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Effect of foliar application of zinc on biofortified rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted to study the comparative performance of zinc in biofortified rice and their effect on yield attributes, yield and zinc concentration of rice at BAU farm, Sabour in Randomized Block Design replicated thrice during *Kharif* season of 2021-22. The variety used was Sabour Aayush. The soil of the experimental plot was silt loam having pH 7.7, organic carbon 0.53%, Low in available Nitrogen (159.88 kg/ha), Phosphorus (26.94 kg P₂O₅/ha), Potassium (196.69 kg K₂O/ha) and initial soil Zn-1.0 mg/kg of soil. The recommended dose of fertilizers i.e. 100-40-20 kg N- P₂O₅- K₂O/ha was applied. In addition to these fertilizers 25 kg zinc sulphate was applied as basal and 0.5% zinc sulphate used as foliar spray at pre flowering and milking stage of rice.

The experimental results revealed that RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate spray as foliar application at pre flowering and milking stage was the best treatment and recorded significantly better values for yield attributes (74.74 grains per panicles, 270.33 panicles per m², 30.18 g test weight), higher grain yield (4.96 t/ha) and higher concentration (30.9 and 91.8 mg kg⁻¹ grain and straw respectively) and uptake of Zn in grain (153.3 g ha⁻¹) and in straw (455.2 g ha⁻¹) of bio fortified rice than soil application alone and single spray of Zn and most other treatments. This study brought out that adequate soil application of Zn sulphate followed by its two foliar applications is the best approach.

Keywords: Biofortified rice, foliar spray, grain yield, zinc

Introduction

In India, Rice (*Oryza sativa* L.) is one of the most important cereals grown under diverse environment and geographical ranges for human food, feed, fodder and raw materials for industries. In India it is grown on 43.39 million hectares and production of 121.46 million tonnes with an average productivity of 2578 kg ha⁻¹ (Directorate of Economics and Statistics, Govt. of India, 2020-21) [4], which is far below than that of most of the countries of the world. In Bihar, total area under this crop is 3.30 million hectares, producing 8.09 million tonnes and with an average productivity of 2447 kg ha⁻¹ (Directorate of Economics and Statistics, Govt. of India, 2020-21) [4].

Zinc (Zn) is now recognized as the fourth major micronutrient deficiency in humans and comes after vitamin A, iron and iodine deficiencies (Bell & Dell, 2008) [1]. Zn deficiency leads to diarrhea and pneumonia in infants and children (Black *et al.*, 2008) [2]; (Graham, 2008) [6] and is considered for responsible for childhood dwarfism (Hotz & Brown, 2004) [7]. Zn plays an important role in production of protein and thus helps in wound healing, blood formation and growth and maintenance of tissue (Bell & Dell, 2008) [1]. Polished rice contains only 13-15 mg Zn kg⁻¹ (Welch, 2005) [13] and a rice based diet is thus likely to be deficient in Zn as compared to diet containing grain legumes and animal proteins, which are rich in Zn (Prasad, 2003) [10]. India, especially Bihar soils are low in available Zn and this leads to production of low Zn containing rice. Keeping this in view, the present investigation was carried out in rice to develop agronomic techniques for capable of producing grains denser in Zn micronutrient.

Materials and Methods

The field experiment was conducted during rainy seasons (*Kharif*) of 2021-2022 at Bihar Agricultural University, Sabour, Bihar (25° 04' N Latitude, 87° 04' E Longitude and 37.19 meter above mean sea levels), The soil of the experimental plot was silt loam having pH 7.7, organic carbon 0.53%, electrical conductivity 0.47 dSm⁻¹, Low in available Nitrogen (159.88 kg/ha), Phosphorus (26.94 kg P₂O₅/ha), Potassium (196.69 kg K₂O/ha) and initial soil Zn-1.0

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mg/kg of soil. The recommended dose of fertilizers i.e. 100-40-20 kg N- P₂O₅- K₂O/ha was applied. In addition to these fertilizers 25 kg zinc sulphate was applied as basal and 0.5% zinc sulphate used as foliar spray at pre flowering and milking stage of rice. The total rainfall received during the crop growth season of the years was 1064 mm. The experiment was laid out in Randomized block design with three replications. The treatments were: Absolute control, RDF (100:40:20), RDF (100:40:20)+20 kg/ha zinc sulphate as basal, RDF (100:40:20)+25 kg/ha zinc sulphate as basal, RDF (100:40:20)+30 kg/ha zinc sulphate as basal, RDF (100:40:20)+20 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage, RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage, RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage, RDF (100:40:20)+20 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage, RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage, RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage. Recommended dose of fertilizers were 100:40:20 kg N:P:K ha⁻¹. The crop received full dose of P (40 Kg ha⁻¹) and K (20 Kg ha⁻¹) and half dose of N (50 Kg ha⁻¹) as basal and the remaining nitrogen (50 kg ha⁻¹) were applied in two splits dose, half at active tillering and the rest half before panicles initiation stage. Foliar application of Zn @ 0.5% was made at pre flowering and milking stage at the rate of 1,000 liters of solution ha⁻¹ (+ 2.5 kg ha⁻¹ lime). Single 25 day old seedlings of rice were transplanted per hill at 20 cm × 10 cm in the second fortnight of July. The test cultivars of rice were sown in rows 20 cm apart as per scheduled. Rice crop was grown as per recommended package of practices and was harvested in the second fortnight of October. Grain yield of biofortified rice along with other yield attributing characters were recorded at harvest. Grain yield was converted to t ha⁻¹ at 14% moisture content. Chemical Analysis of Zn Concentration in

Rice grain, and Rice Straw samples was analysed on an Atomic Absorption Spectrophotometer. Thereafter, the uptake of the Zn was calculated by multiplying Zn concentrations with respective plot yield of rice grain and rice straw yields. Finally recorded data in all the three replications were subjected to statistical analysis and final tabulation were done of the statistically analyzed data. Statistical Analysis All the data obtained from rice for this study were statistically analyzed using the t-test as per the procedure given by K. A. Gomez and A.A. Gomez (1984) [5].

Results and Discussion

Growth, yield attributes and yield

At harvest, treatments receiving Zinc sulphate as basal and foliar application significantly increased plant height (Table 1) over all other treatments. Zn sulphate application significantly increased grains panicle⁻¹, panicles m⁻² and test weight in biofortified rice (Table 1). Panicles m⁻² and grains panicle⁻¹ were observed more with soil + foliar application of Zn sulphate (ZnS), significantly higher than soil application alone of zinc sulphate, which in turn was significantly superior to soil application and single spray of Zn Sulphate. This is because soil applied Zn on Zn deficient soils results in overall better growth, higher yield attributes and grain yield in rice which results in increased uptake of all nutrients. This does not happen with foliar application alone of Zn, which is made at a much latter stage of crop growth, these results are in the conformity with the work done by (Pooniya & Shivay, 2013) [9].

Zn sulphate application significantly increased grain yield of rice (Table 1). The highest values of grain (4.97 tonns/ha) was obtained with soil + two foliar application of Zn Sulphate followed by RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage, which in turn was significantly superior to soil application of ZnS (Shivay *et al.*, 2015) [12] and (Prasad *et al.*, 2014) [11]. Absolute control and basal application of Zinc Sulphate recorded the lowest values for all yield attributes and yields.

Table 1: Effect of zinc application on growth, yield attributes and yield of Biofortified rice

Treatments	Details	Plant height (cm)	Grains per panicle	Panicles m ⁻²	Test weight(g)	Grain yield (ton ha ⁻¹)
T1	Absolute control	96.47	54.12	181.78	23.61	2.14
T2	RDF (100:40:20)	99.26	70.67	237.67	28.67	4.36
T3	RDF (100:40:20)+20 kg/ha zinc sulphate as basal	100.22	71.11	241.00	28.87	4.43
T4	RDF (100:40:20)+25 kg/ha zinc sulphate as basal	100.67	71.89	241.67	29.17	4.61
T5	RDF (100:40:20)+30 kg/ha zinc sulphate as basal	101.11	71.97	249.33	29.30	4.62
T6	RDF (100:40:20)+20 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage	102.00	73.22	250.67	29.47	4.69
T7	RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage	103.11	73.89	258.67	29.73	4.70
T8	RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage	103.22	73.96	261.00	29.71	4.72
T9	RDF (100:40:20)+20 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage	104.11	74.00	264.67	29.88	4.90
T10	RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage	105.56	74.74	270.33	30.18	4.96
T11	RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage	105.78	74.79	274.00	30.43	4.97
	S.Em±	2.13	1.06	16.84	0.61	0.11
	CD (P = 0.05)	6.29	3.73	51.20	1.77	0.30

Zinc Concentration and Uptake

Zinc application increased total Zinc concentration in rice

grain and straw of rice and the highest values were obtained for soil + foliar application of Zinc sulphate (Table 2). Zinc

concentration in rice grain was the highest with RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage and it was significantly similar than that obtained with RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage, these two treatments were superior over rest of the treatments. Lowest Zinc concentration was obtained with absolute control. Zinc uptake significantly increased by rice grain and straw in rice and this resulted in a significant increase in total Zinc uptake by biofortified rice. As regards RDF (100:40:20)+30 kg/ha zinc sulphate as basal application of Zinc sulphate were at par and significantly superior to no application of Zinc in soil. Impa and Johnson-Beebout (2012) [8] reported that

biofortification recovery of Zn with foliar application was 8 times of that obtained with soil application. All basal and two foliar application of Zinc treatments except no application of Zinc significantly increased Zinc uptake by rice grain and straw and total Zinc uptake by biofortified rice crop. The highest values of concentrations and uptake of Zn were obtained by soil + foliar application of Zinc sulphate. This is because soil applied Zinc on Zinc deficient soils results in overall better growth, higher yield attributes and grain and straw yield in rice (Pooniya & Shivay, 2013) [9], which results in increased uptake of all nutrients. This does not happen with foliar application of Zinc, which is made at a much latter stage of crop growth.

Table 2: Effect of zinc application on Zn concentration and Zn uptake in grain and straw of Biofortified rice

Treatments	Details	Zn concentration in rice grain (mg kg ⁻¹)	Zn concentration in rice straw (mg kg ⁻¹)	Zn uptake (g ha ⁻¹) in grain	Zn uptake (g ha ⁻¹) in straw	Total Zn uptake (g ha ⁻¹)
T1	Absolute control	21.1	72.2	45.2	154.5	199.7
T2	RDF (100:40:20)	22.8	77.4	99.4	337.6	437.0
T3	RDF (100:40:20)+20 kg/ha zinc sulphate as basal	25.8	82.9	114.3	367.4	481.7
T4	RDF (100:40:20)+25 kg/ha zinc sulphate as basal	26.6	83.4	122.6	384.5	507.1
T5	RDF (100:40:20)+30 kg/ha zinc sulphate as basal	27.4	86.1	126.6	397.6	524.2
T6	RDF (100:40:20)+20 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage	28.1	86.7	131.8	406.8	538.6
T7	RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage	28.7	88.1	134.9	413.9	548.8
T8	RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering stage	28.8	88.4	135.9	417.0	552.9
T9	RDF (100:40:20)+20 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage	29.1	87.4	142.6	428.3	570.9
T10	RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage	30.9	91.8	153.3	455.2	608.4
T11	RDF (100:40:20)+30 kg/ha zinc sulphate as basal+0.5% zinc sulphate at pre flowering and milking stage	31.2	92.3	155.1	458.9	614.0
	S.Em±	0.54	1.02	2.01	6.02	5.12
	CD (P = 0.05)	1.54	3.05	6.12	18.12	15.76
Initial soil Zn-1.0 mg/kg of soil.						

Conclusions

Based on the results of this study, it can be concluded that the best treatment for biofortified rice was RDF (100:40:20)+25 kg/ha zinc sulphate as basal+0.5 percent zinc sulphate at pre flowering and milking stage, which had significantly better growth, higher values for yield attributes, higher grain yield, and higher concentration and uptake of Zn in grain and straw than soil application of Zn and most other treatments.

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