Australian Journal of Basic and Applied Sciences, 6(7): 587-593, 2012
ISSN 1991-8178

Improving Soil Properties, Maize Yield Components Grown in Sandy Soil Under Irrigation Treatments and Humic Acid Application

Ebtisam I. Eldardiry, Sabreen Kh. Pibars and M. Abd El Hady

Water Relations and Field Irrigation Dept, National Research Centre, Dokk, Giza, Egypt.

Abstract: A field experiment was carried out on a sandy soil at Nubaria, Behera Governorate, Egypt, during the summer season of 2011 in a randomized complete block (factorial, two factors) design cultivated with maize plants (*Zea. mays L.*, cv. single cross 10 hybrid). Experiments investigated the effect of three irrigation treatment (100, 75 and 50 %) of evapotranspiration (ETo) and three humic acid treatments (HA_0, HA_1 and HA_2) on the soil properties and maize plant characters. The main results could be summarized as follows: irrigation treatments 75 % of ETo was the best on modified studied plant and soil characters especially WUE, which reflect maximizing production from water unite. HA application additions had a highly significant effect on improving soil characteristics such as aggregate size, soil pH and EC as compared with control treatment. The HA2 was superior on increasing these values. HA treatments under different irrigation treatments had a positive effect on improving soil aggregates especially under I_3 followed by I_2 and lastly I_1 irrigation treatments. While decreasing in irrigation quantity led to increase aggregates in the 1^{st} depth than the 2^{nd} one. Water treatment 75 % is more closely to the crop water requirement of the maize plant. Increasing irrigation water treatments from 50 to 75 improved cob length , cob diameter and no. of grains row on cob by about 73, 84 and 38 %, respectively, while the change under 100 % irrigation treatments were 35, 65; 28 % in same order. Increasing HA concentration led to improve these characters 13, 10; 10 % and 23, 21, 18 for HA_1 and HA_2 comparing with control one. Same trend was observed under fresh and dry weight of maize cob as affected by irrigation treatments, 75 % was superior where it gave increase 71, 7 and 63, 10 % comparing with irrigation treatments 100 and 50 %, respectively. HA has a promotive effect where the increase on the grain yields of maize plant by about 15.8 and 27.8 % for HA_1 and HA_2 above the control treatment, respectively.

Key words: Sandy soil, water treatment, humic acid, soil properties, maize characters.

INTRODUCTION

Today, there is a recognized and increasing use of humic acids for their beneficial impact on the growth and cultivation of crops particularly in organically-deficient soils. Humic substances consist of a heterogeneous mixture of compounds for which no single structural formula will be sufficient (Baigorri *et al*., 2009). Humic acid is not a fertilizer as it does not directly provide nutrients to plants, but is a compliment to fertilizer. Benefits include: i) Addition of organic matter to organically-deficient soils, ii) Increase root vitality, iii) Improved nutrient uptake, iv) Better formation and stability of aggregates, vi) Increased both water and fertilizer retention, and vii) Stimulate beneficial microbial activity (Wahdan *et al.* 2006). There is a long history of using humic and fulvic acids to improve nutrient uptake (Mackowiak *et al*., 2001). Humates possess extremely high ion-exchange capacities, which allow them to hold cations in a way that makes them more easily available to plant roots and thus improve micronutrient transfer to the plant's circulation system. HA is particularly effective when added with banded fertilizer at the time of planting.

World population will be increasing and to reduce the food insecurity, crop production will have to be doubled. This can be fulfilled by expanding cultivable area and/or increasing soil crop productivity. Also, water is a vital factor for plant growth, development and productivity. So, maximizing crop production from water unite is took place (Huang *et al*., 2007). There are specific problems in the management of sandy soils including their excessive permeability, low water and nutrient holding capacities (Suganya and Sivasamy, 2006).

maize is one of the most important cereal crops especially in Egypt, whether a great attention has been paid to increase its total production, particularly if it is used in the manufacture of bread. In the newly reclaimed desert area through the agronomic practices such as application of bio, organic and/or mineral fertilization are used. This is emphasized by the findings outlined by Moussa *et al* (1998) for the applied micronutrients (Fe, Mn and Zn) and in turn encouraging the vegetative growth and increasing crop yields, even over that of chemically fertilized systems.

This study aimed to evaluate the effect of irrigation treatments and/or humic acid as soil application on some soil characteristics and maize yield and its components.

Corresponding Author: Ebtisam I. Eldardiry, Water Relations and Field Irrigation Dept, National Research centre, Dokki, Giza, Egypt
E-mail: Ebtisam_eldardiry@yahoo.com

MATERIALS AND METHODS

To achieve the aforementioned objectives, a field experiment was carried out on a sandy soil at National Research Centre experimental Station at Nubaria, Behera Governorate, Egypt, during the summer season of 2011 cultivated with maize plants (*Zea. mays L*., cv. single cross 10 hybrid) about 12000 plants per feddan (4200 m^2). Drip irrigation method was used in irrigation and lateral diameter was 16 mm and distance among 30 emitter cm (4 litre/h). The surface soil sample (0-20 cm) of the experimental area was subjected to the different laboratory analysis to determine some physical and chemical properties according to the standard methods (Rebecca, 2004). Soil texture is loamy sand. Values of the soil pH (1:2.5), Soil EC (extracted soil paste), $CaCO_3$, OM and soil exchangeable capacity were 8.05, 1.82 dS/m, 3.6 %, 0.28 % and 7.47 CEC meq/100 g soil, respectively.

The experimental design was a randomized complete block (factorial, two factors) irrigation treatment 100, 75 and 50 % of ET_o (2931,2198 and 1465 m^3/fed/ season) (I1, I2; I3) in the main plot and humic acid treatments HA_0, HA_1; HA_2 (0, 1 and 2 g/litre) in sub main plot with three replicates.

Maize grains (single cross 10 hybrid) were sown at the 1st June 2011. Calcium superphosphate (15 % P_2O_5) was added to each plot before sowing, while urea (46 % N) and potassium sulphate (48 % K_2O) were added in two equal doses, i.e., 15 and 40 days after planting in recommended doses. The samples were taken at harvest to ear length (cm), number of row /cob and grain number/row); grain yield (kg/fed). Aggregate was determined by dry sieving for set 2.00 and 0.85 mm and classified in > 2.00 , 2.00-0.85 and < 0.85 mm after (Haynes and Swift, 1990). Hydraulic conductivity (HC) was measured in the laboratory under a constant head technique (Klute and Dirksen, 1986) using the following formula:

$$HC = (QL)/(At\ \Delta H)$$

Where:
HC: water quantity flowing through saturated soil sample / unit time,
Q: volume of water flowing through saturated soil sample per unite time (L^3/t),
A: cross sectional flow area (L^2) L: length of the soil sample and
ΔH: differences in hydraulic head across the sample (L) and t: time (hr). Soil water retention at 0.1 (field capacity) 15.0 (wilting point) bars and available water were 13.2, 5.6 and 7.6 % on weight basis after Klute (1986).

Data were subjected to analysis of variance in split plot design, irrigation treatments (main plot) and HA treatments (submain plots) and correlation and multiple regressions were estimated after computer's program provided by SAS (2001).

RESULTS AND DISCUSSION

Soil pH and EC

Table (1) illustrate the effect of irrigation treatments and humic acid (HA) as soil application on soil pH and salinity (EC) and aggregate size distribution (dry sieving) at the end of maize season, data noticed that the highest and lowest values of the soil pH and EC were 8.22, 0.85 dSm^{-1} and 7.89, 0.29 dSm^{-1} at $I_3 \times HA_1 \times d_1$; $I_1 \times HA_2 \times d_2$ and $I_1 \times HA_2 \times d_2 \times d_1$; $I_3 \times HA_0 \times d_2$, respectively.

With respect to the irrigation treatments effect on soil pH, data could be arranged in descending order as follows: I3 > I2 > I1 and the opposite were true in case of EC values. Also, HA application changed soil pH by about 0.37 and -0.49 % for HA1 and HA2 comparing with control one, respectively. While application HA1 and HA2 led to increase soil EC by about 51 and 74 % above the untreated plot, respectively. This finding could attribute to ability of HA to retain more nutrients and keep it from leaching and its content from K (Rajpar *et al*., 2011).

Regardless soil depth, there is no clear trend for application HA under different irrigation treatments, whereas HA soil application improve soil EC with increasing HA concentration except under irrigation treatments 100% from ET_o.

Aggregates Distribution:

Regarding to the dry aggregate size distribution as affected by irrigation treatment and HA as a soil application (Table 1), results showed that mostly the first soil depth was improved as a result of HA application under all HA treatments except d_2, $HA_2 \times I_1$ irrigation treatments. Also, data pointed that maximum values of the aggregates size < 0.85 mm, > 0.85-2.00 mm and > 2.00 mm were obtained in the 1st depth as a result of treated soil by HA soil application, except 2nd depth under control treatment, which affected by weight of the previous depth (d_1), migration fine particles and dominant of the coarse ones. HA treatments under different irrigation treatments had a positive effect on improving soil aggregates especially under I_3 followed by I_2 and lastly I_1 irrigation treatments.

According to the effect of irrigation treatments, decreasing in irrigation quantity led to increase aggregates in the 1st depth than the 2nd one, which attributed mainly to dilution effect of the HA application from side and concentrated moisture in this depth and hence increasing in root distribution is expected and its exudates and their role in binding sandy particles to form stable aggregates

Table 1: Effect of water treatments and humic concentration on the aggregate size and soil pH and EC.

Irrigation treatments (ID)	Humic acid (HA)	Soil depth	pH	EC dSm^{-1}	Aggregate size distribution %		
					<0.85mm	0.85- 2.00mm	>2.00 mm
I1	HA_0	d_1	8.05	0.28	11.9	18.3	69.8
		d_2	8.09	0.28	11.3	16.9	71.8
	HA_1	d_1	8.01	0.62	10.4	21.3	68.3
		d_2	8.06	0.77	11.7	19.4	68.9
	HA_2	d_1	7.89	0.71	15.3	20.8	63.9
		d_2	7.92	0.85	14.1	21.1	64.8
	Mean		**8.09**	**0.68**	**12.5**	**19.6**	**67.9**
I2	HA_0	d_1	8.14	0.30	10.8	18.5	70.7
		d_2	8.14	0.30	12.1	16.9	71.0
	HA_1	d_1	8.06	0.46	12.3	21.3	66.4
		d_2	8.13	0.64	10.9	17.7	71.4
	HA_2	d_1	8.14	0.76	16.5	19.5	64.0
		d_2	8.14	0.81	13.2	18.3	68.5
	Mean		**8.13**	**0.55**	**12.6**	**18.7**	**68.7**
I3	HA_0	d_1	8.15	0.31	12.2	15.5	72.3
		d_2	8.12	0.29	13.9	20.6	65.5
	HA_1	d_1	8.22	0.42	15.2	19.8	65.1
		d_2	8.21	0.39	11.3	16.1	72.6
	HA_2	d_1	8.09	0.54	18.3	18.8	62.9
		d_2	8.03	0.55	12.6	18.2	69.2
	Mean		**8.14**	**0.42**	**13.9**	**18.2**	**67.9**
LSD 5%	ID		0.02	0.12	0.6	0.4	0.5
	HA		0.01	0.09	0.4	0.3	0.3
	ID x HA		0.01	0.07	0.3	0.2	0.2

I_1:100 %, I_2: 75 %, I_3: 50 % from ETo, HA: humic acid

With respect to the HA treatments, the increase percentage of aggregate percentage were 1.5, 3.8; 2.0 , 4.5 and 9.9, 14.5 % for aggregates size > 2.00 mm, 0.85-2.00and < 0.85 mm comparing HA_1 and HA_2 with HA_0 (control), respectively. Regardless HA effect, increasing irrigation treatment from I_3 to I_1 led to decrease aggregates in the same trend while the opposite was true in other estimated aggregate size. This finding agreed with obtained by Hagen *et al* (1988) and Tayel *et al* (2010) who found that HA has a great effect on the formation of the aggregate the decrease soil runoff and erosion by wind.

Hydraulic Conductivity:

The effect of different irrigation treatments and HA as soil application on the hydraulic conductivity (HC) was illustrated in Fig. (1). Data on hand revealed that the highest values of the HC (not preferable property) in HA control treatments under studied different irrigation treatments, while the lowest ones were obtained in HA_2 under irrigation treatments I_3 (12.55 cm/h), I_2 (12.05 cm/h) and I_1 (10.45 cm/h). According to the irrigation treatments effect on soil HC, results pointed that irrigation treatments I_2 and I_1 improved HC values by about 1.2 and 13.2 % comparing with control one (irrigation deficit I_3). Regardless the effect of the irrigation deficit, application of HA with different rates was improved water movement in soil by about 13.5 and 21.0 % for HA_1 and H_2 comparing with untreated one.

Also, one can notice that irrigation treatment I_3 has negative effect on the HA application due to mainly to the dilution effect, especially on the 1st layer under 1st HA application rate. While low amount of water applied to the soil (I_1 and I_2) has a good effect on both HC and soil aggregates formation where the happened improvement was attributed to the wet dry cycles (as affected by soil moisture content among two irrigation). These cycles affected indirectly on the aggregate formation and hence on the pathways of the soil water.

Results of HC and aggregate percentages were in harmony with those obtained by Metwally and Khamis (1998) who mentioned that HA play an important role in fixation of soil pathway and increase aggregate stability especially during irrigation. The added also that humus functions to improve the soil's water holding capacity through increase micro structure and macro aggregates which have ability to retain more water . So the most important function of HA within the soil is their ability to hold water. They mentioned that HA help create a desirable soil structure that facilitates water infiltration and helps hold water within the root zone because of their large surface area and internal electrical charges. These aggregates are formed by electrical processes which increase the cohesive forces that cause very fine soil particles and clay components to attract each other. Once formed these aggregates help create a desirable crumb structure in the top soil, making it more friable. Soils with good crumb structure have improved tilth, and more porous openings (open spaces). These pores allow for gaseous interchange with the atmosphere, and for greater water infiltration. Soils which contain adequate HA have improved tilth and are thus more efficiently maintained for crop production (Tayel *et al*., 2010).

Plant Characters:

Regarding to the plant characters such as plant height, plant diameter and leaf length of the cob, data attained that irrigation treatment I_2 was the most effective treatments on improving maize plant characters followed by I_1, comparing with control ones. Also, increasing HA by double improved all the previous studied maize plant characters. The values of these increases were 9, 20; 20, 50 and 5 and 21 % for HA_1 and HA_2 comparing with untreated plots for plant height, plant diameter, S length and leaf length of the cob, respectively.

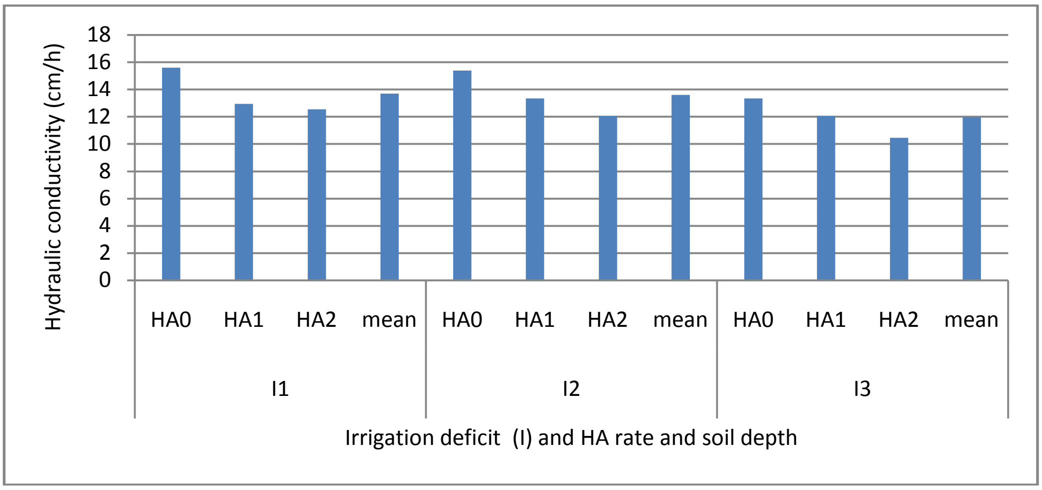

Fig. 1: Effect of irrigation deficit and humic acid as soil application on soil hydraulic conductivity. (LSD 5% irrigation deficiencies: 0.5, HA: 0.3 and interaction: 0.2).

Regarding to the studied plant characters (Table) results showed that increasing irrigation water treatments from I_3 to I_2 improved cob length, cob diameter and no. of grains row on cob by about 73, 84 and 38 %, respectively, while the change under I_1 irrigation treatments were 35, 65; 28 % in same order (El Nagar, 2003 and Ibrahim *et al*., 2005).

With respect to the HA effect on the same previous maize characters, data pointed that increasing HA concentration led to improve these characters 13, 10; 10 % and 23, 21, 18 for HA_1 and HA_2 comparing with control one. Same trend was observed under fresh and dry weight of maize cob as affected by irrigation treatments, I_2 was superior where it gave increase 71, 7 and 63, 10 % comparing with irrigation treatments I_1 and I_3, respectively. The maximum and minimum values of K fresh and dry weight were obtained at I_2, I_3 and HA_2, control at irrigation treatment and HA treatments, respectively.

These findings were in harmony with those obtained by Mishra *et al* (1996) and Badawy (2008) who stated that plant growth is influenced directly and indirectly by HA. Positive correlations between the humus content of the soil. Indirect effects are those factors which provide energy for the beneficial organisms within the soil, influence the soil's water holding capacity, influence the soil's structure, release of plant nutrients from soil minerals, increased availability of trace minerals, and in general improved soil fertility.

Table (2) recorded grain yield under different irrigation water treatments and HA application. The highest and the lowest value of the maize grain yield were obtained under irrigation water I_2 (3504.7 kg/fed) at HA_2 and I_3 (1885.3 kg/fed) at control treatment. Whereas, the grain yield of maize plant at irrigation treatments I_2 and I_3 represented 70.7 and 67.0 % relative to the I_1 irrigation treatments, respectively. Regardless effect of water deficit, HA has a promotive effect where the increase on the grain yield of maize plant by about 15.8 and 27.8 % for HA_1 and HA_2 above the control treatment, respectively.

With respect to the water use efficiency (WUE), data revealed that there is no significant deference between irrigation deficit I_3 (1.52) and I_2 (1.53 kg grain yield /m^3 irrigation water) in addition to the control one (1.08), which increased by about 40.7 and 41.7 kg grain/m^3 irrigation water comparing with control treatment, respectively. Values of the WUE of the maize grain yield were 0.85, 1.32 and 2.18 kg grain yield /m^3 irrigation water for control, HA_1 and HA_2, respectively. While values of the WUE as result of application of HA, the maize grain yield increased by about 55.3 and 156.5 % for HA_1 and HA_2 comparing with untreated plot. These results attributed mainly to the increase of humic acid application rates was associated with the decrease of nutrients leaching, which was reflected on increasing macro- and micronutrient concentrations in potato leaf tissues (Selim *et al* 2012). They added also that water unstressed plants were found to be more efficient than water stressed plants on improving plant growth parameters and tuber production, biochemical indicators and leaf mineral nutrient contents. In addition, such integrated effect leads to accumulate both organic and mineral substances that are essential to plant growth, stimulating and activating the biochemical processes in plants which increasing the grain yield and improving its quality (Malik and Azzam, 1986 and Rajpar *et al* (2011). They reported that humic acid efficiently improves soil fertility and crop productivity, especially on poorly fertile and alkaline-calcareous soils.

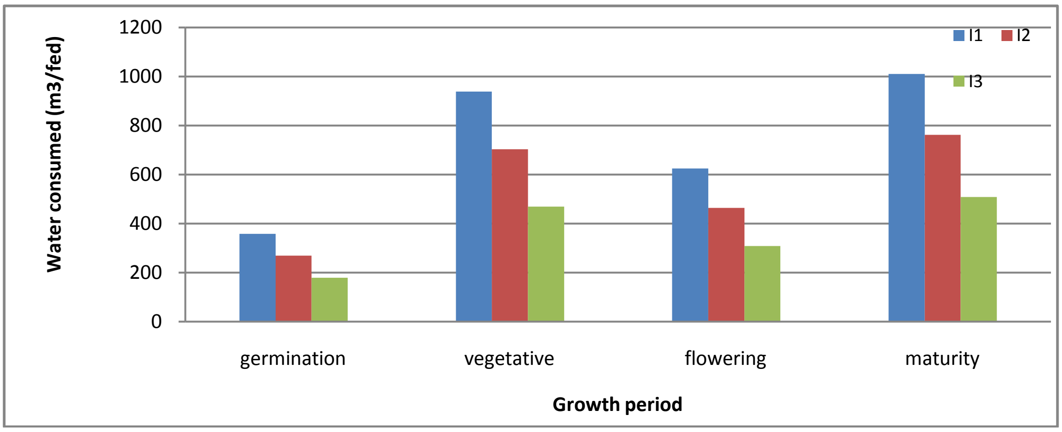

Fig. 2: Water consumed during different growth period of maize plant.

According to obtained result the Fig. (2) illustrate that irrigation water consumed during maize growth period were 2932, 2198; 466.0 m^3/season and 598, 523; 349 mm/season for irrigation treatments I_1, I_2 and I_3 , respectively. Comparing to the FAO value (500-750 mm/season), the applied irrigation of the studied water treatments represented about 93, 70 and 74% relative to the maximum value of FAO value (750 mm/season). This result was in harmony with that obtained by (Abd El Hady *et al*., 2006 and Fereres and Soriano, 2006) who reported that water consumed by maize plants is strongly affected by growth period and the highest amount of irrigation water consumed were recorded in maturity followed by vegetative growth periods and the lowest one was consumed during germination.

Table 2: Effect of irrigation treatments and humic acid as soil application on some maize plant characters.

Irrigation treatments	HA g/l	Maize cob			Plant weight (g)		Plant height	Shoot diameter	Internodes	Length of leaf/cob	Grain yield kg/fed
		Length cm	Diameter cm	No. of row	Fresh	Dry	cm				
I_1	HA_0	23.3	4.6	12.0	381.7	235.3	232.0	1.42	6.4	70.7	2460.0
	HA_1	26.3	4.9	14.3	403.7	265.7	272.7	1.65	5.2	74.3	3187.3
	HA_2	30.3	5.9	15.3	422.0	297.3	285.3	1.93	6.3	81.0	3439.3
	Mean	26.7	5.1	13.9	402.4	266.1	263.3	1.67	6.0	75.3	3165.6
I_2	HA_0	24.0	5.1	13.7	415.7	269.7	271.0	1.63	7.0	80.3	3168.7
	HA_1	27.3	5.7	15.0	439.7	291.7	275.3	1.87	8.0	82.0	3346.0
	HA_2	30.3	6.3	16.3	441.7	313.3	307.0	2.27	7.8	87.3	3504.7
	Mean	27.2	5.7	15.0	432.3	291.6	284.4	1.92	7.6	83.2	3339.8
I_3	HA_0	18.3	3.0	10.7	216.7	153.0	172.0	0.69	7.8	56.7	1885.3
	HA_1	20.7	3.2	10.7	236.7	172.0	196.3	0.88	7.7	62.0	2170.0
	HA_2	20.3	3.2	11.3	303.0	212.0	220.3	1.16	8.5	64.3	2655.3
	Mean	19.8	3.1	10.9	252.1	179.0	196.2	0.91	8.0	61.0	2236.9
LSD 5%	ID	0.4	0.3	1.2	9.4	13.7	14.5	0.21	0.7	4.1	78.2
	HA	0.3	0.2	0.9	8.7	11.3	12.1	0.17	0.5	3.2	77.1
	ID x HA	0.2	0.2	0.7	7.3	9.6	10.3	0.15	0.4	2.7	62.1

I_1:100 %, I_2: 75 %, I_3: 50 % from ETo, HA: humic acid

According to the correlation coefficient, reduction in soil HC (improvement) was correlated positively with the aggregate size < 0.85 (r = 0.782**) followed by 0.85 – 2.00 mm (r: 0.778**). This finding attributed mainly to the effect of both low amount of irrigation treatments (I_2 and I_3) from side and HA application from the other one which help mainly in aggregate formation. These aggregates size was responsible on the storage water in soil. With respect to the pH and EC values, HA rates correlated positively with EC (0.852**) and negatively with (r: 0.654*). Also, most of the studied plant characters were correlated positively with HA rates, especially Yield negatively with I_3 (r: -0.654*), I_1 (r: -0.564*) and positively with irrigation treatments I_2 (0.756**). These finding were in harmony with those obtained by authors.

Conclusion:

It was noticeable from the results that irrigation treatments I_2 was the best one on modified studied plant and soil characters especially WUE, which reflect maximizing production from water unite and has a promotive effect on the most studied plant characters. HA application had a highly significant effect on improving soil characteristics such as aggregate size, soil pH and EC as compared with control treatment. HA_2 was superior on increasing these values. Our findings also revealed that, irrigation treatments I_2 is more closely to the crop water requirement of the maize plant.

REFERENCES

Abd El Hady, M.A., M.S. El Habba, N.A. Noureldin and M.F. Hamed, 2006. Response of wheat productivity and quality to bio-organic and inorganic fertilizers. Annals Agric. Sci., Ain Shams Univ., 51(1): 103-111.

Badawy, A.A., 2008. Effect of water stress and some conditioners on the productivity of peanut crop and water relation in sandy soil. J. Biol. Chem. Environ. Sci., 3(1): 445-454.

Baigorri, R., M. Fuentes, G. González-Gaitano, J.M. García-Mina, G. Almendros and F.J. González-Vila 2009. Complementary multi analytical approach to study the distinctive structural features of the main humic fractions in solution: Gray humic acid, brown humic acid, and fulvic acid. J. Agric. Food Chem., 57: 3266-3272.

El Nagar, G.R., 2003. Integrating of mineral and bio-fixed nitrogen fertilization in maize production under different irrigation regimes. Assiut J. of Agric. Sci., 34(5): 53-75.

Fereres, E. and M.A. Soriano, 2006. Deficit irrigation for reducing agricultural water use. Journal of Experimental Botany, 6: 1-13.

Hagen, L.J., E.L. Skidmore, J.B Layton, 1988. Wind Erosion Abrasion: Effects of Aggregate Moisture. TRANSACTIONS of the ASAE., 31(3):725-728.

Haynes, R.J. and Swift, 1990. Stability of soil aggregates in relation to organic constituents and soil water content. J. Soil Sci., 41: 73-83.

Huang, M.L., X.P. Deng, Y.Z. Zhao, S.L. Zhou, S. Inanaga, S. Yamada, K. Tanaka, 2007. Water and nutrient use efficiency in diploid, tetraploid and hexaploid wheats. J. Integr. Plant Biol., 49: 706-715.

Ibrahim, A.M., S.A. Seaf, El Yazal and R.G. El Sayium, 2005. Response of maize vegetative growth and yield to partial N-mineral replacement by biological nitrogen fixation under different soil moisture stresses. J Agric. Sci. Mansoura Univ., 30: 2259-2273.

Klute, A. and A. Dirksen, 1986. Hydraulic conductivity. In A. Klute (ed.), Methods of Soil Analysi, Part1, Physical and mineralogical methods. 678-734, 9 ASA and SSSA, Madison, WI.

Klute, A., 1986. Water retention: Laboratory methods. In A. Klute (ed.), Methods of Soil Analysi, Part1, Physical and mineralogical methods. 635-662, 9 ASA and SSSA, Madison, WI.

Mackowiak, C., P. Grossl and B. Bugbee, 2001. Beneficial effects of humic acid on micronutrient availability to wheat. Soil Sci. Soc. Am. J., 65(6): 1744-1750.

Malik, K.A. and F. Azam, 1986. Effect of humic acid on wheat *(Triticum aestivum* L.) seedling growth. Environ. and Exp. Botany, 25: 245- 252.

Metwally, Sh.M. and M.A. Khamis, 1998. Comparative effects of organic and inorganic nitrogen sources applied to a sandy soil on availability of N and wheat yield. Egypt. J. Soil Sci., 38: 35-54.

Mishra, O.R., U.S. Tomari, R.A. Sharma and A.M. Rajput, 1995. Response of maize to chemical and bio-fertilizers. Crop Res. Hisar., 9(2): 233-237 (c.f. Field Crops Abs., 1996, 49: 2310).

Moussa, B.I.M., M.S.A. Dahdoh and H.M. Shehata, 1998. Interaction effect of some micronutrients on yield, elemental composition and oil content of peanut. Comm. Soil Sci. Plant Anal., 27(5-8): 1995-2004.

Rajpar, M.B. Bhatti, Zia-ul-hassan, A.N. Shah and S.D. Tunio, 2011. Humic acid improves growth, yield and oil content of *brassica compestris* L. Pak. J. Agri., Agril. Engg., Vet. Sci., 2011, 27(2): 125-133.

Rebecca, B., 2004. Soil Survey Laboratory Methods Manual.(Soil Survey Laboratory Investigations Report No. 42.

SAS, Institute., 2001. SAS statistics users' guide. Release 8.2. SAS Institute, Cary, NC.

Selim, E.M., Shaymaa I. Shedeed, Faiz F. Asaad and A.S. El-Neklawy, 2002. Interactive effects of humic acid and water stress on chlorophyll and mineral nutrient contents of potato plants. Journal of Applied Sciences Research, 8(1): 531-537.

Suganya, S. and R. Sivasamy, 2006. Moisture retention and cation exchange capacity of sandy soil as influenced by soil additives. J. Appl. Sci. Res., 2: 949-951.

Tayel, M.Y., M. Abd El-Hady and Ebtisam I. Eldardiry, 2010. Soil Structure Affected by Some Soil Characteristics. American-Eurasian J. Agric& Environ. Sci., 7(6): 705-712.

Wahdan, A.A.A., A.A. Awadalla and M.M. Mahmoud, 2006. Response of some wheat-maize cropping sequence in a calcareous soil to some mineral or chelated micronutrient forms added to soil in combination with sulphur and organic manures. Fayoum J. Agric. Res. & Dev., 20(1): 25-39.