THE POSSIBLE USE OF HUMIC ACID INCORPORATED WITH DRIP IRRIGATION SYSTEM TO ALLEVIATE THE HARMFUL EFFECTS OF SALINE WATER ON TOMATO PLANTS

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ABSTRACT:

The main purpose of this work was to evaluate the possible use of humic acid mixed with the irrigation water through a drip irrigation system to alleviate the harmful effects of salinity stress on growth, fruit yield and quality of tomato plants (*Lycopersicon esculentum*, c.v. 1077 hybrid). To achieve this target a field experiment was carried out on a private farms at Sedmant El Gabal village, Beni-Suef Governorate, Egypt, which represents one of the those are occupying the desert zone adjacent to the western edge of the Nile Valley during two successive seasons of 2005-2006 and 2006-2007. Two irrigation water resources were used, i.e., the Nile water (C_1S_1, ECiw = 0.56 dS/m and SAR = 2.13) and a mixture of agricultural drainage saline water with the Nile water at a ratio of about 1:1 (C_2S_1, ECiw = 1.89 dS/m and SAR = 5.35). Humic acid was applied at rates of 75, 150 and 225 mg/L through a drip irrigation system twice/week and for a period of 4 months after transplanting.

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 18.95 and 33.09 % as compared to the initial state of soil, respectively. Meanwhile, the corresponding relative increases of the ECe in case of amended saline irrigation water with humic acid at rates 0. 75, 150 and 225 mg/L were 11.75, 5.09 and 2.98 %, vs 10.84, 3.76 and 1.73 % for the ESP values, respectively, with its optimal case at a rate of 225 mg/L. Moreover, the applied humic acids played an important role in improving the values of soil bulk density, total porosity, available water and 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 amended irrigation water positively reflected on the vegetative growth and flowering parameters of tomato plants, i.e., plant height, number of leaves/plant, thickness of stem/plant at soil surface, number of branches/plant, leaf area, number of inflorescences/plant, number of flowers/inflorescence, dry weight/plant, and the chlorophyll a & b contents. It is evidently that such beneficial effect of humic acid on the dry matter productions was more attributed to the leaves area and number, which are contributed to more photosynthesis and better carbohydrates yield. Also, the ability of humic acid for increasing plant nutrient uptake is due to its chelating property. Moreover, the applied humic acid at all the different rates resulted in significant increases for N, P and K in tomato leaves. The reverse was true for Na and Cl, probably due to alleviate the harmful effect of saline irrigation water. In addition, using humic acid at the rates of 150 and 225 mg/L mixed with saline irrigation water registered almost similar tomato yields to those irrigated with the Nile water and higher than those irrigated with either saline water or treated with at a rate of 75 mg/L humic acid. The relative increases in fruit yield/plant or fed could be attributed to significantly higher increments in dry weights and number of flowers/plant. The parameters of tomato fruit quality, i.e. average weight of fruit, fruit firmness, total soluble solids (TSS), vitamin C (ascorbic acid), titrable acidity (citric acid) and total sugar showed significantly increased when treated with amended saline irrigation water with humic acid at the applied rates as compared to the effect of used saline water solely. Thus, the present study shows that the best rate of the applied humic acid mixed with the used irrigation saline water was 150-225 mg/L for achieving the greatest tomato yield of high quality.

Key words: Sandy soil, tomato, humic acid, drip irrigation system and saline irrigation water, tomato vegetative growth and fruit quality.

INTRODUCTION:

The continuous extension 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 the nature 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)**.

Several recent studies have indicated that addition of organic manure, as a natural or synthetic organic materials, to sand soil is necessary due to it has the unique ability to improve the chemical, hydrophysical and biological characteristics of soils or growing media. However, its buffering effect helps maintaining an uniform reaction in soil media, beside it can hold up to 20 times its weight in 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).**

The use of hydrogels, as a soil amendment, to avail suitable environments for planting sandy soils under the severe conditions of the Egyptian desert, i.e., the limited water resources, the inadequate moisture retention and the low fertility of the soils has become an accepted practice. Such supper absorbent material is associated quickly with irrigation water to form a gel, and in turn increases sand soil capacity to retain more pronounced water content. Water retained in this way is available to plants for some considerable time as required, in addition to it leads to alleviate the effect of salinity stress may be due to reduce the osmotic potential. Both chemical and biological properties of the conditioned soil are also improved. Moreover, nutrients uptake, water and fertilizers use efficiency by plants are beneficially increased, consequently plant growth and yield tendency to increase **(El Hady *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. They added that, 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 used either individually or in combination with others, resulted in a significantly increase in crop yield in the sandy soils. This is due to its positive effects on improving hydrophysical properties and nutrients availability in such soils as well as favourable soil media for the nutrients uptake by the grown plants.

Tomato (*Lycopersicon esculentum* Mill) is one of the important widespread crops in the world, and is considered moderately sensitive to salt stress, since it can tolerate a pronounced salinity level. However, salt tolerance of tomato plants increased when the application of salinity was delayed, and fruit quality could be improved, while yield was not significantly reduced when 4 dS/m saline water was applied 16 days after transplanting **(Shuqin *et al*., 2007).**

To gain more benefits about organic materials, this work was undertaken using humic acid through a drip irrigation system to evaluate its positive role for alleviating the hazardous effect of saline water on the grown tomato plants therein.

MATERIALS AND METHODS:

The main purpose of this work was to evaluate the possible use of humic when mixed with the saline irrigation water and added to soil through a drip irrigation system to alleviate the harmful effect of salinity stress on tomato plants grown herein. The humic acid (90.3% producing by Alpha Chemika, Mumbai, India) was used at different levels, i.e., 0, 75, 150 and 225 mg/liter, and added to the experimental soil mixed with saline water (1.89 dS/m) through a drip irrigation system twice/week for a period of 4 months after transplanting. The Nile fresh water (0.56 dSm) was used as a control treatment. The applied saline irrigation water represents a mixture of agricultural drainage (3.27 dS/m) and the Nile fresh water (0.56 dS/m) resources with a ratio of about 1:1. The chemical analyses of applied humic acid (Table, 1) and the above-mentioned irrigation water resources are presented in Table (2).

Table (1): Chemical constituents of applied humic acid

The component	Humic acid (net)	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	Na	Other
%	90.29	0.95	1.04	1.46	2.81	0.92	0.48	0.61	0.09	0.32	0.55	0.04	0.44

Table (2): Chemical analysis of the used irrigation sources (as an average of two successive seasons of 2005-2006 and 2006-2007.

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 (me 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	C_1S_1	C_3S_2	C_2S_1

To achieve this target, 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 two successive agricultural growing season 2005/2006 and 2006/2007. Some physical and chemical properties of the studied soil were determined and presented in Table (3). The experimental treatments were arranged as follows: 1) saline irrigation water alone, 2) saline irrigation water mixed with humic acid at a rate of 75 mg/L, 3) saline irrigation water mixed with humic acid at a rate of 150 mg/L, 4) saline irrigation water mixed with humic acid at a rate of 225 mg/l and 5) the Nile water as a control treatment.

Tomato seeds (*Lycopersicon esculentum*, cv. 1077 hybrid) by Ferry-Morse Company were sown in the nursery on July 9, 2005 and July 6, 2006. Thirty days after seed sowing seedlings were transplanted to the experimental field. The different treatments were arranged in complete randomized blocks design with three replicates. The experimental plot was 480 m^2, each plot was planed to include 20 rows (20 m long and 120 cm width), and the interplant spacing was 30 cm within each row (about 11000 plants/fed). The irrigation water was applied daily through in-line drippers (two plant/emitters with a discharge of 4 L h^{-1}). The applied fertilizers were added as fertigation system, however, the nutrients mixed with water through drip irrigation system. The used fertilizers were urea (46% N) and mono-potassium phosphate (15% P_20_5 and 48% K_2O), with rates of 100 kg N fed^{-1}, 40 kg P_2O_5 fed^{-1} and 48 kg K_2O fed^{-1}. Through the fertigation system, N, P & K fertilizers were injected in weekly intervals through the in-line drippers. The general agricultural practices were applied as recommended for commercial tomato production.

Table (3): Some physical and chemical properties of the studied soil (as an average of two successive seasons of 2005-2006 and 2006-2007.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution %:		*Soluble cations (soil paste, meq/l)*:	
Sand	89.21	Ca^{2+}	9.37
Silt	7.38	Mg^{2+}	3.48
Clay	3.41	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
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 (me/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

Critical levels of the studied available plant nutrients (mg/kg), after Lindsay and Norvell (1978)

Nutrient	N	P	K	Fe	Mn	Zn
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	1.0	0.5-1.0
High	> 80.0	> 10.0	> 170.0	> 6.0	> 1.0	> 1.0

Data of tomato plant parameters recorded:

a. Vegetative growth and flowering characters: At 60 days after transplanting, a random sample consisted of eight plants was taken from each experimental plot to determine some growth and flowering parameters, i.e., plant height, number of leaves/plant, thickness of stem/plant at soil surface, number of branches/plant, leaf area, number of inflorescences/plant, number of flowers/inflorescence, dry weight/plant, and the chlorophyll a & b contents **(Hiscox and Isrealstam, 1979).**

b. Yield potential: Fruit from the whole nine plants were selected at each experimental plot in the ripening stage to determine yield and its components, i.e., number of fruit/plant, and fruit yield/plant, while the total yield was determined with total weight of the harvested fruit through the whole harvesting period excluding the damaged.

c. Chemical analysis: Leaves were taken from the fourth upper of tomato stem of eight randomly plants after 90 days from transplanting, washed with distilled water, dried at 70 ^{0}C and wet digested **(Van Schouwenberg, 1968)** for determining concentrations of N, P **(A.O.A.C., 1990), K, Na (Wilde *et al.*, 1985) and Cl (Higinbotham *et al.*, 1967).**

d. Fruit samples: These samples were taken from the 3rd harvest at red ripe stage from each experimental plot for determining fruit quality parameters, i.e., average weight of fruit, firmness using fruit pressure tester with a probe diameter of 0.8 cm and values expressed in pounds, total soluble solids (TSS) using hand held Brix meter, titrable acidity, vitamin C and total sugar) were evaluated using the methods undertaken by **A.O.A.C. (1990).**

Analytical methods of soil properties:

The collected soil samples at the initial state were analyzed for particle size distribution (International Pipette method after **Piper, 1950),** bulk density **(Black and Hartge, 1986),** hydraulic conductivity and available moisture range **(Klute, 1986),** organic matter content **(Walkely and Black** method after **Hesse, 1971)**, $CaCO_3$ content **(Wright, 1939),** cation exchange capacity, exchangeable sodium %, pH and soil paste extract **(Jackson, 1973).** Available macronutrients of N, P and K in soil 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 determined according to **Jackson (1973).** Available micronutrients of 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 the Atomic Absorption Spectrophotometer.

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, Sedmant El Gabal village, Beni-Suef Governorate, Egypt. 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 retain moisture, Table (3).

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, deep. 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 ($S3s_1s_4$).

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 (s_1)	Soil depth (s_2)	$CaCO_3$ (s_3)	Gypsum (s_4)				
Current	100	100	30	100	100	90	100	27.00	S3	$S3s_1s_4$
Potential	100	100	30	100	100	90	100	27.00	S3	$S3s_1s_4$

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 is water shortage particularly in the 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.

In order to facilitate the safe use of saline water for irrigation, the effects of salinity on crops should be understood and the optimal management strategies should be developed. A field experiment was carried out during two successive growing seasons (summer seasons of years 2005 and 2006) to investigate the effect of saline water on tomato yield and fruit quality under humic acid application through drip irrigation system. The experiment was consisted of a control treatment (the Nile fresh water with ECiw of 0.56 dS/m) and saline water with ECiw of 1.89 dS/m in combination with four humic acid rates (i.e., 0, 75, 150 and 225 mg/L, twice/week and for a period of 4 months after transplanting) to know farther information about the beneficial influence of humic acid on moisture and salinity stresses as well as the biological activity in the experimental soil, consequently their positive reflection on vegetative growth, yield and its components of tomato as a test crop.

II. Influence of amended saline water with humic acid 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.

Table (5): Effects of different applied irrigation waters on the studied soil physico-chemical properties and available nutrient contents in both seasons of 2005-2006 and 2006-2007.

Soil properties	Growing season	Saline irrigation water amended with humic acid at rates				The Nile water
		0	75 mg/L	150 mg/L	225 mg/L	
Bulk density (g/cm^3)	2005-06	1.77	1.70	1.64	1.62	1.61
	2006-07	1.79	1.72	1.65	1.64	1.63
Total porosity %:	2005-06	33.21	35.85	38.11	38.87	39.25
	2006-07	32.45	35.09	37.74	38.11	38.49
Available water %	2005-06	6.37	6.94	7.65	8.02	7.56
	2006-07	6.28	6.89	7.60	7.96	7.48
Hydraulic cond. (cm/h)	2005-06	7.96	9.13	8.75	7.94	10.32
	2006-07	7.83	8.98	8.67	7.81	10.25
Organic matte%	2005-06	0.18	0.20	0.26	028	0.21
	2006-07	0.16	0.21	0.30	0.31	0.23
pH (1:2.5 water susp.)	2005-06	8.17	8.03	7.68	7.61	7.95
	2006-07	8.21	8.07	7.70	7.64	7.98
CEC (me/100 g soil)	2005-06	4.19	4.82	5.53	5.64	4.23
	2006-07	4.24	4.94	5.67	5.75	4.27
ECe (dS/m)	2005-06	3.38	3.17	2.98	2.92	2.89
	2006-07	3.40	3.20	3.01	2.95	2.91
ESP	2005-06	4.59	3.81	3.58	3.50	3.47
	2006-07	4.62	3.86	3.60	3.54	3.50
Macro and micronutrients (mg/kg soil):						
N	2005-06	13.35	18.56	24.97	26.78	20.95
	2006-07	14.01	19.12	25.12	27.24	21.17
P	2005-06	3.50	4.15	5.09	5.37	4.87
	2006-07	3.62	4.27	5.21	5.42	4.33
K	2005-06	49.85	50.92	63.75	67.58	58.60
	2006-07	52.91	54.70	65.08	69.64	60.32
Fe	2005-06	3.45	3.87	4.89	5.08	4.79
	2006-07	3.62	3.99	4.67	5.13	4.95
Mn	2005-06	0.82	0.97	1.07	1.15	0.92
	2006-07	0.85	1.01	1.12	1.24	0.97
Zn	2005-06	0.64	0.75	0.91	0.95	0.87
	2006-07	0.68	0.79	0.65	1.02	0.81
Cu	2005-06	0.42	0.55	0.81	0.86	0.73
	2006-07	0.49	0.59	0.89	0.92	0.76

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 plots (control treatment), whether the salinity and alkalinity levels tended to be increased as compared with the initial soil data (Table, 3). 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 values (as an average of the two seasons) in the root zone of the untreated soil reached 18.95 and 33.09 % as compared to the initial state of soil, respectively. Meanwhile, the corresponding relative increases were 1.75 and 0.72 % in case of using the Nile fresh water. On the other hand, the relative increases in the ECe values in case of amended saline irrigation water with humic acid at rates 0. 75, 150 and 225 mg/L were 11.75, 5.09 and 2.98 % as compared to the initial state of soil, respectively. The corresponding relative increases in the ESP values were 10.84, 3.76 and 1.73 %, respectively.

From these obtained results, it is clear that the applied humic acid plays an important role in reducing the salts accumulation in the experimental soil reached its optimal value when soil was irrigated by amended saline water with humic acid at a rate of 225 mg/L, where the ECe value decreased from 3.390 to 2.935 dS/m, with a percentage relative decrease from 18.95 to 2.98 %. As for the ESP value, it decreased from 4.605 to 3.520, with a percentage relative decrease from 30.09 to 1.73%. Under such actual favourable conditions of soil salinity and sodicity the associated soil physical properties, i.e., bulk density, total porosity, available water and hydraulic conductivity as well as chemical ones, i.e., organic matter content, pH and CEC should be improved, as shown in Table (5).

a. Soil physical properties:

Concerning the variations in soil bulk density among the different used amended irrigation water treatments, data show that a gradually decrease in its values was occurred with increasing the applied humic acid rates, where the greatest rate (225 mg/L) gave the lowest soil bulk density value. This positive effect might 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 amended saline irrigation water with humic acid 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.

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. This is mainly due to humic acid can also soluble in water and make available to plants certain nutrients that would be unavailable otherwise. 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 humic acid affected differently the hydraulic conductivity values of the studied soil, where a gradual decrease in the hydraulic conductivity value was parallel with increasing the applied humic acid levels in irrigation water. 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.

b. Soil chemical properties:

Data in Table (5) also showed that applying humic acid levels in combination with saline water 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 increasing the humic acid levels vs an increase for each of soil organic mater content and CEC. 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 view, the obtained results indicated that building up of soil salinity and sodicity herein was due to the influence of water salinity in the absence of humic acid. On basis of soil ECe and ESP values, soil salinity and sodicity were generally lower in the case of amended saline water with high humic acid level vs a greater salinity sodicity levels in the case of untreated humic acid saline water, 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 (3) 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 irrigated with the tested saline water were drastically negative affected by the excess salts in the soil media, but their contents gradually increased with increasing the applied humic acid levels mixed in the saline irrigation water, which were nearly similar to those irrigated with the Nile fresh water or more in case of the highest level (225 mg/L). 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 oxygencontaining functional groups such as carboxyl, phenolic, alcoholic and quinoid groups, which is beneficial for plant nutrition.

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 its self 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 amended saline water with humic acid on plant parameters:

a. Vegetative growth and flowering parameters:

Vegetative growth and flowering traits of tomato plants, i.e., plant height, number of leaves/plant, thickness of stem/plant at soil surface, number of branches/plant, leaf area, number of inflorescences/plant, number of flowers/inflorescence, dry weight/plant, and the chlorophyll a & b contents were drastically affected by excess of salts in case of applied irrigation saline water (Table, 6).

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).**

Since vegetative growth represents a part of the total biological yield of any crop, its parameters play an important role determinant of the economic yield. Data of the studied tomato growth parameters irrigated with either fresh or saline water amended with different humic acid levels through drip irrigation system also showed significantly increases with increasing the applied levels up to 225 mg/L. 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 which 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 **Duncan (1971)** who obviously 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. This finding is in agreement with it has been reported by **Chawla and Narda (2000).**

In addition, soil application of humic acid to tomato through drip irrigation system increased the availability and uptake of nutrients, and decrease the ECe values (Table, 5) when added up to 225 mg/L, all that reflected the best result on plant growth and flowering parameters. The mechanism of humic acid on stimulating growth may be similar to that of plant growth regulators as humic substances include auxins or function as auxins and thus affect plant metabolism in a positive manner **(Senn and Kingman, 1973)**.

Chlorophyll a and b contents were significantly higher in plants irrigated with either fresh water or saline water amended with humic acid added through drip irrigation system. This is testimony for the longer source activity in such efficient irrigation system, where humic acid levels were applied through about 35 split doses 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 the humic acid with saline irrigation water had a greatly positive effect on vegetative growth and flowering parameters of tomato plants as compared to the applied saline irrigation water alone. However, tomato plants treated with humic acid at a rate of 225 mg/L caused an insignificant increase in vegetative growth and flowering parameters in both seasons as compared to those treated with 150 mg/L, hence both rates (150 and 225 mg/L of humic acid) gave the same effect of the fresh irrigation water (the Nile water as a control treatment).

Table (6): Vegetative growth and flowering parameters of tomato as influenced by the different irrigation water qualities in both seasons of 2005-2006 and 2006-2007.

Growth & flowering parameters	Growing season	The applied irrigation water treatments					L.S.D. at 0.05
		Saline irrigation water amended with humic acid at rates				The Nile water	
		0	75 mg/L	150 mg/L	225 mg/L		
Plant height (cm)	2005-06	37.93	58.41	75.85	76.97	80.25	5.88
	2006-07	40.24	60.03	78.34	79.16	82.14	8.18
Leaves Nos./plant	2005-06	78.76	81.07	83.45	87.79	88.97	6.21
	2006-07	81.32	82.76	85.01	89.05	90.54	7.54
Thickness of stem (cm)	2005-06	1.34	1.53	1.75	1.87	1.84	0.14
	2006-07	1.42	1.65	1.84	1.90	1.89	0.15
Branch Nos./plant	2005-06	13.21	16.34	18.65	19.98	17.89	2.20
	2006-07	14.67	17.75	19.74	21.05	18.76	2.31
Mean of leaf area (cm^2)	2005-06	34.97	41.84	62.97	65.80	64.81	6.26
	2006-07	36.03	44.12	63.18	68.05	66.03	7.41
Inflorescence Nos./plant,	2005-06	16.73	20.87	35.93	38.02	36.25	6.86
	2006-07	17.32	22.41	37.27	39.45	37.68	6.93
Flower Nos./ inflorescence	2005-06	3.20	4.25	5.83	6.12	5.35	0.82
	2006-07	3.84	4.60	6.02	6.94	5.76	0.88
Dry weight/ plant (g)	2005-06	43.56	50.89	89.74	90.68	86.90	9.54
	2006-07	47.13	52.72	92.10	93.02	87.23	10.01
Chlorophyll (a & b)*	2005-06	0.67	0.87	1.07	1.32	0.97	0.14
	2006-07	0.69	0.93	1.24	1.43	1.18	0.11

*mg/g fresh weight

b. Chemical constituents (N, P, K, Na and Cl contents in plant tissues):

The ability of humic acid for increasing plant nutrient uptake is due to its chelating property, which makes the nutrients more available to plants as well as owing to its ability to enhance cell permeability that making a more rapid entry of nutrients into plant cells. Humic acid can also reduce the surface tension of water and increase the effectiveness of nutrients or chemicals. In addition, using drip irrigation with humic acid and attached nutrients had a significantly higher N, P and K contents and uptake by tomato plants over that irrigated with saline water (Table, 7). These increases in N, P and K uptake were due to the frequent application of these nutrients in better availability in root zone coupled with better root activity. Furthermore, it was also due to the reduced loss of these nutrients, particularly under such skeletal soil as compared to furrow irrigation. Similar observations were reported by **Van Sane *et al*. (1996).** 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.

Table (7): N, P, K, Na and Cl % in tomato plants as influenced by different irrigation qualities in both seasons of 2005-2006 and 2006-2007.

Nutritive & non-nutritive elements	Growing season	The applied irrigation water treatments					L.S.D. at 0.05
		Saline irrigation water amended with humic acid at rates				The Nile water	
		0	75 mg/L	150 mg/L	225 mg/L		
N	2005-06	2.84	3.19	3.67	3.69	3.23	0.44
	2006-07	2.90	3.26	3.75	3.63	3.34	0.56
P	2005-06	0.34	0.50	0.53	0.52	0.42	0.07
	2006-07	0.32	0.52	0.53	0.54	0.44	0.06
K	2005-06	1.96	2.07	2.20	2.22	2.26	0.16
	2006-07	2.04	2.08	2.24	2.31	2.35	0.15
Na	2005-06	1.19	1.10	0.75	0.70	0.67	0.09
	2006-07	1.20	1.11	0.79	0.73	0.69	0.15
Cl	2005-06	0.95	0.89	0.55	0.49	0.46	0.11
	2006-07	0.97	0.90	0.58	0.52	0.47	0.16

The above-mentioned results are also in harmony with many various benefits of humic acid, which have been reported to promote an increase in 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 (Table, 6) 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. Moreover, the principal physiological function of humic acid may be that they reduce oxygen deficiency in plants, which results in better uptake nutrients **(Abadia, 1984 and Arancon *et al.*, 2003).**

It is noteworthy to mention that tomato plants treated with 150 mg/l humic acid registered almost similar contents of N, P, K, Na and Cl in both the studied seasons as compared to the applied rate of 225 mg/L humic acid.

c. Tomato fruit yield and quality:

Of course saline stress, as resulted from either irrigation water or soil, is one of the most serious problems faced the agriculture development. However, salinity of irrigation water and soil nutrient deficiencies herein represents the main factors controlling the reduction of the crop yield, particularly under the prevailing arid conditions. In addition, irrigation water salinity may be considered not only diminishing the absorbed nutrients but also possibly playing an important role in damaging the translocation vascular system in higher plants **(Shukla and Mukhi, 1985).**

The obtained data in Table (8) indicate that humic acid added, at a rate of 225 mg/L, as mixed with saline irrigation water through a drip irrigation system registered almost similar yields to those irrigated with the Nile fresh water as well as higher ones over that irrigated with saline water under the same irrigation system. Such relative increases could be attributed to significantly higher increments in dry weights and number of flowers per plant, which positively reflected on the higher number of tomato fruit and yield per plant and fed. Moreover, this distinctive tomato yield advantage reflected under these prevailing conditions is further amplified by such drip system, which leads to maintenance of a favorable available soil water and nutrients status in the root zone.

Table (8): Tomato yield parameters as influenced by the different irrigation water qualities in both seasons of 2005-2006 and 2006-2007.

Fruit yield parameters	Growing season	The applied irrigation water treatments					L.S.D. at 0.05
		Saline irrigation water amended with humic acid At rates				The Nile water	
		0	75 mg/L	150 mg/L	225 mg/L		
Fruit Nos./plant	2005-06	19.69	26.38	32.95	35.81	33.45	3.09
	2006-07	20.17	26.96	34.93	36.42	34.41	2.45
Fruit yield/ plant (kg)	2005-06	0.80	1.65	2.47	2.92	2.62	0.36
	2006-07	0.82	1.74	2.80	3.06	2.87	0.31
Fruit yield (ton/fed)	2005-06	8.97	18.68	29.44	32.31	29.25	3.20
	2006-07	9.10	19.20	30.29	33.89	31.62	3.76

d. Tomato fruit quality:

Tomato fruit quality can be evaluated by different parameters, i.e., average weight of fruit, fruit firmness, total soluble solids, vitamin C (ascorbic acid), titrable acidity (citric acid) and total sugar, as shown in Table (9).

Table (9): Tomato fruit quality parameters as influenced by the different irrigation water qualities in both the studied two seasons.

Fruit quality parameters	Growing season	The applied irrigation water treatments					L.S.D. at 0.05
		Saline irrigation water amended with humic acid at rates				The Nile water	
		0	75 mg/L	150 mg/L	225 mg/L		
Average fruit weight (g)	2005-06	39.31	63.32	83.12	82.01	79.11	7.89
	2006-07	40.16	65.07	81.00	83.82	82.99	9.03
Fruit firmness (Ibs)	2005-06	6.94	7.22	7.64	8.05	7.98	0.31
	2006-07	7.02	7.37	7.93	8.17	8.01	0.35
Total soluble solids% (TSS)	2005-06	6.97	5.82	4.92	4.82	4.57	0.68
	2006-07	6.92	5.75	4.66	4.75	4.46	0.96
Ascorbic acid (mg/100g fresh wt)	2005-06	15.73	16.14	17.42	17.92	18.24	0.91
	2006-07	15.95	16.65	17.82	18.10	19.71	1.01
Citric acid %	2005-06	0.37	0.40	0.44	0.47	0.45	0.04
	2006-07	0.39	0.41	0.46	0.48	0.46	0.03
Total sugar %	2005-06	1.12	1.35	165	1.84	1.78	0.03
	2006-07	1.19	1.48	1.72	1.97	1.85	0.05

The obtained results showed positively significant differences in all the abovementioned parameters as affected by amended saline irrigation water with humic acid at the applied rates added through the drip irrigation system as compared to the effect of the used saline irrigation water solely. This may be due to their better effects on the grown tomato plants. This is in harmony with the findings outlined by **Abou Zied *et al.* (2005)** who found that using some organic polymers and humic acid improves the productivity and quality of some crops grown on a sandy soil. Therefore, it can be concluded that availability of nutrients evenly with humic acid mixed with saline water through a drip irrigation system was responsible for improving tomato yield and the different parameters of fruit quality. Also, these results are in agreement with those reported with **Maggio *et al.* (2006)** who mentioned that such organic substances control many stress adaptation responses including stomatal closure, osmotic adjustment, ion comparetimentation, regulation of shoot versus root growth and modifications of root hydraulic conductivity properties. Also, tomato plants treated with 150 mg/l humic acid registered almost similar fruit quality parameters in both the studied seasons as compared to the applied rate of 225 mg/L humic acid or the used Nile water (control).

Thus, the present work shows that the best rate of humic acid added to a mixture of agricultural drainage saline water with the Nile water at a ratio of about 1:1 (C_2S_1, ECiw = 1.89 dS/m and SAR = 5.35) for tomato plants was 150 or 225 mg/L for producing the greatest fruit yield with high quality.

Finally, it is evident from the abovementioned results that application of organic substances such as humic acid achieve many of the beneficial effects on soil hydrophysical properties and fertility status as well as grown plant parameters, since such acids partially capable to retain water and nutrients in soil for grown plants as well as these organic substances acted like plant growth hormones **(O'Donnell, 1973)**. In addition, it could be interpreted these beneficial reacts of the added humic acid on the basis that it would act as chelating agent, through -OH and -COOH as active groups for micronutrients and water molecules **(Sayed *et al.*, 2007)**, this minimizes the loss of nutrients by leaching.

Moreover, such organic substances are considered as a storehouse with easily mobile or available to uptake by plant roots, and in turn reflected positively on development of crop yield and its attributes. At the same time, the abovementioned results revealed that if suitable management practices were adapted, it was feasible to irrigate tomato using relatively high saline water under arid conditions of Egypt. These management practices included irrigation daily by using drip system, applying balanced fertilization system and using an organic material such as humic acid with irrigation water to alleviate the harmful effects of excessive water and soil salinization for crop production.

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إمكانية استخدام حمض الهيوميك من خلال نظام الرى بالتنقيط لتقليل التأثيرات الضارة لمياه الرى الملحية على نباتات الطماطم

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الهدف الرئيسى لهذه الدراسة هو تقييم إمكانية استخدام حمض الهيوميك مخلوط بمياه الرى الملحية والمضافة إلى التربة الرملية من خلال نظام الرى بالتنقيط لتقليل التأثيرات الضارة الناجمة عن ملوحة مياه الرى على محصول الطماطم (*Lycopersicon esculentum*) صنف هجين ١٠٧٧، وكذلك جودة ثماره، ولتحقيق هذا الهدف أجريت تجربة حقلية بإحدى المزارع الخاصة بقرية سدمنت الجبل – محافظة بنى سويف – مصر وهى تمثل إحدى القرى المتواجدة فى النطاق الصحراوى ذات الرمال السافية والمتاخم للحدود الغربية لرسوبيات وادى نهر النيل خلال موسمين متتاليين ٢٠٠٥- ٢٠٠٦، ٢٠٠٦-٢٠٠٧. وقد أستخدم مصدرين من المياه فى رى أرض التجربة هما مياه النيل (C1S1, ECiw = 0.56 dS/m and SAR = 2.13)، وخليط من مياه الصرف الزراعى والنيل بنسبة ١:١ (C2S1, ECiw = 1.89 dS/m and SAR = 5.35) من خلال نظام الرى بالتنقيط. كما أضيف حمض الهيوميك بمعدلات ٧٥، ١٥٠، ٢٢٥ ملجم/لتر مع مياه الرى من خلال نظام الرى بالتنقيط مرتين أسبوعيا لمدة أربعة أشهر بعد إجراء عملية الشتل.

وتشير النتائج المتحصل عليها إلى أن التربة تحت الدراسة نشأت وتطورت على رسوبيات من الرمال السافية كمادة أصل، كما أنها تتبع الوحدة التقسيمية :

Typic Torripsamments, siliceous, hyperthermic (USDA, 1999)

وتنتمى إلى رتبة الأراضى الهامشية من حيث درجة صلاحيتها للزراعة، وتوضح النتائج أيضا أن استخدام مياه الرى الملحية قد أدت إلى زيادة نسبية فى قيم كلاECe and ESP للتربة فى منطقة الجذور بما يعادل ١٨,٩٥ ، ٣٣,٠٩ ٪ على الترتيب مقارنة بقيمهما فى التربة الأصلية، فى حين كانت الزيادة النسبية فى قيم ECe للتربة فى حالة استخدام مياه الرى المعالجة بحمض الهيوميك بمعدلات ٧٥، ١٥٠، ٢٢٥ ملجم/لتر هى ١١,٧٥، ٥,٠٩، ٢,٩٨ ٪ مقابل ١٠,٨٤، ٣,٧٦، ١,٧٣ ٪ فى قيم ESP على الترتيب، مع الأفضلية فى حالة استخدام حمض الهيوميك بمعدل ٢٢٥ ملجم/لتر. ومن هذه النتائج يتضح أن حمض الهيوميك يلعب دورا هاما فى تحسين قيم الكثافة الظاهرية للتربة، المسامية الكلية، والماء الميسر، والتوصيل الهيدروليكى، المحتوى من المادة العضوية، الرقم الهيدروجينى، والسعة التبادلية الكاتيونية للتربة، المحتوى من المغذيات الميسرة فى التربة، وقد يرجع ذلك إلى التأثير الإيجابى لحمض الهيوميك على تعديل الميزان المائى-الهوائى مما يقلل التأثير المثبط على انطلاق المغذيات من تحلل البقايا النباتية.

و قد انعكست تلك الظروف الجيدة من حيث تحسن فى حالة خواص التربة ومياه الرى المعالجة بصورة إيجابية على قياسات النمو الخضرى والتزهير لنباتات الطماطم ممثلة فى طول النبات، عدد الأوراق/نبات، سمك ساق النبات عند سطح التربة، عدد الأفرع/نبات، مساحة الورقة، عدد النورات/نبات، عدد الأزهار/نورة، الوزن الجاف/نبات، المحتوى من كلوروفيل أ، ب. ومن الواضح فان تلك التأثيرات المفيدة لحمض الهيوميك على تراكم المادة الجافة فى أنسجة النبات كان أكثر ارتباطاً بمساحة الأوراق وعددها وكلاهما أكثر ارتباطاً بعملية التمثيل الضوئى وزيادة تكوين الكربوهيدرات فى النبات، وأيضا قابلية حمض الهيوميك على زيادة امتصاص المغذيات والتى ترجع إلى خاصية خلبه لها وتكوين معقدات معدنية-عضوية أكثر صلاحية للامتصاص بواسطة النبات. كما وأن إضافة حمض الهيوميك بتركيزاته المختلفة لمياه الرى قد أدى إلى زيادة معنوية فى محتوى الأوراق من عناصر N, P and K، والعكس صحيح بالنسبة لعنصرى Na and Cl كنتيجة لمعالجة التأثيرات الضارة الناجمة عن ملوحة مياه الرى. بالإضافة إلى أن حمض الهيوميك المضاف مع المياه الملحية من خلال نظام الرى بالتنقيط بمعدلات ١٥٠، ٢٢٥ ملجم/لتر قد أعطى محصولا متقاربا من ثمار الطماطم وكلاهما مقارب لمحصول النباتات التى تروى بمياه النيل العذبة والذى يعتبر أعلى كثيرا من التى تروى بمياه ملحية فقط أو تلك المعالجة بحمض الهيوميك بمعدل ٧٥ ملجم/لتر من خلال نفس نظام الرى. ومثل هذه الزيادة النسبية فى محصول ثمار الطماطم/النبات أو الفدان ترتبط لحد كبير بالزيادة المعنوية فى الوزن الجاف وعدد الأزهار/نبات والتى تنعكس بصورة إيجابية على العدد الكبير من ثمار الطماطم ومحصولها سواء كانت على مستوى النبات والفدان.

كما وأن قياسات جودة ثمار الطماطم، متمثلة فى متوسط وزن الثمرة، قوة تماسكها، المواد الصلبة الذائبة الكلية، فيتامين C، حمض الستريك، السكريات الكلية تظهر زيادة معنوية فى حالة الرى بالمياه الملحية المعالجة بحمض الهيوميك بالمعدلات موضع الدراسة مقارنة بمياه الرى الملحية فقط غير المعالجة. ولذا فان هذه الدراسة توضح أن أفضل معدل من حمض الهيوميك يمكن استخدامه مخلوطا مع مياه الرى الملحية هو ١٥٠- ٢٢٥ ملجم/لتر لتحقيق أعلى محصول من ثمار الطماطم عالية الجودة.