

Long-Term Application of Zinc and Crop Residue on Yield and Uptake of Micronutrients in Transplanted Rice under Rice-Wheat Cropping System in Calciorthents

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Abstract

A long-term field experiment on integrated nutrient management of zinc and crop residue in rice-wheat cropping system was conducted since 1994. The effect of zinc and crop residues on soil properties and yield of rice was studied after 10 years of cropping cycle on calciorthents. Long-term application of zinc and crop residues increased the organic matter content of soil. The combined use of zinc and crop residues significantly increased crop yield, uptake and availability of micronutrients in soil over chemical fertilizer alone.

Key words : Crop residues, Transplanted rice, Residual effect, Calciorthents.

Rice-wheat is the most widely practiced cropping system in northern India. Both rice and wheat are exhaustive feeders of nutrients. Rice is highly responsive to fertilizer applications and differs considerably from conventional varieties in respect of nutrient requirement mainly because of its high yield potential. The productivity of soil depends upon the adequate and balanced amount of all essential nutrients including the micronutrients. In rice-wheat system, continuous use of NPK fertilizer has remarkably increased production but simultaneously brought about problems related to micronutrients deficiencies, particularly that of zinc in soil. According to Singh (2001) about 45% of the Indian soils are deficient in zinc. Crops require only small amount of Zn for their normal growth but its application rate is high due to low fertilizer use efficiency. Therefore the present study was carried out to assess long-term application of zinc and crop residue on transplanted rice under rice-wheat cropping system.

Methods

A field experiment was conducted during 1993-94 in light textured highly calcareous soil deficient in available zinc (0.56 mg/kg) at Research Farm, RAU,

Pusa. The experiment soil (0—15 cm) had pH (1 : 2) 8.6, EC 0.36 dS/m, organic carbon 0.62 g/kg available N 315 kg/ha, available P 17.3 kg/ha, available K 162 kg/ha, DTPA-Zn 0.56 mg/kg, Fe 15.82 mg/kg, Mn 3.30 mg/kg and Cu 2.28 mg/kg. Four levels of crop residues viz. no crop residue (CR₀), 25% of straw produced (CR₂₅), 50% of straw produced (CR₅₀) and 100% of straw produced (CR₁₀₀) were applied as treatments in main plots. The treatments were given to each crop in each year. The main plot was divided into four sub-plots in which treatments viz., no Zn (Zn₀), 2.5 kg Zn/ha (Zn_{2.5}), 5.0 kg Zn/ha (Zn_{5.0}) and 10 kg Zn/ha (Zn_{10.0}) were superimposed over crop residues levels. These four levels of Zn were applied only to first crop as starter dose. The experiment was laid out in a split plot design with three replications and plot size 5.0 m × 2.0 m. Rice and wheat crops were grown continuously under rice-wheat cropping system. Rice cv Rajshree were grown as 21st test crops during reported period of 2003-04.

Straw and grain samples were taken at the harvest of crop. The grain and straw samples were washed sequentially in detergent solution (0.2% liquid detergent), 0.1 N HCl solution and deionized water and dried in oven at 70C. Finely ground samples were digested in a di-acid mixture (HNO₃ : HClO₄, 3 : 1

Table 1. Long-term effect of zinc and crop residue incorporation on grain and yields of rice.

Zinc levels (kg/ha)	Grain yield (q/ha)					Straw yield (q/ha)				
	Crop residue level (% of straw produce)					Crop residue level (% of straw produce)				
	0	25	50	100	Mean	0	25	50	100	Mean
0	16.3	20.0	21.3	25.0	20.6	28.6	28.3	37.0	42.3	34.0
2.5	22.6	25.0	25.6	32.0	26.3	41.0	46.6	52.6	56.3	49.1
5.0	29.3	31.1	35.3	37.6	33.4	51.0	55.0	57.6	60.0	55.9
10.0	31.3	34.3	35.3	39.3	35.0	57.0	63.0	65.0	68.6	63.4
Mean	24.9	27.8	29.2	33.5	–	44.4	48.9	52.4	56.8	–
	SE ±		CD (<i>P</i> = 0.05)			SE ±		CD (<i>P</i> = 0.05)		
CR	0.82		2.41			0.70		2.32		
Zn	0.74		2.56			0.64		2.39		
CR × Zn	1.63		2.86			1.62		4.65		

vol/vol) and diluted. Digested samples were analyzed for micronutrients using atomic absorption spectrophotometer. Total uptake of micronutrients by grain and straw was computed. Surface soil samples from experimental plots were collected at the harvest of rice crop as 21st crop and analyzed for DTPA-extractable micronutrients as described by Lindsay and Norvell (1978).

Results and Discussion

Crop Yield

The grain and straw yields varied from 16.3 to 39.3 q/ha and 28.6 to 68.6 q/ha, respectively due to different treatment combinations (Table 1). The re-

sidual effect of zinc significantly enhanced the mean grain and straw yields of rice from 20.6 to 35.0 q/ha and 34.0 to 63.4 q/ha, respectively even after 10 years of application. This may be probably due to two reasons : firstly, because of decrease in available zinc levels in soil under no Zn treatment and secondly, due to solubilization of native and applied zinc at higher levels by different crop residues which produces complexing agents and nutrients after microbial decay of crop residue. Increase in yield due to Zn application was also reported by Singh et al. (2004). The mean grain and straw yields of rice increased continuously from 24.9 to 33.5 q/ha and 44.4 to 56.8 q/ha, respectively with increasing crop

Table 2. Long-term effect of Zn and crop residue incorporation on micro-nutrients uptake by rice.

Treatments	Micronutrient uptake (g/ha)			
	Zn	Cu	Fe	Mn
Zn ₀	233	76.3	2416	621
Zn _{2.5}	259	79.5	2425	677
Zn _{5.0}	279	82.6	2460	708
Zn _{10.0}	307	86.3	2449	733
Mean	269	81.2	2437	685
CD (<i>P</i> = 0.05)	21.65	2.18	NS	50.87
CR ₀	206	70.8	2189	598
CR ₂₅	240	78.3	2350	653
CR ₅₀	287	83.9	2530	718
CR ₁₀₀	346	91.7	2681	771
Mean	270	81.2	2437	685
CD (<i>P</i> = 0.05)	20.13	1.29	42.77	37.09

Table 3. Long-term effect of Zn and crop residue incorporation on organic carbon (%) and DTPA extractable micronutrients (mg/kg) in post harvest soil of rice.

Treatments	DTPA extractable micronutrients uptake (mg/kg)				
	OC (%)	Zn	Cu	Fe	Mn
Zn ₀	0.75	0.57	3.30	18.11	4.54
Zn _{2.5}	0.78	0.68	3.28	18.03	4.52
Zn _{5.0}	0.80	0.78	3.39	17.95	4.42
Zn _{10.0}	0.83	1.00	3.20	17.51	4.30
Mean	0.79	0.76	3.30	17.90	4.44
CD (<i>P</i> =0.05)	0.03	0.03	NS	NS	0.12
CR ₀	0.70	0.43	3.10	17.07	4.25
CR ₂₅	0.75	0.58	3.12	17.19	4.25
CR ₅₀	0.81	0.85	3.26	18.17	4.47
CR ₁₀₀	0.89	1.16	3.66	19.16	4.80
Mean	0.79	0.75	3.28	17.90	4.44
CD (<i>P</i> =0.05)	0.02	0.02	0.29	0.19	0.09

residues levels. Addition of crop residues have built up the organic carbon content of soil in the ratio to crop residues levels after their decomposition due to increase in microbial population with time and raised the soil fertility level which might have influenced the yield. The highest yield was recorded at 100% crop residue level and residual Zn of 10 kg/ha. The effects of crop residue and residual Zn on rice yield were statistically significant. The grain and straw yields of rice at 50% crop residue level along with starter dose of 10 kg Zn/ha were at par with yields obtained at 100% crop residue incorporation alone. Increase in crop yield due to Zn application was also reported by Sharma and Bapat (2000).

Micronutrient Uptake

The increase in total Zn uptake by rice from 233 to 307 g/ha with residual effect of zinc was mainly due to increase in yield and Zn concentration in rice with Zn application (Table 2). Crop residue application increased Zn uptake from 206 to 346 g/ha. Crop residue on decay produced a varieties of substance which stimulated the solubility and transport and availability of Zn. Similar results were also reported by Prasad et al. (1995) in calcareous soil under rice-wheat system. The different combination of crop residue and Zn increased Cu, Fe and Mn uptake from 76.3 to 86.3, 2416 to 2449 and 621 to 733 g/ha, respectively with the application of increasing levels of residual Zn. Application of crop residue augmented total uptake of Cu, Fe and Mn from 70.8 to 91.7, 2189 to 2681 and 598 to 771 g/ha respectively. The effect of crop residue on Fe uptake by rice was significant. Similar results were also reported by Sakal et al. (1996).

DTPA Extractable Micronutrients

Crop residues increased DTPA extractable Zn, Fe, Cu and Mn from 0.43 to 1.16, 17.07 to 19.16, 3.10 to 3.66 and 4.25 to 4.80 mg/kg, respectively after harvest of rice (Table 3). Similarly residual Zn increased DTPA extractable Zn from 0.5 to 1.00 and decreased available Fe, Cu and Mn from 18.11 to 17.51, 3.30 to 3.20 and 4.54 to 4.30 mg/kg. Similar results were obtained by Rathore et al. (1974), who also reported that there was antagonistic relationship between Zn and

Fe and Cu in soil. Numerous compounds produced after decay of crop residues including humic and fulvic acids and variety of biochemical substances (organic acid, polyphenols, amino acids and polysachharides) form stable complexes with Zn, Fe, Cu and Mn and promoted their availability in soil. It can be concluded that crop residues after decay, besides supplying micronutrients in readily available form to plants, react with applied and native reserve of micronutrients rendering them available to plant. Organic colloids formed after decay of crop residue, which function as a sink for micronutrients, play a significant role in the solubilization and transport of micronutrients to plant roots by increasing their diffusion and convective flow (Sinha and Prasad 1977).

Conclusion

Increasing levels of crop residue progressively enhanced the yield and micronutrient uptake at various Zn levels. Application of 2.5 kg Zn/ha as a starter dose and 50% crop residues of each crop was much effective as 100% crop residue alone. Crop residues augmented DTPA extractable Zn, Fe, Cu, Mn and OC in soil. Crop residue incorporation and zinc as starter dose hold a great promise not only in securing a high levels of crop productivity and soil fertility but against emergence of multiple micronutrients deficiency and protect from deterioration of soil health.

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