aerobic method.

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