EFFECT OF SOIL AND FOLIAR APPLIED COPPER ON GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT:- The experiment was conducted to evaluate the effect of copper on wheat growth and soil composition through its soil and foliar application. For this purpose, non-saline non-sodic soil (pH = 8.10, EC = 0.85 dS m^{-1}, SAR = 4.60, saturation percentage = 29 % and sandy clay loam) was collected, brought to green house and filled in the pots @ 6.5 kg pot^{-1}. All these pots were irrigated to achieve uniform soil column. This experiment comprised 5 treatments viz., control, soil application of copper @ 2 mg kg^{-1} (level 1), @ 4 mg kg^{-1} (level 2), foliar application of copper @ 1% solution (level 1) and @ 2% solution (level 2). These treatments were replicated thrice. All the pots were arranged using completely randomized design. Soil application of copper was done before sowing wheat seeds. Seeds of wheat (Lasani-2000) were sown and 3 plants were maintained in each pot after germination. Foliar application of copper was done at booting and tillering stage. At maturity, data regarding different yield components were noted and wheat plants were harvested. Grain yield and total biomass was also recorded. Soil samples were collected from all pots and analyzed for copper concentration by using wet digestion method. Results of the experiment indicated that soil application of copper proved better than foliar application in increasing the yield and yield components of wheat. Similarly, foliar application of copper at 4mg kg^{-1} (T_3; level 2) was better than 2 mg kg^{-1} (T_2; level 1).

Key Words: Wheat; Soil, Copper; Soil Application; Foliar Application; Yield Components; Grain Yield; Total Biomass; Pakistan.

INTRODUCTION

Wheat is a main staple food and largest grain source for the people of Pakistan. Wheat contributes 12.5 % to the total value added in agriculture and contributes 2.6 % in overall GDP. Cultivated area under wheat was about 8.66 mha in 2014-15 with the production of 23.5 mt (Economic Survey of Pakistan 2014-15). Presently more than 40% of world's population is micronutrient deficient which is causing health problems and disabilities in children (Sanchez and Swaminathan, 2005). Recent research has discovered that deficiency of micronutrients especially Zn, Cu, Fe, Mn, and B also caused decrease in crop production and productivity (Rashid and Rayan, 2004). Main cause of trace element deficiency is the introduction of high yielding crop varieties and more use of fertilizers. Micronutrient deficiencies in crop plants become important worldwide because over growing population of world is affected by lower level of micronutrient in human food (Welch and Gramham, 1999) and poor content of essential nutrients and micronutrients in grains of modern

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high yielding wheat cultivars are mostly recognized (Fan et al., 2008).

Copper is an essential plant nutrient that plays an efficient role in chlorophyll development, and protein formation from amino acids and gives rigidity to plant because copper strengthens plant cell wall. In tall plants Cu is essential for more than 30 enzymes which acts as redox catalysts like nitrate reductase, cytochrome oxidase or act as dioxygen carrier like heamocynin (Mohamed and Taha, 2003). Copper also has an influence on the metabolic processes of plant like photosynthesis and reduction of respiration in pollen capability and its deficiency increases infertility of spikelet in lot of unfilled grains (Dobermann and Fairhurst, 2000). Foliar application of Cu significantly increases the grain yield of wheat (Karamanos, et al., 2004). These experiments were undertaken to investigate the effect of soil and foliar application of Cu on growth and yield of wheat crop, and concentration in soil.

MATERIALS AND METHOD

A pot experiment was conducted in the research area of College of Agriculture, University of Sargodha, Sargodha. Soil of desired level (pH 8.10, ECe 0.85 dsm^{-1}, SAR 4.6 $(m\ molc\ L^{-1})^{1/2}$, sandy clay loam with sand 47%, silt 24%, clay 29 %, and available copper 0.36 ppm) was selected. Soil was collected in bulk quantity, air dried ground, passed through 2 mm sieve and filled into pots @ 6.5 kg pot^{-1}.

Five treatments were replicated thrice using complete randomized design (CRD). These following treatments were tested with three replications:

T_1 = Control
T_2 = Soil application of copper @ 2 mg kg^{-1} (Level 1)
T_3 = Soil application of copper @ 4mg kg^{-1} (Level 2)
T_4 = Foliar application of copper @1% solution (Level 1)
T_5 = Foliar application of copper @ 2% solution (Level 2)

Copper was applied in the form of copper sulfate. Chemical fertilizers (NPK) were applied to soil @ 140, 110 and 90 kg ha^{-1}, respectively. Wheat seeds (Lassani-2000) were sown in each pot and 3 plants per pot were maintained after germination. Foliar application was applied at tillering and booting stages. Necessary agronomic practices were performed when required. At the maturity of crop data regarding yield components like number of spikes, plant length, fertile and non-fertile spikes were noted from each pot before harvesting. Straw yield, weight of grains and roots were recorded after wheat harvesting.

Characteristics of soil were determined including sand, silt and clay fraction by hydrometer method (Bouyoucos, 1962), saturation percentage, pH of soil saturated paste, electrical conductivity of saturation extract (ECe), cations (Ca, Mg, Na, K), anions (carbonates, bicarbonates, chlorides, sulphates) and sodium adsorption ratio-SAR (US Salinity Lab. Staff, 1954), available phosphorus, (Oleson et al., 1954), available potassium, organic matter (Walkley, 1947) and Cu (DTPA method, 1977; Soltanpour, 1985).

Plant samples were ground and oven dried for 72 h at 65°C. Dried samples were ground by using Wiley mill to attain fine powder. One gram of dried and ground plant sample was taken in conical flask and add 10 ml of digestion mixture which was prepared by the combination of two acids per choleric acid and nitric acid (HNO_3) in 1: 2, respectively. This mixture was kept overnight. Mixture was placed on hot plate and heated until solution becomes colorless. Conical flask was removed from the hot plate to cooled. Solutions were shifted to 50 ml volumetric flask and volume was made with distilled water and stored in plastic bottles. The concentration of Cu was determined from this solution by using atomic absorption spectrophotometer. The data obtained was subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range (DMR) test to differentiate any treatment effects (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Maximum Plant Height

The height of wheat plants significantly increased by the application of Cu to soil as well as when it was applied through foliar spray. Differences among various treatments were significantly different when compared to control. The lowest plant height (60 cm) was noted for control treatment (T_1). Maximum plant height of 75.33 cm was noted for T_3. Soil application of copper proved better compared to application by foliar spray in increasing the height of wheat plants; however, there was no significant difference among both treatments. It was noted from the data that soil application of copper @ 4 mg kg^{-1} and foliar application of copper @ 2% solution had most prominent effect on the plant height compared to other treatments including control (Figure 1). Similarly, level 2 (4 mg kg^{-1}) remained more effective when compared with level 1 (2 mg kg^{-1}) of copper. Response of copper application on wheat also reported by Hazra et al. (1987), Nadim et al. (2011) and Narimani et al. (2010).

Number of Fertile Tillers

Data revealed that numbers of fertile tillers of wheat plants were significantly increased by the application of Cu in soil as well as its foliar spray (Figure 2). Maximum number of tillers (18) were counted for T_3 followed by T_2 (15), T_5 (14) and T_4 (13.6). Data reflected

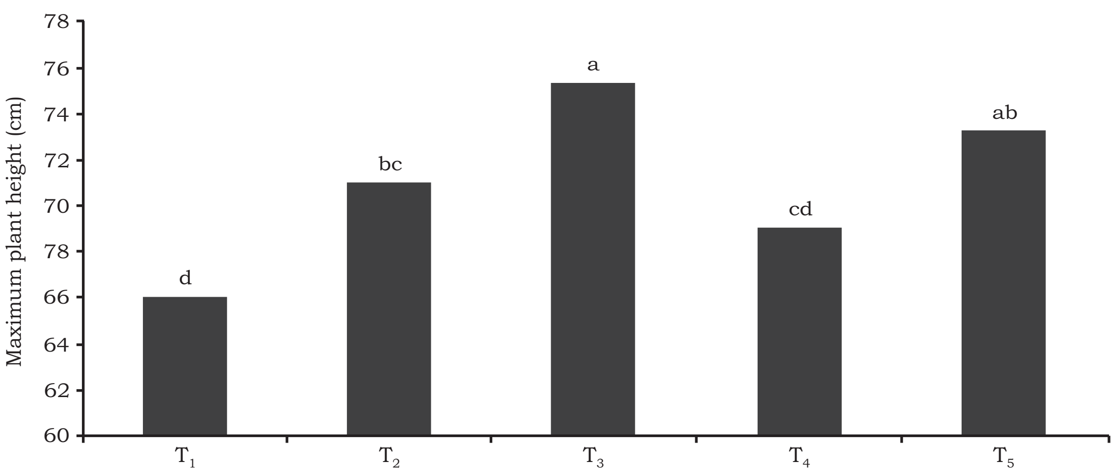

Figure 1. Effect of Cu applied through soil and foliar mode on maximum plant height of wheat (Means followed by same letter do not differ significantly at 5%)

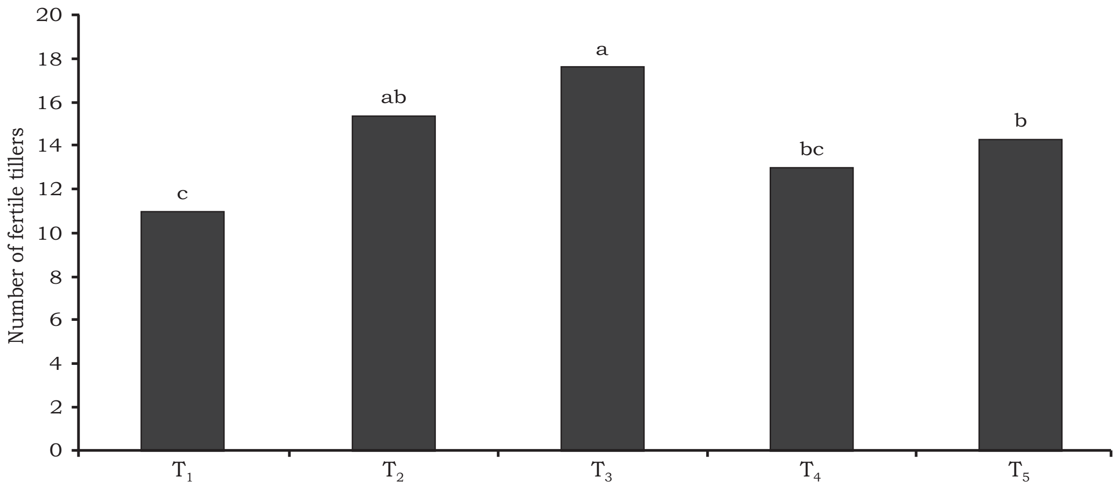

Figure 2. Effect of Cu applied through soil and foliar mode on number of fertile tillers per pot of wheat (Means followed by same letter do not differ significantly at 5%)

that soil application of copper was superior to foliar and had more prominent effect on the number of application of tillers when compared with other treatments and control. However, foliar application of copper also increased the number of fertile tillers of wheat plants significantly when compared with control. Similarly, level 2 (4 mg kg^{-1}) remained more effective when compared with level 1 (2 mg kg^{-1}) of copper.

Total Grains Weight

Total grains weight of wheat plants was significantly increased through the soil and foliar application of copper. Differences among various treatments were significant statistically when compared with control (Figure 3). The minimum grains weight (9.31 g) was noted for control treatment (T_1). Maximum grains weight (13.44) was observed in T_3 followed by T_5. The data reflected that soil application of copper

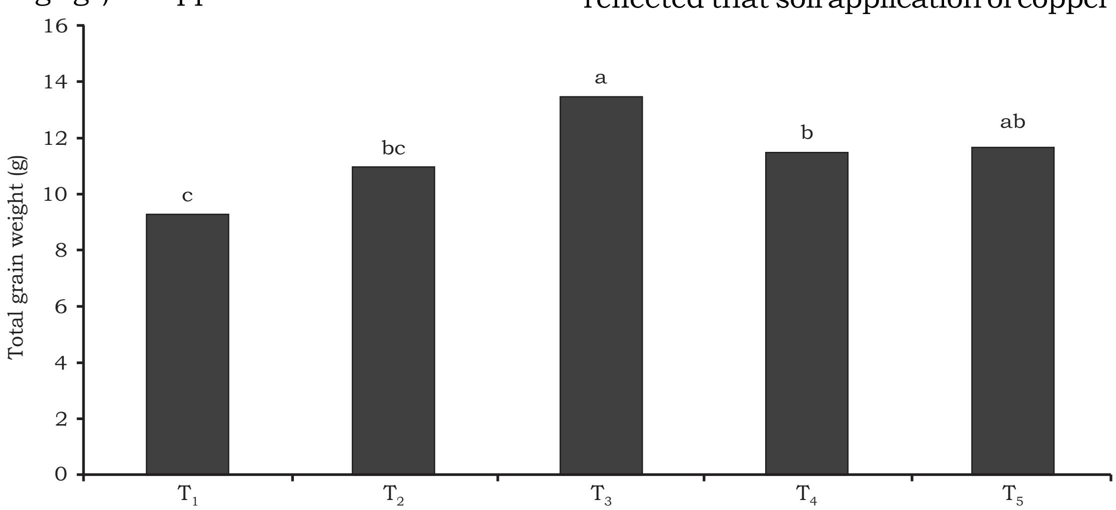

Figure 3. Effect of Cu applied through soil and foliar mode on grains weight of wheat (Means followed by same letter do not differ significantly at 5%)

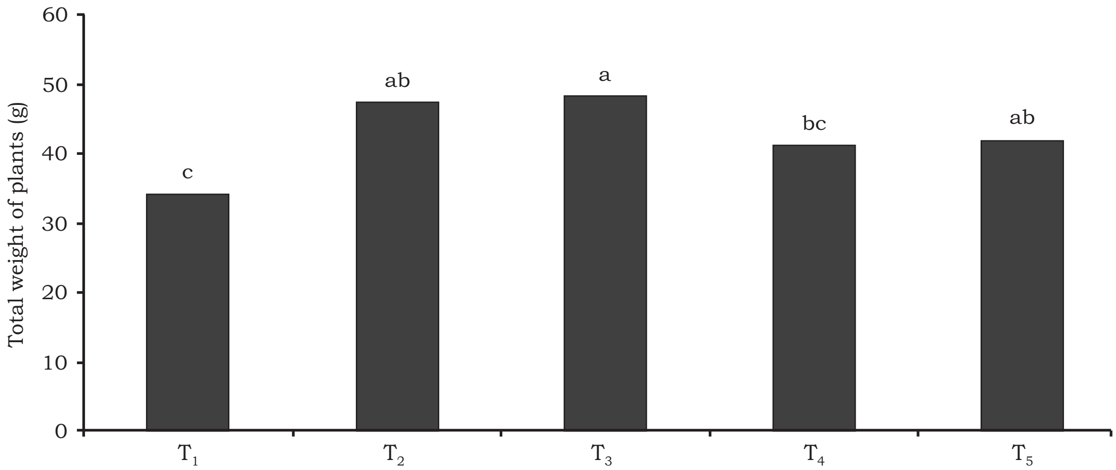

Figure 4. Effect of Cu applied through soil and foliar mode on total weight of plant of wheat (Means followed by same letter do not differ significantly at 5%)

@ 4 mg kg^{-1} and foliar application copper @ 2% solution had most prominent effect on the grains weight as compared with other treatments and control. Present results are in line with the findings of previous researchers (Soleymani et al., 2011; Khan et al., 2010 and Narimani et al., 2010).

Total Biomass of Plant (g)

Data indicated that total biomass of wheat plants were significantly increased due to the soil and foliar application of copper. Differences among various treatments were statistically significant when compared with control (Figure 4). The lowest value of biomass (34.34 g) was noted for control treatment (T_1). Maximum biomass (48.61 g) was noted for T_3 followed by T_2 (53.62 g) and T_5. Soil application of copper proved superior to foliar one in the wheat plant biomass. However, foliar application of copper and manganese also increased the

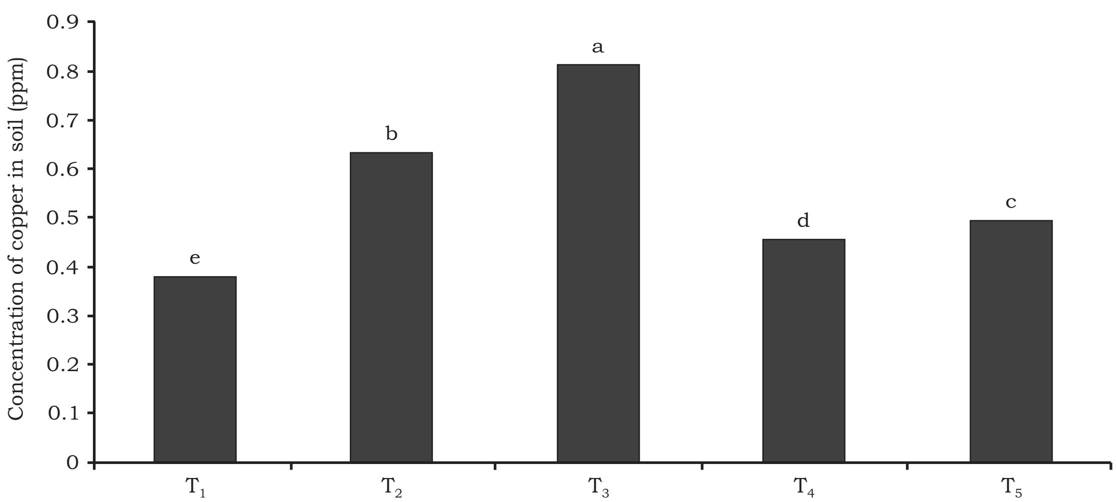

Figure 5. Effect of Cu applied through soil and foliar mode on concentration of copper in soil (Means followed by same letter do not differ significantly at 5%)

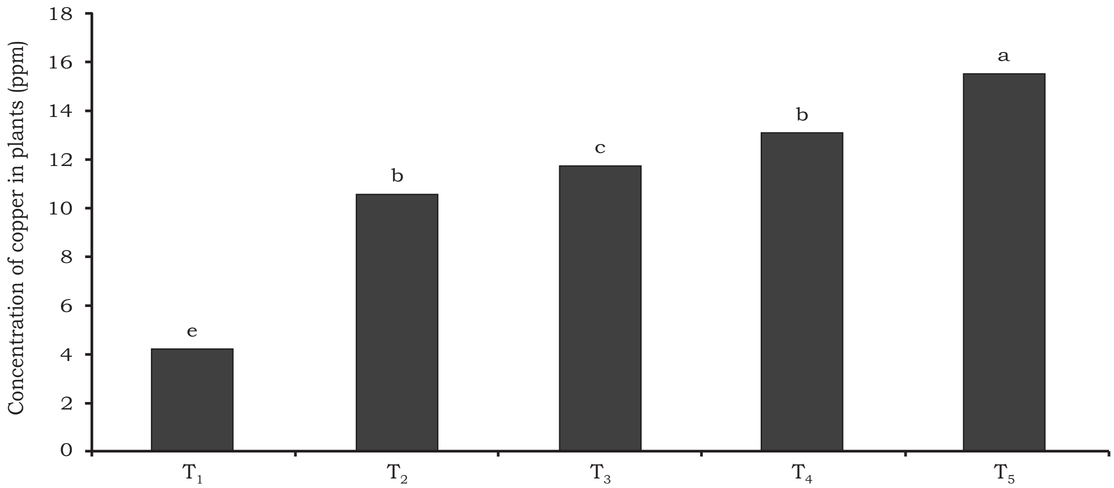

Figure 6. Effect of Cu applied through soil and foliar mode on concentration of copper plant (Means followed by same letter do not differ significantly at 5%)

wheat plant biomass significantly when compared with control. Results of this study are in line with those of Asad and Rafique (2000), Singh et al. (2007).

Copper Concentration in Soil (ppm)

Data indicated that concentration of copper in the soil was enhanced significantly by its soil or foliar application. Differences among various treatments were significant statistically when compared with control (Figure 5). The lowest level of copper 0.37ppm was noted for control treatment (T_1). This level was maximized up to the concentration of 0.81 ppm for T_3 followed by T_2 (0.63 ppm). Foliar application proved inferior to soil application indicating concentration of 0.46 and 0.49 ppm Cu in the soil for T_4 and T_5, respectively. Laegerid et al. (1999), Sangwan and Kuldeep (1993), Arora and Sekhon (1981) and Hodgson (1963) reported that application of copper increased its availability in soil.

Copper Concentration in Plants (ppm)

Data indicated that concentration of copper in wheat plants was increased significantly through soil or foliar mode of application. Differences among various treatments were significant statistically when compared with control (Figure 6). The lowest level of copper 4.24 ppm was noted for control treatment. This level was maximized up to the concentration of 15.48 ppm for T_5 followed by T_4 (13.12 ppm). Foliar application of copper (@ 2% solution had more prominent effect when compared with soil application indicating concentration of 10.61 and 11.76 ppm copper in the plants for T_2 and T_3, respectively. Findings of Karamanos et al. 2004, Tamilselvi et al. (2002), Malhi, et al. (2005) and Curtin et al. (2010) were also in same direction.

It is therefore, concluded that application of copper by various methods had significant effect on wheat and its nutrient quality and boosted the plant height. Soil application and of copper significantly enhanced grains yield, total biomass of plant and total grains weight.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Mr. Azhar Usman Ali	Conceived the idea, Data entry in SPSS and analysis, Results and discussion, Introduction, Data collection
2.	Dr. Ghulam Sarwar	Methodology, Data entry in SPSS and analysis, Result and discussion, Overall management of the article
3.	Mr. Mukkram Ali Tahir	Conclusion, References
4.	Dr. Sher Muhammad	Wrote abstract, Overall management of the article, Technical input at every step, Result and discussion

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