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Productivity, profitability and zinc content in grain of rice as influenced by different levels and sources of zinc

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Abstract
An experiment was conducted at Research cum Instructional farm, IGKV, Raipur, Chhattisgarh, India during *kharif* season of 2016 to assess the effect of different levels and sources of zinc application on growth, yield, zinc content and economics of rice. Nine treatments of zinc fertilization and one control (Without zinc) were allocated randomly in simple randomized block design and replicated thrice. Zinc content was estimated by using standard method described under Harvest Plus (2005) guidelines using Atomic absorption spectrophotometer (AAS200). The results revealed that maximum effective tillers was recorded with application of 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through Zn-EDTA at panicle initiation (PI) and flowering (FL). Almost similar test weight and, grain (55.87 q ha^{-1}) and straw yields (72.73 q ha^{-1}) were recorded with application of 25 kg and 50 kg $ZnSO_4$ ha^{-1} in soil each + Two foliar spray of 0.2% Zn through $ZnSO_4$ and through Zn-EDTA at PI and FL stage and, with three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL stage. The maximum zinc content in grain and straw was observed with application of 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL. The maximum net returns (Rs. 65574 ha^{-1}) and benefit cost ratio (2.60) were recorded with three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL stage.

Keywords: Zinc levels and sources, growth, yield, quality, rice

Introduction
Rice is the most important cereal crop in Asia. India is the second largest producer and consumer of rice in the world. 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) [1]. Zinc deficiency is a well documented problem in food crops, causing decreased crop yields and nutritional quality. 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 most popular and consumable variety MTU-1010 of Chhattisgarh was fertilized with different levels and sources of zinc along with different methods of application under this study.

Materials and Methods
An experiment was conducted at Research cum Instructional farm, IGKV, Raipur, Chhattisgarh, India during *kharif* season of 2016 to assess the effect of different levels and sources of zinc application on growth, yield, zinc content and economics of rice. Nine treatments of zinc fertilization and one control (Without zinc) were allocated randomly in simple randomized block design and replicated thrice. Zinc content was estimated by using standard method described under Harvest Plus (2005) guidelines using Atomic absorption spectrophotometer (AAS200). The soil of experimental field was *Vertisol*, low in available nitrogen (179.54 kg ha^{-1}), medium in phosphorus (10.06 kg ha^{-1}), potassium (250.4 kg ha^{-1}) and in zinc (0.8 ppm) with normal pH (6.7). The recommended dose of fertilizer was 100:60:40 kg ha^{-1} N, P_2O_5 and K_2O, respectively. Zinc was applied as per treatments. Two to three seedlings in each hill were transplanted on 30.07.2016 at spacing of 20 cm x 15 cm and harvested on 11.11.2016.

Results and Discussion

Growth and yield

The growth, yield and quality of rice are presented in table 1. The plant height of rice did not show significant difference due to application of different levels and sources of zinc. Significantly higher effective tillers was recorded with application of 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through Zn-EDTA at panicle initiation (PI) and flowering (FL). However, it was statistically similar to application of 25 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through Zn-EDTA at PI and FL, 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL, and 25 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL. soil application of zinc leads to greater availability of nutrients to plants at all the stages of crop growth. Similar result has been reported by Khan *et al.* (2003) [5]. Statistically similar test weight (1000 grain weight) was recorded with application of 25 kg and 50 kg $ZnSO_4$ ha^{-1} in soil each + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL, 25 kg and 50 kg $ZnSO_4$ ha^{-1} in soil each with Two foliar spray of 0.2% Zn through Zn-EDTA at PI and FL stage and, with three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL stage. The comparative increased in 1000-grain weight with the soil application of zinc might be due to more efficient participation of zinc in various metabolic processes involved in the production of healthy seeds. Similar results have been reported by Ghani *et al.* (1990) [2].

Application of 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL recorded significantly higher grain (55.87 q ha^{-1}) and straw yield (72.73 q ha^{-1}). However, it was statistically at par with three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL, application of 25 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL, 50 kg $ZnSO_4$ ha^{-1} in soil and, 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through Zn-EDTA at PI and FL with respect to grain yield. Zinc is essential for the normal healthy growth and reproduction of plants and plays a key role as a structural constituent in many important biochemical pathways. Zinc fertilizers are used in the prevention of Zn deficiency and in the bio fortification of cereal grains. Similar results have been reported by Ghani *et al.* (1990) [2].

Table 1: Effect of zinc fertilization on growth, yield, quality and economics of rice

Treatments	Plant height (cm)	Effective tillers /hill	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Alkali value	Zinc content in grain (ppm)	Zinc content in straw (ppm)	Net returns (Rs ha^{-1})	Benefit cost ratio
T_1	88.40	8.87	20.87	46.34	65.01	2.30	15.81	14.50	53506	2.33
T_2	88.33	8.87	22.40	47.08	63.64	2.37	17.50	16.90	53090	2.18
T_3	86.13	9.47	22.10	53.97	71.51	2.37	18.05	17.30	62876	2.44
T_4	87.40	9.60	21.73	51.33	66.01	2.38	24.27	20.57	59658	2.44
T_5	87.40	9.87	22.40	43.98	57.47	2.37	20.03	18.07	46952	1.86
T_6	87.73	10.20	22.20	54.68	68.30	2.37	24.90	21.87	63540	2.46
T_7	86.40	10.27	23.20	55.87	72.73	2.39	25.27	22.50	64375	2.36
T_8	86.67	10.87	23.40	48.94	64.53	2.39	22.03	18.10	53744	2.02
T_9	87.53	11.13	22.87	53.87	65.50	2.36	23.13	17.93	59895	2.14
T_{10}	87.80	9.80	21.87	55.65	67.51	2.39	26.00	24.04	65574	2.60
SEm±	0.64	0.41	0.41	1.15	1.33	0.02	0.33	0.26		0.07
CD at 5%	NS	1.23	1.24	3.41	3.98	NS	0.98	0.79		0.21

Treatments: T_1 : Control (no zinc), T_2 : 25 kg ZnSO4 ha^{-1} as soil application, T_3 : 50 kg ZnSO4 ha^{-1} as soil application, T_4 : Two foliar spray of 0.2% Zn through ZnSO4 at panicle initiation and flowering (PI&FL) stage, T_5 : Two foliar spray of 0.2% Zn through Zn-EDTA at PI&FL stage, T_6 : 25 kg ZnSO4 ha^{-1} as soil application + Two foliar spray of 0.2% Zn through ZnSO4 at PI&FL stage, T_7 : 50 kg ZnSO4 ha^{-1} as soil application + Two foliar spray of 0.2% Zn through ZnSO4 at PI&FL stage, T_8 : 25 kg ZnSO4 ha^{-1} as soil application + Two foliar spray of 0.2% Zn through Zn-EDTA at PI&FL stage, T_9: 50 kg ZnSO4 ha^{-1} as soil application + Two foliar spray of 0.2% Zn through Zn-EDTA at PI&FL stage, T_{10} : Three foliar spray of 0.2% Zn through ZnSO4 at tillering, PI &FL stage

Zinc content and economics

The alkali value of rice was not influenced significantly due to application of different levels and sources of zinc. The maximum zinc content in grain and straw was observed with application of 50 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL. However, it was statistically at par with three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL and with soil application of 25 kg $ZnSO_4$ ha^{-1} in soil + Two foliar spray of 0.2% Zn through $ZnSO_4$ at PI and FL. 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 Muamba *et al.* (2013) [6]. The maximum net returns (Rs. 65574 ha^{-1}) and benefit cost ratio (2.60) were recorded with three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL stage. Application of micronutrients was found to be economical having more benefit cost ratio as compared to control. Similar observations were noted by Ghatak *et al.* (2005) [3].

Minimum effective tillers, test weight, grain and straw yield, zinc content in grain and straw was recorded with no application of zinc in rice.

Conclusion

Based on one year study, it can be concluded that three foliar spray of 0.2% Zn through $ZnSO_4$ at tillering, PI and FL stage recorded maximum grain yield (55.65 q ha^{-1}), zinc content in grain (25 ppm) and straw (22.04 ppm), net returns (Rs. 65574 ha^{-1}) and benefit cost ratio (2.60).

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