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# Effect of Foliar Fertilization of Fe, Mn and Zn on Wheat Yield and Quality in Low Sandy Soils Fertility

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**Abstract:** For increasing wheat yield and improve grain quality by increasing Zn and Fe in grains for human food in the developing country. Two field experiments were carried out in newly cultivated sandy soil during the two winter seasons of 2007/08 and 2008/09 at the Experimental Farm of the National Research Center to investigate the effect of micronutrient foliar application on wheat yield and quality of wheat grains. Results indicated that grain yield, straw yield, 1000-grain weight and number of grains/spike, Fe, Mn and Zn concentration in flag leaves and grains as well as, protein content in grain were significantly increased by application of these elements.

**Key words:** Wheat yield · Grain quality · Foliar application · Fe · Mn and Zn

## INTRODUCTION

World Health Organization reported deficiencies of Zn, iron and vitamin A in human population of developing countries. Human Zn deficiency is the fifth major cause of diseases and deaths in these countries [1]. Wheat is the most important crop in Egypt. Nutritional disorders creating deficiency symptoms can be affected by other factors such as poor drainage, soil salinity and unbalanced fertilizer application. El-Fouly [2] reported that the availability of micronutrients such as Fe, Mn and Zn is much affected by pH and $CaCO_3$ content and soil texture usually micronutrient-deficiency problems are bound in calcareous soil of arid and semi-arid regions. Most sandy soils in Egypt suffering from micronutrient deficiency and or high calcium carbonate. Wheat grown under such deficient condition has low yield and micronutrients contents in grains [3]. Wheat grown under such deficient condition has low yield and micronutrients contents in grain. Each element of these micronutrients has its own function in plant growth for example. Potarzycki and Grzebisz [4] reported that zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism– uptake of nitrogen and protein quality; (ii) photosynthesis– chlorophyll synthesis, carbon anhydrase activity; reported that Zn-deficient plants reduce the rate of protein synthesis and protein content drastically Mn is required for biological redo system, enzyme activation, oxygen carrier in nitrogen fixation [5]. Manganese is required for enzyme activation, in electron transport and disease resistance. Gurmani *et al.* [6] studied the effect of Fe, Mn, Zn and Cu on the yield and yield components of rice; they concluded that Zn alone, Mn alone and combined application of Mn and Cu increased the yield significantly over NPK. Zinc, Mn and Cu increased yield by 15, 11 and 10% over NPK, respectively.

The aim of this study is to investigate the effect of micronutrient foliar application on wheat yield and quality of grains in newly soils.

## MATERIALS AND METHODS

Two field experiments were carried out in newly cultivated sandy soil during the two winter seasons of 2007/08 and 2008/09 at the Experimental Farm of the National Research Center at Nobaria to investigate the effect of micronutrient foliar application on wheat yield and quality of grains. Soil sample used for the experimental site was taken to determine mechanical analysis and some physico-chemical properties. The experimental soil used was sandy in texture (sand 88.8%, silt 4.0% and clay 7.2%), pH 8.08, EC 0.42 $dSm^{-1}$, $CaCO_3$ 5.8%, OM 0.24%, P 0.22 mg/100 g, K 8.1 mg/100 g, Ca 92 mg/100 g and Na 12.4 mg/100 g and Fe, Mn, Zn and Cu ppm were 2.89, 3.48, 0.13and 0.1ppm, respectively [7].

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Wheat grains (Sakha-93 cv.) were drilled in rows 20 cm apart at a rate of 60 Kg/ feddan (one feddan=4200 $m^2$) and the plot area was 3x3.5 $m^2$. Treatments were arranged in a completely randomized block design with four replications. Foliar application treatments were applied during tillering and heading stages as follows:

1- Control (NPK 80:50:75)
2-Control + 0.5% Mn $SO_4$, $H_2O$/feddan.
3-Control + 1.0 % $FeSO_4$ $H_2O$/feddan.
4-Control + 0.5 % Zn $SO_4$ $H_2O$/feddan.

Flag leaves were collected at 10-15 dayes after heeding stage and grains after harvest were taken for determining total N according to the method described by Cottonie *et al*. [8]. Zinc, manganese, iron contents were determined using atomic absorption. Grain and straw yield/fed as well as the yield components were determined for each treatment at harvest time.

Statistical analysis was done according to Snedecor and Cochran [9]. The combined analysis was conducted for the data of the two seasons according in Cochran and Cox [10]. The least significant difference (L.S.D) was used to compare between means.

## RESULTS AND DISCUSSION

**Yield and Yield Components:** The results showed that application of Fe, Mn and Zn significantly increased grain yield and yield components of wheat compared with control (Table 1). The results indicated that the highest number of spikes/$m^2$ and number of grains/spike. The highest grain and straw yields (kg/fed) were obtained when wheat plants were treated with Zn. Foliar application treatment with Zn surpassed the other treatments followed by Mn and Fe application. On the other hand, the lowest values of grain and straw yields as well as yield components resulted from the untreated plants in the two growing seasons. Such effects of foliar application with micronutrients (Zn, Mn and Fe) might be due to their critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates and thus their importance in achieving higher yields. Similar results were reported by Welch *et al.* [11], Hall and Williams [12] and Kassab *et al.* [13]. Wheat plants treated with Mn gave the highest 1000 grains weight compared with the other treatments. These results are in agreement with those obtained by Serry *et al*. [14], Zeidan [15]. Ziaeian and Malakouti [16], Zeidan and Nofal [17] and Maralian Habib [18].

**Effect of Fe, Mn and Zn Treatments on Macro and Micronutrient Concentration in Flag Leaves of Wheat:** Macro and micronutrient content in flag leaves of wheat were significantly affected by micronutrient foliar application (Table 2). Results indicated that micronutrient foliar application enhanced plant absorption N, P, Fe, Mn and Zn by increasing these concentrations in the flag leaves of wheat plants. The highest N% and Zn concentration in flag leaves were recorded when plant treated with Zn. While, foliar application with other micronutrient gave similar effects on P %. Similar results were reported by Ziaeian and Malakouti [16]. Also, Potarzycki and Grzebisz [4] reported that zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism–uptake of nitrogen. Data in Table 2 showed that foliar application of Zn directly relates with higher flag leaves Zn concentration, followed by Mn and Fe. This result is accordance with the finding of Yilmaz *et al.* [19], who reported that foliar application of Zn can greatly enhance plant increase Zn concentration in flag leaves.

**Effect Foliar Application of Microelement on Grain Protein, Macro and Micro Nutrients:** Results in Table 3 indicated that foliar application of micro elements significantly increased protein, Fe, Mn and Zn contents

Table 1: Effect of Fe, Mn and Zn fertilization on yield and yield components of wheat

| | Treatments | | | | |
|---|---|---|---|---|---|
| Characters | Control | Fe | Mn | Zn | L.S.D |
| Number of spikes/$m^2$ | 236.0 | 344.0 | 351.0 | 362.0 | NS |
| Number of grains / spike | 36.3 | 40.8 | 40.6 | 42.4 | 5.2* |
| 1000 grains weight (g) | 28.5 | 36.1 | 35.1 | 34.7 | 3.2** |
| Grain yield (kg/fed***) | 1968.1 | 3303.6 | 3331.9 | 3416.8 | 310** |
| Straw yield (kg/fed) | 2682.7 | 4105.9 | 4064.3 | 4173.1 | 420** |

NS: Not Significant, * Significant at 5% level, ** Significant at 1% level, *** fed = one feddan = 4200 $m^2$

Table 2: Effect of Fe, Mn and Zn foliar application on macro and micro nutrients in flag leaves

| | Treatments | | | | |
|---|---|---|---|---|---|
| Micro and micronutrients | Control | Fe | Mn | Zn | L.S.D |
| N% | 2.01 | 2.82 | 2.69 | 2.95 | 0.26** |
| P% | 0.11 | 0.24 | 0.24 | 0.24 | 0.01** |
| K% | 1.82 | 3.10 | 3.18 | 3.16 | NS |
| Fe (mg/kg/) | 16.92 | 101.40 | 89.90 | 82.50 | 4.9** |
| Mn (mg/kg) | 15.50 | 59.00 | 74.00 | 52.90 | 4.0** |
| Zn (mg/kg) | 13.30 | 16.50 | 17.20 | 35.30 | 2.7** |
| Cu( mg/kg) | 4.50 | 5.20 | 5.40 | 5.00 | 2.6** |

NS: Not Significant, * Significant at 5% level, ** Significant at 1% level

Table 3: Macro and micronutrients concentration in grains as affected by micronutrients fertilization

| | Treatments | | | | |
|---|---|---|---|---|---|
| Items | Control | Fe | Mn | Zn | L.S.D |
| Grain protein content (%) | 9.70 | 10.80 | 10.60 | 11.10 | 0.5** |
| Grain P (%) | 0.37 | 0.41 | 0.41 | 0.41 | NS |
| Grain K (%) | 1.27 | 2.32 | 2.35 | 2.29 | NS |
| Grain Fe( mg/kg) Revise | 33.10 | 54.90 | 48.10 | 40.60 | 11.5** |
| Mn (mg/kg) | 42.50 | 42.70 | 54.60 | 40.90 | 15.9** |
| Zn (mg/kg) | 22.00 | 25.80 | 25.90 | 47.10 | 17.0** |
| Cu (mg/kg) | 6.30 | 8.50 | 9.50 | 6.80 | 0.3** |

NS: Not Significant - * Significant at 5% level - ** Significant at 1% level

in grains of wheat compared to control treatments. The plants which treated with Zn gave the highest grain protein. Marschner [20] reported that Zn-deficient plants reduced the rate of protein synthesis and protein content drastically but increase the accumulation of amino acids. Zeidan [15] indicated that Zn application significantly increased grain protein and enhanced grain Zn concentration, while simultaneously reduced grain P concentration. It has been shown previously that Zn deficiency increases root uptake and root-to shoot transport of P in plants [21]. Zn application in Zn deficient soil in Central Anatolia reduced root P uptake and grain deposition of P and thus grain phytate concentrations. Consequently, phytate/Zn ratios showed dramatic decreases by Zn applications [22]. Wheat is highly susceptible to Zn deficiency in such conditions and produces low levels of grain Zn concentration. Poor quality wheat grain is causing Zn deficiency in humans and need immediate attention. Wheat grains contain about 25-30 μg Zn $g^{-1}$ dry weight, while for a measurable impact of Zn biofortification on human health, desired wheat grain Zn concentration should be > 50 μg $g^{-1}$ dry weight [23, 24], who also found that higher Zn content in wheat grains gave plants with better root and shoot and accumulated more dry matter compared to those from the low Zn content in seeds. Improvements in grains quality parameters may be attributed to the role of microelements in enhance accumulation of assimilate in the grains (during grain filling stage) and thus the resultant seeds had greater individual mass [25]. Similar results were reported by Roach and Wulff [26] and Fenner [27].

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