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Effect of soil and foliar application of zinc on nutrient status of soil and nutrient uptake by rice (*Oryza sativa* L.)

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Abstract
The study employed a randomised block design, with four replications comprising six treatments, namely: Application of liquid zinc 39.5% by foliar spraying at 250, 500, and 750 millilitres per hectare; combination of basal zinc sulphate application at 10 kg per hectare + foliar zinc application at 750 millilitres per hectare; and untreated control. The experimental site's soil composition was clay loam, with low levels of nitrogen (196 kg ha^{-1}) and medium levels of phosphorus (20.9 kg ha^{-1}) and potassium (385.39 kg ha^{-1}). It also had low levels of zinc (0.89 ppm), normal pH (7.6), and EC (1.503 dSm^{-1}). MTU 1010 rice was utilised as the test crop.

Keywords: Soil, foliar application, zinc, nutrient status, nutrient uptake, rice (*Oryza sativa* L.)

Introduction
Rice (*Oryza sativa* L.) is one of the crops that is most vulnerable to zinc deficiency. and zinc is the most important micronutrient limiting rice growth and yield. In the calcareous soils of Northern India, rice was initially found to be deficient in zinc (Neue and Lantin, 1994) [6]. It was later discovered to be a common occurrence in lowland rice regions of Asia, occurring alongside deficiencies in phosphorus (P) and nitrogen (N). Nowadays, zinc deficiency is thought to be the most common nutrient problem in lowland rice (Quijano-Guerta *et al*., 2002) [7]. In the United States, zinc is the most widely used micronutrient fertiliser for rice. Boonchuay *et al.* (2013) [1] reported that high concentrations of zinc in rice seed greatly improved the growth and development of seedlings. Zinc compounds can be added to plants or soil to remedy zinc deficiencies. Khan *et al.* (2002) [3] observed that fertilization had significant effect on the grain yield of rice and highest grain yield was recorded with the application of $ZnSO_4$ @ 10 kg ha^{-1}. Multiple symptoms of zinc deficiency typically show up two to three weeks after rice seedlings are transplanted. Plants with deficient leaves stay stunted and in extreme situations may die; those that recover will exhibit a significant delay in maturation and a reduction in production. Deficient leaves acquire brown blotches and streaks that may fuse to cover older leaves altogether. Its absence causes dusty brown patches on the upper leaves, slowed plant development, a reduction in the capacity to tiller, and a rise in the sterility of spikelet's. Naik and Das (2007) [5] noticed that adequate supply of zinc produced more number of productive tillers per m^2. Zinc immobilisation causes deficient symptoms to worsen during the early growth stage; zinc deficiency in rice is generally referred to as Khaira disease. Kulhare *et al*. (2017) [4] reported foliar spray of one per cent zinc salt at tillering and flag leaf stage significantly enhanced the grain and straw yield.

Materials and Methods
The experimental site was the Indira Gandhi Krishi Vishwavidyalaya in Raipur, Chhattisgarh, India, at the Instructional-Research Farm. At longitude 81.36°E and latitude 21.16°N, in the central region of Chhattisgarh, is Raipur, which is 298 metres above mean sea level. Using a soil auger, soil samples were taken zigzag style from eight locations at a depth of 0 to 30 cm from the experimental site. Composite samples formed, the samples were analysed for the initial state of the soil's chemical and physical characteristics, and the analysis's findings were recorded. Twenty-one-day-old seedlings from the nursery bed were carefully taken out to get ready for transplantation. One seedling per hill was transplanted, with a 20 cm × 15 cm space between each plant. Rice was planted with the recommended amount of fertiliser, or 100:60:40 kg NPK ha^{-1}. The remaining nitrogen dose was applied in two equal splits during the crop's tillering and panicle initiation stages.

The 50% dose of nitrogen and the 100% recommended doses of phosphorus and potassium were applied through urea, single super phosphate (SSP), and muriate of potash (MOP) as basal. Zinc was applied as per treatments. Liquid zinc (39.5%) was applied as foliar at 25 DAT and 45 DAT, while solid zinc sulphate (33%) was given as basal.

Results and Discussion

Field experiment on "Effect of soil and foliar application of zinc on growth parameters, yield attributes, yield and economics of rice" conducted at Instructional cum Research Farm, I.G.K.V., Raipur (C.G.). Evaluating zinc's impact upon rice performance was the goal. This chapter presents the findings using tables and graphics and discusses the known scientific viewpoints of national and international researchers as well as the cause-and-effect relationship from observations made throughout the examination.

Chemical study

N, P and K content

Nitrogen, phosphorus and potassium content in grain, straw and soil was estimated after harvest and presented in Table 1, 2 and 3. The difference in nitrogen, phosphorus and potassium content in grain, straw and soil was not found significant due to different treatments.

Table 1: Effect of soil and foliar spray of zinc on availability of nutrient content in grain

Treatment	Nutrient content in grain (%)		
	N	P	K
Application of liquid zinc 39.5% @ 250 ml ha^{-1} at tillering and panicle initiation stage	1.16	0.23	0.30
Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	1.19	0.22	0.31
Application of liquid zinc 39.5% @ 750 ml ha^{-1} at tillering and panicle initiation stage	1.21	0.23	0.32
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal + Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	1.23	0.22	0.33
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal	1.15	0.26	0.30
Untreated control	1.13	0.28	0.29
S.Em±	0.09	0.02	0.02
CD (P=0.05)	NS	NS	NS

Table 2: Effect of soil and foliar spray of zinc on availability of nutrient content in straw

Treatment	Nutrient content in straw (%)		
	N	P	K
Application of liquid zinc 39.5% @ 250 ml ha^{-1} at tillering and panicle initiation stage	0.52	0.12	1.59
Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	0.53	0.13	1.64
Application of liquid zinc 39.5% @ 750 ml ha^{-1} at tillering and panicle initiation stage	0.57	0.14	1.74
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal + Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	0.62	0.13	1.81
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal	0.50	0.15	1.55
Untreated control	0.48	0.17	1.53
S.Em±	0.04	0.01	0.14
CD (P=0.05)	NS	NS	NS

Table 3: Effect of soil and foliar spray of zinc on availability of nutrient content in soil

Treatment	Nutrient content in soil (kg ha^{-1})		
	N	P	K
Application of liquid zinc 39.5% @ 250 ml ha^{-1} at tillering and panicle initiation stage	210.20	22.94	372.88
Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	213.70	23.58	377.25
Application of liquid zinc 39.5% @ 750 ml ha^{-1} at tillering and panicle initiation stage	216.94	24.56	378.35
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal + Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	220.41	28.30	386.14
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal	218.18	26.07	384.92
Untreated control	210.05	21.89	368.86
S.Em±	9.42	1.86	6.91
CD (P=0.05)	NS	NS	NS

N, P and K uptake

Data on N, P and K uptake by grain, straw and its total (grain + straw) have been depicted through fig. 1, 2 and 3. Application of liquid zinc @ 750 ml ha^{-1} registered maximum nitrogen, phosphorus and potash uptake by grain and straw. The lowest values for uptake of these nutrients were noticed under untreated control. Similar of the trend was also observed for total nitrogen, phosphorus and potash uptake.

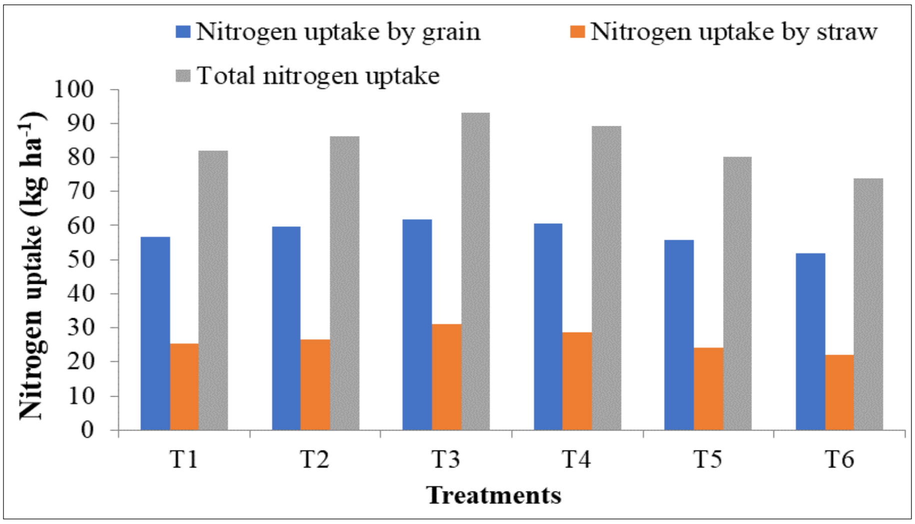

Fig 1: Effect of soil and foliar application of zinc on nitrogen uptake by grain and straw

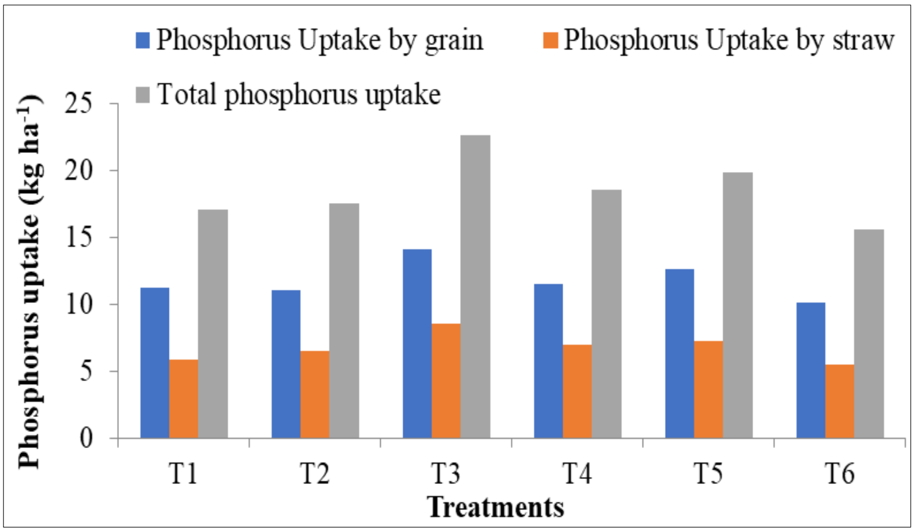

Fig 2: Effect of soil and foliar application of zinc on phosphorus uptake by grain and straw

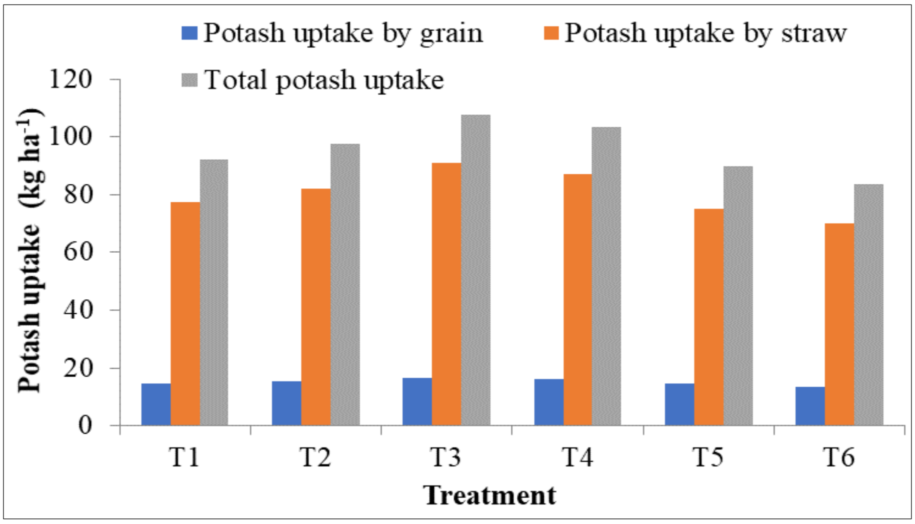

Fig 3: Effect of soil and foliar application of zinc on potash uptake by grain and straw

Zinc content

Zinc content in grain, straw and soil have been analysed and presented in Table 4. Zinc content in grain, straw and in soil increased with the application of zinc compared to untreated control.

The zinc content in soil was significantly increased under combination of basal application of zinc sulphate @ 10 kg ha^{-1} + Application of liquid zinc @ 500 ml ha^{-1} which was at par with basal application of zinc sulphate @ 10 kg ha^{-1}. Significant reduction in zinc content in soil was noticed when zinc was applied through foliar @ 750 or 500 or 250 ml ha^{-1} or not applied i.e. untreated control.

The highest zinc content in grain was recorded under Application of liquid zinc @ 750 ml ha^{-1} but it was at par with zinc sulphate @ 10 kg ha^{-1} in basal+ Application of liquid zinc @ 500 ml ha^{-1} Application of liquid zinc @ 500 ml ha^{-1} and alone zinc sulphate @ 10 kg ha^{-1}. Zinc content in straw was increased with zinc sulphate @ 10 kg ha^{-1} in basal+ foliar application of zinc @ 500 ml ha^{-1} and found to be comparable with foliar application of zinc @ 750 or 500 ml ha^{-1} and basal application of zinc sulphate @ 10 kg ha^{-1}. The lowest zinc content in grain as well as in straw was recorded under untreated control.

Table 4: Effect of soil and foliar spray of zinc on availability of zinc in soil, grain and straw

Treatment	Zinc content (mg/kg)		
	Soil	Grain	Straw
Application of liquid zinc 39.5% @ 250 ml ha^{-1} at tillering and panicle initiation stage	0.96	18.11	23.38
Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	1.03	19.23	25.65
Application of liquid zinc 39.5% @ 750 ml ha^{-1} at tillering and panicle initiation stage	1.04	19.93	26.15
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal + Application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	1.52	19.47	26.80
Zinc Sulphate 33% @ 10 kg ha^{-1} as basal	1.43	18.73	25.25
Untreated control	0.91	16.67	20.68
S.Em±	0.05	0.43	0.71
CD (P=0.05)	0.15	1.31	2.14

Zinc uptake

Zinc uptake by grain, straw and total (grain + straw) have been computed and presented in Table 5.

The highest zinc uptake by grain and total (grain + straw) was obtained under application of liquid zinc @ 750 ml ha^{-1} which was comparable with zinc sulphate @ 10 kg ha^{-1} as basal + Application of liquid zinc @ 500 ml ha^{-1} and Application of liquid zinc @ 500 ml ha^{-1}. Although zinc uptake by straw was maximum under application of zinc sulphate @ 10 kg ha^{-1} + Application of liquid zinc @ 500 ml ha^{-1} but it was at par with Application of liquid zinc @ 750 or 500 ml ha^{-1}. The lowest zinc uptake by grain, straw and total (grain+straw) was observed under untreated control.

The zinc uptake was increased obviously due to their higher concentration and grain and straw yield. The zinc concentration (grain and straw) and grain and straw yield were reduced under untreated control which resulted in reduction in uptake. These findings are in accordance with Fageria *et al.* (2011) [2].

Table 5: Effect of soil and foliar spray of zinc on uptake of zinc by grain and straw

Treatment	Zinc uptake (g/ha)		
	Grain	Straw	Total
Foliar application of liquid zinc 39.5% @ 250 ml ha^{-1} at tillering and panicle initiation stage	88.35	135.45	223.80
Foliar application of liquid zinc 39.5% @ 500 ml ha^{-1} at tillering and panicle initiation stage	96.43	150.17	246.60
Foliar application of liquid zinc 39.5% @ 750 ml ha^{-1} at tillering and panicle initiation stage	100.33	163.49	263.82
Application of Zinc Sulphate 33% @ 10 kg ha^{-1} as basal fb liquid zinc 39.5% @ 500 ml at tillering and panicle initiation stage	97.68	165.61	263.29
Application of Zinc Sulphate 33% @ 10 kg ha^{-1} as basal	90.99	146.77	237.76
Untreated control	76.48	109.59	186.07
S.Em±	3.07	6.24	6.61
CD (P=0.05)	9.24	18.80	19.90

Conclusion

The highest zinc uptake by grain and total (grain + straw) was obtained under foliar application of zinc @ 750 ml ha^{-1} which was comparable with basal application of zinc sulphate @ 10 kg ha^{-1} + foliar application of zinc @ 500 ml ha^{-1} and foliar application of zinc @ 500 ml ha^{-1}. Although zinc uptake by straw was maximum under application of zinc sulphate @ 10 kg ha^{-1} + foliar application of zinc @ 500 ml ha^{-1} but it was at par with foliar application of zinc @ 750 or 500 ml ha^{-1}. The lowest zinc uptake by grain, straw and total (grain+straw) was observed under untreated control.

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