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Impact of Bio-Fertilizer, Humic acid and compost Tea applications on Soil Properties and Egyptian Clover productivity under Saline Soil Conditions

Enshrah I. M. El-Maaz* and Fatma S.H. Ismail**

*** Soils, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt**

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ABSTRACT

Two field experiments were conducted during winter seasons of 2014/2015 and 2015/2016at Sahl El-Hossinia Agric. Res. Station, El-Sharkia – Governorate, Egypt to evaluate the effect of humic acid, compost tea and bio-fertilizer using two methods of application (foliar and soaking) on some chemical and physical soil properties and Egyptian clover (*Trifoliumalexandrinum*L.) var. Meskawy productivity under saline soil conditions. The soil pH and EC values decreased due to different treatments using soaking or foliar application.The lowest value of EC in soil reached (4.61 dSm^{-1})by applying humic acid as foliar application.The soil content of O.M increased in caseof bio-fertilizer, humic acid and compost tea compared with control using soaking or foliar application, however, a high increase was attained by humic acid foliar application.The CEC ($cmolkg^{-1}$) valuewas affected by different fertilizer sources using soaking or foliar application. The high mean value of CEC was 41.42$cmolkg^{-1}$in case of humic acid foliar application compared with other treatments and control. The highest values of field capacity and available water were found in case of humic acid foliar application compared to other treatments and control using soaking or foliar application. The values of soil bulk density of soil profiles treated by all treatments were relatively low compared to those of control, whereas the maximum decrease exists in soil treated byhumic acid foliar application compared to other treatments and control using soaking or foliar application. Adding humic acid as foliar application increased the soil total porosity values compared to other treatments and control. Data showed that the values of drainable pores (DP) and water holding pores (WHP) were higher than the other pores in different treatments. The highest diameters of dry aggregates were affected by humic acid foliar application compared to other treatments and control. The high values of total stable aggregates were observed incase of humic acid foliar application. Applying bio-fertilizer; humic acid and compost tea on seeds using soaking or foliar application increases significantly the clover yield and yield components except the interaction between treatments and methods of application. Humic acid with foliar application gave the highest values of Egyptian clover yield and yield components as compared by other treatments. The obtained data indicate that the Egyptian clover yield was clearly affected by all treatments under saline soil conditions. The beneficial effects of all treatments compared with control using soaking or foliar application on Egyptian clover yield could be arranged as follows according to the increases in dry yield (ton/fed)of clover: Humic acid > compost tea> Bio-fertilizer > control, for soaked application and humic acid > Bio-fertilizer > compost tea > control, for foliar application.

Keywords: Saline soil, Humic acid ,Bio-fertilizer , Compost tea, Egyptian clover productivity.

INTRODUCTION

Mariangela and Francesco, (2015) said that, soil salinization and drought stress mainly occur in the arid and semiarid regions of Mediterranean area, which are characterized by high evapotranspiration rates and low rainfall. In these areas, the leaching of salts is very low; therefore, salt accumulates in soil surface layers. Since high salts content may adversely influence soil properties and crop yields, food security could be limited as a consequence. Tejada and Gonzalez ,(2006) showed that increasing electrical conductivity in saline soil decrease sstructural stability and bulk density. Lauchli and Epstein,(1990)said that, excessive exchangeable sodium and high pH favors swelling and dispersion of clays as well as slaking of soil aggregates through the decrease of soil permeability, available water capacity and infiltration rate. These modifications may further compromise the yield of crops growing on such soils via toxicity and perturbation in water nutrients balance, (Hafsi *et al.*, 2007).

Berseem in a rotation helps to conserve the soil and prevents wind and water erosion and increases the soil organic matter content, especially in newly reclaimed lands and improves soil structure, physical and chemical properties. Berseem is the best crop for sustainable rotation with rice for salt-affected soils. Graves *et al.*, (1996) reported that it is well known for its use in reclamation of salty lands in Egypt. Berseem clover or Egyptian clover (*Trifoliumalexandrinum L.*) is the main annual winter forage leguminous crop in Egypt. Berseem clover has high nutritional quality for animal feed. Berseem also contributes to soil fertility and improves soil physical characteristics (Graves *et al.*, 1996 and El-Nahrawy, 2005).

Ananata,(2002)said that, organic and bio fertilizers seem to be more appropriate agronomic practices as they are considered the important aspects in agronomic clean farming. Among these organic materials are crop residues, farmyard compost, green manure and bio fertilizer as microbial fertilizers and rhizobium, blue green algae and azolla. These are used to improve soil health and increased the yield which plays an important role for minimizing the harmful effect of pesticides and herbicides .Shaban *et al.*,(2013)reported that application of bio-fertilizer and compost with raised bed sowing method improved soil physical properties and yield of wheat in saline soils. Tandon, (2000) and Nasef *et al.*, (2009) found that physical properties (hydraulic conductivity, bulk density and total porosity) of salt affected soil greatly improved when compost, compost tea and bio-fertilizer are applied. Zheljazkov and Warman, (2004) reported that the addition of compost to agricultural soils has beneficial effects on crop development and yields by improving soil physical and biological properties. Applying organic materials to crop soil not only generates a better nutritional state, but furthermore, positively influences other properties, such as soil particles aggregation, water holding capacity and aeration (Pagliai *et al.,* 2004), contributing to generating high production, even with a low or nil application of fertilizers.

Mukhtar *et al.*,(2004) stated that, compost teais a compost extract brewed with a microbial food source like; molasses, rock dust and humic - fulvic acids. Compost tea is a water extract of plant soluble nutrients and microorganisms from compost. The organisms include bacteria, fungi, protozoa and nematodes. When applied to plant surfaces and drench into the rooting zone, it can protect the plant from diseases and enhance its growth. Crops can directly benefit from the macro- and micronutrients found in compost tea. Moussa *et al.*,(2006) found that, adding compost tea by foliar fertilization allows nutrients to be absorbed by the plants directly through stomata on their leaf surfaces. Abd-El-Hameed, (2008) reported that the plant growth of pea which treated with compost tea was positively affected due to spraying compost tea compared with the control treatment. Sarwar*et al.,* (2008)concluded that, the use of composts offers several potential benefits including improves soil texture, helps retain soil moisture, facilitates the mechanical treatment of heavy clay soil, adds nutrients to the soil, stimulates biological activities, encourages vigorous plant rooting system, helps bind nutrients and prevents them from being leached out of the soil. Gaur, (1992) and Sharif *et al.,* (2003)reported that, application of organic materials to the soil reduces the dependence on chemical fertilizers and helps microorganisms to produce polysaccharides, which improve the soil conditions. The influence of organic matter on crop growth and productivity is not just a matter of nutrient supply, but they influence the physical characteristics and the chemical properties of the soil. Abdurrahman *et al.,* (2004)indicated that, compost decreased soil pH (from 9.75 to 8.22), EC (from 12.35 to 2.25 dS m^{-1}) and ESP (from 44.75 to 6.61 %) of the soil. Soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is responsible for adsorbing power of the soils up to 90 %,(Bradyand Weil, 2005).Hussain *et al.*,(2001)reported that, physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields. Physical properties like bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved when FYM (10 t ha^{-1}) was applied in combination with chemical amendments, resulting in enhanced rice and wheat yields in sodic soil.Shaban *et al.*,(2012) indicated that the decrease of EC soil which treated with applied compost led to reflection of the activity of microorganisms to improve characterization of soil such as soil structure; increasing drainable pores, total porosity and aggregate stability, and consequently enhanced leaching process through irrigation fractions.

Humic acid (HA) suspensions based on potassium humate have been applied successfully in many areas of plant production as a plant growth stimulant or soil conditioner for enhancing natural resistance against plant diseases (Scheuerell and Mahaffee, 2004). Several reports indicated the efficiency of HA in reducing some plant diseases, Yigit and Dikilitas, (2008). Asik *et al.,* (2009) concluded that humic substances gave the highest values of available nutrients, yield and nutrients uptake by wheat plant in sandy soils. Sebastiano*et al.,* (2005) found that humic acid had a positive effect on plant growth, grain yield and quality, and photosynthetic metabolism of durum wheat crops. The foliar application of humic acid caused a transitional production of plant dry mass with respect to unfertilized control and split soil N application. Hussein and Hassan, (2011) indicated that humic acids are important soil components; as they can improve chemical and physical properties of soils. Soil organic matter is responsible to increase the water holding capacity of farm soil,(Vengadaramana *et al,* 2012).

The objective of this investigation was to studythe effect of two methods application (foliar and soaking) ofbio-fertilizer, compost tea and humic acid on some physical and chemical soil properties and Egyptian clover (*Trifoliumalexandrinum L.*) var. Meskawy productivity under saline soil conditions.

MATERIALS AND METHODS

A field experiment was conducted for two successive winter seasons 2014/2015 and 2015/2016 at Sahl El-Hossinia Agric. Res. Station, El-Sharkia – Governorate, Egypt. Located at 31o 8' 12.461" N latitude and 31o 52' 15.496 E Longitude, (El-etr *et al.,* 2013).The aim of the experiment was to study the effect of two methods of application (foliar and soaking) ofbio-fertilizer, compost tea and humic acid on some physical and chemical soil properties and Egyptian clover (*Trifoliumalexandrinum L.*) var. Meskawy productivity under saline soil conditions.Some chemical and physical properties of the studied soil before plantingare presented in Table (1).

Seed treatment using bio- fertilizer containing the symbiotic N- Fixing bacteria of *Rhizobium leguminosarum*) which provided by Soil Microbiology Unit at Soils, Water and Environment Res. Inst. Agric. Res. Center Giza, Egypt. Compost tea was prepared by soaking one $m^3$of compost in 500 L water, for 48 hrs, then was squeezed, collected and used as compost tea, according to the method described by Nasef *et al.,* (2009). Chemical analysis of compost tea was done according to the standard methods described by Brunner and Wasmer, (1978). Chemical analysis of compost tea andhumic acid used are shown in Tables (2&3). Ten $kgfed^{-1}$ of clover was sown on 10^{th} and 15^{th} October in 2014 and 2015, respectively. The plot size was 10 m long and 5 m width. The experimental treatments were arranged in completely randomized block design with three replicates.

Table 1. Physical and chemical properties of the studied soil before planting

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture class	O.M (%)	$CaCO_3$ (%)	CEC c mol/kg soil
5.37	23.96	34.52	36.15	Clay Loam	0.50	7.94	37.11

pH (1:2.5)	EC (dS/m)	B.D (g/cm^{3})	T.P (%)	Moisture contents (volumes %) Different tensions (atm)					
				0.001	0.1	0.33	0.66	1.0	15.0
8.05	8.22	1.59	39.77	41.90	32.58	30.79	24.50	20.00	19.60

Pore size distribution (%)					Soil moisture constants (%)		
Q.D.P	S.D.P	D.P	W.H.P	F.C.P	F.C.	W.P.	A.W.
9.32	1.79	11.11	11.19	19.60	30.79	19.60	11.19

Dry aggregates diameter (mm)						
10-2	2 - 1	1- 0.50	0.50-0.25	0.25-0.125	0.125-0.063	<0.063
55.32	22.35	12.08/	5.00	1.11	3.08	1.06

Wet aggregates diameter (mm)						
10-2	2 - 1	1- 0.50	0.50-0.25	0.25-0.125	0.125-0.063	Total (TSA)
5.12	3.07	11.00	6.00	4.18	3.49	32.86

Q.D.P (>28.84 u) Quickly Drainable Pores. S.D.P (28.8-8.62u) Slow Drainable Pores . D.P (8.62u) Drainable Pores W.H.P (8.62-.019 u) Water Holding Pores.F.C.P (<0.19u) Fine Capillary Pores. 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.

Table 2. Chemical analysis of compost tea used in the experiment.

EC (dSm^{-1}) (1:10)	pH (1:2.5)	C	OM	C/N	N	P	K	Fe	Mn	Zn
		(%)			Available (%)			Available ($mgkg^{-1}$)		
2.77	7.40	21.9	47.00	10.23	2.14	0.63	2.28	137	88	59

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

pH	EC (dSm^{-1})	OM (%)	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

The experimental treatments were as follows:

1- Control(seed soaking with 2 Lwater/10 kg seed fed^{-1}).
2- Control(foliar application of water at a rate400Lfed^{-1}).
3- Soaking of seeds in compost tea by2L/10kg seeds fed^{-1}.
4- Foliar application of compost tea at a rate 400 Lfed^{-1}.
5- Soaking of seeds in humic acid by2L/10kg seedsfed^{-1}.
6- Foliar application of humic acid at a rate 2 L humic acid/400 L waterfed^{-1}.
7- Soaking of seeds in bio-fertilizer by 2 L/10 kg seedsfed^{-1}.
8- Foliar application of bio-fertilizer at a rate 10 L bio-fertilizer /400 L water/ fed.

Egyptian clover (*Trifoliumalexandrinum*L.) var. Meskawy was brought from Agric. Res. Center, Giza, Egypt. Seeds of clover were soaked in solutions of bio-fertilizer, compost tea and humic acid for 8 hur.Bio-fertilizer, compost tea and humic acid were applied as foliar on soil and plants three times after 30, 55 and 75 days from sowing.

Urea (46 % N) was added at a rateof 60 kg Nfed^{-1}three times 25, 50 and 70 days from plantingat equal doses. Super Phosphate was added during soil tillage at a rate of 200 kg $P_2O_5fed^{-1}$). Potassium sulphate (48 % K_2O) was added at a rate of 65 kg K_2Ofed^{-1}two times 25 and 50 days from planting.

Soil samples:

Before planting, soil samples from the surface layer (0-30) have been taken from the experiment site, 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 characteristics, i.e., soil pH, organic matter and cation exchange capacity according to the methods described byPage *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). Soil moisture equilibrium values were determined according to the methods described by Richards and Weaver, (1944) and Richards, (1947). Wilting point was determined according to Stakman and Vanderhast, (1962), while field capacity was determined as described by Richards (1954). Pore size distribution was calculated according to Deleenheer and De Boodt, (1965).

Biological yield was recorded by harvesting the whole plot. Seed yield was obtained after separated from plant heads where thousand seed weight (g) was recorded.

Statistical analysis:-

Data was statistically analyzed for analysis of variance (ANOVA) and least significant difference (LSD) at 0.05 probability level which was applied to make comparisons among treatment means according to Gomez and Gomez, (1984).

RESULTS AND DISCUSSIONS

Effect of the applied treatments on some soil properties:-

Soil chemical properties:-

Soil pH:-

Soil pH is one of the most important parameters which reflect the overall changes in soil chemical properties. It is obvious from Table (4)and Fig.(1)that the soil pH decreased slightly due to the application of bio-fertilizer, humic acid and compost tea as soaking or foliar applications. Similar results have been obtained by Rebeka, (2006)who found that compost fertilizer extracts lowered pH, salinity (EC, for lower dilutions) and K concentration while, relatively raised N, P, Ca, and Mg concentrations when used as a source of nutrients for plant growth.. The slight decrease of soil pH values may reflect the activity of microorganisms in decomposing organic matter and releasing organic acids. The results were in harmony with those obtained by Shaban and Omar, (2006) who reported that the effect of bio-fertilizer on soil pH is due to dehydrogenase activity and production of µ moles of H_2 in the rhizosphere of maize root media and its positive effect on increasing the hydrogen moles which react in root zone to form hydrocarbon acid which led to decrease soil pH.

Table 4. Chemical properties of the experiment soil after Egyptianclover harvest (Average of two seasons)

Treatments of fertilization		Soil depth (Cm)	pH (1:2:5)	EC (dS/m)	O.M %	CEC cmol/kg
Bio-fertilizer	Soaking	0-30	7.96	5.40	0.64	41.00
		30-60	7.95	4.77	0.63	41.00
		60-90	7.92	4.77	0.65	41.02
		Mean	7.94	4.98	0.64	41.01
	Foliar	0-30	7.95	5.98	0.62	41.00
		30-60	7.93	5.29	0.63	41.09
		60-90	7.94	5.22	0.63	40.98
		Mean	7.94	5.50	0.63	41.02
Humic acid	Soaking	0-30	7.98	6.13	0.62	40.05
		30-60	7.97	5.70	0.61	40.15
		60-90	7.98	5.68	0.60	40.25
		Mean	7.98	5.84	0.61	40.15
	Foliar	0-30	7.90	5.21	0.66	41.05
		30-60	7.90	4.30	0.67	42.11
		60-90	7.88	4.33	0.69	41.11
		Mean	7.89	4.61	0.67	41.42
Compost - T	Soaking	0-30	8.01	6.98	0.60	39.08
		30-60	7.97	6.23	0.59	38.77
		60-90	7.97	6.22	0.56	39.85
		Mean	7.98	6.48	0.58	39.23
	Foliar	0-30	7.98	5.87	0.60	40.89
		30-60	7.95	5.57	0.61	40.11
		60-90	7.94	5.52	0.61	40.00
		Mean	7.96	5.65	0.61	40.33
Control	Soaking	0-30	8.08	8.23	0.52	37.44
		30-60	8.07	7.93	0.51	37.21
		60-90	8.10	7.92	0.51	37.65
		Mean	8.08	8.03	0.51	37.43
	Foliar	0-30	8.07	8.21	0.51	37.46
		30-60	8.08	7.91	0.51	37.35
		60-90	8.09	7.89	0.50	37.55
		Mean	8.08	8.00	0.51	37.45

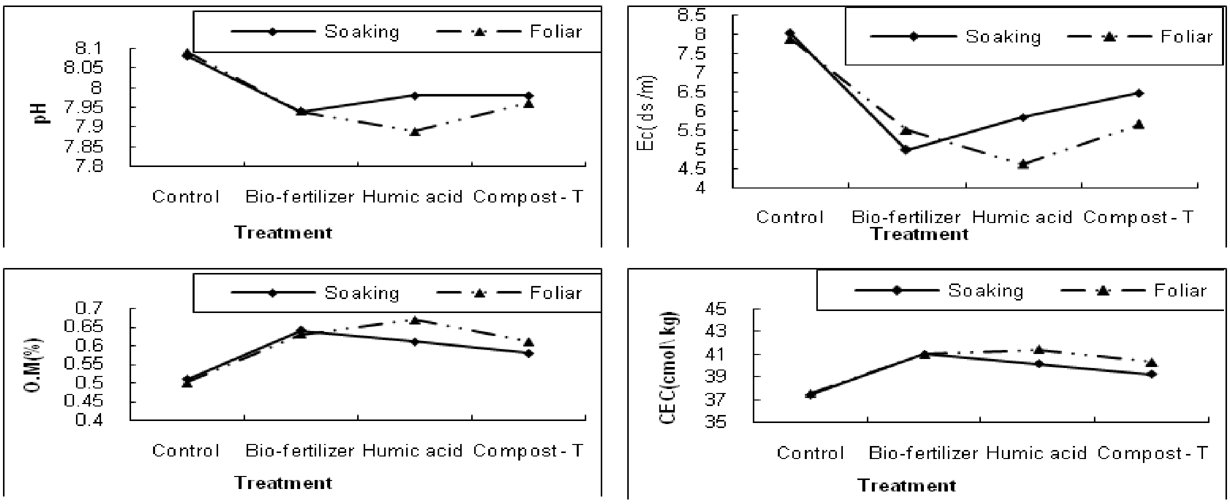

Fig. 1. Effect of different treatments on soil chemical properties in saline soils.

Soil salinity (EC):-

Application of compost on such salt affected soil helps in diminishing salinity and improving soil characteristics, mainly by the increase of salts leaching. Data of soil EC for the experimental plot units using different soil amendments sources are given in Table (4)and Fig.(1). The results indicated that soil EC decreased due to application of all treatments compared with control using soaking or foliar application. The lowest value of EC in soil (4.61 dSm^{-1}) exists in case of humic acid foliar application. These findings are in agreement with those obtained by Abdurrahman *et al.*, (2004)and Hussein and Hassan, (2011).On the other hand, it could be noticed that, mean values of EC in soil can be arranged according to the following order: Bio-fertilizer > humic acid > compost tea > control for soaking method and humic acid > bio-fertilizer > compost tea > control for foliar method. These results could be explained as a reflection of the activityof microorganisms in reducing salinity and simultaneously improving soil structure; increasing drainable pores, total porosity and aggregate stability, and consequently enhanced leaching process through irrigation fractions, (Shaban *et al.,* 2012).

Soil organic matter and cation exchange capacity:-

Organic matter is regarded as the ultimate source of nutrients and microbial activity in soil. It is the deciding factor in soil structure, water holding capacity, infiltration rate, aeration and soil porosity. Data presented in Table (4) and Fig.(1) showed that, the content (%) of O.M increased by soil treated with all treatments compared with control using soaking or foliar application whereas, the high increase was attained in case of humic acid foliar application. The obtained data could be arranged as follows: Bio-fertilizer >humic acid >compost tea > control for soaking method and humic acid > bio-fertilizer > compost tea > control for foliar method, where the treatment of humic acid foliar application increases the mean values of O.M. (%) compared with other treatments and control. These results are in agreement with those of Gaur, (1992) Sharif *et al.,* (2003)and Shaban *et al.,* (2013).

The cation exchange capacity of the soil under different treatments follow the same trend of organic matter. Data in Table (4) and Fig. (1)show that the CEC (cmolkg^{-1})was affected by different fertilizer sources by soaking or foliar application. The addition of compost can increase the soilCECfrom20to70% of the original CEC,(Havlin *et al.,* 1999). The high mean value of CEC (41.42cmol/kg) exists in case of humic acid foliar application compared with other treatments and control. Walker and Bernal, (2008)said that the increase of Ca^{2+} and Mg^{2+} in the exchange complex can be particularly relevant in the reclamation of saline–sodic soils, as it could decrease the proportion of Na^{+} in the exchange complex and consequently improves soil physical properties.

Soil physical properties:-

Physical properties of the experimental soil after Egyptian clover harvest for two seasons as affected by all treatments under study soaking or foliar application will be discussed as follows:-

Moisture retention curves:-

The shape of soil moisture curves depends mainly on some properties of the soil such as texture, structure, soluble salts content, and exchangeable cations. The obtained results showed that, soil moisture contents decreased by increasing the applied pressure and this function is mainly affected by particle size distribution, where the greater clay content,(at subsurface layer), the greater of the water retained at any particular pressure and the more gradual slopes of the tension curves . The moisture retention curves of the soil treated by bio-fertilizer, humic acid and compost tea show relatively low increase in the moisture content at medium suctions compared to control with soaking or foliar application, Table (5) and Fig.(2).On the other hand, the treatment of humic acid foliar application represents the highest increase of moisture content compared to other treatments and control. These findings are in agreement with those obtained by Pagliai *et al.,* (2004) and Shaban *et al.,*(2013).

Soil moisture constants:-

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. Data in Table (6) show that the values of available water are small. This may be attributed to high salinity levels of both irrigation water and soil, which leads to raising of osmotic pressure and accordingly increase the soil retention moisture content at field capacity and wilting point .The increase of soil ESP increases the fine capillary pores (wilting point) compared with that of field capacity which leads to a decrease of the available water. The highest values of field capacity and available water were found in the treatments of humic acid with foliar application compared to other treatments and control with soaking or foliar application. Similar results are also obtained through the work of Pagliai *et al.,* (2004) and Shaban *et al.,(*2013).

Soil bulk density:-

Compost reduces soil bulk density through increasing aggregation. Data showed in Table (7) indicate that, the values of soil bulk density of different soil profiles of all treatments were relatively low and the maximum decrease exists in case of humic acid by foliar application compared to other treatments and control with soaking or foliar application. This is probably due to the organic fraction is much lighter in weight than the mineral fraction in soils. These findings are in close agreement with Khaleel and Reddy, (1981)who found a positive correlation between organic carbon additions and decrease of bulk density. Bronick and Lal, (2005) and Courtney and Mullen ,(2008) reported that, this decrease is a result of the dilution effect caused by mixing of the added organic material with the denser mineral fraction of the soil. Thus, allowing an enhancement of soil porosity and aeration, (Tejada *et al.,* 2008).

Total soil porosity:

Total soil porosity is a special formula which explains the relationship between both the soil real and bulk densities. Data in Table (7) showed that the maximum increase of total soil porosity was found in the soil treated with humic acid by foliar application compared to other treatments and control with soaking or foliar application. These results are in agreement with the results of Tandon, (2000),Nasef *et al.,* (2009)and Hussein and Hassan, (2011).Hussain *et al.,*(2001) stated that, physical properties like bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved when FYM (10 ton ha^{-1}) was applied in combination with chemical amendments, resulting in enhanced rice and wheat yields in sodic soil.

Table 5. Moisture contents (volumes %) of the investigated soil profiles under different tensions (atm) after Egyptian clover harvest(Average of two seasons)

Treatments of fertilization		Soil depth (Cm)	Different tensions (atom)					
			0	(	0.	0.6(	1.	15.0
Bio-fertilizer	Soaking	0-30	50.48	37.68	29.92	20.00	17.25	10.83
		30-60	48.77	35.65	30.37	18.58	15.00	10.48
		60-90	48.00	34.71	31.44	18.47	15.00	11.55
		Mean	49.08	36.01	30.58	19.02	15.75	10.95
	Foliar	0-30	48.21	38.00	32.58	19.98	18.00	14.59
		30-60	50.06	39.78	29.97	20.30	16.23	11.99
		60-90	51.10	41.03	29.07	20.11	15.21	11.07
		Mean	49.79	39.60	30.54	20.13	16.48	12.55
Humic acid	Soaking	0-30	43.00	33.62	30.10	18.41	16.00	14.50
		30-60	44.89	33.15	30.07	18.29	16.12	11.78
		60-90	45.00	33.59	29.07	19.46	15.23	13.45
		Mean	44.29	33.45	29.75	18.72	15.78	13.24
	Foliar	0-30	53.00	40.48	31.29	21.09	17.00	10.58
		30-60	52.00	41.69	32.83	22.80	16.90	11.99
		60-90	52.49	39.69	33.75	22.08	18.02	10.95
		Mean	52.50	40.62	32.62	21.99	17.31	11.17
Compost - T	Soaking	0-30	43.56	33.15	27.45	18.50	15.00	12.01
		30-60	44.26	33.28	28.84	20.00	17.12	13.75
		60-90	45.00	34.02	28.74	18.00	15.00	13.18
		Mean	44.27	33.48	28.34	18.83	15.71	12.98
	Foliar	0-30	49.79	38.36	30.14	22.00	18.29	12.89
		30-60	48.77	37.83	29.92	20.32	17.23	13.67
		60-90	47.99	36.23	30.36	20.39	18.25	13.80
		Mean	48.85	37.47	30.14	20.90	17.92	13.45
Control	Soaking	0-30	40.23	30.88	27.88	17.78	16.00	15.33
		30-60	40.00	30.87	27.89	18.00	16.08	15.54
		60-90	40.25	30.01	27.07	17.99	15.28	14.07
		Mean	40.16	30.59	27.61	17.92	15.79	14.98
	Foliar	0-30	40.48	30.98	27.00	18.90	15.41	14.00
		30-60	41.77	31.99	28.00	18.50	13.30	15.19
		60-90	41.40	31.50	27.50	18.90	13.00	13.59
		Mean	41.22	31.49	27.50	18.77	13.90	14.20

Table 6. Soil moisture constants (%) of the investigated soil profiles under different treatments after Egyptian clover harvest(Average of two seasons)

Treatments of fertilization		Soil depth (Cm)	Soil moisture constants %		
			F.C.	W.P.	A.W.
Bio-fertilizer	Soaking	0-30	29.92	10.83	19.09
		30-60	30.37	10.48	19.89
		60-90	31.44	11.55	19.89
		Mean	30.58	10.95	19.62
	Foliar	0-30	30.14	12.89	17.25
		30-60	29.92	13.67	16.25
		60-90	30.36	13.80	16.56
		Mean	30.14	13.45	16.69
Humic acid	Soaking	0-30	30.10	14.50	15.60
		30-60	30.07	11.78	16.91
		60-90	29.07	13.45	15.62
		Mean	29.75	13.24	16.04
	Foliar	0-30	31.29	10.58	20.71
		30-60	32.83	11.99	20.84
		60-90	33.75	10.95	21.80
		Mean	32.62	11.17	21.12
Compost - T	Soaking	0-30	27.45	12.01	15.44
		30-60	28.84	13.75	15.09
		60-90	28.74	13.18	15.56
		Mean	28.34	12.98	15.36
	Foliar	0-30	32.58	14.59	17.99
		30-60	29.97	11.99	17.98
		60-90	29.07	11.07	18.00
		Mean	30.54	12.55	17.99
Control	Soaking	0-30	27.88	15.33	12.55
		30-60	27.89	15.54	12.35
		60-90	27.07	14.07	13.00
		Mean	27.61	14.98	12.63
	Foliar	0-30	27.00	14.00	13.00
		30-60	28.00	15.19	12.81
		60-90	27.50	13.59	13.91
		Mean	27.50	14.20	13.24

F.C = Field Capacity. **A.W = Available Water.** **W.P = Wilting Point.**

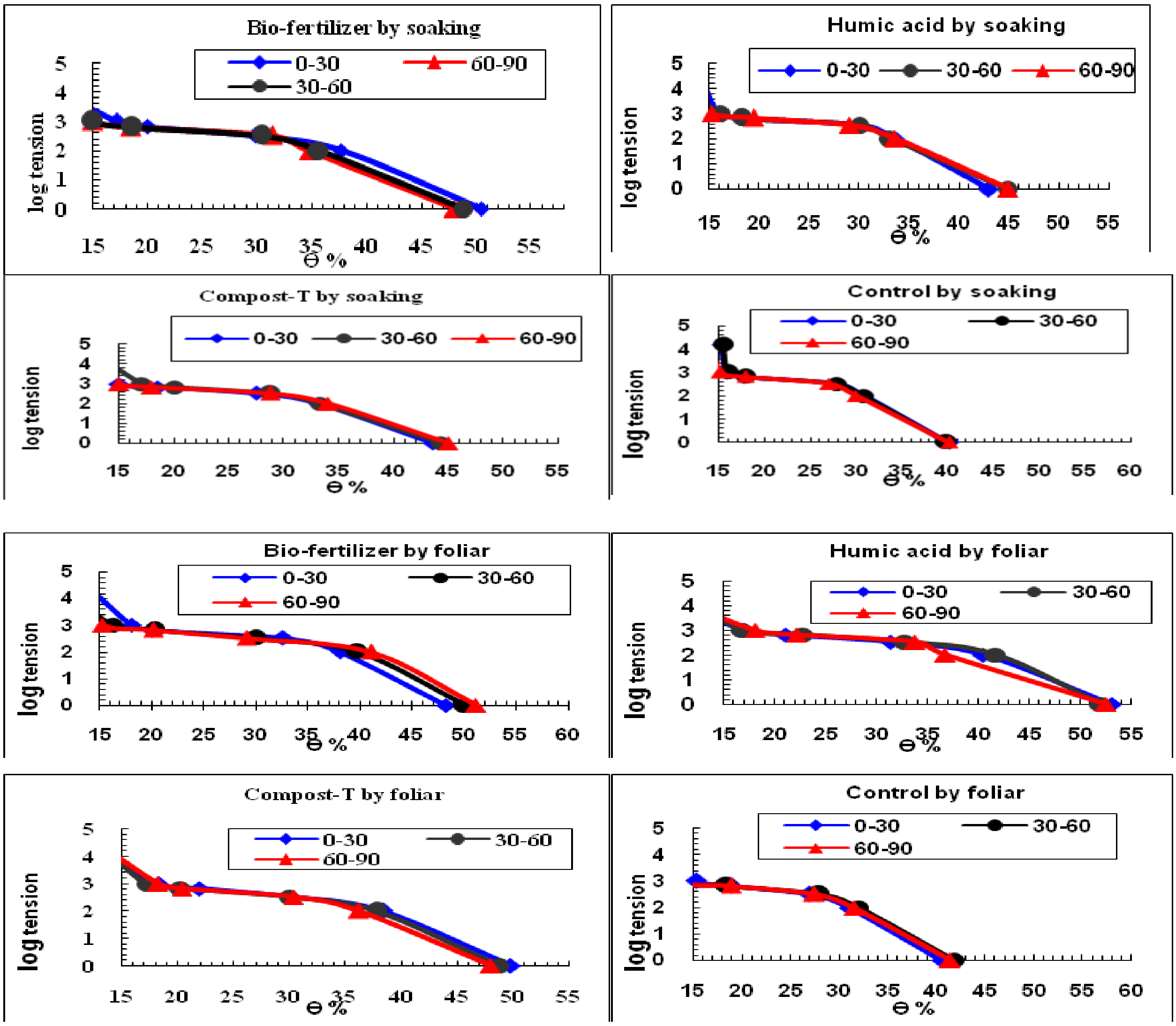

Fig 2. Moisture retention curves for salinesoil as affected by different treatments under study.

Pore size distribution:

Data in Table (7) indicate that the values of drainable pores (DP) and water holding pores (WHP) were higher than the other pores in different treatments. This may be attributed to the use of organic matter which improves physical properties of soil, such as soil porosity, structure, soil aggregation and water holding capacity. The maximum increase exists with humic acid by foliar application. These findings are in close agreement with Tandon, (2000), Nasef *et al.*, (2009)Hussein and Hassan, (2011)and Vengadaramana *et al.*, (2012).

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, .5-.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 for the effect of treatments on aggregation and the implications of treatments on soil aggregation.

Dry –sieved aggregates:-

As a general, data in Table (8) show that the dry aggregates having diameters from 10 to 2 mmand0.5-0.25mm were 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 the lowest values were found. It is worth to mention that the soil treated with humic acid, compost tea and bio-fertilizer by soaking or foliar application are more affected with the occurrence of organic acids that released from organic and bio-fertilizer. The organic acids provide a substantial modification of soil physical properties, such as soil aggregation and drainable pores. These findings are in agreement with those reported by Tandon,(2000),Nasef *et al.*, (2009) and Pagliai *et al.*, (2004).

Table 7. Total porosity (%), bulk density(g/cm^3) and pore size distribution of the soil profiles under different treatments after Egyptian clover harvest(Average of two seasons)

Treatments of fertilization		Soil depth (Cm)	BD (g/cm^3)	T.P. %	Pore size distribution %				
					Q.D.P.	S.D.P.	D.P	W.H.P.	F.C.P.
Bio-fertilizer	Soaking	0-30	1.33	49.81	12.80	7.54	20.34	19.09	10.83
		30-60	1.36	49.06	13.12	5.72	18.84	19.89	10.48
		60-90	1.35	49.81	13.29	4.35	17.64	19.89	11.55
		Mean	1.35	49.56	13.07	5.87	18.94	19.62	10.95
	Foliar	0-30	1.33	50.09	10.21	5.42	15.63	17.99	14.59
		30-60	1.32	50.09	10.28	9.81	20.09	17.98	11.99
		60-90	1.33	49.81	10.07	11.96	22.03	18.00	11.07
		Mean	1.33	50.00	10.19	9.06	19.25	17.99	12.55
Humic acid	Soaking	0-30	1.35	49.06	9.38	3.52	12.90	15.60	14.50
		30-60	1.36	49.57	11.74	3.08	14.82	16.91	11.78
		60-90	1.37	48.06	11.41	4.52	15.93	15.62	13.45
		Mean	1.36	48.90	10.84	3.71	14.55	16.04	13.24
	Foliar	0-30	1.32	51.81	12.52	9.19	21.71	20.71	10.58
		30-60	1.32	50.06	10.31	8.86	19.1718.	20.84	11.99
		60-90	1.33	50.06	12.80	5.94	74	21.80	10.95
		Mean	1.32	50.64	11.88	8.00	20.79	21.12	11.17
Compost - T	Soaking	0-30	1.45	45.28	10.41	5.70	16.11	15.44	12.01
		30-60	1.43	46.06	10.98	4.44	15.42	15.09	13.75
		60-90	1.44	45.66	10.98	5.28	16.26	15.56	13.18
		Mean	1.44	45.67	10.79	5.14	15.93	15.36	12.98
	Foliar	0-30	1.37	48.09	11.43	8.44	19.87	17.25	12.89
		30-60	1.36	47.94	10.94	7.46	18.40	16.25	13.67
		60-90	1.38	46.94	11.76	4.79	16.55	16.56	13.80
		Mean	1.37	47.66	11.38	6.90	18.27	16.69	13.45
Control	Soaking	0-30	1.52	42.64	9.35	3.00	12.35	12.55	15.33
		30-60	1.53	42.26	9.13	2.98	12.11	12.35	15.54
		60-90	1.55	41.51	10.24	2.94	13.18	13.00	14.07
		Mean	1.53	42.14	9.57	2.97	12.54	12.63	14.98
	Foliar	0-30	1.55	42.66	9.50	3.98	13.48	13.00	14.00
		30-60	1.54	43.02	9.78	3.99	13.77	12.81	15.19
		60-90	1.56	42.29	9.90	4.00	13.90	13.91	13.59
		Mean	1.55	42.66	9.73	3.99	13.72	13.24	14.20

Q.D.P (>28.84 u) Quickly Drainable Pores. S.D.P (28.8-8.62u) Slow Drainable Pores. D.P (8.62u) Drainable Pores.
W.H.P (8.62-.019 u) Water Holding Pores. F.C.P (<0.19u) Fine Capillary Pores. BC= Bulk density.
Average of real density (g/cm^3) = 2.65 T.P. =Total porosity.

Table 8. Distribution fractions (%) of dry- sieved aggregates in the studied soil profiles under different treatments after Egyptian clover harvest (Average of two seasons)

Treatments of fertilization		Soil depth (Cm)	Dry aggregates diameter (mm)						
			10-2	2 - 1	1 - 0.50	0.50-0.25	0.25-0.125	0.125-0.063	<0.063
Bio-fertilizer	Soaking	0-30	44.25	7.71	15.00	22.25	6.22	4.02	0.55
		30-60	44.00	8.93	13.02	25.23	5.11	3.25	0.46
		60-90	42.28	10.81	12.35	27.00	4.12	3.00	0.44
		Mean	43.51	9.15	13.46	24.83	5.15	3.42	0.48
	Foliar	0-30	40.44	13.02	11.89	17.66	10.00	5.99	1.00
		30-60	41.11	10.98	12.25	18.66	9.95	6.00	1.05
		60-90	40.00	12.03	13.58	17.24	9.99	6.08	1.08
		Mean	40.52	12.01	12.57	17.85	9.98	6.02	1.04
Humic acid	Soaking	0-30	33.57	8.00	15.55	24.22	10.00	6.66	2.00
		30-60	34.57	9.48	15.28	21.17	11.00	7.02	1.48
		60-90	33.59	9.58	14.89	22.6	11.25	6.54	1.55
		Mean	33.91	9.02	15.24	22.66	10.75	6.74	1.68
	Foliar	0-30	48.58	1.49	15.26	26.00	5.12	3.22	0.33
		30-60	48.00	2.25	15.00	27.00	3.79	3.58	0.38
		60-90	49.21	1.70	12.78	27.89	4.00	4.00	0.42
		Mean	48.60	1.81	14.01	26.96	4.30	3.60	0.38
Compost - T	Soaking	0-30	30.25	9.00	16.59	23.94	10.11	8.11	2.00
		30-60	30.00	9.02	16.23	21.97	11.11	9.68	1.99
		60-90	31.00	8.78	18.28	17.64	12.25	10.00	2.05
		Mean	30.42	8.93	17.03	21.18	11.16	9.26	2.01
	Foliar	0-30	42.00	6.10	14.44	20.22	10.00	6.66	0.58
		30-60	42.08	4.25	15.55	20.22	10.25	6.66	0.99
		60-90	43.15	8.27	14.25	18.25	10.25	5.25	0.58
		Mean	42.41	6.21	14.75	19.56	10.17	6.19	0.72
Control	Soaking	0-30	37.51	7.15	16.22	22.28	8.60	5.81	2.43
		30-60	39.24	8.75	14.43	18.00	9.64	7.69	2.25
		60-90	38.38	6.85	15.18	19.75	10.80	6.57	2.47
		Mean	38.38	7.58	15.28	20.01	9.68	6.69	2.38
	Foliar	0-30	36.39	9.00	13.25	23.98	10.00	6.26	1.12
		30-60	37.00	9.02	15.22	21.04	10.28	6.22	1.22
		60-90	37.25	8.11	13.33	23.74	10.47	5.99	1.11
		Mean	36.88	8.71	13.93	22.92	10.25	6.16	1.15

Wet sieving stable aggregates:-

Data in Table (9) show the values of total stable aggregates and distribution of aggregates size fractions. Data showed that the values of total stable aggregates follow this order; bio -fertilizer>humic acid>compost tea with soaking application and humic acid >compost tea > bio –fertilizer with foliar application compared to control treatment. The highest values of total stable aggregates were observed in case of humic acid foliar application. These results are in agreement with those of McConnel *et al.,* (1993) and Rasool*et al.,* (2007)who concluded that, the application of organic matter in saline soil promotes flocculation of clay minerals, which is essential for the aggregation of soil particles and play an important role inerosion control. The added organic matter aid to glues the tiny soil particles together into larger water stable aggregates, increasing bio pores spaces which increase soil air circulation necessary for growth of plants and microorganisms.

Table 9.Total stable aggregates as percent in the soil profile sunder different treatments after Egyptian clover harvest (Average of two seasons)

Treatments of fertilization		Soil depth (Cm)	Wet aggregates diameter (mm)						
			10-2	2 - 1	1 - 0.50	0.50-0.25	0.25-0.125	0.125-0.063	Total (TSA)
Bio-fertilizer	Soaking	0-30	3.00	4.00	7.78	8.12	3.00	1.10	27.00
		30-60	2.59	3.00	6.55	8.00	3.15	4.69	27.98
		60-90	3.05	2.11	7.01	4.58	3.12	5.82	25.69
		Mean	2.88	3.04	7.11	6.90	3.09	3.87	26.89
	Foliar	0-30	3.00	1.11	12.05	1.00	7.78	7.50	32.44
		30-60	2.77	3.00	9.99	3.33	10.11	4.03	33.23
		60-90	3.00	2.59	11.01	3.00	10.25	5.73	35.58
		Mean	2.92	2.23	11.02	2.44	9.38	5.75	33.75
Humic acid	Soaking	0-30	1.00	1.00	11.12	5.13	4.79	3.12	26.16
		30-60	2.00	2.00	10.66	4.99	4.00	1.35	25.00
		60-90	1.50	3.08	9.05	5.11	2.11	3.72	24.57
		Mean	1.50	2.03	10.28	5.08	3.63	2.73	25.25
	Foliar	0-30	3.00	3.00	10.58	11.58	6.00	4.83	38.99
		30-60	3.08	3.05	9.46	11.88	7.00	2.42	36.89
		60-90	2.58	4.15	10.25	11.00	7.12	1.23	36.33
		Mean	2.89	3.40	10.09	11.49	6.71	2.83	37.41
Compost - T	Soaking	0-30	2.21	5.00	8.12	5.10	2.00	1.90	24.33
		30-60	3.00	5.02	7.08	6.00	1.71	2.00	24.81
		60-90	1.88	6.00	7.50	3.99	2.51	2.00	23.88
		Mean	2.36	5.34	7.57	5.03	2.07	1.97	24.34
	Foliar	0-30	2.13	1.76	11.00	6.12	5.00	3.10	29.11
		30-60	1.99	2.68	11.11	6.66	4.00	2.01	28.45
		60-90	2.09	3. 56	11.00	6.08	3.89	2.68	25.74
		Mean	2.07	2.22	11.04	6.29	4.30	2.60	28.51
Control	Soaking	0-30	1.11	2.28	6.85	4.47	5.00	1.51	21.22
		30-60	1.25	3.00	6.00	4.58	4.02	1.43	20.28
		60-90	1.27	2.22	7.05	5.02	3.17	1.27	20.00
		Mean	1.21	2.50	6.63	4.69	4.06	1.40	20.50
	Foliar	0-30	2.26	5.03	6.06	5.13	1.85	1.95	22.28
		30-60	2.12	4.87	6.22	6.04	1.75	2.02	23.02
		60-90	1.98	5.07	7.56	4.88	1.43	1.62	22.54
		Mean	2.12	4.99	6.61	5.35	1.68	1.86	22.61

Effect of different treatments on yield of Egyptian clover:-

Data presented in Table (10) show that the application of bio-fertilizer, humic acid and compost tea using different methods (soaking and foliar) increased significantly the plant height (cm), fresh yield (tonfed^{-1}), dry yield (tonfed^{-1}), weight of 1000 seeds (g) and weight seeds yield (tonfed^{-1}). Only the interaction between different treatments and methods (foliar and soaking) on fresh weight yield (tonfed^{-1}) was significant, while plant height (cm), dry yield (tonfed^{-1}), weight of 1000 seeds (g) and weight seeds yield (tonfed^{-1}) were not significantly affected. The maximum increase in mean values of plant height (cm), fresh yield (tonfed^{-1}),dry yield (tonfed^{-1}), weight of 1000 seeds (g)and weight seeds yield (tonfed^{-1}) were obtained in case of cut$_2$compared with other cuts. The highest mean values of plant height (cm), fresh yield (tonfed^{-1}), dry yield (tonfed^{-1}), weight of 1000 seeds (g) and weight seeds yield (tonfed^{-1}) exists in case of plants treated with humic acid. These results are in agreement by Ferrara and Brunetti, (2010) who reported that the humic acid is the most active component of soil organic matter and have been shown to have a hormone like activity which stimulates plant growth.Turkmen *et al.,* (2005) indicated that the effect of humic acid application was positive on the plant growth parameters of plant grown in salinity condition. These results may be attributed to humic acid as it has a promoting effect on plant parameters under saline soil. Boris *et al.,* (2010) reported that humic acid substances provided a bio-stimulating effect on plant growth and physiological mechanisms where their effects may depend on hormones and in particular on the presence of auxin and consequently its effect on plant growth and development.

So, it could be concluded that Egyptian clover yield was clearly affected by the studied treatments under saline soil conditions where, their beneficial effect could be arranged as follows: Humic acid >compost tea>Bio-fertilizer> control, for soaked application and humic acid>Bio-fertilizer > compost tea > control, for foliar application.

Finally, this study explains the role of Egyptian clover in saline soils in improving its physical and chemical properties and thus increases soil fertility. Berseem in a rotation helps in conserving the soil and prevents wind and water erosion and increases the soil organic matter content, especially in newly reclaimed lands and improves soil structure and physical and chemical properties, (Graves *et al.*, 1996 and El-Nahrawy, 2005).

Table 10. Effect of different treatments and method of application on yield and yield component ofEgyptian clover (Average of two seasons)

Treatments	Soaking				Foliar			
	Cut $_1$	Cut $_2$	Cut $_3$	Mean	Cut $_1$	Cut $_2$	Cut $_3$	Mean
Plant height (cm)								
Control	68.59	70.25	65.90	68.25	70.14	72.33	68.41	70.29
Bio-fertilizer	78.54	79.77	75.83	78.05	85.53	88.33	82.45	85.44
Compost T	80.56	82.41	79.22	80.73	84.90	86.32	80.72	83.98
Humic acid	81.31	82.24	79.53	81.03	85.87	89.87	84.64	86.79
Mean	77.25	78.67	75.12	77.01	81.61	84.21	79.06	81.63
LSD 0.05. Treatments				2.03				
LSD 0.05. Methods				1.44				
Interaction				ns				
Fresh yield (ton fed^{-1})								
Control	7.83	7.95	7.64	7.81	8.92	9.55	8.19	8.89
Bio-fertilizer	8.73	9.25	8.95	8.98	9.72	10.24	8.99	10.56
Compost T	8.85	9.76	9.25	9.29	10.64	11.34	9.71	9.65
Humic acid	9.94	10.24	9.55	9.91	11.41	12.16	9.98	11.18
Mean	8.84	9.30	8.85	9.00	10.17	10.82	9.22	10.07
LSD 0.05. Treatments				2.23				
LSD 0.05. Methods				1.58				
Interaction				**				
Dry yield (ton fed^{-1})								
Control	0.750	0.810	0.710	0.760	0.880	1.010	0.900	0.93
Bio-fertilizer	1.090	1.150	1.00	1.080	1.120	1.890	1.720	1.580
Compost T	1.270	1.290	0.840	1.130	1.150	1.860	1.450	1.490
Humic acid	1.240	1.320	1.220	1.260	2.010	2.170	1.900	2.030
Mean	1.090	1.140	0.940	1.060	1.290	1.730	1.490	1.510
LSD 0.05. Treatments				0.41				
LSD 0.05. Methods				0.29				
Interaction				ns				
Weight of 1000 seeds (g)								
Control	2.11	2.20	2.15	2.15	2.20	2.29	2.25	2.25
Bio-fertilizer	2.20	2.28	2.24	2.24	2.27	2.35	2.30	2.36
Compost T	2.24	2.34	2.31	2.30	2.32	2.37	2.34	2.34
Humic acid	2.28	2.36	2.31	2.32	2.35	2.43	2.36	2.38
Mean	2.21	2.30	2.25	2.25	2.29	2.36	2.31	2.32
LSD 0.05. Treatments				0.040				
LSD 0.05. Methods				0.028				
Interaction				ns				
Weight of seeds yield (ton/fed)								
Control	0.136	0.150	0.141	0.140	0.198	0.210	0.190	0.200
Bio-fertilizer	0.145	0.160	0.153	0.150	0.245	0.255	0.238	0.260
Compost T	0.152	0.165	0.155	0.160	0.253	0.265	0.246	0.250
Humic acid	0.189	0.214	0.198	0.200	0.269	0.288	0.273	0.280
Mean	0.160	0.17	0.160	0.160	0.240	0.250	0.240	0.240
LSD 0.05. Treatments				0.029				
LSD 0.05. Methods				0.021				
Interaction				ns				

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أثر التسميد الحيوى وحامض الهيوميك و مستخلص الكمبوست على خصائص التربة و انتاجية البرسيم المصري تحت ظروفالأرض الملحية

انشراح إبراهيم محمد المعاز[1] وفاطمة شهاب الدين احمد اسماعيل[2]

*** معهدبحوث الأراضى والمياة والبيئة - مركز البحوث الزراعية - الجيزة - مصر.**

****معهد المحاصيل الحقلية- قسم بحوث العلف- مركز البحوث الزراعية - الجيزة - مصر.**

تم اجراء تجربة حقلية لموسمين شتوين متتالين 2015/2014 و 2015/ 2016 فى مزرعة محطة البحوث الزراعية بسهل الحسينية فى محافظة الشرقية وذلك لدراسة أثر السماد الحيوى وحامض الهيوميك و مستخلص الكمبوست بطريقتين اضافة (رش على النبات والارض و نقع البذور) على بعض خواص التربة االطبيعية والكيميائية و انتاجية البرسيم المصري تحت ظروف الأرض الملحية. وكانت النتائج كما يلى:أظهرت النتائج أن حموضة التربة تميل إلى الانخفاض قليلاً بسبب اضافة السماد الحيوى وحامض الهيوميك و مستخلص الكمبوست (رش على النبات والارض و نقع البذور).وكذلك وجد ان ملوحة التربة انخفضت نتيجةاضافة السماد الحيوى وحامض الهيوميك و مستخلص الكمبوست(رش على النبات والارض و نقع البذور)وكانت أقل قيمة للملوحة في التربة هى (4.61 dSm^{-1})مع اضافة حامض الهيوميك رشا على الأرض و النبات. أيضا زاد المحتوى من المادة العضوية بالتربة و كانت أعلى زيادة مع اضافة حامض الهيوميكرشا على الأرض و النبات مقارنة مع باقى المعاملات و الكنترول، كما لوحظ تحسن في الكثافة الظاهرية وزادت المسامية الكلية و كذلك ازدادت قيم ثوابت الرطوبة عند كل من السعة الحقلية و المحتوى من الماء الميسر كما لوحظ ان هناك زيادة في ثبات التجمعات الأرضية وهذه النتيجة كانت واضحة مع اضافة حامض الهيوميك رشا على الأرض و النبات مقارنة مع باقى المعاملات و الكنترول. أظهرت النتائج أيضا زيادة واضحة فى محصول البرسيم المصرى فى جميع المعاملات مقارنة بالكنترول وكان أعلى محصول فى المعاملة حامض الهيوميك رشا على الأرض و النبات مقارنة بالمعاملات الأخرى تحت الدراسة.لذا، يمكن الاستنتاج أن اضافة السماد الحيوى وحامض الهيوميك و مستخلص الكمبوست عن طريق الرش على الارض والنبات يؤدى الى تحسين خواص التربة الطبيعية والكيميائية وبالتالى زيادة انتاجية وجودة محصول البرسيم المصرى تحت ظروف الأراضى الملحية .