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Improving Productivity and Quality of Two Wheat Cultivars Using Humic Acid and Zinc Foliar Application under Sandy Soil Conditions.

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ABSTRACT

Two field experiments were carried out at the Research and Production Station, National Research Centre, Al-Nubaria district, El-Behaira Governorate, Egypt, during the two successive winter seasons 2013/2014 and 2014/2015.The aim of this study was to investigate the effect of humic acid (two levels (control and 20 mg/L)) and zinc foliar application (four levels of chelated zinc (0, 1.5, 3 and 4.5 g/L)) on yield, yield components and quality traits of two wheat cultivars (Seds-1 and Seds-13). The obtained results indicated that Seds-13 cultivar significantly surpassed Seds-1 in spikelet number per spike, grain yield/ spike, grain yield in kg/feddan (fed. = 4200 m^2), harvest index, protein % and protein yield (kg/fed.). Humic acid foliar spray significantly surpassed without spray (control) in all studied characters except harvest index. Foliar application of 4.5 g/L zinc gave the best results for all studied characters. Cultivar Seds-13 sprayed by humic acid gave the highest values of grain, straw, biological and protein yields/fed. Meanwhile, Seds-13 under4.5 g/L zinc application gave the best values of grain yield/ spike and biological, straw and grain yields/fed. the interaction between humic acid (20 mg/L) and 4.5 g/L zinc recorded the highest values in most of studied characters. Seds-13 x humic acid (20 mg/L) x 4.5 g/L zinc gave the highest values of grain yield/ spike and biological, straw and grain yields/fed. protein % and protein yield/fed. while, Seds-1 x humic acid (20 mg/L) x 4.5 g/L zinc gave the highest values of plant height, straw yield/ teller and grain index.
Keywords: Wheat – Humic acid – Zinc – yield and its components – quality traits.

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INTRODUCTION

Wheat (*Tritium aestivum*, L.) is an important cereal and food crop in Egypt and all over the world. Wheat provides 37 % of the total calories and 40 % of protein for humans in the Egyptian diet (Mujeeb *et al*., 2008).Currently, around 70 % of this crop is used for food, 19 % for animal feed and the remaining 11% is used in industrial applications, including biofuels. The importance of wheat is mainly due to the fact that its grain can be ground into flour, semolina, etc., which form the basic ingredients of bread and other bakery products, as well as pastas, and thus it presents the main source of nutrients to the most of the world population.

Recently, a great attention of several trails has been studied to increase the productivity of wheat especially under newly reclaimed sandy soil, to reduce the gap between production and consumption by increasing wheat production (Ahmed *et al*., 2011 and Bakry *et al*., 2015). Increasing wheat yield per unit area can be achieved by several steps like introducing high yielding varieties and applying the optimum cultural practices. Or on the other hand by applying some agronomic practice to sustain soil fertility through their effect on the physical, chemical and biological properties of soil (Hassanein *et al*., 2013, Hattem *et al*., 2015,Bakry *et al*., 2013 and El-Bassiouny *et al*., 2014). Grain, straw and biological yields and its components were significantly differed owing to varietal differences (Abdel-Ati and Zaki 2006).

Humic acid known as it have a role in increasing plant growth and improve the grain yield (Ayus *et al*., 1999). The advantages of bio-stimulants, such as humic acid, lie in their ability to promote hormonal activity in plants as well as promote antioxidant production in plants, which, in turn, reduces free radicals. It is involved in increasing root vitality, chlorophyll biosynthesis, seed germination rate and improve nutrients uptake (Liu and Cooper 2000). Bakry *et al*., 2013 and El-Bassiouny *et al*., 2014 showed that, there is a significant increase in grain yield and its components of two wheat cultivars with foliar application of humic acid.
Zinc (Zn) is an essential nutrient for plant and human growth, and dietary Zn deficiency is a worldwide nutritional problem. (Shaheen *et al*., 2007 and Potarzycki and Grzebisz 2009), reported that, zinc exerts a great influence on basic plant life processes, such as (i) nitrogen uptake, metabolism and protein quality; (ii) chlorophyll synthesis, carbon anhydrase activity and photosynthesis. Zn-deficient plants reduce the rate of protein synthesis and protein content. Ghasemian *et al*., 2010 declared that, zinc element is essential in chlorophyll production and pollen function. Application of Zn fertilizer either to the soil or as foliar application is one of the effective and productive ways to improve cereal grains (Jiang *et al*., 2008).Significant yield loss can occur in soils where Zn availability is low due to high pH. Typically, soil pH levels greater than 7 are associated with Zn deficiency. In addition to low levels of available Zn in soil due to high pH, some other conditions led to Zn deficiency such as cool wet cloudy weather during the early growing season and sandy low organic matter soils.

The objective of this work to study the effect of humic acid and zinc foliar application on growth, yield and yield components of two wheat cultivars (Seds-1 and Sids-13) under sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Production and Research Station, National Research Centre, Al-Nubaria district, El-Behaira Governorate, Egypt during the two successive winter seasons of 2013/2014 and 2014/2015.This study grown in sandy soil conditions using two Wheat cultivars(Seds-1 and Seds-13)to investigate the effect of foliar application of humic acid (zero as control and 20 mg/L) and chelated zinc foliar application levels (0, 1.5, 3 and 4.5 g/L)applied twice at 30 and 45 days after sowing on yield, yield components and quality traits.. The experimental design was split-split plots design with three replicates. Wheat cultivars assigned in the main plots, while, levels of humic acid in sub- plots and levels of chelated zinc in sub-sub plots (3x3.5 m2 i.e. 10.5 m2).Grains of the two wheat varieties obtained from the Ministry of Agriculture, Egypt. Seeding rate of 70 kg/fed. were drilled in rows 15 cm apart at 15 November in both seasons.NPK (75:31:48) Nitrogen ate 75 kg/fed. in the form ammonium nitrate (33.5% N), 31kg/fed.P2O5as calcium superphosphate (15.5% P2O5)and 48kg/fed.K2O as potassium sulfate (48% K2O) were applied. Sprinkler irrigation practiced at 5-day's intervals.

A soil sample of 0-30 cm depth of the experimental sites subjected to physical and chemical analysis according to the method described by Chapman and Pratt (1979)(Table 1).

Table 1: Mechanical and chemical analysis of the experimental soil (2013/2014 and 2014/2015 seasons).

Mechanical analysis:	2013/2014	2014/2015
Sand %	91.7	90.5

Silt %	3.5	4.2
Clay %	4.8	5.3
Chemical analysis:		
$CaCo_3$ %	3.53	3.51
Organic matter %	0.18	0.17
EC. mmhos/cm^2	0.4	0.3
pH	7.6	7.8
Soluble N%	7.7	8.2
Available P (ppm)	12.0	11.5
Available K (ppm)	15.08	18.5

At harvest, a random sample from each sub-sub plot taken to estimate plant height (cm), spike length (cm), spikelet number per spike and grain yield / spike (g). Plants of one square meter were harvested to estimate biological yield, straw yield, grain yield per fed. and harvest index, a random sample of wheat grain from the harvest area were taken to estimate 100-grain weight (gm), protein content (%) and protein yield/fed. as well as %. N, K, Ca, Cu, Mn, Mg, Fe and Zn in grains were determined according to the method described by A.O.A.C (2005).Grain protein content was estimated according to the method described by Bradford (1976)by multiplying total nitrogen concentration by 5.75. Amino acid contents identification and determination of the amino acid composition of the wheat grain carried out by separated on INGOS Amino Acid Analyzer (Model: AAA 400). (Acid hydrolysis was carried out according to the method of Csomos and Simon-Sarkadi (2002) in brief.

Statistical analysis

The analysis of variance for a split-split plot design was carried out for each studied character in each season. The combined analysis for data from the different seasons was also carried out for all aforementioned characters according to (Snedecor and Cochran 1990) as the results of two seasons followed similar trend. Means were compared by L.S.D. test at 0.05 probability level

RESULTS AND DISCUSSION

1. Effect of Cultivars:

Data presented in Table (2) indicated that Seds-1 and Seds-13 differed significantly in all studied traits in combined analysis, except for biological yield per fed. Seds-13 cultivar surpassed significantly Seds-1 in grain yield due to its great number of spikes/m^2, grain yield/spike, harvest index and protein percentage. In addition, its high protein yield was due its greater grain yield and protein content than Seds-1. Such results are in agreement with those obtained by other investigators (Shaabn *et al*., 2009), (Bakry *et al*., 2013 and 2015) and (El-Bassiouny *et al*., 2014). Moreover, it could be concluded that the results measured by single plant in both cultivars had narrow range due to genetic variations between them.

Table 2: Effect of cultivars on yield and yield components of wheat (combined of 2013/2014 and 2014/2015).

Characters	Varieties		$LSD_{0.05}$
	Seds-13	**Seds-1**	
Plant height (cm)	77.29	91.17	3.15
No. spikes/m^2	370.96	335.21	2.77
Spike length (cm)	9.71	11.63	1.03
spikelet number per spike	16.88	15.96	0.31
Biological yield /teller (g)	5.23	6.7	0.41
Grain yield / spike (g)	2.77	2.59	0.11
Straw yield/ teller (g)	2.46	4.11	0.65
Grain index (g)	3.94	4.35	0.13
Biological yield (ton/fed.)	3.723	3.725	NS
Straw yield (ton/fed.)	2.042	2.1	0.055
Grain yield (kg/fed.)	1680.6	1625.35	33.18
Protein %	8.93	8.47	0.37
Protein yield (kg/fed.)	155.76	139.21	5.85
Harvest index %	45.87	43.74	1.13

NS= Non significant difference

2. Effect of Humic acid:

The Data in Table (3) indicated that humic acid foliar application caused a significant increase in all characters compared with control. Application of humic acid increased grain yield/fed. by 43.2%. This increase was due to the increase in no. of spikes /m^2 (16.98%) and grain yield/spike (30.04%). Such results are in agreement with those obtained by (Liu and Cooper, 2000), (Eyheraguibel *et al*., 2008, Boris *et al*., 2010, Shirzad *et al*., 2012, Bakry, *et al*., 2013 and El-Bassiouny *et al*., 2014). In this connection (Ayus *et al*., 1999 and Jaleel *et al*., 2008) suggested that humic acid promote plant growth and improved yield. The results of humic acid foliar treatment are in good agreement with those obtained by (Boris *et al*., 2010 and Shirzad *et al*., 2012). The beneficial effects of humic acid on plant growth could be referred to its acting as a source of plant growth hormones (gibberellins and auxin). In addition, physiological mechanisms through which humic substances exert their effects may depend on hormones and, in particular, on the presence of auxin like components in their structure and, consequently its effect on plant growth and development (Eyheraguibel *et al*., 2008). Regarding to the increases in root growth, one of the functions of Humic acid is the positive effect on the promotion of root development.

Table 3: Effect of humic acid on yield and yield components of wheat (combined of 2013/2014 and 2014/2015).

Characters	Humic acid (mg/L)		LSD $_{0.05}$
	Control	20	
Plant height (cm)	80.46	88.00	2.45
No. spikes/m^2	325.45	380.72	5.24
Spike length (cm)	10.63	10.71	0.05
spikelet number per spike	16.08	16.75	0.51
Biological yield /teller (g)	5.26	6.67	1.015
Grain yield / spike (g)	2.33	3.03	0.35
Straw yield/ teller (g)	2.93	3.64	0.41
Grain index (g)	3.90	4.39	0.28
Biological yield (ton/fed.)	2.895	4.553	0.25
Straw yield (ton/fed.)	1.536	2.605	0.31
Grain yield (kg/fed.)	1358.68	1947.27	44.17
Protein %	7.86	9.53	1.14
Protein yield (kg/fed.)	107.10	187.87	11.07
Harvest index %	46.93	42.68	1.18

3. Effect of Zinc foliar application:

Data shown in Table (4) indicated that increase Zn level as foliar application caused a gradual and significant increase in all characters. The highest values of grain, biological and protein yields/fed. was obtained with the highest Zn level (4.5 g/L). This increase was accompanied with increase in values of plant height (cm), spike length (cm), spikelet number per spike, No. of spikes/m^2, biological /teller (g), grain yield/ spike (g), straw yield/ teller (g), grain index (g) and protein percentage. Such results are in agreement with those obtained by (Bakry *et al*., 2012 and Singh *et al*., 2012).The grain yield/fed. was increased by (24.62, 40.08 and 59.65%) when wheat plants sprayed with zinc at rates of (1.5, 3 and 4.5 g/L) respectively, over the control. The increase in grain and straw yield as well as protein yield with Zn foliar application may be because Zn plays an important role in biosynthesis of the IAA and initiation of reproductive parts and the favorable effect of zinc on the metabolic reactions within the plants. In this concern (Marschner 1986 and Oosterhuis *et al*., 1991) cleared that zinc is an cofactor of over 300 enzymes and component of a number of dehydrogenases, proteinases and peptidases; thus zinc influences electron transfer reaction including those of the Krebs Cycle and hence affecting the plants energy production.

Table 4: Effect of zinc foliar application on yield and yield components of wheat (combined of 2013/2014 and 2014/2015)

Characters	Zinc foliar application (g/L)				LSD 0.05
	Control	1.5	3	4.5	
Plant height (cm)	75.08	85.75	83.92	92.17	1.77
No. spikes/m^2	320.52	346.17	368.93	376.72	3.15
Spike length (cm)	9.92	10.5	10.17	12.09	0.23
spikelet number per spike	15.08	16.75	16.09	17.75	0.41
Biological yield /teller (g)	5.22	5.91	5.76	6.98	0.18
Grain yield / spike (g)	2.06	2.65	2.89	3.13	0.12
Straw yield/ teller (g)	3.15	3.26	2.88	3.86	0.22
Grain index (g)	3.93	4.23	4.20	4.23	0.17
Biological yield (ton/fed.)	2.920	3.615	4.023	4.338	0.18
Straw yield (ton/fed.)	1.659	2.044	2.256	2.325	0.15
Grain yield (kg/fed.)	1260.97	1571.4	1766.4	2013.13	51.35
Protein %	8.07	8.69	8.95	9.09	0.17
Protein yield (kg/fed.)	102.84	138.98	161.61	186.5	5.13
Harvest index %	43.79	44.06	44.21	47.16	0.11

4. Effect of interaction

Statistical analysis revealed that interactions had significant effects on all studied traits in the combined analysis (Tables 5, 6, 7 and 8).

4-1. Interaction between wheat cultivars and humic acid

Data presented in Table 5 indicated that all of studied characters were respond positively to humic acid application but with different magnitude for the two cultivars. For example, spike length of Seds-13 increased significantly due to application of humic acid. While, such increase did not reach to significance level for Seds-1. Table 5 also indicated that application of humic acid (20 mg/L) increased the biological yield by about 67% for Seds-13 and 48% for Seds-1, this was due to the straw yield increase by 67% and 52% for the two cultivars in the same order. However, grain yield of both cultivars increased by a similar rate (43%). Thus, the harvest index decreased due to humic acid application from 49.38% to 42.25% for Seds-13 and from 44.47% to 43.01% for Seds-1.In addition there were significant differences in all studied characters due to the interaction between the two wheat cultivars and the two levels of humic acid. Seds-1 under humic acid foliar spray at rate of (20 mg/L) produced the tallest plants (95.33 cm),tallest spike (11.58),the highest values of biological and straw yield/ teller (7.39 and 4.34 g), grain yield /spike (3.05 g) and heaviest 100 grains weight (4.68 g).The significant increase in grain yield and its components of wheat with foliar application of humic acid was showed also by (Bakry *et al*., 2013 and El-Bassiouny *et al*., 2014). In this concern (Muharrem *et al*., 2005) pointed that, foliar spray of humic acid substances at 3 to 6 leaf stage significantly increased yield and yield components in common bean. On the other hand, (Reza and Vahid 2011) reported significant differences between wheat genotypes and humic treatments in terms of economic yield and harvest index.

Table 5: Effect of the interaction between varieties and humic acid foliar application on yield and yield components of wheat (combined of 2013/2014 and 2014/2015).

Characters	Varieties				LSD 0.05
	Seds-13		Seds-1		
	Humic acid **(mg/L)**				
	0	20	0	20	
Plant height (cm)	73.92	80.67	87.00	95.33	3.09
No. spikes/m^2	349.98	391.95	300.93	369.49	5.12
Spike length (cm)	9.59	9.83	11.67	11.58	0.33

spikelet number per spike	16.58	17.17	15.59	16.34	1.02
Biological yield /teller (g)	4.52	5.95	6.01	7.39	0.55
Grain yield / spike (g)	2.53	3.01	2.13	3.05	0.21
Straw yield/ teller (g)	1.98	2.94	3.88	4.34	0.25
Grain index (g)	3.78	4.10	4.03	4.68	0.05
Biological yield (ton/fed.)	2.788	4.658	3.003	4.448	0.14
Straw yield (ton/fed.)	1.407	2.677	1.666	2.533	0.11
Grain yield (kg/fed.)	1381.0	1980.2	1336.37	1914.33	15.18
Protein %	7.69	10.17	8.04	8.90	0.35
Protein yield (kg/fed.)	106.57	204.95	107.64	170.79	4.33
harvest index %	49.38	42.35	44.47	43.01	1.15

4-2. Interaction between wheat cultivars and zinc:

It is clear from data in Table 6 that there were significant differences in all studied characters due to the interaction between the two wheat cultivars and the levels of zinc foliar application. Data showed that most of these characters were gradually increased as zn level was increased such as no. spikes /m^2, spikelet number per spike and biological, straw, grain and protein yields for both cultivars, but with different increase rate. For example , protein yield of seds-13 and seds-1 increased by 102.2% and 62.1% respectively, when zn was applied at 4.5 g/L for both cultivars. On the other side, seds-13 produced tallest plants, tallest spike and greatest grain weight per spike at 4.5 g/L zinc foliar spray, while, this was true for seds-1 at 3.0 g/L. In addition, some characters showed no clear trend with increasing zn levels for both cultivars such as grain and harvest index.

Table 6: Effect of the interaction between varieties and zinc foliar application on yield and yield components of wheat (combined of 2013/2014 and 2014/2015).

Varieties	Seds-13				Seds-1				LSD
Zinc (g/L)	Control	1.5	3	4.5	Control	1.5	3	4.5	0.05
Plant height (cm)	69.00	78.50	76.50	85.17	81.17	93.00	91.34	99.17	2.25
No. spikes/m^2	341.64	366.70	383.40	392.11	299.41	325.65	354.46	361.33	4.08
Spike length (cm)	9.50	9.00	8.50	11.84	10.34	12.00	11.83	12.34	1.03
spikelet number per spike	15.83	17.67	15.5	18.5	14.34	15.84	16.67	17.0	0.48
Biological yield /teller (g)	5.10	4.65	4.70	6.48	5.34	7.17	6.82	7.49	0.17
Grain yield / spike (g)	2.08	2.42	2.79	3.8	2.04	2.89	2.99	2.45	0.05
Straw yield/ teller (g)	3.02	2.23	1.92	2.68	3.29	4.29	3.84	5.04	0.12
Grain index (g)	3.75	4.05	3.90	4.05	4.10	4.40	4.50	4.40	0.03
Biological yield (ton/fed.)	2.905	3.505	4.135	4.345	2.935	3.725	3.91	4.33	0.17
Straw yield (ton/fed.)	1.674	1.873	2.292	2.329	1.644	2.215	2.22	2.321	0.15
Grain yield (kg/fed.)	1230.6	1632.2	1843	2016.6	1291.34	1510.6	1689.8	2009.7	13.78
Protein %	7.89	9.01	9.28	9.54	8.25	8.37	8.62	8.63	0.11
Protein yield (kg/fed.)	98.05	150.51	175.93	198.55	107.64	127.46	147.29	174.5	2.75
harvest index %	43.08	47.85	45.35	47.19	44.51	40.27	43.06	47.13	0.02

4-3. Interaction between humic acid and zinc foliar application:

Data presented in Table 7 cleared that all studied characters were significantly affected by this interaction. Biological, grain and protein yields as well as protein content were gradually increased as zinc levels increased but with different increasing rate, for the two humic acid levels, for example biological yield increased by 35.8,49.5 and 60.3% when zinc level increased from zero to 1.5, 3.0 and 4.5 g/L respectively, under zero mg/L level of humic acid. While the increase was 17.2, 31.2 and 42.0 % when humic acid added with 20 mg/L in the same order. However, straw yield reached to maximum with application of humic acid (control) and 3.0 g/L zinc foliar spray, while it continued to increase up to 4.5 g/L zinc foliar spray with 20 mg/L humic acid. With regard to grain yield, increasing zinc level from zero up to 4.5 g/L increased grain yield by 67.4% and 49.1%.

Table 7: Effect of the interaction between humic acid and zinc foliar application on yield and yield components of wheat (combined of 2013/2014 and 2014/2015).

Characters	Humic acid (mg/L)								LSD 0.05
	0				20				
	Zinc (g/L)								
	Control	1.5	3	4.5	Control	1.5	3	4.5	
Plant height (cm)	71.00	83.50	78.84	88.50	79.17	88.00	89.00	95.83	2.15
No. spikes/m^2	285.60	328.28	341.61	346.33	355.45	364.07	396.25	407.11	3.25
Spike length (cm)	9.34	11.17	9.67	12.34	10.50	9.83	10.67	11.84	0.36
spikelet number per spike	14.00	16.84	16.00	17.50	16.17	16.67	16.17	18.00	0.37
Biological yield /teller (g)	4.09	5.15	4.57	7.25	6.35	6.67	6.95	6.72	0.21
Grain yield / spike (g)	1.79	2.35	2.40	2.79	2.33	2.95	3.37	3.47	0.11
Straw yield/ teller (g)	2.29	2.80	2.17	4.47	4.02	3.72	3.59	3.25	0.12
Grain index (g)	3.65	4.15	4.00	3.80	4.20	4.30	4.40	4.65	0.10
Biological yield (ton/fed.)	2.125	2.880	3.170	3.405	3.715	4.350	4.875	5.270	0.16
Straw yield (ton/fed.)	1.146	1.586	1.734	1.680	2.172	2.502	2.778	2.970	0.20
Grain yield (kg/fed.)	978.8	1294.5	1435.8	1725.6	1543.1	1848.3	2097.0	2300.7	17.33
Protein %	7.68	7.84	7.93	8.01	8.46	9.54	9.96	10.17	0.31
Protein yield (kg/fed.)	75.11	101.33	113.7	138.24	130.58	176.64	209.49	234.77	2.45
harvest index %	46.07	45.63	45.35	50.67	41.52	42.49	43.07	43.65	0.21

4-4. interaction between wheat cultivars, humic acid and zinc foliar application:

Data presented in Table 8 showed significant differences between the interactions between wheat varieties, humic acid and zinc foliar spray levels on all studied characters. Data revealed that, both cultivars showed maximum values of the most studied characters when they sprayed with 20 mg/L humic acid and 4.5 g/L zinc twice at 30 and 45 DAS. Data also indicated that the heights grain yield (2388kg/fed.) with highest protein content (11.2%) was achieved by seeding Seds-13 cv., treated with foliar application of 20 mg/L humic acid and 4.5 g/L zinc twice at 30 and 45 days after swing. On the other hand highest value of harvest index (52.84%) was obtained when Seds- 13was not sprayed with humic acid and with the zinc level (1.5 g/L), while the of harvest index of Seds -1 (51.02%) was obtained from zero humic acid with4.5 g/L zinc treatment.

Mineral contents:

Data in Table 9 presented the mean of mineral contents of (K, Mg, Mn, Cu, Fe and Zn) in grains of two wheat cultivars (seds-13 and seds-1) as affected by humic acid and zinc foliar application. The data in the same table indicate that, Seds-13 variety surpassed Seds-1 in all measured minerals contents and humic acid gave the highest mean values in all mineral contents in grains of both cultivars. On the other hand, mean values of minerals contents increased in grains of both cultivars when a zinc level was increased. The interaction between seds-13 with humic acid and zinc at rate of 4.5 g/L gave the highest mean values in all mineral contents except Mg contents. The importance of bio-stimulants lies in their ability to promote hormonal activity in plants as well as promote antioxidant production in plants, which, in turn, reduces free radicals. It is increase root vitality, improved nutrient uptake, (Liu and Cooper, 2000). Foliar applications of humic acid had a significant effect on the dry weight and mineral elements uptake in corn (Khaled and Fawzy, 2011 and Erik *et al*., 2000) mentioned that, the commercial humic acids were found to improve growth, yield production, quality and increased significantly in the accumulation of P, K, Ca, Mg, Fe, Zn and Mn in tissues of some vegetable crops.

Amino acid composition in grain yield:

It has been found in Table 10 of the present investigation that, the mean values of amino acids contents varied in grains of two wheat cultivars (seds-13 and seds-1) as affected by humic acid and zinc foliar application. Data indicated that Seds-13 cultivar surpassed Seds-1 in Aspartic acid, Serine and Leucine of amino acids, while Seds-1 surpassed Seds-13 in Threonine, Glycine, Alanine, Valine, Phenylalanine and Arginine amino acids; also, humic acid gave the highest mean values in all amino acids contents in grains of both cultivars compared with control. On the other hand, amino acids contents increased in grains of both cultivars when a zinc level was increased except Tyrosine, Histidine and Lysine amino acids. The interaction between Seds-13 with humic acid and zinc at rate of 4.5 g/L gave the highest mean values of Aspartic acid, Serine and Leucine amino acids. While, Seds-1 with humic acid and zinc at rate of 4.5 g/L gave the highest mean values of Threonine, Glycine, Alanine, Valine, Phenylalanine and Arginine amino acids. On the other hand, Seds-1 with humic acid and zinc at rate of 1.5 g/L gave the highest mean values of Tyrosine and Lysine. These obtained results are in harmony with those obtained by (Abd Allah *et al*., 2015).

Results of the same Table indicated that, the interaction between Seds-13 with humic acid and zinc at rate of 4.5 g/L gave the highest mean values of essential and non-essential amino acids and the ratio of essential to non-essential amino acids and total amino acids compared with the other treatments. These obtained results are in harmony with those obtained by (Hassanein *et al*., 2013) who reported that, amino acid treatment enhanced the levels of total amino acids, essential amino acids and the ratio of essential to non-essential amino acids in wheat.

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Table 8: Effect of the interaction between humic acid and zinc foliar application on yield and yield components of two wheat cultivars (combined of 2013/2014 and 2014/2015).

Varieties	Humic acid mg/L	Zinc g/L	Plant height (cm)	No. spikes /m2	Spike length (cm)	spikelet number per spike	Biological yield /teller (g)	grain yield/ spike (g)	straw yield/ teller (g)	grain index (g)	biological yield (ton/fed)	straw yield (ton/fed)	grain yield (kg/fed)	protein %	protein yield (kg/fed)	harvest index %
Seds-13	0	0	66.67	315.95	8.67	14.33	3.17	1.83	1.33	3.70	2.15	1.164	985.60	7.47	73.62	45.84
		1.5	74.00	355.40	9.67	17.67	3.63	2.30	1.33	4.10	2.61	1.231	1379.20	7.65	105.51	52.84
		3	69.00	361.05	8.00	15.33	3.73	2.50	1.23	3.70	3.12	1.606	1514.00	7.76	117.49	48.53
		4.5	86.00	367.50	12.00	19.00	7.53	3.50	4.03	3.60	3.27	1.625	1645.20	7.88	129.64	50.31
	20	0	71.33	367.33	10.33	17.33	7.03	2.33	4.70	3.80	3.66	2.184	1475.60	8.30	122.47	40.32
		1.5	83.00	377.99	8.33	17.67	5.67	2.53	3.13	4.00	4.40	2.515	1885.20	10.37	195.50	42.85
		3	84.00	405.75	9.00	15.67	5.67	3.07	2.60	4.10	5.15	2.978	2172.00	10.79	234.36	42.17
		4.5	84.33	416.71	11.67	18.00	5.43	4.10	1.33	4.50	5.42	3.032	2388.00	11.20	267.46	44.06
Seds-1	0	0	75.33	255.25	10.00	13.67	5.00	1.75	3.25	3.60	2.10	1.128	972.00	7.88	76.59	46.29
		1.5	93.00	301.15	12.67	16.00	6.67	2.40	4.27	4.20	3.15	1.940	1209.87	8.03	97.15	38.41
		3	88.67	322.17	11.33	16.67	5.40	2.30	3.10	4.30	3.22	1.862	1357.60	8.10	109.97	42.16
		4.5	91.00	325.15	12.67	16.00	6.97	2.07	4.90	4.00	3.54	1.734	1806.00	8.13	146.83	51.02
	20	0	87.00	343.56	10.67	15.00	5.67	2.33	3.33	4.60	3.77	2.159	1610.67	8.61	138.68	42.72
		1.5	93.00	350.15	11.33	15.67	7.67	3.37	4.30	4.60	4.30	2.489	1811.33	8.71	157.77	42.12
		3	94.00	386.75	12.33	16.67	8.23	3.67	4.57	4.70	4.60	2.578	2022.00	9.13	184.61	43.96
		4.5	107.33	397.50	12.00	18.00	8.00	2.83	5.17	4.80	5.12	2.907	2213.33	9.13	202.08	43.23
$LSD_{0.05}$			2.17	3.55	0.35	1.13	0.23	0.11	0.32	0.10	0.21	0.19	21.15	0.18	2.77	0.14

Table 9: Mean Effect of humic acid and zinc foliar application on mineral contents (ppm) of two wheat cultivars grown under sandy soil.

Varieties	Humc acid Mg/L	Zinc (g/L)	Mineral contents (ppm)						
			Ca	Cu	Fe	K	Mg	Mn	Zn
Seds-13	0	0	1.50	0.02	0.60	6.36	1.44	0.93	0.04
		1.5	1.50	0.02	0.84	5.36	1.51	0.95	0.05
		3	1.54	0.02	1.73	5.45	1.63	0.95	0.06
		4.5	2.07	0.04	2.43	5.17	1.76	0.97	0.06
	Mean		**1.65**	**0.03**	**1.40**	**5.59**	**1.59**	**0.95**	**0.05**
	20	0	1.45	0.02	1.91	5.19	1.66	0.95	0.05
		1.5	1.68	0.02	2.95	5.28	1.87	1.02	0.05
		3	1.87	0.03	3.21	5.67	1.90	1.04	0.06
		4.5	2.21	0.05	3.91	6.32	1.98	1.07	0.09
	Mean		**1.80**	**0.03**	**3.00**	**5.62**	**1.85**	**1.02**	**0.06**
Mean			***1.73***	***0.03***	***2.20***	***5.60***	***1.72***	***0.99***	***0.06***
Seds-1	0	0	1.48	0.01	0.57	5.61	1.50	0.84	0.06
		1.5	1.49	0.02	2.24	5.84	1.63	0.93	0.07
		3	1.52	0.02	2.92	5.94	1.68	0.92	0.07
		4.5	1.90	0.05	2.96	6.23	1.85	0.95	0.08
	Mean		**1.60**	**0.03**	**2.17**	**5.91**	**1.67**	**0.91**	**0.07**
	20	0	1.18	0.01	0.46	5.33	1.52	0.87	0.05
		1.5	1.22	0.01	0.48	5.52	1.53	0.86	0.06
		3	1.29	0.02	0.60	5.43	1.58	0.89	0.06
		4.5	1.58	0.02	3.54	5.67	2.09	0.93	0.07
	Mean		**1.32**	**0.02**	**1.27**	**5.49**	**1.68**	**0.89**	**0.06**
Mean			***1.46***	***0.02***	***1.72***	***5.70***	***1.67***	***0.90***	***0.07***

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Table 10: Mean Effect of humic acid and zinc foliar application on amino acid contents (mg/ 100 g dry weight) of two wheat cultivars grown under sandy soil.

Varieties	Humic acid Mg/L	Zinc g/L	Aspartic acid	Threonine*	Serine	Glycine	Alanine	Valine*	Phenylalanine*	Leucine*	Tyrosine	Histidine*	Lysine*	Arginine*	Essential A A*	Non essential A A	Total amino acids	Ess AA /non ess AA
Seds-13	0	0	7.73	1.77	1.95	0.83	0.36	0.00	0.00	0.46	1.31	1.24	0.04	1.70	5.21	12.18	17.39	0.43
		1.5	8.32	2.11	2.37	2.82	1.66	0.15	0.06	0.73	1.38	0.89	1.05	1.93	6.92	16.55	23.47	0.42
		3	10.81	3.30	5.96	4.01	2.15	0.27	0.18	0.78	0.83	0.71	0.86	2.82	8.92	23.76	32.68	0.38
		4.5	23.83	5.64	10.28	7.03	5.28	0.55	0.24	1.06	0.82	0.54	0.81	4.64	13.48	47.24	60.72	0.29
	Mean		**12.67**	**3.21**	**5.14**	**3.67**	**2.36**	**0.24**	**0.12**	**0.76**	**1.09**	**0.85**	**0.69**	**2.77**	**8.63**	**24.93**	**33.57**	**0.38**
	20	0	13.40	0.00	2.52	1.54	1.15	0.14	0.00	0.04	2.49	1.13	1.17	3.42	5.90	17.10	23.00	0.35
		1.5	17.18	2.08	3.94	2.40	2.45	1.63	0.06	0.35	0.76	0.83	0.97	4.01	9.93	26.73	36.66	0.37
		3	21.27	2.08	5.54	3.25	6.20	1.93	0.33	1.16	0.49	0.78	0.84	5.14	12.26	36.75	49.01	0.33
		4.5	25.28	7.16	29.11	4.01	6.93	2.14	0.68	1.73	0.38	0.78	066	5.70	84.19	65.71	149.9	1.28
	Mean		**19.28**	**2.83**	**10.28**	**2.80**	**4.18**	**1.46**	**0.27**	**0.82**	**1.03**	**0.88**	**17.25**	**4.57**	**28.07**	**36.57**	**64.64**	**0.58**
Mean			***15.98***	***3.02***	***7.71***	***3.24***	***3.27***	***0.85***	***0.19***	***0.79***	***1.06***	***0.86***	***8.97***	***3.67***	***18.35***	***30.75***	***49.10***	***0.48***
Seds-1	0	0	2.80	0.68	1.60	0.00	0.00	0.00	0.12	0.91	1.11	1.06	0.64	21.72	25.13	5.51	30.64	4.56
		1.5	5.61	2.98	2.11	2.66	2.52	1.01	0.15	0.83	2.00	0.24	0.60	4.20	10.01	14.90	24.91	0.67
		3	14.18	3.10	2.11	3.23	2.78	2.52	0.19	0.49	0.68	0.39	0.57	4.28	11.54	22.98	34.52	0.50
		4.5	18.61	5.66	3.16	5.65	6.92	2.89	0.26	0.53	0.61	0.10	0.51	5.42	15.37	34.95	50.32	0.44
	Mean		**10.30**	**3.11**	**2.25**	**2.89**	**3.06**	**1.61**	**0.18**	**0.69**	**1.10**	**0.45**	**0.58**	**8.91**	**15.51**	**19.59**	**35.10**	**1.54**
	20	0	16.79	3.22	1.18	0.97	7.06	1.31	0.24	1.63	1.35	3.12	0.58	5.89	15.99	27.35	43.34	0.58
		1.5	21.76	10.66	2.11	3.23	15.34	1.49	0.26	1.12	3.55	1.50	1.31	11.06	27.40	45.99	73.39	0.60
		3	22.15	10.56	3.16	4.55	12.62	2.81	0.38	1.00	2.24	1.34	0.73	24.82	41.64	44.72	86.36	0.93
		4.5	24.96	11.15	5.07	9.55	16.99	3.09	1.62	0.62	1.57	1.17	0.59	26.37	44.61	58.14	102.75	0.77
	Mean		**21.42**	**8.90**	**2.88**	**4.58**	**13.00**	**2.18**	**0.63**	**1.09**	**2.18**	**1.78**	**0.80**	**17.04**	**32.41**	**44.05**	**76.46**	**0.72**
Mean			***15.86***	***6.00***	***2.56***	***3.73***	***8.03***	***1.89***	***0.40***	***0.89***	***1.64***	***1.12***	***0.69***	***12.97***	***23.96***	***31.82***	***55.78***	***1.13***

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