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The Effect of Sulfur and Sulfate-Fertilizers on Zn and Cu Uptake by the Rice Plant (*Oryza sativa* L.)

[1]M. Ghasempour Alamdari, [2]N.S. Rajurkar, [3]A.M. Patwardhan and [1]H.R. Mobasser
[1]Faculty Member of Agronomy Department, Agricultural College,
Islamic Azad University, P.O. Box 163, Ghaemshahr, Iran
[2]Department of Chemistry, University of Pune, Pune 411 007, India
[3]Interdisciplinary School of Science, University of Pune, Pune 411 007, India

Abstract: The effect of sulfur and sulfate fertilizer on uptake of zinc and copper by rice plant has been examined in the present research. The experiment was carried out in split-split plot design in randomized complete block with 3 replications under different treatments viz., macronutrients in the main plot, sulfur in the sub plot and micronutrients in the sub-sub plot. Zn and Cu content of rice plant leaves have been measured tillering and panicle initiation stages and in the grain. The analysis of obtained data revealed that the maximum Zn content in the leaf at both stages attained when NPK, S and Zn-sulfate were applied. The maximum Cu content in the leaf attained when NPK, S and Cu-sulfate were applied as compared with the control. But, both Zn and Cu content in the grain increased when NPK, S and Zn, Cu and Mn-sulfate were applied together.

Key words: Sulfur, sulfate, Zn, Cu, rice

INTRODUCTION

Zinc deficiency that is called is found to be most common in soils, next to nitrogen and phosphate deficiencies. Zn is perhaps the principal micronutrient that is being tried for improving the quality and yield of rice. It is essential for the healthy growth of rice plant (Aide *et al*., 1999). Needed in various enzyme systems for energy production, protein synthesis and growth regulation. Similarly, copper is an important component of proteins found in the enzymes that regulate the rate of many biochemical reactions in plants; these enzymes are almost limiting factors for rice plant growth (Rehm and Schmitt, 1997). The element elevates the carbohydrate and nitrogen metabolism; therefore inadequate Cu uptake results in stunted growth.

There are reports in the literature mentioning, deficiency of micronutrients such as Zn, Cu, in agronomic soils because of the excessive use of phosphate fertilizers and the existence of alkaline soils. About 30% of the agricultural soils of the world face the lack of these elements (Malakoti and Tehrani, 1999). The optimum soil pH range for healthy growth of most plants is 6.5 to 7.0. Most agricultural soils have pH be tween 5.0 and 8.5 (Miller and Donahue, 1997; Acquaah, 2002). The suitable soil pH of paddy field is 5.5-6.5. Havlin *et al.* (2003) reported that the maximum uptake of Zn and Cu by the plant is under soil pH condition <6.5. Hence it is thought of interest to study the effect of sulfur powder and various elements on soil pH and hence uptake of Zn and Cu by the rice plant.

MATERIALS AND METHODS

Split- split plot design in a randomized complete block has been chosen as an examination field in the present study. Base fertilizer is used as main plot in two levels: (control and NPK-fertilizer) and S powder as sub plot in two levels (control and Sulfur) and sulfate fertilizers as sub-sub plot in five levels (control, Zn sulfate, Cu sulfate, Mn sulfate and Zn, Cu, Mn-sulfate).

Each of these treatments were replicated three times. T_1) Control (without fertilizer), T_2) Zn, T_3) Cu, T_4) Mn, T_5) Zn, Cu, Mn, T_6) S, T_7) S+Zn, T_8) S+Cu, T_9) S+Mn, T_{10}) S+Zn, Cu, Mn, T_{11}) NPK, T_{12}) NPK+Zn, T_{13}) NPK+Cu, T_{14}) NPK+Mn, T_{15}) NPK+Zn, Cu, Mn, T_{16}) NPK+S, T_{17}) NPK+S+Zn, T_{18}) NPK+S+Cu, T_{19}) NPK+S+Mn and T_{20}) NPK+S+Zn, Cu, Mn.

All fertilizers were added to the experimental plots as recommended by Malakoti and Gheybi (1997). N, P and K-

Corresponding Author: M. Ghasempour Alamdari, Faculty Member of Agronomy Department, Agricultural College, Islamic Azad University, P.O. Box 163, Ghaemshahr, Iran

fertilizers were in the form of Urea (50 kg ha^{-1}), Tripl super-phosphate (50 kg ha^{-1}) and potassium sulfate (25 kg ha^{-1}), respectively. Zn, Cu and Mn-fertilizers were as Zn sulfate (30 kg ha^{-1}), Cu sulfate (10 kg ha^{-1}) and Mn sulfate (20 kg ha^{-1}), respectively. Sulfur powder has also been chosen at the rate of 100 kg ha^{-1}

Afterwards, the rice seedling was transplanted in each plot such that the distance of transplanting hill was 25×25 cm and was cultivated 4 stems in each hill. The type of rice variety was Tarom, which belongs to Basmati variety groups.

In order to determine Zn and Cu in different samples, 1 g powdered sample was dried and dissolved in 2 N HCl and solution is diluted to a fixed volume. Cu and Zn concentration was then estimated by atomic absorption spectroscopy technique using PERKIN-ELMER, model-2380 instrument (Malakoti and Gheybi, 1997). Data were analyzed following the analysis of variance technique (ANOVA) and the mean differences were adjudged by Dancans' Multiple Range Tests (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Deficiencies micronutrients like Zn and Cu in soil limit the crop growth and can be corrected by application of fertilizers containing the required nutrients (Wild, 2003). As can be seen from (Table 1), Zn concentration in the leaf at tillering and panicle initiation stage increased when S powder and Zn, Cu and Mn sulfate applied together (T_{10}), as compared with the control. The maximum Zn content in the leaf at both the stages is attained when NPK, S and Zn sulfate are applied together (T_{17}). It was observed that Cu concentration in the leaf at both the stages increased when S powder and Zn, Cu and Mn sulfate applied together (T_{10}).

The maximum Cu content in the leaf is attained when NPK, S and Cu-sulfate are applied (T_{18}), as compared with the control (Table 1). It was found that Zn and Cu content in the leaf were less at panicle initiation stage than tillering stage. Amount of Zn and Cu concentration in the different parts of the plant is in the order: Grain>leaf at tillering>leaf at panicle initiation

Zn availability in the soil and its uptake by the plant depends on the soil characteristics, particularly pH (Mandal *et al*., 2000). Its availability is less to rice plant at soil pH above 7.0 (Aide, 2000). The experimental soil pH in the present study was 7.6, under this conditions Zn uptake by the rice plant is expected to be less. Zn content in the grain increased when S powder and Zn sulfate applied. But, the maximum Zn content in the grain attained when NPK, S and Zn, Cu and Mn-sulfate are applied together. With addition of S and sulfate fertilizers decreased soil pH, which resulted in increasing the Zn uptake. This is in agreement with observations by Das (1996), Malakoti and Nafisi (1996) and Slaton (2001). It was found that Cu content also increased in the grain when NPK, S and Zn, Cu and Mn-sulfate are applied together (Table 1).

An examination of Fig. 1 shows that Zn, Cu and Mn sulfate together (T_5) increased Zn content in the grain (except Cu-sulfate). Further, significant changes produced in Zn content in the grain when T_9, T_{10}, T_{12} and T_{16} were

Table 1: Zn and Cu concentration in the rice plant leaves and grain

	Zn/ppm leaves			Cu/ppm leaves		
Treatments	Tillering	Panicle initiation	Grain	Tillering	Panicle initiation	Grain
T_1	17.3^{i*}	11.8^{h*}	22.9^{k*}	11.6^{d-g*}	5.3^{c-e*}	8.6^{lm*}
T_2	18.3^{c-f}	12.9^{b-d}	23.4^{e-j}	11.6^{d-g}	5.6^{b-d}	18.6^{lm}
T_3	17.6^{h}	11.4^{i}	22.6^{l}	12.3^{b-d}	5.6^{b-d}	19.3^{jk}
T_4	18.0^{d-g}	11.7^{hi}	23.2^{e-j}	11.3^{e-h}	5.0^{f}	18.0^{n}
T_5	18.6^{b-e}	12.5^{c-f}	24.3^{b-e}	12.6^{a-c}	5.6^{b-d}	19.4^{j}
T_6	18.0^{d-g}	12.9^{b-d}	24.0^{c-g}	11.6^{d-g}	6.0^{a-c}	20.1^{c-h}
T_7	18.6^{b-e}	13.3^{a-c}	24.0^{c-g}	11.6^{d-g}	6.0^{a-c}	20^{d-i}
T_8	18.0^{d-g}	11.8^{h}	23.4^{e-I}	12.6^{a-c}	6.3^{ab}	21.3^{b-e}
T_9	19.3^{a-c}	11.8^{h}	24.6^{a-d}	12.0^{c-f}	5.6^{b-d}	19^{j-l}
T_{10}	19.6^{ab}	12.8^{b-e}	25.0^{a-c}	12.6^{a-c}	5.6^{b-d}	21^{c-f}
T_{11}	18.6^{b-e}	12.8^{b-e}	24.0^{c-g}	11.6^{d-g}	5.6^{b-d}	19.3^{jk}
T_{12}	19.0^{a-d}	13.6^{ab}	24.6^{a-d}	11.3^{e-h}	6.0^{a-c}	19.6^{d-i}
T_{13}	18.6^{b-e}	12.2^{d-g}	23.5^{d-h}	12.6^{a-c}	6.3^{ab}	21.3^{b-e}
T_{14}	18.3^{c-f}	12.2^{d-g}	24.0^{c-g}	11.3^{e-h}	5.3^{c-e}	19.3^{jk}
T_{15}	19.0^{a-d}	12.9^{b-d}	25.3^{ab}	12.3^{b-d}	6.0^{a-c}	20.6^{c-g}
T_{16}	19.3^{a-c}	13.3^{a-c}	24.6^{a-d}	11.0^{i}	6.0^{a-c}	21.7^{b-d}
T_{17}	20.3^{a}	13.6^{ab}	26.0^{a}	12.0^{c-f}	6.0^{a-c}	22^{a-c}
T_{18}	19.6^{ab}	12.9^{b-d}	24.0^{c-g}	13.3^{a}	6.3^{ab}	23.9^{ab}
T_{19}	18.3^{c-f}	12.2^{d-g}	24.2^{b-f}	12.3^{b-d}	5.6^{b-d}	20^{d-i}
T_{20}	19.6^{ab}	14.0^{a}	26.0^{a}	13.0^{ab}	6.6^{a}	24.5^{a}

*, Alphabet represent in each column statistically similarly

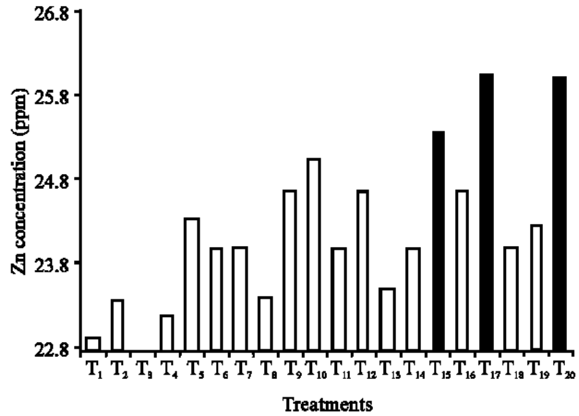

Fig. 1: Zn concentration in the rice grain, black bar graphs represent significant charges

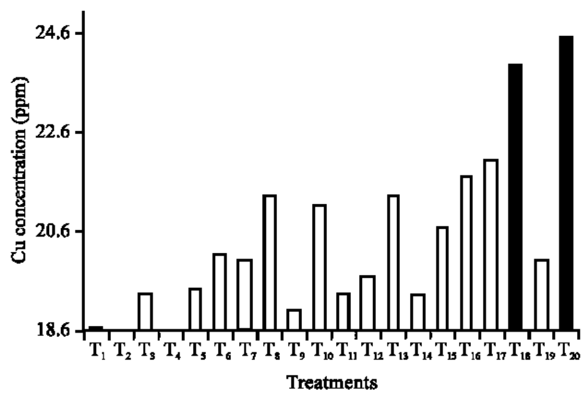

Fig. 2: Cu concentration in the rice grain, black bar graphs represent significant charges

applied. This figure also shows that treatment nos. T_{15}, T_{17} and T_{20} produced vary significant changes (bar graph with black color) on Zn content in the grain as compared with the control. This observation is in agreement with earlier workers (Umar Khan, 2002).

Figure 2 shows that Zn and Mn-sulfate decreased Cu content in the grain as compared with the control. This finding is in agreement with that reported by, Moore and Patrick (1988). Further, examination of Fig. 2 reveals that there are significant changes in Cu content in the grain when T_8, T_{10}, T_{13}, T_{16} and T_{17} applied as compared with the control. It was found that there are significant changes (bar graph with black color) on Cu content in the grain when T_{18} and T_{20} are applied as compared with the control. Figure 1 and 2 showed that both Zn and Cu content in the grain increased when NPK, S and Zn, Cu and Mn-sulfate applied together as compared with the control.

CONCLUSIONS

The application of NPK, S and Zn-sulfate fertilizers together, increases Zn concentration in the leaf as well as grain. Cu concentration also increased by application of NPK, S and Cu-sulfate fertilizers together. NPK, S and Zn, Cu and Mn-sulfate fertilizers together increase both Zn and Cu uptake in the grain. It can be concluded that, using micronutrient fertilizers with S powder together under microelement deficient soils, these elements can be taken up by the rice plant, which might be due to soil decrease, by S powder.

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