



# Asian Journal of Plant Sciences

ISSN 1682-3974

**science**  
alert

**ANSI***net*  
an open access publisher  
<http://ansinet.com>

## Zinc Nutrition of Wheat: II: Interaction of Zinc with other Trace Elements

M. Imtiaz, <sup>1</sup>B.J. Alloway, K.H. Shah, S.H. Siddiqui, M.Y. Memon, M. Aslam and P. Khan  
Nuclear Institute of Agriculture, Tandojam, Pakistan  
<sup>1</sup>Department of Soil Science, University of Reading, UK

**Abstract:** The antagonistic effect of Zn and other micronutrients was studied in sand culture using Long Aston nutrient solution. Five levels of Zn were employed to wheat plant along with other essential plant nutrients. It was observed that Zn application had adverse effect on Fe concentration and Fe uptake in plant. Zinc deficient plants had significantly higher concentration of Fe. The results indicated that as the Zn concentration in the substrate was increased, the Fe concentrations in plants were decreased. Zinc also antagonised the uptake of Mn and Cu in the plants. Zinc had such a pronounced adverse effect on Cu concentration that its concentration dropped to deficiency level ( $3 \mu\text{g ml}^{-1}$ ). The roots always showed higher concentrations of these elements than shoots. The higher concentrations of trace elements were observed during first growth stage as compared with second growth stage.

**Key words:** Zinc, nutrition, micronutrients, wheat

### Introduction

Micronutrients are as important as macronutrients for adequate plant nutrition and a deficiency of just one nutrient can greatly reduce yield. Adequate nutrition of plants with micronutrients depends on many factors. These factors include the ability of the soil to supply these nutrients, rate of absorption of nutrients by the plants, distribution of nutrients to functional sites and nutrient mobility within the plant. Interactions occur between the micronutrients and some macronutrients. Interaction is an influence, a mutual or reciprocal action, of one element upon another in relation to plant growth (Olsen, 1972). Also the differential response to one element in combination with varying levels of a second element applied simultaneously i.e. the two elements combine to produce an added effect not due to one of them alone (Olsen, 1972). Such interactions may take place in the soil and within the plant. These interactions should be taken into account when providing adequate micronutrients supply to plant.

Different nutrients may interact with Zn by affecting the availability of each other from soils and their status in the plant through the process of growth or absorption, distribution and/or utilization. These interactions may enhance or reduce plant growth as a response to Zn. Where an interaction does occur, it is necessary for the diagnosis and treatment of the Zn deficiency to identify the factors and its sites and mode of action (Loneragan and Webb, 1993). The purpose of the present study was to investigate the interactive effect of Zn and other micronutrients on their availability to the wheat plant.

### Materials and Methods

A sand culture pot experiment was conducted in the glasshouse of the Department of Soil Science, University of Reading, UK. The experiment was laid out in a completely randomized design with five Zn treatments given to crop and six replications. Out of these six replicates, three were harvested at 22 days (Zadoks stage 19), after transplantation and designated as stage 1 and the remaining three replicates were harvested after 48 days (Zadoks stage 39) and were called stage 2. Acid washed sand (1kg) was placed in a plastic pot for each treatment. Six germinated seedlings of equal size and vigour were transplanted into each pot at equal depth and spacing. Zinc was applied at the rate of 0, 5, 10, 15 and 20  $\mu\text{g ml}^{-1}$  along with a basal dose of Long Ashton complete nutrient solution (Hewitt and Smith, 1975). The Long Ashton complete nutrient solution was applied as per irrigation requirement of the crop. The chemicals were purified of Zn contamination by the method of Piper (1942). Fresh solution for irrigation was prepared every time from the stock solution and the pH was maintained at  $5.5 \pm 0.1$  with 0.1M HCl or 0.1M NaOH. When the seedlings were transplanted, they were initially irrigated with double distil water (DDW) for two days and then supplied with a 50% basic nutrient solution for a further two more days, but no Zn solution was included during this time. For the rest of the experiment, the Zn treatments were supplied together with the full-strength basic nutrient solution. Each pot was kept at constant moisture content following the weighing of the pots. The day-night temperatures were set at 22 and 18°C, respectively.

Artificial illumination was used to maintain daylight for 16 h and the relative humidity was around 65%. Two days prior to harvest, the plants were again irrigated with DDW alone.

The plants were dug out of the pots with their root system and washed with deionized and later on with double deionized water and placed on paper toweling to remove excess water. After separating the roots and shoots, the fresh weights were recorded. These separate parts were dried in aluminum dishes at 80 °C for 48 h in a large forced drought oven (Wood Colchester Ltd.). After drying, the samples were weighed to record the dry matter yield of the crop for each Zn treatment. The dried samples were separately ground and stored in air tight-stoppered glass bottles. Sub-samples were taken for the chemical analysis and standard laboratory procedures were adopted for chemical analysis (Jackson, 1962).

## Results and Discussion

**Iron concentration and uptake:** Zn application had an adverse effect on Fe concentration in plant tissue. The Zn deficient plants had significantly ( $P \leq 0.05$ ) higher Fe concentrations in shoots than the Zn sufficient plants (Fig. 1,2).

However, the Fe uptake increased during the first growth stage up to 15  $\mu\text{g ml}^{-1}$  of Zn application, but it decreased significantly ( $P \leq 0.05$ ) during the second growth stage by Zn application. Zinc application had a non-significant effect on Fe concentration and uptake in roots during both growth stages.

These results were in line with those of Olsen (1972), who also noted an accumulation of various ions including Fe in Zn deficient plants. Addition of Zn to these plants lowered the Fe concentrations in the leaves. He also observed that the higher levels of Zn in nutrient solutions

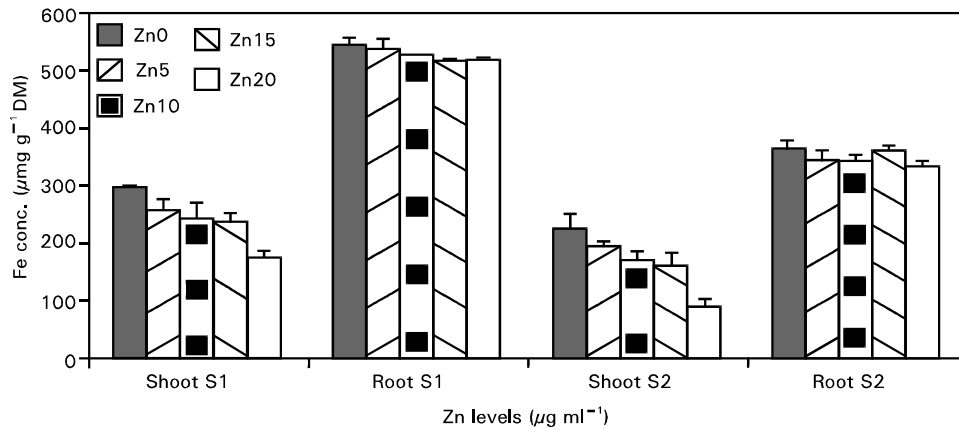


Fig. 1: The effect of applied Zn on Fe concentration in wheat

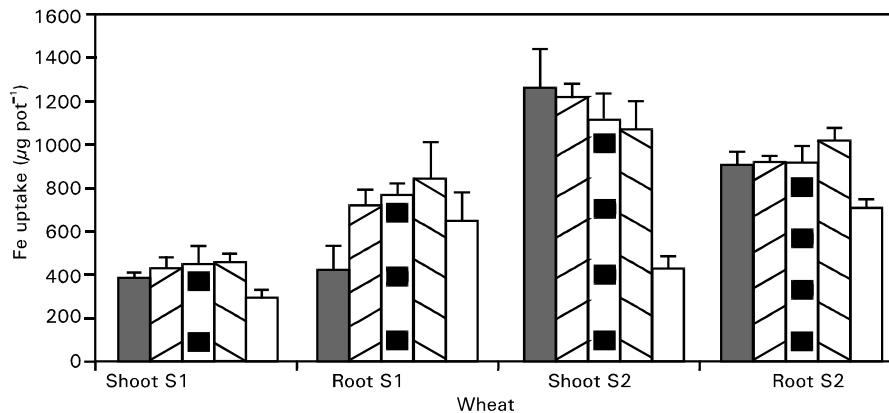


Fig. 2: The effect of applied Zn on uptake of Fe in wheat

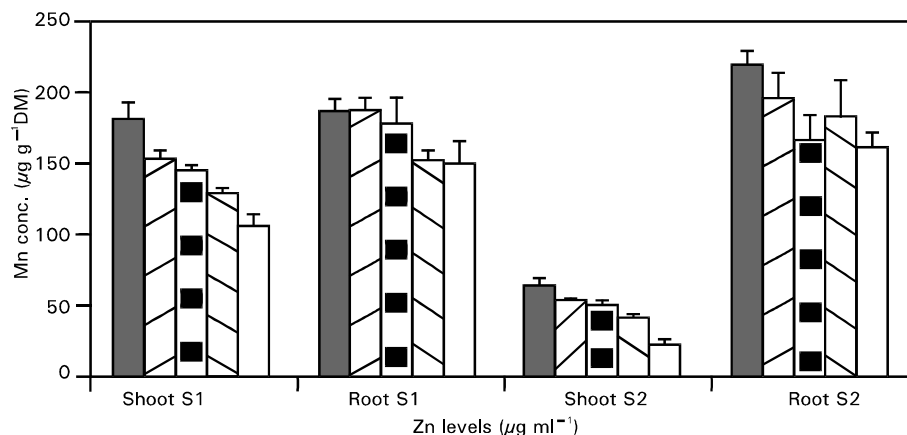


Fig. 3: The effect of applied Zn on Mn concentration in wheat

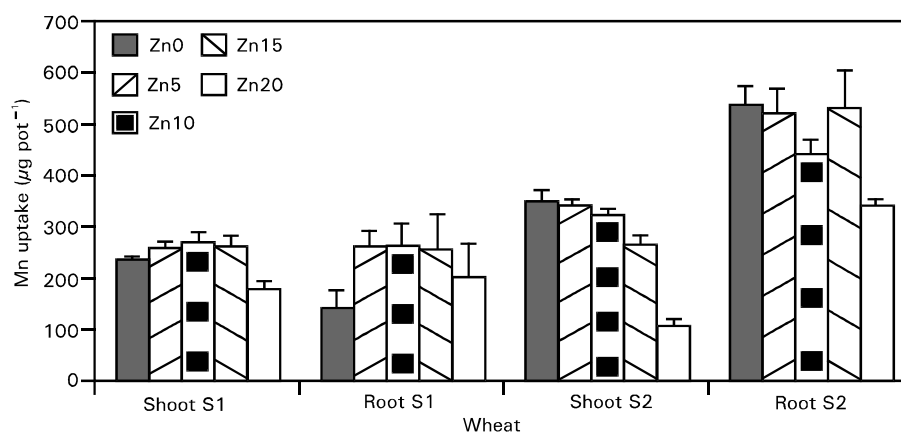


Fig. 4: The effect of applied Zn on uptake of Mn in wheat

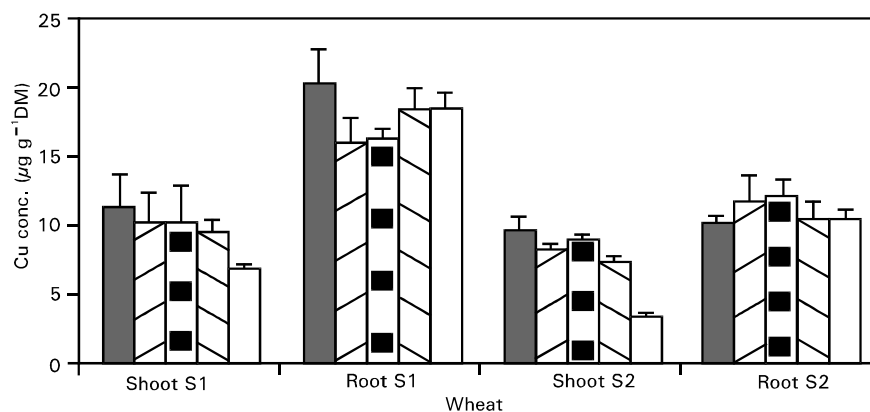


Fig. 5: The effect of applied Zn on Cu concentration in wheat

caused Fe chlorosis at all P levels, but the deficiency symptoms disappeared when the Fe level was increased to  $4.5 \mu\text{g ml}^{-1}$ . Loneragan *et al.* (1982) suggested that Zn deficiency interferes with the control of nutrient ion absorption in a general way, causing ions to accumulate

at higher levels in plant tissue. Thus, Zn plays a role in root-cell membrane function (Graham *et al.*, 1987). Safaya (1976) found that Zn caused an increased Fe uptake mostly due to better growth, but at higher rate of Zn, the growth was retarded and Fe uptake was also reduced.

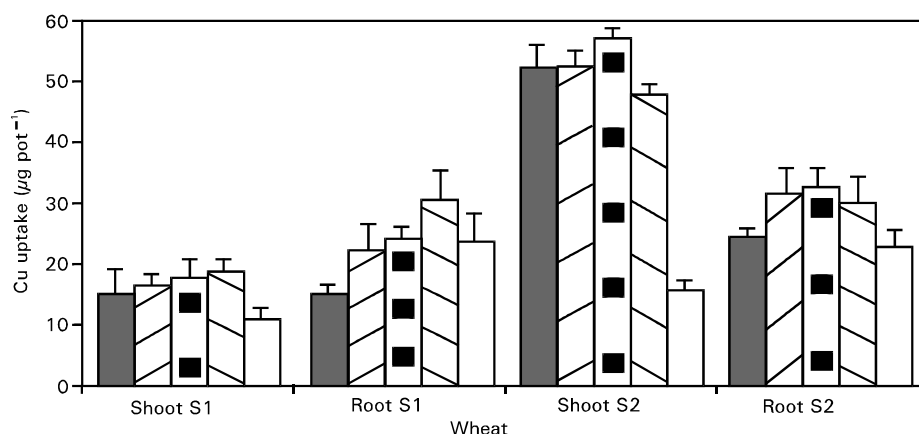


Fig. 6: The effect of applied Zn on uptake of Cu in wheat

**Manganese concentration and uptake:** It was obvious from the data that with increasing Zn applications, Mn concentrations in shoot tissue decreased at both growth stages. Maximum Mn concentrations were found in the control treatments, where no Zn was applied. Higher Zn rates reduced Mn concentrations significantly ( $P \leq 0.05$ ). As with Zn and Fe, the concentration of Mn was also lower in the second stage of growth compared to first growth stage. The roots always had higher Mn concentrations than shoots (Fig. 3 and 4).

Manganese concentrations in roots were also affected significantly ( $P \leq 0.05$ ) by the Zn application. At  $20 \mu\text{g ml}^{-1}$  Zn, the Mn concentration was significantly ( $P \leq 0.05$ ) lower than all other Zn treatments, which were statistically similar with each other.

Manganese uptake was influenced by Zn application as in the first growth stage, the uptake of Mn increased up to  $10 \mu\text{g ml}^{-1}$  Zn but after that it decreased. During the second growth stage, with every increase in Zn concentration in the medium, the Mn uptake was decreased. It seems that the effect of Zn on Mn uptake was less pronounced up to  $15 \mu\text{g ml}^{-1}$  Zn, as the treatments were non-significant with each other. Only the  $20 \mu\text{g ml}^{-1}$  Zn application decreased the Mn uptake in crop.

These results were similar to those of Singh and Steenberg (1974), who found that Mn concentrations in maize plants were substantially decreased with increasing levels of Zn application. They also observed that in barley, the total uptake of Mn by plants decreased with increasing levels of Zn. Safaya (1976) also observed that Zn application reduced Mn concentrations significantly in the tops of P-supplied plants. He also explained that although, the effect of Zn on Mn concentration at 27 days was largely growth regulated, at 48 days the depression

in the concentration was primarily due to severe retardation in the Mn flux during 27-48 days growth.

**Copper Concentration and Uptake:** As with Fe and Mn concentrations, the Cu concentrations in the plants were significantly ( $P \leq 0.05$ ) influenced by Zn application (Fig. 5, 6). Application of Zn had an adverse effect on the Cu concentration in the plant tissue of wheat. It was observed that during the first growth stage of crop, Cu concentrations were significantly lower with  $20 \mu\text{g ml}^{-1}$  Zn application. The highest Cu concentrations were found in Zn deficient plants, but these were statistically similar with the Zn applications of up to  $15 \mu\text{g ml}^{-1}$  Zn. During the second growth stage, Zn had such a pronounced adverse effect on Cu that the concentration of the latter element dropped to deficiency level ( $3 \mu\text{g g}^{-1}$ ) with the  $20 \mu\text{g ml}^{-1}$  Zn application in wheat. The roots always had higher Cu concentrations than shoots and were not affected significantly by Zn treatments.

Copper uptake increased significantly ( $P \leq 0.05$ ) in Zn treated plants relative to the control plants. However, the application rates of Zn from 5 to  $15 \mu\text{g ml}^{-1}$  had no significant effect on Cu uptake, rather Cu uptake decreased significantly ( $P \leq 0.05$ ) at  $20 \mu\text{g ml}^{-1}$  Zn during the first growth stage of wheat. During the second growth stage, Cu uptake decreased significantly with the  $15 \mu\text{g ml}^{-1}$  Zn application and higher rates in wheat.

Similar effects of Zn on the Cu concentration were observed by Kausar *et al.* (1976) who found that application of  $\text{ZnSO}_4$  depressed Cu concentration due to antagonistic effects in both wheat and rice plants. They also observed that in one of the soils studied, Zn depressed Cu concentrations to a deficient level and severely depressed plant yield.

## References

- Graham, R.D., R.M. Welch, D.L. Grunes, E.E. Cary and A.A. Norvell, 1987. Effect of zinc deficiency on the accumulation of boron and other mineral nutrients in barley. *Soil Sci. Soc. Am. J.*, 51: 652-657.
- Hewitt, E.J. and T.A. Smith, 1975. *Plant mineral nutrition*. The English Universities Press Ltd. Norwich, pp: 32.
- Jackson, M.L., 1962. *Soil Chemical Analysis*. Prentice Hall Inc., Englewood Cliffs, N. J., pp: 151-153.
- Kausar, M.A., F.M. Chaudry, A. Rashid, A. Latif and S.M. Alam, 1976. Micronutrient availability to cereals from calcareous soils. I. Comparative Zn and Cu deficiency and their mutual interaction in rice and wheat. *Plant and Soil*, 45: 397-410.
- Loneragan, J.F. and M.J. Webb, 1993. Interactions between Zn and other nutrients affecting the growth of plants. In: *Zinc in Soils and Plants* (Ed.) A. D. Robson, Kluwer Academic Publisher, Dordrecht, pp: 151.
- Loneragan, J.F., D.L. Grunes, R.M. Welch, E.A. Aduayi, A. Tengah, V.A. Lazar and E.E. Cary, 1982. Phosphorus accumulation and toxicity in leaves in relation to zinc supply. *Soil Sci. Soc. Am. J.*, 46: 346-352.
- Olsen, S.R. 1972. Micronutrient Interactions. In: (Eds.) Mortved, J.M.J.J., P.M. Goirdano and W. L. Lindsay. *Micronutrients in Agriculture*. Soil Sci. Soc. Am. Madison, WI., pp: 243-264.
- Piper, C.S., 1942. *Soil and Plant Analysis*. Hassell Press, Adelaide, Australia, pp: 350.
- Safaya, N.M., 1976. Phosphorus-zinc interaction in relation rate of phosphorus, zinc, copper, manganese and iron in corn (*Zea mays* L.). *Soil Sci. Soc. Am. J.*, 71: 132-136.
- Singh, B.R. and K. Steenberg, 1974. Plant response to micronutrients. iii. Interaction between manganese and zinc in maize and barley plants. *Plant and Soil*, 40: 665-667.