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Original Paper

Responses of maize crop (*Zea mays* L.) to foilar spraying with humic acid at different nitrogen levels

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Abstract

Three field experiments in split-split plot design were carried out at Agriculture Research Center, Shandweel Research Station, Sohag Governorate, during the summer seasons 2010, 2011 and 2012 on clay loom soil to evaluate the effect of foliar spray of humic acid (4 cm^3/L) at 30 and 45 days from sowing, under three levels of nitrogen fertilizer (0, 90, and 120 kg N/fed.) on plant growth parameters, some biochemical and mineral contents (NPK) in leaves and grains of two maize hybrids (Single cross Pioneer 30K09 and Three way cross-310). Results showed that S.C. Pioneer 30K09 hybrid surpassed T.W.C.-310 hybrid in the values of P_N, E and G_s as well as N and K-content in leaves and grains, while T.W.C.-310 hybrid surpassed S.C. Pioneer 30K09 hybrid in the values of crude protein content in grains, P-content in both leaves and grains also in N-content in grains, however there were no significant differences between the two maize hybrids in respect to chlorophyll, dry weight, leaf total carbohydrate and grain oil contents. There were gradual and significant increases in all parameters by increasing nitrogen fertilizer dose, the most effective dose of nitrogen fertilizer was 120 kg N/fed. for the most traits, while, application of 90 kg N/fed. led to significant and highest values of P_N, E and G_s, also, P and K-content in leaves and K-content in grains. Thus, it could be concluded that foliar spraying with humic acid combined with adding 90 kg N/fed. gave higher values of all criteria than those obtained by only the recommended dose (120 kg N/fed). Moreover, the two examined hybrids responded to spraying HA under 120 kg N/fed. comparing with their values at the recommended dose only.

Key words: Gas exchange, Humic acid, Nitrogen fertilizer.

Introduction

Maize (*Zea mays* L.) is a genus of the family *Poaceae*, commonly known as the grass family. It is one of the most important cereal crops in the world both as food for human and feed for animals. It is the most efficient crop which can give high biological yield as well as grain yield relatively in a short period of time due to its unique photosynthetic mechanism as C_4 plant (Hatch and Slack, 1996). Maize hybrids are fast growing and high yield (Russell, 1986), which therefore require more nutrients, nitrogen in particular. Selection of potentially high yield hybrids which was well responsive to applied nitrogen is an important tool to improve grain contents (De Carvalho *et al.*, 2012). Different hybrids have different genetic ability for nitrogen absorption, use and translocation (Paponov and Engels, 2003). Interaction between different genotypes and nitrogen fertilization shows the importance of selection of better performing hybrids to improve crop production (Gallais and Coque, 2005).

Nitrogen plays a vital role in nutritional and physiological status of plants, it improved the chlorophyll pigments (Mahama *et al.*, 2016), increased dry matter accumulation (Uribelarrea *et al.*, 2009), enhanced plant physiological processes such as photosynthesis (Sabo *et al.*, 2002) fayzafaheede and promotes changes in mineral composition of plant

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(Uribelarrea *et al.,* 2009). Hence, nitrogen plays a key role in many metabolic reactions, it is an essential element of amino acids, building blocks of proteins and part of the nucleic acids (DNA and RNA). Application of nitrogen fertilizer significantly increased the carbohydrate, crude protein and oil concentration in corn grains (Ibrahim and Kandil, 2007). Maize hybrids which received inorganic fertilizers have higher nutrient contents (Khalil, 1994). Nitrogen is the key element in increasing productivity, as well as grain quality greatly affected by nitrogen fertilizer levels. Moreover, application of nitrogen fertilizer was been reported to have significant effect on grain quality of maize (El-Mekser *et al.,* 2015). Continuous use of synthetic nitrogenous fertilizers was not only polluting the water resource rather was toxic to human as well as for animal life (Cheema *et al.,* 2010). Moreover, sole use of chemical fertilizers is causing deterioration in soil physico-chemical and biological properties. The applied nitrogen is not all taken by crop plant, a large proportion is lost due to ammonia volatilization, denitrification and leaching (Zhang *et al.,* 2009). Also, increasing costs of nitrogen fertilizer and unavailability of fertilizer at the time of need further aggravate economic condition of farmers (Ahmad *et al.,* 2006), especially, in developing countries. To confront this problem, it was necessary to develop alternative methods of supplying nutrients to the growing plant. One of the best methods is foliar application of humic acid (HA).

Humic substances are organic compounds that result from the decomposition of plant and animal materials. Foliar spray of HA to maize expressed several effects on the plant growth (Chen and Aviad, 1990) such as increasing chlorophyll contents (El-Bassiouny *et al.,* 2014), total dry weight (Eyheraguibel *et al.,* 2008), photosynthesis rate, respiration and mesophyll conductance (Boehme *et al.,* 2005). Also, HA increased total carbohydrate contents (Barakat *et al.,* 2015), improved grain protein (Chattha *et al.,* 2015), enhanced quality of various oil seed crops and oil contents (Rajpar *et al.,* 2011 and El-Mekser *et al.,* 2015) and caused higher absorption of macro nutrients including nitrogen, phosphorus and potassium (Tahir *et al.,* 2011).

Due to the importance of humic acid and nitrogen, the present experiment was conducted to investigate the response of maize crop to humic acid and nitrogen levels.

Materials and Methods:

Growth conditions and experimental design:

Three field experiments were carried out during summer seasons of 2010, 2011 and 2012 at the Shandaweel Agricultural Research Station, Sohag Governorate. The experiments were laid out in split-split plot design with three replications. Two maize hybrids (Single cross Pioneer 30K09 and three way cross-310) were randomly assigned in the main plots. Nitrogen fertilizer was added in the soil as urea at a rate of 0, 90 and 120 kg N/fed. were randomly distributed in sub-plot. Spraying HA was randomly distributed in sub-sub plot. Nitrogen fertilizer was added in the soil as urea at a rate of 0, 90 and 120 kg N/fed. in two equal proportions, the 1st half at 20 and the 2nd at 40 days after sowing. Phosphorus fertilizer was added as superphosphate at the rate of 15 kg P_2O_5/feddan before sowing. Potassium as potassium sulfate K_2SO_4 was added to the soil before sowing at the rate of 24 kg K_2O/feddan. Plots which treated with humic acid were sprayed twice with HA at the the rate of 4 cm^3 K-humate/L (30 and 45 days after sowing), but, control was sprayed by water.

Soil analysis:

Surface soil samples (0-30 cm) were collected before planting from the experimental sites in three seasons for physical and chemical characters and data listed in table 1.

Seasons	*Texture*	$CaCO_3$%	Soil pH	O.M%	Available nutrients in soil (ppm)		
					N	P	K
2010	Clay loom	7.50	7.9	0.9	17	19	42
2011	Clay loom	7.70	7.8	1.2	18.5	18	38
2012	Clay loom	7.82	7.8	1.05	20	22	40

Table (1): Soil characterization for the two experimental sites.

Data recorded

A- Plant growth parameters

A-1. Total chlorophyll contents

Data of chlorophyll were recorded twice from randomly chosen five plants at 60 and 80 days after sowing by using the portable chlorophyll meter (SPAD-502, Minolta, Japan) and determined as SPAD unit (Minolta, 1989).

A-2. Total dry weight

Five plants were randomly taken from each sub-sub plot at 60 and 80 days after sowing, each plant was separated into its over-ground and under-ground parts (root, stem and leaves). All plant parts were air dried. Thereafter, the samples were placed in an oven at 70°C ± 5°C to dry the plant material to their constant dry weight. Then dry weight of root, leaves and stem were recorded and total dry weight of plant was calculated.

A-3. Gas exchange parameters

Five leaves of *Zea mays* plants were subjected to analysis of net photosynthetic rate (P_N), transpiration rate (*E*), stomatal conductance (*Gs*) and intracellular CO_2 concentration (*Ci*). Gas exchange parameters were made with a portable infrared gas exchange analyzer and based photosynthesis system (Li-6400, Li-Cor, Lincoln, Nebraska, USA) on the ear leaf of each plant.

Tissue analysis

Leaves of plants at 60 days from planting were collected, rapidly washed in the distilled water and dried in an oven at 70 ºC. At Harvest time, grain samples were taken at full maturity to carry out the biochemical and nutrient contents of the two maize hybrids as follow:

B-1. Biochemical parameters

Total carbohydrate contents were determined by anthrone sulphuric acid method according to Fales (1951). Crude protein contents were calculated by multiplying the values of total nitrogen by 6.25 according to Marschner (1995). Grain oil contents determined by using soxhlet apparatus and petroleum ether as solvent according to A.O.A.C. (1975).

B-2. Nutrient contents

Determination of N, P and K, plant materials (leaves and grains) were done by wet digested using a mixture of concentrated sulphuric acid and hydrogen peroxides (Jackson, 1958). Total nitrogen percentage was determined using micro-kjeldahl method (A.O.A.C. 1995), phosphorus was determined using chlorostannous reduced molybdophosphoric blue color method in H_2SO_4 system and colormetrically determined according to the method introduced by Jackson (1967), and potassium was photometrically determined by using a flame photometer as described by Jackson (1958).

Statistical analysis:

The data were statically analyzed according to Gomez and Gomez (1984), using the computer MSTAT-C statistical analysis package (Freed *et al.*, 1989). Mean values were compared by using the least significant difference (L.S.D.) at 5% and 1%.

Results and Discusion

This work was to study the effects of foliar spray of humic acid under three nitrogen fertilizer levels on vegetative growth, gas exchange, biochemical and nutrient contents of the two maize hybrids. The results and discussion are as follows;

A- Growth parameters

A-1. Total chlorophyll contents.

Field SPAD reading (Table 2) for chlorophyll revealed that there were no significant differences between the examined hybrids at 60 and 80 days from sowing date in 2010 and 2011 seasons. The result was in

agreement with that reviewed by Bermúdez-Cardona *et al.,* (2015) they decided that concentrations of total chlorophyll significantly differed in maize cultivars due to genetic variation. Data in table 2 cleared that the differences between the total chlorophyll values given by adding 90 and 120 kg N/fed. were so narrow without any significant effect between them all over the two sampling dates (60 and 80) and during 2010 and 2011 seasons. The significance was only found between each values of 90 or 120 kg N/fed. and the values obtained by 0 N level. This may be due to the role of nitrogen in accelerates formation of chlorophyll, and increases cell counts and volume/leaf. This result clarifying with those of Hammad *et al.,* (2012). Foliar spray with HA was accompanied by a substantial increase in the values of total chlorophyll than those obtained by spraying with water in both seasons and at the two sampling dates. Ferrara and Brunetti (2008) and Ameri and Tehranifar (2012) noted that HA probably caused an increase in the synthesis of the chlorophyll and/or delayed chlorophyll degradation.

Spraying the two hybrids with HA under 90 kg N/fed. obtained higher values of total chlorophyll more than those obtained by the recommended dose of nitrogen fertilizer. But the highest values of total chlorophyll was obtained by S.C. Pioneer 30K09 hybrid under 120 kg N/fed. combined with spraying HA with values 53.80 and 51.63 SPAD unit at 60 days from sowing and 54.75 and 53.67 SPAD unit at 80 days from sowing for the seasons 2010 and 2011, respectively.

Sampling times		60 days from sowing date						80 days from sowing date					
Seasons		2010			2011			2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)			Foliar spray (C)			Foliar spray (C)			Foliar spray (C)		
		Water spray	Humic acid	Average	Water spray	Humic acid	Average	Water spray	Humic acid	Average	Water spray	Humic acid	Average
S.C. Pioneer 30K09	0 kg N	42.91	45.47	44.19	41.90	46.03	**43.97**	46.10	47.33	46.72	43.45	48.87	45.16
	90 kg N	45.90	52.40	49.55	47.36	51.37	49.36	50.24	54.13	52.19	49.07	53.13	51.10
	120 kg N	48.47	53.80	51.14	49.16	51.63	50.40	51.92	54.57	53.24	50.01	53.67	51.84
Average		**46.09**	**50.56**	**48.32**	**46.14**	**49.68**	**47.91**	**49.42**	**52.01**	**50.72**	**47.51**	**51.89**	**49.70**
T.W.C.-310	0 kg N	42.66	45.57	44.11	39.76	40.33	40.05	47.17	49.07	48.12	41.02	44.71	42.86
	90 kg N	46.22	51.43	48.83	45.92	47.77	46.84	50.16	50.87	50.51	48.09	51.67	49.88
	120 kg N	47.77	51.33	49.55	46.17	48.07	47.12	50.74	51.53	51.14	48.69	52.10	50.40
Average		**45.55**	**49.44**	**47.50**	**43.95**	**45.39**	**44.67**	**49.36**	**50.49**	**49.92**	**45.93**	**49.29**	**47.71**
N levels kg N/fed.	0 kg N	42.79	45.52	44.15	40.83	43.18	42.01	46.64	48.20	47.42	42.24	46.79	44.51
	90 kg N	46.56	51.92	49.24	46.64	49.57	48.10	50.20	52.00	51.35	48.58	52.40	50.49
	120 kg N	48.12	52.57	50.34	47.66	49.85	48.76	51.33	53.05	52.19	49.35	52.88	51.12
Foliar spray		**45.82**	**50.00**		**45.05**	**47.53**		**49.39**	**51.25**		**46.72**	**50.69**	
LSD at		**5%**	**1%**		**5%**	**1%**		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		NS	NS		NS	NS		NS	NS		NS	NS	
Nitrogen (B)		2.20	3.20		1.51	2.75		0.96	1.40		0.75	1.20	
Foliar spray (C)		1.77	2.40		1.01	1.36		1.26	1.71		0.93	1.26	
A x B		3.11	4.52		1.73	3.06		1.36	1.98		1.07	1.55	
A x C		2.50	3.39		2.42	2.93		1.78	2.41		1.31	1.78	
B x C		3.07	4.15		2.74	3.36		2.18	2.96		1.61	2.18	
A x B x C		4.34	5.88		3.46	4.34		3.09	4.18		2.27	3.08	

Table (2): Effect of spraying of humic acid under three levels of nitrogen fertilizer, on total chlorophyll contents in leaves (SPAD unit) at two sampling times for two maize hybrids in 2010 and 2011 seasons.

A-2. Total dry weight.

The obtained results showed that S.C. Pioneer 30K09 hybrid surpassed T.W.C.-310 hybrid in total dry weight without significant differences at 60 days after sowing, in both seasons. Also, the same trend was found after 80 days from sowing but the difference was significant in 2010 season only. These results could be attributed to the genetic differences among the two studied hybrids (Osman, 2006). Results in table 3 showed that total dry weight/plant (g) increased gradually with increasing nitrogen fertilizer rates from 0 to 120 kg N/fed. at the two sampling dates and through the two growing seasons. The most

effective dose of nitrogen fertilizer was 120 kg N/fed. with values (202.16 and 247.58 g at 60 days after sowing and 391.15 and 427.10 g at 80 days from sowing, in 2010 and 2011 seasons, respectively. Ullah *et al.,* (2015) found that nitrogen application increased aboveground biomass (Dry matter accumulation). The nitrogen fertilization encourages the meristimaitc activity and increased the vegetative growth. Similar results were obtained by Leilah *et al.,* (2009). The available data revealed that spraying HA obtained higher values of total dry weight more than those obtained by non-sprayed treatment at the two sampling dates in both seasons. Humic acid affect the solubility of many nutrient elements by building complex forms or chelating agents of humic matter with metallic cations (Chen and Aviad, 1990 and Lobartini *et al.,* 1997).

Spraying both S.C. Pioneer 30K09 and T.W.C.-310 hybrids with HA under 90 kg N/fed. resulted in higher values of total dry weight more than those obtained by the recommended dose of nitrogen fertilizer. But the highest values of total dry weight was obtained by T.W.C.-310 hybrid under 120 kg N/fed. combined with spraying HA at 60 days after sowing with values 215.54 and 265.63 g during 2010 and 2011 seasons, respectively. While, at 80 days from sowing spraying S.C. Pioneer 30K09 hybrid with HA under the same level of nitrogen obtained the highest values of total dry weight with values 388.33 and 474.28 g in 2010 and 2011 seasons, respectively.

Sampling times		60 days from sowing date						80 days from sowing date					
Seasons		2010			2011			2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	158.78	185.81	172.29	159.14	148.07	153.61	265.78	304.28	285.03	286.09	317.68	301.88
	90 kg N	174.42	204.26	189.34	192.49	227.63	210.06	310.15	361.79	335.97	330.11	422.26	376.18
	120 kg N	190.27	205.03	197.65	254.35	263.03	258.69	338.83	388.33	363.58	404.14	474.28	439.21
Average		**174.49**	**198.37**	**186.43**	**201.99**	**212.91**	**207.45**	**304.92**	**351.46**	**328.19**	**340.11**	**404.74**	**372.43**
T.W.C.-310	0 kg N	155.37	162.58	158.97	149.50	183.41	166.46	228.30	252.78	240.54	290.31	331.83	311.07
	90 kg N	169.21	206.59	187.90	188.10	237.80	212.95	265.23	328.60	296.91	335.58	402.31	368.94
	120 kg N	197.98	215.54	206.67	207.30	265.63	236.47	303.20	348.42	325.81	378.17	451.80	414.98
Average		**174.12**	**194.90**	**184.51**	**181.63**	**228.95**	**205.29**	**265.58**	**309.93**	**287.75**	**334.68**	**395.31**	**365.00**
N levels kg N/fed.	0 kg N	157.07	174.19	165.63	154.32	165.74	160.03	247.04	278.53	262.78	288.20	324.76	306.48
	90 kg N	171.81	205.43	188.62	190.30	232.72	211.51	287.69	345.19	316.44	332.84	412.28	372.56
	120 kg N	194.03	210.29	202.16	230.82	264.16	247.58	321.01	368.37	344.69	391.15	463.04	427.10
Foliar spray		**174.31**	**196.64**		**191.81**	**220.93**		**285.25**	**330.70**		**337.40**	**400.03**	
LSD at		5%	1%		5%	1%		5%	1%		5%	1%	
Hybrids (A)		NS	NS		NS	NS		8.57	19.77		NS	NS	
Nitrogen (B)		6.99	10.17		11.90	17.31		6.29	9.16		7.41	10.79	
Foliar spray (C)		4.19	5.67		7.93	10.75		4.53	6.13		6.24	8.46	
A x B		9.89	14.38		16.83	24.48		8.90	12.95		10.49	15.26	
A x C		5.92	8.02		11.22	15.20		6.40	8.67		8.83	11.96	
B x C		7.25	9.82		13.74	18.62		7.84	10.62		10.81	14.65	
A x B x C		10.25	13.89		19.43	26.33		11.09	15.02		15.29	20.72	

Table (3): Effect of spraying humic acid under three levels of nitrogen fertilizer, on total dry weight (g) at two sampling times for two maize hybrids in 2010 and 2011 seasons.

A-3. Gas exchange parameters.

It could be noticed from table 4 that S.C. Pioneer 30K09 hybrid surpassed T.W.C.-310 hybrid with respect to P_N , E and G_s , the contrary was found with C_i without significant differences between the two hybrids. This result was in agreement with that reported by Bermúdez-Cardona *et al.,* (2015), they declared that all cultivars exhibited variation of gas exchange parameters. But for the intra cellular CO_2 concentration (C_i) the opposite effect was found without significant differences between the two hybrids. This result is in agreement of Forrai *et al.,* (2012)

they reported that there are no variations in interacellular CO_2 concentration between species. Adding 90 kg N/efd. obtained the highest values of P_N (20.66 µmol (CO_2) m^2s^{-1}), E (6.68 mmol $m^{-2}s^{-1}$) and G_s (0.239 mol (H_2O) $m^{-2}s^{-1}$), but the highest value of C_i (136.16 µmol mol^{-1}) was obtained under 120 kg N/fed. Nitrogen plays a key role in several crop physiological processes, thus increasing N fertilizer levels was associated with greater photosynthetic rate (Mahama *et al.,* 2016). The positive effect of N fertilizer on P_N, E, G_s and C_i mainly may be due to its role in increasing the size of leaf area (Attia *et al.,* 2008 and Bermúdez-Cardona *et al.,* 2015). Adding 90 kg N/fed. is enough for maximum stomatal conductance (Attia *et al.,* 2008). Foliar spray of HA increased gas exchange parameters than those obtained by non-sprayed treatment with values: P_N (21.03 *V.S.* 13.98 µmol (CO_2) m^2s^{-1}), E (6.88 *V.S.* 4.53 mmol $m^{-2}s^{-1}$), G_s (0.257 *V.S.* 0.142 mol (H_2O) $m^{-2}s^{-1}$) and C_i (136.72 *V.S.* 127.85 µmol mol^{-1}). Many researches reported that the role of HA was increasing the above mentioned parameters, Taiz and Zeiger (2006) argued that foliar spray of HA led to a noticeable enhancement of P_N, this may be due to the effect of HA in stimulating physiological responses of plants (net photosynthesis and chlorophyll content) and improving chloroplast ultrastructure (Fana *et al.,* 2014). Increasing happened in transpiration rate (E) may be due to increasing in photosynthesis rate (P_N). Zhang *et al.,* (2014) noted that exogenous application of HA significantly increased stomatal conductance. Nardi *et al.,* (2007) reported that HA activate secondary metabolism in plants, to increase CO_2 uptake by leaves.

Spraying S.C. Pioneer 30K09 hybrid with HA uner 90 kg N/fed. expressed the highest values of P_N (27.90 µmol (CO_2) m^2s^{-1}) and E (9.01 mmol $m^{-2}s^{-1}$). The highest values of G_s was obtained by spraying T.W.C.-310 hybrid with HA (0.317 mol (H_2O) $m^{-2}s^{-1}$), but for C_i the highest value was obtained by S.C Pioneer 30K09 hybrid under 120 kg N/fed. (145.41 µmol mol^{-1}).

Gas exchange parameters		Photosynthetic rate (µmol (CO_2) m^2s^{-1})			Transpiration rate (mmol $m^{-2}s^{-1}$)			Stomatal conductance (mol (H_2O) $m^{-2}s^{-1}$)			Intercellular CO_2 concentration (µmol mol^{-1})		
		P_N			E			Gs			C_i		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	11.00	20.45	15.73	3.62	6.62	**5.12**	0.107	0.260	0.183	125.13	130.67	127.90
	90 kg N	16.10	27.90	22.00	5.21	9.01	7.11	0.177	0.297	0.237	129.03	123.79	126.41
	120 kg N	18.15	18.00	18.08	5.88	6.26	6.07	0.197	0.240	0.218	131.54	145.41	138.47
Average		**15.08**	**22.12**	**18.60**	**4.90**	**7.30**	**6.10**	**0.160**	**0.266**	**0.213**	**128.56**	**133.29**	**130.93**
T.W.C.-310	0 kg N	9.65	14.50	12.08	3.20	4.69	3.94	0.077	0.147	0.112	125.13	137.88	131.50
	90 kg N	15.05	23.60	19.33	4.88	7.64	6.26	0.167	0.317	0.242	130.37	140.80	135.59
	120 kg N	13.90	21.70	17.90	4.48	7.04	5.76	0.130	0.280	0.205	125.88	141.80	133.84
Average		**12.87**	**19.93**	**16.40**	**4.18**	**6.46**	**5.32**	**0.124**	**0.248**	**0.186**	**127.13**	**140.16**	**133.64**
N levels kg N/fed.	0 kg N	10.33	17.48	13.90	3.41	5.65	4.53	0.092	0.203	0.147	125.13	134.27	129.70
	90 kg N	15.58	25.75	20.66	5.04	8.33	6.68	0.172	0.307	0.239	129.70	132.30	133.99
	120 kg N	16.03	19.85	17.94	5.18	6.65	5.91	0.163	0.260	0.212	128.71	143.60	136.16
Foliar spray		**13.98**	**21.03**		**4.53**	**6.88**		**0.142**	**0.257**		**127.85**	**136.72**	
LSD at		**5%**	**1%**		**5%**	**1%**		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		1.325	NS		0.583	NS		0.054	NS		NS	NS	
Nitrogen (B)		1.035	1.506		0.327	0.476		0.017	0.025		1.37	1.99	
Foliar spray (C)		0.792	1.072		0.233	0.316		0.010	0.014		1.58	2.14	
A x B		1.464	2.130		0.462	0.673		0.025	0.036		1.93	2.81	
A x C		1.119	1.517		0.330	0.447		0.014	0.019		2.24	3.03	
B x C		1.371	1.858		0.404	0.548		0.018	0.024		2.74	3.71	
A x B x C		1.939	2.627		0.578	0.775		0.025	0.033		3.87	5.24	

Table (4): Effect of spraying humic acid under three levels of nitrogen fertilizer, on gas exchange parameters at 60 days from sowing date for two maize hybrids in 2012 season.

B- Biochemical parameters.

B-1. Total carbohydrate in leaves.

The data presented in table 5 shows that there were no significant differences between the two hybrids in the values of total carbohydrate contents in leaves during the two seasons. The differences were mainly due to environment conditions and/or genetic factors (Ibrahem, 2002). The recommended dose of nitrogen fertilizer (120 kg N/fed.) expressed significant than the other levels (0 and 90 kg N/fed.) in increasing total carbohydrate in leaves during 2010 and 2011 seasons. The positive effect of nitrogen on total carbohydrate in leaves may be due to the role of nitrogen on photosynthesis and dry matter accumulation leading to higher total carbohydrate content in maize leaves (Tranavičienė *et al.,* 2008). Foliar spraying with HA to the two hybrids obtained the highest value of total carbohydrate contents (65.02 and 66.06%) during 2010 and 2011 seasons, respectively. This may be attributed to an increase in photosynthesis efficiency as a result of spraying HA and thus led to enhance biosynthesis of carbohydrates (Canellas and Olivares, 2014).

Application of 90 kg N/fed. combined with foliar spray of HA gave higher values of this criteria than those obtained by adding 120 kg N/fed only. Spraying S.C. Pioneer 30K09 hybrid with HA under applying 120 kg N/fed. obtained the highest values of total carbohydrate in leaves (72.69 and 74.47%) during 2010 and 2011 seasons, respectively.

Seasons		**2010**			**2011**		
Maize hybrids (A)	**N levels kg N/fed. (B)**	**Foliar spray (C)**		**Average**	**Foliar spray (C)**		**Average**
		Water spray	**Humic acid**		**Water spray**	**Humic acid**	
S.C. Pioneer 30K09	**0 kg N**	54.87	54.77	54.82	56.11	55.27	55.69
	90 kg N	61.26	69.48	65.37	62.85	70.43	66.64
	120 kg N	65.83	72.69	69.26	66.84	74.47	70.65
Average		**60.65**	**65.65**	**63.15**	**61.93**	**66.72**	**64.33**
T.W.C.-310	**0 kg N**	58.70	60.35	59.53	54.65	61.15	57.90
	90 kg N	60.47	63.30	61.89	61.54	65.89	63.72
	120 kg N	66.53	69.52	68.03	67.06	69.15	68.11
Average		**61.90**	**64.39**	**63.15**	**61.09**	**65.40**	**63.24**
N levels kg N/fed.	**0 kg N**	56.78	57.56	57.17	55.38	58.21	56.80
	90 kg N	60.86	66.39	63.63	62.19	68.16	65.18
	120 kg N	66.18	71.10	68.64	66.95	71.81	69.38
Foliar spray		**61.28**	**65.02**		**61.51**	**66.06**	
LSD at		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		NS	NS		NS	NS	
Nitrogen (B)		0.50	0.73		0.83	1.20	
Foliar spray (C)		0.35	0.48		0.66	0.90	
A x B		0.71	1.04		1.17	1.70	
A x C		0.50	0.67		0.94	1.27	
B x C		0.61	0.83		1.15	1.56	
A x B x C		0.86	1.17		1.62	2.20	

Table (5): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on total carbohydrate content in leaves (%) of two maize hybrids in 2010 and 2011 seasons.

B-2. Total carbohydrate in grains.

Data in table 6 showed that the differences in total carbohydrate contents in grains reached significance only in 2010 season (70.54 *V.S.* 65.56%) for T.W.C.-310 and S.C. Pioneer 30K09 hybrids, respectively. These

differences between hybrids may be due to genetic and/or environmental factors (Moharram, 2011). Adding 120 kg N/fed. increased total carbohydrate significantly more than those obtained by 0 and 90 kg N/fed. The positive role of nitrogen increasing total carbohydrate in grains were noted previously by Tranavičienė *et al.,* (2008). Spraying HA increased significantly total carbohydrate content in grains with values of 69.94 and 71.38% during 2010 and 2011 seasons, respectively. This may be attributed to an increase the photosynthesis efficiency which led to enhance biosynthesis of carbohydrates (El-Bassiouny *et al.,* 2014).

Application of 120 kg N/fed. combined with spraying HA gave highest total carbohydrate in grains especially with S.C. Pioneer 30K09 hybrid (76.71 and 83.56%) in 2010 and 2011 seasons, respectively.

Seasons		**2010**			**2011**		
Maize hybrids (A)	**N levels kg N/fed. (B)**	**Foliar spray (C)**		**Average**	**Foliar spray (C)**		**Average**
		Water spray	**Humic acid**		**Water spray**	**Humic acid**	
S.C. Pioneer 30K09	**0 kg N**	58.01	56.67	57.34	52.38	58.94	55.66
	90 kg N	64.37	67.30	65.84	61.41	76.04	68.73
	120 kg N	70.29	76.71	73.50	70.81	83.56	77.19
Average		**64.23**	**66.89**	**65.56**	**61.54**	**72.85**	**67.19**
T.W.C.-310	**0 kg N**	63.04	66.14	64.59	57.36	66.80	62.08
	90 kg N	69.10	76.12	72.61	64.41	68.23	66.32
	120 kg N	72.11	76.73	74.42	69.72	74.68	72.20
Average		**68.08**	**72.99**	**70.54**	**63.83**	**69.91**	**66.87**
N levels kg N/fed.	**0 kg N**	60.53	61.40	60.96	54.87	62.87	58.87
	90 kg N	66.74	71.71	69.22	62.91	72.14	67.53
	120 kg N	71.20	76.72	73.96	70.26	79.12	74.69
Foliar spray		**66.16**	**69.94**		**62.68**	**71.38**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		3.14	NS		NS	NS	
Nitrogen (B)		1.43	2.08		1.03	1.50	
Foliar spray (C)		0.97	1.32		0.82	1.11	
A x B		2.02	2.94		1.46	2.12	
A x C		1.37	1.86		1.16	1.57	
B x C		1.68	2.28		1.42	1.92	
A x B x C		2.38	3.22		2.01	2.72	

Table (6): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on total carbohydrate contents in grains (%) of two maize hybrids in 2010 and 2011 seasons.

B-3. Crude protein in grains.

The data listed in table 7 shows that T.W.C.-310 hybrid surpassed S.C. Pioneer 30K09 hybrid with respect to crude protein content in grains (10.81 *V.S* 9.38%) and (10.10 *V.S* 9.64%) in 2010 and 2011 seasons, respectively. Demirel *et al.,* (2011) noted that there were significant differences among maize hybrids for crude protein contents. Adding 120 kg N/fed. had a significant effect than the other two doses (0 and 90 kg N/fed.) on crude protein content in grains. This may be due to that nitrogen is an essential element of amino acids which considered the building blocks of proteins (Bould *et al.,* 1984). Spraying HA obtained the highest and significant values of crude protein in grains (10.66 and 10.19%) in 2010 and 2011 seasons, respectively. This increase may be due to the role of HA in enhancing photosynthesis mechanism and protein synthesis (El-Bassiouny *et al.,* 2014).

Adding 90 kg N/fed. combined with HA gave higher values of this criteria than those obtained by the recommended dose only. Spraying HA in combination with 120 kg N/fed. gave the highest values of crude protein in grains especially with T.W.C.-310 hybrid (14.19 and 13.19%) in 2010 and 2011 seasons, respectively.

Seasons		**2010**			**2011**		
Maize hybrids (A)	**N levels kg N/fed. (B)**	**Foliar spray (C)**		**Average**	**Foliar spray (C)**		**Average**
		Water spray	**Humic acid**		**Water spray**	**Humic acid**	
S.C. Pioneer 30K09	**0 kg N**	5.19	6.94	6.06	6.13	6.29	6.21
	90 kg N	10.08	11.66	10.87	10.52	11.18	10.85
	120 kg N	10.67	11.73	11.20	11.15	12.58	11.87
Average		**8.65**	**10.11**	**9.38**	**9.27**	**10.02**	**9.64**
T.W.C.-310	**0 kg N**	5.73	6.17	5.95	5.92	6.29	6.11
	90 kg N	12.13	13.29	12.71	10.79	11.63	11.21
	120 kg N	13.39	14.14	13.77	12.79	13.19	12.99
Average		**10.42**	**11.20**	**10.81**	**9.84**	**10.37**	**10.10**
N levels kg N/fed.	**0 kg N**	5.46	6.55	6.01	6.03	6.29	6.16
	90 kg N	11.10	12.47	11.79	10.66	11.41	11.03
	120 kg N	12.03	12.94	12.49	11.97	12.89	12.43
Foliar spray		**9.53**	**10.66**		**9.55**	**10.19**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		0.197	0.453		0.023	0.053	
Nitrogen (B)		0.262	0.381		0.006	0.009	
Foliar spray (C)		0.164	0.222		0.004	0.005	
A x B		0.370	0.539		0.008	0.012	
A x C		0.232	0.315		0.005	0.007	
B x C		0.284	0.385		0.007	0.009	
A x B x C		0.402	0.545		0.009	0.013	

Table (7): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on crude protein content (%) in grains of two maize hybrids in 2010 and 2011 seasons.

B-4. Oil contents in grains.

The data in table 8 shows that the differences between the two maize hybrids were not significant with respect to oil content in grains during the two seasons.

Adding 120 kg N/fed. had a significant effect in increasing oil content in grains than those obtained by 0 and 90 kg N/fed. This may be due to an increase in phospholipids formation which is considered one of oil constituents (Rifaat and Gendy, 1996). Spraying humic acid obtained the highest values of oil content in grains (7.76 and 7.48%) in 2010 and 2011 seasons, respectively. Its reported that humic acid contains cytokinins and their application resulted in increasing endogenous cytokinins and auxin levels which probability leads to improve yield (Zhang and Ervin, 2004 and Ehsan *et al*., 2014). Zaghloul *et al.*, (2009) noted that application of K-humate is essential for oil yield/plant. Spraying humic acid under the level of 90 0r 120 kg N/fed. gave the higher values of oil content in grains than those obtained by the recommended dose only. Spraying T.W.C.-310 hybrid with HA under the recommended dose obtained the highest values of oil content in grains (8.40 and 8.22%) in 2010 and 2011 seasons, respectively.

Seasons		2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	5.22	6.95	6.09	5.02	6.15	5.59
	90 kg N	5.35	8.07	6.71	5.83	7.76	6.80
	120 kg N	6.52	8.11	7.31	6.43	7.89	7.16
Average		**5.70**	**7.71**	**6.70**	**5.76**	**7.27**	**6.51**
T.W.C.-310	0 kg N	5.04	6.88	5.96	5.20	6.65	5.92
	90 kg N	5.87	8.13	7.00	5.89	8.18	7.04
	120 kg N	7.26	8.40	7.83	6.69	8.22	7.46
Average		**6.06**	**7.80**	**6.91**	**5.93**	**7.68**	**6.81**
N levels kg N/fed.	0 kg N	5.13	6.92	6.02	5.11	6.40	5.76
	90 kg N	5.61	8.10	6.85	5.86	7.93	6.92
	120 kg N	6.89	8.25	7.57	6.56	8.06	7.31
Foliar spray		**5.88**	**7.76**		**5.84**	**7.48**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		**NS**	**NS**		**NS**	**NS**	
Nitrogen (B)		**0.20**	**0.29**		**0.21**	**0.30**	
Foliar spray (C)		**0.29**	**0.39**		**0.24**	**0.32**	
A x B		**0.28**	**0.40**		**0.29**	**0.42**	
A x C		**0.41**	**0.55**		**0.33**	**0.45**	
B x C		**0.50**	**0.68**		**0.41**	**0.56**	
A x B x C		**0.71**	**0.96**		**0.58**	**0.79**	

Table (8): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on oil contents in grains (%) of two maize hybrids in 2010 and 2011 seasons.

A- Nutrient (N, P and K) contents in leaves and grains.

C-1. Nitrogen content in leaves.

From table 9, it could be noticed that S.C. Pioneer 30K09 hybrid surpassed T.W.C-310 hybrid in N-content in leaves (2.720 *V.S* 2.490%) and (2.527 *V.S* 2.370%) in 2010 and 2011 seasons, respectively. This variation may be due to genetic factors (Enujeke, 2013). The recommended dose of nitrogen fertilizer gave the highest N-content in leaves as compared of those obtained at 0 and 90 kg N/fed and this was true for the two hybrids at the two seasons. These data are in same line of Khalil (1994) and Ibrahim and Kandil (2007). Foliar spray of HA for the two hybrids obtained the highest values of N-content in leaves (2.797 and 2.625%) during 2010 and 2011 seasons, respectively. Çelik *et al.*, (2011) reported that humus has beneficial effects on nutrients uptake, transport and availability to the plants. Spraying S.C. Pioneer 30K09 hybrid with HA under applying 120 kg N/fed. gave the highest values of N-content in leaves (3.695 and 3.385%) in 2010 and 2011 seasons, respectively.

Seasons		2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	1.210	1.387	1.298	1.100	1.303	1.202
	90 kg N	3.010	3.688	3.349	2.990	3.377	3.184
	120 kg N	3.333	3.695	3.514	3.005	3.385	3.195
Average		**2.518**	**2.923**	**2.720**	**2.365**	**2.688**	**2.527**
T.W.C.-310	0 kg N	1.155	1.470	1.313	1.027	1.363	1.195
	90 kg N	2.817	3.167	2.992	2.710	3.027	2.868
	120 kg N	2.955	3.375	3.165	2.800	3.293	3.047
Average		**2.309**	**2.671**	**2.490**	**2.179**	**2.561**	**2.370**
N levels kg N/fed.	0 kg N	1.182	1.428	1.305	1.063	1.333	1.198
	90 kg N	2.913	3.427	3.170	2.850	3.202	3.026
	120 kg N	3.144	3.535	3.339	2.902	3.339	3.121
Foliar spray		**2.413**	**2.797**		**2.272**	**2.625**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		0.072	0.167		NS	NS	
Nitrogen (B)		0.125	0.182		0.121	0.176	
Foliar spray (C)		0.111	0.150		0.100	0.136	
A x B		0.177	0.258		0.171	0.249	
A x C		0.157	0.213		0.142	0.192	
B x C		0.193	0.261		0.174	0.236	
A x B x C		0.272	0.369		0.246	0.334	

Table (9): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on N-contents (%) in leaves of two maize hybrids in 2010 and 2011 seasons.

C-2. Nitrogen content in grains.

Table 10 shows that T.W.C-310 hybrid surpassed S.C. Pioneer 30K09 hybrid in N-content in grains (1.729 *V.S.* 1.500%) and (1.616 *V.S.* 1.543%) in 2010 and 2011 seasons, respectively. This variation may be due to genetic factors (Enujeke, 2013). For the two hybrids, the recommended dose of nitrogen fertilizer gave the highest N-content in grains. These data are in same line of Khalil (1994) and Ibrahim and Kandil (2007). Also, spraying the two hybrids with HA obtained higher values of N-content in grains as compared with those of spraying water. Çelik *et al.,* (2011) reported that humus has beneficial effects on nutrients uptake, transport and availability to the plants. Spraying T.W.C.-310 hybrid with HA under applying 120 kg N/fed. obtained the highest values of N-content in grains (2.263 and 2.111%) during 2010 and 2011 seasons, respectively.

Seasons		2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	0.830	1.110	0.970	0.981	1.007	0.994
	90 kg N	1.613	1.865	1.739	1.683	1.789	1.736
	120 kg N	1.707	1.877	1.792	1.784	2.013	1.899
Average		**1.383**	**1.617**	**1.500**	**1.483**	**1.603**	**1.543**
T.W.C.-310	0 kg N	0.917	0.987	0.952	0.947	1.007	0.977
	90 kg N	1.940	2.127	2.034	1.727	1.860	1.794
	120 kg N	2.143	2.263	2.203	2.047	2.111	2.079
Average		**1.667**	**1.792**	**1.729**	**1.574**	**1.659**	**1.616**
N levels kg N/fed.	0 kg N	0.873	1.048	0961	0.964	1.007	0.986
	90 kg N	1.777	1.996	1.886	1.705	1.825	1.765
	120 kg N	1.925	2.070	1.997	1.915	2.062	1.989
Foliar spray		**1.525**	**1.705**		**1.528**	**1.631**	**1.631**
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		0.047	0.109		0.003	0.007	
Nitrogen (B)		0.074	0.107		0.0007	0.0009	
Foliar spray (C)		0.045	0.061		0.001	0.001	
A x B		0.104	0.152		0.001	0.001	
A x C		0.064	0.087		0.001	0.001	
B x C		0.079	0.107		0.001	0.002	
A x B x C		0.111	0.150		0.0017	0.002	

Table (10): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer, on N-contents (%) in grains of two maize hybrids in 2010 and 2011 seasons.

C-3. Phosphorus content in leaves.

From the data listed in table 11, it could be noticed that T.W.C.-310 hybrid surpassed S.C. Pioneer 30K09 hybrid in P-content in leaves (0.260 *V.S.* 0.253%) and (0.298 *V.S.* 0.268%) in 2010 and 2011 seasons, respectively. Variations among maize hybrids for P-content in leaves derive from its genetics and environments condition such as soil factors (Gautam *et al.,* 2011). Application 90 kg N/fed. gave the highest values of P-content in leaves (0.267 and 0.292%) during 2010 and 2011 seasons, respectively. Havlin *et al.,* (2006) reported that nitrogen promotes P uptake from the soil by increasing tap root growth, plant metabolism, P solubility and availability of P by decreasing soil pH through NH^{4+} absorption. Foliar spray of HA for the two hybrids resulted in the higher values of P-content in leaves than those obtained by spraying water. Humic acid enhances cell permeability, which in turn made for rabid entry of minerals in leave cells and so resulted in higher contents of plant nutrients. This effect was associated with function of hydroxyls and carboxyls in these compounds (Ehsan *et al.,* 2014). Fertilizing T.W.C.-310 hybrid with 90 kg N/fed. and spraying with HA gave the highest values of P-content in leaves (0.296 and 0.336%) during 2010 and 2011 seasons, respectively. Generally, spraying any of the two hybrids with HA under adding 90 or 120 kg N/fed. was accompanied with a higher P-content in leaves more than those obtained by recommended dose.

Seasons		2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	0.253	0.261	0.257	0.270	0.270	0.270
	90 kg N	0.259	0.266	0.262	0.275	0.266	0.270
	120 kg N	0.240	0.237	0.238	0.266	0.261	0.264
Average		**0.251**	**0.255**	**0.253**	**0.270**	**0.266**	**0.268**
T.W.C.-310	0 kg N	0.249	0.280	0.264	0.273	0.320	0.297
	90 kg N	0.249	0.296	0.272	0.289	0.336	0.313
	120 kg N	0.232	0.255	0.243	0.272	0.295	0.284
Average		**0.243**	**0.277**	**0.260**	**0.278**	**0.317**	**0.298**
N levels kg N/fed.	0 kg N	0.251	0.270	0.261	0.271	0.295	0.283
	90 kg N	0.254	0.281	0.267	0.282	0.301	0.292
	120 kg N	0.236	0.246	0.241	0.269	0.278	0.274
Foliar spray		**0.247**	**0.266**		**0.274**	**0.291**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		0.001	0.003		0.004	0.008	
Nitrogen (B)		0.002	0.003		0.003	0.004	
Foliar spray (C)		0.001	0.002		0.001	0.002	
A x B		0.003	0.005		0.004	0.006	
A x C		0.001	0.002		0.002	0.003	
B x C		0.002	0.002		0.003	0.003	
A x B x C		0.003	0.003		0.004	0.005	

Table (11): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer, on P-contents (%) in leaves of two maize hybrids in 2010 and 2011 seasons.

C-4. Phosphorus content in grains.

It could be detected from the data presented in table 12, the T.W.C.-310 hybrid surpassed S.C. Pioneer 30K09 hybrid in P-content of grains (0.565 *V.S.* 0.532%) and (0.635 *V.S.* 0.553%) in 2010 and 2011 seasons, respectively. Variations among maize hybrids for P-content in grains derive from its genetics and environments condition such as soil factors, whereas, P-content in grains depends on P-content in leaves (Gautam *et al.*, 2011). The recommended dose of nitrogen obtained the highest values of P-content in grains (0.578 and 0.612%) in 2010 and 2011 seasons, respectively. Havlin *et al.*, (2006) reported that nitrogen promotes P uptake from the soil by increasing tap root growth, plant metabolism, P solubility and availability of P by decreasing soil pH through NH^{4+} absorption. Spraying HA increased P-content in grains more than those obtained by water spraying. Osman *et al.*, (2013) reported that foliar spray of humic acid significantly increased N, P and K contents in wheat grains. It could be conclude that the two examined hybrid responded to increase P-content in grains when sprayed with HA under 120 kg N/fed. more than those obtained by the recommended dose of nitrogen especially T.W.C.-310 hybrid with values 0.591 and 0.661% in 2010 and 2011 seasons, respectively.

Seasons		2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	0.454	0.558	0.506	0.505	0.563	0.534
	90 kg N	0.459	0.587	0.523	0.541	0.583	0.562
	120 kg N	0.545	0.589	0.567	0.551	0.578	0.564
Average		**0.486**	**0.578**	**0.532**	**0.532**	**0.575**	**0.553**
T.W.C.-310	0 kg N	0.550	0.553	0.551	0.620	0.621	0.620
	90 kg N	0.554	0.555	0.555	0.624	0.625	0.624
	120 kg N	0.587	0.591	0.589	0.658	0.661	0.657
Average		**0.564**	**0.566**	**0.565**	**0.634**	**0.636**	**0.635**
N levels kg N/fed.	0 kg N	0.502	0.556	0.529	0.563	0.592	0.577
	90 kg N	0.507	0.571	0.539	0.583	0.604	0.593
	120 kg N	0.566	0.590	0.578	0.605	0.619	0.612
Foliar spray		**0.525**	**0.572**		**0.583**	**0.605**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		0.002	0.006		0.001	0.001	
Nitrogen (B)		0.002	0.003		0.002	0.003	
Foliar spray (C)		0.001	0.002		0.001	0.002	
A x B		0.003	0.004		0.003	0.004	
A x C		0.002	0.002		0.002	0.002	
B x C		0.002	0.003		0.002	0.003	
A x B x C		0.003	0.004		0.003	0.004	

Table (12): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on P-contents (%) in grains of two maize hybrids in 2010 and 2011 seasons.

C-5. Potassium content in leaves.

It could be noticed from table 13 that S.C. Pioneer 30K09 hybrid surpassed T.W.C.-310 hybrid in K-content in leaves (1.824 *V.S.* 1.686%) and (1.772 *V.S.* 1.614%) in 2010 and 2011 seasons, respectively. This may due to genetic factors which cause the different accumulation dynamics and/or nutrient translocation by the hybrid (Coors *et al.*, 1997). Application of 90 kg N/fed. caused the highest K-content values in leaves (2.123 and 1.901%) in 2010 and 2011 seasons, respectively. This may be explained as nitrogen increase the root surface per unit of soil volume and the rate of nutrient uptake. This result is in agreement with those reported by Khalil (1994). Foliar spray of humic acid increased K-content in leaves more than those obtained by spraying water. Several researchers concluded that humic acid as foliar spray enhanced NPK-content in leaves of maize hybrids through enhancing the uptake and accumulation of nutrients by increasing the permeability of cell membrane (Tahir *et al.*, 2011) and enhancing the nutrients absorption (Sharif *et al.*, 2004). This is related to the surface activity of humic substances (Chen and Schnitzer, 1978). Application of 90 kg N/fed. combined with foliar spray of HA gave the highest K-content in leaves especially with T.W.C.-310 hybrid with values 2.301 and 2.315% during 2010 and 2011 seasons, respectively.

Seasons		2010			2011		
Maize hybrids (A)	**N levels kg N/fed. (B)**	**Foliar spray (C)**		**Average**	**Foliar spray (C)**		**Average**
		Water spray	**Humic acid**		**Water spray**	**Humic acid**	
S.C. Pioneer 30K09	**0 kg N**	1.349	2.128	1.739	1.373	1.657	1.515
	90 kg N	1.567	2.280	1.924	1.586	2.298	1.942
	120 kg N	1.416	2.201	1.808	1.431	2.285	1.858
Average		**1.444**	**2.203**	**1.824**	**1.463**	**2.080**	**1.772**
T.W.C.-310	**0 kg N**	1.268	1.589	1.429	1.292	1.612	1.452
	90 kg N	1.283	2.301	1.792	1.405	2.315	1.860
	120 kg N	1.380	2.293	1.837	1.385	1.674	1.530
Average		**1.311**	**2.061**	**1.686**	**1.3.61**	**1.867**	**1.614**
N levels kg N/fed.	**0 kg N**	1.309	1.859	1.584	1.333	1.634	1.484
	90 kg N	1.425	2.291	1.858	1.495	2.307	1.901
	120 kg N	1.398	2.247	1.822	1.408	1.980	1.694
Foliar spray		**1.377**	**2.132**		**1.412**	**1.974**	
LSD at 5%		**5%**	**1%**		**5%**	**1%**	
Hybrids (A)		0.002	0.006		0.005	0.011	
Nitrogen (B)		0.004	0.006		0.001	0.001	
Foliar spray (C)		0.005	0.007		0.001	0.001	
A x B		0.006	0.008		0.001	0.002	
A x C		0.005	0.007		0.001	0.002	
B x C		0.007	0.009		0.001	0.002	
A x B x C		0.009	0.012		0.002	0.002	

Table (13): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on K-contents (%) in leaves of two maize hybrids in 2010 and 2011 seasons.

C-6. Potassium content in grains.

Table 14 cleared that S.C. Pioneer 30K09 hybrid surpassed T.W.C.-310 hybrid in K-content in grains (0.442 *V.S.* 0.432%) and (0.521 *V.S.* 0.490%) in 2010 and 2011 seasons, respectively. This may due to genetic factors which cause the different accumulation dynamics and/or nutrient translocation by the hybrid (**Coors *et al.*, 1997**). Application of 90 kg N/fed. obtained the highest K-content in grains (0.471 and 0.527%) in 2010 and 2011 seasons, respectively. This may be explained as nitrogen increase the root surface per unit of soil volume and the rate of nutrient uptake. This result is in agreement with those reported by **Khalil (1994)**. For the combined effect of hybrids, spraying HA and nitrogen levels, it could be conclude that the two hybrids responded to gave the highest K-content in grains with spraying HA under 90 kg N/fed. especially S.C. Pioneer 30K09 hybrid (0.542 and 0.593%) during 2010 and 2011 seasons, respectively.

Seasons		2010			2011		
Maize hybrids (A)	N levels kg N/fed. (B)	Foliar spray (C)		Average	Foliar spray (C)		Average
		Water spray	Humic acid		Water spray	Humic acid	
S.C. Pioneer 30K09	0 kg N	0.342	0.507	0.425	0.418	0.567	0.493
	90 kg N	0.433	0.542	0.488	0.488	0.593	0.541
	120 kg N	0.380	0.449	0.415	0.456	0.602	0.529
Average		**0.385**	**0.499**	**0.442**	**0.454**	**0.588**	**0.521**
T.W.C.-310	0 kg N	0.315	0.499	0.407	0.432	0.503	0.468
	90 kg N	0.373	0.536	0.455	0.455	0.573	0.514
	120 kg N	0.350	0.518	0.434	0.466	0.512	0.489
Average		**0.346**	**0.518**	**0.432**	**0.451**	**0.529**	**0.490**
N levels kg N/fed.	0 kg N	0.329	0.503	0.416	0.425	0.535	0.480
	90 kg N	0.403	0.539	0.471	0.472	0.583	0.527
	120 kg N	0.365	0.484	0.424	0.461	0.557	0.509
Foliar spray		**0.366**	**0.509**		**0.453**	**0.558**	

LSD at 5%	5%	1%	5%	1%
Hybrids (A)	0.001	0.003	0.007	0.015
Nitrogen (B)	0.001	0.001	0.007	0.010
Foliar spray (C)	0.001	0.001	0.004	0.006
A x B	0.002	0.002	0.010	0.014
A x C	0.001	0.002	0.006	0.009
B x C	0.002	0.002	0.007	0.010
A x B x C	0.002	0.003	0.011	0.014

Table (14): Effect of foliar spray of humic acid under three levels of nitrogen fertilizer on K-contents (%) in grains of two maize hybrids in 2010 and 2011 seasons.

Conclusion:

The study conclude that application of humic acid in combination with nitrogen fertilizer had a significant effect on leaves and grains contents of two maize hybrids. It also improves the nutrient contents of maize crop. Therefore, it can be recommended that spraying maize hybrids with HA could substituted 30 kg N/fed. and this led to minimize the harmful effect and the costs of chemical fertilizers. The results show also that the two hybrids showed a clear response to increase the all criteria when sprayed with HA combined with application of 120 kg N/fed. as compared with their values at the recommended doses only (120 kg N/fed.) in the both seasons.

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الملخص العربي

إستجابة محصول الذرة الشامية لحمض الهيوميك تحت مستويات مختلفة من التسميد النيتروجيني

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أقيمت تجربة حقلية بمحطة بحوث جزيرة شندويل الزراعية - سوهاج - جمهورية مصر العربية، في كل موسم صيفي من مواسم ٢٠١٠ ، ٢٠١١ و ٢٠١٢، و على تربة طميية طينية ذات مستوى منخفض إلى حد ما من العناصر الغذائية، و تهدف هذه الدراسة إلى دراسة تأثير حمض الهيوميك تحت مستويات ثلاثة من التسميد النيتروجيني (صفر ، ٩٠ و ١٢٠ كجم نيتروجين/فدان) على هجينين من هجن الذرة الشامية (هجين فردي بايونير 30K09 و هجين ثلاثي -٣١٠). وقد صممت هذه التجربة في قطع منشقه مرتين في ثلاث مكررات، وضع الهجينان في القطع الرئيسية، ووضعت مستويات الأسمدة النيتروجينية فى القطع الشِّقِيَّة كما وضع الرش الخضري بحمض الهيوميك في القطع تحت الشِّقِيَّة . تمت إضافة الأسمدة البوتاسية والفوسفاتية أثناء تجهيز الأرض للزراعة بالمعدل الموصى به، و تم إضافة مستويات الأسمدة النيتروجينية على دفعتين الأولى عند رية المحاياه والثانية عند الرية التالية لرية المحاياه، كما تم الرش بحمض الهيوميك خضريا على الذرة الشامية على مرتين الأولى بعد ٣٠ يوم من الزراعة والثانية بعد ٤٥ يوم من الزراعة حيث أضيف حمض الهيوميك بمعدل ٤سم^3/لتر للرشه الواحده على هيئة هيومات بوتاسيوم. تم أخذ عينات خضرية بمعدل خمس نباتات للقطعة التجريبية بعد ٦٠ يوم من الزراعة ، كما تم أخذ عينات بذور عند حصاد التجربة لدراسة الصفات الفسيولوجيه و المحتوى العنصري.

وكانت أهم النتائج المتحصل عليها كالتالي:

- تفوق الهجين الفردي على الهجين الثلاثي فى معدل التمثيل الضوئي، التنفس، كفاءة توصيل الثغور، محتوى الأوراق من النيتروجين والبوتاسيوم و محتوى البذور من البوتاسيوم فى كلا الموسمين . بينما تفوق الهجين الثلاثي على الهجين الفردي في محتوى الحبوب من البروتين والنيتروجين والفوسفور و محتوى الأوراق من الفوسفور فى كلا الموسمين. بينما كانت الفروق غير معنوية بين الهجينين في محتوى الأوراق من الكلوروفيل، الوزن الكلي الجاف و محتوى الحبوب من الكربوهيدرات والزيت فى كلا الموسمين.
- أعطى التسميد النيتروجيني بمعدل ١٢٠ كجم نيتروجين/فدان قيماً معنوية لكل من محتوى الأوراق من الكلوروفيل ، الوزن الكلي الجاف و صفات تبادل الغاز و كذلك محتوى الأوراق من الكربوهيدرات و محتوى الحبوب من الكربوهيدرات والبروتين و الزيت، محتوى الأوراق من النيتروجين، و كذلك محتوى الحبوب من النيتروجين و الفوسفور في كلا الموسمين، بينما أدى التسميد النيتروجيني بمعدل ٩٠ كجم نيتروجين/فدان إلى أعلى قيم لمعدل التمثيل الضوئي، التنفس، كفاءة توصيل الثغور و ثاني أكسيد الكربون بين خلوي، و كذلك محتوى الأوراق من الفوسفور والبوتاسيوم و محتوى الحبوب من البوتاسيوم في كلا الموسمين.
- أدى الرش الخضري بحمض الهيوميك إلى زيادة معنوية في قيم جميع الصفات تحت الدراسه في كلا الموسمين عن تلك غير المعاملة بحمض الهيوميك.
- التفاعل المشترك بين التسميد النيتروجيني بمعدل ٩٠ كجم نيتروجين/فدان و الرش الخضري بحمض الهيوميك أعطى أعلى قيم لجميع تحت الدراسة مقارنة بالقيمة المعطاة بإضافة الجرعة الموصى بها من السماد النيتروجيني (١٢٠ كجم نتروجين/فدان) وهذا يعنى أنه بإضافة ثلاث أرباع الجرعه الموصى بها (٩٠ كجم نيتروجين/فدان) والرش الورقي بحمض الهيوميك نحصل على قيم لجميع الصفات تحت الدراسة أعلى من المتحصل عليها عند إضافة بالجرعة الموصى بها (١٢٠ كجم نيتروجين/فدان) و بالتالي يمكننا الإستغناء عن ربع الجرعة الموصى بها من التسميد النيتروجينى لتقليل الآثار الضاره الناتجه من زيادة استخدام الأسمدة النتروجينية وذلك بالرش الخضرى بحمض الهيوميك، أيضاً لتقليل تكاليف الأسمدة النتروجينية.

أظهر الهجينين تحت الدراسة استجابة لزيادة جميع القياسات تحت الدراسة بالرش الورقي لحمض الهيوميك مع التسميد النيتروجيني بمعدل ١٢٠ كجم نيتروجين/فدان (الجرعة الموصى بها) مقارنة بالقيم المعطاه بالتسميد النيتروجيني بنفس الجرعة من السماد الأزوتى ولكن بدون الرش الورقي بحمض الهيوميك.