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IMPACT OF HUMIC ACID APPLICATION AND NITROGEN FERTILIZER LEVEL ON BREAD WHEAT PRODUCTIVITY UNDER SANDY SOIL CONDITIONS

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ABSTRACT: Two field experiments were carried out at the Agricultural Research Station, Faculty of Agriculture, Zagazig University, El-Khattara region, Sharkia Governorate, Egypt during the two successive seasons of 2014/2015 and 2015/2016 to investigate the effect of three rates of humic acid application (0, 2 and 4 kg humic acid/fad.) and five nitrogen fertilizer levels (0, 30, 60, 90 and 120 kg N/fad.) on bread wheat (*Triticum aestivum* L. cv. Sids 12) grown in sandy soil under sprinkler irrigation system. Results of the combined analysis indicated that application of humic acid at 2 kg/ fad., significantly increased plant height (cm), flag leaf area (cm^2), spike length (cm), number of spikes/m^2, straw yield (ton/fad.) and harvest index as compared to control treatment. Furthermore, flag leaf chlorophyll content (SPAD), number of grains/spike, weight of grains/spike (g), 1000-grain weight (g), grain and biological yields (ton/fad.) showed significant increase due to raising humic acid application up to 4 kg/fad. On the other hand, it was found that plant height, spike length, number and weight of grains/spike, number of spikes/m^2, 1000-grain weight, straw yield and harvest index were significantly increased by increasing nitrogen fertilizer levels up to 90 kg N/fad. Whereas, flag leaf area, flag leaf chlorophyll content, grain and biological yields per fad responded to each N increment up to 120 kg N/fad. Most studied traits were significantly affected by the interaction between humic acid and nitrogen fertilizer levels. It could be noticed that, application of humic acid resulted in reducing the requirement to N fertilizer application. The highest grain yield (16.25 ardab/fad.) was achieved by soil application of 4 kg humic acid with 90 kg N/fad.

Key words: Wheat, nitrogen, humic, chlorophyll content.

INTRODUCTION

Wheat (*Triticum aestivum,* L.) is dominant grain crop all over the world as well as in Egypt. It is occupying an important part of the daily diet of millions people. The total cultivated area of wheat in Egypt reached about 1.43 million hectares and the total production overtake 9.28 million tons with an average of 6.51 tons/ha (FAOSTAT, 2016). Using organic fertilizers is very important in food safety and environmental health, therefore it is taken into consideration all over the world. The stimulatory effects of humic substances were directly linked to the improved nutrients uptake (Chen and Aviad, 1990; Chen *et al*., 1999). Furthermore, the effects of humic acid on soil fertility *via* increased microbial population of microorganisms, as well as, improved chemical and physical properties of soil. Moreover, humic acid may had varying biochemical effects on the cell wall, membrane level and the cytoplasm which had caused an increase in photosynthesis and respiration, enhanced protein synthesis and plant hormones activities (Chen and Aviad, 1990). Among organic fertilizers, humic acid considers as a principal component of humic substances, which are the main components of soil. When appropriate humic substances are exist within the soil, nitrogen, phosphorus and potassium

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fertilizer application rates may be reduced (Pettit, 2004). Humic acid had many beneficial effects on soil properties which promotes plant growth and nutrient uptake, as well as increasing yield (Cimrin and Yilmaz, 2005; Asik *et al*., 2009). Khaled and Fawy (2011) reported that humic acid can reduce water loss through evaporation and increase water use efficiency by plants due to increased the water holding capacity of sandy soils. Humic acid was also found to plant chlorosis, increase the permeability of the plant membranes, intensify enzyme systems of plants, accelerate cell division, show greater root development, and decrease stress deterioration. Humic acid reduce soil erosion *via* increasing the cohesive forces of the fine soil particles, promoting of elements chelation and hence, this might play an important role in enriching soil fertility and availability of nutrients. In this respect, many investigators reported significant increase in yield and yield components of wheat due to the application of humic acid (Antoun *et al.,* 2010; Khan *et al.,* 2010; El-Hamdi *et al.,* 2012; Bakry *et al*., 2013; Tufail *et al.,* 2014; Radwan *et al.,* 2015; Anwar *et al.,* 2016). Moreover, Kandil *et al.* (2016) and Manal *et al.* (2016) showed that higher averages of spike length, number of grains/spike, grain weight/spike, 1000-grain weight as well as grain, straw and biological yields of wheat were obtained by application of humic acid, while harvest index was significantly decreased.

Egyptian soils, especially sandy soils, have low residual soil nitrogen content as a result of low content of organic matter and the small amount of organic manures added to it annually. Therefore, nitrogen fertilization is considering one of the key factors for increasing wheat yield. Moussa and Abdel-Maksoud (2011) showed that, increasing nitrogen fertilizer level up to 90 Kg N/fad., tended to cause significant increase in wheat grain yield and yield components *i.e.* spike number/m^2, grain number/spike and 1000-grain weight. Other researchers recorded significant increment in wheat grain and straw yields as well as yield components by raising nitrogen fertilizer level up to 100 Kg N/fad., (Zeidan *et al.,* 2005; Antoun *et al.,* 2010; Zaki *et al.,* 2012; Khaled and Hammad, 2014). Furthermore, Ali *et al.* (2004) and Mowafy (2008) apprehended that nitrogen fertilizer addition up to 120 kg N/fad., caused significant increase in plant height, spike number/m^2, grain weight/spike, 1000- grain weight, grain and straw yields/fad. Farag and El-Khawaga (2013) manifested that each increment in nitrogen level from 25 to 125 kg N/fad., caused significant increases in yield and yield attributes of wheat. Recently, Kandil *et al.* (2016) revealed that wheat yield attributes, grain and straw yields per ha were significantly increased due to raising nitrogen fertilizer level from 166, 214 to 262 Kg N/ha.

Therefore, this investigation was conducted to study the effect of soil application of humic acid and nitrogen fertilizer levels on yield and yield attributes of bread wheat (Sids 12 cultivar) grown in newly reclaimed sandy soil under sprinkler irrigation system.

MATERIALS AND METHODS

Study Site and Objective

Two field experiments were conducted out at the Agricultural Research Station, Faculty of Agriculture, Zagazig University at El-Khattara region, Sharkia Governorate, Egypt during the two successive seasons of 2014/2015 and 2015/2016 to study the effect of humic acid rates and nitrogen fertilizer levels on yield and its attributes of bread wheat (Sids 12 cultivar) grown in sandy soil under sprinkler irrigation system.

Experimental Design and Treatments

The experiment was laid out in randomized complete block design using split plot arrangement of treatments with four replicates. The main plots were allocated for three soil application rates of humic acid *i.e.* 0, 2 and 4 Kg/fad., where humic acid was soil incorporated before sowing. The sub-plots were assigned for five nitrogen fertilizer levels *i.e.* 0, 30, 60, 90 and 120 Kg N/fad., as ammonium sulphate (20.5% N) which was applied in five equal doses, the first was after 15 days from sowing, and then every 15 days. The sub plot area was 14 m^2 (3.5 width × 4 m length) included 20 rows each of 4 m length and 17.5 cm apart. The soil of the experimental site was sandy in texture. Soil samples were collected to depth of 30 cm from the experimental site before planting to determine soil physical and chemical properties (Central Laboratory of Faculty of Agriculture, Zagazig University, Zagazig, Egypt). The experimental soil was sandy in texture where it has a particle size distribution of 92.98, 5.75 and 1.27% for sand, silt and clay, respectively. The soil had an average pH of 8.15 and organic matter content of 0.42%. The average available N, P and K contents were 15.0, 6.1 and 76.0 ppm, respectively.

Agricultural Practices

The preceding crop was maize (*Zea mays*, L.) in both seasons of the study. The grains of Sids 12 wheat cultivar were sown at a seeding rate of 75 Kg/fad., on 24th and 23rd November in the first and the second seasons, respectively. Phosphorus fertilizer was added during seed bed preparation at rate of 31 Kg P_2O_5/fad., in the form of calcium superphosphate (15.5% P_2O_5), while potassium fertilizer was applied at rate of 48 kg K_2O/fad., as potassium sulphate (48% K_2O) in one dose with the first dose of nitrogen fertilizer. Wheat plants were grown under sprinkler irrigation system, solid system (130 m^3/hr.) where irrigation was followed twice weekly. The harvest was performed on 1st may in both seasons.

Studied Characters

At heading, ten guarded plants were taken at random from each experimental plot to determine plant height (cm), flag leaf area (cm^2) which was determined according to Lui and Subbo Roo (1951), In addition to flag leaf chlorophyll content, which was measured as SPAD units with handheld chlorophyll meter (SPAD-502 plus), according to Castelli *et al.* (1996). At harvest, ten spikes were taken at random from each experimental plot to estimate the following traits: spike length (cm), number of grains/spike and weight of grains/spike (g). Thereafter, bulk sample included all wheat plants in 2 m^2 in each sub plot was used to measure number of spikes/m^2, 1000-grain weight (g), grain yield (ardab/fad.), straw yield (ton/fad.), biological yield (ton/fad.) and harvest index (HI).

Statistical Analysis

The obtained data of the two seasons and their combined were statistically analyzed as mentioned by Gomez and Gomez (1991) using the computer MSTAT statistical analysis package (MSTAT-C, 1991). Least significant differences (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Steel *et al*. (1997). The error mean squares of split plot design were homogenous (Bartlett's test), the combined analysis was calculated for all the studied characters in both seasons. In interaction Tables, capital letters were used to compare the values in rows, while small letters were used to compare the values in columns.

RESULTS AND DISCUSSION

Effect of Humic Acid Rates

Yield attributes

Results presented in Tables 1, 2 and 3 indicate that humic acid application had a marked effect on all studied yield attributes traits in both seasons and their combined analysis. Application of humic acid at 2 Kg/fad., significantly increased each of plant height, flag leaf area, spike length and number of spikes/m^2, as compared to control treatment, concerning to the combined analysis. Moreover, flag leaf chlorophyll content, number and weight of grains/spike as well as 1000-grain weight exhibited significant increase due to raising humic acid application up to 4 Kg/fad., regarding to the combined results. The beneficial effects of humic acid on plant growth may be ascribed to the increasing of cell membrane, oxygen uptake, respiration and photosynthesis, nutrients uptake, root and cell elongation and ion transport (Nardi *et al*., 2002).

Grain, straw, biological yields and harvest index

Results given in Tables 3 and 4 show significant increments in grain, straw and biological yields as well as harvest index during both growing seasons and their combined analysis due to soil application of humic acid, as compared to without humic acid application. Regarding to the combined analysis results, it could be mentioned that soil application of humic acid at 2 Kg/fad., significantly increased straw yield and harvest index. Furthermore, grain and biological yields showed significant

Table 1. Plant height (cm), flag leaf area (cm^2) and chlorophyll content (SPAD value) of wheat as affected by humic acid rate, nitrogen fertilizer level and their interaction during both seasons and their combined analysis

Main effects and interaction	Plant height (cm)			Flag leaf area (cm^2)			Chlorophyll content (SPAD value)		
	1st season	2nd season	Comb.	1st season	2nd season	Comb.	1st season	2nd season	Comb.
Humic acid rate (H)									
0 kg/fad.	77.87b	76.67b	77.27b	24.19b	20.99b	22.59b	37.26b	34.99b	36.13c
2 kg/fad.	85.53a	78.87b	82.20a	27.48a	23.76a	25.62a	42.66a	39.94ab	41.30b
4 kg/fad.	83.47a	85.60a	84.54a	29.01a	25.57a	27.29a	46.76a	44.37a	45.57a
F-test	*	*	**	**	**	**	*	*	**
Nitrogen fertilizer level (N)									
0 kg N/fad.	61.78d	67.11d	64.45d	18.87e	15.49e	17.18e	36.43d	34.02d	35.23e
30 kg N/fad.	73.6zc	74.11c	73.89c	23.12d	19.70d	21.41d	39.38c	36.72c	38.05d
60 kg N/fad.	85.11b	81.78b	83.45b	27.40c	23.93c	25.67c	42.98b	40.39b	41.69c
90 kg N/fad.	94.33a	87.89a	91.11a	31.21b	27.67b	29.44b	44.90b	42.47b	43.69b
120 kg N/fad.	96.56a	91.00a	93.78a	33.87a	30.40a	32.14a	47.44a	45.23a	46.34a
F-test	**	**	**	**	**	**	**	**	**
interaction									
H × N	*	*	*	*	*	**	NS	NS	**

*, ** and NS indicate significant at 0.05, 0.01 and not significant, respectively.

Table 2. Spike length (cm), number of grains/spike and weight of grains/spike (g) of wheat as affected by humic acid rate, nitrogen fertilizer level and their interaction during both seasons and their combined analysis

Main effects and interaction	Spike length (cm)			No. of grains/spike			Weight of grains/spike (g)		
	1st season	2nd season	Comb.	1st season	2nd season	Comb.	1st season	2nd season	Comb.
Humic acid rate (H)									
0 kg/fad.	9.09 b	9.59 b	9.34 b	34.73 b	33.27 b	34.00 c	1.162 c	1.111 b	1.137 c
2 kg/fad.	9.67 ab	10.64 a	10.16 a	38.33 a	37.20 a	37.77 b	1.431 b	1.476 a	1.454 b
4 kg/fad.	10.05 a	11.03 a	10.54 a	41.00 a	39.07 a	40.04 a	1.650 a	1.489 a	1.570 a
F-test	*	**	**	*	*	**	**	**	**
Nitrogen fertilizer level (N)									
0 kg N/fad.	7.54 c	9.52 d	8.53 c	30.44 d	29.67 d	30.06 d	0.954 d	0.874 d	0.914 d
30 kg N/fad.	9.49 b	10.19 c	9.84 b	33.44 c	33.11 c	33.28 c	1.197 c	1.136 c	1.167 c
60 kg N/fad.	9.82 b	10.45 bc	10.14 b	38.22 b	36.44 b	37.33 b	1.453 b	1.352 b	1.403 b
90 kg N/fad.	10.51 a	10.88 ab	10.70 a	43.00 a	40.78 a	41.89 a	1.702 a	1.662 a	1.682 a
120 kg N/fad.	10.66 a	11.05 a	10.86 a	45.00 a	42.56 a	43.78 a	1.764 a	1.770a	1.767 a
F-test	**	**	**	**	**	**	**	**	**
interaction									
H x N	NS	NS	NS	NS	NS	NS	**	NS	**

*, ** and NS indicate significant at 0.05, 0.01 and not significant, respectively.

Table 3. Number of spikes/m^2, 1000-grain weight (g) and grain yield (ardab/fad.) of wheat as affected by humic acid rate, nitrogen fertilizer level and their interaction during both seasons and their combined analysis

Main effects and interaction	No. of spikes/m^2			1000-grain weight (g)			Grain yield (ardab/fad.)		
	1st season	2nd season	Comb.	1st season	2nd season	Comb.	1st season	2nd season	Comb.
Humic acid rate (H)									
0 kg/fad.	276.1 b	289.3 b	282.7 b	35.05 b	36.11 b	35.58 c	9.68 c	9.06 c	9.37 c
2 kg/fad.	330.5 a	348.1 a	339.3 a	39.58 a	38.55 ab	39.07 b	11.53 b	11.19 b	11.36 b
4 kg/fad.	341.4 a	361.2 a	351.3 a	42.77 a	40.63 a	41.70 a	12.84 a	12.78 a	12.81 a
F-test	**	*	**	*	*	**	**	**	**
Nitrogen fertilizer level (N)									
0 kg N/fad.	254.9 d	275.1 d	265.0 d	33.24 d	31.17 d	32.21 d	6.79 d	5.61 e	6.21 e
30 kg N/fad.	285.7 c	305.9 c	295.8 c	36.88 c	35.93 c	36.41 c	8.85 c	8.32 d	8.59 d
60 kg N/fad.	320.8 b	335.3 b	328.1 b	40.47 b	39.39 b	39.93 b	12.03 b	11.66 c	11.84 c
90 kg N/fad.	352.3 a	367.3 a	359.8 a	42.57 a	42.30 a	42.44 a	14.23 a	14.12 b	14.17 b
120 kg N/fad.	366.3 a	380.7 a	373.5 a	42.51 a	43.37 a	42.94 a	14.84 a	15.34 a	15.09 a
F-test	**	**	**	**	**	**	**	**	**
interaction									
H x N	NS	NS	*	**	NS	**	*	NS	*

*, ** and NS indicate significant at 0.05, 0.01 and not significant, respectively. One ardab= 150 kg

Table 4. Straw yield (ton/fad.), biological yield (ton/fad.) and harvest index (%) of wheat as affected by humic acid rate, nitrogen fertilizer level and their interaction during both seasons and their combined analysis

Main effects and interaction	Straw yield (ton/fad.)			Biological yield (ton/fad.)			Harvest index (%)		
	1st season	2nd season	Comb.	1st season	2nd season	Comb.	1st season	2nd season	Comb.
Humic acid rate (H)									
0 kg/fad.	2.85 b	2.74 b	2.80 b	4.15 c	3.95 c	4.05 c	30.19 b	29.49 b	29.84 b
2 kg/fad.	3.31 a	3.15 a	3.23 a	5.04 b	4.83 b	4.94 b	34.45 a	34.21 a	34.33 a
4 kg/fad.	3.54 a	3.26 a	3.40 a	5.46 a	5.18 a	5.32 a	35.31 a	36.96 a	36.14 a
F-test	*	**	**	**	**	**	**	**	**
Nitrogen fertilizer level (N)									
0 kg N/fad.	1.90 d	1.76 d	1.83 d	2.87 d	2.55 e	2.71 e	33.03 bc	30.82 d	31.93 bc
30 kg N/fad.	2.68 c	2.58 c	2.63 c	3.96 c	3.78 d	3.87 d	31.81 c	31.40 cd	31.61 c
60 kg N/fad.	3.54 b	3.29 b	3.42 b	5.30 b	4.99 c	5.15 c	32.71 c	33.59 bc	33.15 b
90 kg N/fad.	3.95 a	3.76 a	3.86 a	6.04 a	5.83 b	5.94 b	34.40 ab	35.20 ab	34.80 a
120 kg N/fad.	4.09 a	3.86 a	3.98 a	6.27 a	6.11 a	6.19 a	34.64 a	36.77 a	35.71 a
F-test	**	**	**	**	**	**	**	**	**
interaction									
H x N	*	**	**	NS	NS	**	**	*	**

*, ** and NS indicate significant at 0.05, 0.01 and not significant, respectively.

increase due to raising humic acid application up to 4 Kg/fad. It could be noticed that increasing humic acid rates from 0 to 2 and up to 4 Kg/fad., resulted in relative increases amounted to 21.24% and 36.71% in grain yield/fad., 15.36% and 21.43% in straw yield, 21.98% and 31.36% in biological yield as well as 15.05% and 21.11% in harvest index, concerning combine analyses. The improvement of wheat grain yield and its attributes due to humic acid application may be attributed to that humic acid stimulates the biochemical processes in plants including photosynthesis and total chlorophyll content (Akinremi *et al*., 2000). In addition, humic acid may improve the assimilation of major and minor elements, enzyme activation and protein synthesis and increasing dry matter accumulation which consequently increased yield and quality (Ulukan, 2008). In this connection, El-Hamdi *et al.* (2012) showed that number of grains/spike, spike length, 1000-grain weight, grain and straw yields/fad., were significantly increased due to humic acid application.

In addition, many researchers recorded significant enhancement in grain yield and its attributes due to humic acid application (Antoun *et al.,* 2010; Khan *et al.,* 2010; Bakry *et al*., 2013; Tufail *et al.,* 2014; Radwan *et al.,* 2015; Anwar *et al.,* 2016). Moreover, the obtained results are in agreement with those reported by Kandil *et al.* (2016) who stated that application of humic acid resulted in significant increase in number of spikes/m^2, spike length, grain weight/ spike, 1000-grain weight. Furthermore, Manal *et al.* (2016) showed that the highest values of yield and yield attributes of wheat were obtained by addition of humic acid as compared with the check treatment.

Effect of Nitrogen Fertilizer Levels

Yield attributes

Results presented in Tables 1, 2 and 3 reveal that all yield attributes showed positive and significant response to increasing nitrogen fertilizer levels during both growing seasons and their combined analysis. The combined results clearly showed that plant height, spike length, number and weight of grains/spike, number of spikes/m^2 and 1000-grain weight were significantly increased by raising nitrogen fertilizer levels up to 90 kg N/fad. Whereas, flag leaf area and flag leaf chlorophyll content detected positive significant response with each increase in nitrogen fertilizer level up to 120 kg N/fad.

Grain, straw, biological yields and harvest index

As shown in Table 3, straw yield and harvest index were significantly increased by raising nitrogen fertilizer levels up to 90 kg N/fad., regarding the combined results. Furthermore, grain and biological yields exhibited positive significant response due to raising nitrogen fertilizer levels up to 120 kg N/fad., (Table 4). Depending on the combined analysis result, the relative increase in grain yield due to N fertilizer application amounted to 38.33% , 90.66%, 128.18% and 142.99% for increasing N fertilizer levels from 0 to 30, 60, 90 and 120 kg N/fad., respectively. Also, the relative increase in biological yield due to raising N fertilizer levels from 0 to 30, 60, 90 and 120 kg N/fad, amounted to 42.80%, 90.04%, 119.19% and 128.41%, respectively.

The increment in yield attribute characters associated with raising nitrogen fertilizer levels may be ascribed to the role of nitrogen in improving wheat growth by enhancement the meristematic activity and cell division leading to increases in internodes length and number of fertile tillers and also metabolic, photosynthesis processes as well as forming filled grains consequently producing heavier grains (Seadh *et al.*, 2009). The favorable effect of raising nitrogen fertilizer level on grain yield and its attributes may be attributed to the fact that nitrogen considers one of the major elements for plant nutrition which increases the vegetative growth of plant and compose strong plants with long spikes. In addition, nitrogen support plant to uptake other elements, leading to increasing growth of plants, consequently enhancing growth measurements and all yield components.

The compatible effect of high nitrogen fertilizer levels on increasing wheat grain yield and its attributes was also reported by Zeidan *et* *al.* (2005), Antoun *et al.* (2010), Moussa and Abdel-Maksoud (2011), Zaki *et al.* (2012) and Farag and El-Khawaga (2013) as well as Khaled and Hammad (2014). Moreover, the obtained results are in accordance with those stated by Kandil *et al.* (2016) who recorded significant increase in number of spikes/m^2, spike length, number of grains/spike, grain weight/spike, 1000-grain weight, grain and straw yields of wheat due to raising nitrogen fertilizer level from 166, 214 up to 262 kg N/ha.

Effect of the Interaction

Yield attributes

The offered results in Table 5, show the effect of the interaction between humic acid and nitrogen fertilizer levels on yield attributes. The obtained results reveal that plant height, number of spikes/m^2 and 1000-grain weight showed gradual significant positive response to raising N fertilizer levels up to 120 Kg N/fad., under without humic acid application. On the other hand, under the application of humic acid (2 or 4 Kg/fad.) the aforementioned traits were significantly and positively responded to raising N fertilizer levels only up to 90 Kg N/fad., In addition, weight of grains/spike showed significant increment due to raising N fertilizer levels up to 90 Kg N/fad., under without humic acid application and when it was applied at the highest rate (4 Kg/fad.) while under the application of 2 Kg humic acid/fad., weight of grains/spike showed gradual significant and positive response to raising N fertilizer levels up to 120 Kg N/fad. Furthermore, flag leaf area and chlorophyll content (SPAD value) presented gradual significant and positive response to increasing N fertilizer levels up to 120 Kg N/fad., under the control treatment (without humic acid application) and the lower application of humic acid (2 Kg/fad.), while under the application of the highest rate of humic acid (4 Kg/fad.) flag leaf area and chlorophyll content (SPAD value) were significantly increased due to raising N fertilizer levels up to 90 Kg N/fad. Weight of grains/spike exhibited significant response to raising N fertilizer levels up to 120 Kg N/fad., under the application of 2 Kg humic acid/fad., whereas, it responded only to raising N fertilizer levels up to 90 Kg N/fad., under control treatment and application of 4 Kg humic acid/fad.

It could be noticed that, the lowest values of plant height (60.50 cm), flag leaf area (13.70 cm^2), flag leaf chlorophyll content (30.50), weight of grains/spike (0.763 g), number of spikes/m^2 (232) and 1000-grain weight (27.73 g) were obtained under the control treatment (without humic and without nitrogen applications). On the other direction, the highest values of plant height (96.50 cm) and 1000-grain weight (45.85 g) could be achived under the treatment of 4 kg humic acid with 90 kg N/ fad., as well as, the highest value for each of flag leaf area (32.92 cm^2), chlorophyll content (49.02 SPAD unite) and number of spikes/m^2 (401.2) was appreciable *via* the concomitant of 4 kg humic acid with 120 kg N/fad.

Grain, biological yields and harvest index

Results presented in Table 6, clearly indicate that grain and biological yields as well as harvest index showed positive and gradual significant response to raising N fertilizer levels up to 120 Kg N/fad., when humic acid wasn't applied, while under the application of 2 or 4 Kg humic acid/fad., grain and biological yields were significantly increased due to raising N fertilizer levels up to 90 Kg N/fad. However, nitrogen fertilizer levels showed no significant effect on harvest index under humic acid application (2 or 4 Kg/fad. It could be noticed that, the lowest values of grain yield (4.61 ardab/fad.), biological yield (2.14 ton/fad.) and harvest index (25.27) were observed under control treatment (without humic acid + without N fertilizer), while the highest values of grain yield (16.25 ardab/fad.), biological yield (6.50 ton/fad.) and harvest index (37.54) were achieved under the treatment of 4 Kg humic acid + 90 Kg N/fad. In this respect, Chen and Aviad (1990) reported that the stimulatory effects of humic substances have been directly related to the improved uptake of macronutrients, such as nitrogen, phosphorus and sulfur. In addition, Pettit (2004) indicated that soil application of humic substances reduced the requirement for nitrogen, phosphorus and potassium fertilizer applications.

Table 5. Plant height (cm), flag leaf area (cm^2), chlorophyll content (SPAD value), weight of grains/spike (g), number of spikes/m^2 and 1000-grain weight (g) of wheat as affected by the interaction between humic acid rates and nitrogen fertilizer levels (combined analysis)

Humic acid rate	Nitrogen fertilizer level				
	0 kg (N/fad.)	30 kg (N/fad.)	60 kg (N/fad.)	90 kg (N/fad.)	120 kg (N/fad.)
			Plant height (cm)		
	E	D	C	B	A
0 kg/fad.	60.50 b	70.33 b	79.67 b	84.17 b	91.67 b
	D	C	B	A	A
2 kg/fad.	65.00 a	72.83 b	84.83 a	92.67 a	95.67 a
	D	C	B	A	A
4 kg/fad.	67.83 a	78.50 a	85.83 a	96.50 a	94.00 a
			Flag leaf area (cm^2)		
	E	D	C	B	A
0 kg/fad.	13.70 c	18.72 b	23.18 b	26.43 c	30.90 b
	E	D	C	B	A
2 kg/fad.	17.05 b	22.28 a	26.38 a	29.80 b	32.58 a
	D	C	B	A	A
4 kg/fad.	20.78 a	23.23 a	27.43 a	32.08 a	32.92 a
			Flag leaf chlorophyll content (SPAD value)		
	E	D	C	B	A
0 kg/fad.	30.50 c	32.30 c	36.47 c	39.32 c	42.03 b
	E	D	C	B	A
2 kg/fad.	35.25 b	38.10 b	41.67 b	43.52 b	47.97 a
	D	C	B	AB	A
4 kg/fad.	39.93 a	43.75 a	46.92 a	48.22 a	49.02 a
			Weight of grains/spike (g)		
	D	C	B	A	A
0 kg/fad.	0.763 b	0.933 c	1.107 c	1.393 c	1.487 b
	E	D	C	B	A
2 kg/fad.	0.947 a	1.203 b	1.470 b	1.762 b	1.885 a
	D	C	B	A	A
4 kg/fad.	1.033 a	1.362 a	1.632 a	1.892 a	1.930 a
			Number of spikes/m^2		
	E	D	C	B	A
0 kg/fad.	232.0 b	254.5 b	278.7 b	308.5 b	339.8 b
	D	C	B	A	A
2 kg/fad.	281.2 a	319.0 a	340.2 a	376.7 a	379.5 a
	D	C	B	A	A
4 kg/fad.	281.8 a	313.8 a	365.3 a	394.3 a	401.2 a
			1000-grain weight (g)		
	E	D	C	B	A
0 kg/fad.	27.73 c	32.17 c	36.62 c	39.55 c	41.83 b
	D	C	B	A	A
2 kg/fad.	33.27 b	37.25 b	40.32 b	42.05 b	42.45 b
	D	C	B	A	A
4 kg/fad.	35.62 a	39.80 a	42.85 a	45.70 a	44.53 a

Table 6. Grain yield (ardab/fad.), biological yield (ton/fad.) and harvest index (%)of wheat as affected by the interaction between humic acid rates and nitrogen fertilizer levels (combined analysis)

Humic acid rate	Nitrogen fertilizer level				
	0 kg N/fad.	30 kg N/fad.	60 kg N/fad.	90 kg N/fad.	120 kg N/fad.
			Grain yield (ardab/fad.)		
	E	D	C	B	A
0 kg/fad.	4.61 c	6.43 b	9.49 c	12.14 c	14.17 c
	D	C	B	A	A
2 kg/fad.	6.38 b	9.20 a	12.14 b	14.13 b	14.96 b
	D	C	B	A	A
4 kg/fad.	7.62 a	10.14 a	13.90 a	16.25 a	16.15 a
			Biological yield (ton/fad.)		
	E	D	C	B	A
0 kg/fad.	2.14 b	2.97 c	4.28 c	5.19 c	5.66 b
	D	C	B	A	A
2 kg/fad.	2.87 a	3.97 b	5.40 b	6.10 b	6.35 a
	D	C	B	A	A
4 kg/fad.	3.11 a	4.66 a	5.75 a	6.50 a	6.57 a
			Harvest index (%)		
	D	CD	C	B	A
0 kg/fad.	25.27 c	27.49 b	29.54 c	32.07 c	34.84
	A	A	A	A	A
2 kg/fad.	33.14 b	34.70 a	33.64 b	34.79 b	35.38
	A	B	A	A	A
4 kg/fad.	37.37 a	32.63 a	36.27 a	37.54 a	36.88

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تأثير إضافة حامض الهيوميك ومستوى السماد النيتروجيني على إنتاجية قمح الخبز تحت ظروف الأراضي الرملية

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أقيمت تجربتان حقليتان خلال الموسمين الشتويين المتتاليين ٢٠١٥/٢٠١٤ و ٢٠١٦/٢٠١٥ في المزرعة التجريبية التابعة لكلية الزراعة - جامعة الزقازيق بمنطقة الخطارة (تربة رملية)- محافظة الشرقية- جمهورية مصر العربية، بهدف دراسة تأثير إضافة حامض الهيوميك (بدون إضافة، ٢ و ٤ كجم حامض هيوميك/فدان) ومستوي السماد النيتروجيني (بدون إضافة، ٣٠، ٦٠، ٩٠ و ١٢٠ كجم ن/ فدان) على محصول القمح المزروع في الأراضي الرملية تحت نظام الري بالرش، وقد أشارت نتائج التحليل المشترك للموسمين أن إضافة حامض الهيوميك بمعدل ٢ كجم/فدان أدى إلى حدوث زيادة معنوية في كل من ارتفاع النبات، مساحة ورقة العلم، طول السنبلة، عدد السنابل/م٢، محصول القش ودليل الحصاد مقارنة بعدم إضافة حامض الهيوميك، بينما أدى إضافة حامض الهيوميك بمعدل ٤ كجم/ فدان إلى حدوث زيادة معنوية فى محتوى ورقة العلم من الكلوروفيل، عدد ووزن الحبوب/سنبلة، وزن الـ ١٠٠٠ حبة، محصول الحبوب والمحصول البيولوجى/فدان، ومن ناحية أخري، فقد أدى زيادة مستوى السماد النيتروجينى حتى ٩٠ كجم ن/ فدان إلى حدوث زيادة معنوية فى كل من ارتفاع النبات، طول السنبلة، عدد ووزن الحبوب/سنبلة، عدد السنابل/م٢، وزن الـ ١٠٠٠ حبة، محصول القش/فدان ودليل الحصاد، بينما حدثت زيادة تدريجية ومعنوية فى مساحة ورقة العلم ومحتواها من الكلوروفيل وكذلك محصول الحبوب والمحصول البيولوجى/فدان مع كل زيادة فى مستوى السماد النيتروجينى حتى ١٢٠ كجم ن/فدان، وتأثرت معظم الصفات تحت الدراسة بالتفاعل بين عاملي الدراسة، وأدى إضافة حامض الهيوميك لتقليل الحاجة لإضافة السماد النيتروجيني تحت ظروف الأراضي الرملية، من خلال نتائج هذه الدراسة يمكن التوصية بإضافة حامض الهيوميك بمعدل ٤ كجم والسماد النيتروجيني بمعدل ٩٠ كجم ن/فدان للحصول على أعلى محصول حبوب ومحصول بيولوجى للفدان تحت ظروف الأراضي الرملية بمحافظة الشرقية.

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