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# LONG TERM EFFECT OF RESIDUAL ZINC AND CROP RESIDUE ON YIELD, AND UPTAKE OF MICRONUTRIENTS IN RICE IN CALCAREOUS SOIL

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## ABSTRACT

*Present investigation is a part of long term experiment which was started in 1994 in highly calcareous and zinc deficient soil in split plot design with crop residue levels in main plots and zinc levels in sub plots. For present investigation 17$^{th}$ cycle rice crop was grown as 33$^{rd}$ crop. Long term application of crop residues along with Zn increase grain yield (30.3 to 43.0 q ha$^{-1}$) and straw yield (58.7 to 78.32 ha$^{-1}$) in rice. Concentration of micronutrients increased in rice grain from 18.40 to 29.85 mg of Zn, 4.74 to 8, 58 mg of Cu, 46.0 to 56.0 mg of Fe and 40.2 to 51.4 mg kg$^{-1}$ of Mn. The uptake of micronutrient by rice crop increased from 57.1 to 121.4 g of Zn, 14.6 to 30.8 g of Cu, 142.8 to 229.2 g of Fe and 126.5 to 206.5 g Mn ha$^{-1}$. The highest yield was recorded in residual effect of 10 kg Zn ha$^{-1}$ along with crop residue of 100% of the straw produced by the crop. The residual value of 5 kg Zn ha$^{-1}$ + 100% of crop residue was the next promising treatment in enhancing the crop yield.*

**Key words:** Crop residue, yield, micronutrients, uptake, concentration, rice, calcareous soil

## INTRODUCTION

Rice is the unique grain that is entirely used as human food. It is an important crop in India contributing 45% to the total food grain production and staple food for more than 60% of world population (Singh et al. 2012). Zinc deficiency is a major problem in calcareous soils. The solubility and availability of zinc are highly dependent on pH. Due to high pH, the calcareous soils are mostly deficient in Zn. Only 5-6 per cent of total Zn in calcareous soil of Bihar accounted to bio-available forms (Sakal et al., 1996) which indicates the lower availability in soil, Zinc deficiencies are likely to escalate further as our soils have to produce extra food, fiber, fuel fodder and fruit per unit area per unit time to meet the additional food requirements of burgeoning population. In order to achieve higher crop production, balanced and integrated nutrient supply and proper management of soil fertility is essential. Continuous use of inorganic fertilizers started to deplete the soil fertility so now the time is to adopt the method of plant waste material used as organic source like crop residue incorporation to recycle the nutrient added to the previous crops. Application of different levels of crop residues along with common recommended dose of major nutrients for efficient growth of crop prevent the decline in organic carbon and also bridge up the gap between potential and actual yield of rice. Further, use of crop residue had favourable effect on physico chemical and biological properties of soil due to supply of macro and micro-nutrients to the crop properly. Further more, the decomposition and mineralization of crop residue is a slow process which could match the nutrient requirement of a crop and thus limits the loss of precious plant food. Therefore, the present study was undertaken to gain the systematic information on the long term effect of crop residue in rice crop in calcareous soils.

## MATERIALS AND METHODS

A field experiment was started in kharif 1994 in light textured highly calcareous soil deficient in available Zn at RAU Research Farm, Pusa in split-spot design with three replications. Crop residues were assigned to main plot and Zn levels to sub-plots. Rice was grown as general crop applying recommended dose of N, $P_2O_5$, and $K_2O$ before the start of experiment. After harvest, the straw was weighed and treated as crop residue. The initial soil had pH 8.6, EC 0.36 dSm$^{-1}$, organic carbon 6.2 g kg$^{-1}$, free $CaCO_3$ 35.6% and DTPA extractable Zn 0.56 mg kg$^{-1}$, Fe 17.1 mg kg$^{-1}$, Cu 3.14 mg kg$^{-1}$ and Mn 4.56 mg kg$^{-1}$. Four levels of crop residues (0, 25, 50 and 100% of straw produced) are being incorporated in main pots continuously after each crop harvest since the commencement of experiment. Four Zn levels (0, 2.5, 5.0 and 10.0 kg Zn ha$^{-1}$) in sub-plots were applied only once to first crop rice during Kharif, 1994 as starter dose. Rice cv. Rajshree was grown as 33$^{rd}$ during reported period of 2010 and 2011. Recommended dose NPK (120:60:40) was applied to rice crop as urea, single superphosphate and muriate of potash respectively. The half of nitrogen and entire dose of P and K were applied at the time of transplanting of rice and remaining N fertilizer was applied in the equal splits at tillering and flower initiation stage. The crop residue in terms of straw production in respective treatment plots was added after the harvest of wheat crop. The crop was allowed to grow till maturity to record grain and straw yield. The plant samples (grain and straw) from rice plots were collected, processed and washed sequentially in detergent solution (0.2% liquid), 0.01 N HCI and detonized water and dried in oven at 70°C. Finely ground samples were digested in a di-acid mixture and digests were analyzed for micronutrients using atomic absorption spectrophotometer. The micronutrients uptake by rice crop was computed by contents of micronutrient with grain and straw yield.

## RESULTS AND DISCUSSION

### Crop yields

The grain and straw yield of 33rd rice crop due to residual zinc (table 1) varied from 33.6 to 38.3 and 62.5 to 73.9 q ha$^{-1}$ respectively. This may be due to solubilization of native as well as applied zinc at higher levels by crop residues which produces complexing agents (Singh and Tripathi, 2005). Crop residue significantly increased the mean grain and straw yields of rice from 31.0 40.6 and 63.9 to 73.9 q ha$^{-1}$, respectively (Table 1). Highest yield of rice crop was recorded in treatment receiving 10 kg Zn ha$^{-1}$ as starter dose along with incorporation of 100% of the straw produced by each crop. The interactive effects of crop residue and residual Zn on rice yield were statistically significant. There was an linear increase in yield due to increasing levels of crop residues at all the residual levels of zinc. The improvement in organic carbon, microbial population and physical properties of the soil may be the reason of the more crop productivity (Prasad and Sinha, 1995; Pandey, 2012). (Rathod *et al.* (2012) also reported similar results. The residual value of 5 kg Zn ha$^{-1}$ + 100% of crop residue was the next promising treatment in enhancing the crop yield. Yadav et al. (2013) also reported response of rice to zinc and organic matter application.

Table 1: Effect of zinc and crop residue (CR) levels on yield of rice (17th cycle)

| Residual Zn (kg ha$^{-1}$) | Crop residue (% of straw produced) | | | | |
|---|---|---|---|---|---|
| | 0 | 25 | 50 | 100 | Mean |
| | | | **Graim yield (q ha$^{-1}$)** | | |
| 0 | 30.3 | **32.5 | 34.0 | 37.7 | 33.6 |
| 2.5 | 31.2 | 33.0 | 37.3 | 40.0 | 35.4 |
| 5.0 | 31.3 | 36.7 | 38.7 | 41.7 | 37.1 |
| 10.0 | 31.3 | 38.7 | 40.7 | 43.0 | 38.3 |
| Mean | 31.0 | 35.2 | 37.7 | 40.6 | - |
| CD (P=0.05) | | CR 1.21, Zn 1.13, CR x Zn, 2.26 | | | |
| | | | **Straw yield (q ha$^{-1}$)** | | |
| 0 | 58.7 | 59.7 | 61.3 | 70.3 | 62.5 |
| 2.5 | 61.7 | 62.8 | 65 | 74.7 | 66.1 |
| 5.0 | 66.3 | 68 | 70.3 | 72.3 | 69.2 |
| 10.0 | 69 | 73.7 | 74.7 | 78.3 | 73.9 |
| Mean | 63.9 | 66.1 | 67.8 | 73.9 | - |
| CD (P=0.05) | | CR 1.36, Zn 1.62, CR x Zn, 3.24 | | | |

### Concentration of micronutrients

It is evident from the data (Table 2) that increasing levels of crop residue along with residual Zn increased the concentration of zinc, copper, iron and manganese in grain and straw of rice. Increasing levels of crop residue enhanced the average Zn concentration in rice grain from 18.4 to 29.8 and in straw from 23.6 to 30.6 mg kg$^{-1}$ whereas residual Zn increased the mean Zn concentration in rice grain from 23.9 to 28.1 and in straw from 24.2 to 27.9 mg kg$^{-1}$. Tripathi and Rawat (2002) reported similar results. The increase in Zn content may be attributed to increased availability of Zn due to addition of crop residue. Yadav *et al.* (2013) reported similar results in rice. Copper content in rice grain and straw increased significantly with incorporation of crop residue over control. Significant increase in copper concentration in rice grain and straw was found with zinc application. It varied from 5.3 mg kg$^{-1}$ at control to 6.7 mg kg$^{-1}$ at residual 10 kg Zn ha$^{-1}$. The significant increase in Mn content in grain and straw of rice was observed with the increase in the levels of applied crop residue. The maximum Mn content in rice grain and straw was obtained in the highest level (100%) of crop residue and lowest in control. The mean Mn content in rice grain varied from 40.8 to 50.9 mg kg$^{-1}$ and in straw it varied from 62.7 to 66.9 mg kg$^{-1}$ with increase in level of crop residue incorporation from 0 to 100%. Increasing level of residual Zn without crop residue incorporation produced fluctuating effect on Fe content in rice grain and straw (Table 2). Incorporation of crop residue increased the Fe content in grain and straw of rice crop. Further, increasing levels of crop residue incorporation progressively and significantly increased the mean Fe content in the crop (Table 2). The increase was from 46.0 to 56.0 and 93.4 to 108.5 mg kg$^{-1}$ in rice grain and straw, respectively (Chandel *et al.* 2013).

Table 2: Effect of residual Zn and crop residue on concentration of micronutrient cations (mg kg$^{-1}$) in rice

| **Treatment** | **Zinc** | | **Copper** | | **Iron** | | **Manganese** | |
|---|---|---|---|---|---|---|---|---|
| **Crop residue (%)** | **Grain** | **Straw** | **Grain** | **Straw** | **Grain** | **Straw** | **Grain** | **Straw** |
| 0 | 18.4 | 23.6 | 4.6 | 5.8 | 46.0 | 93.4 | 40.8 | 62.7 |
| 25 | 26.5 | 26.8 | 5.8 | 6.2 | 49.4 | 99.2 | 44.8 | 61.7 |
| 50 | 28.2 | 27.3 | 6.6 | 6.9 | 53.3 | 103.1 | 48.6 | 65.1 |
| 10 | 29.8 | 30.6 | 7.5 | 7.1 | 56.4 | 108.5 | 50.9 | 66.9 |
| CD (P=0.05) CR | 0.56 | 1.45 | 1.28 | 0.20 | 1.24 | 1.91 | 3.46 | 3.09 |
| Residual Zn (kg ha$^{-1}$) | | | | | | | | |
| 0 | 23.9 | 24.2 | 5.3 | 6.2 | 48.4 | 95.8 | 44.6 | 62.0 |
| 2.5 | 24.9 | 26.8 | 6.1 | 6.4 | 50.3 | 99.4 | 46.0 | 62.8 |
| 5.0 | 25.9 | 27.8 | 6.5 | 6.6 | 52.6 | 102.8 | 47.2 | 63.9 |
| 10.0 | 28.1 | 27.9 | 6.7 | 6.7 | 56.4 | 106.3 | 47.4 | |
| CD (P=0.05) | 1.30 | 1.16 | 0.78 | NS | 1.09 | 1.35 | NS | 3.09 |

**Uptake of micronutrients**

It is evident from the data (Table 3) that increasing levels of crop residue increased the uptake of zinc, copper iron, manganese by grain and straw. The uptake of zinc by grain with zinc varied from 81.5 to 109.9 and 152.6 to 218.6 g ha$^{-1}$ by straw. The Zn uptake obviously increased with the application of Zn. Yadav *et al.* (2013) observed that Zn and crop residue treatment exerted a favourable influence on zinc uptake by rice crop. Crop residue also increased Zn uptake from 57.1 to 121.4 g ha$^{-1}$ in grain and 151.3 to 226.7 g ha$^{-1}$ in straw. The minimum Zn uptake was recorded at no crop residue (control) and maximum at 100% crop residue. These approaches are in accordance with the findings of Dubey and Chauhan (2002) and Singh and Tripathi (2005). Tripathi and Kumar (2013), Meena *et al.* (2008).

Table 3: Effect of residual Zn and crop residue on uptake of micronutrient cations(g ha$^{-1}$) by rice

| **Treatment** | **Zinc** | | **Copper** | | **Iron** | | **Manganese** | |
|---|---|---|---|---|---|---|---|---|
| | **Grain** | **Straw** | **Grain** | **Straw** | **Grain** | **Straw** | **Grain** | **Straw** |
| Crop residue (%) | | | | | | | | |
| 0 | 57.1 | 151.3 | 14.6 | 37.4 | 142.8 | 559.2 | 126.5 | 401.4 |
| 25 | 93.9 | 178.7 | 20.8 | 40.9 | 174.5 | 656.2 | 158.2 | 408.0 |
| 50 | 106.5 | 186.8 | 25.3 | 47.0 | 201.1 | 701.6 | 183.7 | 442.9 |
| 10 | 121.4 | 226.7 | 30.8 | 52.5 | 229.2 | 802.4 | 206.5 | 494.6 |
| CD (P=0.05) | 4.7 | 8.5 | 4.9 | 1.2 | 9.0 | 24.0 | 6.33 | 9.55 |
| Residual Zn (kg ha$^{-1}$) | | | | | | | | |
| 0 | 81.5 | 152.6 | 18.2 | 39.2 | 163.8 | 601.0 | 150.9 | 388.1 |
| 2.5 | 89.5 | 178.9 | 22.0 | 42.8 | 179.1 | 658.6 | 164.1 | 415.6 |
| 5.0 | 97.9 | 193.4 | 24.7 | 46.2 | 196.3 | 712.8 | 176.3 | 442.7 |
| 10.0 | 109.9 | 218.6 | 26.5 | 49.7 | 208.4 | 786.9 | 183.6 | 500.6 |
| CD (P=0.05) | 5.0 | 9.3 | 2.8 | 5.7 | 6.1 | 17.8 | 5.11 | 9.01 |

The uptake of copper by rice grain and straw was maximum under the residual effect of 10 kg Zn ha$^{-1}$. The ranges of copper uptake in grain and straw were from 18.2 to 26.5 and 39.2 to 49.7 g ha$^{-1}$, respectively. Copper uptake by rice crop was found to be significantly highest (30.8 g ha$^{-1}$ in grain and 52.5 g ha$^{-1}$ in straw) under sole crop residue (100%) treated plots. This might be due to higher supply of copper through enhanced availability from the soil due to incorporation of crop residue. This was in line of harmony with the finding of Singh *et al.* (2013). Iron uptake in rice was found to be ranging between 163.8 and 208.4 g ha$^{-1}$ in grain and 601.0 and 786.9 g ha in straw with residual effects of zinc. Incorporation of crop residue also enhanced the iron uptake by rice grain and straw from 142.8 to 229.2 and 559.2 to

802.4 g $ha^{-1}$, respectively. The maximum and minimum uptake of iron was recorded when 100% crop residue was incorporated into soil and absolute control, respectively. This showed that crop residue increased the grain and straw yield of rice and iron content and ultimately iron uptake by the crop. Chandel *et al.* (2013) also reported similar results. The residual effect of zinc resulted in significantly higher uptake of manganese by rice crop. Manganese uptake by rice grain and straw increased from 150.9 to 183.0 and 388.1 to 500.6 g $ha^{-1}$, respectively with residual 10 kg Zn $ha^{-1}$. This increase may be attributed to increased grain and straw production due to residual effect of zinc. Incorporation of crop residue resulted in higher uptake of Mn by rice grain and straw than no crop residue (control) treatment. Crop residue improves the physic-chemical properties of soil. The improved physic-chemical properties and availability of Mn at a slow rate for longer time with the use of crop residue might be responsible for higher uptake of Mn (Singh *et al.* 2013).

It is concluded that a long term incorporation of crop reside and residual effect of zinc increased yield, concentration and uptake micronutrient in rice crop. The highest yield was recorded in treatment receiving 10 kg Zn $ha^{-1}$ as starter dose along with 100%crop residue incorporation. The residual value of 5 Kg Zn $ha^{-1}$ + 100% of crop residue was the next promising treatment in enhancing the crop yield.

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