Effect of Some Organic Soil Conditioners Under Drip Irrigation System on Improving Quantity and Quality Maize Yield

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ABSTRACT:

The main purpose of this work was to evaluate the possible use of some organic soil-conditioners under drip irrigation system to improve the quality and yield of maize crop (*Zea mays L.*, cv. single cross 10 hybrid. To achieve this target a field experiment was carried out on a private farm at Sedmant El Gabal village, Beni-Suef Governorate, Egypt, which represents one of those are occupying the desert zone adjacent to the western edge of the Nile Valley during the summer seasons of 2010 and 2011. The irrigation water resource was used as a mixture of agricultural drainage saline water with the Nile water at a ratio of about 1:1 (C2S1, ECiw = 1.89 dS/m and SAR = 5.35). The applied organic soil conditioners individual or in combined treatments were solid K-humate (12% K_2O) at a rate of 1.50 kg fed^{-1}, and 3.00 kg fed^{-1} solid calcium alginate, which were thoroughly mixed with the 5 cm soil surface layer.

The obtained data reveal that the studied soil is mainly encompassing the wind blown sand deposits as a parent material, and it is classified as Typic Torripsamments, siliceous, hyperthermic and it could be evaluated as marginally suitable. The results also show that usage of saline water resulted in relative increases of the ECe and ESP values in the root zone reached 18.60 and 32.75 % as compared to the initial state of soil, respectively. Meanwhile, the corresponding relative increases of the ECe in case of soils amended with K-humate, calcium alginate and K-humate + Calcium alginate were 4.56, 11.23 and 2.46 %, vs 10.12, 3.47 and 1.16 % for the ESP values, respectively, with its optimal case at K-humate + Calcium alginate. Moreover, the applied K-humate and calcium alginate individualy or in combined treatments played an important role in improving the values of soil bulk density, total porosity, field capacity, available water, hydraulic conductivity, organic matter content, pH, CEC and available nutrients. The latter may be due to modified air-moisture regime that leads to alleviate the depressive effect of salinity stress on the released nutrient from organic residues.

These favourable conditions of the improved soil due to amendments or conditioners treatments positively reflected on the maize vegetative growth characters (i.e., plant height, dry weight of leaves/plant, leaf contents of chlorophyll a & b, total carbohydrates and sugars); ear characters and grain yield (i.e., ear length, ear diameter, ear weight, raw number/ear, grain number/raw, grain number/ear, weight of 100 grain and grain yield/fed.) and grain quality parameters (i.e., its contents of reducing sugars and crude protein % as well as macro- & micro-nutrient contents of N, P, K, Fe, Mn, Zn and Cu), with superiority to the combined treatment (K-humate + Calcium alginate). It is evidently that such beneficial effect of K-humate and Calcium alginate on the dry matter production was more attributed to the leaves area and number, which are contributed to more photosynthesis and better carbohydrates yield. Also, the ability of K-humate and calcium alginate for increasing plant nutrient uptake which may be rendered to its chelating property that resulted in significant increases for N, P and K in maize leaves. On the other hand, the reverse was true for Na and Cl, probably due to alleviate the harmful effect of saline irrigation water. The parameters of maize quality, i.e. contents of reducing sugars and crude protein % showed significantly increased when treating the soil with saline irrigation water treatments with K-humate and calcium alginate as compared to the control treatment (saline water solely). Thus, the present study shows that the best applied treatment was K-humate + calcium alginate for achieving the greatest maize yield of high quality.

Key words: Sandy soil, maize, K-humate, calcium alginate, drip irrigation system, saline irrigation water, maize vegetative growth and quality.

INTRODUCTION:

The continuous extension in reclamation and cultivation of desert soils of Egypt either those are characterized by calcareous or sand in nature as well as the development of their techniques have become urgent and essential due to the tremendous increase in population. Such extension needs new surface or underground water supplies due to the inadequate of the Nile water supply for irrigating the agricultural new areas beside the ancient ones. Hence, the reuse of drainage water mixed or even not mixed with the Nile water may be the only possible choice in such specific localities. The continuous usage of such low quality water on the short or long run is expected to cause a deterioration of soil characteristics depending on physical or chemical composition of irrigation water. For example, the hazardous effect of applied saline irrigation waters depends mainly on their salinity levels and attained specific ions as well as soil nature **(Rajesh and Bajwa, 1997)**.

Hence, soil management practices of sandy soils are usually carried out through addition of natural or chemical soil amendments that have become one of the most important practices for improving physical and chemical properties of these soils, and in turn enhancing their productivity. Several recent studies indicate that addition of some organic soil-conditioning materials to sandy soil is necessary due to their unique ability to improve chemical, hydrophysical and biological characteristics of soils or growing media. However, their buffering effects help in maintaining an uniform reaction in soil media, beside to their altimated water holding power which reach up to 20 times their weight water. This is important particularly for sandy soils to improve soil moisture conditions, especially during summer seasons. It is evident that humic acid plays a very important role in metal mobilization, availability of nutrients, chelation of heavy metals from soils and adsorbed on the mineral surfaces by functional groups. Moreover, the functional groups gave key information regarding the nature, reactivity and the chemical structures of the humic substances **(El Ghazoli, 1998 and Abdel Fattah and Abdel Hady, 2004).**

In regard to the potential of the humic acids, continuous development has led to availability of various commercial humic acid based products and they are widely marketed. The humic acid products are usually available in the form of inexpensive soluble salts, referred to as potassium humate **(Fong *et al.,* 2007)**. Potassium humate causes an increase in crop quality and tolerance of plant to drought, saline, cold, diseases and pests stresses **(Gadimov *et al.,* 2007)**.

Calcium alginate (C_6 H_7 $Ca_{1/2}$ O_6)n as hydrogels are the cross-linked networks containing a large fraction of water, which were used as the precursors of calcium carbonate ($CaCO_3$) mineralization for the first time. The well-defined geometry, the permeability, and the ion-exchange property of these pregels favored the facile fabrication of calcite superstructures through the slow in pouring of ammonia and carbon dioxide gases. When calcium alginate hydrogels sponged up a relatively high amount of liquid, the resulting products with the outside calcite sequences transcribed the sponge like pregel beads with the outside nucleation sites of carboxyl groups.

Alginic acid is a naturally occurring hydrophilic colloidal polysaccharide obtained from the various species of brown seaweed (Phaeophyceae). It is a linear copolymer consisting mainly of residues of ß-1,4-linked Dmannuronic acid and a-1,4-linked L-glucuronic acid. These monomers are often arranged in homopolymeric blocks separated by regions approximating an alternating sequence of the two acid monomers. On the other hand, alginic acid acts as seaweed extract to control alternate bearing soil-conditioning agent. It combines with metal radicals in the soil, forming polymers of greatly increased molecular weight. These cross-linked polymers improve the water-holding characteristics of the soil **(Verkleij, 1992**

and Lattner *et al.,* 2003) which, consequently, stimulates root growth and the activities of beneficial microorganisms **(Chen *et al.,* 2003).**

Management of saline irrigation water must be oriented to minimize the salinity level of soil as well as to provide an adequate environmental for plant roots. **Daif *et al.*, (2004)** found that humic acid drastically reduced anions sorption either when added with them or introduced before. The reduction rate is dependent on the concentration of organic ligands, pH value of the system and chain length and/or carboxyl density as well as the way in which anions and humic acid are added. The most effective concentration of humic acid is 11.6% w/w. **Salib (2002) and Abou-Zied *et al.,* (2005)** reported that application of humic acid, as an organic soil amendment resulted in a significantly increase in crop yield and its components in the sandy soils. This is due to its positive effects on improving hydrophysical properties and nutrients availability in such soils as well as maintaining favourable soil media for the nutrients uptake by the grown plants.

In Egypt, maize is one of the most important cereal crops, whether a great attention has been paid to increase its total production, particularly in the newly reclaimed soils through the agronomic practices such as application of some organic soil-conditioning. This is emphasized by the obtained findings by **Mona *et.al.*, (2011)** for the application of K-humate and calcium alginate and their beneficial effects on some soil characteristics, vegetative growth and crop yield of plants grown in sandy soil with a significant superiority for the combined treatments .

To gain more benefits about organic materials, this work was undertaken using K-humate and calcium alginate under a drip irrigation system to evaluate positive role their in improving maize yield, its quality and alleviating the hazardous effect of saline water.

MATERIAS AND METHODS:

The main purpose of this work was to improve maize yield (Zea mays L., cv. single cross 10 hybrid), its quality and alleviate the harmful impacts of salinity stress under drip irrigation system. The applied organic soil conditioners were solid K-humate (12% K_2O) at a rate of 1.50 kg fed^{-1}, as individual or combined with solid calcium alginate at a rate of 3.00 kg fed^{-1}, then they were thoroughly mixed with drip irrigation system. The applied saline irrigation water represents a mixture of agricultural drainage (3.27 dS/m) and the Nile fresh water (0.56 dS/m) with a ratio of about 1:1. The chemical analyses of the above-mentioned irrigation water resources are presented in Table (1).

A field experiment was conducted on a sandy soil at a private farm occupied a portion of the desert zone adjacent to the western edge of the Nile Valley, namely Sedmant El Gabal village, Beni-Suef Governorate, Egypt, during the summer seasons of 2010 and 2011. Some physical and chemical properties of the studied soil were determined and presented in Table (2). The experimental treatments were arranged as follows: **1)** saline irrigation water treatment alone (as control), **2)** saline irrigation water treatment added to K-humate at a rate of 1.50, 3.00 kg fed^{-1} **3)** saline irrigation water treatment added to calcium alginate at a rate of 3.00 kg fed^{-1} and **4)** saline irrigation water added to K-humate + calcium alginate .

The IR (infra red) bands of the used K-humate were identified according to the standard method described by **Kononova, (1966)** to identify the active groups **(Stevenson, 1994)**, as shown in Table (3). It is noteworthy to mention that the active –OH and –COOH represent pronounced values, so as K-humate is considered as a best metabolic effect. In addition, **Nardi et al., (1999)** suggested that humic fractions exhibited an auxin like activity.

Table (1): Chemical analysis of the used irrigation water sources.

Water characteristics	The Nile water	Drainage water	Mixed Water
pH	7.32	7.81	7.46
ECiw (dS/m)	0.56	3.27	1.89
Total dissolved solids (mg/l)	358.4	2092.8	1209.6
Soluble ions (meq L^{-1}):			
Ca^{++}	1.61	5.34	4.78
Mg^{++}	1.19	7.16	3.12
Na^{+}	2.50	19.00	10.65
K^{+}	0.35	1.45	0.60
CO_3^{--}	0.00	0.00	0.00
HCO_{3-}	2.20	9.00	5.75
Cl^{-}	2.35	15.38	9.86
SO_4^{--}	1.10	8.57	3.54
SAR	2.13	7.60	5.35
RSC	--	--	--
Irrigation water suitability	C1S1	C3S2	C2S1

Table (2): Some physical and chemical properties of the studied soil*.

Soil characteristics	**Value**	**Soil characteristics**	**Value**
Particle size distribution :		*Soluble cations (soil paste, meq/l)*:	
Sand%	89.20	Ca^{2+}	9.37
Silt%	7.40	Mg^{2+}	3.48
Clay%	3.40	Na^{+}	15.60
Textural class	Sand	K^{+}	0.25
Soil physical properties:		*Soluble anoions (soil paste, meq/l)*:	
Bulk density g cm^{-2}	1.63	CO_3^{2-}	0.00
Total porosity %	38.50	HCO_3^{-}	2.55
Available water %	7.41	Cl^{-}	15.90
Hydraulic conductivity cm h^{-1}	10.25	SO_4^{2-}	10.25
Field capacity %	12.57		
Wilting %	5.12		
Soil chemical properties:		*Available macro and micronutrients (mg/kg)*:	
pH (1.25 soil water suspension)	7.98	N	13.09
$CaCO_3$ %	1.65	P	3.20
Gypsum %	0.23	K	46.75
Organic matter %	0.19	Fe	3.18
CEC (meq/100 b soil)	4.15	Mn	0.92
ESP	3.46	Zn	0.75
Ece (dS/m, soil paste extract).	2.85	Cu	0.53

***Determined after (Page et al., 1982 and Klute, 1986)**

Table 3: Some chemical compositions of the used K-humate

Typical Analysis

Humic Acid	Potassium	Moisture	Water Soluble Potassium Humate (dry)
70% min	10%	15% max	85% min

Properties

pH	Solubility	Appearance
9-10	90%	Black granules

Organic Components

C	H	O	N	S
45-55%	1-3%	25-33%	0.5-1% 2.09	0.1-0.3%

Minerals

Na	K	Ca	Mg	Fe	Cu
0,5% Max	10-15% Min 3.42	0.5% Min	0.05% Min	1500 mg/kg Min	5mg/kg Min
Zn	**Mn**	**P**	**Si**	**Mo**	**B**
15mg/kg Min	15mg/kg Min	0.02-0.05% 0.15	10mg/kg Min	0.5mg/kg Min	200mg/kg Min

Heavy Metals

Al	Cr	Pb	As	Hg	Cd
0.1% Max	10mg/kg Max	15mg/kg Max	5mg/kg Max	1mg/kg Max	1mg/kg Max

Functional Groups

Total acidity	Total carboxyl	Total hydroxyl	Total carbonyl	Phenolic hydroxyl	Alcoholic hydoxyl
588 cmol/kg	382 cmol/kg	195 cmol/kg	43 cmol/kg	126 cmol/kg	54 cmol/kg

Maize seeds (single cross 10 hybrid) were sown at the second week of May 2010 and 2011 in soil, under drip irrigation system. Nitrogen and potassium fertilizers were added to the experimental soil plots in two equal doses during the growing period (after 15 and 40 days) in the forms of ammonium sulphate (20.5 % N) and potassium sulphate (48 % K_2 O) at rates of 120 kg N/fed and 100 kg K_2O /fed, respectively. Also, 30 kg P_2O_5 /fed as calcium superphosphate fertilizer (15 % P_2O_5) was added during preparing the soil for cultivation.

Data of maize plant parameters recorded:

Two plant samples (each of them represented by ten plants and were chosen randomly from each treatment in the three replicates) were taken from each experimental plot. The first sample was taken at 65 days after planting to determine some growth characters, i.e., plant height (m), dry weight of leaves/plant (g), leaf content of chlorophylla & b (mg/g F.W.), leaf content of carbohydrates and sugars (mg/g D.W.). The second sample was taken at harvest (about 4 months after planting) to estimate ear characters (i.e., ear length in cm, ear diameter in cm, ear weight in g, raw number/ear, grain number/raw, grain number/ear); grain yield (kg/fed.) and grain quality (weight of 100 grain in g, contents of reducing sugars (mg/g D.W.), crude protein %, macronutrients as N, P and K % and micronutrients as Fe, Mn, Zn and Cu in mg/kg).

The plant samples of either fresh maize leaves or grains were washed with distilled water, dried at 70 C^o and wet digested with H_2SO_4 and H_2O_2 **(Van Schouwenberg, 1968)** for determining contents of N, P **(A.O.A.C., 1990),** K, Na **(Wilde *et al.,* 1985) and** Cl **(Higinbotham *et al.*, 1967)** in grain. Also, leaf chlorophyll a, b and total carbohydrates as well as reducing sugars in both leaves and grains were determined according to the methods described by **(Welburn and Lichtenthaler, 1984**), **(Herbert *et al.,* 1971)** and **(A.O.A.C., 1990)**, respectively. Moreover, crude protein was calculated by multiplying total N content by 6.25 **(Hesse, 1971)**.

Analytical methods of soil properties:

The disturbed and undisturbed soil samples were collected from the treated experimental plots inside the range of drippers before and after running the experimental treatments to monitor the changes in soil physico-chemical properties and the nutrients status, soil bulk density, total porosity, hydraulic conductivity, available water range **(Klute, 1986)**, soil organic matter (Walkely and Black method), pH, ECe and ESP **(Page *et al.,* 1982)**. Available macronutrients (N, P and K) were extracted by 1 % potassium sulphate, 0.5 M sodium bicarbonate and 1 N ammonium acetate, respectively **(Soltanpour and Schwab, 1977)** and their contents in soil were extracted and determined according to **Page *et al.,* (1982)**. Available micronutrients (Fe, Mn, Zn, and Cu) in soil were extracted using ammonium bicarbonate-DTPA extract according to **Soltanpour and Schwab (1977)**, and their contents in soil were measured by using Inductively Coupled Plasma Spectrometry instrument (Plasma JY Ultima).

Statistical analysis:

The obtained data of plant parameters were subjected to the statistical analysis, where the least significant difference test (L.S.D.) at 0.05 level was used to verify the differences between treatments as mentioned by **Snedccor and Cochran (1980).**

RESULTS AND DISCUSSION

I. A general view on both experimental soil and used irrigation water:

a. Soil:

The experimental sand soil represents one of the scattered private farms that are mainly encompassing the wind blown sand deposits as a parent material, and occupying the desert zone adjacent to the Nile alluvium of the western edge of the Nile Valley, namely Sedmant El Gabal village, Beni-Suef Governorate, Egypt. The field morphological examination show that, it is developed under climatic conditions of long hot rainless summer and short mild winter, with scare amounts of rainfall. Due to the prevailing quartz grains, it is characterized by siliceous in nature and surveyed as non-saline and non-sodic sand soil under dry climate as well as poorer in macro and micronutrient contents and soil moisture retention, Table (2).

Taxonomic unit of the current experimental soil is identified and named on the basis of soil morphological and physico-chemical properties at the family level according to **Soil Survey Staff (1999)** as Typic Torripsamments, siliceous, hyperthermic. Also, according to parametric system undertaken by **Sys and Verheye (1978),** the intensity degrees of soil limitations and suitability categories for the studied soil were calculated and shown in Table (4). It is cleared from data obtained that soil texture and gypsum are the most effective limitations for soil productivity; with an intensity degree for each of soil limitations lies in the range of slight-very severe (rating >90 - <40). Also, the suitability condition in either in current or potential classes of the studied soil could be categorized as marginally suitable ($S3_{s1s4}$).

Table (4): Soil limitations and rating indices for the evaluation of the studied soil.

Suitability condition	Topography (t)	Wetness (w)	S				Soil salinity/ Alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
			Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)				
Current	100	100	30	100	100	90	100	27.00	S3	$S3_{s1s4}$
Potential	100	100	30	100	100	90	100	27.00	S3	$S3_{s1s4}$

It is cleared from data obtained that soil texture (s_1) and gypsum (s_4) are the most effective limitations for soil productivity, respectively. The relative coarse texture (s_1) has a direct adverse effect due to the dominant of sand fraction, which is not partially capable to retain neither soil moisture nor nutrients for growing plants and organisms. Also, such soil is located at the end of irrigation canal tail, hence it has water shortage particularly in summer season. Moreover, it is poor not only in the nutrient-bearing minerals, but also in organic matter that represent a storehouse of the essential nutrients in soil. Consequently, such severe conditions of inadequate fresh irrigation water resource; saline water utilization in irrigation gets more and more attention.

b. Irrigation water:

According to **Ayers and Westcot (1985)** scale, the used irrigation Nile water belongs to the first class (C_1S_1, ECiw < 0.75 dS/m and SAR < 6.0), which denoted no problems for soil salinity and sodicity. On the other hand, the agricultural drainage water lies within both the third and second categories for salinity and sodicity levels (C_3S_2, ECiw > 3.0 dS/m and SAR 6.0-9.0) that denote severe and increase problems are expected for soil sodicity, respectively. The mixed water lies in between (C_2S_1), where the ECiw = 0.75-3.00 dS/m and SAR < 6.0, that denote an increase problem for soil salinity and no problems are expected for soil sodicity.

II. Influence of Applied Soil Organic Amendments on soil properties:

Undoubtedly, executing an amendment for the low quality water, i.e., saline drainage water is one of the most additional developments, which accelerated the direction towards agricultural utilization at the newly reclaimed desert areas of Egypt. This aspect is more related to the fact that agriculture utilization can be grown as a supplemental approach to increase the recycling of the low quality water sources by using updated techniques.

Data presented in Table (5) showed the hazard effects on soil properties as a result of the used saline drainage water for irrigating the untreated soil (control treatment), whether the salinity and alkalinity levels tended to be increased as compared with the initial soil data (Table, 2). Such conditions are negatively reflected on the different physical, chemical and fertility properties of the soil under investigation. The abovementioned statements are emphasized by a marked increased of the ECe and ESP in the root zone of the untreated soil as compared with the initial state of soil. On the other hand, the relative increases in the ECe values in case of saline irrigation water treatments amended with K-humate and calcium alginate individual or in combined treatments were 4.56, 11.23 and 2.46 %, as compared to the initial state of soil, respectively. The corresponding relative increases in the ESP values were 10.12, 3.47 and 1.16 %, respectively.

a. Soil physical properties:

Concerning the variations in soil bulk density among the different used amended irrigation water treatments, data show a gradually decrease in its values was application of K-humate and calcium alginate individual or in combined, where the K-humate + calcium alginate gave the lowest soil bulk density value. This positive effect may be attribute to the pronounced content of organic colloidal particles, which plays an important role for modifying distribution pattern of pore spaces in soil. These findings are in agreement with those obtained by **Batey (1990)** who reported that soil bulk density was closely related to solid phase properties and pore spaces. Since the applied humic acid possesses a positive effect for soil bulk density (i.e., reduced its value), hence it leads to increase total porosity of the soil.

However, the application of K-humate and calcium alginate encouraged the creation of medium and micro pores (i.e., water holding and useful pores) between simple packing sand particles, and in turn increasing capillary potential. Thus, the promotive effect of organic amendments on the soil porosity in the studied sandy soil may be due to the values of soil bulk density behaved the opposite trend with those obtained from total porosity.

Table (5): Effect of the applied treatments on physico-chemical properties of the studied soil and available nutrient contents in both seasons of 2010 and 2011 .

Soil properties	Growing season	Organic soil amendments				L.S.D. at 0.05
		Control	K-humate	Calcium alginate	K-humate + Calcium alginate	
Bulk density (g/cm^3)	2010	1.77	1.70	1.59	1.50	0.11
	2011	1.79	1.72	1.61	1.52	0.12
Total porosity %:	2010	33.18	35.09	37.74	42.11	2.88
	2011	32.45	35.80	38.09	43.21	2.93
Available water %	2010	6.28	6.89	7.73	10.34	0.65
	2011	6.37	6.94	7.78	10.58	0.67
Field capacity %	2010	10.57	11.98	13.88	17.30	1.32
	2011	11.02	12.62	14.54	18.27	1.35
Wilting point %	2010	4.29	5.09	6.15	7.30	0.48
	2011	4.65	5.68	6.76	7.69	0.52
Hydraulic cond. (cm/h)	2010	15.94	14.19	12.92	9.93	0.87
	2011	15.19	13.90	12.30	9.38	0.83
Organic matte%	2010	0.16	0.26	0.20	0.30	0.02
	2011	0.18	0.28	0.23	0.32	0.03
CEC (me/100 g soil)	2010	4.19	5.53	4.82	6.24	0.41
	2011	4.24	5.67	4.94	6.56	0.44
ECe (dS/m)	2010	3.38	2.98	3.17	2.92	0.22
	2011	3.40	3.01	3.20	2.95	0.22
ESP %	2010	4.59	3.81	3.58	3.50	0.25
	2011	4.62	3.86	3.60	3.54	0.27
Macro and micronutrients (mg/kg soil):						
N	2010	13.35	24.97	18.56	30.78	1.87
	2011	14.01	25.12	19.12	31.24	1.91
P	2010	3.50	5.33	4.15	6.73	0.41
	2011	3.62	5.78	4.27	6.80	0.43
K	2010	49.85	63.75	50.92	71.58	4.62
	2011	52.91	65.08	54.70	72.64	4.77
Fe	2010	3.45	4.67	3.87	6.08	0.38
	2011	3.62	4.89	3.99	6.13	0.40
Mn	2010	0.82	1.07	0.97	1.59	0.10
	2011	0.85	1.12	1.01	1.63	0.10
Zn	2010	0.64	0.91	0.75	1.07	0.07
	2011	0.68	0.95	0.79	1.11	0.08
Cu	2010	0.42	0.81	0.55	0.86	0.05
	2011	0.49	0.89	0.59	0.92	0.06

In general, this increase may be related to the increase of storage pores in the studied sandy soil and physical improvement of soil, which can be regarded as an index of an improved soil structure. Moreover, a thin coat of translocated K-humate as organic material partially covered the walls interconnected vughs **(Brewer, 1964 and Amjad *et al.,* 2010)**, which are usually the most common pores in this soil.

The abovementioned case is more attributed to an increase in soil moisture content at field capacity, which is more dependent upon the modified soil structure, surpassed that occurred at the wilting point, which is more affected by soil texture that is non-effected, and consequently a pronounced increase in soil available water range was achieved. These findings are confirmed by **Askar *et al*., (1994)** who found that the addition of organic materials to soil greatly increased the water holding pores and decreased the area between the boundary lines (drying and wetting curve) of the hysteresis loops. In addition, such organic substances of humic acid have high ability to retain a pronounced content of water. These results are emphasized by **Cheng *et al*., (1998)** who reported that active organic acids decreased the loss of soil moisture, and in turn enhanced the water retention. Also, it is noteworthy to mention that one of the valuable characteristics of humic substances is the ability to absorb and retain quite large amounts of water. These humic substances also allow the reduced supply of water in its very thin film to be more easily released during drought conditions, and thus be made available to the roots of the plants. In addition, humic acid helps water penetrate and permeate plant cells, assisting nutrient uptake and water storage during drought conditions. That means it may balance water during drought conditions and assist plant transpiration, the transport of water and nutrients of the cell tissues as well as assist in the accumulation of soluble sugars which helping to prevent wilting **(Jackson, 2006).**

Results presented in Table (5) also show that the applied K-humate and calcium alginate individual or in combined treatments affected differently the hydraulic conductivity values of the studied soil, where a gradual decrease in the hydraulic conductivity value was parallel with applied K-humate and calcium alginate mixed in the 5 cm soil surface layer. The improvement of hydraulic conductivity in such loose soil may be attributed to the positive effects of such released active organic acids, which occupy the larger pores and encouraged the creation of medium and micro pores between the simple packing sand particles, consequently inhibiting the rapid velocity of down-movement of water in saturated condition. These results are in agreement with those of **El-Fayoumy and Ramadan (2002).** On the other hand, the beneficial effects of the applied organic materials on the studied different soil hydrophysical properties under maize crop could be arranged in the following order: K-humate+calcium alginate > calcium alginate > K-humate.

In general, data showed that, the soils treated with the combined organic soil conditioners (K-humat and Ca-alginate) possess relatively high values as compared to those amended with applied K-humate and calcium alginate individual. This due to the fact that organic substances attain a pronounced high content of active organic compounds that enhancing the water molecules to be chelated. Thus, the applied organic soil conditioners surpassed K-humate to improving the previous soil hydophysical properties. This was true, since the active -OH and -COOH represent pronounced values and have been found to be a profound effect on not only the biological activity, but also on soil structure **(El-Fakharani, 1999 and Moustafa *et al.,* 2005).**

b. Soil chemical properties:

Data in Table (5) also showed that applying K-humate and calcium alginate individual or in combined regardless the absolute changes in some soil chemical properties, i.e., pH, organic matter content and CEC were noticeable, however, soil ECe, ESP and pH values tended to decrease with applying K-humate and calcium alginate vs an increase for each of soil organic mater content and CEC.

Hence, the combined treatment of (K-humat + Ca-alginate) is considered the superiority over than the other treatments was great enough to reach the level of significance under the prevailing conditions of the current experiment. This was true, since the accumulation of such active organic acids in soil leads to reduce soil pH vs an increase in soil organic component, besides the cation exchange capacity of humic acid is high and varies from 200 to 500 milli-equivalent per 100 grams at pH 7, and in turn positively reflected on soil CEC.

As a general, the obtained results indicated that building up of soil salinity and sodicity in control treatment herein was due to the influence of water salinity in the absence of K-humat and Ca-alginate. On basis of soil ECe and ESP values, soil salinity and sodicity were generally lower in the case of amended saline water treatments with K-humate and calcium alginate individual or in combined vs a greater salinity sodicity levels in the case of untreated K-humate and calcium alginate, probably due to the occurrence of the charged sites (i.e., COO-) accounts for the ability of humic acid to chelate and retain cation in non-active forms.

c. Soil available macro and micronutrient contents:

The magnitudes of available nutrients in the initial state of the tested sandy soil; Table (2) showed that the studied nutrients (N, P, K, Fe, Mn, Zn and Cu) lay within the low-medium range, according to the critical levels of nutrients undertaken by **Lindsay and Norvell (1978).** In general, this is true since this soil is not only poor in the nutrient-bearing minerals, but also in organic matter content, which are considered as storehouse for the essential plant nutrients. On the other hand, data illustrated in Table (5) indicated that the available contents of the studied macro- (N, P and K) and micronutrients (Fe, Mn, Zn and Cu) in soils were increased with applied K-humate and calcium alginate individual or in combined. These findings are in harmony with those outlined by **Humax (2006)** who pointed out that humic acid has a high complexation ability with ions in the environment due to the high carbon content (60 %) of both aliphatic and aromatic character and the richness in oxygen-containing functional groups such as carboxyl, phenolic, alcoholic and quinoid groups, which is beneficial for plant nutrition. Also, humic acid partially capable to retain nutrients for growing plants, where it would act as complexing agents **(Mackowiak et al., 2001)**. Enhanced plant growth following addition of humic substances has sometimes been related to increased micronutrient availability especially iron and zinc. There are also numerous reports of metal concentration being reduced to non- toxic levels following addition of complexion humic substances. Soil pH and organic matter content significantly affect the solubility of Fe, Mn, Zn and Cu **(Prasad and Sinha, 1982)**. In addition, humic acid can incorporate iron into chelate, maintaining its availability to plants, although still in insoluble form **(Ramasamy *et al.*, 2006)**. Therefore, these chelating agents, through active groups for micronutrients, are considered as a storehouse with easily mobile or available to uptake by plant roots, and in turn reflected positively on development of yield and its attributes for the studied crop. It is worthy to mention that the positive effect of organic soil conditioners may be due enhancing crop production and fertilizer uptake by plants through improvement of soil hydrophysical properties and thus increased soil ability to supply plants with their requirements of water and air along the growing season.

The beneficial effects of the applied organic materials on soil fertility (available nutrient contents) under cultivated crop could be arranged in the following order: K-humate+calcium alginate > K-humate > calcium alginate.

In general, the relative increase in available nutrient contents may be attributed to the modified suitable air-moisture regime that control the availability of nutrients, besides the applied humic acid leads to alleviate the depressive effect of salinity stress on the released nutrient from either organic residues or nutrient bearing minerals. These findings are supported by those obtained by **Hegazi (1999)** who found a negative correlation between salinity and available plant nutrients in soil. In addition, the suitable air-moisture regime in such sand soil positively affected biological activity and the supply of available nutrients, particularly from the organic source. Moreover, humic acid is considered as a chelated agent for some macro and micronutrients.

It was also observed that the humic acid and the attached nutrients, as easily soluble ones, were retained at a shallow depth (within the surface 30 cm depth) under drip irrigation system, and consequently their organo-metalic molecules and ions entirely soil are more mobile and available to uptake by plant roots. **Alva and Mozzafari (1995)** confirmed these findings as they reported that using drip irrigation method maintained high concentrations of nutrients at shallow depth of soil.

III. Influence of Applied Soil Organic Amendments on Plant Parameters:

a. Vegetative growth Characters:

The obtained data illustrated in Table (6) showed a positively effect of the applied treatments on the studied vegetative growth characters and the greatest values were achieved by plants supplied with K-humate + calcium alginate. Meanwhile, the lowest values were recorded at the treatment of calcium alginate. These findings were similar and true in both the studied two seasons of study. These findings are in harmony with those reported by **Gupta and Gupta (1984)** who found that salinity stress negatively affected plant growth through the influence of several factors on physiological processes, i.e., photosynthesis, osmotic potential, specific ion effect and ion uptake. The previously behaviour could be primarily due to an adjustment of subcelluler ion distribution to maintain osmotic potentials and favourable water relations **(Treeby and Van-Steveninck, 1988).** Also, these results are in agreement with those reported by **El Masry and Hassan (2001).**

It is evidently that impact of the applied treatments of humic acid on the dry matter productions was more attributed to the leaves area and number. This is due to the obtained increases in the total dry matter accumulations can be interpreted on the fact that higher leaves area and number contributed to more photosynthesis and better carbohydrates yield. These findings are in harmony with those obtained by **Chawla and Narda (2000)** who cleared the importance of canopy structure in light interception, vegetative growth and yield. Also, higher values of such plant parameters were more related to drip irrigation system, which represents an efficient irrigation procedure than furrow irrigation.

Table (6): Effect of the applied treatments on vegetative growth characters of maize plants in both seasons of 2010 and 2011.

vegetative growth characters	Growing season	Organic soil amendments				L.S.D. at 0.05
		Control	K-humate	Calcium alginate	K-humate + Calcium alginate	
Plant height (m)	2010	1.86	2.46	2.35	2.63	0.18
	2011	1.91	2.59	2.44	2.79	0.20
Leaves dry weight (g)	2010	66.90	81.07	73.46	89.79	6.02
	2011	67.32	82.47	75.01	91.45	6.16
Chlorophyll a (mg/g F.W*.)	2010	1.27	1.53	1.75	1.87	0.13
	2011	1.35	1.65	1.84	1.90	0.12
Chlorophyll b (mg/g F.W.)	2010	0.87	1.14	1.09	1.20	0.08
	2011	0.91	1.23	1.16	1.32	0.07
Total carbohydrates (mg/g F.W.)	2010	62.97	78.70	65.38	90.20	5.83
	2011	64.43	80.29	66.03	92.05	5.99
Total sugars (mg/g F.W.)	2010	55.17	64.78	59.45	69.96	4.77
	2011	56.02	66.54	60.98	71.84	4.85

* F.W.=Fresh weight

In addition, soil application of organic materials such as K-humate and calcium alginate individual or in combined treatments to maize under drip irrigation system increased the availability and uptake of nutrients, and decrease the ECe values (Table, 5), all that reflected the best result on vegetative growth of maize plants. The mechanism of humic acid on stimulating growth may be similar to that of plant growth regulators as humic substances include auxins and thus affect plant metabolism in a positive manner.

Chlorophyll a and b contents were significantly higher in plants irrigated with saline water treatments amended with organic soil amendments (K-humate and calcium alginate) mixed with the 5 cm soil surface layer under drip irrigation system. This is testimony for the longer source activity in such efficient irrigation system, where humic acid was applied to match the nutrients uptake by crop. This enhanced the current photosynthesis for developing vegetative growth parameters that leading to the development of dry matter production per plant in the case of amended saline irrigation water as compared to the plants irrigated with untreated saline water (Table, 6). These findings are in harmony with results obtained by **(Hebbar *et al*., 2004).**

In general, mixed K-humate and calcium alginate had a greatly positive effect on vegetative growth of maize plants as compared to the applied saline irrigation water treatments alone.

b. Ear Characters:

As for ear characters, data in Table (7) reveal that the beneficial effects of the applied treatments were extended to the ear characters, i.e. ear length, ear diameter, ear weight, raw number/ear, grain number/raw and grain number/ear. A parallel trend of the relative increase percentages in the afore mentioned characters were occurred for the combined treatment of (K-humate + calcium alginate) that reached 33.60, 15.47, 25.21, 14.13, 31.80 and 35.50 % over the control treatment, respectively. Such increases in the studied ear characters were probably due to many factors that suggested by many workers, i.e., **a)** its ability to release plant promoting substances might be stimulated plant growth **(El Merich *et al.,* 1997**), **b)** increasing the water and nutrients uptake from the soil and **c)** its stimulation effect on cell division and expansion and physiological processes (**Sarig *et al.,* 1984).** Also, It is evident that the combined treatment (K-humate+ calcium alginate) showed superior increases as well as K-humate as an individual treatment, followed by calcium alginate. These results could be explained according to the finding of **Quaggiotti *et al.,* (2004)** who reported that the humic acid as K-humate is colloidal in nature with particles of different size. In the rhizosphere, an interaction between root system and humic matter is possible when humic matter present in the soil solutions are small enough to flow into apoplast and reach the plasma membrane. **Viveganandan and Jauhri (2000)** found that humic acid in general is the most versatile organic compound. This is mainly due to its natural origin from soil processes, contains chemical structures which can oxidize or reduce elements, photosensitize chemical reactions and enhance or retard the uptake of toxic compounds or micronutrients to plants and microorganisms thereby greatly benefiting plant growth.

Table (7): Effect of the applied treatments on ear characters of maize plants in both seasons of 2010 and 2011.

ear characters	Growing season	Organic soil amendments				L.S.D. at 0.05
		Control	K-humate	Calcium alginate	K-humate + Calcium alginate	
Ear length (cm)	2010	16.01	19.14	17.86	21.39	1.44
	2011	16.22	20.72	19.00	23.20	1.55
Ear diameter (cm)	2010	4.20	4.60	4.46	4.85	0.34
	2011	4.23	4.71	4.53	4.99	0.35
Ear weight (g)	2010	168.70	201.54	185.64	211.23	14.60
	2011	173.16	210.95	193.19	224.10	15.35
Raw number/ear	2010	13.80	15.38	14.56	15.75	1.11
	2011	13.87	15.53	14.68	15.96	1.13
Grain number/raw	2010	31.90	38.79	34.90	42.05	2.84
	2011	32.12	39.98	35.78	43.45	2.93
Grain number/ear	2010	452.65	580.47	546.37	613.25	42.35
	2011	463.98	602.12	464.34	639.20	41.85

c. Grain Yield and Quality:

The obtained results in Table (8) indicate that the prevailing favourable conditions of vegetative growth and ear characters positively reflected on the maize grain yield and its quality. That was true,since the effect of combined treatment of (K-humate+ calcium alginate) showed a considerably greater in each of grain yield (kgfed^{-1}), straw yield (kgfed^{-1}), weight of 100 grain, reducing sugars, oil% and crude protein compared with the control treatment. These increases were statistically confirmed (L.S.D. at 0.05), however, the combined treatment exhibited superior over the other individual studied ones. These results are in harmony with those undertaken by **Yu *et al*., 1999** who showed that the beneficial effects of the applied treatments on either ear length or diameter might be due to their stimulation effect on cell division and expansion. In addition, the increase in number or weight of grain/ear also may be attributed to the increment in cell division and cell elongation. In this respect, **Cheng *et al.,* 1998** suggested that grain yield may sometimes be limited by photosynthesis (source) and grain (sink) simultaneously and it is possible to increase grain yield by keeping safe the balance between them. Also, such beneficial effects of the studied treatments were actually reflected on increasing maize grain yield and its quality due to the applied organic amendments decreased the loss of soil moisture, enhanced soil water retention and the drought resistance of grown plants as well as increased the ability rate of leaves for photosynthetic process, increased the grain filling intensity, and consequently increased the grain weight. Also, these results were true for maize as summer crop, and confirmed as effect of the organic materials obtained by **Rathore, (2009)** who reported that the applications of organic materials such as seaweed extract could be a promising option for yield enhancement. These benefits are more related to the improvement of soil hydrophysical properties that is increased soil ability to supply plants with their requirements of water and air along the growing season **.** Accordingly, the positive effect of the applied treatments (solely or together) on the studied vegetative growth and ear characters of maize plants as well as grain yield and its quality could be arranged in an ascending order of (K-humate+ calcium alginate) > (K-humate) > (calcium alginate) > control treatment.

Table (8): Effect of the applied treatments on grain yield and quality of maize plants in both seasons of 2010 and 2011.

Grain yield and its quality parameters	Growing season	Organic soil amendments				L.S.D. at 0.05
		Control	K-humate	Calcium alginate	K-humate + Calcium alginate	
Yield						
Grain yield (kg fed^{-1})	2010	1849.96	2125.00	2000.10	2276.25	156.93
	2011	1865.21	2174.54	2040.42	2375.95	162.11
Straw yield (kg fed^{-1})	2010	3220.25	3796.15	3520.35	4022.30	277.23
	2011	3259.86	3901.14	3601.20	4158.30	285.29
Grain quality						
Weight of 100 grain (g)	2010	31.04	35.01	32.91	36.35	2.54
	2011	31.11	35.17	33.04	36.59	2.58
Reducing sugars (mg/g D.W*.)	2010	25.35	36.03	30.50	38.97	2.58
	2011	25.43	36.21	30.64	39.24	3.00
Protein content %	2010	15.07	19.98	17.35	22.45	1.48
	2011	15.16	20.16	17.48	22.73	2.01
Oil %	2010	2.14	2.32	2.24	2.56	0.18
	2011	2.15	2.36	2.26	2.61	0.19

*D.W. Dry weight

d. Chemical constituents (macro –micro nutrients, Na and Cl contents) in plant tissues):

The maize grain contents of the studied (macro –micro nutrients, Na and Cl contents), which are presented in Table (9), showed a greatly response to either applied solely or combined treatments, with considerably greater values strictly associated with the applied (K-humate+ calcium alginate), since it surpassed the control. The aforementioned results indicated that the applied organic amendments affect directly or indirectly the tested nutrients uptake. This means that the applied organic soil amendments are considered as a storehouse with easily mobile or available to be taken by plant roots and consequently, positively reflected on development of yield. Also, these findings indicated an important role for K-humate in improving the efficiency of nutrients uptake, and in turn increasing the quantity and quality of both maize seeds and foliages. These results are confirmed by **Mackowiak, (2001) and Madlain, (2002)** who reported that the beneficial effect of humic acid on dry matter yields may be attributed to improving the bio-availablity of micronutrients by complexion, which prevent early micronutrients deficiency. Application of seaweed extract induced higher yields and a better nutrient use efficiency **(Rathore et al., 2009 and Viqar, 2011).** This means that the applied humic acid through drip irrigation system plays an important role for increasing the supplying power of soil capacity against nutrient loss and deficiency. On the other hand, Na and Cl contents were significantly reduced, probably due to the pronounced decreases in irrigation water salinity. Also, this benefit was positively reflected on the vegetative growth and plant contents of N, P and K. These findings are in agreement with those obtained by **Habashy (2005)** who reported that fertigation system increased N, P and K contents in leaf tissues of tomato.

The above-mentioned results are also in harmony with many various benefits of humic acid, which have been reported to promote an increase nutrient uptake and stimulate plant growth. However, it promotes plant growth by its effects on ion transfer at the root level by activating the oxidation-reduction state of the plant growth medium and so increased absorption of nutrients, especially micronutrients, by preventing precipitation in the nutrient solution. In addition, it enhances cell permeability, which in turn made for a more rapid entry of nutrients into root cells and so resulted in higher uptake of plant nutrients. This effect was associated with the function of hydroxyls and carboxyls in these compounds. The principal physiological function of humic acid may be that they reduce oxygen deficiency in plants, which results in better uptake nutrients **(Humax, 2006).**

Table (9): Effect of applied treatments on maize grain contents of macro&micro-nutrients and non-native nutrients in both seasons of 2010 and 2011.

Grain content of nutrients	Growing season	Organic soil amendments				L.S.D. at 0.05
		Control	K-humate	Calcium alginate	K-humate + Calcium alginate	
Macronutrients %						
N	2010	2.84	3.46	3.19	3.69	0.25
	2011	2.90	3.54	3.26	3.63	0.26
P	2010	0.32	0.51	0.40	0.57	0.04
	2011	0.34	0.54	0.42	0.60	0.04
K	2010	1.96	2.20	2.07	2.22	0.16
	2011	1.99	2.28	2.13	2.33	0.17
Micronutrients (mg kg^{-1})						
Fe	2010	59.54	73.75	63.48	84.76	5.52
	2011	59.61	74.14	63.70	85.56	5.58
Mn	2010	47.20	60.25	53.93	68.10	4.51
	2011	47.64	61.05	54.42	69.02	4.57
Zn	2010	32.10	39.40	36.60	46.18	3.04
	2011	32.35	39.95	37.00	47.35	3.12
Cu	2010	7.85	10.09	8.92	11.83	0.77
	2011	8.06	10.54	9.30	12.85	0.73
non-native nutrients%						
Na	2010	1.19	0.75	1.10	0.70	0.06
	2011	1.20	0.79	1.11	0.73	0.07
Cl	2010	0.95	0.55	0.89	0.49	0.05
	2011	0.97	0.58	0.90	0.52	0.06

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