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PJBS

ISSN 1028-8880

# Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 4 (7): 770-774, 2001


# Effect of Trace-nutrient Foliar Fertilizer on Nutrient Balance, Growth, Yield and Yield Components of Two Cereal Crops

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**Abstract:** The effect of two doses of a trace nutrient foliar fertilizer containing 5.2 % Mn, 0.65 % Zn and 0.65 % Cu was studied on the nutrient concentration and balance within the leaves and their impact on the yield and yield components of wheat and maize. Results showed that foliar fertilizer feeding increased the concentrations of Mg, Ca, Fe, Mn, Zn and Cu in the leaves of wheat and maize. In maize leaves, N, P and K were also enhanced especially with the higher dose (T2). Use of the fertilizer led also to nutrient ratios in the leaves near the recommended levels. In wheat, P/Mn, P/Zn and Fe/Zn while in maize, N/P, N/K, N/Fe, P/Mn and P/Zn approached the sufficient levels. This led to significant increases in yield and some of the yield components. Plant heights, number of tillers/plant, grain and straw yields of wheat were significantly increased using the higher dose (T2). Meanwhile, ears No./plant, ear weight, grains weight/ear, weight of 100 grains and yield of maize were significantly increased with both foliar doses (T1& T2) however, T2 was superior in increasing weight of 100 grains and yield.

**Key words:** Wheat, maize, foliar feeding, nutrient balance, yield

## Introduction

Intensive agriculture and use of high productivity cultivars led to a continuous decrease in soil micronutrient content. In addition, unfavorable soil conditions such as high pH values and high $CaCO_3$ content cause the less availability of these nutrients to plant roots (Page, 1962, Cottenie and Kiekens, 1974). Unless such nutrients are amended, low productivity is expected.

Addition of micronutrients to soil proved to be less beneficial (Darjeh *et al.*, 1991, Yaserbi *et al.*, 1994). In such a case, they are needed in high quantities and under soil high pH conditions, converted in a short period, to unavailable forms (Lindsay, 1974). Foliar application is recommended by many investigators as a useful method to supply micronutrients, especially for the short period staying crops (Wallace and Wallace, 1983, Takkar and Walker, 1993; El-Fouly *et al.*, 1995; Shaaban, 1996; Shaaban *et al.*, 1996; El-Fouly and Shaaban, 1998).

Wheat is the first and maize is the third in terms of total world production from cereals (FAO, 1992). They are sensitive to micronutrient deficiency, especially manganese and zinc. Deficiency of one or more of these nutrients give rise to nutrient unbalance which disturbed the physiological and biochemical processes within the plant organs and resulted in low yields (Shaaban and Abou El-Nour, 1996; El-Fouly and Shaaban, 1998).

This work was conducted to investigate the effect of different doses of manganese and zinc in addition to copper on nutrient concentrations and balance within the leaves of winter wheat and hybrid maize and impact of this on yield and yield components.

## Materials and Methods

A field experiment was carried out during the seasons 1997/1998 and 1998/1999 at the experimental station of the National Research Center, Shalakan, Kalubia, Egypt with wheat (*Triticum aestivum* L. var. Gemmiza 3) and corn (*Zea mays* var. Mono-hybrid 10).

**Experimental design:** The experiment was carried out as randomized complete block (RCB) design with four replications and plots area of 3.9 $m^2$.

Table 1: Physical and chemical characteristics of wheat and maize soils

| | Wheat | Maize |
|---|---|---|
| **Physical characteristics** | | |
| pH | 8.6 H | 8.7 H |
| E.C. (dS/m) | 0.16 D | 0.2 D |
| $CaCO_3$ %) | 1.8 A | 1.4 A |
| O.M.(%) | 1.6 A | 1.5 A |
| Sand (%) | 12.8 | 13.0 |
| Silt (%) | 36.0 | 34.0 |
| Clay (%) | 51.2 | 53.0 |
| Texture | Clay | Clay |
| **Nutrient content** | | |
| ***Exchangeable Macro nutrients*** **(mg/100g soil)** | | |
| P | 2.21 A | 2.1 A |
| K | 29.5 A | 23.2 A |
| Mg | 194 A | 224 A |
| ***Available Micronutrients*** **(mg/Kg soil)** | | |
| Fe | 4.6 L | 5.5 L |
| Mn | 2.4 L | 3.3 L |
| Zn | 0.6 L | 0.8 L |
| Cu | 5.0 A | 4.8 A |

A = Adequate, H =High, D= Deficient, L= low, H= high (Ankerman and Large, 1974)

**Sowing and basic fertilization:**

**Wheat:** Wheat was sown at the last third of November using the polishing method. Before sowing, soil was prepared and received super mono-phosphate (15.5 % $P_2O_5$) at the rate of 475 Kg/ha. The plants received nitrogen fertilization at a rate of 166 Kg N/ ha.(ammonium nitrate 33.5 % N) added as three equal splits (with soil preparation, before 1st and 2nd irrigation: 21 and 44 days after sowing). Potassium was added as three equal splits with nitrogen at the rate of 60 Kg K/ha (potassium sulfate 48 % $K_2O$). The plants were regularly irrigated every three weeks.

**Maize:** Grains were sown at the beginning of June. Before sowing, soil was prepared and received super mono-phosphate (15.5 % $P_2O_5$) at the rate of 475 Kg/ha. The seeds were sown in 50 cm lines at 25 cm distance and 4-5 cm depth at a rate of 2-3 seeds per hole and irrigated. The soil was hoed 2 times (before the 1st and 2nd irrigation). Before the

Table 2: Yield and yield components of wheat as affected by foliar application of micronutrients compound

| Treatment | Average plant height (cm) at 120 days age | Average No. of tillers/ plant | Average yield of 1.0 m2 (Kg grains + straw) (gm) | Average grain yield of 1.0 m2 (gm) | Average weight of 100 100 grains | Average grain yield (ton/ha) | Average straw yield (ton/ha) |
|---|---|---|---|---|---|---|---|
| Control | 107.3 a | 4.0 a | 905 a | 247.1 a | 4.21 a | 2.47 a | 6.6 a |
| T1 | 118.1 b | 4.0 a | 1115 a | 382.6ab | 5.15 a | 3.83 ab | 7.3 a |
| T2 | 122.9 b | 6.0 b | 1754 b | 457.0 b | 5.57 a | 4.57 b | 13.0 b |
| LSD 0.05 | 9.249 | 1.194 | 0.416 | 144.01 | 2.617 | 1.436 | 4.493 |

Column values with same letters are not significantly different (P = 0.05)

Table 3: Yield and yield components of maize as affected by foliar application of micronutrients compound

| Treatment | Plant height) at 90 days age (cm) | Average ear No. /plant | Average ear weight (gm) | Average grains weight/ ear (gm) | Average of 100 grains weight (gm) | Average plot yield (Kg/3.9 m²) | Average yield (ton ears/ha) |
|---|---|---|---|---|---|---|---|
| Control | 281.2 a | 1.4 a | 204.2 a | 169.7 a | 39.7 a | 4.71 a | 12.07 a |
| T1 | 282.4 a | 1.6 a | 238.5 b | 201.7 b | 41.8 b | 5.11 b | 13.11 b |
| T2 | 288.7 b | 1.9 a | 248.3 b | 218.2 b | 46.8 c | 5.43 c | 13.92 c |
| LSD 0.05 | 2.25 | 0.56 | 11.86 | 17.89 | 1.47 | 0.1 | 0.49 |

Column values with same letters are not significantly different (P = 0.05)

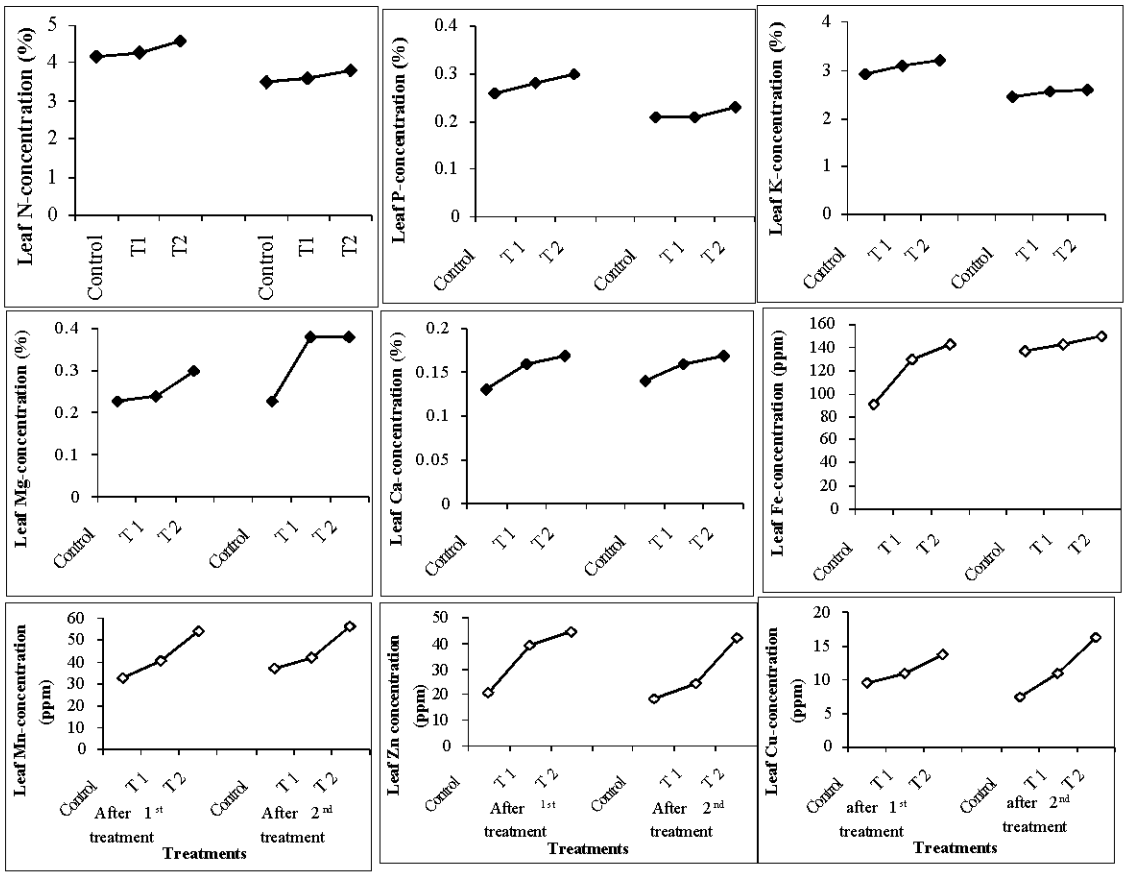


Fig.1: Nutrient concentrations in wheat leaves as affected by doses of the used trace nutrient fertilizer

1st irrigation, the plants were thinned to leave 1 plant per hole. The plants were fertilized with nitrogen and potassium at the rates of 250 Kg N and 114 Kg K/ ha, with the same fertilizers used in wheat fertilization. Nitrogen and potassium were added as three equal splits (with soil preparation, before 1st and 2nd irrigation: 21 and 35 days after sowing). The plants were then regularly irrigated every 14 days.

**Treatments:** The plants were two times foliar sprayed (at 45 and 60 days after sowing) with a trace nutrient fertilizer containing 5.2 % manganese, 0.65 % zinc, 0.65 % copper (v/v) as follows:

Control: sprayed with tap water

T1: 2.0 ml/l trace nutrient fertilizer in the spray solution

T2: 4.0 ml/l trace nutrient fertilizer in the spray solution

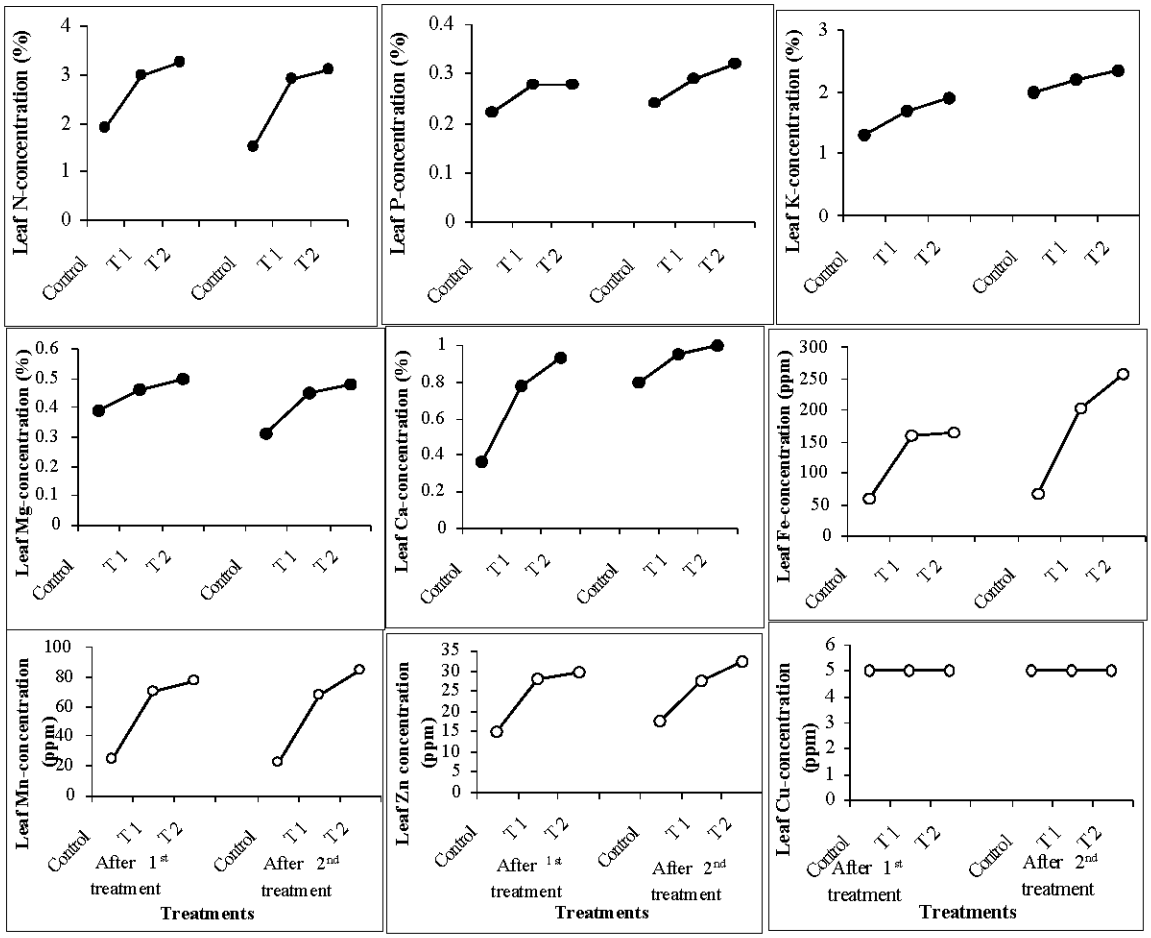


Fig. 2: Nutrient concentrations in maize leaves as affected by doses of the used trace nutrient fertilizer

**Sampling and sample analysis:**

**Soil:** after soil preparation and before fertilization, a representative soil sample was taken. The sample was air-dried and passed through a 2.0 mm sieve pores. Soil physical and chemical characteristics are shown in Table 1. Soil mechanical analysis was carried out using the hydrometeric method (Bauyoucos, 1954); pH and E.C (electric conductivity): were determined in soil/water extract (1:2.5) (Jackson, 1973); Calcium carbonate content was determined using Calcimeter (Black, 1965); and organic matter (O.M.) was determined by potassium dichromate method (Walkely and Black, 1934).

Soil phosphorus was extracted using sodium bicarbonate (Olsen *et al.*, 1954). Potassium (K) and magnesium (Mg) were extracted with ammonium acetate (Chapman and Pratt, 1978), while Fe, Mn, Zn and Cu were extracted using DTPA (Lindsay and Norvell, 1978).

**Plant materials:** Leaf samples were taken 10 days after spraying. The upper three mature leaves from wheat and the upper mature leaf from maize were sampled. Samples were washed with tap water, distilled water, with 0.01 N HCl and bidistilled water, oven dried at 70°C for 24 hours and ground. One-gram sample was dry-ashed in a muffle furnace at 550°C for 6 hours using 3 N $HNO_3$. The residue was, then, suspended in 0.3 N HCl.

**Measurements:** Total nitrogen content of the samples was determined using Bauschi digestion and distillation apparatus. Phosphorus was photometrically determined in the dry ashed residue using the Molybdate-Vanadate method and measured using the UVNIS Spectrophotometer (Perkin-Elmer Lambda2). Potassium and Ca were measured in the extract using Flame photometer (Jenway PFP7). Mg, Fe, Mn, Zn and Cu were measured using the Atomic Absorption Spectrophotometer (Zeis PMQ3).

**Yield determinations:**

**Wheat:** At 120 days age, plant height was measured and tillers/plant were counted. The plants were harvested at the beginning of May and the yield of grains and straw in 1.0 $m^2$ was weighed and the average yield (ton/ha) was then calculated. Average weight of 100 grain was also recorded.

**Maize:** Number of ears/plant was counted and plant height was measured at 90 days age. The plants were harvested at 120 days age. Average ears No./plant, average ear weight, average grains weight/ear, average 100 grains weight, average plot yields were determined and average yield (ton ears/ha) was also calculated.

**Data analysis:** Data were statistically analyzed using Costate Statistical Package (Anonymous, 1989).

## Results and Discussion

**Nutrient concentrations:** Treating wheat and maize plants with the trace nutrient fertilizer increased concentrations of nutrients within the leaves, especially after the second treatment. Despite the used compound contains only manganese, zinc and copper, concentrations of Mg, Ca, and micronutrients: Fe, Mn, Zn and Cu in wheat leaves (Fig.1) and all the determined nutrients except Cu in maize leaves (Fig. 2) were increased, especially with the higher dose (T2). Foliar absorption of Mn, Zn and Cu which, are lacked in the soil solution and also less available as a result of high pH, energized the biochemical processes of nutrient uptake. The role of manganese in photosynthesis and zinc as a component in dehydrogenases and copper in cytochrome oxidase led to production of more solutes and energy that increase active absorption and translocation of nutrients (Fageria *et al.*, 1997).

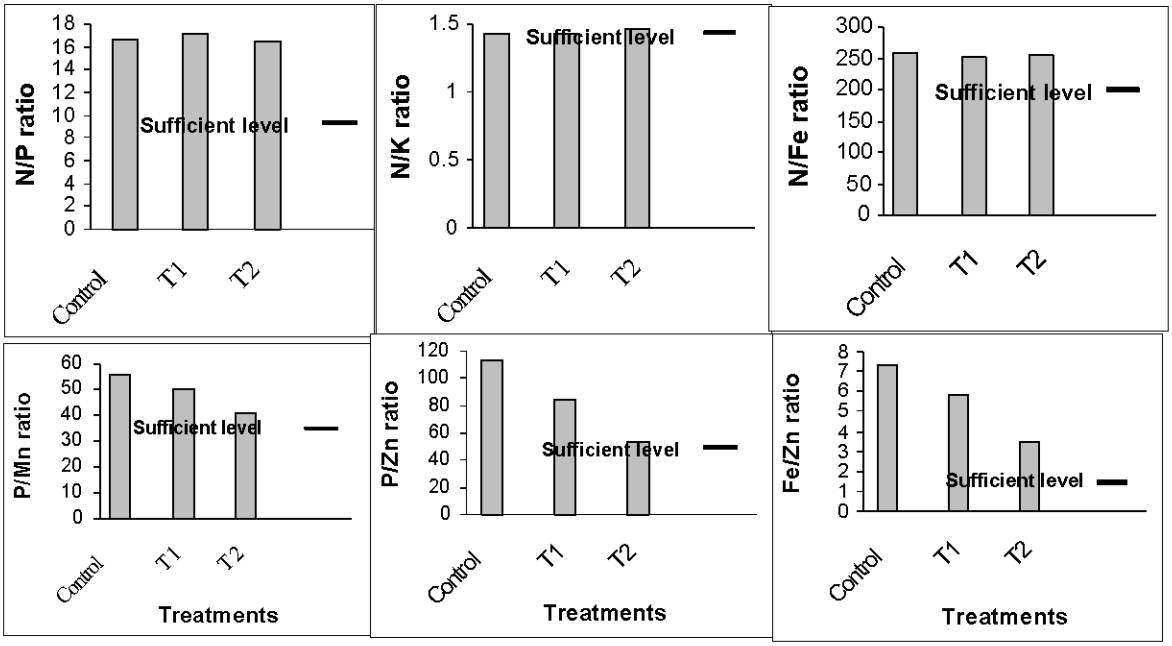


Fig. 3: Nutrient ratios in the leaves of wheat as affected by different doses of the used trace nutrient fertilizer

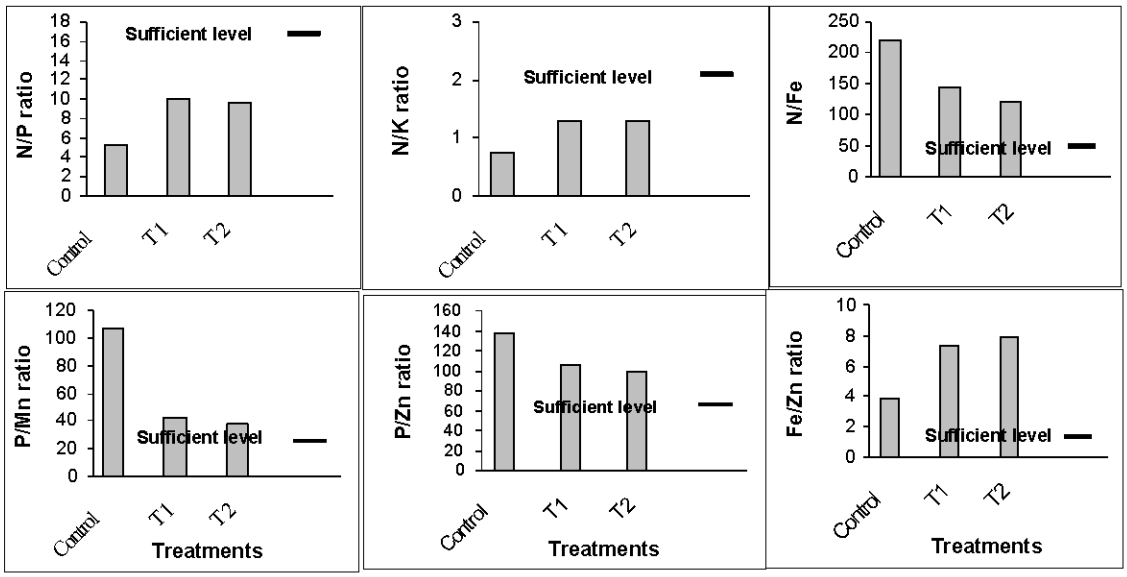


Fig. 4: Nutrient ratios in the leaves of maize as affected by different doses of the used trace nutrient fertilizer

**Nutrient balance:** Nutrient ratios in the leaves of wheat (Fig.3) and Maize (Fig. 4) were affected with the foliar feeding of the plants by the trace nutrient fertilizer and the treatment T2 was the best in general. In wheat leaves the ratios directly related to Mn and Zn (i.e. P/Mn, P/Zn and Fe/Zn) were affected positively, where they were very near to the sufficient values recommended by Rueter (1986) and Fageria *et al*. (1997). As they treated with the trace nutrient fertilizer, maize leaf nutrient ratios mostly approached the values recommended by the same authors. However, they were still far from the sufficient levels. The ratios P/Mn and P/Zn were the only two, which are very near to the sufficient recommended values. This can be attributed to manganese and zinc concentrations increase as a result of the foliar treatments.

**Yield and yield components:**

**Wheat:** Yield and yield components of wheat plants as affected by foliar application of the trace nutrient fertilizer are shown in Table 2. Averages of plant height, number of tillers/plant, grain yield and straw yield were significantly increased as compared to control. The treatment T2 was the best.

**Maize:** Similar trend was found with maize plants (Table 3). Averages of plant height, ear weight, grains weight/ear, 100 grains weight and yield of unit area were significantly increased. The treatment T2 was also superior in increasing the plant height, 100 grains weight and yield.

Yield increase of both wheat and maize is a real reflection to the increase of nutrient concentrations and the improvement occurred in the nutrient balance within the plant tissues as a result of trace nutrient fertilizer foliar application. Similar results were reviewed by El-Fouly and Shaaban (1998) for cotton plants. Low yields of control plants can be attributed to lack of these nutrients which, disturb the nutrient balance and act as limiting factors for the growth (Mengel and Kirkby, 1987; Shaaban and Abu El-Nour, 1996).

**From the present work, it can be concluded that:** Yield of wheat and maize plants grown under unfavorable soil conditions are negatively affected with the lack of micronutrients, especially manganese and zinc.

Amendment of these nutrients through foliar application can increase macro and micronutrient concentrations in the leaves and improve the nutrient balance, which led to yield increases. The plants should be treated with a proper dose at proper time.

## Acknowledgment

The author wishes to thank the project " Micronutrients and Other Plant Nutrition Problems in Egypt" and its coordinator Prof. Dr. Mohammed M. El-Fouly for facilitating the work. A deep gratitude due to the spirit of Prof. Dr. Abdel-Hamid H. Firgany for his sincere helps during a part of the study.

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