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Impact of Humic Acid Application on Productivity of some Maize Hybrids under Water Stress Conditions

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ABSTRACT

Two field experiments were carried out at the experimental farm of the Faculty of Agriculture (Saba Basha), Alexandria University at Abees region, Alexandria, Egypt during two successive seasons of 2013 and 2014 to study the combined effect of water stress and humic acid on the growth analysis, yield and components of three maize hybrids. The experimental design was a split-split plot with three replicates. The main results could be summarized as follow; the irrigation interval had significant effects on growth analysis characters, where irrigation every 15 days recorded higher mean value for most of studied characters i.e., growth, yield and its components attributes as compared with irrigation every 20 days. Increasing irrigation interval, significantly, decreased grain yield and its components. On other hand, irrigation every 20 days increased grain protein content. Maize hybrids significantly differed in some growth analysis, yield, its components, and protein percentage. The"T.W.C.352" hybrid followed by "S.C.168" were superior to"S.C.166" hybrid in yield and its components under the irrigation intervals treatments. Also, application of14.40 kg/ha., of humic acid significantly increased growth analysis, grain yield, and its components the untreated treatment (control). Generally, it can be concluded that application humic acid at 14.4 kg/ha., was effective to avoid a significant increase in growth analysis and grain yield when the irrigation analysis interval was 10 and15 days with "T.W.C.352"and "S.C.168"hybrids understudy.

Key words: *maize; hybrid; water stress; irrigation interval; humic acid; growth; yield; component.*

Introduction

Maize (*Zea mays,* L.) is an important cereal crop which ranks the third after wheat and rice .In Egypt, cultivated area from maize about1.00 million hacter, in 2012 season, produced 7.20million tons grains, with an average production of 7.20 tons/ha., this production, however, does not meet consumption where about 5 million tons are improved (FAO, 2011).Moreover, the strategy bused in mixing maize grain partly with wheat to reduce wheat importing and increase self sufficiency from bread, wheat is partly based on making use of maize or reduce maize export using maize in forage and silage crop.

This in turn necessitates more extension in the maize cultivated area and as well as optimizing the needs of irrigation water. Optimal water management strategies thus become an important factor due to limitations in the supply of irrigation water caused by uncontrolled increase in rice cultivated area which receives a great part of irrigation water in the summer seasons.

Several studies had been carried out to explore the effect irrigation interval on maize growth, yield attributes and its components. El-Nomany *et al.* (1990) reported that exposed maize plants to water stress i.e. irrigation every 18 days instead to 12 days)decreased significantly plant height, ear length, number of grain/row, number of rows/ear,1000-grain weight, grain and straw yields. Also, Mahrous (1991) stated that increasing irrigation intervals up to 35 days, significantly, decreased plant height and grain yield of maize plants. Meanwhile, Ibrahim *et al.* (2005),Samuel *et al.*(2005) and Mohsen *et al.*(2012) detected that 100- kernel weight, grain weight/ear and grain yield decreased due to extreme drought .

Performance of crop cultivars across diverse environments and its response to different kinds of biotic and abiotic stresses is an important concern of plant breeders. Based on this emphasis it is always given to yield performance under water deficit conditions (Golabadi *et al.* 2006). Water deficit stress and cultivar had significant effects on grain yield. Water deficit stress at vegetative phase had significant effect on leaf solution; proteins and reduced it in stress treatments in comparison with control. At the end of each phase of stress, water deficiency induced significant increase of proline in leaves. Water deficit stress led to significant decrement of chlorophyll content in examined cultivars. Water deficiency had significant effect on free amino acid content of leaf at the end of reproductive stress (Soltani *et al.* 2013).

Humic acid its a water -solubleorganic acid, naturally, presented in soil organic matter; it could be recognized that humic acid substances have many beneficial effects on soil structure and soil microbial populations as well as increase modify mechanisms involved in plant growth stimulation , cell permeability and

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nutrient uptake and increasing yield .Mayhew(2004)showed that humic substances may possibly enhance the uptake of minerals through the stimulation of microbiological activity.

Pettit (2004) reported that humic substances have a very profound influence on the growth of plant roots .Since, humic and fulvic acids are applied to the soil enhancement of root initiation and increased root growth. Bakry *et al*. (2009) reported that significant increase in maize vegetative growth characters (plant height and leaf contents of chlorophyll a&b, ear characters and grain yield/ear length, ear diameter ,rows number/ear ,grains number/row and grain yield/plot and grain quality parameters (weight of 100- grains)due to humic acid application. Also, Daur and Bakhashwain (2013) stated that significant differences were observed for all the studied parameters across the humic acid levels. Application of 25 kg humic acid/ha., may be recommended to improve growth and quality of maize fodder in similar environmental conditions. Aisha *et al*. (2014) reported that increasing rate of humic acid increased growth characters, yield characters and increase the percentage of protein. The highest mean values of the growth characters, roots characters and the percentage of protein were associated with plants which received higher level level of humic acid (14.40 l/ha.) with compost.

Therefore, the objective of this study were;1) evaluation the effect of water stress and available humic acid on the maize growth yield and its components, andtheir on growth yield and its components.

Materials and Methods

Two field experiments were conducted at the farm, of the Faculty of Agriculture (Saba Basha), Alexandria University, during the summer growing seasons of 2013 and 2014 to study the effects of both water stress and humic acid rates on three maize hybrids. Soil samples were taken before wheat seeding to depth of 10 -30 and 30 - 60 cm from the experimental site. The soil samples were air dried, passed through a 2 mm sieve, and then analyzed according (Rhoades *et al.,* 1982). The soil type of experimental site was clay loamy. Mechanical and chemical analysis of the experimental site is presented in Table (1).

Table 1: Some physical and chemical properties of the experimental soil during 2012 and 2013 seasons.

Soil parameter		
Season		
	2012	2013
Particle size distribution %		
Sand	37	39
Silt	34	32
Clay	30	30
Textural class	Clay loam	Clay loam
Chemical properties		
pH (1:1) (soil: water suspension)	8.30	8.29
EC (1:1) (soil: water extract), dS/m	3.75	3.81
Soluble cations (1:2) (cmo1/kg soil)		
K^+	1.60	1.57
Ca^{++}	9.3	8.8
Mg^{++}	18.3	18.5
Na^{++}	13.50	13.8
2- Soluble anions (1:2) (cmo1/kg soil)		
CO^-_3+ HCO^-_3	2.90	2.80
CL	20.4	19.80
SO^-_4	12.50	12.60
Calcium carbonate, %	6.50	7.00
Total nitrogen, %	1.10	1.11
Available P (mg/kg)	3.70	3.55
Organic matter, %	1.47	1.45

The preceding cultivated crop was wheat (*Triticum aestivum*, L.) during both seasons of the study. The experimental design was split-split plot with three replicates and the treatments were distributed at random as follow:

The experiment was designed in a split-split plot with three replicates was used where the irrigation interval treatments (10, 15 and 20 days) were allocated in main plots, the three maize hybrids (S.C.166 .S.C.168 and T.W.C.352) were allocated, randomly, to the sub-plots .While the three humic acid rates (0, 7.2 kg/ha. and 14.4 kg/ha.) were arranged in the sub-sub plots.

Each sub plot consisted of 6 ridges, 3 meters in length, 60 cm width and 20 cm between hills. Maize grains were hand- planted in hills 20 cm on a part at the rate of 2-3 grains/hill using dry sowing method (Afeer) on one side of the ridge on 1st June and 6th April in 2013 and 2014 seasons, respectively. The plants were thinned to one plant per hill before the first irrigation .Hoeing twice was done before controlling weeds before the first and second irrigation .The irrigation treatments were applied after 30 days from sowing.

The applied of mineral fertilization was nitrogen fertilizer as ; 240 kg N ha^{-1} in the form of urea (46.5 % N) which applied in an equal two doses with the first and second irrigation, and phosphorus fertilizer; 480 kg ha^{-1}

from calcium super phosphate fertilizer (15.5% P_2O) which was applied as one dose. Potassium sulphate (48% K_2O) was added before the first irrigation at rate of 120 kg K_2O/ha., which was applied at the first dose of nitrogen fertilizer.

The tested growth characters which were recorded are plant height (cm) was recorded at harvest, leaf area index was measured according to the method described by Radford (1967) from this equation, LA = K (L x B), where; LA= leaf area (cm^2), K= Constant (0.75), L= leaf length (cm), B = Maximum leaf width (cm).The Chlorophyll pigments were measured by direct digital reading on chlorophyll meter SPAD-502, where the value measured by the chlorophyll present in the plant leaf. The values are calculated based on the amount of light transmitted by the leaf in two wave length regions in which the absorbance of chlorophyll is different. Total chlorophyll transferred from SPAD units which determined by digital apparatus (SPAD-502) to mg m^{-2} according to this formula which suggested byMonje and Bugbee (1992); Coste *et al.* (2010).

$Y = 1.034 + 0.308 * X + 0.11 * X^2$

Where; X= SPAD reading

Ear length (cm), Number of ears plant^{-1}, number of rows ear^{-1}, number of kernels row^{-1}, Number of kernels/ear, 100 kernels weight (g), Straw yield, Grain yield, and Biological yield per hectare, and Harvest index (H.I. %). Data are measurements were obtained as an average of ten ears random from each plot.

Protein percentage was determined according to the improved Kjeldahl methods of Association of Official Agricultural Chemicts (AOAC, 1970). Crude protein percentage was calculated by multiplying the total nitrogen for each sample by 6.25.

Results and Discussions

The present work was carried out to explore response of four yellow hybrids of maize to three plant population densities on growth attributes, yield, and its components under Alexandria governorate conditions during 2012 and 2013 seasons.

The attained results will be presented as following;

Growth characters as plant height (cm), Leaf area index (LAI) and chlorophyll (mg/m^2) of three hybrids of maize were affected, significantly, by water stress and humic acids rates during growing seasons 2013 and 2014, (Table 2).The results , also, indicated that those water stress, maize hybrids and humic acid had significant effects on most of growth attributes.

Recorded data in Table (2) indicated that the highest mean values of plant height at harvested, leaf area index (LAI) and chlorophyll were recorded with irrigation at every 15 days, while the shortest plants were irrigated at every 20 days during both seasons. Drought stress decreases photosynthetic rate and disrupts carbohydrates metabolism in leaves (Abdel- Aziz and El- Bialy, 2004). Similar results were obtained by El-Namany *et al*. (1990) and Hefni and El-Shabbagh (1993). Also, Soltani *et al.* (2013) showed that water deficit stress led to significant decrement of chlorophyll content in all examined cultivars.

However, drought stress has deleterious effects on the seedling establishment, vegetative growth, photosynthesis, root growth, anthesis, anthesis-silking interval, pollination and grain formation in maize crop. The deleterious effects of drought can be mediated by application of nutrients which may enhance tolerance to drought stress. Among the nutrients potassium can enhance the tolerance in maize plant for drought stress. The application of potassium enhanced root growth and stem elongation. Similarly, potassium increased leaf water potential, osmotic potential and turgor potential under drought stress (Aslam *et al.,* 2013).

Notably, “S.C.168” hybrid recorded the tallest plants, while “S.C.166” hybrid gave the highest value of plant height at harvested, leaf area index (LAI) and chlorophyll in both growing seasons, nevertheless was no significant effect between “S.C.168” and “T.W.C.352” hybrids. Plant breeders and major seed companies have developed maize genotypes with enhanced yields in water deficient environments. Phenotypic traits, such as silking, yield, grain number, carbon allocation to roots, leaf rolling and leaf chlorophyll content, were used to select stress tolerant maize germplasm (Araus *et al.,* 2012). Also, Atta- Allah (1996) and Farhad*et al*. (2011) found high significant differences between the investigated maize hybrids under their studies concerning plant height character.

Also, data of Table (2) showed that the tallest plants (179.59 and 202.59 cm), highest LAI (5.23 and 5.21) and chlorophyll (191.59 and 212.52 mg/m^2) were obtained by treated soil with the highest rate of humic acid (14.4 kg/ha.), while the lowest mean value of plant height(158.22 and 181.35 cm), LAI (4.38 and 4.12) and chlorophyll (136.54 and 133.04 mg/m^2) were recorded by untreated (control) treatment in the first and second seasons, respectively. However, the increased in growth analysis characters by humic acid treatment may be due to enhance uptake of macronutrients such as nitrogen, phosphorus and sulphur and micronutrients (Fe, Zn, Cu and Mn) as well as beneficial effects on soil structure soil (Chen *et al*., 1999). Daur (2013**)** referred to a better performance of humic acid with significant differences in many parameters including plant height, leaf area index, and chlorophyll content.

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The interaction between water stress X maize hybrid or water stress X humic acid or maize hybrid or water stress X hybrid X humic acid was significant for some growth analysis during both cropping seasons (Table 2).

Yield and its components and grain protein content i.e., ear length (cm), number of row/ear, number of kernels/row, number of kernels/ear, 100 kernel weight (g), straw yield tons/ha., grain yield tons/ha, biological yield tons/ha., and harvest index (%) of three hybrids of maize had significantly as affected by water stress and humic acid rates during growing seasons 2013 and 2014 (Tables 2 and 3).

Table 2: Means of plant height, leaf area index (LAI), Chlorophyll, ear length (cm),number of row ear^{-1}, number of kernels/row, and number of kernels/ear of three maize hybrids as influenced by water stress and humic acids during both seasons of 2013and 2014.

Treatments	Plant height (cm)		LAI		Chlorophyll mg/m^2		Ear length (cm)		Number of row ear^{-1}		No. of kernels row^{-1}		No. of kernels ear^{-1}	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Water stress (W)														
Irrigation every 10 days	169.93	189.81	4.82	5.10	168.39	184.59	16.91	20.37	14.13	11.93	23.28	28.75	325.44	347.11
Irrigation every 15 days	173.04	197.50	4.99	4.51	163.85	164.46	13.36	16.67	13.77	11.57	23.07	26.81	298.07	318.63
Irrigation every 20 days	163.97	188.25	4.52	4.46	144.91	163.09	13.18	16.59	12.96	10.76	22.18	29.53	294.78	315.44
$LSD_{0.05}$	1.35	1.67	0.202	0.424	13.23	7.51	1.040	1.075	0.612	0.612	1.223	2.266	15.29	13.28
Maize hybrids (H)														
SC.166.	163.93	186.68	4.76	4.74	154.36	153.09	13.55 b	16.73	13.47	11.27	21.09	26.78	278.30	299.22
SC.168.	172.44	194.88	4.81	4.73	158.52	183.50	14.24 b	17.65	13.70	11.50	22.06	27.29	292.52	311.59
TWC352.	170.56	194.01	4.76	4.60	164.27	175.55	15.66	19.26	13.70	11.49	25.38	31.01	347.48	370.37
$LSD_{0.05}$	3.04	3.61	0.235	0.416	8.89	6.66	0.978	1.04	0.551	0.550	1.264	1.572	13.75	13.10
Humic acid (kg/ha.) (HA)														
0	158.22	181.35	4.38	4.12	136.54	133.04	13.14	16.57	12.56	10.36	21.51	27.80	268.74	287.44
7.20	169.11	191.62	4.72	4.74	149.02	166.58	14.41	17.69	14.18	11.98	22.01	26.46	299.00	320.15
14.40	179.59	202.59	5.23	5.21	191.59	212.52	15.90	19.39	14.13	11.93	24.99	30.82	350.56	373.59
$LSD_{0.05}$	1.88	2.43	0.227	0.377	15.84	9.72	0.915	0.882	0.856	0.856	1.593	2.061	15.56	14.09
Interactions														
W x H	**	**	N.S.	N.S.	**	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
W x HA	**	**	N.S.	N.S.	*	**	N.S.	N.S.	N.S.	N.S.	N.S.	*	*	*
Hzbrid x Humic acid	**	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
W x H x HA	**	**	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	*	**	**	**

- *, **: significant at 0.05 level of probability. - N.S.: not significant.

Data as shown in Table (2 and 3) detected that water stress, maize hybrid and humic acids rates affected, significantly, the most of yield and its components attributes; whereas, irrigation every 15 days led to the highest mean values of most yield and its components parameters namely; ear length, number of row/ear, number of kernels/row, number of kernels/ear, 100- kernel weight (g), grain, straw and biological yield stons/ha., harvest index % in both season, respectively. Meanwhile, irrigation of maize plants every 20 days recorded the lowest ear length, number of kernels/row, number of kernels/ear, 100- kernel weight (g), grain yield tons/ha., straw yield tons/ha., and biological yield tons/ha., but protein content increased with irrigation every 20 days during both seasons (11.09 and 10.38 %).These results reveal that increasing irrigation interval from every 10 to 20 days resulted in a significant decrease in maize plants all parameters except protein %. These finding indicate that high water stress enhanced the growth plants of maize thereby its yield attributes. In this connection Abdel-Aziz and El- Bialy (2004) and Ibrahim and Kandil (2007) as they reported a significant decrease in maize grain yield due to prolonging the irrigation intervals to 18 days. On the other hand, El- Sabbagh (1993) found that the mean values of protein percentage were increased by increasing depletion of soil moisture from 40 to 80 %, while irrigation after 40 % of depleting gave the highest mean values of protein yield of maize.

With regard response of maize hybrids "TWC.352"possessed the highest mean values of most of yield and its components without significant difference with hybrid "S.C. 168" as compared with other hybrid "S.C.166".Also"TWC352"gave the highest protein content in grains (10.97 and 10.17 %) during both seasons of the study, respectively(Tables 2 and 3).This finding may be take place due to the wide genetic base of the three way crosses as compared to single cross hybrids. Similar results were obtained by Atta-Allah (1996) and Attia (1999).

Regarding the effect of humic acid rates, the results detected that application rate 14.40 kg/ha., from humic acids recorded the highest value for most of yield, its components, expect number of rows/ear at 7.20 kg/ha., while the lowest values of all yield characters were resulted from untreated treatment (control) in both seasons (Tables 2 and 3). Also, higher rate of humic acid at (14.40 kg/ha.) recorded higher content protein in grains, meanwhile SC.166 achieved lower protein content in grain during two cropping seasons.

The favorable effect of humic acid treatments might have been due to the effective role in improvement early maize growth more dry matter accumulation and stimulated the building of metabolic products that translocate to grains. Moreover, the describable effects in improvement in plant growth characters such as plant height and ear leaf area which reflected in turn increase in the different yield components such as ear length number of kernels/ear and 100- grains weight. These findings are in coincidence with those recorded by Chen *et al.* (1999), Bakry *et al.* (2009), Attia *et al.* (2013) and Balbaa and Awad (2013).

Table 3: Means of 100- kernel weight (g), straw yield tons ha^{-1} , Grain yield tons ha^{-1} , biological yield tons ha^{-1} , harvest index (%) and protein %of three maize hybrids as influenced by water stress and humic acids during both seasons of 2013and 2014.

Treatments	100 kernel weight (g)		Stover yield tons ha^{-1}		Grain yield tons ha^{-1}		Biological yield tons ha^{-1}		Harvest index (%)		Protein %	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Water stress (W)												
Irrigation every 10 days	35.54	40.46	7.55	7.96	5.61	5.32	13.16	13.27	42.79	39.80	10.54	9.79
Irrigation every 15 days	34.48	39.29	7.31	7.23	4.10	4.73	12.31	11.96	41.03	39.38	10.64	9.87
Irrigation every 20 days	29.68	34.51	7.10	6.49	4.22	3.99	11.31	10.47	37.65	37.91	11.09	10.38
$LSD_{0.05}$	1.75	1.92	1.07	0.1311	0.1024	0.0864	1.073	0.2135	3.515	0.226	0.2883	0.3813
Maize hybrids (H)												
SC.166.	31.37	36.30	7.57	6.89	4.51	4.25	12.08	11.15	37.52	37.98	10.70	9.95
SC.168.	33.75	38.60	7.81	6.89	4.70	4.39	12.50	11.28	38.03	38.81	10.61	9.90
TWC352.	34.60	39.36	6.59	7.89	5.62	5.39	12.21	13.28	45.92	40.30	10.97	10.17
$LSD_{0.05}$	1.76	1.75	0.793	0.184	0.2254	0.1833	0.7183	0.3644	3.307	0.4208	0.3291	0.3572
Humic acid (kg/ha.) (HA)												
0	30.26	35.21	7.41	6.87	4.53	4.27	11.93	11.13	38.33	38.08	9.83	9.09
7.20	30.99	36.01	7.49	7.04	4.77	4.50	12.60	11.54	39.07	38.83	10.47	9.66
14.40	38.46	43.04	7.06	7.77	5.53	5.27	12.59	13.03	44.07	40.18	11.97	11.27
$LSD_{0.05}$	1.63	1.60	0.586	0.1928	0.2171	0.1900	0.5272	0.3779	2.549	0.4208	0.2677	0.2451
Interactions												
W x H	N.S.	N.S.	N.S.	**	**	**	N.S.	**	*	**	N.S.	N.S.
W x HA	*	*	*	**	**	**	N.S.	**	**	**	**	**
Hzbrid x Humic acid	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	**	N.S.	N.S.
W x H x HA	N.S.	N.S.	N.S.	**	**	**	N.S.	**	**	N.S.	N.S.	N.S.

- *, **: significant at 0.05 level of probability. - N.S.: not significant.

Furthermore, results of both tables, also, showed significant the first order and the second order interaction effect among/between irrigation and humic acid rates on three maize hybrids on some characters of yield and its components (Tables 2 and 3).

In Conclusion using irrigation maize plants every 15 days produced highest value of most of growth attributes, yield, it components and protein %, also, the maize hybrid “TWC352” and rate of humic acid 14.40 kg/ha., recorded the highest mean values of most of studied characters under Alexandria conditions.

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