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Allivating Salinityand Sodicity by Adding Some Soil Amendments

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ABSTRACT

Nine hundred thousand hectares of the irrigated lands in Egypt are salt affected soils. Such conditions threaten not only the sustainability of land use for crops production, but also the whole ecosystem. The current study aimed at investigating the growth performance of some important crops in Egypt cultivated in saline sodic clayey soils of El-Hossainia and El-Fayoum soils. To attain the aim of the study, field experiments were conducted in the investigated soils during the summer and winter seasons of the years 2013 and 2014. Rice followed by sugar beet were grown in the saline sodic soil of El-Hossainia soil; whereas sunflower followed by wheat were grown in the saline sodic soil of El-Fayoum. The amendments involved gypsum at a rate of 100% of the gypsum requirements (GR), compost at its recommended dose (100%) for each soil, a combination between gypsum at 50% of the GR and compost at 50% of its recommended dose, beside of diluted H2SO4 at a rate equivalent to GR and finally bio-treatment with halophytic bacteria (Biotoul). Selected physical and chemical properties i.e. soil-water retention, soil bulk density, soil hydraulic conductivity, organic matter, soil pH and EC were considered in this study. Crop yield and growth performance of the grown plants were determined at the end of the growing seasons. The sole application of gypsum or compost at their recommended rates as well as the combined application of these amendments at 50% of these rates improved physical and chemical properties of the investigated saline sodic soils. Consequently, these treatments resulted in higher growth and growth parameters as compared with the other treatments i.e. diluted sulphuric acid and Biotoul.

Keywords : Saline sodic soil, soil amendments, rice, sugar beet, sun flower, wheat

INTRODUCTION

Nine hundred thousand hectares of the irrigated lands in Egypt are salt affected soils(Abou-Baker and El-Dardiry, 2016). Such conditions threaten not only the sustainability of land use for crops production (Dionisio-Sese and Tobita, 1998; Pitman and Läuchli, 2002), but also the whole ecosystem(Kotb *et al.*, 2000).There are three types of salt-affected soils: (1) saline soils (EC> 4 dSm^{-1}) (2) sodic soils (exchangeable sodium percentage (ESP)> 15) and (3) saline-sodic (EC > 4 dSm^{-1} and ESP > 15) (Eynard *et al.*, 2005).To improve the crop yield for plants grown in saline soils, leaching is thought to be the most effective method for removing excess salts from the root zone (Abrol *et al.*, 1988).Egypt is moving towards water scarcity after the construction of the Grand Ethiopian *Renaissance* Dam(Mustafa et al., 2013)and farmers, especially those at the end of the irrigation canals, suffer from lack of fresh water available for irrigation rather than finding sufficient water for the leaching process(Farid *et al.*, 2014). Under such conditions, saline soils could be reclaimed using biological or mechanical techniques (Ravindran *et al.*, 2007). It is thought that the agricultural soils of Egypt are going towards salinity and Sodicity. The only way for sustaining crop production in Egypt is to select salt tolerant cultivars and recommend appropriate amendments to lessen, to some extent, the hazardous effects of the soil salinity and sodicity on the grown plants.

Sodic soils contain excess sodium (Na^+) that negatively affect soil structure and crop yield productivity (Qadir *et al.*, 2001). Some amendments were found to be effective in ameliorating sodic soils. Gypsum ($Ca_2SO_4.2H_2O$) is a low cost material that can be used effectively in reclamation of sodic soil(Amezketa *et al.*, 2005; Makoi and Verplancke, 2010) to replace exchangeable Na in soil (Guo et al., 2006). Another effective amendment is organic matter. Organic mattercan dissolve insoluble calcium salts in soils(Yamada *et al.*, 2003)to replace the exchangeable sodium ions, which are then leached out of the root zone (Ilyas *et al.*, 1997)beside of neutralizing the residual sodium carbonate in soil, to reduce pH (Choudhary *et al.*, 2011). Sulfuric acid is a well-known amendment that can preventing soil crusting and reclaim sodic soils (Amezketa et al., 2005). Microbial amelioration is a promising approache for reclaiming sodic soils (Sahin *et al.*, 2011) through selection of suitable halophytes(Rabhi *et al.*, 2008).

Vegetative bioremediation“ depends on growing appropriate plant species that can tolerate ambient soil salinity and Sodicity levels (Qadir and Oster, 2004). A moderate tolerant crop e.g. maize (*Zea mays* L.) (Yin et al., 2004) was used effectively in soil reclamation when applying appropriate techniques (Makoi and Ndakidemi, 2007). These techniques include using soil amendments (manures and gypsum, etc.), and selecting salt-tolerant cultivars (Eynard *et al.*, 2005). Probably, plants can increase their tolerance towards salinity through increasing the rate of formation of soil aggregate and thus improve soil porosity. It is well known that plant roots can “enmesh particles together while realigning them and releasing organic compounds that hold particles together(Bronick and Lal, 2005)beside increase the stability of soil aggregates(Six *et al.*, 2000).The current study aimed at investigating the performance of the salt-tolerant important crops in Egypt grown in sodic clayey soils amended with different soil amendments.

MATERIALS AND METHODS

Materials of study

1-Soils

Surface soil samples (0-30 cm) were collected from south El-Hosainiya plain (north east of the Delta region, Sharqueya Governorate), and Tamia experimental station (Tamia, El-Fayoum governorate)to represent saline sodic soils of different physical and chemical properties. Samples were air dried, crushed, sieved to pass through a 2.0mm sieve and analyzed for their physical and chemical properties according to the standard methods outlined by Page et al.(1982) and Klute (1986). Physical and chemical properties of the investigated soils are recorded in Table1.

Table 1. Physical and chemical characteristics of the investigated soils

Character	EC, dS m^{-1}	pH	SP %	OM, g kg^{-1}	$COCO_3$ g kg^{-1}	ESP	Particle size distribution percent				
							Clay	Silt	Fine Sand	Coarse Sand	Textural class
El – Hossainia	14.12	8.15	90	2.15	21.5	19.29	65.52	25.33	6.23	2.92	Clay
El-Fayoum	8.40	8.11	70	2.10	68.4	27.54	41.35	38.15	14.15	6.35	Clay loam

2-Compost

Compost was brought from El- Khalil Company, El-Khatatba under a trade name of El-Khalil compost.Its chemical and physical properties are presented in Table 2.Two rates of compost were used in this study i.e. 36 m^3 ha^{-1}corresponding to the recommended dose applied in the area of study and 18 m^3 ha^{-1} corresponding to 50% of the recommended dose of compost.

Table 2. Some characteristics of El-Khalil Compost

Property		Value
EC	dS m^{-1} (1:10)	3.38
pH	(1:10)	7.55
Bulk density	Mg m-3	0.584
Organic matter	g kg-1	330.0
Organic Carbon	g kg-1	207.9
C|N ratio	ratio	21.43
Total N	(%)	0.97
Total P	(%)	1.23
Total K	(%)	1.34
DTPA-extractable Fe	(mg/kg)	2100.00
DTPA- extractable M n	(mg/kg)	257.00
DTPA- extractable Zn	(mg/kg)	59.00
DTPA- extractable Cu	(mg/kg)	25.00

3-Gypsum

Gypsum(purity 85%) was obtained from Army Chemical Factory (Koam Oshem branch, El-Fayoum). Gypsum requirements were calculated using Schoonover method(1952). The estimated values were46 Mg gypsum ha^{-1}recommended for the reclamation of El-Fayoum soil and 28 Mg ha-1recommended for the reclamation of El-Hosania soil. Gypsum was then broadcasted on the surface soil and then mixed thoroughly with the uppermost surface soil layer (30 cm).

4-Sulphuric acid

Sulphuric acid (density 1.84 Mg m-3, MW= 98.09, CAS Registry Number: 7664-93-9) was used in the current study. Sulfuric acid was applied to the investigated soils diluted with irrigation water at rates equivalent to the gypsum requirements in the investigated soils.

5- Biotoul compound

Biotoul compound, obtained from Soil, Water and Environmental Research Institute (SWRI), ARC, Giza, Egypt consisted of 0.98% N,0.45%P,0.96%Cu,0.07% Fe,039%Mn,0.17 %Zn and some bacterial strains i.e. Azotobacter chrooccum, Azospierillum, lipoferrum, Phosphate dissolving Bactria (Bacillus megateirum). Seeds of crops of the bio-treatments were inoculated with Biotoul compound.

Field experiment

El-Hossainia field experiment

Seeds of rice(*Oryza sativa L.* Giza 178) were grown during the summer season of year 2013.Plants received NPK fertilizers at recommended doses of the Ministry of Agriculture i.e. 167kg N ha^{-1} as$(NH_4)_2SO$ (20.5% N), 16 kg P ha^{-1} as calcium super phosphate (6.6% P) and 48 kg K ha^{-1} as potassium sulfate (40% K). Sugar beet (*Beta vulgaris*, Diema-Fernsh) was grown in the investigated soil during the winter season of 2013/2014. NPK fertilizers were applied to soil at rates of 167 kg N ha^{-1} as $(NH_4)_2SO$, 16 kg P ha^{-1} as calcium super phosphate and 96kg K ha^{--1}respectively as recommended by the Egyptian Ministry of Agriculture. All the agricultural recommended practices were followed as usual.

El-Fayoum soil

Sun Flower (*Helianthus annuus*, Giza 102) seeds were grown during the summer season of year 2013. NPK fertilizers were applied at the recommended rates of the Ministry of Agriculture i.e. 107 kg N ha^{-1},35 kg P $ha^{-1}$and 48 kg K ha^{-1}.

Wheat (*Triticum vulgare,* Sakha 94) was grown during the winter season of years 2013/2014. NPK were applied at rates of 214 kg N ha^{-1}, 16 kgP ha^{-1} and 40 kg K ha^{-1}. All the agricultural practices were followed as usual recommended.

Plant analysis

At the physiological maturity growth stage, plants were harvested, the parameters of the plant growth and crop yield for each treatment were determined. Oil in sunflower seeds was determined by Soxhlet apparatus after being extracted with petroleum ether (A.O.A.C, 1975).Juice of sugar beet was extracted from fresh macerated roots using lead acetate and its content of sucrose was determined polarimetically (Mustafa et al., 2013). Carbohydrates % in beet roots were determined according to the Official Analysis Method (A.O.A.C, 2005).

Data analysis

Data were statistically analyzed using the SPSS statistical software program through analysis of variance (ANOVA) and Danken test at 0.05 probability level. For the grain crops i.e. rice and wheat crops, harvest index (HI) was calculated as the ratio of harvested grain to total shoot dry matter (Unkovich *et al.*, 2010).

RESULTS

Soil-water retention as affected by the different soil amendments and plants grown thereon

Results shown in Table 3 reveal that ameliorating the investigated soils with either compost, gypsum, diluted H_2SO_4 or Biotoul improved significantly soil-water retention during both the summer and winter seasons. The highest soil-water retention values were found in soils treated with gypsum; whereas, the least ones were detected in soils treated with Biotoul. Application of “50% compost + 50% gypsum” resulted in significantly lower values of soil-water retention than those attained with amelioration with either compost or gypsum solely. It is worthy to mention that the effect of the grown plant during reclamation seemed to be negligible and that the amelioration effect is mainly related to the types and rates of the used treatments.

Table3. Soil moisture contents (%) as affected by the different soil amendments and plants grown thereon.

	Soil tension (Bar)													
	0.001	0.01	**0.33**	**0.66**	**1**	**3**	**15**	**0.001**	**0.01**	**0.33**	**0.66**	**1**	**3**	**15**
	El-Hosania soil													
	Rice (Summer season)							Sugar beet (Winter season)						
100% CMPT	68.50	65.30	33.80	39.20	37.20	31.30	18.90	68.80	65.75	32.80	39.00	33.30	31.00	18.30
100% GPSM	66.60	63.70	34.40	38.60	33.70	30.90	18.30	66.70	63.80	34.00	38.20	36.80	30.50	18.00
50%CMPT+ 50%GPSM	64.30	62.20	33.20	37.20	33.20	29.60	19.10	64.95	62.50	32.80	36.80	32.90	29.20	19.00
H_2SO_4	62.80	60.70	31.70	36.50	31.90	28.90	19.90	62.90	60.90	31.50	36.20	31.50	28.50	19.80
Biotoul	61.60	59.80	31.10	36.30	31.60	28.60	20.00	61.70	59.90	31.20	36.00	31.20	28.30	20.00
Control	58.60	56.80	29.60	36.10	31.50	28.50	20.00	57.30	55.60	26.90	36.00	31.20	28.00	17.50
	El-Fayoum soil													
	Sun flower (Summer season)							Wheat (Winter season)						
100% CMPT	57.80	30.20	28.60	28.00	24.60	22.20	18.00	56.70	29.40	27.80	29.10	27.30	23.60	17.80
100% GPSM	62.70	34.70	31.90	31.70	26.80	24.70	18.70	64.60	35.30	32.80	29.90	28.20	24.00	19.80
50%CMPT+ 50%GPSM	68.60	37.60	34.20	33.10	29.40	27.10	19.80	69.10	37.90	35.00	30.60	29.30	24.40	21.00
H_2SO_4	63.50	34.10	31.50	29.80	26.10	24.50	18.70	64.20	34.40	31.80	29.60	28.00	23.80	19.60
Biotoul	60.80	32.90	30.90	29.60	24.90	23.40	18.40	61.70	33.40	31.40	29.10	27.10	23.40	19.40
Control	58.40	30.60	28.80	29.30	24.60	22.40	18.00	59.80	32.00	30.00	29.20	27.40	23.60	19.00

CMPT: compost; GPSM: gypsum

Soil hydraulic conductivity as affected by the different soil amendments and plants grown thereon

Table 4 shows that the application of compost or gypsum solely to the investigated soils increased significantly soil hydraulic conductivity. The increases occurred with application of either 100% compost or 100% gypsum were significantly higher than those attained with application of "50% compost + 50% gypsum". It is worthy to find that the hydraulic conductivity, in general, was higher during the winter season than the corresponding values during the summer ones. Also, Biotoul treatment increased significantly the hydraulic conductivity of the investigated soils.

Table 4. Soil hydraulic conductivity (cm h^{-1}) as affected by the different soil amendments and plants grown thereon

Treatment	EL – Hossainia		EL-Fayoum	
	Rice	**Sugar Beat**	**Sun Flower**	**Wheat**
100% compost (CMPT)	0.086^a	0.12^b	0.06^c	0.11^b
100%Gypsum (GPSM)	0.076^b	0.18^a	0.08^a	0.17^a
50% CMPT + 50% GPSM	0.046^d	0.08^c	0.02^f	0.09^c
H_2SO_4	0.056^c	0.07^d	0.07^b	0.08^d
Biotoul	0.016^e	0.06^e	0.04^d	0.06^e
Control	0.001^f	0.03^f	0.03^e	0.05^f

Soil bulk density as affected by the different soil amendments and plants grown there on.

Table 5 shows that values of soil bulk density increased in the saline sodic soils with application of all treatments except for compost; however, the combined application of "50% compost and 50% gypsum" resulted in the highest values of soil bulk density. The grown plants seemed to be of an obvious effect on values of bulk density in both the investigated soils.

Table 5. Soil bulk density (Mg m^{-3}) as affected by the different soil amendments and plants grown thereon

Treatment	EL – Hossainia		EL-Fayoum	
	Rice	**Sugar Beet**	**Sun Flower**	**Wheat**
100% compost (CMPT)	1.21^f	1.17^f	1.20^f	1.18^f
100%Gypsum (GPSM)	1.34^b	1.24^b	1.24^c	1.22^c
50% CMPT + 50% GPSM	1.41^a	1.30^a	1.33^a	1.28^a
H_2SO_4	1.30^c	1.23^c	1.29^b	1.24^b
Biotoul	1.26^d	1.21^d	1.22^d	1.20^d
Control	1.24^e	1.18^e	1.21^e	1.19^e

Soil organic matter as affected by the different soil amendments and plants grown thereon.

Application of compost or gypsum solely or together at 50% of their recommended rates to the studied soils resulted in relatively higher contents of organic matter in soils compared with the other treatments (Table 6). H_2SO_4 and Biotoul treatments resulted in the lowest significant increases in soil organic matter. The soil organic matter also varied according to the grown plant type.

EC and pH of the soils treated with different soil amendments.

Table 7 shows that application of compost solely or $H_2SO_4$to the studied soils decreased significantly soil pH and EC. Although, the application of gypsum decreased soil EC and pH in Hossainia soil; however, in

Fayoum soil, the results seemed confusing especially that the application of gypsum decreased slightly soil pH, with no significant effect on soil EC. Biotoul was found to be of the least effect on both soil pH and EC in El-Hossainia soil, yet, it wais ineffective in minimizing such parameters in El-Fayoum soil.

Table 6. Soil organic matter (g kg^{-1}) as affected by the different soil amendments and plants grown thereon.

Treatment	EL – Hossainia		EL-Fayoum	
	Rice	SugarBeat	SunFlower	Wheat
100% compost (CMPT)	4.7^{a}	4.6^{a}	4.4^{a}	4.2^{a}
100% gypsum (GPSM)	3.5^{c}	3.4^{c}	3.3^{c}	3.3^{c}
50% CMPT + 50% GPSM	4.2^{b}	4.2^{b}	4.3^{b}	4.1^{b}
H_2SO_4	2.7^{d}	2.5^{d}	2.5^{d}	2.2^{d}
Biotoul	2.3^{e}	2.2^{e}	2.4^{e}	2.2^{d}
Control	2.1^{f}	2.1^{f}	2.4^{e}	2.2^{d}

Table 7. EC and pH of the investigated soils treated with different soil amendments

Treatment	El-Hossainia		El-Fayoum	
	EC_e dS m^{-1}	pH	EC_e dS m^{-1}	pH
100% compost (CMPT)	7.27^{d}	7.66^{cd}	7.46^{b}	7.78^{c}
100% gypsum (GPSM)	6.26^{f}	7.70^{bcd}	8.36^{a}	7.87^{b}
50% CMPT + 50% GPSM	9.86^{c}	7.61^{d}	7.17^{c}	7.71^{cd}
H_2SO_4	6.58^{e}	7.70^{bcd}	6.86^{d}	6.70^{e}
Biotoul	9.82^{c}	7.78^{b}	8.37^{a}	7.94^{ab}
Control	14.11^{a}	8.13^{a}	8.39^{a}	8.01^{a}

Growth parameters and yield components of plants grown in saline-sodic soils treated with different soil amendments

Application of compost to the investigatedsoils recorded the highest significant increases in thegrowth and growth parameters of both rice and sun flower (Table 8). On the other hand, application of gypsum to the investigatedsoils recorded the highest increases in the growth parameters of sugar Beet plants beside of its superior effects on the grain and straw yields of the winter wheat. Treating soils with either H_2SO_4 or Biotoul recorded slight; however, significant increases in the growth parameters of all crops under study except for rice.

Carbohydrates % of sugar beet and oil % of sun flower slightly increased due to all the studied treatments except for Biotoul; however, such increases were significant. Values of harvest index of both rice and wheat slightly flocculated between 0.57- 0.64 and 1.33-2.30, respectively. As a matter of fact, these ranges of flocculation seemed somewhat lower than the corresponding ones of the control treatments.

Table 8. Growth parameters and yield components of plants grown in the saline-sodic soils treated with different soil amendments

Treatment	Rice				Sugar beet			
	Grain yield Mg.ha^{-1}	Straw yield, Mg ha^{-1}	100-grain weight	Harvest Index	Weight Mg.ha^{-1}	Diameter of sugar beet, cm	Carbohyd rate, %	Sucrose %
100% CMPT	7.05^{a}	11.24^{a}	1.49^{a}	0.63	43.57^{c}	19.93^{a}	0.12^{a}	21^{a}
100% GPSM	6.81^{b}	10.83^{b}	1.67^{b}	0.63	45.00^{a}	18.98^{b}	0.12^{a}	20^{b}
50%CMPT+ 50%GPSM	6.33^{c}	9.91^{c}	1.45^{c}	0.64	40.95^{b}	17.99^{c}	0.11^{b}	19^{c}
H_2SO_4	2.76^{d}	4.83^{d}	1.09^{d}	0.57	40.95^{d}	15.99^{d}	0.11^{b}	17^{d}
Biotoul	2.76^{d}	4.52^{f}	1.06^{d}	0.61	40.24^{e}	14.99^{e}	0.11^{b}	16^{e}
Control	2.76^{d}	4.19^{f}	1.06^{d}	0.66	40.23^{e}	11.96^{f}	0.10^{c}	15^{f}
	Sun flower				**Wheat**			
	Yield	**Length of Stalk, cm**	**Diameter of disk, Cm**	**Oil, %**	**grain Mg.ha^{-1}**	**straw Mg.ha^{-1}**	**100-grain weight**	**Harvest Index**
100% CMPT	60.45^{a}	114.66^{c}	32.66^{b}	60.45^{a}	3.16^{a}	2.30^{a}	1.92^{a}	1.37
100% GPSM	55.12^{c}	119.66^{b}	34.66^{a}	55.12^{c}	3.33^{b}	2.50^{f}	1.95^{b}	1.33
50%CMPT+ 50%GPSM	55.52^{b}	97.66^{d}	31.66^{c}	55.52^{b}	2.50^{c}	1.50^{b}	1.79^{c}	1.67
H_2SO_4	51.72^{d}	73.66^{e}	29.66^{d}	51.72^{d}	2.45^{d}	1.20^{c}	1.43^{d}	2.04
Biotoul	51.36^{e}	65.66^{f}	26.66^{e}	51.36^{e}	2.30^{e}	1.00^{d}	1.40^{e}	2.30
Control	51.36^{e}	159.66^{a}	24.66^{f}	51.36^{e}	2.30^{f}	0.98^{e}	1.25^{f}	2.35

CMPT: compost; GPSM: gypsum

DISCUSSION

Sodic soil is characterized by the presence of high concentrations of sodium (Na) as an exchangeable cation (Sumner, 1993) causing clay dispersion (Campos *et al.*, 2006; Qadir *et al.*, 2007), deterioration of soil hydraulic properties(Qadir and Schubert, 2002) and adversely affect the plant growth(Dagar *et al.*, 2001; Akhter *et al.*, 2003; Qadir *et al.*, 2003). Thus, ameliorating such soils is the only mean to improve soil properties and attain better crop yield. Plant assisted remediation is a promising approach to replace the more costly chemical approaches (Qadir *et al.*, 2002). Soil organic carbon (SOC) pool should also be considered in soil reclamation studies because SOC is an important measure of soil health (Wong et al., 2010). Hydraulic conductivity is one of the important parameters to be considered in the hydrological cycle (Candemir and

Gülser, 2012). Application of compost or gypsum to the studied soils improved soil-water retention and, at the same time, improved soil hydraulic conductivity. Generally, the residual soil organic matter increased but the soil bulk density increased in such soils. However, such changes in EC and bulk density differed, to some extent, from a crop to another. Accordingly, it can be deduced that all growth parameters and yield components of the cultivated crops improved with applying such amendments.

Compost for ameliorating soil salinity and sodicity

Results indicate that application of the organic matter improved soil physical properties, decreased soil EC and pH and increased plant growth and yield components in the investigated soils, especially at its highest rates i.e. 100% OM. Compost applications released acids which could ultimately increase the solubility of soil $CaCO_3$ to replace the exchangeable sodium by calcium (Avnimelech *et al.*, 1994). Thus, reduction in pH and ESP values occurred due to application of the compost to the alkali (sodic) soils (Rao and Pathak, 1996). Also, organic matter increases the formation of soil aggregates (Six *et al.*, 2004; Abbas et al., 2012) and stabilizes soil structure and enhances plant growth (Avnimelech *et al.*, 1994; Puget *et al.*, 2000) beside of stimulating soil microbial biomass (SMB)(Wong *et al.*, 2009).

Gypsum for ameliorating soil salinity and sodicity

Gypsum applications improved soil physical properties and increased the crop yield in investigated sodic soils. Gypsum supplied calcium (Ca^{2+}) directly to soils to replace excess exchangeable sodium (Na^+) (Qadir and Oster, 2002) and; therefore, improved the infiltration rate and hydraulic conductivity in soils(Sahin *et al.*, 2003; Gharaibeh *et al.*, 2009; Reading *et al.*, 2012; Batool *et al.*, 2015).Accordingly, leaching of salts from soils was improved (Gharaibeh *et al.*, 2009). It is worthy to mention that the internal soil swelling increased water holding capacity of the soil at low electrolyte concentrations (Mace and Amrhein, 2001). Such conditions could improve the crop growth (Hamza and Anderson, 2002; Yao *et al.*, 2013), encouraging further root exudates to increase formation of soil aggregations(Angers and Caron, 1998), in addition to the residual organic carbon in soils resulted from increasing crop yield. Thus, gypsum increases water retention in soils (Moret-Fernández and Herrero, 2015).

No reductions occurred in soil pH and EC with gypsum applications to El-Fayoum soil. It seems that the mode of action of gypsum in El-Fayoum soil is, mainly due to antagonizing the effect of Na and reducing its uptake by plants (Navarro *et al.*, 2000; Montesano and van Iersel, 2007). Accordingly, the plant growth parameters and yield components of sun flower and wheat plants grown in El-Fayoum soil were lower than those attained due to application of compost to the soil.

Application of diluted H_2SO_4 for ameliorating soil salinity and sodicity

Although soil pH and EC decreased with applying diluted sulphuric acid with irrigation water,and that the measured values of pH and EC were lower than those attained due to applications of either gypsum or compost; however, the corresponding increases in the crop yield components which were treated with the acidified irrigation water were significantly lower than those attained with applications of either gypsum or compost. Such a result probably indicates that the ameliorating effect of the compost exceeded the effect of just acidifying soil rhizosphere which increased the solubility of insoluble CaCO3 found in the soil. Diluted acids can solubilize the native CaCO3 to supply sufficient Ca^{2+} for reclamation of sodic soils (Qadir *et al.*, 1996). Probably the grown plants played significant roles in the process of ameliorating the investigated saline sodic soils.

Biological approach to improve crop yield grown in saline- sodic soils

Slight or insignificant changes took place in the abovementioned physical and chemical characteristics of the investigated soils with application of Biotoul. The crop performance slightly changed with Biotoul application. Such a result probably indicates that increasing plant tolerance towards salinity sodicity is not enough to attain better crop yield without further improvements in soil physical and chemical characteristics.

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التخفيف من حدة الملوحة والصودية بإضافة محسنات التربة

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تبلغ مساحة الارض المروية في مصرو المتأثرة بالأملاح تسعة مائة الف هكتار ومثل هذه الظروف تهدد بعدم إستدامة إنتاج المحاصيل في تلك الا{اضي، كما تهدد النظام البيئي بأكمله، وبالتالي، تهدف الدراسة الحالية إلي التعرف علي تأثير بعض محسنات التربة علي الحد من ملوحة وصودية التربة وكذلك علي بعض المحاصيل المنزرعة في أراضي ملحية صودية في مناطق الحسينية والفيوم، وللتحقق من هدف الدراسة ، فإنه تم اجراء تجربة حقلية لمعرفة أثر هذه المحسنات علي الاراضي محل الدراسة خلال فصلي الصيف والشتاء (2013- 2014) حيث تم زراعة محصول الأرز يليه محصول بنجر السكر في منطقة الحسينية بمحافظة الشرقية ، كما تمت زراعة محصول عباد الشمس يليه محصول القمح في أرض ملحية قلوية في طامية بمحافظة الفيوم، وكانت معدلات إضافة محسنات التربة هي: (1) إضافة الجبس 100% من إحتياجات الجبسية للارض، (2) إضافة الكمبوست بمعدل 100%من الكمية الموصي بها، (3) إ ضافة مزيج من 50% الكمبوست : 50% الجبس من الدفعات الموصي بها، (4) إ ضافة حمض الكبريتيك المخفف وذلك بما يعادل الجبس الموصي اضافته للتربة عند 100%من الاحتياجات الجبسية، (5) إ ضافة مركب حيوي عبارة عن بكتريا مقاومة للملوحة تحت الاسم التجاري(بيوترول)، وقد تم تقدير بعض الخصائص الفيزيائية والكيميائية للتربة وهي احتجاز التربة للرطوبة تحت قيم مختلفة من الشد الرطوبي، كما قدرت الكثافة الظاهرية و التوصيل الهيدروليكي للتربة ومحتوي التربة من المادة العضوية وحموضة التربة والتوصيل الكهربي للتربة، بالإضافة إلي التقديرات المحصولية ومؤشرات نمو المحاصيل المنزرعة في نهاية موسم نموها ، حيث ادت الإضافات الفردية لكل من الكمبوست بمعدل 100% من الكمية الموصي بها وكذلك الجبس بمعدل 100% من الاحتياجات الجبسية الي تحسين الخواص الفيزيائية والكيميائية للتربة الملحية الصودية وقد أعطت اعلي محصول من كل من (الارز-بنجر السكر- عباد الشمس - القمح)، أما بالنسبة لباقي المعاملات الاخري وهي 50% من المعدل الموصي به لكل من الكمبوست والجبس بالاضافة الي حمض الكبريتيك المخفف والمركب الحيوي(البيوترول). فكانت ذات أثر اقل علي كل من التربة والمحصول.