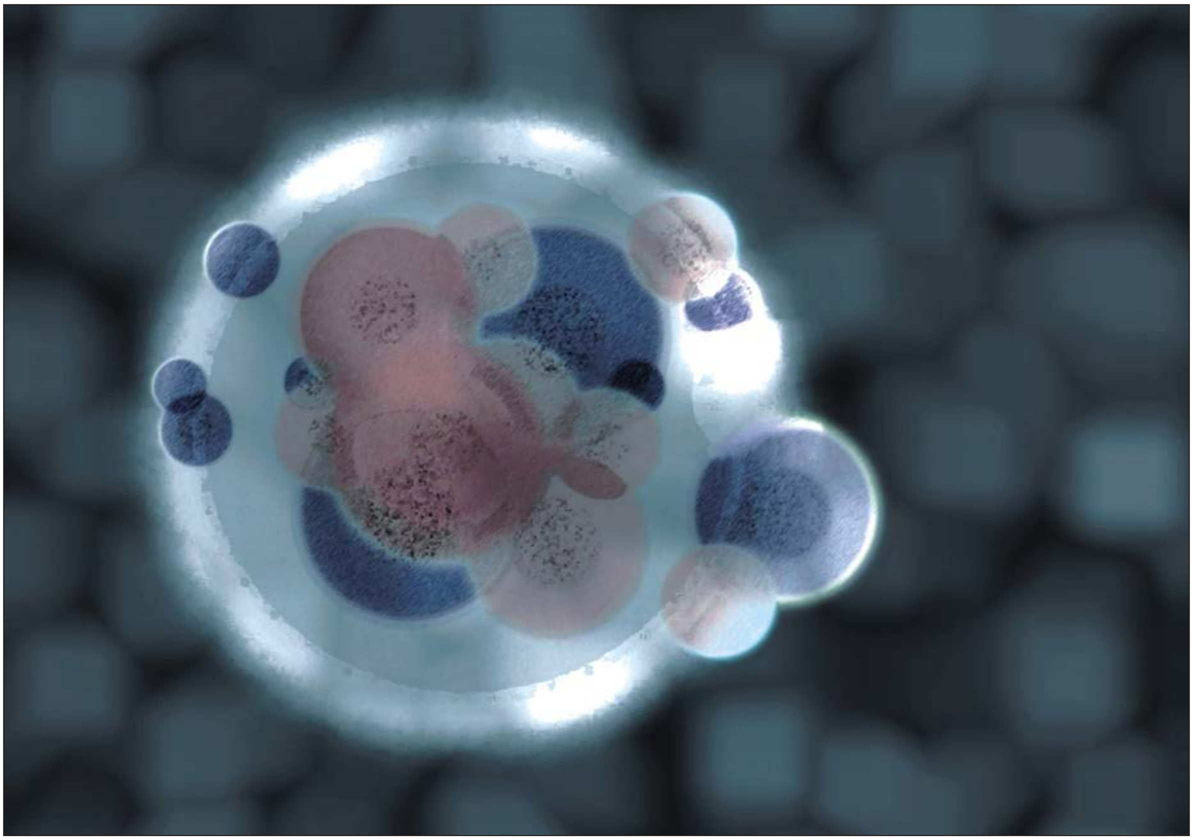

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Influence of Micronutrients Foliar Application and Nitrogen Fertilization on Wheat Yield and Quality of Grain and Seed

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Abstract: The field experiment was conducted at Tag AL-Ezz, Agricultural Research Station Farm, Dakahlia Governorate, Agricultural Research Center, Egypt (+7 m altitude, 31° 36' latitude and 30° 57' longitude), during 2005/2006 and 2006/2007 seasons to study the effect of foliar application with micronutrients (untreated (control), spraying with water, Cu, Mn, Fe and Zn at the rate of 500 ppm of each as well as the mixture of these 4 micronutrients at the rate of 500 ppm of each) under nitrogen levels 50, 70 and 90 kg N fed^{-1}, as well as, their interactions on yield and its components, grains quality and chemical composition of wheat cultivar Giza 168. Also, a laboratory experiment was conducted at Seed Technology Research Unit at Mansoura, Dakahlia Governorate, Field Crops Research Institute, Agricultural Research Center, Egypt, to determine germination percentage and seedling vigor tests (seed quality) of the resultant seed from field experiment. Results indicated that foliar application of the micronutrients mixture at the rate of 500 ppm produced the highest values of grain yield and its components, chemical composition as well as quality parameters of both grains and seed with significant differences compared with other foliar application treatments in both seasons. The second best treatment was the application of Zn followed by Mn in both seasons. Cu and Fe treatments were similar in their effects and the difference between them were insignificant in most traits. The highest values of both straw and grain yields and yield components as well as quality parameters of grains and seed were resulted from increasing nitrogen levels up to 90 kg N fed^{-1} as compared with other levels (50 and 70 kg N fed^{-1}) in both seasons. The results under the present conditions of Tag El-Ezz show that foliar application with mixture of micronutrients in addition to fertilizing with 90 kg N fed^{-1} can be maximize wheat straw and grain yields and gave the best quality parameter of both grains and seed. Moreover, it can be recommended that spraying wheat plants with Cu or Mn or Fe or Zn or mixture (at the rate of 500 ppm) and adding 70 kg N fed^{-1}, which surpassed grain yield over untreated (control) + 90 kg N fed^{-1}.

Key words: Wheat, *Triticum aestivum* L., micronutrient, Zn, Mn, Fe and Cu, foliar application, nitrogen levels, yield, quality

INTRODUCTION

Wheat (*Triticum aestivum* L.) is cultivated worldwide primarily as a food commodity. Because of its importance in the Egyptian diet, wheat is considered a strategic commodity. Calderini and Slafer (1998) noticed that only 3 of the 21 countries (Egypt, Germany and India) exhibited a clear continuous increase in wheat yield (per unit area) during the last decade. Cropping intensity in Egypt accompanied with shortage in fertilization led to a serious depletion of both macro and micro nutrients from soil.

Micronutrients, such as transition metals like Fe, Cu, Mn and Zn are essential for growth and development of the living plants, as they are found in most redox reactions fundamental for cellular processes and in proteins and enzymes for structural and catalytic enzyme activities (Hall and Williams, 2003). These nutrients are known to be required for all higher plants (Welch *et al.*, 1991) and shortage of them in culture media causes deficiency symptoms and reducing growth (Marschner, 1995). Soil organic matter use led to a significant and direct impact on the availability of Zn, Fe and Mn, but has little influence on the availability of soil Cu (Zhang *et al.*, 2001). In addition, the interaction of other soil macro and micro nutrients also affected micronutrients uptake by crops (Aulakh and Malhi, 2005). However, the soil

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application of micronutrients fertilizers in the cultivation may not meet the crop requirement for growth and nutrient use, thus the alternative effective approach is to apply these micronutrients as a foliar spray (Arif *et al.*, 2006). Foliar application of wheat with different micronutrients could be equal or more effective than soil applications and used effectively to overcome the problem of micronutrients deficiency in subsoil (Modaihsh, 1997; Torun *et al.*, 2001). Kassab *et al.* (2004) concluded that the foliar application with a 2% solution from each of Fe, Mn, Zn and Mg significantly increased wheat yield components, grain and straw yields fed^{-1} as well as carbohydrates yield fed^{-1}. Karamanos *et al.* (2004) reported that maximum grain yield of wheat was obtained by foliar Cu application.

Nitrogen is often the most important plant nutrients. Wheat is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization (David *et al.*, 2005). The efficiency of nitrogen fertilizer depends, much, on the level of available soil nitrogen in the rooting zone. Until now, on a world-wide-scale the adjustment of nitrogen fertilizer rates to nitrogen soil tests is rare (Sieling *et al.*, 2005). Many workers all over the world concluded that using nitrogen fertilizer in suitable needed rates could improve growth, yield and its components as well as quality of wheat i.e., Sayed *et al.* (2003), Tammam and Tawfils (2004), Allam (2005), Seadh and Badawi (2006), Ibrahim (2007) and Mekhemar (2008).

During parental development, nutritive status can be modify the grain size, elemental composition percentage and rate of germination and longevity of seeds (Roach and Wulff, 1987; Fenner, 1992). Ascher *et al.* (1994) concluded that seed nutrition combined with soil nutrition gave better yields and better seed quality of wheat. Rengel and Graham (1995) found that higher Zn content in wheat seeds gave plants with better root and shoot and accumulated more dry matter compared to those from the low Zn content in seeds. Generally, trace mineral content in seeds are essential to help seedling survive and accelerate initial growth (Bouis, 2003). Nylor (1993) showed that wheat seed produced from parent plant receiving greater amount of nitrogen had a higher and faster germination percentage compared to those received lower amount of nitrogen.

The present experiment was undertaken to investigate the response of wheat cultivar Giza 168 to foliar application with micronutrients and soil nitrogen fertilization on yields and its components as well as grains and seed quality under the environmental conditions of Dakahlia Governorate at Tag El-Ezz district.

MATERIALS AND METHODS

The field experiment was conducted at Tag AL-Ezz, Agricultural Research Station Farm, Dakahlia Governorate, Agricultural Research Center, Egypt, during 2005/2006 and 2006/2007 seasons to study the effect of foliar application with micronutrients and soil applied nitrogen levels on yield and its components, grain and seed quality of wheat cultivar Giza 168. In addition to, laboratory experiment was conducted at Seed Technology Research Unit at Mansoura, Dakahlia Governorate, Field Crops Research Institute, Agricultural Research Center, Egypt, to determine germination percentage, speed of germination and seedling vigor tests (seed quality) of seeds resultant from field trials.

Field experiment: A split -plot in CRB design with three replicates was used. The main plots were allocated to seven foliar nutrition treatments as follows: untreated control, spraying with water, spraying solution of: $CuSO_4$, Mn-EDTA, Fe-EDTA and Zn-EDTA at the rate of 500 ppm of each as well as the mixture of the micronutrients together at the rate of 500 ppm of each element. The foliar solution volume was 200 Liter fed^{-1} and spraying was conducted by hand sprayer (for experimental plots) until saturation point twice after 30 and 50 days from sowing. The sub plots were assigned to three nitrogen level treatments of: 50, 70 and 90 kg N fed^{-1}. The nitrogen fertilizer in the form of ammonium nitrate (33.0% N) was used in two equal doses prior to each of the first and the second irrigations.

Before planting, soil samples for both physical and chemical analysis for the experimental soil were undertaken according to Jackson (1973) and corresponding data are presented in Table 1. Each experimental unit was 10.5 m^2 (3×3.5 m). The preceding summer crop was rice (*Oryza sativa* L.) in both seasons.

Potassium fertilizer in the form of potassium sulphate (48% K_2O) at the rate of 50 kg fed^{-1} was applied in one dose before the first irrigation. Calcium super phosphate (15.5% P_2O_5) was applied during soil preparation at the rate of 150 kg fed^{-1}. The planting dates were at November 23rd and 26th in the first and second seasons, respectively. Wheat grains at the rate of 60 kg fed^{-1} were broadcasted using (Afir) method. The other recommended agricultural practices for growing wheat were followed.

Studied characters

Yield components: At harvesting time, one square meter was randomly selected from each experimental plot to estimate the following characters: plant height (cm),

Table 1: Physical and chemical soil characteristics at the experimental sites during 2005/2006 and 2006/2007

	Physical characteristics							
Seasons	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Soil texture	$CaCO_3$ (%)	Field capacity (%)	Real density (g cm^{-3})
2005/2006	6.2	32.6	24.7	35.5	Clay loam	2.45	34.3	2.66
2006/2007	5.8	33.2	25.3	35.7	Clay loam	2.54	35.2	2.65

	Chemical characteristics					
				Available nutrients (ppm)		
Seasons	pH soil paste	EC (dS m^{-1})	Organic matter (%)	N	P	K
2005/2006	7.6	2.2	1.72	32.3	7.1	232
2006/2007	7.8	2.4	1.83	36.4	7.3	240

number of spikes m^{-2}, spike length (cm), number of spikelets/spike, number of grains/spike and 1000 grain weight (g).

Yield determination: Grain yield (ardab fed^{-1}) was calculated by harvesting whole plants in each plot and left to dry on air, then they were threshed and the grains (which were at 13% moisture) were weighted (kg), then converted to ardab per fed (one ardab = 150 kg). Straw yield (t fed^{-1}): The straw resulted from each experimental plot was weighted in kg, then it was converted to tons per fed.

Wheat grain quality and chemical composition: Carbohydrates percentage in grains was determined by Hedge and Hofreiter (1962). Nitrogen in grains and straw was determined by microkjeldahl methods (Jackson, 1967). Crude protein percentage was calculated by multiplying the total nitrogen values in wheat flour by 5.17. Phosphorous in grains and straw was determined by the methods described by Cooper (1977). Potassium in grains and straw was determined using flamephotometer as described by Peterburgski (1968).

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split -plot design using MSTATC computer software package according to Gomez and Gomez (1984). Least Significant of Difference (LSD) method was used to test the differences between treatment means at 5% level of significance as described by Waller and Duncan (1969).

Laboratory experiment: The germination experiment consisted of four replications of 100 seeds from each treatment. 50 seeds were placed on two sheets of blotter paper in 14 cm diameter Petri-dishes. The blotter paper was moistened with adequate distilled water. The Petri-dishes were placed in a growth chamber at 20°C. Standard germination tests were followed according to AOSA (1993). Germination percentage was expressed as the percentage of seed germinating normally after 8 days. The four replications were also used to evaluate daily speed of germination (during germination test) according to Agrawal (1986). Shoot and root lengths (cm) were determined at random from 10 normal seedlings taken from each replicate at the end of standard germination test and dried in a forced air dry oven at 110°C for 17 h (Agrawal, 1986) to obtain seedlings dry weight in milligrams. Data were subjected to the statistical analysis according to the technique of Analysis of Variance (ANOVA) for the factorial completely randomized design as published by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Yield and yield components: Foliar application with the applied micronutrients had a significant effect on plant height, number of spikes m^{-2}, spike length, number of spikelets/spike, number of grains/spike, 1000-grain weight, grain and straw yields in both seasons (Table 2, 3). The mixture of four micronutrients (Cu, Mn, Fe and Zn) at the rate of 500 ppm of each significantly ranked first and produced the highest values of grain and straw yields as well as all its components with significant differences compared with the other singular micronutrient foliar application treatments in both seasons. Foliar application treatment with Zn was in the second rank and followed by Mn treatment. Cu and Fe treatments were seemed equally in their effect and the difference between them were insignificant in most cases. The lowest values of grain and straw yields and yield components were resulted from the untreated treatment in the two growing seasons. Such effects of foliar application with micronutrients (Cu, Mn, Fe and Zn) might be due to its critical role in crop growth, involving in photosynthesis processes, N-fixation, respiration and other biochemical and physiological activates and thus their importance in achieving higher yields. Similar results were reported by Welch *et al.* (1991), Hall and Williams (2003) and Kassab *et al.* (2004).

Data presented in Table 2 and 3 reveal that, grain yield and its components i.e., plant height, number of spikes m^{-2}, spike length, number of spikelets/spike, number of grains/spike, 1000 grain weight, grain and straw

Table 2: Plant height, No. of spikes m^{-2}, spike length, number of spikelets/spike and number of grains/spike as affected by foliar application with micronutrients and nitrogen fertilizer levels during 2005/2006 and 2006/2007 seasons

	Character									
	Plant height (cm)		No. of spikes (m^{-2})		Spike length (cm)		No. of spikelets/spike		No. of grains/spike	
Treatment	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Foliar application with micronutrients										
Untreated control	100.9	99.7	368.0	350.2	10.96	10.80	20.1	19.9	59.6	57.8
Water	104.4	103.2	399.5	386.2	11.47	11.23	20.7	20.4	62.8	60.8
Cu 500 ppm	109.7	108.6	425.3	408.4	11.77	11.57	21.3	21.1	65.6	64.3
Mn 500 ppm	112.1	110.3	436.4	417.3	11.89	11.79	21.7	21.5	66.6	65.2
Fe 500 ppm	111.1	108.5	423.1	408.4	11.80	11.70	21.5	21.3	66.0	64.7
Zn 500 ppm	113.5	112.1	445.7	429.3	12.05	11.86	22.0	21.7	67.5	66.1
Mixture	118.2	116.1	468.9	455.5	12.48	12.17	22.3	22.1	71.4	69.8
LSD 5%	0.9	0.9	7.8	9.0	0.06	0.06	0.1	0.2	0.8	0.5
N-levels										
50 kg N fed^{-1}	105.5	103.4	366.8	355.4	11.12	11.03	20.5	20.4	62.1	60.2
70 kg N fed^{-1}	110.1	108.6	419.8	401.5	11.92	11.71	21.6	21.3	65.6	64.1
90 kg N fed^{-1}	114.3	113.0	484.9	466.8	12.29	12.03	22.0	21.8	69.2	67.9
LSD 5%	0.7	0.5	9.7	4.8	0.06	0.06	0.1	0.1	0.7	0.7
Interaction	*	*	*	*	*	*	NS	*	*	*

Table 3: 1000-grain weight, grain and straw yields as well as crude protein and carbohydrates percentages in grains as affected by foliar application with micronutrients and nitrogen fertilizer levels during 2005/2006 and 2006/2007 seasons

	Character									
	1000-grain weight (g)		Grain yield (ardab fed^{-1})		Straw yield (t fed^{-1})		Protein (%)		Carbohydrates (%)	
Treatment	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Foliar application with micronutrients										
Untreated control	37.10	36.50	17.99	17.55	4.00	3.88	12.4	12.3	69.2	68.2
Water	38.20	37.30	18.49	17.94	4.09	3.99	12.6	12.4	69.6	69.3
Cu 500 ppm	39.80	38.40	19.84	19.71	4.29	4.24	13.3	13.1	70.4	69.8
Mn 500 ppm	40.50	39.40	20.32	20.07	4.39	4.36	13.5	13.2	71.5	70.5
Fe 500 ppm	39.80	38.60	19.94	19.80	4.32	4.28	13.3	13.1	70.6	70.1
Zn 500 ppm	41.30	40.60	20.77	20.56	4.54	4.50	13.6	13.5	72.5	71.3
Mixture	43.00	42.30	21.97	21.05	4.88	4.72	13.9	13.7	72.9	71.9
LSD 5%	1.00	0.80	0.24	0.21	0.08	0.09	0.1	0.1	0.4	0.4
N-levels										
50 kg N fed^{-1}	36.40	34.90	17.14	16.93	3.68	3.61	11.6	11.4	67.7	67.0
70 kg N fed^{-1}	40.50	39.80	20.55	20.15	4.47	4.39	13.8	13.6	70.9	70.4
90 kg N fed^{-1}	43.00	42.30	22.01	21.49	4.93	4.84	14.3	14.2	74.2	73.1
LSD 5%	0.60	0.60	0.16	0.22	0.06	0.08	0.1	0.1	0.5	0.3
Interaction	*	*	*	*	*	NS	*	*	NS	NS

yield fed^{-1} were significantly increased by increasing nitrogen fertilizer level up to 90 kg N fed^{-1}. These results were noticed in the two growing seasons. Wheat plants fertilized with the highest level of nitrogen (90 kg N fed^{-1}) had the highest values of grain yield and its components, followed by plants fertilized with 70 then 50 kg N fed^{-1} in both seasons. Noteworthy, the percentage of increasing values of most mentioned characters due to increasing nitrogen levels from 50 to 70 kg N fed^{-1} was more than those of increasing nitrogen levels from 70 to 90 kg N fed^{-1}. This means that the response of wheat to increase nitrogen levels from 70 to 90 kg N fed^{-1} was less than that when nitrogen was increased from 50 to 70 kg N fed^{-1}. The most important role of nitrogen fertilizer in plant is mainly in its presences in the nucleic acid and protein structure. In addition, nitrogen is also found in chlorophyll molecule. Chlorophyll enables plant to transfer energy from sunlight by photosynthesis to assimilates (chemical energy form). Therefore, the nitrogen supply to the plant will influence the amount of protein, protoplasm and chlorophyll formed. In turn, this influences cell size and number, photosynthetic activity and growth, hence increasing all yield components as well as grain and straw yield per unit area. These results are in agreement with those obtained by David *et al.* (2005), Sieling *et al.* (2005) and Seadh and Badawi (2006).

Grain quality and chemical compositions: Quality parameters of grains (protein and carbohydrates percentages) and chemical composition i.e., N, P and K concentrations in grains and straw show significant response to micronutrients foliar application treatments in both seasons as shown in Table 3 and 4. Application with mixture of Cu, Mn, Fe and Zn at the rate of 500 ppm,

Table 4: N, P and K percentages in wheat grains and straw as affected by foliar application with micronutrients and nitrogen fertilizer levels during 2005/2006 and 2006/2007 seasons

	Character											
	N (%)				P (%)				K (%)			
	In grains		In straw		In grains		In straw		In grains		In straw	
Treatments	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Foliar application with micronutrients												
Untreated control	2.16	2.14	1.15	1.17	0.236	0.236	0.132	0.136	1.22	1.26	1.59	1.62
Water	2.19	2.17	1.17	1.20	0.246	0.246	0.131	0.140	1.24	1.28	1.61	1.64
Cu 500 ppm	2.31	2.28	1.23	1.26	0.273	0.263	0.141	0.148	1.30	1.35	1.64	1.70
Mn 500 ppm	2.34	2.30	1.30	1.31	0.287	0.284	0.149	0.155	1.35	1.40	1.67	1.73
Fe 500 ppm	2.32	2.29	1.28	1.29	0.284	0.281	0.146	0.150	1.31	1.37	1.65	1.71
Zn 500 ppm	2.38	2.35	1.31	1.34	0.295	0.289	0.154	0.157	1.35	1.42	1.68	1.74
Mixture	2.43	2.39	1.32	1.36	0.311	0.317	0.167	0.171	1.37	1.44	1.71	1.76
LSD 5%	0.02	0.02	0.01	0.02	0.003	0.002	0.002	0.001	0.01	0.02	0.01	0.01
N-levels												
50 kg N fed^{-1}	2.02	1.99	1.19	1.20	0.256	0.246	0.127	0.135	1.22	1.25	1.63	1.66
70 kg N fed^{-1}	2.40	2.36	1.23	1.26	0.262	0.272	0.152	0.155	1.28	1.37	1.65	1.72
90 kg N fed^{-1}	2.50	2.47	1.33	1.36	0.309	0.302	0.158	0.162	1.41	1.46	1.67	1.72
LSD 5%	0.01	0.01	0.01	0.01	0.002	0.003	0.001	0.002	0.01	0.02	NS	NS
Interaction	*	*	*	*	*	*	*	*	*	*	*	*

resulted in the highest values of these traits with significant differences compared with other foliar application treatments in the two growing seasons. Generally, it was observed that the foliar application treatments with micronutrients assorted as: Mixture>Zn > Mn>Fe>Cu>water> untreated in both seasons. This improvement in grains quality and chemical composition may be due to the role of microelements in maintaining balanced plant physiological growth. Even though micronutrients are present in small amounts in plants, they activate about 100 enzymes in plant. It is inferred that plant not to be able to survive without adequate of sufficient micronutrients because they are essential to the synthesis of DNA and RNA and to metabolizing carbohydrates, lipids and proteins. Micronutrients also play a key role in the release of carbon dioxide and in the function of vitamins (Marschner, 1995).

Data in Table 3 and 4 illustrate that crude protein and carbohydrates as well as N, P and K percentages in grains and straw were significantly increased by increasing nitrogen levels in both seasons, except K% in straw in both seasons. From the data, each increase in nitrogen associated with a significant increase in grain quality parameters, this observation was true in the two growing seasons. Generally, the highest values of these traits were obtained as a result of increasing nitrogen fertilization up to 90 kg N fed^{-1}. This improvement in quality parameter due to increasing nitrogen levels may be reflected to the role of nitrogen fertilizer in improving growth and dry matter accumulation which led to increasing the uptake of most nutrients. The results achieved in this work are partially compatible with those obtained by Allam (2005) and Mekhemar (2008).

Seed quality: Foliar application treatments with micronutrients exhibited significant effect on seed quality parameters (germination percentage, speed of germination, shoot length, root length and 10 seedlings dry weight) in both seasons (Table 5). The mixture of Zn, Fe, Mn and Cu at the rate of 500 ppm produced the highest values of the above mentioned characters in both seasons. Foliar application with Zn alone ranked after the formerly mentioned treatments in both seasons. Other foliar application treatment exceeded untreated (control) and spraying with water, this observation was true in both seasons. The improvement in seed quality parameters may be reflected 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 and germinated quickly (Baskin and Baskin, 1998). Also, high micronutrient accumulation in seeds particularly Zn and Mn may be produce more viable and vigorous seedlings, because they supplying the young seedlings with these trace elements until it has developed a large root system enough to take over this role (Bouis *et al*., 2000). Similar results were reported by Roach and Wulff (1987) and Fenner (1992).

Seed quality characters were significantly affected due to increasing nitrogen fertilization rates from 50 up to 90 kg N fed^{-1} in both seasons (Table 5). Each increase in nitrogen rates from 50 to 70 and 90 kg N fed^{-1} associated with a significant increase in studied seed parameters in the two growing seasons. The highest values of seed quality parameters were resulted from those fertilized wheat plants with 90 kg N fed^{-1}. This enhancement in seed quality parameter due to increasing addition of

Table 5: Germination percentage, speed of germination, shoot length, root length and 10 seedlings dry weight as affected by foliar application with micronutrients and nitrogen fertilizer levels during 2005/2006 and 2006/2007 seasons

	Character									
	Germination (%)		Speed of germination		Shoot length (cm)		Root length (cm)		10 seedlings dry weight (mg)	
Treatment	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Foliar application with micronutrients										
Untreated control	87.4	86.7	42.4	42.3	8.20	7.94	8.80	8.88	121.4	119.7
Water	90.0	89.2	43.0	43.1	8.51	8.26	9.08	8.92	125.5	124.6
Cu 500 ppm	93.1	91.8	45.5	45.6	8.82	8.61	9.39	9.20	130.5	129.8
Mn 500 ppm	95.8	94.4	46.3	46.0	9.45	9.32	9.91	9.75	139.9	138.9
Fe 500 ppm	94.4	93.2	45.8	45.7	9.13	9.00	9.66	9.46	135.4	134.5
Zn 500 ppm	98.0	97.4	46.6	46.3	9.84	9.70	10.22	10.07	144.8	144.1
Mixture	98.3	98.0	47.0	46.8	10.17	9.99	10.39	10.25	147.7	147.4
LSD 5%	0.5	0.5	0.5	0.4	0.04	0.04	0.03	0.04	0.54	0.60
N-levels										
50 kg N fed^{-1}	90.0	90.3	41.7	42.0	8.01	7.82	9.01	8.91	119.7	118.7
70 kg N fed^{-1}	94.4	92.7	45.9	45.5	8.84	8.60	9.65	9.50	134.9	134.2
90 kg N fed^{-1}	97.1	95.8	48.0	47.8	10.62	10.50	10.25	10.10	150.5	149.4
LSD 5%	0.3	0.3	0.3	0.3	0.03	0.03	0.02	0.06	0.35	0.39
Interaction	*	*	*	*	*	*	NS	*	*	*

Table 6: Number of spikes m^{-2}, number of grains/spike, 1000 grain weight and grain yield as affected by the interaction between foliar application with micronutrients and nitrogen fertilizer levels during 2005/2006 and 2006/2007 seasons

	Characters							
	No. of spikes (m^{-2})		No. of grains/spike		1000-grain weight (g)		Grain yield (ardab fed^{-1})	
Treatments	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Untreated								
50 kg N fed^{-1}	293.3	274.6	55.9	53.4	33.0	32.1	15.09	14.53
70 kg N fed^{-1}	369.3	350.6	60.3	58.7	38.4	37.8	18.84	18.46
90 kg N fed^{-1}	441.3	425.3	62.6	61.2	40.1	39.6	20.04	19.66
Water								
50 kg N fed^{-1}	318.6	305.3	58.6	56.8	34.4	32.8	15.54	14.94
70 kg N fed^{-1}	420.0	404.0	64.2	61.2	39.4	38.8	19.39	18.76
90 kg N fed^{-1}	460.0	449.3	65.6	64.3	41.0	40.4	20.55	20.12
Cu								
50 kg N fed^{-1}	356.0	344.0	60.9	59.7	36.3	34.7	16.96	17.35
70 kg N fed^{-1}	436.0	418.6	66.5	65.0	40.5	38.7	20.55	20.24
90 kg N fed^{-1}	484.0	462.6	69.3	68.1	42.6	42.0	22.02	21.55
Mn								
50 kg N fed^{-1}	366.6	356.0	61.6	60.5	37.5	35.5	17.75	17.72
70 kg N fed^{-1}	449.3	422.6	67.8	65.8	40.7	40.5	20.98	20.54
90 kg N fed^{-1}	493.3	473.3	70.4	69.3	43.6	42.5	22.23	21.96
Fe								
50 kg N fed^{-1}	348.0	346.6	61.1	60.0	36.5	34.4	17.13	17.42
70 kg N fed^{-1}	437.3	417.3	67.0	65.4	40.6	39.8	20.62	20.36
90 kg N fed^{-1}	484.0	461.3	69.8	68.6	42.3	41.7	22.06	21.62
Zn								
50 kg N fed^{-1}	378.6	364.0	62.6	61.2	38.3	36.8	18.15	18.12
70 kg N fed^{-1}	454.6	436.0	68.6	67.2	41.0	41.1	21.20	21.10
90 kg N fed^{-1}	504.0	488.0	71.3	70.0	44.8	43.9	22.95	22.48
Mixture								
50 kg N fed^{-1}	405.3	398.6	68.2	65.4	39.4	38.5	19.40	18.47
70 kg N fed^{-1}	473.3	460.0	70.5	69.9	42.9	42.5	22.27	21.61
90 kg N fed^{-1}	528.0	508.0	75.5	74.1	46.8	46.2	24.24	23.06
LSD 5%	25.8	19.9	1.8	1.9	1.6	1.7	0.43	0.59

nitrogen levels may be ascribed to increase N content of seeds which positively correlated with germination percentage and seedling size (Nylor, 1993).

Interaction: Regarding the interactions between foliar application with micronutrients and nitrogen levels on studied characters, there are many significant effects. We have reported enough the significant interaction on number of spikes m^{-2}, number of grains/spike, 1000 grain weight and grain yield only (Table 6). The best interaction treatment which produced the highest values of grain yield and its components was foliar application with the mixture of Cu, Mn, Fe and Zn (at the rate of 500 ppm) beside fertilization with 90 kg N fed^{-1}. Foliar spraying wheat plants with Cu or Mn or Fe or Zn or mixture plus adding 70 kg N fed^{-1} exceeded treatment of untreated + 90 kg N fed^{-1} in number of grains/spike, 1000 grain weight and grain yield in both seasons, except treatment of Cu + 70 kg N fed^{-1} in 1000 grain weight in the second season only. Also, spraying wheat plants with Zn or mixture +70 kg N fed^{-1} significantly surpassed treatment of untreated + 90 kg N fed^{-1} in number of spikes m^{-2} in both seasons. While, untreated +90 kg N fed^{-1} treatment exceeded spraying wheat plants with Cu or Fe + 70 kg N fed^{-1} (in both season) or Mn +70 kg N fed^{-1} (in the second season) in number of spikes m^{-2} without significant differences between them.

CONCLUSION

In general, the obtained results show that foliar application with mixture of studied micronutrients (Cu, Mn, Fe and Zn) at the rate of 500 ppm in addition to mineral fertilizing with the highest nitrogen level (90 kg N fed^{-1}) produced the highest values of wheat straw and grain yields as well as grain quality in addition to improve germination of the resultant seeds and seedling growth. Moreover, it can be recommended that spraying wheat plants with Cu or Mn or Fe or Zn or mixture (at the rate of 500 ppm) and adding 70 kg N fed^{-1}, which exceeded in grain yield upon untreated (control) + 90 kg N fed^{-1}.

REFERENCES

Agrawal, P.K., 1986. Seed Vigor Concepts and Measurements. In: Seed Production Technology, Srivastava, J.P. and L.T. Simarsk (Ed.). ICARDA, Aleppo, Syria, pp: 190-198.

Allam, S.A., 2005. Growth and productivity performance of some wheat cultivars under various nitrogen levels. J. Agric. Sci. Mansoura Univ., 30: 1971-1980.

Arif, M., M.A. Khan, H. Akbar and S. Ali, 2006. Prospects of wheat as a dual purpose crop and its impact on weeds. Pak. J. Weed Sci. Res., 12: 13-17.

AOSA., 1993. Association of official seed analysts rules for testing seeds. J. Seed Tech., 16: 1-113.

Ascher, J.S., R.D. Graham, D.E. Elliott, J.M. Scott and R.S. Jessop, 1994. Agronomic Value of Seed with High Nutrient Content. In: Wheat in Heat-Stressed Environments: Irrigated, Dry Areas and Rice- Wheat Farming Systems, Saunders, D.A. and G.P. Hettel (Eds.). CIMMYT, Mexico, D.F., pp: 297-308.

Aulakh, M.S. and S.S. Malhi, 2005. Interactions of nitrogen with other nutrients and water effect on crop yield and quality nutrient use efficiency carbon sequestration and environmental pollution. Adv. Agron., 86: 342-409.

Baskin, C.C. and J.M. Baskin, 1998. Seeds Ecology Biogeography and Evolution of Dormancy and Germination. Academic Press, New York.

Bouis, H.E., R.D. Graham and R.M. Welch, 2000. The consultative group international agricultural research (CGIAR) micronutrients project Justification and objectives. Food Nutr. Bull., 21: 374-381.

Bouis, H.E., 2003. Micronutrients fertilization of plants through plant breeding; can it improve nutrition in man at low cost. Micronutrients Groups Sym. Micronutrients Suppl. Proc. Nut. Soc., 62: 403-411.

Calderini, F.D. and G.A. Slafer, 1998. Changes in yield and yield stability in wheat during the 20th century. Field Crops Res., 57: 335-347.

Cooper, T., 1977. The Tools of Biochemistry. John Wiley and Sons, New York.

David, C., M.H. Jeuffroy and J.M. Meynard, 2005. Nitrogen management of organic winter wheat decision-making through model-based explorations. Procedings of the Researching Sustainable Systems International Scientific Conference on Organic Agriculture, Adelaide, Australia, September 21-23, http://orgprints.org/4215/.

Fenner, M., 1992. Environmental influences on seed size and composition. Hortic. Rev., 13: 183-213.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Wiley and Sons, Inc., New York, ISBN-10: 0471870927, pp: 95-109.

Hall, J.L. and L.E. Williams, 2003. Transition metal transporters in plants. J. Exptl. Bot., 54: 2601-2613.

Hedge, J.E. and B.T. Hofreiter, 1962. Carbohydrates Chemistry. Academic Press, New York.

Ibrahim, M.E.M., 2007. Impact of nitrogen levels on growth and yield of sugar beet intercropped with faba bean and wheat. M. Sc. Thesis, In Agron., Fac. of Agric. Mansoura Univ.,

Jackson, M.L., 1967. Soil Chemical Analysis. 1st Edn. Prentic Hall Inc., New Delhi, USA.

Jackson, M.L., 1973. Soil chemical analysis. Prentice Hall of Indain. Pvt. Ltd. New Delhi, 47: 219-220.

Karamanos, R.E., Q. Pomarenski, T.B. Goh and N.A. Flore, 2004. The effect of foliar copper application on grain yield and quality of wheat. Can. J. Plant Sci., 84: 47-56.

Kassab, O.M., H.A.E. Zeing and M.M. Ibrahim, 2004. Effect of water deficit and micronutrients foliar application on the productivity of wheat plants. Minufiya J. Agric. Res., 29: 925-932.

Marschner, H., 1995. Mineral Nutrition of Higher Plant. 2nd Edn., Academic Press Ltd., London, UK.

Mekhemar, G.A.A., 2008. Response of wheat (*Triticum aestivum* L.) to different mineral nitrogen levels and inoculation with N_2 fixing bacteria. J. Agric. Sci. Mansoura Univ., 33: 447-467.

Modaihsh, A.S., 1997. Foliar application of chelated and non-chelated metals for supplying micronutrients to wheat grown on calcareous soil. Expt. Agric., 33: 237-245.

Naylor, R.E.L., 1993. The effect of parent plant nutrition on seed size, viability and vigour and germination of wheat and triticale at different temperatures. Ann. Applied Biol., 123: 379-390.

Peterburgski, A.V., 1968. Hand Book of Agronomic Chemistry. Kolop Publishing House, Moscow, pp: 29-86.

Rengel, Z. and R.D. Graham, 1995. Importance of seed Zn content for wheat growth on Zn-deficient soil. 1. Vegetative growth. Plant Soil, 173: 259-266.

Roach, D.A. and R.D. Wulff, 1987. Maternal effects in plants. Ann. Rev. Ecol. Syst., 18: 209-235.

Sayed, M.A., A.M. Osman, M.A. Aly and M.A.E. Saaddawy, 2003. Effect of irrigation water regime and nitrogen levels on two wheat cultivars under sandy soils. Proceedings of the 11th Annual Conference of Misr Society of Agriculture, (ACMSA'2003), England, pp: 310-318.

Seadh, S.E. and M.A. Badawi, 2006. Wheat response to sowing methods and nitrogen fertilizer levels. J. Agric. Sci. Mansoura Univ., 31: 8097-8106.

Sieling, K., C. Stahl, C. Winkelmann and O. Christen, 2005. Growth and yield of winter wheat in the first 3 years of a monoculture under varying N fertilization in NW Germany. Europ. J. Agron., 22: 71-84.

Tammam, A.M. and M.B. Tawfils, 2004. Effect of sowing date and nitrogen fertilizer levels in relation to yield and yield components of durum wheat (*Triticum turgidum var. durum*) under Upper Egypt environments. J. Agric. Sci. Mansoura Univ., 29: 5434-5442.

Torun, A., I. Gültekin, M. Kalayci, A. Yilmaz, S. Eker and I. Cakmak, 2001. Effects of zinc fertilization on grain yield and shoot concentrations of zinc boron and phosphorus of 25 wheat cultivars grown on a zinc-deficient and boron-toxic soil. J. Plant Nut., 24: 1817-1829.

Waller, R.A. and D.P. Duncan, 1969. A bays rule for symmetric multiple comparison problem. Am. Stat. Assoc. J., 64: 1485-1503.

Welch, R.M., W.H. Allaway, W.A. House and J. Kudata, 1991. Geographic Distribution of Trace Element Problems. In: Micronutrient in Agriculture, Mortvet, J.J., F.R. Cox, L.M. Shuman and R.M Welch (Eds.). Soil Science Society Am., Madison, WI, pp: 31-57.

Zhang, S.X., X.B. Wang and K. Jin, 2001. Effect of different N and P levels on availability of zinc, copper, manganese and iron under arid conditions. Plant Nutr. Fert. Sci., 7: 391-396.