Response of Some Wheat Cultivars to Nano- , Mineral Fertilizers and Amino Acids Foliar Application

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ABSTRACT

Wheat is the major source of food for human nutrition and a part of daily dietary need in one form or more. There is need to increase its productivity vertically and horizontally. In order to improve productivity of three wheat cultivars, nano- technological fertilizer, common mineral fertilizer and amino acids as foliar applications were tested. Two field experiments were conducted at El-Horaia village, Abou El- Matamir district, El- Behira Governorate, Egypt, during 2014/2015 and 2015/2016 growing seasons, in split plot design with three replications. The main plots included foliar application (mineral, amino acids, nano fertilizer, mineral + amino acids, mineral + nano- fertilizer, and amino acids + nanofertilizer), while three bread wheat cultivars (Sids 12, Sids 11 and Giza 168) were allocated in the sub plot. The obtained results revealed such significant increases in plant height, spikes number/m^2, spikelets number/spike, grains number/spike, 1000- kernel weight, grain, straw, and biological yields/fed., as well as harvest index (%) using nano- fertilizer + amino acids during both growing seasons. Meanwhile, the applied mineral fertilizer, alone; gave the lowest mean values of the studied traits. However, "Sids 12" cultivar recorded the highest means values of the studied characters. Spray "Sids 12" cultivar by nano-fertilizer and amino acids; recorded the highest mean values of yield and its components. On the other hand, "Giza 168" cultivar, possessed the lowest ones.

Key words*:* wheat; cultivars; productivity; nano-fertilizer; foliar; mineral; amino acids

INTRODUCTION

Filling up of the gap between production and consumption of wheat crop to confront its consumption exaggerated is an urgent prerequisite. Whereas, the local production of wheat grains (about 9.4 million tons) covers only 60% of the local consumption demand which reflects on the demand import about 40% of wheat grains from abroad (FAO, 2014). Whereas, wheat is the major source of food for human nutrition and a part of daily dietary need in one form or more. It is the main winter cereal crop in Egypt.Wheat is the most widely grown crop in the world with its unique protein characteristics and serves as an important source of food and energy (Abedi *et al*., 2010). Wheat grains contain 8–20% protein, which are divided into prolamins like gliadins and glutenins and non-prolamins consist of water-soluble albumins and salt-soluble globulins (Singh and Skerritt, 2001). Therefore, it must be increased wheat cultivated area in long term and increase productivity per area unit in short term by applying the good agricultural practices (GAP) through determining the best method of application, level and mixture of applicable nutritional elements.

Nanotechnology as a new technology has solved many difficult problems in different fields of science and industry and has found its reposition and functions in agriculture. Nanotechnology has crucial mode of action in all stages of production, processing, storage, packing and transportation of agricultural products (Scott and Chen, 2003). Also, nano-iron oxide compared to other treatments as organic materials and Fe citrate facilitated photosynthesis and transformation of Fe in peanut (Liu *et al*., 2005). The promoting effect of nanoparticles on seedling growth and development were reported by Zhu *et al*. (2008).

Nanofertilizers are the most important function of nanotechnology in the production phase of agriculture. Application of nanofertilizers instead of common fertilizers, where nutrients are provided to plants gradually and in a controlled manner. Meanwhile, the nanotechnology increases the application efficiency of fertilizers, decreases pollution and risks of chemical fertilization (Naderi *et al*., 2011). Nano materials are much smaller and lighter, they interact better in the environment and may be solved the problem of Fe nutrition in soil salinity and lime soils. Iron Nano-oxide is smaller than the common iron oxides and forms more complexes and makes the Fe more available to plants (Mazaherinia *et al.,* 2010 a). Ladan *et al*. (2012) tested the effect of iron nanofertilizer on spinach and reported that application of 4 kg/ha iron nanofertilizer; increased leaf weight by 58% and leaf area index by 47% compared with the control plants. Delgado and Sanchez-Raya (2007) reported that application of Fe fertilizer on sunflower; reduced stress effects and increased NPK absorption and plant growth and yield. Balali and Malakouti (2002) found that application of iron fertilizer; increased protein and Fe concentration in grains and straw of wheat and increased grain yield by

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20%. The positive effect of spraying basil plants with iron nanofertilizer was, also, noticed by Peyvandi *et al.* (2011) who reported that Fe nanoparticles increased root length, stem height, chlorophyll content and shoot dry weight compared with the common iron fertilizers. Amuamuha *et al.* (2012) investigated also, the effect of different concentrations of iron nanoparticles (1, 2 and 3 g/l) on marigold in growth stages of stem elongation and flowering. They reported that the highest flower yield and essential oil percentage were achieved when 1 g/l iron nanoparticles was applied at stem elongation stage.

Spraying compounds with the technology of Nano indicated that the highest values of spike weight, 1000 kernel weight, biological, and grain yields and protein content were achieved in the first spraying time after 45 days after sowing. Among the Fe concentrations, the highest values of spike weight 1000- grain weight, biological yield, grain yield and protein content were achieved in Fe concentration and the lowest values were achieved in the control (Bakhtiari *et al.*, 2015).

Foliar application of elements gave significant effect on yield traits and protein content on some wheat cultivars during both seasons compared with control treatment. Moreover, foliar application with combination of elements; produced the highest values of plant height, tillers number/ m^2, spikes number/m^2, spike length, number of spikelets/spike, number of grains/spike, 1000- grain weight, grain yield, straw yield, biological yield and harvest index %, respectively, in both seasons followed by Zn foliar application followed by foliar application of Mn followed by Fe foliar application then Cu foliar application (Mekkei and El Haggan, 2014).

Amino acid application containing Zn enhanced growth and productivity (Datir *et al.,* 2012). Also, amino acids affected the physiological yield of the plant and its growth directly or indirectly (Abd El-Aal *et al.,* 2010). The application of amino acid with chemical fertilizers could augment the function of plants (Ashoori *et al.,* 2013). The significant role of amino acid as the constituent element of plant proteins in biochemical and physiological functions of the plant, its application is essential (Ebrahimi *et al.*, 2014;Shetta and Zayed 2016).

This investigation was conducted aiming to explore the effect of foliar application of nano-, mineral and amino acids on some wheat cultivars productivity in new soils.

MATERIALS AND METHODS

Two field experiments were carried out to study foliar application of nano, mineral fertilizer and amino acids effect on yield, yield components and quality of three wheat cultivars. Field experiments were conducted in El-Horaia village, Abou El-Matamir, El-Behira Governorate, Egypt, during the two successive seasons 2014/2015 and 2015/2016 in sandy loam soil.

A split plot design with three replicates was used. Foliar fertilization treatments (mineral fertilizer, amino acids, nano- compounds, mineral fertilizer + amino acids, mineral fertilizer + nano, and amino acids + nano fertilizer) occupied the main plots. Wheat cultivars (Sids 12, Sids 11 and Giza 168) allocated in sub-plots. Some physical and chemical characteristics of the studied soil before sowing are presented in Table (1) which were determined according to Page *et al.* (1982) and Klute (1986)

Mineral fertilizer (Caila Total) used at rate 1.5 cm/l (water), Amino acids (Dicka Hana compound) at rate 1 cm/l (water) and nano-compound namely; Amino-mineral at rate 1 cm/l water added as foliar application at two times i.e., after 45 and 65 days from sowing. Analysis of the three fertilizer compounds are shown in Table (2).

The size of each sub plot was 10.50 m^2 (3.5 x 3.0 m) surrounded by ditches to avoid water movement into adjacent plots. The preceding crop was maize (*Zea mays* L.) during both growing seasons.

Sowing method was broadcasting in both seasons. Sowing dates were 21^{th} and 28^{th} November during both 2014/2015 and 2015/2016 seasons, respectively, while seeding rate was 75 kg grains/fed. The first irrigation was applied at 21 days after sowing then plants were irrigated every 21 days till the dough stage.

However, nitrogen fertilizer in form of urea (46.5 % N) at rate of 70 kg N/fed., was added in three doses. The first dose (20 kg N/fed.) was added at sowing time, the second dose (30 kg N/fed.) was added before the first irrigation (21 days after sowing) and the third dose (20 kg N/fed.) was added (21 days after the first irrigation). Super phosphate (15.5 % P_2O_5) fertilizer was applied before sowing at rates of 100 kg/fed. Potassium fertilizer was applied before sowing (during seedbed preparation) at rate of 50 kg/fed., in the form of potassium sulphate (48 % K_2O). All other agricultural treatments for wheat production were carried out as recommended by the Ministry of Agriculture.

Recoded data include Plant height (cm), spike length (cm), spike number/m^2, spikelets number /spike, grains number /spike, 1000-grain weight (g), grain yield, straw yield, biological yield (kg/fed) and harvest index (%).

For wheat chemical determinations, samples of wheat grains were ground and 0.5 g dry powder of each were digested by concentrated mixture of H_2SO_4/$HClO_4$ acids according to Sommers and Nelson (1972). Nitrogen was determined by micro- Keldahl, according to Jackson (1976) and multiply by 5.75 to determine protein percentage. Phosphorus was determined, spectrophotometrcally, using ammonium molybdate/stannus chloride method according to Chapman and Pratt (1978). Potassium was determined by a flame photometer, according to Page *et al*. (1982). Concentrations of Fe, Mn and Zn were determined using Atomic Absorption apparatus (Jackson, 1976).

All collected data were subjected to analysis of variance according to Gomez and Gomez (1984). All statistical analysis was performed using analysis of variance technique by means of CoStat computer software package (CoStat, Ver. 6.311., 2005). The least significant differences (LSD at 0.05) used to compare the treatment's means.

Table 1. Some soil physical and chemical properties of the experimental sites during 2014/2015 and 2015/2016 seasons

Soil characteristics		
	Seasons	
Particle size distribution	2013	2014
Soil texture (%)	Sandy loam	Sandy loam
Sand %	60.90	61.03
Silt %	10.60	10.05
Clay %	28.50	28.92
pH (1: 2.5 water suspension)	8.10	7.99
EC (dSm^{-1})	3.41	3.53
Soluble Cations (meq/L.)		
Ca^{++}	7.60	8.00
Mg^{++}	4.20	4.85
Na^{+}	5.10	5.00
K^{+}	0.50	0.55
Soluble Anions (meq/L.)		
HCO_3^-	3.00	3.95
Cl^-	3.80	3.10
$SO4^{--}$	10.30	10.20
O.M. (%)	1.85	1.90
$CaCO_3$ (%)	22.50	23.70
Available Mineral N(mg/kg)	22.40	25.60
Available P (mg/kg)	5.12	5.50

Table 2. Structure of mineral fertilizer, amino acids and Nano- compounds

Structure	Mineral fertilizer (Caila Total)	Amino acids (Dicka Hana compound)	Nano-compound (Aminomineral)
N %	20	-	8
P %	20	4	5
K %	20	-	6
Fe %	0.10	3	4
Zn %	0.05	2	4
Mn %	0.05	2	2
Cu %	0.05	-	-
Amino acid %	-	10	-
Humic acid %	-	15	-
Fulvic acid %	-	10	-
Br %	-	-	0.02
Mo %	-	-	0.02
EDTA	-	-	1.50
Inert integrant (%)	39.75	54.00	69.46

RESULTS AND DISCUSSION

The obtained data in the current study will be presented as follows:

Data presented in Table (3) revealed the effect of foliar application of nano- compounds, mineral and amino acids and their interactions on plant height, spike length (cm), and spikes number/m^2 of Sids 12, Sids 11 and Giza 168 wheat cultivars during both 2014/2015 and 2015/2016 seasons.

Concerning foliar fertilization effects on plant height, data shown in Table (3) indicated that foliar application with a mixture of nano- fertilizer + amino acids treatment; recorded the tallest plant heights (103.64 and 104.20 cm) during the first and second seasons, respectively as compared with other treatments and amino acids treatment alone that produced (102.40 and 102.84 cm) during both seasons, respectively. Meanwhile, the shortest plants (91.58 and 92.30 cm) were recorded with the foliar application of mixture of nano + mineral fertilizer during both growing seasons. The increments in characters as average values may be taken place due to the role of amino acids and nano-fertilizer enhancing cell division and enlargement both longitudinal and transvessely; and subsequently plant growth and develop wheat plants. Also, the obtained data are shown in Table (3) disclosed that the highest mean values for spike length (11.85 and 12.35 cm) and spikes number/m^2 (312.00 and 316.66 spikes/m^2) achieved *via* foliar application of nano fertilizer + amino acids during both seasons, respectively. The increase in characters may be given rise due to the role of amino acids and nano- fertilizer for increasing growth promoting substance within inter – and intra plant tissues. Likewise, the enhancement in plant height in corn might be due to fundamental role of Zn in maintaining structural stability of cell membranes and use in protein synthesis, membrane function and cell elongation as reported by Welch (2008). On the other hand, the shortest spike (9.62 and 10.04 cm), and the lowest spikes number/m^2 (241.66 and 246.66) were gained owing to foliar application of mineral fertilizer during both seasons. These results are in harmony with those of Peyvandi *et al.* (2011) who reported that Fe nanoparticles increased root length, stem height, chlorophyll content and shoot dry weight compared with the common iron fertilizer and with Amuamuha *et al.* (2012) who stated that the highest flower yield and essential oil percentage were achieved when 1 g/l iron nanoparticles was applied at stem elongation stage. Also, Prasad *et al*. (2012) who revealed that using nanoscale zinc oxide had significant effect on the germination, growth and yield.

It this respect, data of Table (3) also, demonstrated that wheat cultivars did not exerted, significantly, effect on plant height during both growing seasons. Nevertheless, wheat cultivars were, significantly, affected spike length during both growing seasons. Whereas, “Sids 12” cultivar achieved the longest spike (11.50 and 11.45 cm), while “Giza 168” cultivar; gave the shortest spike (10.36 and 10.66 cm) during two seasons, respectively. Also, the wheat cultivar “Sids 12” recorded the highest spikes number/m^2 (282.55 and 287.55 spikes/m^2) in both seasons, each in trun. While “Giza 168” cultivar; recoded the lowest number (265.22 and 270.00 spikes/m^2) which had no significant difference with “Sids 11” during 2014/2015 and 2015/2016 seasons. These differences between wheat cultivars are mainly due to genetically differences make up between the three cultivars. These results are in agreement with those obtained by Mekkei and El Haggan (2014) who concluded that nano- fertilizer and amino acids increased growth and yield and its components.

Concerning the interaction between applied foliar application and wheat cultivars, the presented data in Tables (3) revealed that foliar applications X wheat cultivars affected significantly the plant height, spike length, and spikes number/m^2 in both growing seasons. Likewise, “Sids 12” cultivar sprayed with nano- fertlizer + amino acids reseeded in the highest values for plant height (106.00 and 104.47 cm), spike length (12.50 and 12.83 cm), and spikes numbers/m^2 (324.33 and 329.33) during both seasons. Meanwhile the lowest plant height (90.65 and 87.20 cm) when wheat plants were foliar application of nano + mineral fertilizer or mineral treatment alone, spike length (8.70 and 9.43 cm), and spikes number/m^2 (233.33 and 238.33 spikes) when, the wheat cultivar “Giza 168” plants were fertilized with mineral fertilizer alone in both seasons.

Data tabulated in Table (4) reported that the highest values for spikelets number/spike (18.72 and 18.39 spikelets), grains number/spike (56.33 and 54.83 grains) and 1000- kernel weight (53.04 and 54.45 g) were recorded with applying the combination of nanofertilizer + amino acids treatment during both seasons as compared with other treatments without significant difference with mixture of nano + mineral fertilizer for 1000- kernel weight (52.97g) in the first season, and mineral + amino acid application treatment (54.65 g) in the second season. However, the lowest mean values for spikelets number/spike (15.05 and 14.94), grains number/spike (46.00 and 43.95 grains) and 1000- kernel weight (40.79 and 49.57g) was gained with foliar application of mineral fertilizer alone during both seasons of the study.

Table 3. Plant height, spike length and spikes number/m^2 for three wheat cultivars (C) as affected by foliar fertilization (F) and their interaction during 2014/2015 and 2015/2016 seasons

Attributes	Foliar fertilization (F)	Season 2014/2015							Season 2015/2016						
		Wheat cultivar (C)			Average (F)	L.S.D. at 0.05			Wheat cultivar (C)			Average (F)	L.S.D. at 0.05		
		Sids 12	Sids 11	Giza 168		C	F	C x F	Sids 12	Sids 11	Giza 168		C	F	C x F
Plant height (cm)	Mineral	97.33	96.75	100.51	98.20b				87.20	98.55	102.31	96.02b			
	Amino acids	102.67	102.09	102.45	102.40a				100.00	107.22	101.31	102.84a			
	Nano fertilizer	96.00	95.42	94.17	95.20bc				97.80	97.22	95.97	97.00b			
	Mineral + Amino acids	93.33	92.75	99.00	95.03bc	ns	3.71	6.42	95.13	94.55	100.73	96.80b	ns	3.44	5.94
	Nano + mineral	92.33	91.75	90.65	91.58c				94.13	93.55	89.21	92.30c			
	Nano + amino acid	106.00	105.42	99.51	103.64a				104.47	103.89	104.25	104.20a			
	Average (C)	97.94	97.36	97.72					96.46	99.16	98.96				
Spike length (cm)	Mineral	10.50	9.65	8.70	9.62c				10.53	10.17	9.43	10.04d			
	Amino acids	12.50	11.65	10.80	11.65a				11.67	12.50	11.27	11.81b			
	Nano fertilizer	11.00	10.43	9.63	10.35b				10.67	10.67	10.10	10.48d			
	Mineral + Amino acids	11.83	10.98	11.08	11.30a	0.344	0.607	1.05	12.33	10.67	10.57	11.19c	0.393	0.468	0.81
	Nano + mineral	10.67	10.72	10.53	10.64b				10.67	11.62	10.85	11.05c			
	Nano + amino acids	12.50	11.65	11.40	11.85a				12.83	12.50	11.73	12.35a			
	Average (C)	11.50a	10.85b	10.36c					11.45a	11.36a	10.66b				
Spikes number /m^2	Mineral	253.33	238.33	233.33	241.66e				258.33	243.33	238.33	246.66e			
	Amino acid	276.67	261.67	243.67	260.67d				281.67	266.67	248.33	265.56d			
	Nano fertilizer	266.33	251.33	236.33	251.33de				271.33	256.33	241.33	256.33de			
	Mineral + Amino acid	270.33	255.33	293.00	272.89c	5.98	9.99	17.31	275.33	260.33	298.00	277.89c	5.53	10.03	17.38
	Nano + mineral	304.33	289.33	282.67	292.11b				309.33	294.33	287.67	297.11b			
	Nano + amino acid	324.33	309.33	302.33	312.00a				329.33	314.33	306.33	316.66a			
	Average (C)	282.55a	267.55b	265.22b					287.55a	272.55b	270.00b				

Mean values in the same column/row marked with the same letter are not significantly different at 0.05 level of probability.
ns: not significant difference at 0.05 level of probability.

Table 4. Average of yield attributes for three wheat cultivars (C) as affected by foliar fertilization (F) and their interaction during 2014/205 and 2015/2016 seasons

attributes	Foliar fertilization (F)	Season 2014/2015							Season 2015/2016						
		Wheat cultivar (C)			Average	L.S.D. at 0.05			Wheat cultivar (C)			Average	L.S.D. at 0.05		
		Sids 12	Sids 11	Giza 168	(F)	C	F	C x F	Sakha 93	Sids 12	Giza 168	(F)	C	F	C x F
Spikelets number/spike	Mineral	16.33	14.83	14.00	15.05d				18.00	13.83	13.00	14.94d			
	Amino acids	19.00	17.50	15.67	17.39b				19.67	16.50	14.67	16.95c			
	Nano fertilizer	18.00	16.50	15.00	16.50c				18.00	15.50	14.67	16.06c			
	Mineral + Amino acids	20.33	18.83	14.67	17.94b	0.126	0.691	1.20	19.33	17.83	14.33	17.16b	0.959	0.890	1.54
	Nano + mineral	18.00	16.50	14.00	16.17c				19.00	15.50	13.67	16.06c			
	Nano + amino acids	20.00	18.50	17.67	18.72a				20.33	17.50	17.33	18.39a			
	Average (C)	18.61a	17.11b	15.17c					19.06a	16.11b	14.61c				
Grain number/spike	Mineral	48.00	45.00	45.00	46.00c				48.67	41.50	41.67	43.95c			
	Amino acids	54.67	51.67	45.67	50.67b				53.43	49.50	44.00	48.98b			
	Nano fertilizer	54.00	51.00	49.33	51.44b				53.33	46.50	44.00	47.94 b			
	Mineral + Amino acids	55.20	52.20	49.67	52.36b	2.81	2.80	4.85	56.00	53.50	50.00	53.17a	2.19	2.24	3.88
	Nano + mineral	55.33	52.33	47.67	51.78b				57.27	46.50	41.00	48.26 b			
	Nano + amino acid	61.00	56.50	51.50	56.33a				60.67	52.50	51.33	54.83a			
	Average (C)	54.70a	51.45a	48.14b					54.90a	48.33b	45.33c				
1000- kernel weight (gm)	Mineral	43.66	41.11	37.59	40.79c				55.67	53.11	39.93	49.57b			
	Amino acids	49.33	46.77	47.57	47.89b				61.33	52.63	45.67	53.21a			
	Nano fertilizer	43.00	40.44	43.63	42.36c				55.00	52.44	42.00	49.81b			
	Mineral + Amino acids	44.33	41.77	52.29	46.13b	1.48	3.24	5.61	56.33	52.29	55.33	54.65a	1.03	3.34	5.78
	Nano + mineral	58.00	55.44	45.46	52.97a				53.00	47.33	48.00	49.44b			
	Nano + amino acids	51.67	49.11	58.33	53.04a				53.00	51.67	58.67	54.45a			
	Average (C)	48.33a	45.77b	47.48a					55.72a	51.58b	48.27c				

Mean values in the same column/row marked with the same letter are not significantly different at 0.05 level of probability.

The results shown in Table (4), also, demonstrated that the highest mean values for spikelets number/spike (18.61 and 19.06 spikelets/spike), grains number/spike (54.70 and 54.90 grains) and 1000- kernel weight (48.33 and 55.72 g) were obtained by wheat cultivar “Sids 12”, while “Giza 168” cultivar had the lowest ones of these characters expect 1000- kernel weight during both studied seasons. On the other hand, Giza 186 cultivar had no significant difference with “Sids 12” cv. for 1000- kernel weight (47.48 g) in the first season, only. These differences between wheat cultivars may be due to genetically differences make up between the three cultivars. Buhedma (2011); Raza *et al.* (2012); Al-Temimi *et al.* (2013); Bakry *et al.* (2013) found high significant differences between wheat cultivars under their studies for yield and its components.

The present data in Table (4) revealed that foliar applications X wheat cultivars affected significantly spikelets number/spike, grains number/spike and 1000- kernel weight (gm) in both growing seasons. Likewise, “Sids 12” cultivar sprayed with nano- fertlizer + amino acids recorded in the highest mean values for spikelets number/spike (20.00 and 20.33), grains number/spike (61.00 and 60.67 grains/spike) and the heaviest 000- kernel weight (58.33 and 58.67g) recorded with Giza168 + nano + amino acids during both growing seasons, respectively. Meanwhile the lowest spikelets number/spike (14.00 and 13.00 spikelets) when the wheat cultivar “Giza 168” plants were sprayed with mineral fertilizer alone in both seasons, but the lowest grains numbers/spike (45.00 and 41.00 grains) were recorded with “Giza 168” cv. when sprayed with mineral fertilizer in the first season, and with mineral + nano fertilizer in the second season and 1000- kernel weight (37.59 and 39.93 g) were recorded by fertilizing “Giza 168” cultivar with mineral fertilizer in the first and the second season, respectively.

Data presented in Table (5) revealed that the highest values for grain yield (2620.76 and 2677.39 kg/fed.), straw yield (3408.76 and 3402.55 kg/fed.) and biological yield (6029.51 and 6079.94 kg/fed.) were recorded owing to foliar application with nano- fertilizer + amino acids treatment as compared with other treatments during both seasons of the study, respectively. Nevertheless, the lowest mean values for grain yield (1955.26 and 1920.58 kg/fed.), straw yield (2743.26 and 2679.08 kg/fed.) and biological yield (4698.51 and 4599.65 kg/fed.) were achieved with mineral fertilizer during both seasons. These results are in agreement with those of Zoz *et al.* (2012) who showed that higher concentration of zinc foliar application allowed obtaining 26% more in the number of spikes/m^2 compared to non-supply of nutrient. Also, Bakhtiari *et al.* (2015) indicated that nano-fertilizer; increased wheat grain yield and its components. Nano-chalate zinc application expressed a positive effect on yield and yield components. For instance, soil application of nano- chalate zinc produced the highest 100-grain weight and seed yield (Mosanna and Behroztar, 2015). Significant increase was recorded on yield attributes of faba bean using foliar application of nano- fertilizer in both growing seasons (Gomaa *et al.*, 2016).

Data of Table (5), also, revealed that “Sids 12” wheat cultivar achieved the highest mean values for grain yield (2575.94 and 2415.23 kg/fed.), straw yield (3318.48 and 3130.98 kg/fed.) and biological yield (5894.42 and 5546.21 kg/fed.) during both seasons. On the other side, the lowest mean values for grain yield (1954.18 and 1942.76 kg/fed.), straw yield (2771.16 and 2719.26 kg/fed.) and biological yield (4725.33 and 4662.01 kg/fed.) were recorded with wheat cultivar only in both studying seasons. Tahir *et al.* (2009) cleared that among yield components, number of fertile tillers is very important because the higher number of fertile tillers can be formed the more final crop yield.

With respect to the interaction between fertilizers foliar application and wheat cultivars, data in Table (5) disclosed that wheat cultivar “Sids 12” X nano fertilizer + amino acids; achieved the highest values for grain yield (2935.80 and 2861.83 kg/fed.), straw yield (3723.80 and 3520.33 kg/fed.) and biological yield (6659.60 and 6382.16 kg/fed.) during both seasons. On the other side, the lowest mean values for grain yields (1755.10 and 1733.07 kg/fed.), straw yields (2543.10 and 2491.57 kg/fed.) and biological yields (4298.20 and 4224.64 kg/fed.) were recorded with spraying “Giza 168” with amino acids alone in both seasons.

Results presented in Table (6) indicated that wheat plants sprayed by nano- fertilizer + amino acid registered or led to the highest mean values of protein (13.84 and 13.56%) and grain P contents (13.41 and 14.86 %) but the highest mean values for grain K contents (6.64 and 6.36 %) were recorded with foliar application of mineral fertilizer + amino acids during both growing seasons. One the other hand, the lowest ones for grain protein % (10.0 and 9.64 %), grain P contents (10.03 and 11.59 %) were obtained when the plants were sprayed with mineral fertilizer; meanwhile, the lowest grain contents for K (4.73 and 4.45 %) were obtained by spraying amino acids alone during both growing seasons. It is know that foliar application by all micronutrients gave significant effect on yield traits and protein content.

Table 5. Grain, straw and biological yield for three wheat cultivars (C) as affected by foliar fertilization (F) and their interaction during 2014/2015 and 2015/2016 seasons

attributes	Foliar fertilization (F)	Season 2014/2015							Season 2015/2016						
		Wheat cultivar (C)			Average	L.S.D. at 0.05			Wheat cultivar (C)			Average	L.S.D. at 0.05		
		Sids 12	Sids 11	Giza 168	(F)	C	F	C x F	Sids 12	Sids 11	Giza 168	(F)	C	F	C x F
Grain yield (kg/fed.)	Mineral	1985.57	1840.33	2039.87	1955.26d				1873.17	1901.93	1986.63	1920.58 c			
	Amino acids	2387.73	2237.23	1755.10	2126.69c				2398.97	2011.83	1733.07	2047.96 b			
	Nano fertilizer	2737.07	2201.90	1917.20	2285.39b				2312.43	2122.00	1846.93	2093.79 b			
	Mineral + Amino acids	2719.33	2282.07	1844.67	2282.02b	94.72	142.47	246.76	2749.00	1964.30	1873.33	2195.54 b	189.47	196.99	341.20
	Nano + mineral	2690.13	2386.07	1863.23	2313.14b				2295.97	1766.73	1768.23	1943.64 c			
	Nano + amino acids	2935.80	2621.47	2305.00	2620.76a				2861.83	2722.00	2448.33	2677.39 a			
Average (C)		2575.94a	2261.51b	1954.18c					2415.23 a	2081.47b	1942.76b				
Straw yield (kg/fed.)	Mineral	2773.57	2628.33	2827.87	2743.26e				2631.67	2660.43	2745.13	2679.08 b			
	Amino acids	3175.73	3025.23	2543.10	2914.69d				3001.00	2770.33	2491.57	2754.30b			
	Nano fertilizer	3170.00	2989.90	2705.20	2955.03cd				3070.93	2880.50	2605.43	2852.29b			
	Mineral + Amino acids	3589.67	3070.07	2806.53	3155.42b	150.30	146.68	254.05	3507.50	2322.80	2739.87	2856.72b	226.77	197.11	341.40
	Nano + mineral	3478.13	3174.07	2651.23	3101.14bc				3054.47	3280.50	2526.73	2702.14b			
	Nano + amino acids	3723.80	3409.47	3093.00	3408.76a				3520.33	3480.50	3206.83	3402.55 a			
Average (C)		3318.48a	3049.51b	2771.16c					3130.98a	2773.30b	2719.26b				
Biological yield (kg/fed.)	Mineral	4759.14	4468.66	4867.74	4698.51d				4504.84	4562.36	4731.76	4599.65 b			
	Amino acids	5563.46	5262.46	4298.20	5041.37c				5399.97	4782.16	4224.64	4802.26 b			
	Nano fertilizer	5907.07	5191.80	4622.40	5240.42bc				5383.36	5002.50	4452.36	4946.07 b			
	Mineral + Amino acids	6309.00	5352.14	4651.20	5437.45b	242.09	276.59	479.07	6256.50	4287.10	4613.20	5052.27 b	414.42	391.31	677.76
	Nano + mineral	6168.26	5560.14	4514.46	5414.29b				5350.44	5047.23	4294.96	4897.54 b			
	Nano + amino acids	6659.60	6030.94	5398.00	6029.51a				6382.16	6202.50	5655.16	6079.94a			
Average (C)		5894.42a	5311.02b	4725.33c					5546.21a	4980.64b	4662.01b				

- Mean values in the same columns/rows marked with the same letters are not significantly different at 0.05 level of probability.

Table 6. Grain protein, P and K content (%) for three wheat cultivars (C) as affected by foliar fertilization (F) and their interaction during 2014/205 and 2015/2016 seasons

attributes	Foliar fertilization (F)	Season 2014/2015							Season 2015/2016						
		Wheat cultivar (C)			Average	L.S.D. at 0.05			Wheat cultivar (C)			Average	L.S.D. at 0.05		
		Sids 12	Sids 11	Giza 168	(F)	C	F	C x F	Sids 12	Sids 11	Giza 168	(F)	C	F	C x F
Protein %	Mineral	9.43	8.68	11.88	10.00d				9.54	8.37	11.01	9.64d			
	Amino acids	13.99	9.35	9.58	10.97cd				13.68	9.04	8.89	10.54cd			
	Nano fertilizer	13.01	10.96	10.98	11.65bc				12.70	10.65	10.67	11.34bc			
	Mineral + Amino acids	11.88	11.33	10.87	11.36bc	0.912	1.15	1.99	11.57	11.01	10.56	11.05bc	1.06	1.17	2.04
	Nano + mineral	12.84	12.45	12.04	12.44b				12.53	12.15	11.73	12.14b			
	Nano + amino acids	14.39	14.05	13.07	13.84a				14.08	13.74	12.86	13.56a			
Average (C)		12.59a	11.14b	11.40b					12.35a	10.83b	10.95b				
Grain P %	Mineral	8.98	11.14	9.98	10.03c				10.54	12.70	11.54	11.59c			
	Amino acids	11.57	11.52	11.20	11.43bc				13.13	13.08	12.76	12.99bc			
	Nano fertilizer	13.33	13.28	12.37	12.99ab				14.89	14.84	13.93	14.55ab			
	Mineral + Amino acids	13.67	13.62	12.43	13.24ab	ns	1.83	3.18	15.23	15.18	13.99	14.80ab	ns	1.82	3.14
	Nano + mineral	13.00	12.95	10.90	12.28ab				14.56	14.51	12.46	13.84ab			
	Nano + amino acids	13.00	12.95	14.27	13.41a				14.56	14.51	15.51	14.86a			
Average (C)		12.26	12.58	11.86					13.82	14.14	13.37				
Grain K %	Mineral	5.20	5.16	5.24	5.20de				4.65	4.88	4.96	4.83de			
	Amino acids	4.92	4.88	4.40	4.73e				4.64	4.60	4.12	4.45e			
	Nano fertilizer	6.63	6.59	5.67	6.30ab				6.35	6.31	5.39	6.02ab			
	Mineral + Amino acids	7.07	7.02	5.84	6.64a	0.170	0.507	0.878	6.79	6.74	5.56	6.36a	0.238	0.518	0.898
	Nano + mineral	5.73	5.69	5.24	5.55cd				5.45	5.41	4.96	5.27cd			
	Nano + amino acids	5.86	5.82	5.87	5.85bc				5.59	5.54	5.59	5.57bc			
Average (C)		5.90a	5.86a	5.38b					5.58a	5.58a	5.10b				

Mean values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.

They are needed in trace amounts, but their adequate supply improves nutrients availability and positively affects the cell physiological that is reflected in yield (Toyama *et al*., 2001). Also, Khan *et al*. (2006) stated that Cu, Fe, Mn and Zn contents of wheat grain increased with application of mineral fertilizers. Micronutrients as nano- fertilizer can be used in crop production to increase yield (Reynolds, 2002). Nano-fertilizer with small size and large surface area are expected to be the ideal material for use as fertilizer in plants.When materials are transformed to a nanoscale, they change their physical, chemical and biological characteristics as well as catalytic properties and even more increase the chemical and biological activities (Mazaherinia *et al*., 2010 b).Further, nano- fertilizers have been developed and have provided a new efficient alternative to normal regular fertilizers. The properties of nano-particles (more surface area) may help in increasing the reactive points of these particles and hence increase the reactivity of these nanoparticles, which could induce changes in the physio-chemical properties of these nanoparticles which help in the absorption of fertilizers in the plants (Anonymous, 2009).

Results of Table (6) illustrated that wheat cultivar "Sids 12" surpassed other cultivars, in which achieved the highest values for protein (12.59 and 12.35%) and grain K content (5.90 and 5.59 %) in both growing seasons. One the other hand, the lowest ones for grain protein % (11.14 and 10.83 %) were achieved with "Sids 11" which had no significant difference with "Giza 168" during both seasons. However, Giza 168; recorded the lowest grain contents of K (5.38 and 5.10 %) during both growing seasons, respectively. Also, data in Table (6) reveal that there is no significant difference among the three wheat cultivars in this study regarding grain P content during both seasons. K, Zn, and Mn were significant increased due to foliar application of macronutrients. There were significant differences between the two varieties for most studied characteristics (Abd El-Ghany *et al*., 2013).

Respecting the interaction between applied foliar application and wheat and wheat cultivars, the recorded data in Table (6) indicated that wheat cultivar "Sids 12" plants sprayed with nano + amino acids achieved the highest values for protein contents (14.39 and 14.08 %), while the lowest grain protein % (8.68 and 8.37 %) recorded with foliar application as the mineral fertilizer + "Sids 11" during both seasons. However, "Giza 168" cv. with nano fertilizer + amino acids recorded the highest values for grain P contents (14.27 and 15.51 %) and grain K contents (5.87 and 5.59 ppm). Meanwhile, the lowest ones for grain P content (8.98 and 10.54 %) achieved with "Sids 12" + mineral, and lowest content of K (4.40 and 4.12 %) with nano-fertilizer application to "Giza 168" in both seasons, respectively.

Data in Table (7) revealed that wheat plants sprayed by mineral fertilizer + amino acid achieved the highest values for grain Fe content (3.04 and 3.01 ppm), One the other hand, the lowest ones for Fe (2.02 and 1.99 ppm) were given when wheat plants were sprayed with mineral fertilizer during both growing seasons. Also, Table (7) disclosed that wheat plants that sprayed with a combination of nano- fertilizer + amino acid; gave rise to the highest values for grain Mn contents (3.27 and 3.23 ppm) and Zn (0.926 and 0.891 ppm), On the other extreme, the lowest ones for Mn (2.13 and 2.09 ppm) and Zn (0.787 and 0.747 ppm) were recorded when plants were sprayed with mineral fertilizer which had no significant difference among it and mineral alone, and nano- fertilizer alone during the two growing seasons. These results agreed with those obtained by Moussavi-Nik *et al.* (2012), Leta *et al*. (2013) and Mekkei and El Haggan (2014) who revealed that there was a positive effect of micronutrient on these characters.

Further data in Table (7) demonstrated that wheat cultivar "Giza 168" was superior to the other cultivars which achieved the highest values for Fe (3.62 and 3.59 ppm) and grain Mn contents (3.67 and 3.63 ppm). On the other hand, the lowest ones for grain Fe content (1.76 and 1.73 ppm) and Mn (1.43 and 1.39 ppm) were recorded with "Sids 12". However, there is no significant differences among the tested three wheat cultivars in terms of grain Zn content during both seasons.

With reference to the interaction between applied foliar application and wheat cultivars, the obtained data in Table (7) declared that wheat cultivar "Giza 168" plants sprayed with nano + amino acids recorded the highest values for Fe contents (3.87 and 3.84 ppm), grain Mn content (4.28 and 4.24 ppm) and Zn (0.977 and 0.953 ppm). However, the lowest ones for grain Fe (1.27 and 1.24 ppm), Mn (1.40 with mineral in the first season and 1.01 ppm with nano fertilizer in the second season) and Zn (0.747 and 0.707 ppm) were recorded with Sids 12 cultivar in 2014/2015 and 2015/2016 seasons. However, there is no significant differences among the three wheat cultivars in grain Zn content in the two seasons.

Table 7. Grain Fe, Mn and Zn content (ppm) for three wheat cultivars (C) as affected by foliar fertilization (F) and their interaction during 2014/205 and 2015/2016 seasons

attributes	Foliar fertilization (F)	Season 2014/2015							Season 2015/2016						
		Wheat cultivar (C)			Average	L.S.D. at 0.05			Wheat cultivar (C)			Average	L.S.D. at 0.05		
		Sids 12	Sids 11	Giza 168	(F)	C	F	C x F	Sids 12	Sids 11	Giza 168	(F)	C	F	C x F
Fe (ppm)	Mineral	1.27	2.05	2.75	2.02c				1.24	2.02	2.72	1.99c			
	Amino acids	1.60	2.27	3.63	2.50b				1.57	2.24	3.60	2.47b			
	Nano fertilizer	2.00	2.95	3.70	2.88a				1.97	2.92	3.67	2.85a			
	Mineral + Amino acids	1.97	2.92	4.23	3.04a	0.34	0.09	0.58	1.94	2.89	4.20	3.01a	0.34	0.10	0.58
	Nano + mineral	1.93	2.88	3.53	2.78ab				1.90	2.85	3.50	2.75ab			
	Nano + amino acids	1.80	2.75	3.87	2.81ab				1.77	2.72	3.84	2.78ab			
Average (C)		1.76c	2.64b	3.62a					1.73c	2.61b	3.59a				
Mn (ppm)	Mineral	1.40	2.23	3.06	2.23c				1.36	2.19	3.02	2.19c			
	Amino acids	1.28	2.00	3.10	2.13c				1.24	1.96	3.06	2.09c			
	Nano fertilizer	1.05	2.28	3.58	2.30c				1.01	2.24	3.54	2.26c			
	Mineral + Amino acids	1.33	2.14	4.21	2.56b	0.29	0.26	0.45	1.29	2.10	4.17	2.52b	0.29	0.26	0.45
	Nano + mineral	1.19	3.30	3.81	2.77b				1.15	3.26	3.77	2.73b			
	Nano + amino acids	2.35	3.18	4.28	3.27a				2.31	3.14	4.24	3.23a			
Average (C)		1.43c	2.52b	3.67a					1.39c	2.48b	3.63a				
Zn (ppm)	Mineral	0.747	0.860	0.855	0.821b				0.707	0.820	0.815	0.781b			
	Amino acids	0.813	0.777	0.772	0.787b				0.773	0.737	0.732	0.747b			
	Nano fertilizer	0.853	0.842	0.837	0.844b				0.813	0.802	0.797	0.804b			
	Mineral + Amino acids	0.893	0.908	0.943	0.915a	ns	0.06	0.11	0.853	0.868	0.897	0.873a	ns	0.07	0.11
	Nano + mineral	0.883	0.798	0.793	0.825b				0.843	0.758	0.783	0.795b			
	Nano + amino acids	0.910	0.890	0.977	0.926a				0.870	0.850	0.953	0.891a			
Average (C)		0.850	0.846	0.863					0.810	0.806	0.830				

Mean values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.
ns: not significant difference at 0.05 level of probability.

CONCLUSION

From the above recorded results during both growing seasons, it could be concluded that nano-techonological compound combined with amino acids increased yield and its components of wheat crop and "Sids 12" cultivar; was more response with this treatment under at El-Horia, El-Behira Governorate conditions, Egypt.

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الملخص العربي

إستجابة بعض أصناف القمح للرش الورقي لأسمدة النانو والأسمدة المعدنية والأحماض الأمينية

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أقيمت تجربتان حقليتان بقرية الحرية– أبو المطامير – محافظة البحيرة خلال موسمى زراعة ٢٠١٤/٢٠١٥، ٢٠١٥/٢٠١٦ تحت ظروف تربة رملية صفراء، لدراسة تأثير الرش الورقي ببعض أسمدة النانو ولأسمدة المعدنية والأحماض الأمينية على أنتاجية ثلاثة أصناف من قمح الخبز. استخدم تصميم القطع المنشقة مرة واحدة فى ثلاثة مكرارات وكانت مساحة كل قطعة شقية (١٠.٥م^٢)، حيث وزعت ٦ معاملات للرش الورقي وهي (السماد المعدني – مركب الأحماض الأمينية، سماد النانو، السماد المعدنى + مركب الأحماض الأمينية، السماد المعدني+ سماد النانو، مركب الأحماض الأمينية + سماد النانو) عشوائياً بالقطع الرئيسية، بينما وزعت الأصناف الثلاثة من قمح الخبز (سدس ١٢، سدس ١١ و جيزة ١٦٨) عشوائياً على القطع الشقية خلال موسمى الزراعة. وتم تسجيل مجموعة من القياسات والتقديرات وتشمل أرتفاع النبات، وعدد السنابل/م^٢، وعدد السنيبلات/السنبلة، وعدد الحبوب/سنبلة، ووزن ١٠٠٠ حبة، والمحصول ومحتوى الحبوب من البروتين، والفوسفور والبوتاسيوم، والحديد والمنجنيز والزنك عند الحصاد.

وتتلخص أهم النتائج فيما يلى:

- أوضحت النتائج أن هناك زيادة معنوية فى أرتفاع النبات، عدد السنابل/م^٢، عدد السنيبلات/سنبلة، عدد الحبوب/سنبلة، وزن ١٠٠٠ حبة، محصول الحبوب ومحصول القش والمحصول البيولوجي للفدان ودليل الحصاد عند الرش بسماد النانو + مركب الأحماض الأمينية خلال موسمى الدراسة. بينما أعطى الرش بالسماد المعدني منفرداً أقل القيم للصفات المدروسة.
- كانت هناك اختلافات معنوية بين الأصناف الثلاثة نتيجة للرش الورقي لسماد النانو والمعدني والأحماض الأمينية حيث تفوق صنف القمح "سدس ١٢" أعطى أعلى متوسطات لصفات المحصول ومكوناته خلال موسمي الدراسة
- أظهر التداخل بين عاملي الدراسة فروق معنوية لصفات المحصول ومكوناته حيث أعطى الرش الورقي لصنف القمح "سدس ١٢" بسماد النانو والأحماض الأمينية أعطت أعلى متوسطات لصفات المحصول ومكوناته.
- توصى الدراسة بزراعة صنف القمح(سدس ١٢) وتسميده ورقياً بسماد النانو مع الأحمض الأمينية حيث أن ذلك حقق أعلى انتاجية تحت ظروف منطقة الزراعة.