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Effect of Cu, Fe, Mn, Zn Foliar Application on Productivity and Quality of Some Wheat Cultivars (*Triticum aestivum* L.)

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A B S T R A C T

Two field experiments were conducted in the successive winter seasons 2011/2012 and 2012/2013 at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University to study the effect of Cu, Fe, Mn, Zn foliar application on yield and quality of four wheat cultivars (Sids 13, Sakha 94, Misr 1 and Gemeiza 7). A spilt-plot design in a randomized complete block design with three replications was used. Results showed that foliar application by all micronutrients gave significant effect on yield traits and protein content in both seasons compared with control treatment. Moreover, foliar application wit combination of micronutrients (Cu+Fe+Mn+Zn) produced the highest values of plant height (85.03 and 87.17 cm), tillers number m^{-2} (318.4 and 329.3), spikes number m^{-2} (279.33 and 282.9), spike length (9.32 and 9.56 cm), number of spikelets $spike^{-1}$ (16.26 and 16.37), number of grains $spike^{-1}$ (39.73 and 40.98), 1000-grain weight (42.50 and 43.26 g), grain yield (6.270 and 6.400 ton ha^{-1}) , straw yield (12.58 and 12.77 ton ha^{-1}), biological yield (18.84 and 19.17 ton ha^{-1}) and harvest index (33.21 and 33.36 %), respectively, in both seasons followed by Zn foliar application followed by Mn foliar application followed by Fe foliar application then Cu foliar application. Among wheat cultivars Sids 13 cultivar ranked 1st in all yield traits and protein content in both seasons followed by Misr 1 followed by Gemeiza 7 cultivar. Howeve, Sakha 94 gave the lowest values of yield traits and protein content. It concluded that sowing Sids 13 cultivar with foliar application micronutrients (Cu+Fe+Mn+Zn) produce high grain yield and greatest grain protein content.

Keywords: *Wheat, Cultivars, Micronutrients, Foliar application, Zn , Cu, Mn, Fe, Yield, Grain quality, straw, biological, Protein*.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the first most important cereal crop in Egypt and covers 1,418,708 ha of land with an annual production 9,460,200 ton, according to FAO 2013 (Anonymous, 2014). In Egypt, most soils suffering from micronutrients deficiency due to intensive cropping system and no interesting by micronutrients foliar application at Egyptian local farmers. Arif . (2006) found that foliar application of micronutrients at tillering, jointing and booting stages help in improving yield of wheat. While, zinc, copper, iron and manganese contents of leaf, straw and grain of wheat increased with the application of conditioner and mineral fertilizers. Shaheen . (2007) stated that increased yield of wheat required Zn status of soils to be improved by Zn fertilization. Chaudry . (2007) stated that micronutrients (Zn, Fe, and B) significantly increased the wheat yield over control when applied single or in combination with each other.

Malakouti (2008) stated that the highest yield was obtained by adding all the micronutrients to NPK fertilizer. Also, NPK + micronutrients significantly increased protein content of wheat kernel from 11.66% to 12.01%. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, eliminating losses through leaching, and fixation and helps in

regulating the uptake of nutrients by plants (Manomani and Srimath, 2009). Kumar . (2009) concluded that Cu fluxes and it's interactions with other micronutrients (Fe, Mn and Zn) was affect the growth and yield of wheat plants Abbas . (2009) found that different Zn levels did not significantly affect plant height, but significantly on spike length, number of spikelets per spike, 1000-grain weight and straw yield. Habib (2009) reported that Zn and Fe spray increased grain yield of wheat and its revelant traits compared to control and that out of the studied treatments, the treatment of Fe+Zn+ resulted in the highest grain yield.
El-Ghamry . (2009) found that foliar micronutrients (Boron, Molybdenum and zinc) gave the maximum mean values of all investigated yield parameters. Ali . (2009) stated that solutions of zinc, boron and zinc plus boron were used as foliar spray, each applied at tillering, jointing and boot stage. Significant increase was recorded in number of spikes m^{-2}, grains spike-1, thousand grain weight, biological yield and grain yield for foliar application of zinc and boron as both control treatments. Khan .(2010) reported that there was no effect of micronutrient application on number of tillers, fertile tillers and spike length. Exogenous application of Shelter(commercial micronutrients mixture: Zn=2%, Fe=1%, Mn=2%, Cu=1%, B=1%) significantly improved the number of grains per spike, 1000-grain weight, grain yield, straw yield, biological yield and harvest index at different growth stages of wheat. An increase in the number of grains per spike, 1000-grain weight, straw yield and biological yield was recorded when Shelter was applied at least at three growth stages. Maximum grain yield, net economic returns were recorded when Shelter was applied at tillering, jointing, booting and earing.

Zeidan . (2010) reported that grain yield, straw yield, 1000-grain weight and number of grain /spike and protein content in grain were significantly increased by application 0.5% Mn SO_4, H_2O , 1.0% Fe SO_4, H_2O and 0.5% Zn SO_4, H_2O per feddan at tillering and heading stages compared with control. Jam . (2011), studied that the effect of combination of different concentrations of Fe and Zn fertilers (2,4 and 8:1000). They found that the application of Zn and Fe micronutrients increased grain yield and its components. Farhan and Al-Dulaemi (2011) indicated that all micronutrients treatments showed significant increase in all morphological, physiological and productivity characters compared with control treatment. Combination of iron + zinc+ copper gave the highest values of plant height, number of leaves, leaf area/plant, number of tiller/plant, grain yield and protein content. However, Treatments of combinations between two elements together came second while treatments with each element alone came third.

Nadim . (2011) found that boron application improved the wheat grains and yield while the use of copper and manganese had also positive effect on wheat productivity. Among different micronutrients, zinc application produced minimum number of grains $spike^{-1}$, while the use of iron did not improve plant growth. Habib (2012) concluded that foliar application of Zn and Fe increased grain yield and its quality when compared with control. Pavithra and Patil (2013) found that foliar application of Starter @ 2% at 15 and 45 DAS + Booster @ 2% at 55 and 70 DAS recorded significantly higher yield components like effective tillers per square meter, number of grains per ear head, 1000-grain weight (43.10 g), grain yield (39.97 g ha^{-1}) and quality parameters i.e. protein, gluten, starch, zeleny, zinc content in wheat grains. This treatment also recorded higher nutrient uptake at harvest and higher net returns as compared to control treatment.

El Habbasha . (2013) reported that spraying wheat with *Azospillium*, nutrient solution and biocide compound shows significant differences in most yield and yield attributes except number of grains/spikelet, seed index, harvest index and grain protein content. Also, significant differences between wheat cultivars (Sakha 93 and Sakha 94) in most of studied characters of yield and yield attributes except , spike length , number of spikelets /spike, number of grains/spikelet, seed index, harvest index and seed protein content. Nadim . (2013) reported that boron application recorded higher number of tillers m^{-2}, number of grains $spike^{-1}$and grain yield (ton ha^{-1}). The use copper also showed encouraging results similar to boron. Ghafari and Razmjoo (2013) suggested that Fe foliar application increased antioxidant enzymes activities and chlorophylls contents, harvest index, 1000-grain weight, grain yield and protein content in grain. Faraji . (2014) concluded that applying Zn increased number of spikesm^{-2}, harvest index, 1000-grain weight , grain , straw and biological yields. Harsini .(2014) indicted that foliar application by iron at (tillering and heading) increased yield traits and protein content in grain.

Regarding to wheat cultivars, Kandil . (2001) reported that significant differences were observed among the tested wheat cultivars (Giza 164 Sakha 69 and Sids 1) in grain yield and its attributes. Giza 164 cultivar was higher in grain yield than the two other ones. Bayoumi . (2008) evaluated nine wheat genotypes; seven local varieties with two introduced genotypes from (ICARDA). Combined analysis of variance over two seasons showed highly significant differences among wheat genotypes in all the studied traits. Sarwar . (2010) studied on three wheat cultivars (AS-2002, SH-2002 and Aqab-2000). Wheat cultivar AS-2002 recorded highest grain yields which higher than the other two cultivars. Mohamed (2013) stated that Sids 12 cultivar was the highest in yield and its components compared with commercial cultivars (Sakha 93, Sakha 94, Gemmeiza10 and Giza 168) and other tested lines.

Keeping in view all these aspects, the aim of this study was to investigate the effect of the application of Fe, Zn, Mn, Cu micronutrients on grain yield and quality of four wheat cultivars.

MATERIALS AND METHODS

Two field experiments were conducted in the successive winter seasons 2011/2012 and 2012/2013 at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, Giza, to study the effect of six micronutrients foliar (Control :NPK, F_1: NPK+ Zn , F_2: NPK+Fe , F_3: NPK+Mn, F_4: NPK+Cu and F_5: NPK + Zn + Fe+ Mn + Cu) on four wheat cultivars (Sids 13, Gemmeiza 7, Sakh 94 , Misr 1). A spilt plot design in a randomized complete blocks arrangement with three replications was used to conduct all trials. The four wheat cultivars were randomly assigned for main plots. The micronutrients foliar treatments were randomly arranged for main plots. The four wheat cultivars were randomly assigned for sub plots. Each plot consisted of fifteen rows, four meters long with 20 cm between rows (plot area 12 m^2). The preceding summer crop was maize in both seasons. In both seasons, the soil texture was clay loam.

Table1. Physical and chemical analysis of soil at experimental site in 2011/12 and 2012/13 seasons

Season	Clay %	Silt %	Sand %	Organic %	pH -	Salinity $ds.m^{-1}$	N ppm	P ppm	K ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm
2011/12	38.3	23.2	38.5	1.8	7.8	0.84	36	15.7	210	0.64	12.9	8.4	0.54
2012/13	37.9	24.3	37.8	1.7	7.9	0.76	38	15.4	211	0.53	12.8	9.2	0.51

Sowing was done by means single row hand drill on 14th and 15th May in both season, respectively. Seeding density was 350 seeds m^{-2}. The recommended dose of chemical fertilizer were added as positive control i.e. nitrogen fertilizer was add at a rate of 190 kg/ha as urea (46%) in three equal doses at sowing , early tillering and booting staqges, while phosphorus were added at a rate of 120 kg /ha for both P_2O_5 and K_2O, respectively at seed bed preparation. Foliar application treatments were applied during tillering, booting and heading stages as follow:

1-Control
2- Zn SO_4, H_2O 10 kg ha^{-1}
3- Fe SO_4,H_2O 12 kg ha^{-1}
4- Mn SO_4, H_2O 12 kg ha^{-1}
5-Cu SO_4, H_2O 8 kg ha^{-1}
6- Zn+Fe+Mn+Cu combination.

At harvest, one square meter was taken randomly from the middle area of each plot to determine plant height (cm), number of tillers and spikes per m^2, spike length (cm) number of spikelets per spike, number of grains per spike and thousand grain weight (g). Grain, straw and biological yields (ton ha^{-1}) were determined from the whole plot area. Harvest index was calculated as the ratio of grain yield to biological yield and was expressed in percent.

Grain crude protein percentage was estimated according the improved Kjeldahl method of AOAC (1990). Data for each trait were analyzed for a split-plot design according to the procedure outlined by Steel . (1997). Comparisons between means were made using least significant differences (LSD) at 0.05 probability level.

RESULTS AND DISCUSSION

1. Effect of micronutrients foliar application:

1.1. Yield and yield components:

Data in Table (2) showed that the effect of micronutrients foliar application on yield and its components in 2011/2012 and 2012/2013 seasons. Results revealed that significant differences between micronutrients treatments in all yield traits in both seasons. The results indicated that plant height was increased by application of Zn, Fe, Mn , Cu and combination of all micronutrients by(3.22 , 3.26%) , (4.78, 5.24%), (7.22, 6.33%), (8.21, 6.75%) and (10.91, 11.47%) respectively, compared with control treatment in both seasons.

Different foliar application treatments significantly influenced number of tillers m^{-2} in both seasons (Table 2), so that the highest number of tillers m^{-2} (318.35 and 329.28) was obtained from F_5 treatment (mixture of all micronutrients) and the lowest one from control (no foliar application) in both seasons. Also, number of tillers m^{-2} was significantly increased by Cu, Fe, Mn and Zn foliar application compared with control treatment in both seasons.

Number of spikes m^{-2} was significantly impacted by foliar application treatments in both seasons (Table 2). The highest number of spikes m^{-2} (318.35 and 329.28) was obtained from F_5 treatment which was (13.37 and 11.43%) higher than that obtained from control treatment in both seasons. Cu foliar application caused increase in number of spikes m^{-2} by 4.73 and 3.34%, respectively compared with control treatment in both seasons. Also, Fe, Mn and Zn foliar application gave an increase in number of spikes m^{-2} by (7.17, 5.79%), (8.60, 6.95%) and (9.59, 8.89%), respectively, compared with control treatment in both seasons.

Spike length was significantly affected by foliar application treatment in 2011/2012 and 2012/2013 seasons (Table 2).The highest spike length (9.32 and 9.56 cm) was produced from F_5 treatment (mixtures of micronutrients) followed by Mn application (9.31 and 9.28 cm), Zn application (9.18 and 9.32 cm) , Fe application (9.11 and 9.20 cm) and Cu application (8.98 and 9.13 cm), respectively in both seasons. The lowest spike length was obtained from control treatment (8.86 and 8.95cm), respectively in both seasons.

Table 2. Effect of foliar application by some micronutrients on yield and its components of wheat in 2011/2012 and 2012/2013 seasons

Character	Season	Foliar application treatments*						$LSD_{0.05}$
		Control	F_1	F_2	F_3	F_4	F_5	
Plant height (cm)	1st	76.66	79.13	80.33	82.20	82.95	85.03	1.23
	2nd	78.20	80.75	82.30	83.15	83.48	87.17	1.64
No. of tillers m^{-2}	1st	276.38	289.95	298.10	305.93	313.98	318.35	6.25
	2nd	288.13	297.97	304.25	310.75	318.28	329.28	7.85
No. of spikes m^{-2}	1st	246.75	258.43	264.43	267.98	270.43	279.33	5.68
	2nd	253.88	262.38	268.60	271.53	276.45	282.90	3.64
Spike length (cm)	1st	8.86	8.98	9.11	9.31	9.18	9.32	0.18
	2nd	8.95	9.13	9.20	9.28	9.32	9.56	0.13
No. of spikelets spike^{-1}	1st	15.17	15.84	15.87	15.96	16.00	16.26	0.13
	2nd	15.21	16.01	16.11	16.20	16.26	16.37	0.11
No. of grains spike^{-1}	1st	34.81	36.43	37.65	38.08	38.60	39.73	1.05
	2nd	35.98	37.10	37.88	39.13	39.60	40.98	1.07
1000-grain weight (g)	1st	37.42	39.48	40.08	41.06	41.30	42.50	0.98
	2nd	39.20	40.05	41.18	41.60	42.05	43.26	0.75
Grain yield (t ha^{-1})	1st	5.600	5.720	5.830	6.010	6.140	6.270	0.081
	2nd	5.660	5.800	5.910	6.120	6.250	6.400	0.075
Straw yield (t ha^{-1})	1st	11.96	12.08	12.21	12.31	12.43	12.58	0.057
	2nd	12.11	12.25	12.41	12.54	12.64	12.77	0.061
Biological yield (t ha^{-1})	1st	17.55	17.79	18.04	18.32	18.56	18.84	0.065
	2nd	17.76	18.05	18.32	18.67	18.89	19.17	0.0.37
Harvest index (%)	1st	31.81	32.06	32.27	32.75	33.02	33.21	0.38
	2nd	31.78	32.08	32.18	32.76	33.07	33.36	0.21

*Control (NPK), F_1: Zn, F_2: Fe, F_3: Mn, F_4: Cu and F_5: Zn + Fe+ Mn + Cu combination).

The effect of foliar application treatments was significant on number of spikelets spike^{-1} in both seasons (Table 2). The Results showed that the highest number of spikelets spike $^{-1}$ (16.26 and 16.37) was obtained from F_5 treatment in both seasons, while the lowest value was produced under control treatment in both seasons. However, number of spikelets spike $^{-1}$differed only slightly among foliar application treatments showing that this trait is more controlled by genetics than by environmental factors.

The number of grains spike^{-1} was significantly affected by foliar application treatments in 2011/2012 and 2012/2013 seasons (Table 2). Results indicated that the highest number of grain spike^{-1} (39.73 and 40.98) was produced under F_5 treatment compared with other foliar application in both seasons. However, the lowest value (34.81 and 5.98) was obtained from control treatment in both seasons.

The effect of foliar application treatments was significant on 1000-grain weight in both seasons (Table 2). F_5 treatment gave the highest 1000-grain weight (42.50 and 43.26 g), respectively in both seasons compared with other treatments. However, the lowest value of 1000-grain weight (37.42 and 39.20 g) was recorded at control treatment in both seasons.

The data given in Table 2 indicated that micronutrients had significant effect on grain yield in 2011/12 and 2012/13 seasons. Foliar application by any element or combination of all elements caused an increase in grain yield in different proportions compared with control treatments in both seasons. Cu foliar application increased grain yield by 2.14 and 2.47 %, respectively in both seasons compared with control treatment. Fe folia application produced an increase in grain yield by 4.11 and 4.42 %, respectively in both seasons compared with control treatment. Mn foliar application improved grain yield by 7.32 and 8.12%, respectively in both seasons compared with control treatment. Zn foliar application gave an increase in grain yield by 9.64 and 10.4%, respectively compared with control treatment. Foliar application by combination of all micronutrients under study gave the greatest grain yield (6.270 and 6.400 ton ha^{-1}) in both seasons compared with other treatments.

The results presented in Table 2 showed that the foliar application treatment was significantly affected on straw yield in both seasons. All micronutrients treatments were significantly increased straw yield in both seasons compared with control treatment. Mixture of Zn + Fe + Mn + Cu microelements gave the greatest straw yield (12.58 and 12.77 ton ha^{-1}) followed by Zn foliar application (12.43 and 12.64 ton ha^{-1}) followed by Mn foliar application (12.31 and 12.54 ton ha^{-1}) and Fe foliar application (12.21 and 12.41 ton ha^{-1}), respectively in both seasons. However, Cu foliar application gave slightly increase in straw yield compared with control treatment.

From the data presented in the Table (2) revealed that there was significant differences among foliar application treatments for biological yield (ton ha^{-1}) in 2011/2012 and 2012/2013 seasons. The highest biological yield (18.84 and 19.17 ton ha^{-1}) was recorded in F_5 (Combination of Cu +Fe + Mn + Zn micronutrients) followed by F_4(Zn foliar application) which was (18.56 and

18.89ton ha^{-1}) followed by F_3 (Mn foliar application) which was (18.32 and 18.67 ton ha^{-1}) followed by F_2 (Fe foliar application) which was (18.04 and 18.32 ton ha^{-1}) followed by F_1(Cu foliar application) which was (17.79 and 18.05 to ha^{-1}) whereas the lowest was observed in control treatment which was (17.55 and 17.76 ton ha^{-1}), respectively in both seasons.

According to results shown in the Table (2) revealed that there was significant effect among the foliar application treatments for harvest index (%) in 2011/2012 and 2012/2013 seasons. Maximum harvest index (33.21 and 33.36 %) was recorded in F_5 (Cu + Fe + Mn +Zn) compared with other treatments in both seasons. However, the lowest value of harvest index (31.81 and 31.78 %) was noticed at control treatment.

Considering the aforementioned facts, it could be concluding that the foliar application by Cu or Fe or Mn or Zn and their combination increased grain yield. This might be due to increasing in number of spikes m^{-2}, number of grain spike^{-1} and grain weight spike^{-1} by micronutrient foliar application. These results corroborate the findings of Arif . (2006), Malakouti (2008), Kumar . (2009), Abbas . (2009), Khan . (2010), Zeidan . (2010), Jam . (2011), Farahan and Al-Dulaemi (2011), Nadim . (2013), Faraji . (2014) and Harsini . (2014).

1.2. Protein content:

Fig.1 illustrated that significant effect of different micronutrients foliar application on protein content in wheat grain in both seasons. Foliar application caused markedly increase in protein content in both seasons. The greatest protein content (11.01 and 11.11 %) was recorded at F5 treatment (combination of Cu + Fe + Mn + Zn micronutrients) followed by Zn application (10.91 and 11.01%) followed by Mn application (10.86 and 10.93%) followed by Fe application (10.79 and 10.88%) then Cu application (10.69 and 10.80%), respectively in both seasons. However, the lowest protein content (10.57 and 10.67 %) was obtained in control treatment, respectively in both seasons. These results are in agreement with those obtained by Malakouti (2008), Zidan . (2010), Farhan and Al-Dulaemi (2011), Pavithra and Patil (2013), El Habbasha . (2013), Ghafari and Razmjoo (2013) and Harsini etal. (2014)

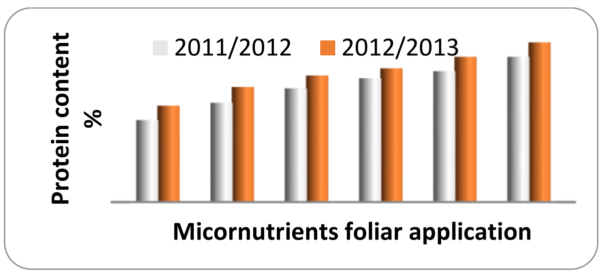

Figure 1. Effect of different micronutrients foliar application on protein content (%) in grain of wheat in 2011/12 and 2012/13 seasons

2.Effect of wheat cultivars:

2.1. Yield and yield components:

The data on yield and yield attributes i.e. plant height , number of tillers m^{-2}, number of spikes m^{-2}, spike length ,number of spikelets spike^{-1}, number of grain spike^{-1},1000-grain weight (g), grain, straw and biological yields differed significantly due to wheat cultivars (Table 3) in 2011/12 and 2012/13 seasons. It was evident that wheat cultivars Sids 13 surpassed in plant height (83.04, 83.65 cm) the other three cultivars (Sakha 94, Misr1 and Gemeiza 7). However, wheat cultivar Sakha 94 produced the lowest value of plant height (79.68 and 81.67 cm), respectively in both seasons.

Tillering is an important development stage that allows the plants to compensate under low plant population or taking advantage of good growing conditions. The appearance of tillers is closely coordinated with leaves on the main stem while the number of tillers formed depends on the variety and growing conditions (Reddy, 2004). The data presented in Table (3) revealed that the differences between wheat cultivars were significant in number of tillers m^{-2} in both seasons. Sids 13 cultivar produced the highest number of tillers m^{-2} (314.55 and 320.30) followed by Misr1 cultivar (301.83 and 312.12) followed by Gemeiza 7 (298.10 and 308.18) and Sakha 94 (287.30 and 291.83), respectively in both seasons.

Regards to number of spikes m^{-2} the wheat cultivars were significantly different in both seasons (Table 3). Sids13 cultivar gave the highest number of spikes m^{-2} (277.10 and 279.88) followed by Misr 1 (274.17 and 278.22) followed by Gemeiza 7(269.85 and 275.75) and Sakha 94 cultivar (237.10 and 243.30), respectively in both seasons.

Table 3. Effect of some wheat cultivars on yield and its components in 2011/2012 and 2012/2013 seasons

Character	Season	Wheat cultivars				$LSD_{0.05}$
		Sids 13	Sakha 94	Misr 1	Gemeiza 7	
Plant height (cm)	1st	83.04	79.68	81.24	80.57	1.12
	2nd	83.65	81.67	82.69	82.03	1.32
No. of tillers m^{-2}	1st	314.55	287.30	301.83	298.10	2.35
	2nd	320.30	291.83	312.12	308.18	2.84
No. of spikes m^{-2}	1st	277.10	237.10	274.17	269.85	3.01
	2nd	279.88	243.30	278.22	275.75	2.68
Spike length (cm)	1st	9.80	8.37	9.16	9.17	0.12
	2nd	9.87	8.42	9.41	9.25	0.21
No. of spikelets $spike^{-1}$	1st	16.68	15.56	15.75	15.68	1.11
	2nd	16.82	15.67	16.12	15.98	1.28
No. of grains $spike^{-1}$	1st	41.65	32.04	41.12	35.38	1.35
	2nd	42.72	33.53	41.87	35.65	1.47
1000-grain weight (g)	1st	41.72	39.46	40.39	39.65	1.14
	2nd	42.61	40.16	41.54	40.58	1.21
Grain yield (t ha^{-1})	1st	6.480	5.220	6.310	5.710	0.034
	2nd	6.560	5.390	6.390	5.750	0.054
Straw yield (t ha^{-1})	1st	12.92	11.50	12.43	12.18	0.67
	2nd	13.10	11.71	12.65	12.35	0.72
Biological yield (t ha^{-1})	1st	19.40	16.72	18.74	17.88	0.34
	2nd	19.66	17.10	19.04	18.10	0.61
Harvest index (%)	1st	33.38	31.18	33.65	31.88	1.02
	2nd	33.36	31.48	33.57	31.73	1.05

Spike length (cm) was significantly affected by different wheat cultivars in both seasons (Table 3). The highest spike length (9.80 and 9.87 cm) was recorded from Sids 13 cultivars followed by Misr 1 and Gemeiza 7, while the lowest one (8.37 and 8.42 cm), respectively in both seasons.

The number of spikelets $spike^{-1}$ was affected by wheat cultivars significantly in 2011/12 and 2012/13 seasons (Table3). The results cleared that wheat cultivar Sids 13 surpassed in number of spikelets $spike^{-1}$ (1.68 and 16.82) the other three wheat cultivars (Sakha 94, Misr 1 and Gemeiza 7). Meantime, Sakha 94 cultivar gave the lowest value (15.56 and15.67), respectively in both seasons.

Number of grains $spike^{-1}$is an important yield contributing parameter which greatly influences the crop production. The data given in (Table 3) indicated that wheat cultivars significantly affected the grains number $spike^{-1}$. Among wheat cultivars, Sids 13 had the maximum number of grains $spike^{-1}$ (41.65 and 42.72)

Data given in Table 3 clearly indicate that, wheat cultivar Sids 13 gave the highest 1000-grain weight (41.72 and 42.61 g) followed by wheat cultivar Misr 1 (40.39 and 41.54 g) and Gemeiza 7 (39.65 and 40.58 g), respectively in both seasons. Meanwhile, Sakha 94 wheat cultivar produced the lowest value (39.46 and 40.16 g), respectively.

Data shown in Table (3) revealed that the significant differences among wheat cultivars respecting of grain yield (ton ha^{-1}) in 2011/2012 and 2012/2013 seasons. Sids 13 gave the highest grain yield (6.480 and 6.560 ton ha^{-1}) followed by Misr 1 (6.310 and 6.390 ton ha^{-1}) and Gemeiza 7 (5.710 and 5.750 ton ha^{-1}), respectively in both seasons. However, Sakha 94 cultivar gave the lowest grain yield (5.220 and 5.390 ton ha^{-1}), respectively.

Regarding the effect of wheat cultivars on straw and biological yields, data in Table 3 revealed that the significant different between wheat cultivars were observed in straw and biological yields in both seasons. Sids 13 cultivar gave the highest straw and biological yields (12.92, 13.10 and 19.40, 19.66 ton ha^{-1}) followed by Misr 1 cultivar (12.43, 12.65 and 18.74, 19.04 ton ha^{-1}) then Gemeiza 7 (12.18, 12.35 and 17.88, 18.10 to ha^{-1}) in both seasons, respectively. However, Sakha 94 produced the lowest values of straw and biological yields (11.50, 11.71 and 16.72, 17.10 ton ha^{-1}) in both seasons.

Data in Table 3 showed that the effect of wheat cultivars on harvest index (%) in 2011/12 and 2012/13 seasons. Results indicated that significantly differences between cultivars on harvest index in both seasons. Misr 1 cultivars gave the highest harvest index (33.65 and 33.57%) followed by Sids 13 (33.38 and 33.36%) and Gemeiza 7 (31.88 and 31.73 %) in both seasons, respectively.

From the above results it concluded that the Sids 13 cultivar was superior in grain yield and its components compared with other three wheat cultivars in both seasons. These results are in harmony with those obtained by Kandil . (2001), Bayoumi . (2008), Sarwar . (2010) and Mohamed (2013).

2.2. Protein content:

Fig.2 illustrated that the varietal differences in grain protein content (%) were significant in 2011/2012 and 2012/2013 seasons. Results revealed that Sids13 cultivar gave the highest protein content (12.31 and 12.39 %) followed by Misr 1 cultivar (11.61 11.73%), respectively in both seasons. Moreover, the differences between Sids 13 and Misr 1 in protein content (%) were not significant. It was , however, at par statistically with Gemeiza 7 (9.90 and 9.96 %) and Sakha 94 (9.40 and 9.52 %), respectively in both seasons. Similar findings with obtained by of Mohamed (2013).

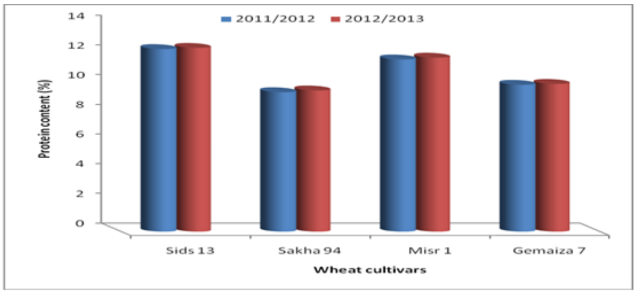

Figure 2. Effect of some wheat cultivars on grain protein content (%) in 2011/12 and 2012/13 seasons.

3. Interaction effect:

3.1. Grain yield:

The interaction between micronutrients foliar application and wheat cultivars shows significant differences in grain yield (ton ha^{-1}) in 2011/2012 and 2012/2013 seasons (Fig. 3 and 4). Combination treatment (Cu + Fe + Mn + Zn) gave the highest grain yield for all wheat cultivars (6.78, 6.80, 5.56, 5.89, 6.52, 6.65 and 6.20, 6.26 ton ha^{-1}), respectively compared with other foliar application treatments in both seasons. Sids 13 cultivar produced the highest grain yield under all foliar application treatments followed by Misr1 cultivar followed by Gemeiza 7, respectively in both seasons. However, Sakha 94 cultivar produced the lowest grain yield under all foliar application treatments.

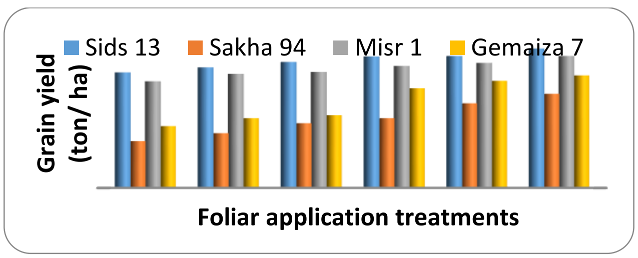

Figure 3. Effect of interaction between micronutrients foliar application and wheat cultivars on grain yield (ton ha^{-1}) in 2011/2012 season

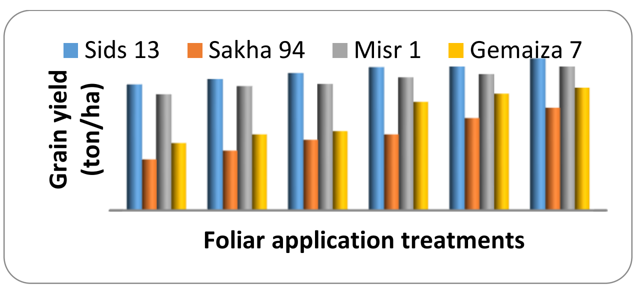

Figure 4. Effect of interaction between micronutrients foliar application and wheat cultivars on grain yield (ton ha^{-1}) in 2012/2013 season.

3.2. Protein content:

Data presented in Fig. 5 and 6 show the interaction between foliar application treatments and wheat cultivars on grain protein content (%) in both seasons, significant differences between treatments were noticed. Foliar application with combination of microelements (Cu, Fe, Mn and Zn) increased protein content in grain of all wheat cultivars followed by Zn foliar application followed by Mn foliar application followed by Fe foliar application and Cu foliar application compared with control treatment in both seasons. Moreover, Sids 13 cultivar was surpassed the three other wheat cultivars under all foliar application treatments. However, Sakha 94 cultivar gave the lowest protein content under all foliar application treatments in both seasons.

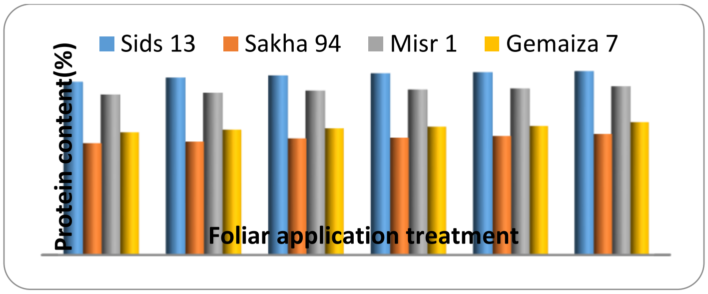

Figure 5. Effect of interaction between micronutrients foliar application and wheat cultivars on grain protein content (%) in 2011/2012 season.

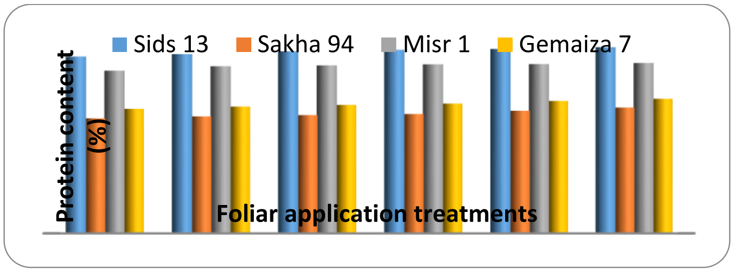

Figure 6. Effect of interaction between micronutrients foliar application and wheat cultivars on grain protein content (%) in 2012/2013 season

CONCLUSION

It could be concluded that from the present research, the use of micronutrients significantly affected wheat yield. Combination of micronutrients (Cu + Fe + Mn + Zn) had significantly positive effect on most of yield contributing parameters of all wheat cultivars

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