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The Efficiency of Some Soil Amendment and Growth Stimulators On Soil Salinity and Its Impact on the Yield, Quality and Nutritional Value of Egyptian Clover Varieties

Zeinab A. Mohamed[1], Wafaa A. Hafez[2] and Nabila A. Mohamed[1]

[1]Forage Research Department, Field Crop Research Institute, Agriculture Research Center, Giza, Egypt
[2] Soil, Water and Environment Research Institute, Agriculture Research Center, Giza, Egypt.

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ABSTRACT

The productivity of forage crops under salt stress limits sustainable yield production and forage nutrition. A field experiment was conducted to study the effects of some soil amendments and plant growth simulators on saline soil properties. Three multi-cut Egyptian clover varieties, Sakha-4, Gemmiza and Giza-6 were tested for adaptability, productivity and nutritive values for two winter seasons by management soil salinity in semi-arid region, of the North Sinai Governorate, Egypt. The soil amendments included sulphur (2.5 t ha^{-1}), gypsum (5 t ha^{-1}), compost (12 t ha^{-1}) and a composite of compost, gypsum and sulphur (6 t ha^{-1}compost + 2.5 t ha^{-1}gypsum + 1.2 t ha^{-1}sulphur); and the plant growth stimulators are potassium silicate (2 mm L^{-1}) and nanoparticles of $CaCO_3$ (5 g L^{-1}).The pH, k and Cu values demonstrated an insignificantly (p<0.0.5) across all soil amendment and growth stimulators, however the EC dSm^{-1}, OM% and (N, P, Zn, Mn, and Fe) mg kg^{-1} hada positive significantly ($p<0.05$) in soil with using soil and plant applications after plant cutting. Linear regression has a descending relationship significant (P<0.0.5) between ECE mol.kg and ESP % (R^2 = 33.5*) in the first growing season with high significant ascending relation between Ec (dSm^{-1}) and OM% (R^2 = 0.818**) in the second growing season. Giza-6 followed by Gemmiza-1 were better performances with higher forage dry yield compared with those of Sakha-4, which could be attributed to differences in salt-stress tolerance. The digestibility coefficients of CPY, DCP, fiber fractionation values, total digestive nutrients (TDN %) and relative feeding value (RFV %) over varieties increased significantly (P<0.05) with using soil amendments and growth regulator in salt affected soils.

Keywords: Soil salinity, Soil amendments, Compost, Sulphur, Gypsum, Potassium silicates, Nano particles of $CaCO_3$; Egyptian clover, Yield, Nutritive values.

1. Introduction

Salinity is one of the most important abiotic stresses, limiting crop production in arid and semi-arid regions, where soil salt content is naturally high and precipitation can be insufficient for leaching (Zhao *et al.,* 2007). According to the FAO (2008), over 6% of the world's land is affected by either salinity or sodicity which accounts for more than 800 million ha of land. Salinity affects plant growth through the following factors; (1) water stress, which is caused by low osmotic potential of the solution, (2) imbalance of nutrition, and/or (3) specific ion effects. These factors are easily combined to influence plant growth (Munns and Tester, 2008).

All major living processes, such as growth, photosynthesis, and protein and lipid metabolism, are affected by accumulation of salts in soil (Evelin *et al.,* 2009). Soil salinity is generally characterized by measuring electrical conductivity (EC) and expressed in units of deci-siemens per meter (dS m^{-1}). A minor concentration of K^+ may have helpful effects on soil permeability caused by the exchangeable Na^+ by K^+ with lower dispersive potential, rising aggregates stability and soil pore connectivity (Buelow *et al.,* 2015). ESP of 15 is considered as the critical limit for soil sodicity (Qadir *et al.*, 2005).

Corresponding Author: Zeinab Mohamed, Forage Research Department, Field Crop Research Institute, Agriculture Research Center, Giza, Egypt.

Chemical amendments have long been applied as ameliorators of sodic soils. A lot of these amendments include gypsum, sulphuric acid and sulphur (Bello, 2012), which have been found to be effective in ameliorating sodicity of soil.

Sulphur is one of the essential nutrients for plant growth and ranging from 0.2 to 0.5% in plant tissue on dry matter basis. It is required in similar amount as that of phosphorus (De Kok *et al.,* 2002).

Gypsum is the most commonly used amendment in Egypt. Gypsum is a moderately soluble source of plants essential nutrients, calcium and sulphur (Dick *et al.,* 2008). It can improve plant growth and improve the physical and chemical properties of soils primarily by maintaining a favorable soil solution electrolyte concentration. Choudhary *et al.,* (2011) revealed that the application of gypsum to saline-sodic and sodic soils, adsorbed sodium on the soil complex is being replaced by the calcium.

Organic amendments increase soil organic matter content and offer many benefits. Organic matter improves soil aeration, water infiltration, and both water-and nutrient-holding capacity. Many organic amendments contain plant nutrients and act as organic fertilizers. Also it is an important energy source for bacteria, fungi and earthworms that live in the soil. The role of compost in salt-affected soils is very vital as an organic source to improve the physical properties of such soils which have been deteriorated to the extent that water and air passage become extremely difficult. It is considering as a perfect organic amendment in saline agriculture as well as for reclamation of salt-affected soils (Zaka *et al.,* 2003 and Sarwar *et al.,* 2010). Physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields.

The decaying organic matter increases soil CO_2 concentrations and releases H+ when it dissolves in water. The released H+ enhances $CaCO_3$ dissolution and liberates more calcium (Ca) for sodium (Na) exchange (Ghafoor *et al.,* 2008). Moreover, organic materials improve the soil physicochemical properties that accelerate exchange of cations on soil solids and leaching of salts from the root zone (Clark *et al.,* 2007), The significance of organic matter has been proven through its effect on improving the physical conditions of soils for crop growth besides its role as fertilizers. In addition, potassium silicate was found to increase seedling germination and seed yield andquality of bean plants grown under salt stress conditions (Abou Baker *et al.,* 2011). Nanoparticles of $CaCO_3$ also have been recently used to increase pearl millet potential to modulate salt stress (Abd El-Naby *et al.,* 2016).

The vertical expansion of Egyptian clover cultivation in saline-affected areas with improving yield productivity under its conditions is a nominal objective to promote Egyptian agriculture. Egyptian clover or Berseem clover (*Trifoliumalex andrinum*, L.) is the main annual forage crop in Egypt. The salt tolerance of crop plants is a very acute problem in agriculture. It has attracted the attention of many investigators and practical agricultural workers because of the need to increase yield on saline soils and to develop and utilize new saline areas in Egypt. The effect of soil salinity has multifarious effects on germination, seedling establishment, plant growth, yield and quality. Salinity can significantly decrease crops' growth and yield due to the osmotic, ionic and oxidative stresses (Taha *et al.,* 2020). It's a heavy N producer and the least winter hardy of all true annual clovers and considered as soil-improvement crop. Legumes are considered a practically salt sensitive family (Maas and Hoffman, 1977) within which limited variability for salinity tolerance has been detected (Johansen *et al.,* 1990). Quality and digestibility of dry forage is affected by stage of maturity, which is reflected on its nutritive values. Cell wall constituents analyzed as fiber insoluble in a neutral detergent solution (NDF), were shown to consist of cellulose, hemicellulose, and lignin, with lignin and cellulose being combined in acid detergent fiber (ADF). Thus, neutral-detergent-fiber (NDF) is an estimate of total cell-wall concentration for forages and results the fraction best correlated to digestibility (Goering and Van Soest, 1970). The cutting height is a very important parameter which influenced plant yield, quality of the harvested forage and plant regeneration speed and sustainability of culture (Onyeonagu and Ugwuanyi, 2012).

Orak and Ates, (2005) were determined some physiological basis of salt tolerance of available genotypes of Egyptian (*Trifoliumalex andrinum* L.) at early seedling growth. Salinity reduced water potentials in the leaves of (*Trifolium* sp.), reduced length and dry mass of the stem and affects the length and conductivity of the root. Successful silage crop production is based on a number of key factors that include species and variety selection, soil type, soil pH, fertilizer regime, pest control, optimal harvest date and storage losses (Ross *et al.,* 2004a &b; King, 2007).

Abd El-Naby *et al.* (2018) were reported that the composite, compost and gypsum soil amendments were the most effective treatments resulting in the greatest herbage yield and quality values.

A chief part of berseem clover (*Trifoliumalex andrinum* L.) is dependent on plant potential yield, quality and nutritional value. The quality of Egyptian clover dry yield material depends on the chemical composition and nutritional value of fodder and varieties. This study aimed to: a) Evaluate the effect of some soil amendments and plant growth stimulator on salt soil properties and b) Improve forage productivity and quality by management salinity stress and c) Investigate the effect of used applications on forage nutritive value under saline soil conditions.

2. Materials and Methods

2.1. Field experiment

Three registered multi-cut Egyptian clover Miskawi varieties, Sakha-4, Gemmiza and Giza-6, adapted to clay soil, were tested to compare their biochemical constituents and yield performances in response to various soil amendments and growth stimulators. The present study was carried out over two winter growing seasons, starting 20 September 2016 and 2 October 2017, on a private farm in Gilbana Village, Quntra Sharke. This area is located in the semi-arid region of the North Sinai Governorate, Egypt and lies on the north-western Mediterranean coast of the Sinai, between 30°20′–32°40′ E and 30°30′–31°05′ N (Ahmed *et al.,* 2015). Temperatures ranged from 14 to 26 °C during the Egyptian clover growing period from sowing until harvest. Gilbana Village's soil is newly reclaimed saline soil with a sandy clay texture. This area is irrigated with El-Salam Canal water (Nile water mixed 1:1 with agricultural drainage water). Some physical and chemical properties of the investigated soil are presented in Table 1.

2.2. Soil preparation

The soil surface was leveled using laser techniques. Deep subsoil ploughing was performed, and two field drains at 10 m distances and initial depths of 90 cm were constructed and fed an irrigation canal that was established in the middle of the experimental plot. The plot units were subjected to continuous and alternative leaching processes before the Egyptian clover varieties were sown.

2.3. Experimental design and treatments

The design was a randomized complete block and replicated three times. The soil amendments included sulphur (2.5 t ha^{-1}), gypsum (5 t ha^{-1}), compost (12 t ha^{-1}) and a composite of compost, gypsum and sulphur (6 t ha^{-1}compost + 2.5 t ha^{-1}gypsum + 1.2 t ha^{-1}sulphur); and the plant growth stimulators are potassium silicate (2 mm L^{-1}) and nanoparticles of $CaCO_3$ (5 g L^{-1}).

The plot area was 6 m2 (3 m × 2 m). The sowing density was calculated using 45 kg seeds ha^{-1}; therefore, 27 g seeds $plot^{-1}$ were necessary. Prior to planting, but after the preparation of the seedbed, (46% N) was applied as N fertilizer at the rate of 175 kg ha^{-1}, and calcium super-phosphate (15.5% P_2O_5) was incorporated into the topsoil at the rate of 36.5 kg $P_2O_5ha^{-1}$. Furthermore, 57 kg KO_2 ha^{-1}as potassium sulphate (48% KO_2) was added. The clover was harvested using a hand sickle mower. Four cuts were taken in each growing season. In both years, the first harvest was done at 60 d after sowing, and after 30-d intervals for three consecutive cuts. Plants were cut 5–8 cm above ground level. To determine the forage dry weights, 200 g samples from each plot were dried at room temperature without direct exposure to sunlight. When the weight of samples was stable for three successive days, the obtained weights were considered as dry weight percentages (%) of dry matter production (t ha^{-1}) for each treatment. Observations, including shoot and root length $plant^{-1}$, number of shoots and crown diameters, were recorded after each cut (10 plants were sampled randomly from each plot). Dry herbage yield was determined by weighing the dried material of each plot. The chemical compositions of Egyptian clover, including crude protein, crude fiber, and carbohydrate, In addition, nutritive forage values were calculated.

Table 1: Some physical and chemical properties of the experimental soil.

Particle size distribution		
Coarse sand (%)	7.44	
Fine sand (%)	68.44	
Silt (%)	9.60	
Clay (%)	14.52	
Textural class	Sandy clay	
Organicmatter(kg^{-1})	0.52	
$CaCO_3$(g kg^{-1})	5.69	
SAR %	12.29	
ESP%	14.75	
CEC(Meq/100gsoil)	23.65	
	Before leaching	**After leaching**
pH (1:2.5)	8.3	8.1
EC (dSm^{-1})	12.8	10.3
Cations (m molc^{-1})		
Ca^{2+}	32.5	22.2
Mg^{2+}	33.5	20.7
Na^{+}	60.5	58.7
K^{+}	1.5	1.4
Anions (m molc^{-1})		
HCO^{-3}	2.5	1.5
Cl^{-}	95.5	73.8
SO^{-4}	30.0	27.7
Available macronutrients after leaching (mg kg^{-1})		
N		86
P		3.1
K		104.4
Available micronutrients after leaching (mg kg^{-1})		
Fe		2.8
Mn		1.1
Zn		0.5
Cu		0.2

2.4. Preparation of compost, gypsum and sulphur

Gypsum (97% pure) was sieved to increase its solubility. Compost was prepared by mixing straw of rice (*Oryza sativa* L.), maize (*Zea mays* L.), sesame (*Sesamum indicum* L.) and faba bean (*Vicia faba* L.) with farm manure. The mature compost was obtained after 3 months of composting and was passed through a 10-mm-diameter sieve prior to use. Sulphur (99% pure), gypsum and compost were incorporated into the soil and ploughed with a mould board plough (30 cm deep). The fields were then irrigated. The treatments were left for 10 d to dry. All soil treatments were applied one month before sowing to ensure complete decomposition of compost and potassium silicate, and soil was irrigated after sowing. Irrigation was carried out until the soil attained its saturated state. The compost chemical properties are shown in Table 2. The compost analyses were performed in accordance with the standard methods described by Brunner and Wasmer (1978).

2.5. Preparation of potassium silicate and nanoparticles of $CaCO_3$

Liquid potassium silicate (10% K_2O and 25% SiO_2) and nanoparticles of $CaCO_3$were prepared at rates of 2 mL $L^{-1}$and 5 g L^{-1}, respectively. These were sprayed on plants 21 d after sowing and applications were repeated every 21 d.

Table 2: Chemical analysis of the used compost.

Moisture content %	EC dSm^{-1} (1:10)	pH (1:10)	C	N	C/N	O.M	Total P	Total K	Available P	Available K	Fe	Mn	Zn	Cu	NH_4-N	NO_3-N
			(%)						(mgkg^{-1})							
20.25	2.35	7.22	32	2.47	1:13	55	0.84	1.62	298	415	211	112	78	23	780	415

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Soil analyses

Surface soil samples (0–30 cm depth) were collected before planting and in the first and second growing seasons, air-dried, sieved to pass through a 2 mm mesh and mixed thoroughly. Calcium carbonate, soil organic matter (SOM), total soluble ions and electrical conductivity (EC) were determined using the saturated soil paste extract, while the pH was measured using the soil suspension (1:2.5) as described by Page *et al.* (1982). Available N was measured in accordance with the modified Kjeldahl method of Black (1965). Available P, K and micronutrients [Fe, Zn and manganese Mn] were extracted using ammonium bicarbonate as described by Soltanpour (1985) and determined using an inductively coupled plasma spectrometer model 400.

As well asSodium adsorption ratio (SAR) was calculated using the concentration of Na and Ca + Mg in soil extracts using the formula:

$$SAR = \frac{(Na^{+})}{(Ca^{2+} + Mg^{2+})^{1/2}}$$

Where, Na, Ca and Mg are in mmol L^{-1} .

Exchangeable Sodium percentage (ESP) was estimated using the following equation:

ESP=Naexch+/[Caexch2++Mgexch2++Kexch++Naexch+] ×100

All parameter were evaluated as described by Cottenie *et al.* (1982). Cations exchange capacity (c molc kg^{-1} soil) was determined according to Jackson (1973).

2.6. Plant analyses

2.6.1. Laboratory analysis

Samples of ten plants were collected randomly from each plot before cutting and then oven dried at 70 ºC. The plant samples were ground, 0.5 g of each sample was digested according to the methods described by Black (1965). The plant content of nitrogen was determined by Kjedahl method (Chapman and Partt, 1961). P, K, Fe, Mn and Zn were determined in plant digestion by Inductively Coupled Plasma Spectrometer (ICP) plasma 400 according using the methods described by Cottenie *et al.* (1982) and Page *et al.* (1982).

Chemical compositions of Egyptian clover, including crude protein, crude fiber, and carbohydrate. Crude protein was calculated by multiplying the values of total N by 6.25 (Boisen *et al.,* 1987). The total ash content was estimated using the furnace incineration gravimetric method described by James (1995). The crude fiber percentage was determined in accordance with AOAC (1984). Total available carbohydrate as a percentage of glucose was determined and calculated as described by James (1995).

Digestible dry matter (DDM,%DM), dry matter intake (DMI, %DM), neutral detergent soluble % (NDS) were estimated according to and soluble fiber were estimated according to Aydın *et al.,* (2010), relative feeding value % (RFV) was estimated according to Uttam *et al.* (2010) and relative forage quality % (RFQ) was estimated according to (Moore and Undersander, 2002).

2.7. Statistical analyses

The data obtained from the laboratory experiments were combined into a single analysis, which was performed using SAS 9.1 statistical software (SAS Institute 2004). The data were subjected to an analysis of variance, and means were separated by least significant differences if the *F*-test was significant between varieties (Bruning and Kintz 1977) at $p = 0.05$. Bartlett's (1937) test was performed prior to the combined analysis to determine the homogeneity of individual error terms, which indicates the homogeneity of variances. Regression relationships linear model was tested where the data indicated a curvilinear relationship, a nonlinear regression model proposed by Cousens (1985).

3. Results and Discussion

3.1. Effects of the studied amendments and Egyptian clover on some soil chemical properties: - Soil pH

Soil pH directly affects the life and growth of plants because it affects the availability of all nutrients. Slight differences of soil pH occurred when different amendments and stimulating plant growth were applied (Tab.3). However, a contrast based comparison of treated vs. control pH indicated a significant reduction across all treatments associated with soil amendments. The pH of the soil decreased on average with the amendments application this decrease ranged from 7.9 to 7.46 for Land additives and from 7.9 to 7.53 for Composite treatment + plant Growth stimulator during the two grown seasons. This behavior may be due to the organic matter (compost) fraction where the negative charged surfaces are increased due to the dissociation of H+ from certain functional groups particularly from carboxylic (-COOH) and phenolic (-C_6H_4OH) groups. These results are in agreement with (Shaban *et al.,* 2013, Abd El-Naby *et al.,* 2016 and 2018); they found that the soil pH was decreased with gypsum application in from 8.54 to 7.54. Ja reported relative decreases in soil pH from the Control which varied from 8.35 to 8.31 and 8.37 to 8.17 averaged over two seasons for gypsum and sulphur treatments, respectively. The effects of Egyptian clover cultivation on soil pH led to decreasing slightly the soil pH values during the growing seasons. The highest value of soil pH was 7.9in control (non-treated) compared with the initial after leaching (8.1) These results agreed with those reported by Abd El-Naby, et al.(2013, 2016 and 2018), who indicated that the effect of alfalfa on saline soil improvement was significant and as result of the high activity of dehydrogenase enzyme and the released carbon dioxide in the rhizosphere cause the formation of carbonic acids and thus the decrease of pH of the root zone compared with initial soil pH after leaching.

3.2. Soil salinity

The effects of soil amendments, plant growth promoting and Egyptian clover cultivation on soil salinity are illustrated in Table (3). The soil EC was decreased with all treatment were efficient decreasing in EC values after Egyptian clover cutting compared with the initial soil EC (Table-3). The highest mean value of EC was 9.66 dSm^{-1} for control, while the lowest mean values of EC was 7.33 dSm^{-1} for composite treatment after cutting, hence the mean values of soil EC were 8.08, 7.68,7.35 and 7.33 dSm^{-1} for sulpher, Gypsum, compost and composite treatment, respectively. The relative decreases of mean values of initial soil EC as affected by soil amendments were (21.6, 25.4, 28.6 and 28.8 %) for sulpher, Gypsum, compost and composite treatment, respectively. compared with the initial soil EC after leaching. (Table 3) These results are in agreement with Abd El-Naby *et al.,* 2016 and 2018. While, the relative decreases of mean values of control as affected by Egyptian clover was 6.21% These decreased of soil EC may be due to the improvement in soil porosity and hydraulic conductivity by adding soil amendments, which resulted from enhancement the leaching of salts. These results are in contrary with Hussain *et al.,* (2001); they reported that the slight decrease occurred when different amendments were applied in combination or alone except for use of sulphur or its combination with FYM. The relative decreases of mean values of K-Silicate and Nano particles treatment as affected by Egyptian clover were 18.05 and 15.15% for K-Silicate and Nano particles treatment, respectively. These results are in agreement with Latrach *et al.* (2014) who indicated that planting alfalfa led to a significant decrease in salt content in upper soil layer.

3.3. Soil organic matter (SOM)

Soil organic matter content obtained results proved that all the applied treatment have a positive impact on soil organic matter %. The maximum increase was detected in response to composite and compost treatment (2.78 and 2.37), respectively. This is consistent with Tejada *et al.* (2006), who reported that the effect of organic amendments on soil organic carbon depended on the chemical nature of the amendments. The role of compost in salt-affected soils is very vital because the organic source is ultimate opportunity to improve the physical properties of such soils which have been deteriorated to the extent that water and air passage become extremely difficult in such soils. Resultantly, the water stands on the surface of these soils for weeks long. The plants when grown under these conditions often die due to deficiency of root respiration. The compost can be a very good organic amendment in saline agriculture as well as for reclamation of salt-affected soils (Sarwar *et al.,* 2011).

3.4. Available macro and micronutrients in soil

The data presented in Table (3) illustrated soil contents of available N, K and P (%). Available N, P and K content was increased as a result of salt affected soil treated by the soil amendments. This increasing may be attributed to observed effect of amendment application on decreasing soil pH and hence increased the availability of N, P and K in the soil. This effect was more pronounced in soil treated with composite, compost, sulphur and nano particles in case of N% and in soil treated with

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compost, composite and gypsum in case of K%. These findings are in agreement with the results obtained by Mahmoud (2011).

All the applied soil treatments were negatively affect P availability compared to control. In general, the application of gypsum increased the solubility of N and K, whereas it decreased the solubility of P, whereas P may be related with soluble Ca++ released from added gypsum formed less soluble P compounds namely Calcium phosphate. The application of compost increased the solubility of all tested nutrients in the study soil (Table 3). These results are in agreements with El Rashidi *et al.,* (2010), they found that an application of peat improved the solubility of most nutrients in the soil. Sulphur element plays a great role in plant metabolism and supplying it into soil caused reduction in the soil pH, consequently enhances the solubility and availability of many elements (Lal *et al.,* 2000).

3.5. Available micronutrients in soil

It is evident from data present in Table (3) that pronounced an increase in soil available microelement contents (Fe, Mn, Cu and Zn) as a result of application soil amendments. The availability of micronutrients in soil depends on the change of soil pH, resulted from the treatments of the tested soil amendments. Thus, it could be concluded that the more pronounced increase in the available Cu and Zn contents as a result of applied different soil amendments may be attributed to improve soil pH. This finding is in agreement with results obtained by Mahmoud (2011). These increases may be due to the release of organic acids up on decomposition of the applied organic matter because of the organic matter is considered as a source of Fe, Mn and Zn. These results are in agreement with Abdel Aal *et al.,* (2003).

Table 3: Soil EC, pH, EC, O.M, macro and micronutrients content in soil after harvesting of two treated seasons.

Treatments	EC Dsm^{-1}	pH (1:2.5)	OM %	N	P	K	CU	Zn	Mn	Fe
					(mg kg^{-1})					
Control	9.66	7.9	0.91	84	3.54	149	0.31	0.17	1.42	3.83
Sulphur (S)	8.08	7.5	1.13	187	3.08	133	0.32	0.11	1.67	5.77
Gypsum (G)	7.68	7.56	1.32	196	2.51	135	0.35	0.12	1.74	5.15
Compost (C)	7.35	7.66	1.37	248	3.09	127	0.32	0.09	1.29	5.99
ºC + G + S	7.33	7.46	1.78	339	3.77	125	0.35	0.08	1.73	6.49
K -Silicate	8.44	7.53	1.07	103	3.53	146	0.32	0.15	0.87	6.21
Nano-particles	8.74	7.57	1.02	178	3.73	142	0.33	0.12	0.73	6.34
Grand mean	8.30	7.58	1.17	175.6	3.414	138.9	0.33	0.12	1.18	5.86
LSD (0.05)	0.19	n.s.	0.18	81	0.12	n.s.	n.s.	**0.02**	**0.16**	**2.15**
Probability	**0.01<**	**0.05<**	**0.01<**	**0.01<**	**0.01<**	**<0.05**	**0.05<**	**0.01<**	**0.01<**	**0.05<**

ºCombination of compost, gypsum and sulphur

3.6. Regression relationships

Figures $1_{a \text{ and } b}$ shows significant decreased linear regression relationship was obtained between ECE mol.kg and ESP % in the first (R^2 = 33.5*) and insignificant relationship in the second growing season R^2 = 0.173). As showed in figures ($1_{c \text{ and } d}$) insignificant regression relationship between ECE and OM% in first growing season (R^2 = 0.176) and high significant relation in the second growing season (R^2 = 0.818**). Descending linear were created between CEC and ESP relationship, whereas an ascending linear regression were found between CEC and OM relations for the first and the second growing seasons (Fig. 1).

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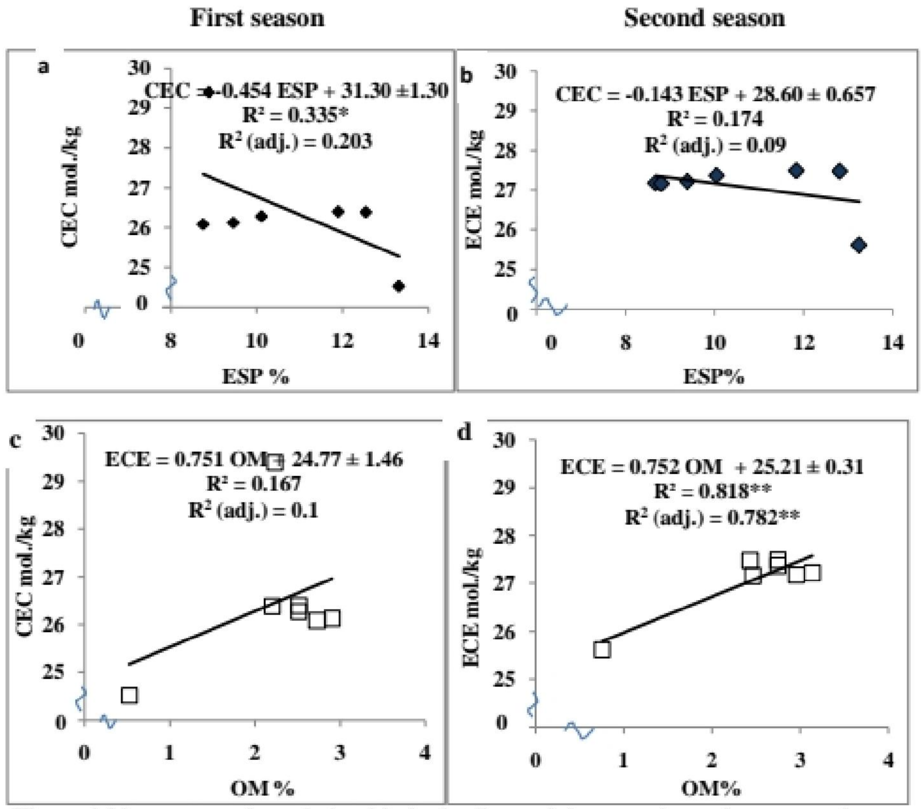

Figure 1. Linear regression relationship in the first and the second growing seasons between: 1) CEC and ESP (a and b) and 2) between CEC and OM% (c and d), respectively.

Fig. 1: Linear regression relationship in the first and the second growing seasons between: 1) CEC and ESP (a and b) and 2) between CEC and OM% (c and d), respectively.

3.7. Total forage dry yield

The effect of soil amendments and plant growth stimulators on forage dry yield (t ha^{-1}) of berseem clover varieties is presented in Table 4. Forage dry yield over the four cuts was affected by treatments on the three varieties over two seasons. Giza-6 produced greater dry forage yield t ha^{-1} than Gemmiza-1 and Sakha-4 varieties in each season. Applications of the four soil amendments and the two plant growth stimulators resulted in greater herbage yield than that of the control in the first and second seasons.

Giza-6 produced superior forage dry yields that varied from 12.61and 14.64 t ha^{-1} under control conditions to 18.98 and 20.86 ha^{-1} after application of the composite soil treatment in the first and the second growing seasons, respectively. Comparing the productivity as assessed by forage dry yield in plants grown in untreated saline soil, it was found that Giza-1 and Gemmiza-1 were more tolerant to salinity stress than Sakha-4.

The best tolerant plants were recorded for Giza-6 and Gemmiza-1 than Sakha-4 grown in salt affected soil over all soil amendments and plant growth applications. Sakha-4 had the lowest growth parameters over the two growing seasons. Plants of Giza-6 followed by Gemmiza-1 were better performance with higher forage dry yield compared with those of Sakha-4, which could be attributed to differences in salt-stress tolerance.

Varietal differences in response to salt stress have been reported in other agricultural crops by several researchers (Sharma 2013 and Abd El-Naby *et al*., 2018).

Table 4: Total dry yield (t h-[1]) across four cuts among season 2016/17 and season 2017/18, respectively.

Treatments	Sakha-4		Giza-6		Gemmiza	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	12.23	13.61	12.61	14.64	12.81	14.23
Sulphur (S)	17.03	17.7	17.03	18.89	16.98	18.54
Gypsum (G)	17.66	18.28	18.57	18.99	17.08	19.32
Compost (C)	18.17	18.25	18.39	20.59	18.21	19.65
C + G + S	18.77	18.93	18.90	20.86	19.03	20.07
K Silicate	15.56	17.81	17.55	18.18	17.39	17.79
Nano- particles	16.01	17.61	17.13	17.84	17.05	17.42
Grand mean	16.281	17.287	17.228	18.402	17.021	17.986
L.S.D (0.05)	2.15	2.02	2.98	2.91	1.94	1.86
Probability	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

ºCombination of compost, gypsum and sulphur

Potassium silicate and nanoparticles produced the depressed forage dry yield of the three varieties; Sakha-4, Giza-6 and Gemmiza-1; over all of the studied treatments. This may be because of the higher effect of soil salt stress. Salinity damagingly on germination process and also plant establishment of Egyptian clover was low affects than of alfalfa seed germination and alfalfa plant stands in the same experimental area.

3.8. Plant agronomic traits

Plant agronomic measures; plant height, stem diameter, number of tillers, number of branches, fresh and dry weights; and root measures; root length crown diameter and weight over the three studied varieties, Sakha-4, Giza-6 and Gemmiza-1, over four cuts and two growing seasons are presented in Table 5. Substantial variation in salt tolerance was observed with significant differences ($p < 0.05$) of number of branches per plant among the application of soil amendments and spraying of plant growth stimulator. The other shoot and root traits differed for all soil amendments and the plant-growth stimulators were applied ($p < 0.01$).

The composite soil treatment gave rise to the highest values for all of the analyzed growth parameters over all varieties compared with those of the control, other soil treatments and applied growth stimulators. The optimistic effects measured were ranked in the following order: composite (compost + gypsum + sulphur) > compost >gypsum > sulphur> potassium silicate > nanoparticles.

The control root length had the tallest one compare with the treated roots. Shoot agronomic measures; plant height, stem diameter, number of tillers, number of branches, fresh and dry weights; and root measures; root length crown diameter and weight of the three studied varieties, Sakha-4, Giza-6 and Gemmiza-1, over cuts and seasons are presented in Table 6. Considerable variation in salt tolerance was observed with significant differences ($p < 0.05$) of number of branches, forage weight and crown diameter per plant over soil amendments and plant growth stimulator applications. The other shoot and root traits differed for varieties over soil amendments and the plant-growth stimulators were applied ($p < 0.01$).

Giza-6 and Gemmiza-1 recorded the best adapted and more tolerant varieties to salt soil stress than Sakha-4 grown in salt affected soil over all soil amendments and plant growth applications. Sakha-4 had the lowest growth parameters over the two growing seasons. Plants of Giza-6 followed by Gemmiza-1 were better with higher growth parameters compared with those of Sakha-4, which could be attributed to differences in salt-stress tolerance. Varietal differences in response to salt stress have been reported in other agricultural crops by several researchers (Sharma 2013 and Abd El-Naby, *et al.,* 2018).

Table 5: Means of agronomic characters per plant over cuts, varieties and two growing seasons 2016/17 and 2017/18, respectively.

Treatments	Shoot						Root		
	Plant height	Stem diameter	No. Tillers	No. branches /stem	Forage yield	Dry yield	Root Length	Crown diameter	Root weight
Control	71.56	0.58	9.11	7.67	67.44	17.28	17.44	1.80	5.64
Sulphur (S)	73.67	0.64	13.89	8.00	83.11	20.93	15.33	2.53	6.89
Gypsum (G)	72.11	0.60	14.67	8.89	76.50	18.61	15.33	2.44	6.78
Compost (C)	76.0	0.62	14.0	8.00	79.67	21.72	16.44	2.29	6.14
*C + G + S	78.11	0.62	16.0	8.22	85.17	21.94	15.89	2.78	8.04
K Silicate	77.22	0.67	13.78	8.44	73.78	17.84	15.33	2.33	6.22
Nano particles	73.11	0.65	11.78	7.89	71.44	17.79	15.3	2.07	5.67
Grand mean	74.73	0.64	12.785	8.045	75.78	19.52	16.19	2.205	6.37
L.S.D (0.05)	3.72	0.04	4.16	1.04	17.26	4.71	1.56	0.53	1.55
Probability	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01

ºCombination of compost, gypsum and sulphur

3.9. Macro and micro-nutrients concentrations in plant tissues over varieties

Data in Table 6 show that N, P and K contents. These contents were increased by all compost, sulphur and gypsum, composite (C, G and S), Nano-particles, and Potassium silicate application, the compared to control. The lowest contents of these nutrients were observed for the control treatments. The N, P and K concentration in Egyptian clover varieties plants (%) in the two seasons were decreased with increasing soil salinity, the data of N, P and K content in Egyptian clover plants show relative increase with decrease of soil salinity as a result of adding different amendments.

Table 6: Plant evaluation for macro and micro-nutrient contents in shoot parts of Egyptian clover plants over varieties and the two growing seasons.

Treatment	Macronutrients			Micronutrients			
	N	P	K	Mn	Zn	Fe	Cu
Control	2.19	76.48	2.41	25.45	5.67	249.39	3.39
Sulphur (S)	2.66	89.96	3.32	36.05	8.39	288.85	4.04
Gypsum (G)	2.76	85.59	2.93	34.91	6.28	273.81	3.81
Compost (C)	2.79	90.33	3.36	41.06	7.1	346.24	4.03
C + G + S	2.81	91.66	3.71	45.55	7.38	347.82	4.69
K Silicate	2.42	85.86	3.63	39.06	7.70	331.51	5.00
Nano particles	2.51	89.98	3.68	38.00	8.28	339.39	4.71
Grand mean	2.55	88.63	3.28	37.25	7.31	312.63	4.28
LSD (0.05)	0.072	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Probability	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

ºCombination of compost, gypsum and sulphur

N contents in plant tissues ranged from 2.2 to 2.8, P contents ranged from 0.76 to 0.91% and K contents ranged from 2.41 to3.7 %, respectively. The relative increases of the contents of N, P and K in the plant tissues are mainly depend on the type of treatments used. Compost and composite (C, G and S) gave the highest content of N% in plant tissues over the four cuts, P performed higher contents of compost (0.90%) and composite (C, G and S) (0.91%) This finding is in agreement with results obtained by Kandil& Gad (2010). They reported that the nutrient (N, P and K) uptake by tomato, onion and sunflower were strikingly increased by the application of sulphur compared to gypsum.

On the other hand, the effects of using soil amendments and simulating plant growth applications under saline soil on the concentrations of Mn, Zn, Fe and Cu in Egyptian clover varieties plants were presented in Table 7. Sulphur application at rates of (1) mg fed^{-1} to saline soil was associated with changes of Mn, Zn, Fe and Cu accumulation in the plant tissues of Egyptian clover varieties plants. The corresponding mean values of Mn (25.45, 45.55mg. Kg^{-1}), Zn (5.67, 8.39mg. Kg^{-1}), Fe (249.39, 347.82mg.Kg^{-1}) and Cu (3.39, 5.00 mg. Kg^{-1}) per four cuts in plant tissues.

3.10. Forage nutritive value

Table (7) presents the results regarding the dry matter (DM%) content of the analyzed samples. Considerable differences ($P \leq 0.05$) among treatments for Fiber fractions; acid detergent fiber% (ADF), nutrient detergent fiber% (NDF) acid detergent lignin (ADL) % and the forage feed quality; total digestive nutrients % (TDN) and relative feeding value (RFV) %. Combined analysis over varieties was done according to insignificant differences between them across all estimated values.

Table7: Mean average of fiber fractionation values (NDS, ADF, NDF and ADL%), total digestive nutrients (TDN%) and relative feeding value (RFV%) over varieties.

Treatments	CPY t/ha	DCP %	NDS %	ADF %	NDF %	ADL %	TDN %	RFV %
Control	4.59	9.92	47.87	28.99	35.64	6.01	63.93	173.20
Sulphur (S)	6.83	11.55	51.26	26.11	33.98	5.55	67.64	179.00
Gypsum (G)	6.93	11.26	52.73	24.99	32.80	5.33	69.09	189.89
Compost (C)	7.73	12.48	52.96	23.93	32.66	5.40	70.46	184.87
C + G + S	8.07	12.68	53.39	23.39	32.59	5.31	71.15	187.54
K Silicate	6.66	11.44	48.57	27.86	35.63	5.75	65.38	191.96
Nanoparticles	6.62	11.52	48.33	27.88	35.27	5.81	65.36	194.54
Grand mean	6.78	11.55	50.73	26.16	34.08	5.5	67.57	185.86
LSD (0.05)	0.96	2.15	1.13	0.94	0.71	0.28	1.22	n.s.
Probability	**	*	**	**	**	**	**	n.s.

ºCombination of compost, gypsum and sulphur

Acid detergent fiber % (ADF) values varied from 23.39% of composite (S+G+C) to 28.99% of control. Nutrient detergent fiber % (NDF) values varied between 35.64% of control and 32.59% of control whereas, acid detergent lignin% (ADL%) ranged from 6.01% of control to 5.31% of composite. Plant stimulators treatments performed high ADL content.

The TDN percentage ranged from 63.93% for control to 71.15 % composite treatment with an average of 67.57% over all the studied amendments. The relative forage quality (RFV%) ranged from 173.20 for control up to 194.54% for (S+G+C) treatment, also berseem performed insignificant RFV% over studied varieties under salt affected soil. Abd El Naby *et al.,* (2016) studied some Egyptian clover genotypes under fertile clay soil and reported that berseem genotypes had a prime performance of RFV% as a superior intake%.

4. Conclusion

The salt sensitivity of plants varies during their lifecycle, but the seedling and establishment stages are the most sensitive. In that case, the impacts on crop yields and quality can be drastic, as the vegetative stage, is the most susceptible for crop yield and quality in Egyptian clover crop. From this study and also the previous one (Abd El-Naby *et al.,* 2018), applying some mineral, organic amendments and growth stimulator to solve salt soil problems without a significant decrease in yield, it depends on leaching soil before planting and then providing the crop with the necessary water needs (water consumption) and then the crop can be adapted and the soil structure and texture can be gradually improved. Berseem, Egyptian clover, is a relatively tolerant crop to moderate salinity stress especially in seedling stage and it is a good adapting grown with low reduces in yield, while the yield will drop off with higher salinity levels. The applications of combined compost, Gypsum and sulphur with the suitable rates to saline soil were effective to improvement the physical, chemical and biological soil properties and yield criteria. The nutrient values of the three studied varieties were close up to insignificant differences across the estimated traits.

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