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# Effect of Zn on Starch Content of Paddy and Zinc Content of Soil, Leaf and Root of Rice Grown in Calcareous Soils

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## ABSTRACT

A pot culture study was conducted to evaluate the effect of different levels of zinc on the Zn content of leaf, soil, roots and starch content of paddy in eight different calcareous soil series of D.I.Khan. Zn as $ZnSO_4$ was applied @ 0, 5, 10 and 15 kg $ha^{-1}$ along with the basal doses of 120 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ $ha^{-1}$. Zn contents of root, leaf before and after flowering and Zn content of soil before flowering and after harvest increased. There was no effect of Zn on starch in paddy. Maximum Zn content of rice leaf before and after flowering was observed with application of 15 kg Zn $ha^{-1}$ in these soil series. In Ramak soil series paddy had the highest starch content while it was the lowest grown on Tikken soil series.

**Key Words:** Rice; Zn; Calcareous Soils

## INTRODUCTION

Rice has been reported more prone to Zn deficiency than upland crops like wheat (Kausar *et al*., 1976). In submerged calcareous soils the availability of zinc becomes low hence its, deficiency has been reported countrywide in rice soils (Bhatti & Rashid, 1985). It is therefore, imperative to apply zinc to such soils in addition to major nutrients for obtaining maximum yields. Application of zinc to soil is the most satisfactory way to cure zinc deficiency except for crops such as citrus on alkaline soils (Katyal & Randhawa, 1983). Zinc deficiency is the most common nutrient disorder constraining rice productivity worldwide and is effectively controlled by field application of zinc sulphate (Rashid, 1996). Increases in the level of zinc increase the Zn content of roots more than that of shoots (Gangwar *et al*., 1977; Mehdi *et al*., 1990). It has been reported that P and Zn application significantly increased root CEC which in turn increased nutrient uptake (Julan *et al*., 1990; Tiwari *et al*., 1975). Fe and Zn either alone or in combination significantly influenced uptake of each other (Hussain, 1973). Combined application of NPK, organic manures (GM or FYM) and Zn significantly increased the Zn, N and K contents while lowered the P content of paddy and straw (Yaseen *et al*., 1999).

## MATERIALS AND METHODS

A pot experiment was conducted on eight calcareous soils i.e. Notak, Zandani, Saggu, Tikken, Rustum, Ramak, Sodhra and Shahdera. Bulk soil samples from 0-30 cm depth were collected from the selected sites before sowing of crop and analyzed for physico-chemical characteristics according to the methods described by Page *et al*. (1982). These measurements are presented in Table I. Rice variety IRRI-6 was used in these studies. Ten kilogram of air dried, ground and sieved (2-mm sieve) soil of each soil series was put into earthen pots (26-cm dia) lined with polythene. Zinc in the form of $ZnSO_4.7H_2O$ at the rate of 0, 5, 10 and 15-kg $ha^{-1}$ was applied to pots. Pots were placed according to Split Plot Design with soil series as main plot and Zn levels as sub plot in three repeats. N, P and K were applied as basal dressing at the rates of 120 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ $ha^{-1}$ in the form of urea, TSP and $K_2SO_4$, respectively. All P, K, Zn and half dose of N were applied at the sowing time. The remaining half of N was applied at panicle initiation. The crop was transplanted during the last week of June and harvested during the 1st week of October. Crop was harvested at maturity, tissue samples for all the treatment were oven dried at 70°C. Flag leaf and soil samples were collected potwise at panicle initiation stage and after harvest. Plant material was prepared by dry ash method as described by Issac and Johnson (1975) and Zn was determined by atomic absorption spectrophotometer. Ground plant samples were analyzed for starch and zinc content following standard procedures as given by Page *et al*. (1982). Statistical analysis of all the data was done using Fisher Analysis of Variance Technique and least significant difference test was applied at 5% probability level to determine the difference among treatment means (Steel & Torrie, 1984).

## RESULTS AND DISCUSSION

**Effect of Zn on the zinc content of rice leaf before flowering**. Data on zinc content of rice leaf under different levels of zinc application to soil before flowering in eight soil series are given in Table II. It was observed that the Zn content of rice leaf varied significantly among the Zn treatments and soil series. The zinc content of rice leaf before flowering increased significantly with zinc addition. Maximum zinc content of 69.09 ppm in leaf was recorded in

**Table I. Physico-Chemical Properties of Eight Soilseries of D.I. khan district**

| | | Soil Series | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Unit** | **Notak** | **Zandani** | **Saggu** | **Tikken** | **Rustam** | **Ramak** | **Sodhra** | **Shahdera** |
| Clay | % | 50 | 42 | 56 | 26 | 35 | 77 | 11 | 13 |
| Silt | % | 40 | 46 | 27 | 43 | 60 | 30 | 02 | 60 |
| Sand | % | 10 | 12 | 17 | 31 | 05 | 03 | 87 | 27 |
| **Textural class** | | **Silty clay** | **Silty clay** | **Clay** | **Clay Loam** | **Silty clay loam** | **Clay** | **Loamy Sand** | **Silt Loam** |
| PH | | 8.10 | 8.10 | 8.30 | 7.90 | 8.00 | 8.40 | 8.10 | 8.00 |
| EC | dS/m | 4.00 | 3.50 | 3.80 | 3.00 | 3.20 | 3.60 | 3.70 | 3.25 |
| CEC | me/ 100g | 14.20 | 7.50 | 23.20 | 14.20 | 12.70 | 24.30 | 2.60 | 13.20 |
| $CaCO_3$ | % | 16.00 | 15.00 | 16.50 | 12.00 | 13.00 | 19.00 | 16.00 | 13.00 |
| OM | % | 0.56 | 0.62 | 0.56 | 0.78 | 0.69 | 0.51 | 0.54 | 0.67 |
| | | **Soluble Constituents.(1:5)** | | | | | | | |
| $Ca^{++}+Mg^{++}$ | me/L | 2.80 | 2.60 | 2.90 | 2.20 | 2.30 | 3.20 | 3.00 | 2.50 |
| $CO_3^{-}$ | me/L | 0.55 | 0.45 | 0.60 | 0.30 | 0.55 | 0.45 | 0.60 | 0.30 |
| $HCO_3^{-}$ | me/L | 2.30 | 1.80 | 2.60 | 1.50 | 1.52 | 3.80 | 2.80 | 1.60 |
| $Cl^{-}$ | me/L | 2.60 | 2.29 | 2.70 | 2.20 | 2.27 | 3.00 | 2.80 | 2.27 |
| $SO_4^{-}$ | me/L | 0.41 | 0.36 | 0.56 | 0.20 | 0.25 | 0.80 | 0.61 | 0.30 |
| Total N | % | 0.029 | 0.030 | 0.028 | 0.045 | 0.042 | 0.025 | 0.027 | 0.040 |
| Avail.P | ppm | 11.00 | 7.60 | 11.30 | 4.98 | 6.40 | 14.20 | 11.50 | 7.30 |
| Avail.K | ppm | 78.00 | 95.00 | 78.00 | 120.0 | 104.0 | 74.00 | 75.00 | 99.00 |
| Avail.Zn | ppm | 0.23 | 0.30 | 0.18 | 0.45 | 0.40 | 0.13 | 0.14 | 0.38 |

the treatment receiving the highest zinc fertilization of 15 kg $ha^{-1}$. Minimum zinc content of 21.50 ppm in leaf was recorded in the control treatment. Similar results were reported by Sahu *et al.* (1996), Singh *et al*. (1996), Srivastava *et al*. (1999) and Iqbal *et al*. (2000).

In case of soil series, the plant grown in Tikken soils had maximum zinc content of 57.24 ppm. This might be attributed either to its original higher zinc content or to its lower pH and lower $CaCO_3$ content as suggested by Navrot and Ravilovitch (1969) who reported that zinc deficiency in soils with high content of $CaCO_3$ was due to the formation of insoluble $ZnCO_3$. Similar findings were reported by Mahendra and Singh (1981). They stated that the availability of zinc might had been decreased either as a result of its precipitation as $Zn(OH)_2$ due to increase in pH or its adsorption on $CaCO_3$ which released zinc slowly. Kausar *et al.* (1979) also reported a negative correlation between pH and available zinc in Punjab (r = -0.78) and in N.W.F.P.(r = -0.72). Rashid *et al.* (1987) also reported that availability of zinc to plants is inversely related to soil pH.

**Table II. Effect of soil application of zinc on the zinc content of rice leaf before flowering**

| **Soil Series** | **Treatments** | | | | **Mean** |
|---|---|---|---|---|---|
| **S. No** | **$T_1$** | **$T_2$** | **$T_3$** | **$T_4$** | |
| Notak | 20.17p | 38.49m | 54.70ij | 70.03ef | 43.27d |
| Zandani | 22.01op | 43.23l | 61.77h | 72.22d | 49.81c |
| Saggu | 19.57p | 36.70m | 53.03ij | 58.14efg | 41.86de |
| Tikken | 26.21n | 47.93k | 67.10g | 87.74a | 57.24a |
| Rustam | 23.76no | 44.49kl | 63.00h | 79.89b | 52.78b |
| Ramak | 18.81p | 35.53m | 51.37j | 56.99fg | 40.65e |
| Sodhra | 20.17p | 37.42m | 55.11i | 61.51e | 43.55d |
| Shahdera | 21.30op | 42.87l | 60.56h | 76.22c | 50.24c |
| Mean: | 21.50d | 40.83c | 58.33b | 69.09a | |

Values followed by the same letter are not significantly different at 5% level of probability

**Table III. Effect of soil application of zinc on the zinc content of soil before flowering**

| **Soil Series** | **Treatments** | | | | **Mean** |
|---|---|---|---|---|---|
| **S. No** | **$T_1$** | **$T_2$** | **$T_3$** | **$T_4$** | |
| Notak | 0.250qr | 0.450mno | 0.760efg | 0.840d | 0.575e |
| Zandani | 0.395p | 0.600jk | 0.790def | 0.911c | 0.674d |
| Saggu | 0.293q | 0.500lm | 0.690hi | 0.823d | 0.577e |
| Tikken | 0.510i | 0.720gh | 0.980ab | 1.020a | 0.808a |
| Rustam | 0.440nop | 0.650ij | 0.911c | 0.980ab | 0.745b |
| Ramak | 0.210r | 0.400lmn | 0.590jk | 0.750de | 0.487g |
| Sodhra | 0.240r | 0.460op | 0.630k | 0.806fg | 0.534f |
| Shahdera | 0.419nop | 0.629jk | 0.840d | 0.950bc | 0.709c |
| Mean: | 0.345d | 0.551c | 0.774b | 0.885a | |

Values followed by the same letter are not significantly different at 5% level of probability

**Effect of Zn on the zinc content of soil before flowering**. Data on zinc contents of soil before flowering under different levels of zinc application in eight soil series of D.I.Khan are given in Table III. Maximum zinc content of 0.885 ppm before flowering was recorded in the treatment receiving 15 kg Zn $ha^{-1}$ followed by the treatments receiving 10 and 5 kg Zn $ha^{-1}$ while minimum zinc content of 0.345 ppm was noted in control. All the three levels of zinc fertilization applied to soil significantly increased the zinc content over control. Similar results were reported by Srivastava *et al*. (1999).

As regards variations in the extractable Zn content of the soil series, the minimum zinc content was extracted for Ramak soil series, being significantly different from the other soil series. Maximum zinc content was extracted from the soil of Tikken followed by that of Rustam soil series. Similar results were reported by Kausar *et al*. (1979) and Rashid *et al*. (1987). Interaction between the various Zn levels and soil series were also significant. The highest value of 1.020-ppm Zn content of soil was recorded for plants growing in Tikken soil series receiving 15 kg Zn $ha^{-1}$. The lowest value of 0.21-ppm Zn content of soil was recorded for plants growing in Ramak soil series without Zn application.

**Effect of Zn on the zinc content of rice leaf after flowering**. The pattern of variations in zinc contents in rice

plants after flowering as influenced by different levels of zinc in eight soil series presented in Table IV was similar to that before flowering. The variations in the treatments as well as soil series were significant. Maximum zinc content of 60.47 ppm was recorded in the treatment receiving the highest zinc fertilization of 15 kg $ha^{-1}$ which was significantly higher than the treatments receiving Zn fertilization @ 10 and 5 kg $ha^{-1}$ $ZnSO_4$. Minimum zinc content of 19.50 ppm was recorded in control. Similar results were reported by Ram *et al.* (1995), Sahu *et al.* (1996), Singh *et al.* (1996) and Srivastava *et al.* (1999). Interaction between the various Zn levels and soil series was significant. The highest value of 78.24 ppm Zn content of leaf was recorded for plants growing in Tikken soil series receiving 15 kg Zn $ha^{-1}$ that was statistically at par for plant growing in Rustam soil series receiving 15 kg Zn $ha^{-1}$. The lowest value of 17.75-ppm Zn content of leaf was recorded for plants growing in Sodhra soil series without Zn application.

**Effect of Zn on the zinc content of soil after harvest**. Maximum zinc content of 0.773 ppm was recorded in treatment treated with 15 kg Zn $ha^{-1}$ that was statistically higher than all other treatments. Lowest zinc content of 0.241 ppm was obtained in pots where no zinc was applied. Total zinc content per pot showed a progressive increase in a linear pattern with an increase in zinc application which might be due to increase in available zinc by increasing zinc levels. However, the Zn content of soil was reduced at harvesting time as compared to that before flowering, probably because of its uptake by plants and adsorption by soil particles. Similar results were reported by Srivastava *et al.* (1999) and Asad and Rafique (2000).

The lowest zinc content was extracted for Ramak soil series, being significantly different from the other soil series. Maximum zinc content was extracted from the soil of Tikken followed by that of Rustam and Shahdera soil series. Interaction between the various Zn levels and soil series was significant. The highest value of 0.990-ppm Zn content of soil was recorded for pots of Tikken soil series receiving 15 kg Zn $ha^{-1}$. The lowest value of 0.30-ppm Zn content of soil was recorded for the pots of Sodhra soil series without Zn application.

**Effect of zinc on the Zn content (ppm) of rice roots**. All the zinc levels enhanced the Zn content of root significantly over control. Significantly higher value of 92.64 ppm Zn content was recorded in roots treated with 15 kg Zn $ha^{-1}$ followed by treatments receiving 10 and 5 kg Zn $ha^{-1}$. Minimum value of 36.43-ppm Zn content was obtained in control. Gangwar *et al.* (1977) and Mehdi *et al.* (1990) reported that increases in the level of zinc increase the Zn content of roots more than that of shoots.

The interaction between the zinc levels and the soil series was also significant. The highest value of 104.15.50-ppm Zn content of roots was recorded for plants growing in Tikken soil series receiving 15 kg Zn $ha^{-1}$. The lowest value of 33.60-ppm Zn content of roots was recorded for check

**Table IV. Effect of Zn on the zinc content of rice leaf after flowering**

| Soil Series | Treatments | | | | Mean |
|---|---|---|---|---|---|
| S. No | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| Notak | 18.25n | 26.45jk | 46.49f | 50.75e | 35.49e |
| Zandani | 19.50mn | 23.10klm | 47.31f | 68.10b | 39.50d |
| Saggu | 17.75n | 23.50kl | 54.20e | 48.15f | 35.90e |
| Tikken | 23.58kl | 34.45h | 58.15d | 78.24a | 48.61a |
| Rustam | 21.20lmn | 31.51hi | 52.15e | 74.75a | 44.90b |
| Ramak | 18.00n | 23.47kl | 42.16g | 47.12f | 32.69f |
| Sodhra | 17.50n | 23.15klm | 43.60fg | 49.56f | 33.45f |
| Shahdera | 20.20lmn | 29.70ij | 51.25e | 67.10c | 42.06c |
| Mean: | 19.50d | 26.92c | 49.41b | 60.47a | 60.47a |

Values followed by the same letter are not significantly different at 5% level of probability

**Table V. Effect of soil zinc application on Zn content of soil after harvest**

| Soil Series | Treatments | | | | Mean |
|---|---|---|---|---|---|
| S. No | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| Notak | 0.190q | 0.380mn | 0.570ij | 0.710fg | 0.462d |
| Zandani | 0.281p | 0.560ijk | 0.720e | 0.790cd | 0.588c |
| Saggu | 0.147qr | 0.330ndp | 0.560ijk | 0.660fg | 0.424e |
| Tikken | 0.400m | 0.590hi | 0.860b | 0.990a | 0.710a |
| Rustam | 0.340no | 0.530jk | 0.780d | 0.870b | 0.630b |
| Ramak | 0.130r | 0.330nop | 0.460I | 0.630gh | 0.387f |
| Sodhra | 0.140qr | 0.367mn | 0.510kl | 0.697ef | 0.428e |
| Shahdera | 0.300op | 0.560ijk | 0.720e | 0.840bc | 0.605bc |
| Mean: | 0.241d | 0.456c | 0.648b | 0.773a | |

Values followed by the same letter are not significantly different at 5% level of probability

**Table VI. Effect of soil application of zinc on Zn content (ppm) of rice roots**

| Soil Series | Treatments | | | | Mean |
|---|---|---|---|---|---|
| S. No | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| Notak | 35.00hij | 54.05r | 72.15q | 90.25cde | 62.86d |
| Zandani | 36.65gh | 57.30pq | 76.15mn | 93.38bc | 65.75c |
| Saggu | 34.08ij | 53.70q | 70.20klm | 88.10def | 61.52de |
| Tikken | 42.60cd | 63.60o | 83.15mn | 104.15a | 73.38a |
| Rustam | 39.20efg | 60.10op | 78.35hi | 96.60b | 68.56b |
| Ramak | 33.60jkl | 51.00q | 68.12i-l | 85.50fg | 59.56e |
| Sodhra | 33.80ijk | 51.80q | 68.60n | 87.10efg | 60.33e |
| Shahdera | 37.01gh | 56.15q | 75.35n | 96.01bc | 66.13c |
| Mean: | 36.43d | 36.43d | 74.01b | 92.64a | |

Values followed by the same letter are not significantly different at 5% level of probability

**Table VII. Effect of soil application of zinc on % starch content of rice paddy**

| Soil Series | Treatments | | | | Mean |
|---|---|---|---|---|---|
| S. No | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| Notak | 85.48 | 84.97 | 84.17 | 83.99 | 84.65a |
| Zandani | 85.42 | 84.95 | 84.23 | 83.96 | 84.64a |
| Saggu | 85.48 | 85.00 | 84.35 | 83.99 | 84.71a |
| Tikken | 85.24 | 84.71 | 83.93 | 83.81 | 84.42a |
| Rustam | 85.19 | 84.89 | 83.99 | 83.81 | 84.47a |
| Ramak | 85.54 | 85.06 | 84.45 | 84.17 | 84.81a |
| Sodhra | 85.48 | 85.00 | 84.41 | 83.99 | 84.72a |
| Shahdera | 85.36 | 84.89 | 84.18 | 83.98 | 84.60a |
| Mean: | 85.40a | 84.93ab | 84.21b | 83.96b | |

Values followed by the same letter are not significantly different at 5% level of probability

plants growing in Ramak soil series.

**Effect of Zn on % starch of rice paddy**. Statistically analyzed data regarding starch concentration in paddy as influenced by various levels of zinc and soil series are presented in Table VII. The data showed that the Zn fertilization had adversely affected the starch of paddy as compared to control. The highest starch content of 85.40% was recorded in control, which was statistically at par with the treatment receiving 5 kg Zn $ha^{-1}$ but more than other treatments. However, there was no effect of Zn application on starch content of paddy in soil series. Rajub (1999) reported similar results.

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