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Effectiveness of Humic Acid Applicationin Improving Saline Soil Properties and Fodder Beet Production

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ABSTRACT

Two field experiments were carried out at Bahr Hadous drain and El-Salam canal locations in Sahl El-Hossinia , El-Sharkia -Governorate, Egypt, for winter seasons of 2014/2015 and 2015/2016, to study the effect of humic acid application on some physical and chemical soil properties and fodder beet (*Beta vulgaris L.)* productivity and quality in saline soil conditions irrigated with different water sources i.e. [Bahr Hadoos drainage water and Nile water from El-Salam canal mixed with agricultural drainage (1:1)].The obtained results show a noticeable reduction in soil pH and salinity as a result of treating the soil with humic acid compared to control. The effect is more obvious in case of applying humic acid high rate of (2400 ml/400 L water,T_4) irrigated with El-Salam canal water than Baher Hados drain water .The soil O.M content and cation exchange capacity values were improved by applying humic acid high rate where soil OM content reached 0.80 and 0.73 % in case of using El-Salam canal and Baher Hados drain water compared with 0.63 and 0.55 % for control treatment, respectively. The highest diameter of dry aggregates was affected by the application of humic acid high rate with El-Salam canal water than Baher Hados drain water .Moreover, the maximum values of total stable aggregates were obtained in case ofhumic acid high rate using El-Salam canal water compared to Baher Hados drain water and control treatments. The data also show that the values of hydraulic conductivity were lowand increased by humic acid application. The highest value of hydraulic conductivity was obtained in case of applying humic acid high rate using El-Salam canal water than Baher Hados drain watercompared to control treatment. Applying humic acid high rate decreased the soil bulk density and increased total soil porosity valuesusingEl-Salam canal water as compared to Baher Hados drain water and control treatments. The maximum values of field capacity and available water were recordedin case of applying humic acid high rate using El-Salam canal than Baher Hados drain water compared to control. The result show an increase in fodder beet yield in all treatments compared to control and was higher in the case of humic acid high rate with El-Salam canal than Baher Hados drain water. Generally, the study recommends using humic acid (2400 ml/400 L water,T_4) with El-Salam canal or Baher Hados drain which improves soil chemical and physical properties and thus increases the productivity of saline soil.

Keywords: -Humic acid –irrigation water – fodder beet–Saline soil.

INTRODUCTION

In Egypt, irrigation water is scarce with the continuous demand increase of agricultural, domestic and industrial purposes. To face this increasing demand, the water supply is supplemented by the reuse of agricultural drainage water. This does not satisfy the water quality standards (defined for irrigation purposes)(Donia, 2012). Egypt has been practicing drainage water reuse since the 1930s. This was adapted through an official drainage water reuse policy in the late 1970s. The Government of Egypt is undertaking major projects to divert considerable amounts of drainage water to newly reclaimed areas. One of the projects, diverting drainage water to new reclaimed areas, started in 1985.The irrigation scheme of the canal is based on the concept of partial reuse of agricultural drainage water. El-Salam canal has been designed to supply the irrigation water as a mixture of Nile water and agricultural drainage water, MWRI andRTB ,(2007).The mixing ratio of both waters is 1:1. This ratio was determined to reach an amount of total dissolved solids (TDS) of not more than 1000-1200 mg/l to be suitable for cultivation,(Hafez *et al.*, 2008).JICA, (1989) said that, El-Salam canal is one of the national promising projects for reusing drainage water in irrigation. Namely, drainage water from Hadous drain (1.905 B m^3/year) and El-Serw drain (0.435 B m^3/year) in a 1:1 mixing ratio with the Nile river water (2.11 B m^3/year) delivered from Damietta branch.Balba, (1997) said that, El-Salam canal project has been planned to cultivate about 620,000 feddans, ofwhich 220,000 feddans are in Hussenya plain and south Port Said areas at the western bank of Suez Canal, about 400,000 feddans in south El-Qantara Shark, Tina plain, Rabaa, Bir El-Abd and El-Sir and Quarir areas at the eastern bank of the Suez Canal. The total length of El-Salam Canal is 242 km, 87 km in the west and 155 km in the east side of the Suez Canal. The water in the canal from Bir El-Abd to El-Manarah will be under pressure in pipes to allow lifting of water to the area of El-Sir and El-Quarir, and to avoid the sand dunes in this area. The tunnel underneath the Suez Canal delivers 14 million m3 of water/day. National Water Research Center, (2009)stated that, Bahr Hadous is the largest drain in the eastern Delta with total length of about 64 km. The total served area of Bahr Hadous drain is about 814,000 feddans and its current total discharge reaches 1.75 BCM/year.Bahr Hadous drain is one of the major sources of El Salam canal project. The remaining amount of drainage water flows into Lake Manzala through the end weir of Bahr Hadous drain. Determination of salinity removal over time may require a long residence time, which should be investigated in outdoor tanks and not in real wetlands. The best cost - effective scenario in terms of salinity removal should be firstly produced to decision makers in order to be later implemented in branch drains of Bahr Hadous drain.

Gulser *et al.*, (2010)concluded that, soil salinity is one of the most important problems in arid and semi-arid regions of the world involved in reducing the yield of wide variety of crops. Farhoudi *et al.,* (2012) and Hussain et al.,(2013) said that, soil salinity and/or sodicity affects many physiological and biochemical processes (photosynthesis, protein synthesis, nutrients uptake etc.) in plants, which lead to impaired growth and productivity of almost all arable crops.Qadir *et al.,* (2007); Feizi *et al.,* (2010)reported that, the major cation on exchange complex is Na^+, due to which saline-sodic soils endure deterioration in physical properties, like swelling, dispersion of clay, hard setting and surface crusting. Lauchli and Epstein, (1990) said that, the excess exchangeable sodium (Na^+) and the high soil pH, as a result of salt accumulation, cause deformation of soil structure and decrease in hydraulic conductivity and infiltration rate of soils. These processes, which affect plant growth, are related to the increase in the concentration of salt in the root zone, as water is removed from the soil profile due to evapotranspiration. Wong, (2007)concluded that, slaking occurs upon wetting, causing larger aggregates to break into smaller ones as result of swelling and air entrapment. Further wetting induces dispersion causing clay particles to diffuse out of the aggregates. The accumulation of Na^+ causes the interparticle distance to continuously increase and the individual clay particles to disperse.Eldardiry *et al.,* (2013) concluded that, reuse of low water quality is considered as animportant component of the water policies. They said that, chemical characteristics under salt-affected soilcould be used as a tool for expect soil hydrophysicalproperties deterioration and improvement of some soil properties could help in overcoming soil deterioration under reuse of agriculture drainage water.

Ouni *et al.,* (2013)found that,humic acid is mainly derived from the bio, chemical degradation of plant and animal residues and from microbial synthetic activity and they constitute a significant fraction of the soil organic matter (65-70%).Humic substances gave the highest values of available nutrients, yield and nutrients uptake by wheat plant in sandy soils,(Asik *et al.,* 2009). Sebastiano *et al.,* (2005)concluded that humic acid had a positive effect on plant growth, grain yield and quality, and photosynthetic metabolism of durum wheat crops.Hua et al.,(2008)found that,humic acid is promoted led to improve soil salinity and plant growth. Çimrin *et al.,* (2010)indicated that, humic acid can be used as a growth regulator to control hormone level, improve plant growth and enhance stress tolerance. Muscolo *et al.,* (2007) found that,the complex biological activity of humic matter depends on its concentration, chemical characteristics and molecular size and weight. Peizzeghello et al.,(2013)indicated that, the humic acid enhances plant growth significantly due to the increasing cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus uptake and supplying root cell growth.Tejada *et al.,* (2006) reported that the humic acid affect the plant growth both directly and indirectly. The indirect effect of humic acid improves physical, chemical and biological condition of soil, while the direct effects are attributed to its metabolic activity in plant growth. Tarek et al ., (2008) found that the soil EC was significantly reduced from 60 dSm^{-1} to about 25, 23 and 17 dSm^{-1}, respectively, for the leached control, barley, and fodder beet. Mohamed, (2012) reported that the EC value decreased significantly with the application of humic acid (2.0 and 3.0g kg^{-1}) doses. El-Sherief *et al.,* (2013)concluded that the humic acid treatment led to decrease soil pH and soil salinity. Pang *et al.,* (2010) said that,addition of organic matter such as farmyard manure (FYM), green manure and municipal solid waste is an effective strategy for salt-affected soils remediation. Ould-Ahmed *et al.,* (2010) stated that, use of organic amendments may promote sustainability because of long-term ameliorative effects on chemical, physical and biological properties of soil.Nusier,(2004)said that organic matter generally increased the ability of the soils to hold water, expand the available water capacity and decreased the modulus of rupture of compacted soils,(i.e. sandy loam, clay loam and clay). Several authors pointed out that organic amendments positively affected soil physical properties, penetration resistance and yield of crops,(Tester, 1990and Carter *et al.,* 2004).Gulser *et al.,* (2010)said that, the reclamation of salt affected soil requires the improvement of physical, chemical and biological properties. Soil humic substances (HS) such as humic acid (HA) and fulvic acid (FA), are mainly derived from the (bio) chemical degradation of plant and animal residues and from microbial synthetic activity and they constitute a significant fraction of the soil organic matter (65-70%).Hua *et al.,* (2008)reported that, humic acid application provide many benefits to agricultural soil, including increased ability to retain moisture, better nutrient-holding capacity, better soil structure and higher levels of microbial activity.

Fodder beet (*Beta vulgaris L.*) is one of the promising winter forage crop which can grow successfully under limited water and nutrients supply, (El-Sarag, 2013). It can tolerate high salinity during vegetative growth and could be cultivated successfully in saline soils, (Niazi *et al.,* 2000).

Owing to the benefits of humic acid and growing Fodder beet (*Beta vulgaris L.*) in salt-affected soils, this studywas conducted to assess the improvement in soil physical and chemical properties and fodder beet productivity and quality in case of saline soil conditions irrigated with different water sources i.e. [Bahr Hadoos drainage water and Nile water from El-Salam Canal mixed with agriculturaldrainage (1:1)].

MATERIALS AND METHODS

Two field experiments were carried out at Bahr Hadous drain and El-Salam canal locations in Sahl El-Hossinia , El-Sharkia -Governorate, Egypt, for winter seasons of 2014/2015 and 2015/2016, to study the effect of humic acid application on some physical and chemical soil properties and fodder beet (*Beta vulgaris L.)* productivity and quality in saline soil conditions irrigated with different water sources i.e. [Bahr Hadoos drainage water and Nile water from El-Salam canal mixed with agriculturedrainage (1:1)].Chemical and physical properties of the studied soil before planting are presented in Table (1).Chemical analysis of humic acid and different irrigation sources used are shown in Tables (2&3).In both seasons, each experiment was carried out in a split plot design with three replicates. The area of each experiment was one feddan. Each experimental plot was 5 X 10 m divided into rows with 50 cm apart and 25 cm between hills.The experiment plots units were subjected to some pretreatments processes as follows: a) leveling the soil surface by using lasar technique. b) Deep sub-soiling ploughing. c) Drainage water flow towards the main collectors of 2 m in depth and d) establishment of an irrigation canal in the middle part of the experiment plot unit as described by (Shaban, 2005).

The humic acid was distributed at random in the main plot, while the different locations (sources water Hadous drain and EL-Salam Canal) were treated as a sub plot.Humic acid was applied three times after 30, 55 and 75 days from sowing.

The treatments were as follow:

1-(T_1) Control without humic acid

2-(T_2) Humic acid at rate (800 ml/400 L water) as foliar application.

3-(T_3) Humic acid at rate (1600 ml/ 400L water)as foliar application.

4-(T_4) Humic acid at rate (2400 ml/ 400 L water)as foliar application.

Fodder beet seeds (*Beta vulgaris L.*, Variety Monovert) were sown in the 15th October 2014 and 20th October 2015 seasons, respectively. Rice was the preceding crop in both seasons.

Table 1. Chemical and physical properties of the studied soils irrigated from El-Salam canal and Bahr Hadoos drain before planting

A-El-Salam canal

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	CEC c mol/kg soil
2.21	30.56	23.07	44.16	Clay	0.58	41.08

pH (1:2:5)	EC (dS/m)	Dry Aggregates Diameter (mm) 10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	<0.063	Wet Aggregates Diameter (mm) 10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	Total (TSA)
8.14	12.49	47.71	25.49	14.99	3.18	3.53	3.68	1.42	8.56	14.01	8.36	4.23	1.57	2.05	39.31

B .D (g/cm^3)	T.P. %	H.C. (cm h^{-1})	Soil moisture constants % F.C.	W.P.	A.W.
1.26	52.45	0.066	32.60	19.20	13.20

B-Bahr Hadoos drain

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	CEC c mol/kg soil
4.93	36.87	25.96	32.24	Clay loam	0.55	31.38

pH (1:2:5)	EC (dS/m)	Dry Aggregates Diameter (mm) 10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	<0.063	Wet Aggregates Diameter (mm) 10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	Total (TSA)
8.10	10.66	50.90	25.52	14.34	1.04	1.79	3.36	2.95	10.26	10.26	8.02	4.33	1.79	2.69	37.36

B .D (g/cm^3)	T.P. %	H.C. (cm h^{-1})	Soil moisture constants % F.C.	W.P.	A.W.
1.34	49.43	0.007	29.30	17.60	11.70

BC= Bulk density Average of real density (g/cm3) = 2.65 T.P. =Total porosity. F.C = Field Capacity.
A.W = Available Water. W.P = Wilting Point. H.C=Hydraulic conductivity. E.C=Electric conductivity.

Table 2. Mean values of chemical properties of different irrigation sources used

Irrigation sources	pH (1:2:5)	EC (dSm^{-1})	Cations (meq L^{-1}) Ca^{2+}	Mg^{2+}	Na^+	K^+	Anions (meq L^{-1}) Cl^-	CO_3^{2-}	HCO_3^-	SO_4^{2-}	SAR
El-Salam Canal	7.98	1.75	3.50	4.50	8.70	0.75	6.75	-	1.50	9.20	4.35
Bahr Hadous drain	8.03	3.31	7.50	9.50	15.10	0.95	13.50	-	2.50	17.05	5.18

SAR= Sodium adsorption ratio.

Table 3. Chemical properties of the humic acid substance used in the experiment

pH	EC (dSm^{-1})	O.M. (%)	Macronutrients (%)			Micronutrients ($mgkg^{-1}$)		
			N	P	K	Fe	Mn	Zn
7.63	2.98	72.00	1.98	0.36	3.40	395	249	32.18

Nitrogen in the form of urea (46 % N) at a rate of100 kg N /fed was added after 30, 55 and 75 days from planting. Thinning was done after 30 days from sowing. Potassium sulphate (48 % K_2O) at a rate of 75 kg K_2O /fed was added after 30 and 55 days from planting, whereas super phosphate (15.5 % P_2O_5) at a rate of 31 kg P_2O_5 /fed was added during soil preparation before planting.

At harvest in 25 May 2015 and 2016, 10 plants were taken from the central ridges to determine the forage yield (root length, fresh and dry weight of root and top).

Soil samples:

Before planting, soil samples from the surface layer (0-30) have been taken from the studied soil, air-dried, ground, sieved through a 2 mm sieve and analyzed for some physical and chemical properties as recorded in Table (1). After harvest, undisturbed and disturbed soil samples have been collected from the surface layers and sub-surface layers at soil depths of 0-30, 30-60 and 60-90 cm. for all plots for two seasons. The soil samples were air- dried and analyzed for some physical and chemical properties, i.e., soil pH, organic matter and cation exchange capacity according to the methods described by Page *et al.*, (1982).Particle size distribution was carried out by the pipette method described by Gee and Bauder, (1986). The total soluble salts (EC) were determined using electrical conductivity meter at 25°C in soil paste extract as dSm^{-1}(Jackson, 1976).Soil bulk density, total soil porosity and dry aggregates were determined according to Richards, (1954).Stability of water stable aggregates was determined using the wet sieving technique described by Yoder, (1936) and modified by Ibrahim, (1964). Wilting point was determined according to Stakman and Vanderhast, (1962), while field capacity was determined as described by Richards, (1954).

Statistical analysis:-

Obtained results were subjected to the proper statistical analysis according to Snedcor and Cochran**, (1990)** and the treatments were compared by L.S.D. at 0.05 level of probability.

RESULTS AND DISCUSSIONS

Changes in soil chemical properties:-

Soil pH:-

Soil pH has a considerable impact on soil chemical properties. Data in Table (4) and Fig.(1) show the changes existing in some soil chemical properties in response to the application of humic acid at different rates using two sources of irrigation water. Data showed that the soil pH of soil irrigated by El-Salam canal water was lower than the soil irrigated by Baher Hados drain water.The soil pH decreased slightly due to the application of humic acidat different rates by irrigation either with El-Salam canal or Baher Hados drain compared to control. These finding are in agreement with those of El-Sherief *et al.,* (2013).A decrease in pH values could be attributed to various acids or acid is forming compounds that were released from the added organic acids (Abdel–Fattah, 2012).Brady, (1990) concluded that, the applying of organic matter to clay soils had no significant change in soil pH because of it is higher buffering capacity.

Table 4. Chemical properties of the experiment soils after Fodder beet harvest (Average of two seasons)

Locations	Rate of humic acid (ml/400Lwater)	Depth Cm	pH (1:2.5)	EC (dSm^{-1})	O.M (%)	CEC c mol/kg soil
El-Salam canal	Control	0-30	8.08	10.31	0.66	45.50
		30-60	8.09	10.22	0.63	46.00
		60-90	8.10	10.06	0.61	45.50
		Mean	8.09	10.19	0.63	45.66
	800	0-30	8.00	9.02	0.69	46.00
		30-60	8.02	8.98	0.68	46.00
		60-90	8.02	9.00	0.67	45.98
		Mean	8.01	9.00	0.68	45.99
	1600	0-30	7.86	7.95	0.78	48.02
		30-60	7.86	7.83	0.75	47.67
		60-90	7.82	7.56	0.74	47.55
		Mean	7.85	7.78	0.76	47.75
	2400	0-30	7.80	6.31	0.82	50.20
		30-60	7.80	6.00	0.80	49.00
		60-90	7.66	5.89	0.78	48.86
		Mean	7.75	6.07	0.80	49.35
Mean			7.87	7.62	0.75	47.70
Bahr Hadoos drain	Control	0-30	8.08	12.10	0.57	33.56
		30-60	8.08	12.00	0.54	33.92
		60-90	8.09	11.89	0.54	33.51
		Mean	8.08	11.99	0.55	33.66
	800	0-30	8.01	11.66	0.62	35.66
		30-60	8.00	11.50	0.60	35.02
		60-90	8.00	11.31	0.58	34.45
		Mean	8.00	11.49	0.59	35.04
	1600	0-30	7.98	10.78	0.66	38.86
		30-60	7.91	10.66	0.65	38.81
		60-90	7.91	10.56	0.63	38.02
		Mean	7.93	10.67	0.65	38.56
	2400	0-30	7.86	8.22	0.75	41.22
		30-60	7.86	8.06	0.74	41.00
		60-90	7.76	8.00	0.71	40.18
		Mean	7.83	8.09	0.73	40.80
	Mean		7.92	10.08	0.66	38.13

Soil salinity (EC):-

The dissolved salts concentration (electrical conductivity) values measured in soil paste extract at the end of the experiment are shown in Table (4) and Fig.

(1). In general, EC of soil irrigated with El-Salam canal water was lower than the other one which was irrigated by Baher Hados drain water. EC decreased as a result of the application of humic acidat different ratesby irrigation either with El-Salam canal or Baher Hados drain compared to control. The lowest EC value exists in case of(T_4) treatment by irrigation either with El-Salam canal or Baher Hados drain. The positive effects of all treatments followed the order of: T_4> T_3> $T_2$with El-Salam canal or Baher Hados drain. This is due to the effectiveness of humic acid in increasing macro pore spaces and removing salts from soils by leaching. Data agree with the results reported by Tarek *et al.,* (2008);Mohamed, (2012)and El-Sherief *et al.,* (2013). Organic matter such as HA may play as salt-ion chelating agents, which detoxify the toxic ions, especially Na^+ and Cl^-, as indicated by low EC in soil treated with organic matter.Qadir *et al.,* (2001)stated that, the addition of organic matter can accelerate the leaching of Na^+ and decrease ESP and EC values.

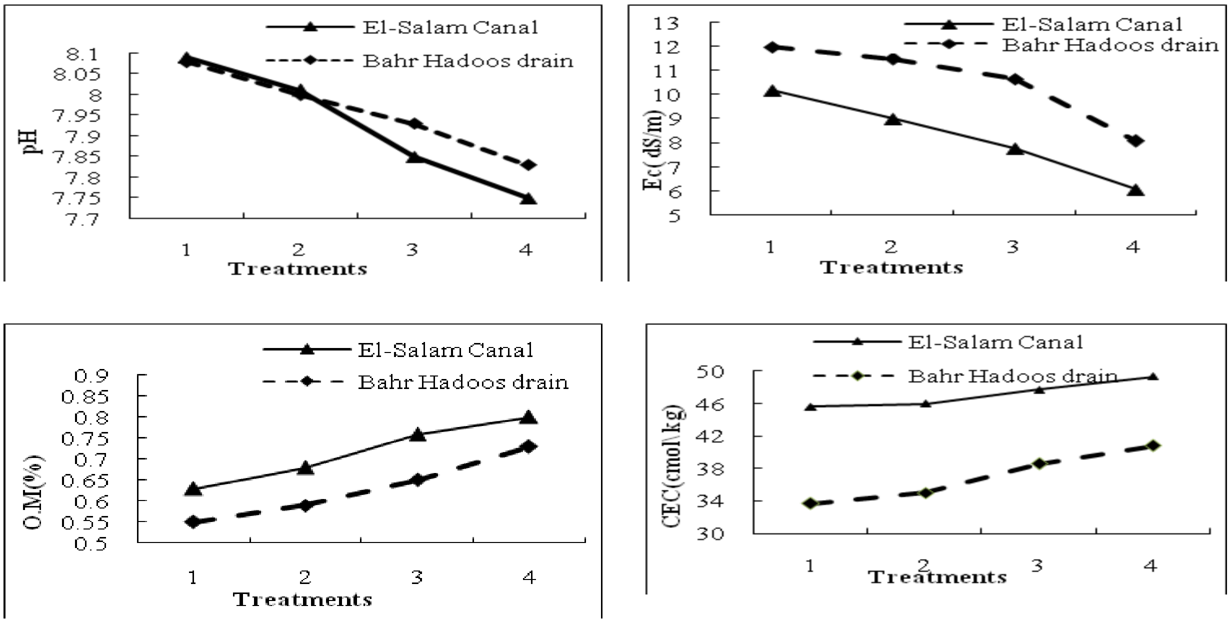

Fig. 1. Effect of different treatments on the chemical properties of the studied soils.

Changes in soil organic matter and cation exchange capacity:-

Organic amendments are very important since they contain both major and minor elements necessary for plant growth and help in improving physica land chemical properties of the soil. Results show that all applied treatments increased OM content as compared to control treatment with El-Salam canal or Baher Hados drain. The soil irrigated by El-Salam canal water has a high content of OM compared to the other soil irrigated byBaher Hados drain water.The treatment of humic acid (2400 ml/400 L water,T_4) recorded high increases in OM content of soil being 0.80 and 0.73 % in case of El-Salamcanal and Baher Hados drain compared to 0.63 and 0.55 % for control treatment, respectively. In this respect, the data agree with results reported by Gulser *et al.*, (2010) and Ouni *et al.*, (2013).

Cation Exchange Capacity is one of the most important indicators for evaluating soil fertility, more specifically fornutrient retention and thus it prevents cations from leaching.The cation exchange capacity of the soil under different treatment stake the same trend of organic matter where the treatment of humic acid (2400 ml/400 L water,T_4) recorded high increases in CEC with El-Salam canal than Baher Hados drain. According to Amlinger *et al.,* (2007), soil organic matter contributes about 20 – 70% of the CEC for many soils. In absolute terms, CEC of organic matter varies from 300 to 1,400 $cmolkg^{-1}$soil being much higher than CEC of any inorganic material. These results are in agreement with those of Agegnehu *et al.,* (2014); Abdel-Rahman, (2009) and Mohammad *et al.,* (2004) who said that compost amendment resulted in an increase of CEC due to input of stabilized OM being rich in functional groups into soil. Similar results were obtained from Dadhich *et al.,* (2011)who stated that application of farmyard manure significantly increased the organic carbon and CEC of the soil.

Soil physical properties:-

Soil aggregation: -

Distribution of dry or wet stable aggregates showed marked variations associated with different treatments. The aggregate categories studied in this experiment are of the following diameters (mm): 10-2, 2-1, 1-0.5, 0.5-0.25, 0.25-0.125, 0.125-0.063 and < 0.063.For reasons of data presentation they are designated as follows, respectively: very large, large, medium, sub – medium, small, very small and extremely small. Dry aggregation covered the 7 categories, but wet aggregation (because of its nature) covered only 6 categories. Data show marked changes in all categories. Discussions will cover the three aggregate categories of very large sub–medium and very small aggregates as representative of the effect of treatments on aggregation.

Dry –sieved aggregates:-

It is obvious from the data in Table (5) that the dry aggregates having diameters from 10 to 2 mm and0.5-0.25 mmwere found to be the largest size presented in the different treatments under study. The percentages of other sizes of dry aggregates decrease as their diameters decrease, especially the aggregates having diameters less than 0.063 mm where thelowest values were found. As a general, the soil treated with humic acid high rate with El-Salam canal irrigation water are more affected compared to Baher Hados drain with other treatments and control.The organic acids have a great effect on soil physical properties,such as soil aggregation and drainable pores. These results are similar to the results of Bouajila and Sanaa, (2011) who showed that application of manure and household wastes compost resulted in a significant increase of structural stability.

Wet sieving stable aggregates:-

Soil structure is defined by size and spatial distributions of particles, aggregates and pores in soils. The volume of solid soil particles and the pore volume influences air balance and root penetration ability. Data in Table (6) show the values of total stable aggregates as well as distribution of aggregates size fractions. Data showed that the values of total stable aggregates of the soil irrigated by El-Salam canal water was higher than the aggregates of the soil irrigated with Baher Hados drain water. The maximum values of total stable aggregates was observed bythe treatment of humic acid (2400 ml/400 L water,T_4) with El-Salam canal or Baher Hados drain compared to control treatment. The application of humic acid on soil physical parameters was of positive effect on aggregate stability, which can be attributed to organic matterincrease and microbial activity which led to increase aggregate stabilizing factors. These results are in agreement with those of(Amlinger *et al.*, 2007)who said that, besides clay minerals, fine roots, hyphen networks as well as glue-like polysaccharides originated from root and microbial exudates significantly contribute to the formation of micro-aggregates. Such behavior might be the result of elevated organic matter content and important microbial activities.

Finally, the values of total aggregates were plotted against EC, O.M and CEC with El-Salam canal and Baher Hados drain, these parameters are shown in Fig (2).The correlation between EC, OM% and CECand total aggregates % have been generally positivein the soil irrigated with El-Salam canalwater. The same trend was observed for Baher Hados drain but,the soil irrigated with El-Salam canalwater was highly positive compared to Baher Hados drain. This indicatethe positive effect among all studied parameters (EC, OM% and CEC and total aggregates %).

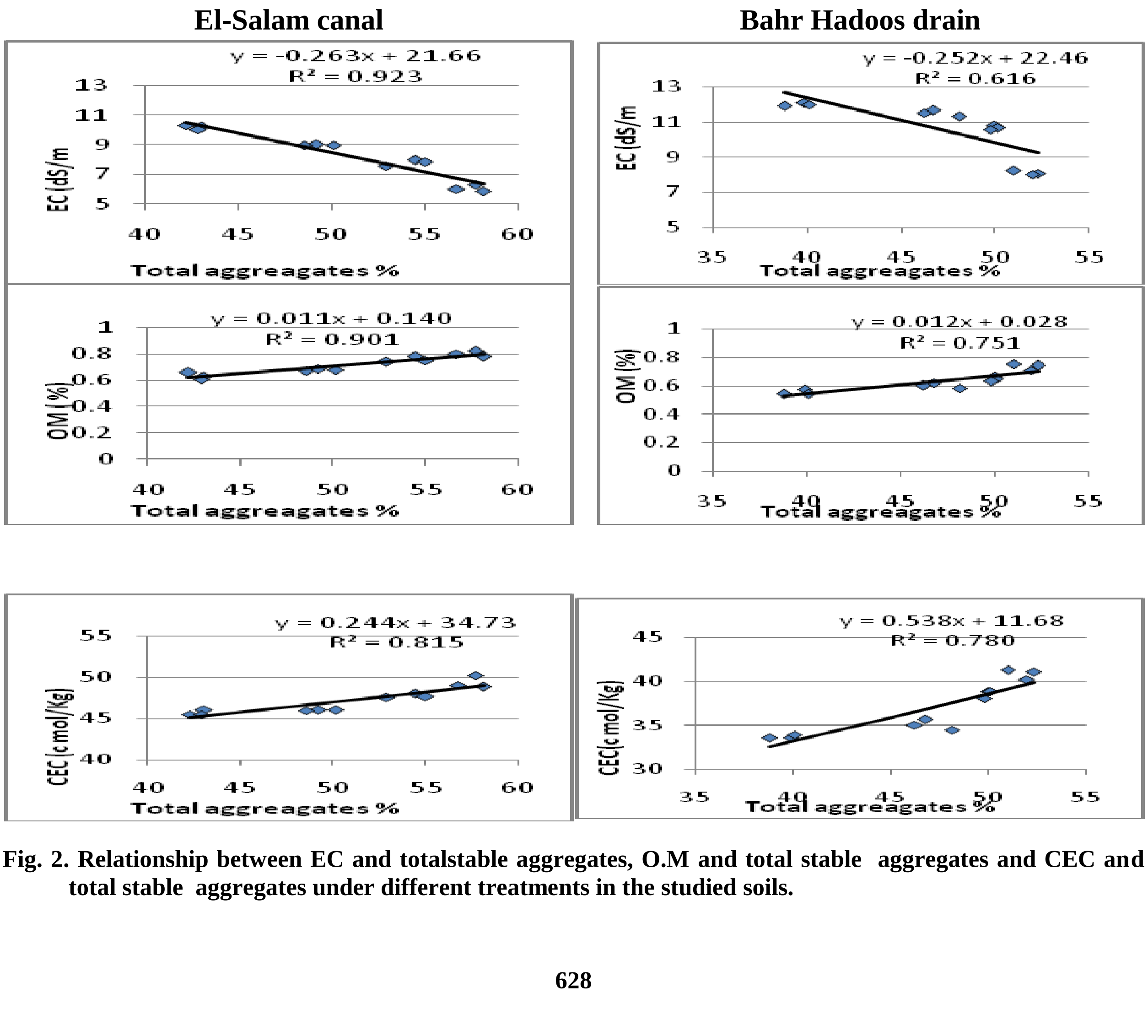

Fig. 2. Relationship between EC and totalstable aggregates, O.M and total stable aggregates and CEC and total stable aggregates under different treatments in the studied soils.

Table 5. Distribution fractions (%) of dry- sieved aggregates after Fodder beet harvest (Average of two seasons)

Locations	Rate of humic acid (ml/400Lwater)	Depth Cm	Dry aggregates diameter (mm) 10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	<0.063
El-Salam canal	Control	0-30	45.00	25.23	16.44	4.12	3.59	3.79	1.83
		30-60	45.12	26.26	14.55	4.09	4.44	4.01	0.53
		60-90	44.13	27.00	16.02	4.02	3.47	4.05	1.31
		Mean	44.75	26.16	15.67	4.08	3.83	3.95	1.22
	800	0-30	36.15	22.55	17.00	9.25	7.02	6.60	1.43
		30-60	35.89	22.35	18.02	8.01	7.55	5.58	2.60
		60-90	36.99	23.56	18.02	9.16	6.06	5.00	1.21
		Mean	36.34	22.82	17.68	8.81	6.88	5.73	1.75
	1600	0-30	33.02	20.00	18.39	10.99	8.05	7.02	2.53
		30-60	32.28	19.89	19.58	10.56	8.05	7.00	2.64
		60-90	31.47	23.48	16..45	11.00	7.52	6.68	1.40
		Mean	32.26	21.12	18.99	10.85	7.87	6.9	2.19
	2400	0-30	31.25	20.05	16.00	14.00	9.02	8.88	0.80
		30-60	31.00	18.00	18.98	14.05	8.25	7.75	1.97
		60-90	30.89	19.18	19.08	14.25	8.02	7.24	1.34
		Mean	31.05	19.08	18.02	14.1	8.43	7.96	1.37
Mean			36.1	22.29	17.59	9.46	6.75	6.14	1.63
Bahr Hadoos drain	Control	0-30	48.88	25.52	16.00	2.00	3.31	3.01	1.28
		30-60	47.48	25.00	15.35	2.25	4.55	4.99	0.38
		60-90	48.99	25.58	16.78	2.01	3.01	2.89	0.74
		Mean	48.45	25.37	16.04	2.09	3.62	3.63	0.8
	800	0-30	46.66	23.33	17.44	3.01	4.88	3.33	1.35
		30-60	45.89	22.55	18.58	4.58	3.69	3.01	1.70
		60-90	45.98	25.08	19.58	2.22	3.56	3.01	0.57
		Mean	46.18	23.65	18.53	3.27	4.04	3.12	1.21
	1600	0-30	45.00	22.08	20.01	4.33	4.01	4.02	0.55
		30-60	44.99	22.00	18.01	4.58	5.00	3.58	1.84
		60-90	44.02	22.99	20.44	3.58	4.00	3.69	1.28
		Mean	44.67	22.36	19.49	4.16	4.34	3.76	1.22
	2400	0-30	41.25	25.12	18.02	3.28	4.10	5.50	2.73
		30-60	40.58	25.56	16.25	5.01	5.02	5.15	2.43
		60-90	39.79	27.99	17.00	3.58	5.00	4.87	1.77
		Mean	40.54	26.22	17.09	3.96	4.71	5.17	2.31
Mean			44.96	24.4	17.79	3.37	4.18	3.92	1.39

Table 6. Total stable aggregates as percent in the soil profiles under different treatments after fodder beet harvest (Average of two seasons)

Locations	Rate of humic acid (ml/400Lwater)	Depth Cm	Wet aggregates diameter (mm) 10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	Total (TSA)*
El-Salam canal	Control	0-30	8.74	13.28	9.93	4.85	1.62	3.79	42.21
		30-60	7.98	14.23	10.02	4.77	2.01	4.01	43.02
		60-90	11.29	12.25	9.45	5.01	1.77	3.12	42.89
		Mean	9.34	13.25	9.80	4.88	1.88	3.64	42.71
	800	0-30	7.59	14.73	11.17	8.56	2.62	4.52	49.19
		30-60	10.40	13.59	10.25	8.66	2.55	4.66	50.11
		60-90	7.85	14.48	11.00	8.14	2.60	4.48	48.55
		Mean	8.10	14.27	10.81	8.45	2.59	4.55	49.28
	1600	0-30	4.92	10.75	11.34	16.50	7.09	3.84	54.44
		30-60	3.77	11.25	12.02	17.01	6.80	4.15	55.00
		60-90	6.95	9.26	11.55	14.12	7.00	4.01	52.89
		Mean	5.21	10.42	11.64	15.88	6.96	4.00	54.11
	2400	0-30	5.78	14.61	10.81	15.00	5.32	6.14	57.66
		30-60	9.26	12.38	10.11	13.14	5.55	6.25	56.69
		60-90	10.42	12.99	10.09	13.00	5.27	6.35	58.12
		Mean	8.49	13.33	10.34	13.71	5.38	6.25	57.49
	Mean		7.27	12.67	10.93	12.68	4.98	4.93	53.63
Bahr Hadoos drain	Control	0-30	11.02	11.11	8.21	4.44	2.00	3.11	39.89
		30-60	11.56	11.00	8.54	4.12	1.89	3.00	40.11
		60-90	11.72	9.99	8.12	4.00	1.88	3.08	38.79
		Mean	11.43	10.70	8.29	4.19	1.92	3.06	39.59
	800	0-30	10.48	13.02	10.02	8.46	2.22	2.55	46.75
		30-60	9.10	12.84	9.65	8.99	2.56	3.11	46.25
		60-90	12.7	13.00	9.47	7.87	2.12	2.99	48.12
		Mean	10.75	12.95	9.71	8.44	2.30	2.88	47.04
	1600	0-30	9.54	9.99	10.25	10.00	6.96	3.25	49.99
		30-60	11.14	8.94	10.25	10.23	5.54	4.01	50.11
		60-90	11.92	10.00	10.00	9.56	5.19	3.11	49.78
		Mean	10.87	9.64	10.17	9.93	5.89	3.46	49.96
	2400	0-30	6.78	12.58	11.02	10.06	5.11	5.45	51.00
		30-60	9.38	13.08	10.76	9.48	4.48	5.12	52.30
		60-90	8.34	13.01	10.83	9.58	5.23	5.00	51.99
		Mean	8.17	12.89	10.87	9.71	4.94	5.19	51.76
	Mean		9.93	11.83	10.25	9.36	4.38	3.84	49.59

***TSA= Total stable aggregates**

As illustrated above, the relation between EC, OM% and CECand totalaggregates %is more obvious in case of El-Salam canalthan Baher Hados drain, which may be due toEl-Salam canal water that containsNile water mixed with agricultural drainage (1:1)having low EC value.

Soil hydraulic conductivity (HC):-

Hydraulic conductivity refers to the rate at which water flows through soil. For instance, soils with well-defined structure contain a large number of macropores, cracks, and fissures which allow for relatively rapid flow of water through the soil.Data in Table (7) show that the values of hydraulic conductivity were lowand increasedby adding humic acid. The highest values of hydraulic conductivity were observedbyapplying humic acid (2400 ml/400 L water,T_4) with El-Salam canal compared toBaher Hados drain and control treatments.When sodium-induced soil dispersion causes loss of soil structure, the hydraulic conductivity is also reduced.Patrick, (1983)mentioned that soil hydraulic conductivity (HC) in saturated soil matrix depends mainlyon the soil structure, which can be described in terms of spatial distribution of pore spaces. He added that soil sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) were the most important factors that affect indirectly the water flow through soil column. Also the dominant mono equivalent cation (Na^+) plays a vital role in soil deterioration and aggregates breakdown. Tayel and Abdel Hady,(2005) reported that soil EC and pH had a higher direct effect on HC value through negative relationship and described on the base of soil alkalinity.

Table 7. Soil moisture constants (%), total porosity (%), hydraulic conductivity(cm $^{h-1}$) and bulk density(Mg m^{-3}) after fodder beetharvest(Average of two seasons)

Locations	Rate of humic acid (ml/400Lwater)	Depth Cm	Hydraulic conductivity (cm h^{-1})	T.P. %	BD (Mgm^{-3})	Soil moisture constants %		
						F.C.	W.P.	A.W.
El-Salam canal	Control	0-30	0.08	53.96	1.21	35.55	16.53	19.02
		30-60	0.08	53.58	1.22	35.00	16.00	19.00
		60-90	0.077	52.83	1.24	34.89	16.31	18.58
		Mean	0.079	53.46	1.22	35.15	16.28	18.87
	800	0-30	0.09	54.72	1.19	37.85	17.32	20.53
		30-60	0.099	55.09	1.18	38.01	17.06	20.95
		60-90	0.10	54.34	1.2	37.66	17.23	20.43
		Mean	0.096	54.72	1.19	37.84	17.20	20.64
	1600	0-30	0.13	56.23	1.15	44.55	21.51	23.04
		30-60	0.13	56.60	1.14	43.52	19.52	24.00
		60-90	0.11	56.60	1.14	45.02	21.47	23.55
		Mean	0.12	56.48	1.14	44.36	20.83	23.53
	2400	0-30	0.15	61.49	1.1	48.71	21.16	27.55
		30-60	0.15	62.11	1.11	49.07	22.65	26.42
		60-90	0.12	66.74	1.11	48.88	22.18	26.70
		Mean	0.14	63.45	1.11	48.89	21.99	26.89
Mean			0.12	58.22	1.15	41.56	19.68	22.49
Bahr Hadoos drain	Control	0-30	0.06	50.57	1.31	33.50	19.84	13.66
		30-60	0.05	51.13	1.29	33.77	22.22	11.55
		60-90	0.041	50.94	1.30	33.25	21.25	12.00
		Mean	0.050	50.88	1.30	33.51	21.10	12.41
	800	0-30	0.02	51.69	1.28	35.78	20.85	14.93
		30-60	0.075	52.08	1.27	36.00	20.76	15.24
		60-90	0.078	51.69	1.28	35.89	21.08	14.81
		Mean	0.058	51.82	1.28	35.89	20.89	14.99
	1600	0-30	0.066	53.21	1.24	41.54	24.52	17.02
		30-60	0.086	53.96	1.22	41.08	24.55	16.53
		60-90	0.088	53.96	1.22	42.00	25.00	17.00
		Mean	0.080	53.71	1.23	41.54	24.69	16.85
	2400	0-30	0.099	54.72	1.20	45.76	25.72	20.04
		30-60	0.097	55.47	1.19	45.88	25.70	20.18
		60-90	0.089	56.23	1.19	45.66	24.99	20.67
		Mean	0.095	55.47	1.19	45.77	25.47	20.30
Mean			0.074	53.67	1.23	41.07	23.68	17.38

Total soil porosity:

Total soil porosity is a special formula which explains the relationship between both the soil real and bulk densities. On the other hand, it is an index of the relative volume of pores in soil. Data in Table (7) indicated that the values of total soil porosity increased in soil treated with humic acid at any rate compared to control where the highest value was found in the treatment of humic acid high rate of 2400 ml/400 L water (T4) with El-Salam canal compared to Baher Hados drain. These results are in agreement with those ofVengadaramana *et al.,* (2012).Similar results were obtained by Oo *et al.*, (2013)who reported that the use of organic amendments resulted in substantial flocculation and the formation of a large number of soil aggregates. As a consequence aggregate stability, soil porosity, water infiltration, and water-holding capacity of soil are improved, which result in minimizing the impact of drought.

Soil bulk density:-

Organic matter reduces soil bulk density through increasing aggregation. Data in Table (7) show that, bulk density of the soil irrigated byEl-Salam canal water was lower than the other soils irrigated by Baher Hados drainwater. The values of soil bulk density of soil profiles treated byhumic acid at any rates were relatively lower than those of control, and the maximum decrease exists in case of humic acid high rate of 2400 ml/400 L water ($T_{4)}$ with El-Salam canal or Baher Hados drain compared to other treatments and control .These results are confirmed with the results of Amlinger *et al.,* (2007)who observed that compost application influences soil structure in a beneficial way by lowering soil density as a result for the admixture of low density organic matter into the mineral soil fraction. This positive effect has been detected in most cases and it is typically associated with an increase in porosity because of the interactions between organic and inorganic fractions. In addition, the organic fraction is much lighter in weight than the mineral fraction in soils. Accordingly, the increase in the organic fraction decreases the total weight and bulk density of the soil, (Brown and Cottone, 2011).

Soil moisture constants:-

The amount of water available to plant depends on two factors: the quantity of water that is able to infiltrate into the soil and the quantity of water that the soil is able to hold onto. Field capacity and available water holding capacity are influenced by the particle size, structure and content of OM.However, clay soils, due to its higher matric potential and smaller pore size will generally hold significantly more water by weight than sandy soils. In this respect, data in Table (7) indicate that the values of available water were low. The highest valuesof field capacity and available water were observed at the treatment of humic acid at the high rate (2400 ml/400 L water ,T_4)with El-Salam canal compared toBaher Hados drainand control treatments.Brown and Cottone, (2011) have indicated that , texture is the primary factor affecting water holding capacity and also increasing organic carbon is a significant factor in improving soil water holding capacity. They also confirmed that compost application had the greatest effect on soil water holding capacity on coarser textured soils with smaller to no change in water holding capacity on finer textured soils.

Effect of humic acid at different rates on yield and yield components of fodder beet:-

Fodder beet productivity:

Data in Table (8) show that the Fodder beet root length (cm) was significantly affected by applying the different irrigation water resources, however, the root diameter was not affected. Moreover, the application of humic acid follows the same trend of water resources in their effecton both the beet root length and diameter. The increase in humic rate of application was accompanied by an increase in both the root length and diameter. The interaction between irrigation water resources and different rates of humic acid is insignificant. The humic acid applied increases the ability of plants to maintain higher nitrogen content. The increase of nitrogen increases root length (cm) and root diameter (cm).These results are in agreement with those reported by Said- Al Alh and Hussein, (2010) who found that the humic acid application led to an increase in growth parameters compared with control due to the effect of humic acid on solubilization and uptake of nutrients.

Fresh and dry root and top:

Data in Table (8) show that the effect of either the irrigation water sources or humic acid on dry root /plant was significant, while the effect of different irrigation water sources on fresh root /plant was insignificant. Moreover, the fresh root was significantly affected by humic application. The interaction between irrigation water sources and humic acid different rates were significant in case of dry root /plant while it is insignificant by using fresh water. On the other hand, the effect of irrigation water resources and humic acid different rates on dry top only was significantly increased with increasing humic rate.

Table 8. Yield and yield component of fodder beet as affected by humic acid

Locations	Rate of humic acid (ml/400L water)	Root length (cm)	Root diameter (cm)	Weight of root /plant (kg)		Weight of Top/plant (kg)		Weight of root yield (ton/fed)		Weight of Top yield (ton/fed)	
				Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
El-Salam canal	Control	18.96	7.90	1.890	0.560	2.136	0.753	16.99	1.59	18.80	1.77
	800	26.90	10.66	2.580	0.789	2.260	0.853	19.70	1.80	21.04	1.98
	1600	31.76	12.73	3.780	0.853	2.300	0.870	22.88	2.00	23.70	2.23
	2400	38.22	14.50	3.794	0.863	2.350	0.897	23.10	2.17	24.78	2.34
Mean		28.96	11.45	3.01	0.77	2.26	0.84	20.67	1.89	22.08	2.08
Bahr Hadoos drain	Control	15.78	5.66	0.780	0.290	1.880	0.670	12.86	1.30	14.10	1.45
	800	20.64	7.95	0.965	0.359	1.960	0.695	15.36	1.75	16.90	1.89
	1600	25.92	9.44	1.660	0.389	2.164	0.734	18.90	1.80	19.73	2.05
	2400	34.39	12.88	1.773	0.400	2.218	0.789	20.73	1.97	21.45	2.19
Mean		24.18	8.98	1.29	0.36	2.06	0.72	16.96	1.71	18.05	1.90
LSD(0.05) irrigation type		1.40	ns	ns	0.044	ns	0.002	1.27	ns	1.22	ns
.SD(0.05)humic acids rates		1.98	ns	0.62	0.062	ns	0.003	1.81	ns	1.74	ns
Interaction		ns	ns	ns	**	ns	**	ns	ns	ns	ns

The dry and fresh yields of root and top (ton/fed) fodder beet increased when irrigated with Bahr Hadous drain combined with humic acid high rate than that irrigated with El-Salam Canal. The interaction between irrigation water resources and humic different rates on fresh and dry yield of root and top were insignificant. The relative increase of mean valuesreached 21.88 % for fresh root yield and 15.79 % for dry root yield when irrigated with Bahr Hadous drain water compared with El-Salam canal irrigation water using humic acid at different rates. Also, the relative increases of mean value were 22.32 % for top fresh yield and 9.47 % for dry top yield as affected by irrigating with Bahr Hadous compared with El-Salam canal combined with different rates of humic application. This result show the response of fodder beet plants regarding the effect of irrigation water of Bahr Hahdous drain and the highest rate of humic acid which led to greater productivity of fodder beet. These results are in agreement with those of Kassab *et al.*, (2012)who found that the role of water supply at adequate potassium fertilizer amount led to positive effect on physiological processes such as respiration, transpiration, enzyme reaction and cells turgidity of plant size and growth and activity of meristemic tissues responsible for elongation. Rady, (2012) indicated that, humic acid affects directly and indirectly the physiological processes of plant growth. Ouni *et al.*, (2013) reported that humic acid affects the metabolic processes, nucleic acid synthesis, and ion uptake and influences the production of RNA.

Generally, the present study recommends using humic acid high rate (2400 ml/400 L water,T_4) with El-Salam canal or Baher Hados drainwhich improves soil chemical and physical properties and thus increases the productivity of saline soil.

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فعاليةحامض الهيوميك فى تحسين خواص الأرض الملحية وإنتاجية بنجر العلف

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تم اجراء تجربة حقلية لموسمين شتوين متتالين 2015/2014 و 2015/ 2016 فى مزرعة محطة البحوث الزراعية بسهل الحسينية فى محافظة الشرقية وذلك لدراسة تأثير حامض الهيوميك على بعض خواص التربة االطبيعية والكيميائية و انتاجية بنجر العلف (*Beta vulgaris L.*) تحت ظروف الأرض الملحية والتى تروى بمصادر رى مختلفة(مصرف بحر حادوس- ترعة السلام بنسبة1:1 مياة نيل و مياة صرف زراعى).وكانت أهم النتائج المتحصل عليها كما يلى:* أشارت النتائج إلى انخفاض ملحوظ في حموضة التربة والملوحة نتيجة لاضافة حامض الهيوميك للتربة مقارنة بالكنترول.وكانت ذلك أكثر وضوحا مع اضافة حامض الهيوميك بمعدل2400 مل/400لتر مياة فى حالة الرى من ترعة السلام عن مصرف بحر حادوس . و زادت المادة العضوية و كذلك ازدادت قيم السعة التبادلية الكاتيونية وهذه النتيجة كانت واضحة تحت تأثير المعاملة بحامض الهيوميك بمعدل2400 مل/400لتر مياة فى حالة الرى من ترعة السلام أكثر من مصرف بحر حادوس وقد سجلت المادة العضوية 0.80 فى حالة الرى بمياة ترعة السلام ,0.73 فى حالة الرى من مصرف بحر حادوس بينما كانت 0.63 ,0.55 فى حالة الكنترول.* لوحظ ان هناك زيادة في ثبات التجمعات الأرضية و كانت التجمعات أكثر ثباتا فى حالة الأرض التى تروى من ترعة السلام. وهذه النتيجة كانت واضحة مع اضافة حامض الهيوميك بمعدل2400 مل/400لتر مياة سواء فى حالة الرى من ترعة السلام أو مصرف بحر حادوس مقارنة مع باقى المعاملات و الكنترول.* أدى استخدام المعاملة حامض الهيوميك بمعدل2400 مل/400لتر مياة إلى زيادة التوصيل الهيروليكى مقارنة مع باقى المعاملات و الكنترول.أيضا اوحظ حدوث تحسن طفيف في الكثافة الظاهرية وزادت المسامية الكلية و كذلك ازدادت قيم ثوابت الرطوبة عند كل من السعة الحقلية و الماء الميسر نتيجة المعاملة بحامض الهيوميك بمعدل2400 مل/400لتر مياةوكان ذلك أكثر وضوحا فى حالة الرى من ترعة السلام عن مصرف بحر حادوس مقارنة بباقى المعاملات. * أظهرت النتائج أيضا زيادة فى محصول بنجر العلف فى جميع المعاملات مقارنة بالكنترول وكان أعلى محصول فى حالة المعاملة بحامض الهيوميك بمعدل2400 مل/400لتر مياةسواء فى حالة الرى من ترعة السلام أو مصرف بحر حادوس.كما لوحظ زيادة فى محصول بنجر العلف فى الأرض التى تروى بمياة ترعة السلام عن التى تروى من مصرف بحر حادوس.* وبصفة عامة توصى الدراسة باستخدام حامض الهيوميك بمعدل2400 مل/400لتر مياة وذلك لأن حامض الهيوميك يعمل على تحسين خواص التربة الكيميائية و الطبيعية وبالتالي زيادة الأنتاجية فى الأراضى الملحية.