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Response of Three Bread Wheat Cultivars to Foliar Spray by Some Micro- Nutrients Nano- Particles

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Abstract

A field experiment was carried out during 2017/18 and 2018/19 seasons at the Agronomy Department Experimental Farm, Agriculture Faculty, Assiut University, to study the effect of foliar spray by some Nano micro-nutrients on production of three bread wheat cultivars. The experiment was laid out in randomized complete block design (RCBD) using strip plot arrangement with three replications. Foliar spray with tap water (solvent as a control) and Foliar spray with Fe, Mn, Zn, Fe+Mn, Fe+Zn, Mn+Zn and Fe+Mn+Zn in Nano form at 200 ppm were allocated horizontally, while bread wheat cultivars (Sids-1, Sids-12 and Gemmeaza-11) were arranged vertically. The obtained results show that the foliar spray treatment by some micro-nutrients Nano-particles had a significant effect on plant height, kernels number spike^{-1}, 1000 kernel weight, kernel weight spike^{-1} and grain yield in both seasons. Thus, wheat plants which were sprayed by Fe+Mn+Zn produced the highest mean values of the most previous traits. Furthermore the studied cultivars had a significant effect on all studied traits. In addition, Gemmeaza-11 cultivar produced the highest mean values of most studied traits in the two growing seasons. Here too, the interaction between some micro-nutrients Nano-particles and bread wheat cultivars had a highly significant ($P \leq 0.01$) and significant ($P \leq 0.05$) influence on grain yield in the first and second seasons respectively. Thus, the highest mean values of grain yield (26.80 and 26.95 ardab fed.$^{-1}$ in the tow respective seasons) were obtained from Gemmeaza-11 cultivar which was sprayed by Fe+Mn+Zn Nano-particles in both seasons.

Keywords: *Wheat, cultivars, Micro-nutrients, Nano-particles.*

Introduction

Wheat (*Triticum sp.* L.) considers the most important cereal crop in the world regarding to its cultivated area and production. The cultivated area of wheat in Egypt during 2018 season was about 3.1 million feddan with the total yield production of 8.45 metric tons, While, the total consumption reached about 19.6 million metric tons in the same year (USDA, 2018). So that, increasing wheat production in order to reduce the gap between production and consumption is the strategic aim in Egypt. Therefore, a great attention should be done to overcome or minimize the gap between wheat production and consumption. Increasing production per unit area appears to be the one of the main objective of reducing the wheat gap. Increasing wheat yield per unit area could be attained by cultivating high-yielding cultivars and implement recommended cultural practices. The productivity and quality of wheat depends on several factors like climate, agronomic management practices, varietal response, soil type etc. The response of different wheat genotypes to foliar application of microelements in a Nano form can support the expression of microelements-efficient and microelements-inefficient genotypes.

Fe, Mn, Zn are considered as the most essential micro-nutrients which plays very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome, plant enzymes activated, carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation, regulation and maintenance of the gene expression required for the tolerance of environmental stresses in plants (Hafeez *et al*., 2013).

Nano-particle is defined based on the size at which fundamental properties differ from those of the corresponding bulk material (Banfield and Zhang, 2001). Nano-particles overlap in size with colloids, which ranges from 1 nm to 1 mm in diameter (Buffle, 2006). Novel properties that differentiate Nano-particles from the bulk material typically develop at a critical length scale of under 100 nm. The “novel properties” mentioned are entirely dependent on the fact that at the Nano-scale, the physics of nanoparticles mean that their properties are different from the properties of the bulk material. Particle size may affect agronomic effectiveness of Fe, Mn and Zn fertilizers. Decreased particle size results in increased number of particles per unit weight of applied the fertilizer. Decreased particle size also increases the specific surface area of a fertilizer, which should increase the dissolution rate of fertilizers with low solubility in water (Mortvedt, 1992). Rameshraddy *et al.* (2017) indicated that the foliar application of finger millet by ZnO Nano showed higher plant height and increased yield. Zenhom *et al.* (2018), indicated that, there were significant differences between the different tested wheat cultivars in plant height and grain yield traits Otherwise, the difference between tested wheat cultivars didn't reach a significant level with regard to No. of kernels spike^{-1}. Moreover; Gemmeaza-11 cultivar gave the highest mean value of plant height (108.00 cm) and grain yield fed^{-1} (3169 kg). On the other hand, Sids 12 cultivar gave the lowest mean values of, grain yield fed^{-1} (2773 kg), whereas Giza 171 cultivar gave the lowest mean value of plant height (86.67 cm).

The objective of this study was to elucidate:

1- The effect of foliar application by Nano form of Fe, Mn, and Zn on wheat yield.

2- The performance of three bread wheat cultivars across the different treatments combinations of the foliar applications.

Materials and Methods

A field experiment was carried out during 2017/18 and 2018/19 seasons at the Agronomy Department Experimental Farm, Agriculture Faculty, Assiut University, Assiut, Egypt (lat 27° 03' N, long 31° 01' and alt 70 m asl) to study the effect of foliar spray by some Nano micro-nutrients on production of three bread wheat cultivars. The mechanical and chemical analyses of the experimental soil are presented in Table 1.

Table 1. Some mechanical and chemical properties of the experimental soil.

Properties	2017/18	2018/19
Mechanical analysis:		
Sand	27.00	27.80
Silt	23.00	22.20
Clay	50.00	50.00
Soil type	Clay	Clay
Chemical analysis:		
pH	7.63	7.85
Organic matter %	1.80	1.70
Total N%	0.09	0.08

Experiment, treatments and design:

The experiment was laid out in randomized complete block design (RCBD) using strip plot arrangement with three replications. Foliar spray with tap water (solvent as a control) and foliar spray with Fe, Mn, Zn, Fe+Mn, Fe+Zn, Mn+Zn and Fe+Mn+Zn in Nano form at 200 ppm were allocated horizontally and their application time was after 45 and 60 days from sowing, while bread wheat cultivars (Sids-1, Sids-12 and Gemmeaza-11) were arranged vertically. The experimental unit was (3 x 3.5m) 10.5 m^2 and the sowing method was broadcasting. Grains were sown at December 6th and 9th in the first and second seasons, respectively. The preceding summer crop was maize in both seasons. All other cultural practices recommended for wheat crop were done.

Measured traits:

a- Plant height (cm): It was determined from soil surface until the upper tip of plants and average of five guarded stems which were taken randomly from each experimental unit.

b- Spike length (cm): It was determined as average of five random spikes from each experimental unit.

c- Number of kernels spike^{-1}: Average number of kernels spike^{-1} was obtained from five random spikes from each experimental unit.

d- Kernels weight spike^{-1} (g): It was estimated an average of grain weight obtained from five random guarded spikes in each experimental unit.

e- Thousand kernel weight (g): The weight of 1000-kernel represented each experimental unit was weighted.

f- Grain yield (ardab/fed.): The mature wheat plants from each experimental unit were harvested then threshed and grain yield was weighted in kilogram then transferred into ardab per feddan (one ardab = 150 kg).

Statistical Analysis

All collected data were subjected to analysis of variance (ANOVA) using Proc Mixed of SAS package version 9.2 (SAS 2008) and means were compared by revised Least Significant Difference (R LSD) at 5% level of significant (Steel & Torrie, 1981).

Results and Discussion

1- Plant height (cm):

Data presented in Table 2 show that foliar spray treatment by some micro-nutrients Nano-particles, wheat cultivars and their interactions had a highly significant ($P \leq 0.01$) effect on plant height in both seasons. Thus, the tallest wheat plants (100.89 and 107.04 cm in the tow respective seasons) were obtained from foliar application with Fe+Mn+Zn in both seasons. Otherwise, the shortest plants (92.49 and 102.44 cm in the tow respective seasons) were obtained from control treatment in both seasons. The amount of increment reached about 9.08 and 4.49% in the first and second seasons respective. This may be due to the very important role of Fe, Mn and Zn in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome, plant enzymes activated, carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis which was reflected in an increase in plant height. Similar trend was observed by Mekkei and El Haggan (2014), Fathi *et al.* (2017), Ghasemi *et al.* (2017), Kandil &Marie (2017) and Rameshraddy *et al.* (2017).

Furthermore, the tallest wheat plants (103.20 and 113.38 cm in the tow respective seasons) were obtained from Sids-1 cultivar in both seasons. Otherwise the shortest plants (87.88 and 96.62 cm in the tow respective seasons) were obtained from Sids-12 cultivar in both seasons. This may be due to the genotypic behavior in combination with the environmental conditions, which may be suitable for Sids-1 cultivar than the rest cultivars. These findings are in a good line with those obtained by Moayedi *et al.* (2010), Mushtaq *et al.* (2012), Zaki *et al.* (2015), El Hag (2016), Kandil *et al.* (2016), Hendawy (2017), Hassanein *et al.* (2018) and Zenhom *et al.* (2018).

Moreover, the tallest wheat plants (113.07 and 117.20 cm in the tow respective seasons) were obtained from Sids-1 cultivar which was sprayed by Fe+Mn+Zn Nano-particles in both seasons. On the other hand, the shortest plants (84.80 and 93.40 cm in the tow respective seasons) were obtained from Sids-12 cultivar which was sprayed by Mn+Zn Nano-particles in the first season and control (tap water) in the second one.

Table 2. Effect of some micro-nutrients Nano-particles, cultivars and their interaction on plant height (cm) of wheat in 2017/18 and 2018/19 seasons.

Season	2017/2018				2018/2019			
Cultivars (C) / Treatments (T)	Gemmeaza-11	Sids-1	Sids-12	Mean	Gemmeaza-11	Sids-1	Sids-12	Mean
Control	91.80	96.27	89.40	**92.49**	105.40	108.53	93.40	**102.44**
Fe	94.13	99.60	88.07	**93.93**	105.40	109.60	95.00	**103.33**
Mn	95.33	100.07	88.20	**94.53**	104.93	111.73	95.80	**104.16**
Zn	96.60	101.20	88.87	**95.56**	106.20	112.93	96.53	**105.22**
Fe+Mn	98.27	103.00	90.20	**97.16**	107.33	114.60	97.00	**106.31**
Fe+Zn	100.73	107.27	88.67	**98.89**	105.60	116.60	98.00	**106.73**
Mn+Zn	99.47	105.13	84.80	**96.47**	106.67	115.87	97.60	**106.71**
Fe+Mn+Zn	104.73	113.07	84.87	**100.89**	104.33	117.20	99.60	**107.04**
Mean	**97.63**	**103.20**	**87.88**	----	**105.73**	**113.38**	**96.62**	----
F test and $RLSD_{0.05}$	**F test**		**R $LSD_{0.05}$**		**F test**		**R $LSD_{0.05}$**	
T	**		2.19		**		1.29	
C	**		0.74		**		0.83	
T x C	**		3.79		**		2.21	

where: ** mean significant at 1% level of probability

2- Spike length (cm):

Data illustrated in Table 3 focus that foliar spray treatment by some micro-nutrients Nano-particles did not affected significantly spike length of wheat in the two growing seasons. Whatever, the highest mean value of spike length in the first season (11.78 cm) was obtained from wheat plants which were sprayed with Zn. While, the maximum mean value of spike length in the second season (12.63 cm) was recorded from wheat plants which were sprayed by tab water (control). Otherwise, the shortest spikes (10.87 and 12.07 cm in the tow respective seasons) were obtained from Fe treatment in the first season and Fe+Zn treatment in the second one. These findings conflicted with those obtained by Mohsen *et al.* (2016) in barley and Ghasemi *et al.* (2017) in rice.

Furthermore, the exhibited data in Table 3 reveal that the spike length trait was affected highly significant ($P \leq 0.01$) and significant ($P \leq 0.05$) by the tested wheat cultivar in the first and second seasons, respectively. The longest wheat spikes (12.68 and 13.82 cm in the tow respective seasons) were obtained from Gemmeaza-11 cultivar in both seasons. Otherwise the shortest spikes (10.76 and 11.50 cm in the tow respective seasons) were obtained from Sids-1 cultivar in both seasons. This may be due to the genotypic behavior in combination with the environmental conditions, which may be suitable for Gemmeaza-11cultivar than the rest studied cultivars. These findings are harmony with those reported by Gheith *et al.* (2013), Noureldin *et al.* (2013), Fergani *et al.* (2014) and Solomon & Anjulo (2017).

Moreover, the spike length trait did not affected significantly by the interaction between micro-nutrients and cultivars in both seasons.

Table 3. Effect of some micro-nutrients Nano-particles, cultivars and their interaction on spike length (cm) of wheat in 2017/18 and 2018/19 seasons.

Season	2017/2018				2018/2019			
Cultivars (C) / Treatments (T)	Gemmeaza-11	Sids-1	Sids-12	Mean	Gemmeaza-11	Sids-1	Sids-12	Mean
Control	12.20	11.13	10.67	**11.33**	13.78	12.00	12.11	**12.63**
Fe	12.07	10.27	10.27	**10.87**	13.89	11.44	11.67	**12.33**
Mn	12.53	10.80	11.40	**11.58**	13.89	11.56	11.78	**12.41**
Zn	12.93	11.20	11.20	**11.78**	13.78	11.44	12.44	**12.56**
Fe+Mn	12.47	11.00	11.13	**11.53**	13.56	11.67	12.11	**12.44**
Fe+Zn	12.53	10.53	10.47	**11.18**	13.56	11.33	11.33	**12.07**
Mn+Zn	13.27	10.47	10.40	**11.38**	13.89	11.00	11.89	**12.26**
Fe+Mn+Zn	13.47	10.67	11.00	**11.71**	14.22	11.56	11.33	**12.37**
Mean	**12.68**	**10.76**	**10.82**	----	**13.82**	**11.50**	**11.83**	----
F test and RLSD$_{0.05}$	**F test**		**R LSD$_{0.05}$**		**F test**		**R LSD$_{0.05}$**	
T	NS		-		NS		-	
C	**		0.86		*		1.39	
T x C	NS		-		NS		-	

Where: NS, * and ** mean non-significant and significant at 5% and 1% level of probability, respectively.

3- Number of kernels spike^{-1}:

The exhibited data in Table 4 reveal that foliar spray treatment by some micro-nutrients Nano-particles had a highly significant (P ≤ 0.01) effect on kernels number spike^{-1} in both seasons. Sprayed wheat plants by Fe+Mn+Zn produced the highest number of kernels spike^{-1} (62.72 and 67.44 kernels spike^{-1} in the tow respective seasons). Otherwise, the lowest mean values of kernels number spike^{-1} (44.31 and 41.58 kernels spike^{-1} in the tow respective seasons) were obtained from control treatment in both seasons. This may be due to the same fertilizers treatment gained the longest spike and highest number of spikletes spike^{-1} as well as fertility which led to an increase in number of kernels spike^{-1}. These results are in accordance with those obtained by Afshar *et al* (2014) a, Zain *et al* (2015), Kandil and Marie (2017) and Gomaa *et al* (2018).

Here too, the obtained data in Table 4 show that the tested bread wheat cultivars had a highly significant (P ≤ 0.01) effect on number of kernels spike^{-1} in the two growing season. The highest mean values of kernels number spike^{-1} (57.47 and 60.54 kernels spike^{-1} in the tow respective seasons) were obtained from Sids-12 cultivar in both seasons. Otherwise, the lowest mean values of kernels number spike^{-1} (46.90 and 49.38 kernels spike^{-1} in the tow respective seasons) were registered from Sids-1cultivar in both seasons. This may be due to the genotypic behavior in combination with the environmental conditions, which may be suitable for Sids-12 cultivar than the rest studied cultivars These finding are in a good line with those obtained by Bendidi *et al.* (2016), El Hag (2016), Kandil *et al.* (2016), El hag (2017), Hendawy (2017) and Solomon & Anjulo (2017).

Concerning the interaction effect on kernels number spike^{-1}, data presented in Table 4 denote that kernels number spike^{-1} reacted significantly to the interaction between some micro-nutrients Nano-particles foliar spray and bread wheat cultivars in second season only. Thus, the highest mean value of kernels number spike^{-1} (79.80 kernels spike^{-1}) was obtained from Sids-12 cultivar which sprayed by Fe+Mn+Zn in the second season.

Table 4. Effect of some micro-nutrients Nano-particles, cultivars and their interaction on kernels number spike^{-1} of wheat in 2017/18 and 2018/19 seasons.

Season	2017/2018				2018/2019			
Cultivars (C) / Treatments (T)	Gemmeaza-11	Sids-1	Sids-12	Mean	Gemmeaza-11	Sids-1	Sids-12	Mean
Control	39.73	38.53	54.67	**44.31**	49.73	35.00	40.00	**41.58**
Fe	48.33	43.65	56.80	**49.59**	55.80	39.13	49.20	**48.04**
Mn	50.80	44.20	59.07	**51.36**	59.60	44.93	56.07	**53.53**
Zn	51.87	44.97	60.00	**52.28**	57.47	47.40	59.87	**54.91**
Fe+Mn	53.90	45.73	62.45	**54.03**	70.60	49.67	62.73	**61.00**
Fe+Zn	60.33	50.40	52.33	**54.36**	60.87	59.47	69.07	**63.13**
Mn+Zn	56.13	48.00	50.47	**51.53**	69.20	52.40	67.60	**63.07**
Fe+Mn+Zn	64.42	59.73	64.00	**62.72**	55.47	67.07	79.80	**67.44**
Mean	**53.19**	**46.90**	**57.47**		**59.84**	**49.38**	**60.54**	----
F test and RLSD$_{0.05}$	**F test**		**R LSD$_{0.05}$**		**F test**		**R LSD$_{0.05}$**	
T	**		5.64		**		5.32	
C	**		4.93		**		3.01	
T x C	NS		-		**		7.46	

Where: NS and ** mean non-significant and significant at 1% level of probability, respectively.

4- Thousand grain weight (g):

Data recorded in Table 5 prove that the foliar spray treatment by some micro-nutrients Nano-particles had a highly significant ($P \leq 0.01$) and significant ($P \leq 0.05$) effect on 1000- kernel weight in the first and second seasons, respectively. Thus, the highest mean values of 1000-kernel weight (50.62 and 50.16 g in the tow respective seasons) were obtained from foliar spray with Fe+Mn+Zn in the first season and from Fe+Zn in the second one. This may be due to the small size of ZnO NPs increase zinc absorption via wheat plants and consequently increased photosynthesis process which led to an increment in metabolic translocation from sources to sinks (kernels) resulted in fill grains. These findings are harmony with those obtained by Afshar *et al.* (2014) b. Otherwise, the lowest mean values of 1000- kernel weight (37.73 and 46.37 g in the first and second seasons, respectively) were obtained from Fe+Mn+Zn in the first season and control treatment in the second one.

Furthermore, the illustrated data in Table 5 reveal that the tested bread wheat cultivars had a highly significant ($P \leq 0.01$) effect on 1000 kernel weight in both seasons. The maximum mean values of 1000 kernel weight (50.89 and 52.41 g in the two respective seasons) were obtained from Gemmeaza-11 cultivars in the both seasons. This may be due to the genotypic behavior in combination with the environmental conditions, which may be suitable for Gemmeaza-11 cultivar than the rest cultivars. Similar trend was observed by Noureldin *et al.* (2013), Solomon and Anjulo (2017) and Farag *et al.* (2018).

Moreover, the interaction between some micro-nutrients Nano-particles foliar spray and bread wheat cultivars had non-significant effect in the both seasons. Whatever, the highest mean values of 1000- kernel weight (53.40 and 54.07 in the tow respective seasons) were obtained from Gemmeaza-11 cultivar which was sprayed by Fe+Mn+Zn in the both seasons respectively.

Table 5. Effect of some micro-nutrients Nano-particles, cultivars and their interaction on 1000- kernel weight (g) of wheat in 2017/18 and 2018/19 seasons.

Season	2017/2018				2018/2019			
Cultivars (C) / Treatments (T)	Gemmeaza-11	Sids-1	Sids-12	Mean	Gemmeaza-11	Sids-1	Sids-12	Mean
Control	48.00	46.66	39.07	**44.58**	52.58	43.73	42.81	**46.37**
Fe	51.26	47.60	43.77	**47.54**	53.03	47.12	42.54	**47.56**
Mn	52.27	47.08	44.54	**47.96**	52.62	46.18	40.73	**46.51**
Zn	51.40	47.55	44.58	**47.84**	52.25	49.07	42.78	**48.03**
Fe+Mn	52.14	47.64	47.47	**49.09**	52.12	47.58	43.20	**47.64**
Fe+Zn	49.25	48.10	47.07	**48.14**	52.95	50.27	47.27	**50.16**
Mn+Zn	49.44	47.23	44.47	**47.04**	49.64	50.80	45.27	**48.57**
Fe+Mn+Zn	53.40	50.72	47.74	**50.62**	54.07	47.21	45.74	**49.01**
Mean	**50.89**	**47.82**	**44.84**	----	**52.41**	**47.75**	**43.79**	----
F test and $RLSD_{0.05}$	**F test**		**R $LSD_{0.05}$**		**F test**		**R $LSD_{0.05}$**	
T	**		2.22		*		2.85	
C	**		2.87		**		3.77	
T x C	NS		-		NS		-	

Where: NS, * and ** mean non-significant and significant at 5% and 1% level of probability, respectively.

5- Kernel weight spike^{-1} (g):

It is clear from the data presented in Table 6 that the foliar spray treatment by some micro-nutrients Nano-particles had a highly significant ($P \leq 0.01$) effect on kernel weight spike^{-1} in both seasons. Wheat plants which were sprayed by Fe+Zn in the first season and Fe+Mn+Zn in the second one produced the highest mean values of kernel weight spike^{-1} (2.35 and 3.33 g in the tow respective seasons). On the other hand, the lowest mean values of kernel weight spike^{-1} (1.89 and 2.11 g in the tow respective seasons) were obtained from control treatment in both seasons. This is to be logic since the same treatment produced the highest mean values with regard to 1000-kernel weight (Table 5) and consequently produced the highest mean values of kernel weight spike^{-1}. These results are agreement with those obtained by Afshar *et al.* (2014) b.

Moreover, the data exhibited in Table 6 reveal that the studied cultivars had a significant ($P \leq 0.05$) and a highly significant ($P \leq 0.01$) effect on kernel weight spike^{-1} in the first and second seasons, respectively. Thus, the highest mean values of kernel weight spike^{-1} (2.62 and 3.20 g in the tow respective seasons) were obtained from Gemmeaza-11 cultivar in both seasons. On the contrary, the lowest mean values of kernel weight spike^{-1} (2.01 and 2.33 g in the tow respective seasons) were obtained from Sids-1 cultivar in both seasons. This is to be logic since the same cultivar surpassed the others two cultivar with regard to 1000-kernel weight trait and consequently gained the highest mean values of kernel weight spike^{-1}. Similar trend was observed by Gheith *et al.* (2013), Noureldin *et al.* (2013) and Seleem & Abd El – Dayem (2013).

Kernels weight spike^{-1} trait reacted a highly significantly ($P \leq 0.01$) to the interaction between micro nutrients and cultivars in the second season only (Table 6). The maximum mean value of kernel weight spike^{-1} (3.69 g) in the second season was obtained Gemmeaza-11 bread wheat cultivar which was sprayed by Fe+Mn+Zn. On the contrary, the differences between treatment combinations with cultivars failed to be significant at 5% level of probability in the first season.

Table 6. Effect of some micro-nutrients Nano-particles, cultivars and their interaction on kernel weight spike-1 of wheat in 2017/18 and 2018/19 seasons.

Season	2017/2018				2018/2019			
Cultivars (C) / Treatments (T)	Gemmeaza-11	Sids-1	Sids-12	Mean	Gemmeaza-11	Sids-1	Sids-12	Mean
Control	2.08	1.51	2.09	**1.89**	3.00	1.64	1.69	**2.11**
Fe	2.36	1.76	2.23	**2.12**	3.10	1.82	2.37	**2.43**
Mn	2.46	1.83	2.18	**2.15**	3.13	2.09	2.55	**2.59**
Zn	2.53	1.87	2.48	**2.29**	3.15	2.22	2.70	**2.69**
Fe+Mn	2.58	1.92	2.33	**2.28**	3.68	2.38	2.85	**2.97**
Fe+Zn	2.83	2.20	2.04	**2.35**	3.22	2.68	3.45	**3.12**
Mn+Zn	2.66	2.06	2.20	**2.31**	3.42	2.45	3.10	**2.99**
Fe+Mn+Zn	3.48	2.95	3.43	**3.28**	2.93	3.36	3.69	**3.33**
Mean	**2.62**	**2.01**	**2.37**	----	**3.20**	**2.33**	**2.80**	----
F test and $RLSD_{0.05}$	**F test**		**R $LSD_{0.05}$**		**F test**		**R $LSD_{0.05}$**	
T	**		0.22		**		0.23	
C	*		0.39		**		0.13	
T x C	NS		-		**		0.44	

Where: NS, * and ** mean non-significant and significant at 5% and 1% level of probability, respectively

6- Grain yield (ardab fed.$^{-1}$):

Data presented in Table 7 show that foliar spray treatment by some micro-nutrients Nano-particles and wheat cultivars had a highly significant ($P \leq 0.01$) effect on grain yield in both seasons. In addition, application of Fe+Mn+Zn produced the maximum grain yield (26.08 and 26.44 ardab fed.$^{-1}$ in the first and second seasons respectively). While, the lowest mean values of grain yield

(18.50 and 20.23 ardab fed.$^{-1}$ in the tow respective seasons) were obtained from control treatment in both seasons. This is to be expected since the same trend was observed with regard to kernels weight spike^{-1} (Table 6) trait. Similar trend was observed by Afshar *et al.* (2014) b.

Furthermore, the illustrated data in Table 7 reveal that the tested bread wheat cultivars had a highly significant (P ≤ 0.01) effect on grain yield in both seasons. The maximum mean values of grain yield (23.70 and 24.08 ardab fed.$^{-1}$ in the two respective seasons) were obtained from Gemmeaza-11 cultivar in the both seasons. This superiority of Gemmeaza-11 bread wheat cultivar in grain yield was due to the superiority in kernels weight spike^{-1}. Similar trend was observed by Gheith *et al.* (2013), Fergani *et al.* (2014), El hag (2017) and Farag *et al.* (2018).

Moreover, the interaction had a highly significant (P ≤ 0.01) and significant (P ≤ 0.05) influence on grain yield in the first and second seasons respectively. Here too, the highest mean values of grain yield (26.80 and 26.95 ardab fed.$^{-1}$ in the tow respective seasons) were obtained from Gemmeaza-11 cultivar which was sprayed by Fe+Mn+Zn nanoparticles in both seasons.

Table 7. Effect of some micro-nutrients Nano-particles, cultivars and their interaction on grain yield (ardab fed.-1) of wheat in 2017/18 and 2018/19 seasons.

Season	2017/2018				2018/2019			
Cultivars (C) / Treatments (T)	Gemmeaza-11	Sids-1	Sids-12	Mean	Gemmeaza-11	Sids-1	Sids-12	Mean
Control	20.29	16.83	18.39	**18.50**	20.57	21.16	18.97	**20.23**
Fe	21.07	20.04	20.93	**20.68**	25.41	22.62	20.17	**22.74**
Mn	22.35	21.46	21.82	**21.88**	23.01	22.88	21.49	**22.46**
Zn	23.66	22.10	22.22	**22.66**	22.80	23.34	22.01	**22.72**
Fe+Mn	24.07	23.32	23.51	**23.63**	24.57	24.25	22.76	**23.86**
Fe+Zn	25.96	25.90	24.76	**25.54**	26.65	25.78	24.65	**25.69**
Mn+Zn	25.38	24.38	23.86	**24.54**	23.75	25.01	24.14	**24.30**
Fe+Mn+Zn	26.80	26.53	24.92	**26.08**	25.91	26.95	26.45	**26.44**
Mean	**23.70**	**22.57**	**22.55**	----	**24.08**	**24.00**	**22.58**	----
F test and RLSD$_{0.05}$	**F test**		**R LSD$_{0.05}$**		**F test**		**R LSD$_{0.05}$**	
T	**		0.49		**		1.05	
C	**		0.44		**		0.42	
T x C	**		0.95		*		2.04	

Where: * and ** mean significant at 5% and 1% level of probability, respectively.

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استجابة ثلاثة أصناف من قمح الخبز للرش الورقى ببعض العناصر الصغرى النانومترية

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الملخص

تم اجراء تجربة حقلية خلال موسمى ٢٠١٧-٢٠١٨ و ٢٠١٨-٢٠١٩ فى مزرعة قسم المحاصيل البحثية – كلية الزراعة – جامعة أسيوط لدراسة تأثير الرش الورقى ببعض العناصر الصغرى النانومترية على إنتاج ثلاثة أصناف من قمح الخبز. نُفِذت التجربة بتصميم القطاعات كاملة العشوائية بترتيب الشرائح المنشقة حيث تم وضع معاملات الرش الورقى (بماء الصنبور {كنترول} والرش الورقى بالحديد، المنجنيز، الزنك، الحديد+المنجنيز، الحديد+الزنك، المنجنيز+الزنك، الحديد+المنجنيز+الزنك) فى الصورة النانومترية بمعدل ٢٠٠ جزء في المليون أفقياً بينما رُتِبت أصناف قمح الخبز (سدس ١ و سدس ١٢ و جميزه ١١) رأسياً. أوضحت النتائج التى تم الحصول عليها أن معاملات الرش الورقى ببعض العناصر الصغرى النانومترية كان لها تأثير معنوى على صفات ارتفاع النبات وعدد حبوب السنبلة و وزن الألف حبة و وزن حبوب السنبلة ومحصول الحبوب للفدان فى كلا الموسمين. وأعطت نباتات القمح التى رُشت بالحديد والمنجنيز والزنك أعلى المتوسطات لمعظم الصفات سابقة الذكر، علاوة على ذلك فإن الأصناف محل الدراسة كان لها تأثير معنوى على جميع الصفات التى تم دراستها. بالإضافة إلى أن صنف جميزه ١١ أعطى أعلى القيم فى أغلب الصفات التى تم دراستها خلال موسمى الزراعة. كما كان للتفاعل بين الرش الورقى ببعض العناصر الصغرى النانومترية وأصناف قمح الخبز تأثير عالى المعنوية فى الموسم الأول وتأثير معنوى فقط فى الموسم الثانى علي صفة محصول الحبوب للفدان، حيث تم الحصول علي أعلى القيم لهذه الصفة والتي بلغت ٢٦,٨٠ ، ٢٦,٩٥ أردب/فدان فى الموسمين على التوالى من زراعة الصنف جميزه ١١ و رشه ورقياً بواسطة الحديد+المنجنيز +الزنك فى الصورة النانومترية فى كلا الموسمين.