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Environmental Management of Salt Affected Soils and its Effect on Yield and Quality of Summer Forage Grasses in North Sinai

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TWO FIELD experiments were conducted in Galbana village at Sahl El-Tina site., North Sinai Governorate during two summer seasons (2013 and 2014), to evaluate the effect of some soil amendments and simulating plant growth on soil properties, forage productivity and quality by management salinity of soil and plant resistant to salt. Two forage grasses, Pearl millet (Shandaweel-1) and local Sudan grass, were used and designed in complete randomized blocks (RCBD) with three replications.

Results demonstrated that the soil salinity (EC) was decreased after leaching from 17.78 to 13.42 d Sm^{-1} . Soil EC values of Sudan grass and Pearl millet resulted low decreasing with control, potassium silicate and nano praticles of ($CaCO_3$) treatments in the first and the second seasons. Available macro and micronutrients (mg kg^{-1}) were increased in soil and plant tissues by adding the soil amendments and simulating plant growth, whereas potassium silicate and nano particles of $CaCO_3$ treatments gave the lowest values.

Both Sudan grass and pearl millet reported significant differences (P≤ 0.05) among yield and its components for the first, second cuts and total yield in the first and second growing seasons. In the first season Sudan grass increased in total dry yield percentages more than fresh yield of compost treatment. Potassium silicate, sulphur and nano-particles of $CaCO_3$ recorded higher total fresh and dry yield in the second season. For the first season nano particles of $CaCO_3$, potassium silicate and composite of compost, gypsum and sulphur increased the total fresh and dry yield of Pearl millet, also in the second season nano particles of $CaCO_3$ treatment reported the higher total fresh and dry yield. Adding of soil amendments and simulating plant growth treatments increased the efficiency of soil and plant potential to moderate salt stress and increase yield and quality per unit area.

Keywords: Soil salinity, Soil amendments, Compost, Sulphur, Gypsum, Potassium silicates, Nano particles of $CaCO_3$; Sudan grass and pearl millet, Yield, Quality.

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Two major environmental factors that currently reduce plant productivity are drought and salinity (Serrano *et al.*, 1999). Salinity becomes a concern when an "excessive" amount or concentration of soluble salts occurs in the soil, either naturally or as a result of mismanagement such as poor irrigation practices. Salinity in the soil or irrigation water is a major stress and especially in arid and semi arid regions, can severely limit crop production (Shannon, 1998).

In Egypt, improving salt affected soils is considered as an important part in the agricultural security program. Gypsum is commonly used for the reclamation of saline-sodic and sodic soils (Amezketa *et al.,* 2005). Gypsum and organic matter are used as amendment for sodic soil reclamation and for reducing the harmful effects of high sodium irrigation water in agricultural areas because of its solubility, low-cost, availability and ease of handling (Wong *et al.,* 2009). Studies on the effects of gypsum application on saline-sodic soil reclamation have shown that the soil receiving gypsum at higher rates removes the greatest amount from the soil columns and causes substantial decreases in soil electrical conductivity (EC) and sodium adsorption ration (SAR) (Hamza & Anderson, 2003).

Addition of organic matter and gypsum to the surface soil will decrease spontaneous dispersion and EC down to the subsoil, compared to the addition of gypsum alone (Vance *et al.*, 1998). Compost is an organic matter resource resulting from exploiting wastes through controlled bioconversion processes. Several studies have shown the benefits of organic amendments in improving physical, chemical and biological properties of soil depending on the amount and composition (Courtney & Mullen, 2008) of the applied material.

Sulphur is an efficient amendment for improving the physical, chemical and nutritional properties of the soil and for increasing crop yields especially when its application followed by organic manure application. Kandil & Gad (2010) stated that sulphur addition enhances plant growth parameters, reduces pH of soil solution and consequently increases the solubility of the fixed minerals and hence its concentration in the root zone. Potassium silicates encourage seedling germination and establishment, salt tolerance and increase seed yield and quality (Abou Baker *et al.*, 2011). Nano-particles of dolomite have been used recently as an alternative to conventional fertilizers for slow release and efficient use by plants (Bilal, 2010).

Sudan grass *(Sorghum sudanense (Piper) Stapf.)* and Pearl millet (*Pennisetum glaucum (L.*) R. Br.) are important warm-season cereals in the semi-arid tropical regions of Asia and Africa, primarily grown for grain production and used as a major source of dietary energy. They are warm-zone cereals grown as forage for livestock in regions where high temperature and low rainfall during late summer and early autumn results in feed deficits on pastoral farms. Sorghum, Sudan grass and pearl millet are C_4 species with high photosynthetic potential and dry matter production ability. Millets are classified with maize, sorghum, and coix (Job's tears) in the grass sub-family *Panicoideae* (Yang *et al.*, 2012).

Millets are major food sources for millions of people, especially those who live in hot, dry areas of the world. They are grown mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields (Adekunle, 2012). In contrast, millet is the major source of energy and protein for millions of people in Africa. It has been reported that millet has many nutritious and medical functions (Yang *et al.,* 2012). It also has a low consumption of nitrogen (Olanite *et al.,* 2010); is adapted to hot and dry environments (Yan *et al.,* 2012) and high salt tolerance (Saberi, 2013).

Sorghum and pearl millet gave 4.1 t/ha dry matter that was 37% more than maize (Singh & Singh, 1995). Vyas & Rai (1985) compared the green forage yield of maize, sorghum and pearl millet with pearl millet giving 44% and sorghum 54% higher yields than maize. Choi *et al.* (1993) showed that the digestibility of pearl the millet hybrid *Chungaecho* varied from 63.4% (one cut) to 57.6% (four cuts) compared to 57.6% and 47.3%, for the same treatments of a sorghum-sudan grass hybrid (Rai *et al.,* 2004). Pearl millet has high levels of lipids, as well as high quality and well-balanced proteins (Elyas *et al.,* 2002). The general effect of salinity is the reduction in growth of sorghum grass (Ghoulam *et al.,* 2002).

In view of global climate change, rising temperatures, increasing water shortages, salinity and increased demand for animal products (meat and milk), these summer grasses have recently gained added importance for their forage value. Despite their differences, these crops have wide agro-ecological adaptation, drought tolerance, a wide range of germplasm with varying degrees of photoperiod sensitivity associated with forage yield and permit multi-cut forage production and grazing (Rai *et al.,* 2004).

The current study aimed to: a) Evaluate the effect of some soil amendments on stimulating plant growth on soil properties and b) Improve forage productivity and quality by management of salinity of soil and plant resistance to salt.

Material and Methods

The present study was carried out during three summer growing seasons from 2012 till 2014, at the private farm at Gilbana Village of Quntra Sharke. Data of the first summer season (2012) was canceled because the low of survival plants. This area is located in the semi arid region of North Sinai Governorate, Egypt and lies in the north-western Mediterranean coast of Sinai, between 32- 35 $^\circ$ and 32-45 $^\circ$ E and 31- 0.0 $^\circ$ and 31- 25° N, (Kaiser, 2009). Gilbana Village soil is a sandy loam in texture. This area is irrigated with El-Salam canal water (Nile water mixed with agriculture drainage water in the proportion 1:1. Some physical and chemical properties of the investigated soil are presented in Table 1.

Soil tillage
The soil experimental filed was subjected to continuous leaching process by adding water to soil basins until it reaches a height of 15 cm above the soil surface. Such height of water was kept constant for 3 days. Two weeks after the leaching process, lazar technique was used for leveling the soil surface followed

by deep sub-soiling, plowing and establishing field drains at a depth of 90-cm at the beginning of each drain followed by establishment of an irrigation canal in the middle part of the experimental area.

TABLE 1. Some Physical and chemical properties of the experimental soil.

Particles size distribution						
Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Textural class	O.M.%	CaCO$_3$%
7.44	68.44	9.60	14.52	Sandy clay	0.41	7.85
pH (1:2.5)	EC (dS/m)	Cations (m molc^{-1})				Anions (m molc^{-1})		

pH (1:2.5)	EC (dS/m)	Ca^{++}	Mg^{++}	Na$^+$	K$^+$	HCO$^-_3$	Cl$^-$	SO$^{--}_4$
Before leaching								
8.37	17.78	38.18	41.87	131	2.34	1.93	130.4	81.99
After leaching								
8.35	13.42	10.58	26.13	101	2.01	1.00	100	38.72
Available Macronutrients (mg/kg)			Available Micronutrients (mg/kg)					
N	P	K	Fe		Mn	Zn		Cu
60	3.10	168	2.13		1.45	0.72		0.008

The experiment treatments were (a) Control (untreated), (b) Four soil amendments: sulphur (S) (1Mg/ fed), gypsum (G) (2 Mg/ fed), compost (5 Mg/ fed) and composite of (compost, gypsum and sulphur) (C, G and S) and (c) Two stimulating plant growth applications, potassium silicate (k silicate) (2gm/L) and nano particles of Ca CO$_3$ (5gm/L).

Preparation compost, gypsum and sulphur

Gypsum, of 97% purity was sieved to increasing its solubility. Compost was prepared by mixing straw of rice; maze; sesame and faba bean with farm manure. The mature compost was obtained after 3 months of composting and was passed through a sieve of 10-mm in diameter prior to use in this study. The used amounts of compost; gypsum and sulphur (of 99% purity) were incorporated in soil and ploughed and followed by irrigation. The treatments were lift for 10 days for drying. Compost was added 25 days before forage planting at a rate of 5 ton fed^{-1}. All soil treatments were applied one month before sowing to assure their complete decomposition and soil was irrigated after sowing. Irrigation was carried out to saturation state of the soil. The compost chemical properties are shown in Table 2. The compost analyses were done according to the standard methods described by Brunner & Wasmer (1978).

TABLE 2. Chemical properties of the used compost.

Moisture content %	EC dSm^{-1} (1:10)	pH (1:10)	C	C/N	O.M	N	P	K	Fe	Mn	Zn
			(%)						(mgkg^{-1})		
20.25	2.35	7.65	29	1:10	50	2.87	0.73	1.57	215	120	94

Preparation of potassium silicate and nano particles of CaCO₃

Liquid Potassium silicate (K$_2$O 10%, SiO$_2$ 25%) was prepared at a rate of 2 ml/L and Nano particles of CaCO$_3$ at a rate of 5 g/L. These were sprayed on plants 21 days after sowing and repeated every 21 days.

Field experiments

Treatments were designed in a completely randomized block (RCBD) with three replicates. The pearl millet cultivar (Shandaweel-1) and local Sudan grass treatments were arranged in plots of size 12 m^2 (3x4 m). The seeds were hand drilled in rows 4m in length and 25 cm apart at the seeding rate of 15 kg/fed.

Growth characters (plant height, stem diameter, number of tillers, leaf/stem ratio (L/S%), fresh weight (FW) and dry weight (DW)) per each cut and total fresh and total dry weight over the two cuts were measured. Germination % was measured after 15 and 30 days from sowing and then the average mean of the two percentages was conducted. Harvest occurred at approximately 100-120 cm plant height (Miron *et al.*, 2007) of the two harvest times. After weighing, ten plants were randomly sampled from harvested material from each plot/crop to determine the dry matter % and dissected into leaf and stem components to allow calculation of the yield of each component and the leaf / stem ratio (L\S%). All samples were dried in a forced air oven at 70°C for 72 h. Standing % was calculated by counting the number of plants in the second cut as a percentage of the number of plants in the first cut.

Nitrogen fertilizer in the form of ammonium sulphate (20.6% N) was divided into three equal doses. The first dose was applied after germination with the first watering and other doses applied after the first and second cuts.

Recommended rate of phosphorus, 15.5% P$_2$O$_5$ (150 kg/fed) as mono-super phosphate and potassium, 48% K$_2$O (50 kg/fed) as potassium sulphate were applied before sowing. The sowing dates were the 22nd of June in the 2013 season and the 15th of June in the 2014 season. The common agricultural practices of Sudan grass and pearl millet were followed and two cuts were obtained for each season at 65 and 110 days after sowing.

Soil analysis

A surface soil sample (0- 30 cm) was collected, air- dried, sieved to pass through a 2 mm sieve and mixed thoroughly. Calcium carbonate, organic matter, total soluble ions and electrical conductivity (EC) were determined in the saturated soil paste extract while the pH was measured using a pH meter in soil suspension (1: 2.5) as described by Page *et al.* (1982). Available nitrogen was measured according to the modified Kjeldahal method by Black (1965). Available phosphorous, potassium and micronutrients (Mn, Fe, and Zn) were extracted using ammonium bicarbonate (DTPA) as described by Soltanpour (1985) and determined using Inductively Coupued Plasma (ICP) Spectrometry model 400.

Plant analysis

At each of the two harvest times, ten plants were sampled randomly from each plot. The shoots were separated, dried at 70 $^{\circ}$C for three days to determine their dry weight. Dry samples were ground and digested using H_2SO_4 and $HClO_4$ acid mixture according to the method described by Black (1965). Plant contents of N, P, K, Fe, Mn and Zn were determined in the plant digests using the methods described by Rebbeca (2004).

Statistical analysis

Data collected were subjected to analysis of variances using the SAS Statistical Software SAS (2004). Differences between means were compared using both LSD and Duncan's test.

Resuts and Discussion

Effect of studied applications on soil chemical properties

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 (Fig.1). However, a contrast based comparison of treated vs. control pH across all treatments indicated a significant reduction in pH associated with soil amendments. The pH of the soil decreased on average with the amendments application this decrease ranged from 8.4 to 8.08 for Sudan grass and from 8.4 to 7.95 for pearl millet 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 Khan *et al.* (2006); they found that the soil pH was decreased with gypsum application in from 8.54 to 7.54. Mahmoud (2011) 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.
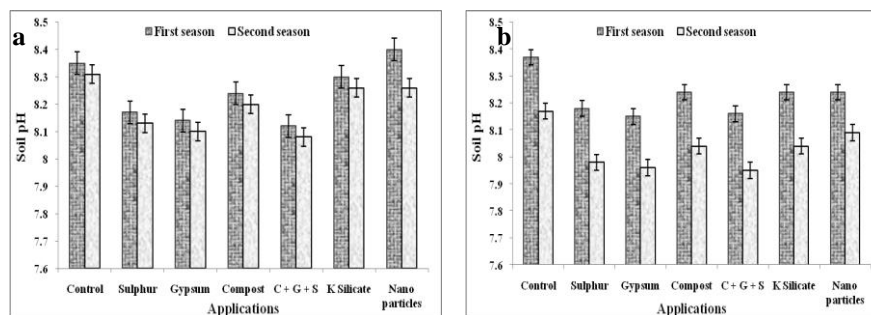
Fig. 1. Soil pH after plant harvested (±SE) for two forage grasses (a) Sudan grass and (b) Pearl millet.

Soil salinity (EC dSm^{-1}) values were decreased from 17.78 dSm^{-1} to 13.42 dSm^{-1} after leaching (Table 1). The effect of different soil amendments application on the soil salinity (EC dSm^{-1}) after harvesting for the two successive growing seasons are presented in Table 3. The soil amendments showed significant reductions on EC for gypsum, compost and composite of (C,G and S) for both seasons. Sudan grass treatments gave EC values ranged from 8.85 dSm^{-1} (Gypsum) to 12.47 dSm^{-1} (control) with an average of 10.16 dSm^{-1} for the 1st season and also ranged from 5.63 dSm^{-1} (composite of (C+G+S)) to 10.68 dSm^{-1} (Control) with an average of 7.91 dSm^{-1} in the 2nd season. Similar decreases of soil EC dSm^{-1} were found for pearl millet across treatments (Table 3-b). In the 1st season EC reduction values ranged from 8.62% (Compost) to 11.97% (Control) with a mean of 9.66% across pearl millet treatments. For the 2nd growing season treatments produced similar reductions in soil Ec dSm^{-1} which ranged from 5.33 dSm^{-1} (Compost) to 10.38 dSm^{-1} with a mean of 7.61 dSm^{-1}.

Figure 2 shows the soil EC ($\pm$ SE) reduction% of treatments related to the soil EC of control (untreated) of Sudan grass and Pearl millet forage grasses. Soil EC reduction, related to control, ranged from 11.22% (K silicate) to 37.83% (gypsum) with an average of 22.08% across the two seasons. Gypsum and sulphur applications gave the highest EC reduction (29.03 and 26.30%) in the first growing season while, composite (C, G and S), gypsum and compost applications gave the highest reduction (47.28, 46.63 and 42.70%, respectively) in the second season. 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.

TABLE 3. Soil EC, macro and micronutrients content in soil after harvesting of two treated seasons.

Treatment	EC (dSm^{-1})		Available macronutrients (mg kg^{-1})						Available micronutrients (mg kg^{-1})							
			N		K		P		Mn		Zn		Fe		Cu	
Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
									a-Sudan grass							
Control	12.47	10.68	80.0	130	320	570	10.89	11.14	2.81	3.06	0.66	0.91	30.75	31.0	0.13	0.38
Sulphur	9.19	7.47	160.0	170	410	660	11.08	13.03	3.27	3.52	1.21	1.46	31.11	31.36	0.14	0.38
Gypsum	8.85	5.70	130.1	230	410	660	12.97	13.22	5.62	5.87	1.34	1.59	32.90	33.15	0.23	0.48
Compost	9.96	6.12	160.1	330	410	660	14.91	15.16	8.79	9.04	2.14	2.39	34.06	34.31	0.34	0.59
C + G + S	9.80	5.63	150.0	310	410	660	13.76	14.01	10.29	10.54	1.68	1.92	36.32	36.41	0.28	0.53
K silicate	10.7	9.80	130.0	270	420	670	12.77	13.02	8.54	8.79	0.98	1.23	31.25	31.57	0.14	0.39
Nano particles	10.12	9.96	110.1	250	410	660	12.78	11.33	4.28	4.53	0.67	0.92	31.32	31.50	0.13	0.38
Mean	10.16	7.91	130	260	420	650	12.74	12.99	6.23	6.48	1.24	1.49	32.53	32.76	0.20	0.45
LSD(0.05)	0.303	0.490	0.041	0.083	0.033	0.033	0.012	0.012	0.989	0.989	0.281	0.028	1.245	0.303	0.490	0.542
									b-Pearl millet							
Control	11.97	10.38	110	230	320	640	11.94	22.99	8.68	17.35	0.21	0.43	24.24	26.24	0.13	0.27
Sulphur	8.35	7.17	160	330	410	830	12.81	25.63	10.13	24.99	0.25	0.50	28.58	30.58	0.18	0.43
Gypsum	9.30	5.82	160	300	410	830	13.37	26.75	11.21	25.15	0.25	0.50	30.92	32.92	0.23	0.47
Compost	8.62	5.33	180	350	560	970	14.73	28.49	18.27	36.53	0.31	0.63	34.86	36.86	0.34	0.67
C+ S+ G	9.46	5.40	170	350	490	970	14.24	29.46	15.32	30.64	0.29	0.59	30.96	32.96	0.24	0.49
K silicate	9.62	9.50	130	270	490	1130	12.24	24.49	12.57	22.43	0.24	0.47	26.74	28.74	0.21	0.37
Nano particles	10.2	9.66	130	250	330	670	12.33	24.65	12.49	20.25	0.23	0.46	25.12	27.12	0.19	0.36
Mean	9.66	7.61	150	300	430	950	13.09	26.06	12.67	25.33	0.26	0.51	28.78	30.78	0.22	0.44
LSD(0.05)	0.303	0.490	0.020	0.039	0.932	0.324	0.040	0.080	0.0865	0.173	0.023	0.046	0.5708	0.303	0.490	0.0631

C+ G+ S = composite of (C, G and S) and k silicate= Potassium silicate
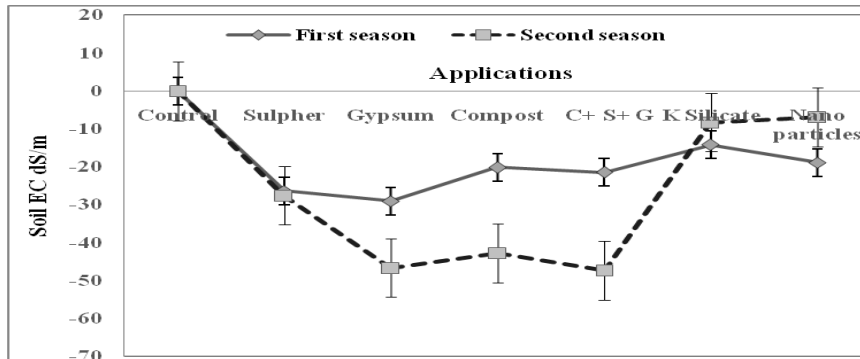
Fig. 2. Soil EC reduction % (±SE) related to control treatment in first and second growing seasons.

Available macronutrients in soil

The presented data in Table 3 show the soil contents of available N, P and K (mg kg^{-1}). Available macronutrients content was increased as a result of salt affected soil treated by the soil amendments. This increasing may be attributed to the effect of different application rate of sulphur, compost, gypsum and composite (C, G and S) caused an increasing in the availability of N, P and K in the soil as well as these contents were increased with adding of soil amendment treatments. Compost, sulphur and gypsum applications recorded significantly increasing of available N, P and K soil content in the first and second seasons, respectively. Whereas, both of Potassium silicate and Nano particles treatments gave the lowest value of available N, P and K in the1st and 2nd seasons. These findings are in agreement with the results obtained by Mahmoud (2011).

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 found less soluble P compounds namely Calcium phosphate. The application of compost increased the solubility of all tested nutrients in the study soil. These results are in agreements with El Rashidi *et al.* (2010), they found that the application of peat improved the solubility of most nutrients in the soil. Sulphur element plays a great role in plant metabolism and supplying it to the soil caused reduction in the soil pH, consequently enhances the solubility and availability of many elements (Lai *et al.,* 2000).

Available micronutrients in soil

It is evident from data present in Table 3 that increase of soil available microelement contents (Mn, Zn, Fe and Cu) were resulted from soil amendment applications. 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 Mn , Zn, Fe and Cu contents as a result of increasing the applied rates of 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 Mn, Zn and Fe. These results are in agreement with Abdel Aal *et al*. (2003) who found that the application of organic materials caused a substantial increase in Mn, Zn, Fe and Cu in soil. Sulphure, Compost, Gypsum, Composite (C+ G +S) caused an increasing in the availability of (Mn, Zn, Fe and Cu) whereas Nano-particles and Potassium silicate improved the plant tolerance to salt stress.

Forage Sudan grass and Pearl millet yield and yield components

Data presented in Table 4 (a,b) show the effect of soil amendments application (sulphur, gypsum, compost, composite (C, G and S), k silicate, and nano-particles) on yield and yield component of Sudan grass and Pearl millet plants.

TABLE 4-a. Means of forage yield and yield components for two cuts of Sudan grass in two growing seasons at Sahl El -Tina salt soils.

Treats	Germination %	1st cut						Stand %	2st cut						Total	
		Plant height	Stem diameter	No. tillers	L/S%	FW t.fed^{-1}	DW t fed^{-1}		Plant height	Stem diameter	No. tillers	L/S%	FW t.fed^{-1}	DW t.fed^{-1}	F W	D W
First season																
Control	38.33	86.33	0.87	1.23	47.17	9.85	2.66	74.67	172.67	1.11	4.27	51.75	13.47	3.63	23.32	6.29
Sulphur	59.00	107.33	1.07	1.75	57.00	10.40	2.81	89.33	243.33	1.13	6.17	64.58	17.00	4.59	27.40	7.43
Gypsum	53.33	104.00	0.83	2.17	58.50	9.32	2.52	81.33	222.00	1.13	5.60	67.42	14.73	3.98	24.05	6.51
Compost	51.00	124.67	1.30	2.13	60.00	11.44	3.09	88.00	242.67	1.10	6.47	68.5	16.38	4.43	27.82	7.52
C+G+ S	47.67	106.67	1.20	1.93	62.17	10.69	2.91	88.33	211.00	1.03	8.37	69.17	16.59	4.48	27.28	7.39
K silicate	56.67	146.67	1.50	2.31	64.50	11.11	2.99	82.67	227.67	1.17	8.40	67.83	17.04	4.60	28.15	7.59
Nano particles	61.67	140.00	1.29	2.03	64.50	10.77	2.97	93.00	216.67	1.11	7.64	70.75	24.44	6.60	35.21	9.57
Mean	52.52	116.52	1.17	1.93	59.12	10.51	2.85	85.33	219.43	1.11	6.71	65.71	17.09	4.62	27.6	7.47
L.S.D. (0.05)	16.42	27.21	0.67	0.43	8.73	3.91	1.09	22.91	51.48	0.21	3.18	14.99	6.90	1.86	4.37	1.76
Second season																
Control	46.67	91.33	0.73	3.39	46.33	11.10	3.33	81.53	186.33	0.97	8.33	58.00	18.07	4.88	29.17	8.21
Sulphur	63.33	109.00	1.20	4.73	59.00	22.97	6.89	89.00	213.67	1.07	17.00	67.67	30.33	8.19	53.3	15.08
Gypsum	55.67	114.67	0.97	4.85	60.00	19.98	5.99	83.33	204.00	0.83	13.30	64.00	24.97	6.74	44.95	12.73
Compost	54.00	158.33	1.31	4.75	67.67	19.81	5.70	91.00	234.67	1.50	15.02	63.33	28.00	7.56	47.81	13.26
C+ G+ S	53.33	123.33	1.23	5.66	59.67	22.32	6.74	87.67	216.67	1.20	13.11	66.33	27.73	7.49	50.05	14.23
K silicate	58.99	132.33	1.22	5.21	69.33	21.27	6.38	87.67	219.00	1.30	16.67	65.33	32.11	8.67	53.38	15.05
Nano particles	65.33	135.00	1.27	4.45	69.35	21.34	6.40	95.67	227.33	1.29	18.56	67.67	30.67	8.28	52.01	14.68
Mean	56. 76	123.43	0.85	4.72	61.62	19.83	5.92	88.02	211.67	1.165	14.75	64.62	27.41	7.40	47.24	13.32
L.S.D. (0.05)	15.67	n.s.	0.395	1.32	n.s.	4.696	1.41	16.42	47.20	n.s.	11.37	2.088	4.797	1.294	7.168	2.043

C+ G+ S = composite of (Compost, Gypsum and Sulphur) and k silicate= Potassium silicate

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TABLE 4b . Means of forage yield and yield components for two cuts of Pearl millet in two growing seasons at Sahl El-Tina salt soils.

Treats	Germination %	1st cut						Stand %	2st cut						Total	
		Plant height	Stem diameter	No. tillers	L/S%	FW t.fed⁻¹	DW t.fed⁻¹		Plant height	Stem diameter	No. tillers	L/S%	FW t.fed⁻¹	DW t.fed⁻¹	FW	DW
First season																
Control	25.33	54.33	0.33	3.54	45.00	6.93	1.58	48.33	82.67	0.43	7.73	46.65	7.33	2.16	14.26	3.74
Sulphur	42.04	100.67	0.53	6.41	58.35	12.67	4.25	66.67	89.00	0.60	9.63	63.35	13.02	4.29	25.69	8.54
Gypsum	53.33	82.00	0.68	5.66	61.65	12.32	4.18	56.67	100.0	0.63	10.95	58.35	14.58	4.65	26.90	8.83
Compost	51.67	99.33	0.40	7.32	45.00	7.95	1.81	73.33	140.0	1.03	13.73	63.35	9.67	3.05	17.62	4.86
C+ G+ S	39.33	84.33	0.73	6.97	60.00	11.00	3.82	68.33	126.67	0.63	13.67	55.00	14.94	4.44	27.32	8.97
K silicate	49.67	120.67	0.73	7.43	63.35	13.02	4.37	80.00	106.67	0.77	12.80	59.05	16.32	5.15	27.96	8.81
Nano particles	53.67	105.33	0. 70	7.11	63.35	13.67	4.86	80.00	166.67	0.87	10.27	68.35	16.17	5.29	29.84	10.15
Mean	45.01	92.38	0.57	6.35	56.67	11.08	3.55	67.62	115.95	0.71	11.25	59.16	13.15	4.15	24.23	7.70
L.S.D. (0.05)	13.88	24.17	0.33	2.12	3.55	6.07	1.46	22.27	52.97	0.094	2.86	2.61	4.15	1.251	7.80	1.95
Second season																
Control	26.67	83.33	0.52	2.37	37.00	8.79	2.59	62.00	91.67	0.60	7.10	43.17	6.63	2.03	15.42	4.62
Sulphur	45.0	124.75	0.91	7.23	58.00	13.81	4.34	75.33	115.00	0.63	10.43	60.67	15.19	4.38	29.00	8.72
Gypsum	66.67	113.67	0.93	6.43	56.00	12.78	3.83	82.67	112.67	0.80	11.77	60.67	21.77	6.07	34.55	9.90
Compost	41.67	124.67	1.13	7.53	56.00	15.13	4.74	80.67	153.33	0.67	10.60	57.67	17.54	4.52	32.67	9.26
C+ G+ S	63.67	94.67	1.03	5.43	47.33	11.95	4.24	77.50	137.33	1.03	10.50	58.31	21.37	5.94	33.32	10.18
K silicate	61.6	111.33	1.22	6.62	65.10	16.26	4.84	84.67	141.33	0.87	12.67	59.67	23.71	6.16	39.97	10.98
Nano particles	71.67	112.67	1.23	6.67	64.00	18.54	5.76	86.00	152.33	0.77	12.36	62.67	23.75	6.18	42.29	11.94
Mean	53.85	109.30	1.00	6.04	54.78	13.89	4.25	78.41	129.09	0.77	10.78	57.55	18.57	5.04	32.46	9.37
L.S.D. (0.05)	15.34	31.24	0.45	1.92	28.26	9.28	3.15	24.85	51.80	0.34	3.00	11.42	9.04	2.47	18.32	5.62

C+ G+ S = composite of (Compost, Gypsum and Sulphur) and k silicate= Potassium silicate

Sudan grass (Piper) growth attributes

There were significant differences (P< 0.05) among yield and its components for the first, second cuts and total yield in the first and second seasons of forage Sudan grass in salt soil stress (Table 4-a).

First season: In the 1st cut, germination recorded 38.33% for control. The soil amendment increased germination from 47.67% for composite (C, G and S) treatment to 61.67% for (Nano–particles) treatment, with an average mean of 52.52% across all studied treatments. Potassium silicate recorded the best performances of plant height (146.67 cm), stem diameter (1.50cm), No. tillers (2.31) and leaf/ stem ratio (64.50%), respectively. Compost treatments had the highest fresh and dry yield (11.44 and 3.09 t fed⁻¹) followed by k silicate (11.11 and 2.99 t fed⁻¹), whereas Control gave lowest fresh and dry yield over all treatments (9.85 and 2.66 t fed⁻¹, respectively).

Control treatment with recorded the lowest sand of established plants (74.67%) while the highest percentage (93%) recorded with nano –particles in the 2nd cut. Sulphur and compost treatments had the tallest plants (243.33 and 242.67cm) over all treatments, also k silicate performed the highest values of stem diameter and No. tillers plant^{-1}(1.17 cm and 8.40, respectively). Nano – particles, k silicate and sulphur demonstrated the higher fresh (24.44, 17.04 and 17.00 t fed^{-1}) and dry yield (6.60, 4.60 and 4.59 t fed^{-1}) comparing with the other soil amendment. Nano –particles, k silicate and composite (C, G and S) performed the highest total yield for fresh (29.84, 27.96 and 27.32 t fed^{-1}) and dry yield (10.15, 8.81 and 8.97 t fed^{-1}). The increase in yield was mainly due to greater plant height plant^{-1}, stem diameter plant^{-1}, number of tillers plant^{-1} and leaf /stem ratio. These results confirm the findings of Bukhari (2009).

Second season: As shown in Table 4-a there were significant effects (P< 0.05) of soil amendment treatments of yield and yield components among 1st, 2nd cuts and total fresh and dry yield.

Data of the first cut showed that germination increased in all treated plants and control when compared with first season percentages. Nano–particles gave the highest germination (65.33%). The tallest plants was noticed for compost (158.33 cm) while, control gave the shortest plants (91.33 cm). Compost and nano-particles treatments gave the highest stem diameter values (1.31 and 1.27, respectively) while, gypsum and control had the lowest values (0.97 and 0.73 cm, respectively). Number of tillers ranged from (3.39) of control to (5.66) of composite (C, G and S) with mean average of (4.72). Nano- particles and k silicate recorded the highest percentage of leaf/stem ratio across all treatments (69.35 and 69.33%). Compost application had significantly increased biomass yields of forage grasses compared to unfertilized control plots (Warman & Termeer, 2005).

Sulphur, nano-particles, composite (C,G and S) and k silicate treatments performed the highest fresh yield (22.97, 21.34, 22.32 and 21.27 t fed^{-1}) and dry yield (6.89, 6.40, 6.74 and 6.38 t fed^{-1}), respectively. Standing after the first cut indicated higher establishment of plants under salt soil with an average of (88.02%) across all treatments.

Second cut shows the tallest plants and largest stem diameter (234.67 and 1.50 cm) of compost across all treatments. Nano-particles and sulphur treatments recorded the largest number of tillers plant^{-1} (18.56 and 17.00) and highest leaf stem ratio (67. 67%). Higher fresh and dry yield for all treatments, was occurred in the second season comparing with first season. Hanafey & Abd El-Rahman (2014) reported that a nano particle was significantly increased shoot biomass of wheat. These results were agreed with Kandil & Gad (2010).

K silicate, nano-particles and sulphur showed the highest fresh yield (32.11, 30.67 and 30.33 t fed^{-1}) and dry yield (8.67, 8.28 and 8.19 t fed^{-1}). K silicate, sulphur and nano-particles also gave the highest total fresh (53.38, 53.30 and 52.01 t fed^{-1}) and dry yield (15.05, 15.08 and 14.68 t fed^{-1}), respectively. Cakmak

(2005) suggest that the improvement of K-nutritional status of plants might be of great importance for the survival of crop plants under environmental stress conditions, such as drought, chilling, and high light intensity. The superior yield for potassium silicate; may be due to the role of potassium in water regulation, intake and increase water use efficiency (Abou- Baker *et al.,* 2011), in addition to the role of potassium in mitigating the toxic effect of Na (Abou-Baker *et al.,* 2012). Nano practices $CaCO_3$ fertilizer used for improving wheat productivity under salt-affected soil conditions via enhancement growth traits; increasing leaf pigments and membrane stability index (Hanafey & Abd El- Rahman, 2014).

Pearl millet growth attributes
The effects of some soil amendments were significant differences (P< 0.05) on yield and yield components of forage Pearl millet in the two successive seasons (Table 4-b).

First season: Germination among treatments recorded that nano- particles and gypsum were the highest percentages in the 1st season (53.67% and 53.33%) and 2nd season (71.67% and 66.67%), respectively (Table 4-b). Control treatment had the lowest values overall treatments across cuts and seasons. In the first cut k silicate treatment reported the highest plant height (120.67cm), stem diameter (0.73cm), number of tillers (7.43) and L/S% (63.35%), respectively. Whereas, compost treatment gave the highest plant height (140.0 cm), stem diameter (1.03cm) and number of tillers (13.73) in the second cut. The highest fresh and dry yielding recorded for nano particles and k silicate treatments in the 1st cut (13.67, 4.86 t fed^{-1} and 13.02, 4.37 t fed^{-1}, respectively) and in the 2nd cut (16.17, 5.29 t fed^{-1} and 16.32 and 5.15 t fed^{-1}, respectively). In the second cut nano particles, k silicate and compost treatments recorded the highest stand of establishment in salt soils (80.0, 80.0 and 73.33%). Compost, composite (C, G and S) and k silicate treatments performed the highest number of tillers (13.73, 13.67 and 12.80, respectively). The highest total fresh and dry yield recorded for Nano particles (29.84 and 10.15 t fed^{-1}), k silicate (27.96 and 8.81 t fed^{-1}) and composite (C, G and S) (27.32 and 8.97 t. fed^{-1}) treatments over the two cuts in the first season (Table 4-b). Sulphur fertilization can be increased yield and the quality of forages in the areas of sulphur deficient soils (Hallmark & Brown, 1994).

Second season : In the 2nd season there were significant effects (P< 0.05) of soil amendment treatments over the two cuts on yield and yield components (Table 4-b).

Germination ranged from 26.67% for control to 71.67% for nano particles treatment. In the 1st cut sulphur and compost treatments had the tallest plants (124.75 and 124.76 cm), while in the 2nd cut nano particles and compost treatments (153.33 and 152.33) showed the tallest plants. Compost and sulphur treatments recorded the highest number of tillers (7.53 and 7.23) in the 1st cut, whereas both of k silicate and nano-particles treatments gave the highest number of tillers (12.67 and 12.36) in the 2nd cut. Stand of establishing plants averaged

from 62.00% for control to 88.0% for nano particles with average mean 78.41% over all treatments.

In the 1st cut leaf stem ratio ranged from 37.00% of control to 69.33% for both K silicate and nano particles treatments. Whereas, nano particles, sulphur and gypsum had the highest leaf stem ratio (62.67, 60.67 and 60.67%) in the 2nd cut. Nano particles treatment performed the highest fresh and dry yield in the 1st cut (18.54, 5.76 t fed^{-1}), 2nd cut (23.75, 6.18 t fed^{-1}) and total yield across cuts (42.29 and 11.94 t fed^{-1}), respectively.

Macro and micro-nutrients concentrations in forage

Data in Table 5 (a,b) show that in forage of 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 pearl millet and sudan grass plants (%) in the two seasons were decreased with increasing soil salinity, The data of N, P and K content in Pearl millet and Sudan grass plants show relative increase with decrease of soil salinity as a result of adding different amendments. In 1st season N contents in Sudan grass plant tissues ranged from 0.87 to 1.72 % in the 1st cut and from 1.38 to 2.23% in the 2nd cut. While in the 2nd season N contents in plant tissues ranged from 1.07 to 1.86 % in the 1st cut and from 1.39 to 2.150%, in the 2nd cut. P contents ranged from 0.76 to 0.93% in the 1st season and from 0.79 to 0.84 % in the 2nd season. K contents ranged from 2.13 to 2.43 % in the 1st season and from 2.24 to 3.45 % in the 2nd season, respectively. The relative increases of the contents of N, P and K in the plant tissues of Sudan grass 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 two cuts and seasons. In the 1st season P performed higher contents of compost (0.94%) and composite (C, G and S) (0.84%) of the 1st cut and for compost (90.99%) and nano-particles (0.98%) of the 2nd cut, respectively. In the 2nd season compost and K silicate treatments (0.93 and 0.84%) of the 1st cut, while K silicate and nano-particles treatments (0.98 and 0.96%) of the 2nd cut recorded the highest P contents. K content recorded an average of (2.13 and 2.43) for the 1st and 2nd cuts in the 1st season and (2.24) over cuts in the 2nd season. 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 Sudan grass and Pearl millet plants were presented in Table 5 (a,b). 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 Sudan grass and Pearl millet plants. The corresponding mean values of Mn (23.22, 38.56 mgKg^{-1}), Zn (6.76, 7.92 mgKg^{-1}), Fe (319.13, 526.8 mgKg^{-1}) and Cu (3.84, 5.91 mgKg^{-1}) per each cut in the 1st season also, Mn (34.88, 32.75 mgKg^{-1}), Zn (7.17, 7.40 mgKg^{-1}),

Fe (and 526.8, 370.27 mgKg^{-1}) Cu and (5.42, 4.25 mgKg^{-1}) in the 2nd season, respectively. While, the corresponding mean values of Mn, Zn, Fe and Cu accumulation in Pearl millet plants per each cut were (39.53, 48.18 mgKg^{-1}) of Mn, (6.61, 7.60 mgKg^{-1}) of Zn, (421.29, 450.92 mgKg^{-1}) of Fe and (4.49, 4.35 mgKg^{-1}) of Cu contents in the 1st season. In The 2nd season the micronutrients were accumulated (28.30, 32.61 mgKg^{-1}) of Mn, (7.20, 8.35 mgKg^{-1}) of Zn, (624.80, 657.10 mgKg^{-1}) of Fe and (6.74, 6.53 mgKg^{-1}) of Cu per each cut, respectively. This finding is in agreement with results obtained by Carter & Cutcliffe (1990). They found that gypsum had little effect on soil porosity and structure indices, but it has a role in changing soil pH and significantly influenced soil microbial biomass. El-Rashidi *et al.* (2010) found that the application of peat improved the solubility of most nutrients and proved to be useful as an amendment for gypsum-rich soils and increases its productivity. These results are in agreement with the results obtained by Kandil, & Gad (2010).

TABLE 5a. Sudan grass content of macro- and micronutrients as affected by the studied treatments.

Treatments	Macronutrients (%)						Micronutrients (mgkg^{-1})							
	N		P		K		Mn		Zn		Fe		Cu	
First cut														
Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	0.870	1.070	0.58	0.64	0.31	0.43	2.45	33.00	2.75	3.40	174.25	217.80	2.10	2.70
Sulphur	1.460	1.650	0.73	0.76	1.86	1.95	11.10	23.50	8.05	5.75	245.60	357.40	2.80	3.45
Gypsum	1.630	1.625	0.74	0.77	2.57	2.61	30.45	28.95	5.30	8.40	222.90	442.80	2.35	3.75
Compost	1.720	1.865	0.94	0.93	2.92	2.97	30.70	24.65	7.20	7.77	253.85	581.40	3.15	4.75
C+ G + S	1.710	1.825	0.84	0.78	2.27	2.36	30.90	53.90	8.40	8.77	405.00	667.00	4.30	6.65
K silicate	1.460	1.645	0.77	0.84	3.03	3.33	27.40	43.15	8.30	8.43	451.70	672.80	4.90	7.20
Nano particles	1.440	1.520	0.73	0.79	1.92	2.05	29.55	37.00	7.30	7.69	480.60	748.25	7.30	9.45
Mean	1.583	1.600	0.76	0.79	2.13	2.24	23.22	34.88	6.76	7.17	319.13	526.8	3.84	5.421
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Second cut														
Control	1.380	1.390	0.81	0.66	0.53	0.42	34.45	3.25	4.25	3.3	255.15	300.4	2.80	2.7
Sulphur	1.670	1.890	0.91	0.77	1.98	1.96	30.90	16.6	6.60	8.95	363.60	246.65	3.75	2.7
Gypsum	1.740	1.850	0.97	0.81	2.75	2.63	33.00	31.55	9.25	5.55	464.20	288.65	4.03	2.8
Compost	2.230	2.150	0.99	0.84	3.30	3.02	27.15	36.1	8.50	8.3	582.25	356.8	4.95	3.8
C+ G + S	1.965	1.970	0.93	0.85	2.47	2.32	55.35	37.25	9.30	9.35	652.05	443.15	7.20	4.7
K Silicate	1.875	1.770	0.94	0.98	3.82	3.45	47.85	36.2	8.80	8.6	699.05	459.15	8.85	5.5
Nano particles	1.650	1.740	0.98	0.96	2.15	1.92	41.20	32.75	8.73	7.75	876.35	497.1	9.80	7.55
Mean	1.930	1.823	0.93	0.84	2.43	2.24	38.56	0.79	7.92	7.4	556.09	370.27	5.91	4.25
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**

**: indicate significance at 0.01 level of probability.

C+ G+ S = composite of (Compost, Gypsum and Sulphur) and K silicate= Potassium silicate

TABLE 5b. Pearl millet content of macro- and micronutrients as affected by the studied treatments.

Treatments	Macronutrients (%)						Micronutrients (mgkg⁻¹)							
	N		P		K		Mn		Zn		Fe		Cu	
Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
First cut														
Control	0.793	0.97	0.61	0.61	1.82	1.85	2.23	3.53	3.31	5.50	170.95	256.42	3.20	4.80
Sulphur	1.24	1.38	0.82	0.94	2.63	2.85	24.15	31.95	6.7	6.70	249.65	374.48	3.70	5.55
Gypsum	1.245	1.36	0.99	0.82	2.06	3.44	45.50	25.95	5.95	8.40	318.95	478.42	3.50	5.25
Compost	1.546	1.87	0.94	0.61	2.94	3.87	42.70	33.85	7.95	8.45	390.6	585.90	4.05	6.07
C+ G+ S	1.551	1.84	0.81	0.76	3.61	3.55	62.15	36.65	7.00	7.45	469.55	704.33	4.65	6.97
K silicate	1.31	1.56	0.94	0.54	3.42	4.68	33.55	39.55	6.80	5.20	652.25	978.38	5.50	8.25
Nano particles	1.27	1.55	0.69	0.80	3.93	3.13	66.45	26.60	8.60	8.70	697.1	995.65	6.85	10.27
Mean	1.279	1.504	0.83	0.73	2.92	3.34	39.53	28.30	6.61	7.20	421.29	624.80	4.49	6.74
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Second cut														
Control	1.06	1.39	0.66	0.62	1.86	1.88	2.63	5.05	3.87	6.40	183.75	275.63	3.40	5.10
Sulphur	1.43	1.58	0.97	0.99	2.54	2.53	34.35	34.10	7.50	7.85	265.60	398.40	3.65	5.47
Gypsum	1.465	1.70	0.61	0.86	2.43	3.75	55.00	31.05	6.85	9.50	336.35	504.52	3.40	5.10
Compost	1.59	2.05	0.96	0.71	3.18	3.86	55.45	42.25	8.75	9.10	444.10	666.15	4.25	6.38
C+ G+ S	1.58	1.97	0.88	0.87	3.00	3.67	72.35	36.70	8.55	9.60	525.60	788.40	4.80	7.20
K silicate	1.64	1.84	0.97	0.61	2.79	4.91	45.75	43.10	8.65	6.75	654.00	981.00	5.15	7.72
Nano particles	1.534	1.72	0.63	0.89	3.66	3.72	71.75	36.05	9.05	9.25	747.05	985.58	5.80	8.70
Mean	1.471	1.750	0.81	0.79	2.78	3.47	48.18	32.61	7.60	8.35	450.92	657.10	4.35	6.53
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**

**: indicate significance at 0.01 level of probability.

C+ G+ S = composite of (Compost, Gypsum and Sulphur) and K silicate= Potassium silicate.

From the obtained results, it could be concluded that the application of tested soil amendments (compost, sulphur and gypsum, composite (C, G and S) and simulating plant growth applications (nano-particles and K silicate) under saline soil condition. Using of soil amendments under salt affected soils led to increase the soil content of available macro- and micronutrients contents, increase soil fertility and positively reflected on forage yield and yield components. Thus it could be recommended that using of the compost at a rate 5 Mg fed⁻¹ gave an economic crop and get on the fertility of the soil suitable for the production of a good forage yield.

Conclusion

Saline sandy clay soils which are poor in physical and chemical properties as well as low in fertility can be used for pasture in the North Sinai, if managed correctly. Soils of Sahl El-Tina in North Sinai require to high-quality management to produce high yielding under its specialized conditions. Adding of soil amendments and simulating plant growth to alleviate the negative effects of salinity conditions and improve plant adaptation to salt soils and increase plant

efficiency to improve yield and quality of Sudan grass and Pearl millet forage crops. Also, reduce the high cost of buying consumed fodder and maintaining the long term productivity of soils for sustainable agriculture.

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إدارة الأراضي المتأثرة بالأملاح وتأثيرها على محصول وجودة الأعلاف في شمال سيناء

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أجريت تجربتين حقليتين في قرية جلبانة بمنطقة سهل الطينة التابعة لمحافظة شمال سيناء خلال موسمين زراعيين متتاليين (٢٠١٣ و ٢٠١٤)، و ذلك لتقييم تأثير إضافة بعض محسنات التربة و رش منظمات النمو الورقية على خواص التربة وإنتاجية العلف وجودته من خلال إدارة التربة لتقليل تأثير الملوحة و زيادة قدرة النباتات على تحمل الملوحة. تم إستخدام محصولي علف صيفيين هما الدخن (شندويل-١) و حشيشة السودان المحلية، وقد نفذت التجارب بتصميم القطاعات التامة العشوائية في ثلاث مكررات .

وأظهرت النتائج أنخفاض ملوحة التربة (EC) بعد الغسيل من ١٧,٧٨ إلى١٣,٤٢ dSm^{-1}. و كان الإنخفاض في نسب EC في التربة لكلا من حشيشة السودان والدخن أقل ما يمكن لمعاملة الكنترول مقارنة بمحسنات التربة و كذلك الرش بجزيئات النانو و سليكات البوتاسيوم في موسمي الزراعة الأول و الثاني. وزادت نسب العناصر الكبرى والصغرى المتاحة (ملج كجم$^{-1}$) في التربة وأنسجة النبات بإضافة محسنات التربة بينما كانت نسبها أقل عند الرش بمنظمات النمو سواء سيليكات البوتاسيوم أوجزيئات النانو .

أظهرت كلا من حشيشة السودان والدخن فروقا معنوية (P≤ 0.05) بين المحصول ومكوناته في الحشة الأولى و الحشة الثانية و المحصول الكلي في الموسم الزراعي الأول و كذلك في الموسم الثانى .

فى موسم النمو الأول كانت الزيادة في نسب المحصول الجاف لعلف حشيشة السودان أكثر من محصول العلف الأخضر مع إضافة الكمبوست. حققت معاملات الرش بسيليكات البوتاسيوم و إضافة الكبريت للتربة و الرش بجزيئات النانو (كربونات الكالسيوم) أعلى إنتاجية لمحصول العلف الأخضر و الجاف في الموسم الزراعي الثانى .

حقق علف الدخن زيادة في محصول العلف الكلي الأخضر و الجاف مع رش جزيئات النانو (كربونات الكالسيوم) و سليكات البوتاسيوم و كذلك بإضافة مركب (كمبوست و الجبس و الكبريت) للتربة في موسم النمو الأول و كذلك أظهرت النتائج أن الرش بجزيئات النانو (كربونات الكالسيوم) أعطى أعلى إنتاجية للمحصول العلفي الأخضر و الجاف في موسم النمو الثانى .

أدت إضافة محسنات التربة و رش منظمات نمو النبات إلى زيادة كفاءة التربة و كذلك زيادة قدرة النباتات على تحمل الإجهاد الملحي وزيادة إنتاجية المحصول العلفي وجودته في وحدة المساحة تحت ظروف الأراضي المتأثرة بالاملاح .