Impact of Many Amendments and Their Mixtures on Soil Properties and Squash Production in Saline-sodic Soil

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ABSTRACT: A field experiment using squash crop (*Cucurbita pepo* L.) variety askandrani was carried out at the Experimental Farm, Faculty of Agriculture (Saba-Basha), Alexandria University, Egypt during 2014 growing season. The farm is located at Abees region 31˚ 10.102′ N and 29˚ 58.085′ E with altitude of (-5m) below sea level. The present research studied the effect of soil amendments such as animal manure, bagasse, sulphur and gypsum with different combinations on the physical and chemical properties of saline-sodic soil and also its effects on squash growth and fruit yield characteristics besides the nutrients content of leaves and fruits. Seventeen treatments of soil amendments were applied to soil and mixed thoroughly with the upper 30 cm layer. The squash was sowing at 13th October. Seeds were sown at 4-5 seeds in each hill with spacing of 0.25 m within each row and 0.6 spacing, and then thinned to one plant after 2 weeks from sowing. After emergence, the plots were irrigated by the furrow irrigation method. Harvesting was at 6, 11 and 27 December. Vegetative growth, yield and yield components and nutrients content of leaves and fruits were measured. Also, physical and chemical characteristics were determined. The obtained results revealed that all vegetative characters (leaf fresh and dry weights, leaf water content, gross plant weight and chlorophyll contents) were not affected by amendments treatments. The highest values were attained with animal manure (24 ton/ha) plus gypsum (4 ton/ha). The maximum squash fruit yield characters (fruit diameter, fruit length, fruit weight and fruit yield) were attained with animal manure plus gypsum treatment. The value of squash fruit yield was significantly increased with soil amendments treatments and the maximum value was attained with animal manure plus gypsum treatment (6954.0 kg/ha, it is accounted as 271.30% over the control treatment. All macro- and micro-nutrients content of leaves and fruits are significantly affected by application of soil amendments, especially animal manure plus gypsum treatment. The soil physical properties such as bulk density, mean weight diameter, geometric mean diameter, structure coefficient and geometric standard deviation are significantly improved by applications of soil amendments. The soil stability index (SI), Kelly's ratio (KR) and permeability index (PI) indicates an excess level of sodium and the soil qualified to alkali hazards. Thus soil has problem about the water permeability. All soil chemical properties including the nutrients availability were improved as a result of application of different soil amendments, especially animal manure plus gypsum. Also, soil available macro- and micro-nutrients were improved with application of soil amendments. It is clear that animal manure plus gypsum treatment is the best treatment for improvement of the sodic soil.

Keywords: salt-affected soil, sodic soil, organic amendments, natural amendments, gypsum, physical properties, squash plants

INTRODUCTION

Accumulation of excessive salts in irrigated soils can reduce crop yields, reduce the effectiveness of irrigation, destruction of soil structure, and affect other soil properties. Salt stress is one of the most serious limiting factors for crop growth and production in arid and semi-arid regions. In Egypt, many areas in Nile delta are mainly saline or saline-sodic soils with heavy texture. Meanwhile, the addition of organic matter in conjunction with gypsum has been found to reduce the adverse effect of soil properties associated with sodic soils (Wong *et al.*, 2009). Abou El-

Defan *et al.* (2005) studied the effect of farmyard manure, gypsum and their mixture on some soil characteristics irrigated with drainage water. They found that both EC and ESP values significantly decreased, especially with application of farmyard manure mixed with gypsum. El-Banna *et al.* (2004) found that treating the soil with gypsum+ FYM as well as with potassium fertilization insure a better environmental condition for wheat plants to grow healthy.

Levy and Mamedov (2002) showed that increasing organic matter contents in organic matter deficient sodic soils improved structural stability and improved permeability. Similarly, other waste products originating from treated wastewater in the form of solids or semi-solids have been identified as the potential ameliorants of sodic soils (Graber *et al*., 2006).

Gypsum is the most common chemical amendments applied for removal the salinity and sodicity from soils. It is low cost, available and easily handling (Wong *et al*., 2009; Abdel-Fattah, 2012). Several studies suggested that the application of gypsum to saline sodic and sodic soil can ameliorate the physical and chemical soil properties such as bulk density, hydraulic conductivity, water infiltration, soil pH, electrical conductivity, exchangeable sodium percentage and sodium adsorption ratio (Gharaibeh *et al*., 2009; Khan *et al*., 2010; Negim, 2016).

In recent time, various organic amendments such as farmyard manures and composts have been effectively used to improve salt affected soils (Feizi *et al*., 2010). Solid waste such as Press-mud (filter cake or filter mud) produced by the sugar mills industry as enrichment source of organic matter and other nutrients such as N, P, K, Ca, Mg, Fe, Zn, Cu and Mn and can be applied to soils for improving the physical, chemical and biological properties (Muhammad and Khattak, 2011; Negim, 2016; Jamil, 2008; Muhammad and Khattak, 2009). It also contains sulfur, which helps to acidify the soil. This acidification makes soluble calcium available and thus improves soil structure and increases the leaching of salts. In addition, press-mud is capable of improvement of soil texture, structure, organic matter contents, the water holding capacity and aeration of soil (Haq *et al*., 2001; Ghulam *et al*., 2010).

The unfortunate increase in land degradation due to salinity and sodicity requires special management practices. It appears that soil amendments applications to saline–sodic soils are necessary for improving soil physical and chemical properties. The aim of the present work was to explain the effect of soil amendments such as animal manure, bagasse, sulphur and gypsum on soil properties and squash production in saline-sodic soil.

MATERIALS AND METHODS

Experimental site and conditions

This study was conducted during the 2014 winter season at the Experimental Farm, Faculty of Agriculture (Saba-Basha), Alexandria University, Egypt. The farm is located at Abees region (31˚ 10.102′ N and 29˚ 58.085′ E with altitude of -5 m under sea level). This area is characterized by a semi-arid climate; the weather is hot and dry from May to August where temperatures ranged from 25-30 °C. On the other hand, the rainfall occurs in winter with an average of 186.2 mm per year. The average wind speed was 10.61 m/s and the average relative humidity was 69.5 % (Saeed *et al*., 2015).

Soil of the experimental site

Soil samples were collected from the experimental area from (0-10 cm), (10-20 cm) and (20-40 cm). Some physical and chemical properties of the field experiment soil are presented in Table (1). The soil properties were performed according to the methods outlined in Carter and Gregorich (2008). The soil of the experimental site is clayey texture with water table level of 1 m down the soil surface and the groundwater is moderately saline (2.5 dS/m), Saeed *et al*.(2015). Table (2) shows the chemical analysis of irrigation water used in the present study according to Ayers and Westcot (185), there is no restriction on the use of this water for irrigation.

Table (1).Some physical and chemical properties of the experimental site soil

Soil parameters	Unit	Soil depth (cm)		
		0-10	10-20	20-40
Particle size distribution				
Sand	%	29.7	29.7	32.2
Silt	%	15.0	17.5	15.0
Clay	%	55.3	52.8	52.8
Textural class	-	Clay	Clay	Clay
Soil bulk density	Mg/m^3	1.24	1.25	1.25
Soil moisture content at field capacity (θ_{fc})	m^3m^{-3}	0.351	0.362	0.369
Soil moisture content at permanent wilting point (θ_{wp})	m^3m^{-3}	0.092	0.093	0.094
Available water content	m^3m^{-3}	0.259	0.268	0.275
Organic matter content (%)	%	2.87	2.87	2.15
Total calcium carbonate	%	18.12	18.12	15.78
Electrical Conductivity (EC), (1:1, soil: water extract)	dS/m	6.98	6.29	5.94
pH (1:1, soil : water suspension)	-	8.05	8.15	8.25
Soluble Cations:				
Ca^{2+}	meq/l	2.38	1.69	1.42
Mg^{2+}	meq/l	7.85	6.05	4.50
Na^{+}	meq/l	58.15	54.13	52.13
K^{+}	meq/l	1.35	1.12	1.12
Soluble Anions:				
$CO^{=}_{3+}$ HCO^{-3}	meq/l	10.20	9.92	2.12
Cl^{-}	meq/l	44.00	44.39	41.00
$SO^{=}_{4}$	meq/l	14.03	7.70	12.54
SAR	-	25.71	27.51	30.30

Table (2). Chemical analysis of irrigation water used in the field experiment

Parameters	Value	Unit
pH	7.35	-
EC_{iw}	0.60	dSm^{-1}
Soluble Cations		
Ca^{+2}	1.89	$meql^{-1}$
Mg^{+2}	0.81	$meql^{-1}$
K^{+}	2.74	$meql^{-1}$
Na^{+}	0.46	$meql^{-1}$
Soluble Anions		
$CO^{=}_3 + HCO^{-}_3$	1.98	$meql^{-1}$
Cl^{-}	0.81	$meql^{-1}$
SO_4^{-2}	3.14	$meql^{-1}$
SSP	46.44	%
SAR	2.36	-
PS	2.38	$meql^{-1}$
RSC	-0.72	$meql^{-1}$

Squash cultivation

Squash (*Cucurbita pepo* L.) variety askandrani was selected for this study at 2014 winter season. Plant sowing date was at 13 October, 2014. Seeds were sown at 4-5 seeds in each hill with spacing of 0.25 m within each row. Thinning to one plant per hill was carried out after 15 days from sowing to obtain a final plant population of 26700 plants/ha. The experimental plot was 3.5 m length and 0.6 m spacing, each plot contains 3 rows. After emergence, the plots were irrigated by furrow irrigation method. Irrigation was terminated at 1 December 2014, and harvesting data was at 6, 11 and 27 December 2014. All agricultural field practices were done as usually recommended for squash cultivation (Ministry of Agriculture and Land Reclamation). Phosphorus fertilizer as calcium superphosphate (15.5% P_2O_5) was fully added to the soil during soil preparation at rate of 370 kg ha^{-1}. Ammonium Nitrate (33.5% N) at the rate of 168 kg ha^{-1} were applied at two equal doses, one after sowing and the second after 15 days later. Potassium Sulfate (48% K_2O) was added at the rate of 67 kg K_2O ha^{-1} in two equal doses, one after sowing and the second after 15 days later.

Amendments applications

Seventeen treatments of soil amendments were applied as shown in Table (3).The amendments were applied to the soil and mixed thoroughly with the upper 30 cm soil. The used organic amendments were subjected to some chemical analyses as shown in Table (4).

Table (3). Amendments and treatments used in the present study

Treatments	Rate of application
Control	Without any application
Animal manure	24 ton/ha
Bagasse	24 ton/ha
Wheat straw	24 ton/ha
Sulphur	720 kg/ha
Gypsum	4 ton/ha
Animal manure + Sulphur	24 ton/ha +720 kg/ha
Animal manure + Gypsum	24 ton/ha +4 ton/ha
Animal manure + Wheat straw	24 ton/ha + 24 ton/ha
Sulphur + Gypsum	720 kg/ha + 4 ton/ha
Wheat straw +Sulphur	24 ton/ha + 720 kg/ha
Wheat straw + Gypsum	24 ton/ha + 720 kg/ha
Bagasse + Sulphur	24 ton/ha + 720 kg/ha
Bagasse + Gypsum	24 ton/ha + 4 ton/ha
Organic acid +Sulphur	10 kg/ha + 720 kg/ha
Organic acid +Gypsum	10 kg/ha + 4 ton/ha
Bagasse +Sulphur + Gypsum	24 ton/ha + 720 kg/ha + 4 ton/kg

Table (4). Some chemical analyses of the tested organic amendments

Parameters	Animal manure	Bagasse	Wheat straw
pH (1:10)	8.9	7.9	7.5
EC (1:10), dS/m	12.6	4.5	9.6
OM (%)	47.41	46.45	44.28
Soluble Ions (mg/kg)			
N	130.0	90	70.0
P	40.0	20.0	24.0
K	305.0	210.0	80.0
Ca	35.0	41.5	37.4
Mg	31.4	25.7	20.5
Fe	32.4	28.0	7.9
Mn	27.6	20.9	15.4
Cu	17.1	5.8	2.3
Zn	2.2	6.5	5.4
Total elements (%)			
N	1.27	0.57	0.92
P	0.69	0.55	0.51
K	2.50	1.60	2.05

Studied characters

Vegetative growth characters

Three plants from the center row of each plot were taken at 55 days after sowing (DAS) at harvesting date. The following data were recorded:
Leaf fresh and dry weights per plant (g)
Leaf water content (%)
Gross plant weight (g)
Chlorophyll a, b and total contents (mg/g fresh weight) as determined by the method of Metzner *et.al.*(1965).

Yield and yield components: The following data were recorded:
Fruit length and diameter (cm), No. of fruits per plot, average fruit weight (g), fruit weight per plot (g) and gross fruit weight (ton/ha)

Nutrients content: The following data were recorded: Leaves and fruit nutrients content.

Soil physical characters: Soil samples were taken from each treatment after harvesting and the following data were recorded:
Soil bulk density (Mg/m^3) using soil core method (Carter and Gregorich (2008);
Mean weight diameter (mm) according to Van Bavel (1949) method;
Geometric mean diameter (mm) using the method of (Shirazi and Boersma, 1984);
Structure coefficient, structural stability index (SI) as described by Pieri (1992);
Permeability index (PI) as described by Doneen (1964); and
Kelley's ratio (KR) as described by (Kelley, 1951 and 1963).

Soil chemical characters: Soil pH, Electrical Conductivity (dS/m), soluble cations (meq/l), soluble anions (meq/l), total calcium carbonates (%), and organic matter (%) were determined according the methods outlined in Carter and Gregorich (2008).

Soil available nutrients: Soil available macro-nutrients (N, P and K) and soil available micro-nutrients (Fe, Mn, Cu and Zn) as follows:

Available nitrogen content (mg/kg): The soil sample was extracted by 2M KCl (1:20), available N was determined in soil extract by Nessler's method (Bermner and Mulvaney, 1982).

Available phosphorus content (mg/kg): Available phosphorus was extracted with 0.5 M $NaHCO_3$ solution adjusted to pH 8.5 according to Olsen *et al.* (1954). Available phosphorus was determined by ascorbic acid molybdenum blue method. Reading was recorded on spectrometer using 880 nm wave length (Jackson, 1973).

Available potassium content (mg/kg): The extraction was done by ammonium acetate (1N of pH 7.0) and potassium was determined by flame photometry according to (Jackson, 1973)

DTPA-extractable micronutrients: Ten grams of air dried soil sample was shaken with 20 ml of extracting solution (0.005 M DTPA + 0.01 M calcium chloride + 0.1 M TEA, pH 7.3) for two hours. The soil suspension was filtered using Watman No. 42 filter paper and the contents of Fe, Mn, Cu and Zn were measured by atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

Plant chemical analysis: Leaves and fruit samples were taken at harvesting from each treatment and the N, P and K percentages were determined in the dry leaves and fruit. Their dry weights were determined following drying in a drying chamber to a constant weight at 75°C for 72 hour. After dryness, the plant samples were milled and stored for analysis as reported. However, 0.5g of the fruits and leaves powder was wet-digested with H_2SO_4–H_2O_2 mixture according (Lowther, 1980) and the following determinations were carried out in the digested solution: nitrogen (N), Phosphorous (P), potassium (K), iron (Fe), copper (Cu), manganese (Mn), and zinc (Zn) were determined according to Jackson (1973).

Nitrogen content: Total nitrogen was determined in digested plant material calorimetrically by Nessler`s method (Chapman and Pratt, 1961). Reading was achieved using wave length of 420 nm and N content was determined as percentage.

Phosphorus content: Total phosphorus was determined by the Vanadomolyate yellow method as given by Jackson (1973) and the intensity of color developed was read in spectrophotometer at wave length of 405nm.

Potassium content: Potassium was determined according to the method described by Jackson (1973) using Beckman Flame photometer.

Statistical analysis: The one-way analysis of variance (ANOVA) was carried out to determine the statistical significance of the treatment effects on the squash yield and soil characters using procedures outlined in Statistix (2003). The comparison between means was tested using least significant difference procedure at a significance level of 0.05 (Statistix, 2003).

RESULTS AND DISCUSSION

Vegetative growth

The leaf vegetative growth data of squash plants as affected by amendments application are presented in Table (5). The data reveal that all vegetative characters were not affected significantly by amendments application. The leaf fresh weight was reached the maximum value (5.78 g) with the treatment of animal manure plus gypsum, while the minimum value (2.77 g) was with sulphur plus gypsum treatment. The maximum value was 23.24% higher than the control treatment. The leaves dry weight has maximum value (0.92 g) with animal manure plus gypsum treatment, but the minimum value was attained with sulphur plus gypsum treatment. The maximum value was 19.48% higher than control treatment. Also, the maximum value of leaf water content (85.97%) was attained with organic acid plus sulphur treatment, while the lowest value (81.89%) was attained with sulphur treatment. Concerning the plant gross weight, the maximum value was 740.0 g with animal manure plus Sulphur treatment, while the minimum value (370.0 g) was attained with sulphur and gypsum treatment. The maximum value was 44.16% higher than the control treatment. Chlorophyll a and b contents were 0.683 and 0.530 mg/g fresh weight with animal manure plus gypsum treatment, respectively. The lowest values were 0.227 and 0.183 mg/g fresh weight attained with animal manure and bagasse plus sulphur treatments, respectively. The total chlorophyll content behaved the same trend.

As for the influence of organic fertilizers on vegetable production, Mohy El-Din (1997) mentioned that addition of organic waste significantly increased the fresh and dry weight of cucumber shoots during the autumn and spring seasons. Disadvantages of using manures include the hard and high cost of handling and distribution associated with the large amount of manure required obtaining sufficient quantities of nutrients for vegetables.

Fruit yield characters

Table (6) illustrates the squash fruit characters as affected by amendments treatments. All characters are significant at 1% probability level. Fruit diameter was reached the maximum value (3.6 cm) at animal manure plus gypsum treatment while the minimum value (1.4 cm) was attained at sulphur plus gypsum treatment. The maximum value was 4.00% higher than the control treatment. Also, the fruit length was reached the maximum value (17.0 cm) at wheat straw plus gypsum treatment, while the minimum value (9.1 cm) was attained at bagasse treatment. The maximum value was 49.10% higher than the control treatment. Concerning the average fruit weight, the highest value (199.5 g) was attained with animal manure plus gypsum treatment, while the lowest one (62.5 g) was attained with bagasse treatment. The maximum value was 52.20% higher than the control treatment. The fruit gross weight per plot has a maximum value (3650.0 g/plot) and was attained with animal manure plus gypsum treatment. The minimum value (425.5 g/plot) was attained with bagasse plus gypsum treatment. The maximum value was 271.20% higher than the control treatment.

Regarding the animal manure plus gypsum treatment, the obtained data showed that the early and total fruit yield of squash increased significantly up to 6954.0 kg/ha with animal manure plus gypsum accounted as 271.30% over the control treatment (Table 6). Using animal manure only or sulphur treatment led to an increase in the early and total yield (5701.4 and 4850.8 kg/ha) of squash as 204.42 and 159.00%, respectively comparing to the control treatment (Table 6).

Table (5). Vegetative growth of squash plants as affected by soil amendments application

Treatments	Leaf Fresh weight (g/plant)	Leaf Dry weight (g/plant)	Leaf water content (%)	Gross plant weight (g/plant)	Chlorophyll a content (mg/g FW)	Chlorophyll b content (mg/g FW)	Total chlorophyll content (mg/g FW)
Control	4.69	0.77	83.58	513.33	0.234	0.399	0.633
Animal manure	3.61	0.60	83.38	546.67	0.227	0.293	0.520
Bagasse	3.31	0.58	82.48	526.67	0.275	0.336	0.611
Wheat straw	3.71	0.64	82.75	660.00	0.602	0.318	0.920
Sulphur	4.03	0.73	81.89	428.33	0.595	0.321	0.916
Gypsum	4.67	0.73	84.37	530.00	0.443	0.471	0.914
Animal manure + Sulphur	4.52	0.71	84.29	540.00	0.344	0.257	0.601
Animal manure + Gypsum	5.78	0.88	84.78	740.00	0.683	0.530	1.213
Animal manure + Wheat straw	5.16	0.75	85.47	630.00	0.377	0.319	0.696
Sulphur + Gypsum	2.77	0.47	83.03	370.00	0.364	0.347	0.711
Wheat straw +Sulphur	3.56	0.64	82.02	456.67	0.568	0.375	0.943
Wheat straw + Gypsum	3.96	0.71	82.07	473.33	0.629	0.399	1.028
Bagasse + Sulphur	5.36	0.80	85.07	512.33	0.234	0.183	0.417
Bagasse + Gypsum	4.39	0.74	83.14	440.00	0.337	0.363	0.700
Organic acid +Sulphur	4.99	0.70	85.97	500.00	0.479	0.366	0.845
Organic acid +Gypsum	5.20	0.92	82.31	436.67	0.286	0.523	0.809
Bagasse +Sulphur + Gypsum	3.82	0.55	85.60	470.00	0.610	0.308	0.918
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Nutrients content

Leaf nutrients content: Leaf nutrients content of squash plants were significantly affected by amendments treatments as shown in Table (7). The macro-nutrients content (N, P, K, Ca and Mg) reached the maximum values, i.e. 5.94, 0.82, 3.90, 4.68 and 4.68%, respectively with animal manure plus gypsum. The lowest values (3.52, 0.48, 2.13, 2.51 and 2.00%, respectively) were attained with the other different treatments. The highest values were 68.75, 24.24, 7.44, 27.17 and 27.52%, respectively more than the control treatment. All nutrients content are significantly affected by application of amendments treatments.

The micro-nutrients content (Fe, Mn, Cu and Zn) reached the maximum values i.e. 384.8, 57.1, 94.1 and 70.7 mg/kg, respectively with animal manure plus gypsum treatment. The lowest values (244.4, 23.5, 65.9 and 22.5 mg/kg, respectively) were attained with the other different treatments. The highest values were about 13.12, 52.3, 13.1 and 72.20 mg/kg, respectively more than the control treatment. All micro-nutrients content are significantly affected by application of soil amendments.

In general, the growth of squash increased by application of animal manure. While the increase of N, P, and K % contents of squash leaves was due to the increase in soil organic matter, soil moisture and nutrient contents and availability in soil.

Fruit nutrients content: Fruit nutrients content of squash plants as affected by application of amendments are shown in Table (8). The contents of N, P, K, Ca and Mg reached the maximum values, i.e. 4.60, 0.98, 5.95, 3.68 and 4.86%, respectively with animal manure plus gypsum. The lowest values (2.41, 0.36, 4.10, 2.51 and 1.82%, respectively) were attained with the other different treatments. The highest values were 29.64, 63.33, 25.26, 22.26 and 14.35%, respectively more than the control treatment. All macro-nutrients content are significantly affected by application of soil amendments.

The micro-nutrients content (Fe, Mn, Cu and Zn) reached the maximum values, i.e. 279.5, 62.5, 51.2 and 41.4 mg/kg, respectively with animal manure plus sulphur treatment. The lowest values (128.6, 42.2, 32.0 and 18.7 mg/kg, respectively) were attained with the other different treatments. The highest values were 28.62, 12.61, 21.04 and 55.64%, respectively more than the control treatment. All micro-nutrients content are significantly affected by application of soil amendments except for copper content.

The application of manures to soil provides potential benefits including improving the fertility, structure, water holding capacity of soil, increasing soil organic matter and reducing the amount of synthetic fertilizer needed for crop production (Eghball, 2002; Phan *et al*., 2002).

Manures are the main sources of nitrogen (N) supply in organic crop production. Nitrogen availability from applied manure includes the inorganic N (NO_3-N and NH_4-N) plus the amount of organic N mineralized following application. Nitrogen mineralization differs for different manure types since the inorganic/organic fraction and quality of organic N varies (Zaman *et al.*, 2004; Mikha and Rice, 2004). Raw manure is an excellent source for organic crop production. It supplies nutrients and organic matter and stimulating the biological processes in the soil that help to build up soil fertility. However, a number of cautions and restrictions still need more investigations, based on concerns about produce quality, food contamination, soil fertility imbalances, weed problems, and pollution hazards. Manure is an important source of plant nutrients Zaman *et al.* (2004), as it increases soil total N (Mikha and Rice, 2004) and improves the nutrient status of the soil (Eghball and Power, 1999) whom reported that 58% of beef manure N was available for plant uptake during the first 2 years after application.

Table (6). Squash fruit characteristics as affected by soil amendments application

Soil amendments	Average fruit diameter (cm)	Average fruit length (cm)	Average fruit weight (g)	Fruit weight (g)/plot	fruit yield (kg/ha)
Control	3.5	11.4	131.1	983.3	1872.9
Animal manure	3.2	11.8	144.6	2993.2	5701.4
Bagasse	2.9	9.1	68.0	1502.8	2862.5
Wheat straw	3.3	14.9	157.1	974.0	1855.3
Sulphur	3.3	14.3	140.7	2546.7	4850.8
Gypsum	2.6	9.8	119.0	2070.6	3944.0
Animal manure + Sulphur	3.4	12.0	128.0	934.4	1779.8
Animal manure + Gypsum	3.6	13.6	199.5	3650.9	6954.0
Animal manure + Wheat straw	3.3	11.4	176.3	1022.5	1947.7
Sulphur + Gypsum	1.4	13.6	110.9	1829.9	3485.4
Wheat straw +Sulphur	3.1	10.8	88.1	740.0	1409.6
Wheat straw + Gypsum	1.6	17.0	130.9	1636.3	3116.7
Bagasse + Sulphur	1.8	9.3	93.3	531.8	1013.0
Bagasse + Gypsum	3.3	9.9	92.5	425.5	810.5
Organic acid +Sulphur	1.8	11.5	162.7	2261.5	4307.7
Organic acid +Gypsum	2.6	11.9	125.5	2271.6	4326.8
Bagasse +Sulphur + Gypsum	2.3	12.8	135.9	2160.8	4115.8
LSD (0.05)	**1.4***	**3.5****	**25.7****	**1398.5****	**1.65****

Physical properties of soil

Table (9) showed that the soil bulk density ranged between 1.65 to 1.85 Mg/m^3 with average of 1.76 Mg/m^3. The lowest value was attained with animal manure plus gypsum treatment, while the highest value was attained with wheat straw treatment.

The low value was under the control treatment by 7.82%. The mean weight diameter (MWD) ranged between 0.663 and 0.752 mm with average value of 0.71 mm. The highest value was attained with animal manure plus gypsum treatment, while the lowest value was attained with gypsum treatment. The geometric mean diameter (GMD) has the highest value (0.575 mm) with animal manure plus gypsum, while the lowest value (0.475 mm) was attained with only animal manure treatment. The highest value was more than the control treatment by 6.09%. The structure coefficient (Cr) has the highest value (1.478) with animal manure plus gypsum, while the lowest value (1.072) was attained with gypsum treatment. The highest value was more than the control treatment by 11.55%. The geometric standard deviation (**δg**) reached the maximum value of 2.956 with animal manure and bagasse +sulphur+ gypsum treatments, while the lowest one (2.353) was attained with animal manure plus gypsum treatment. The lowest value was less than the control treatment by about 7.50%.

The structural stability index (SI) has highest value of 2.48 with bagasse plus sulphur treatment and lowest value with only bagasse treatment with average of 1.89. The structural stability index (SI) < 5% indicates a structurally degraded soil (Pieri, 1992). The highest value of Kelly's ratio (KR) is 2.86 was attained with animal manure plus gypsum treatment, while the lowest value was attained with wheat straw plus gypsum treatment with average of 2.01. The highest value was more than the control treatment by about 43.00%. The values of KR>1.0 indicates an excess level of sodium (Kelly, 1946). Thus, this soil is qualified to alkali hazards (Karanth, 1987). The permeability index (PI) was the highest value (102.51) with bagasse plus sulphur treatment, while the lowest one (76.98) was attained with sulphur plus gypsum treatment. The average value was 88.87. The values (PI) were more than 75 indicated that the soil has problem about the water permeability.

Table (7). Leaf nutrients content of squash plants as affected by soil amendments treatment

Soil amendments	Macro-nutrients content (%)					Micro-nutrients content (mg/kg)			
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
Control	3.52	0.66	3.63	3.68	3.67	340.0	37.5	83.2	41.0
Animal manure	3.98	0.78	3.80	2.51	4.01	323.8	30.9	73.1	30.6
Bagasse	4.14	0.52	3.03	3.34	4.17	291.1	28.2	70.9	28.5
Wheat straw	4.90	0.72	3.20	3.18	2.77	380.2	29.5	80.3	34.0
Sulphur	4.38	0.48	3.40	2.84	4.34	301.7	48.5	83.2	38.2
Gypsum	3.81	0.64	2.63	3.68	2.00	351.7	54.2	70.7	64.8
Animal manure + Sulphur	5.12	0.71	3.47	4.01	3.37	374.5	24.4	65.9	22.5
Animal manure + Gypsum	5.94	0.82	3.90	4.68	4.68	285.2	57.1	94.1	68.2
Animal manure + Wheat straw	5.87	0.69	3.67	3.34	2.84	248.8	23.5	76.1	28.0
Sulphur + Gypsum	3.99	0.62	2.97	2.68	4.68	347.6	49.0	77.5	70.6
Wheat straw +Sulphur	4.70	0.63	2.13	3.68	4.68	244.4	40.3	84.6	38.5
Wheat straw + Gypsum	4.22	0.57	3.33	4.34	2.34	370.7	35.1	81.6	26.5
Bagasse + Sulphur	5.15	0.63	3.80	3.18	3.34	320.2	32.3	76.9	36.5
Bagasse + Gypsum	4.47	0.65	3.13	2.84	4.01	299.5	38.8	66.2	27.9
Organic acid +Sulphur	5.48	0.72	2.90	3.01	2.95	336.7	50.5	83.9	31.4
Organic acid +Gypsum	4.05	0.54	3.03	3.01	2.51	352.5	25.6	76.7	35.1
Bagasse +Sulphur + Gypsum	5.02	0.53	2.60	3.51	2.84	384.8	45.6	71.4	41.0
LSD (0.05)	**1.45***	**0.19***	**0.95****	**0.99****	**0.85***	**78.5***	**22.6****	**70.9****	**23.7****

Table (8). Fruit nutrients content of squash plants as affected by amendments application

Treatments	Macro-nutrients content (%)					Micro-nutrients content (mg/kg)			
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
Control	3.54	0.60	4.75	3.01	4.25	217.3	55.5	42.3	26.6
Animal manure	3.60	0.71	4.73	2.67	2.83	147.8	55.2	43.3	35.0
Bagasse	2.41	0.39	4.27	2.68	2.58	279.0	54.0	42.3	27.8
Wheat straw	3.94	0.95	4.10	3.26	3.34	223.0	50.2	49.4	20.5
Sulphur	3.18	0.97	4.67	3.01	2.43	128.7	45.0	41.8	24.9
Gypsum	3.30	0.36	4.67	3.51	2.84	151.2	43.9	32.0	32.1
Animal manure + Sulphur	3.50	0.57	4.78	3.50	1.82	161.3	52.7	42.2	21.3
Animal manure + Gypsum	4.60	0.98	5.95	3.68	4.77	128.6	62.5	51.2	38.4
Animal manure + Wheat straw	3.76	0.44	5.40	2.54	3.93	191.5	56.3	37.6	33.4
Sulphur + Gypsum	4.45	0.59	5.60	2.51	2.73	213.8	49.3	45.5	41.4
Wheat straw +Sulphur	4.00	0.40	5.10	3.01	3.04	141.1	47.4	43.5	33.7
Wheat straw + Gypsum	3.89	0.59	4.60	3.26	2.84	152.4	50.7	42.8	21.0
Bagasse + Sulphur	4.25	0.48	5.00	2.76	2,43	175.7	60.0	45.8	29.0
Bagasse + Gypsum	3.53	0.57	5.54	3.50	1.82	161.1	52.6	42.4	21.3
Organic acid +Sulphur	3.83	0.67	5.55	3.26	4.86	212.1	45.3	43.0	22.2
Organic acid +Gypsum	3.78	0.79	5.37	3.18	4.05	213.1	45.0	48.1	34.3
Bagasse +Sulphur + Gypsum	3.29	0.63	4.27	2.68	4.46	218.4	42.2	42.6	18.7
LSD (0.05)	**NS**	**0.53***	**1.61****	**NS**	**1.68****	**89.6****	**35.0****	**NS**	**18.5****

Table (9). Some physical properties of soil treated with amendments

Treatments	BD Mg/m^3	MWD (mm)	GMD (mm)	Cr	δg	SI	KR	PI
Control	1.79	0.738	0.542	1.325	2.544	1.52	2.00	81.22
Animal manure	1.84	0.667	0.475	1.003	2.958	2.04	1.95	81.13
Bagasse	1.74	0.705	0.506	1.194	2.811	1.02	2.52	99.96
Wheat straw	1.85	0.677	0.498	1.115	2.729	2.04	1.76	87.46
Sulphur	1.70	0.718	0.536	1.345	2.523	1.70	2.85	97.65
Gypsum	1.73	0.663	0.490	1.072	2.723	1.89	2.31	85.28
Animal manure + Sulphur	1.71	0.721	0.524	1.227	2.668	2.40	1.84	86.69
Animal manure + Gypsum	1.65	0.752	0.575	1.478	2.956	2.28	2.86	88.89
Animal manure + Wheat straw	1.65	0.744	0.553	1.426	2.479	1.97	1.40	82.04
Sulphur + Gypsum	1.77	0.745	0.553	1.389	2.461	1.78	1.70	76.88
Wheat straw +Sulphur	1.83	0.714	0.521	1.245	2.651	1.76	1.88	90.17
Wheat straw + Gypsum	1.80	0.667	0.561	1.471	2.416	1.91	1.30	87.06
Bagasse + Sulphur	1.77	0.687	0.499	1.162	2.787	2.48	1.97	92.14
Bagasse + Gypsum	1.76	0.719	0.521	1.259	2.702	1.52	2.07	102.51
Organic acid +Sulphur	1.77	0.717	0.527	1.366	2.666	1.83	1.75	97.45
Organic acid +Gypsum	1.76	0.695	0.510	1.280	2.778	1.97	2.77	89.48
Bagasse +Sulphur + Gypsum	1.75	0.733	0.557	1.466	2.353	2.04	1.31	84.86
LSD (0.05)	**0.105****	**0.053***	**0.053***	**0.25***	**0.381****	**0.153***	**0.245***	**15.43****

Chemical properties of soil

Table (10) shows the effects of soil amendments application on some soil chemical properties. The soil pH ranged between 7.92 and 8.97 with an average of 8.46. Also, soil salinity (EC) was ranged between 2.12 and 5.53 dS/m with an average value of 3.64 dS/m. The soluble cations; Ca^{+2}, Mg^{+2}, Na^{+} and K^{+} ranged between 2.45 and 6.37; 3.04 and 6.27; 9.78 and 25.87 and 0.20 and 1.42 meq/l, respectively with average values of 3.90, 4.68, 17.29 and 0.59 meq/l, respectively. The soluble anions; HCO_3^-, Cl^- and $SO_4^=$ ranged between 6.13 and 8.58, 8.30 and 14.93 and 8.96 and 12.85 meq/l, respectively. The average values were 7.79, 12.35 and 10.26 meq/l, respectively. Calcium carbonate content ranged between 3.68 and 22.10% with an average of 13.93. Also, organic matter content ranged between 0.71 and 1.72% with an average value of 1.31%.

Soluble sodium percentage (SSP) of soil ranged between 54.02 and 71.16% with an average value of 62.42%. The lowest value was attained with animal manure plus gypsum treatment and was lower than the control treatment by about 24.079%. Also, sodium adsorption ratio (SAR) ranged between 6.12 and 14.77 with an average value of 9.28. The lowest value was attained with animal manure plus gypsum treatment. It is lower than the control treatment by 58.56%. The expected exchangeable sodium percentage (ESP) ranged between 7.79 and 17.02% with an average value of 11.48%. The lowest value was attained with animal manure plus gypsum treatment. It is lower than control treatment by about 54.82% (Table 11). From the obtained results it can be concluded that the animal manure plus gypsum treatment is the best treatment for improvement the saline-sodic soil.

Gypsum (Amezketa *et al*., 2005) and organic matter (Wong et al., 2009) are some of the amendments which have been used. Gypsum is the most commonly used amendment for sodic soil reclamation and for reducing the harmful effects of high sodium irrigation water in agricultural areas (Amezketa *et al*., 2005). Studies on the effect of gypsum application on saline-sodic soil reclamation have shown that the soil receiving gypsum at higher rate removes the greatest amount of Na^{+} from the soil columns and causes a substantial decrease in soil electrical conductivity (EC), sodium adsorption ratio and SAR (Hamza and Anderson, 2003).

Table (10). Some chemical properties of soil treated with soil amendments application

Treatments	pH	EC dS/m	Soluble cations (meq/l)				Soluble anions (meq/l)			$CaCO_3$ (%)	OM (%)
			Ca	Mg	Na	K	HCO_3	CL	SO_4		
Control	8.94	3.67	5.36	7.30	23.44	0.59	10.80	14.60	11.27	20.00	1.05
Animal manure	8.33	2.95	3.22	6.64	18.87	0.78	8.13	11.86	12.00	21.71	1.42
Bagasse	8.42	2.85	3.69	4.22	19.88	0.66	8.01	13.40	10.15	10.52	0.71
Wheat straw	8.54	2.47	3.32	5.54	15.49	0.36	5.49	13.62	10.64	14.92	1.41
Sulphur	8.11	3.08	4.30	3.65	18.37	0.52	7.74	11.07	9.84	11.57	1.18
Gypsum	8.20	3.41	6.07	4.05	17.33	0.63	8.32	14.14	13.26	11.05	1.31
Animal manure + Sulphur	8.14	3.36	5.53	5.02	15.17	0.85	8.37	14.05	12.43	3.68	1.68
Animal manure + Gypsum	8.14	3.27	6.38	2.83	13.46	0.99	6.63	12.35	10.05	4.74	1.72
Animal manure + Wheat straw	8.64	2.45	3.48	6.38	21.89	0.72	7.43	12.28	11.02	11.58	1.37
Sulphur + Gypsum	8.51	2.71	3.88	5.54	16.71	0.94	7.70	14.07	10.33	9.47	1.23
Wheat straw +Sulphur	8.42	2.91	3.47	6.59	18.60	0.44	7.64	15.62	11.86	19.47	1.22
Wheat straw + Gypsum	8.27	2.45	4.20	6.00	13.85	0.44	6.21	15.25	11.26	22.10	1.32
Bagasse + Sulphur	8.40	2.80	3.77	5.65	18.34	0.28	6.91	12.86	11.14	16.32	1.58
Bagasse + Gypsum	8.54	2.86	3.08	6.09	18.90	0.51	6.60	16.87	10.80	18.14	1.06
Organic acid +Sulphur	8.30	2.60	3.08	6.17	16.15	0.60	7.12	15.67	12.97	11.58	1.27
Organic acid +Gypsum	8.00	3.27	5.25	3.06	17.11	1.27	6.96	12.24	8.00	15.78	1.37
Bagasse +Sulphur + Gypsum	8.24	2.24	4.44	5.07	12.66	0.26	5.99	10.74	15.36	14.21	1.41
LSD (0.05)	**0.44****	**1.09****	**1.37****	**1.78***	**7.16****	**0.30****	**0.42***	**2.1009****	**1.23****	**6.09****	**0.30****

Table (11). Sodium hazard of soil treated with soil amendments application

Treatments	ESP (%)	SAR	SSP (%)	RSE %	RSSE %
Control	17.02	14.77	71.16	-	-
Animal manure	12.79	11.08	60.75	24.85	14.63
Bagasse	12.37	10.43	69.91	27.32	1.76
Wheat straw	15.38	11.24	61.84	9.64	13.10
Sulphur	14.28	12.22	68.19	16.10	4.17
Gypsum	11.28	8.47	62.54	33.73	12.11
Animal manure + Sulphur	13.35	9.55	60.79	21.56	14.57
Animal manure + Gypsum	7.69	6.12	54.02	54.82	24.09
Animal manure + Wheat straw	13.28	10.03	56.23	21.97	20.98
Sulphur + Gypsum	8.08	6.50	55.31	52.53	22.27
Wheat straw +Sulphur	10.67	8.96	63.85	37.31	10.27
Wheat straw + Gypsum	10.07	7.55	62.76	40.83	11.80
Bagasse + Sulphur	10.33	8.68	65.44	39.31	8.04
Bagasse + Gypsum	9.11	7.65	66.20	46.47	6.97
Organic acid +Sulphur	8.98	9.85	62.10	47.24	12.73
Organic acid +Gypsum	12.24	7.85	60.63	28.08	14.80
Bagasse +Sulphur + Gypsum	8.20	6.85	59.46	51.82	16.44
LSD (0.05)	**4.39****	**3.87****	**11.65***	**17.32***	**8.23***

Removal sodium efficiency (RSE) in percentage of Na-removed from soils at the end of the experiment was calculated as follows:

$$RSE = \frac{(ESP_i - ESP_f)}{ESP_i} \times 100$$

Where:

ESP_i : exchangeable sodium percentage before the soil amendments application, and

ESP_f : exchangeable sodium percentage after the soil amendments application at the end and after plant harvest.

The removal sodium efficiency (RSE) or percentage of Na-removed from the soils at the end of the experiment in used soils was significantly reduced after the application of the amendments (Table 11). RSE of animal manure plus gypsum revealed the highest value (54.82%) among the treatments followed by 51.82 and 47.24% for Bagasse +Sulphur + Gypsum and Organic acid +Sulphur treatments, respectively. Also, the removal of soluble sodium efficiency (RSSE%) was calculated by the same equation using SSP instead of ESP. The value of RSSE for animal manure plus gypsum revealed the highest value (24.09%) among the treatments followed by 22.27 and 20.98 for Sulphur + Gypsum and animal manure plus wheat straw treatments, respectively.

The obtained results confirmed that animal manure plus gypsum treatment was the best method for reclamation the salt-affected soil.

Available nutrients in soil

Table (12) showed that the soil available nutrients were significantly affected by application of soil amendments. The values of available N, P and K ranged between 122.1 and 324.4; 9.2 and 71.4 and 162.5 and 250.0 mg/kg, respectively with an average value of 269.9, 39.1 and 202.9 mg/kg, respectively. The higher values were attained with animal manure plus gypsum treatment. These values are higher than the control treatment by 165.62, 296.97 and 11.11%, respectively. Also, the content of available Fe, Mn, Cu and Zn ranged between 4.1 and 11.3; 8.2 and 18.4; 4.2 and 4.9 and 0.4 and 1.2 mg/kg, respectively with an average values of 7.9, 13.8, 4.6 and 0.8 mg/kg, respectively. The higher values were attained with animal manure plus gypsum treatment. These values are higher than the control treatment by 76.56, 77.22, 13.95 and 82.35%, respectively. It is clear that all soil amendments increased the soil available nutrients.

Although the use of chemical amendments, like gypsum, successfully improved the chemical properties of these soil, but fails to restore nutritional and biological properties of reclaimed soils. As a cost-effective and environmentally acceptable strategy, saline-sodic soil can also be reclaimed through organic bio-amelioration (Gill *et al*., 2009). The incorporation of organic amendments to sodic soil enhances microbial activity that transforms the organic materials into long chain aliphatic compounds capable of binding and stabilizing soil aggregates. Bio-amelioration method has great advantage over chemical amendments such as: (1) improvement of soil hydraulic conductivity, (2) increases the plant nutrients availability in amended soil, (3) environmental services through soil carbon sequestration. It is concluded that bio-amelioration approach for sodic land reclamation would not only improve the soil fertility, but also make able the reclaimed sodic soil for agriculture that can fulfil the food requirements of growing population. Also, Gypsum application successfully reduces exchangeable sodium percentage (ESP) of sodic soils, but fails to improve the physical and biological properties of the soil (Tejada *et al*., 2006).

Recently, organic bio-amelioration approach has proved to be an efficient, low cost and environmentally acceptable strategy to ameliorate sodic and saline-sodic soils. Input of organic matter conditioner such as mulch, manures, compost and recyclable organic waste/residues have been investigated for their effectiveness in sodic soils amelioration. It has been demonstrated that the application of organic matter to sodic soils can accelerate Na^+ leaching, decrease the exchangeable sodium percentage and increase infiltration rate and aggregate stability of amended soils (Jalali and Ranjbar, 2009).

Numerous studies showed the benefits of organic amendments in improving physical, chemical and biological properties of soil. Although, these parameters can be changed slowly and several years are necessary to obtain significant differences, biological and biochemical parameters are more sensitive and can provide earlier measurements of changes produced by soil management (Melero *et al*., 2007; Courtney and Mullen, 2008; Chitravadivu *et al*., 2009).

Soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is responsible for up to 90% adsorbing power of the soils. Cations such as Ca^{2+}, Mg^{2+} and K^{+} are produced during its decomposition (Brady and Weil, 2005). **O**rganic amendments decreased soil sodicity and increased exchangeable Ca2+ and Mg^{2+} (Anand, 1992).

Table (12). Available nutrients content in soil as affected by soil amendments application

	Available macro-nutrients (mg/kg)			Available micro-nutrients (mg/kg)			
	N	**P**	**K**	**Fe**	**Mn**	**Cu**	**Zn**
Control	122.13	20.50	225.00	6.4	10.1	4.3	0.7
Animal manure	307.27	40.13	168.75	5.8	17.9	4.5	0.4
Bagasse	219.90	39.88	225.00	11.0	14.6	4.3	0.7
Wheat straw	307.30	50.38	212.50	9.1	12.1	4.6	0.7
Sulphur	323.13	17.25	162.50	8.1	14.6	4.7	0.7
Gypsum	252.27	9.16	200.00	6.3	11.5	4.4	0.8
Animal manure + Sulphur	280.53	57.38	193.89	8.6	12.7	4.2	1.0
Animal manure + Gypsum	324.40	81.38	250.00	11.3	18.4	4.9	1.2
Animal manure + Wheat straw	306.30	45.13	250.00	6.3	14.1	4.8	1.00
Sulphur + Gypsum	200.27	16.25	175.00	4.6	10.2	4.5	0.8
Wheat straw +Sulphur	280.50	52.88	218.75	8.8	13.4	4.7	0.8
Wheat straw + Gypsum	283.9	43.25	206.25	7.9	8.3	4.8	0.7
Bagasse + Sulphur	215.63	33.38	193.75	10.4	18.3	4.8	0.8
Bagasse + Gypsum	255.30	25.75	193.75	6.2	10.6	4.4	0.4
Organic acid +Sulphur	267.27	57.00	218.75	9.4	15.1	4.2	0.8
Organic acid +Gypsum	323.53	48.60	187.50	4.1	14.8	4.6	1.2
Bagasse +Sulphur + Gypsum	303.53	36.50	168.75	10.0	17.6	4.8	1.0
LSD (0.05)	**52.15****	**30.22****	**28.05****	**2.9****	**6.1****	**0.2****	**0.2****

Finding of previous study showed that incorporation of organic bio-ameliorants improve the growth and yield of major crops (*Triticum aestivum* L. and *Oryza sativa* L.) under the sodic condition (Yaduvanshi and Sharma, 2008; Choudhary *et al*., 2011). The incorporation of organic bio-ameliorants into sodic soils significantly increased the root growth and yield of wheat (*Triticum aestivum* L.) crop, due to continuing supply of readily-available nutrients, due to mineralizing organic matter (Gill *et al*., 2009). In addition, there would be polysaccharides and mycelial exudates released from the mineralization of organic matter seem to play an important role in plant growth promotion (Srinivasan *et al.*, 2011).

The most effective procedures for saline-sodic soils reclamation are based on the removal of exchangeable and soluble sodium out of the soil profile. A method of saline or saline-sodic soils reclamation using a combination of organic manure and gypsum was evaluated and proved to be the best soil amendment for reducing soil pH, soil salinity, and soil sodicity. As shown in the present study, the sodium removal efficiency was the highest with treating the soil with animal manure plus gypsum. Consequently, squash yield was the highest at the same treatment.

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الملخص العربي

تأثير عديد من المحسنات وتوليفاتها على خصائص التربة وإنتاج الكوسة فى تربة ملحية- صودية

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أجريت تجربة حقلية على الكوسة صنف اسكندراني فى المزرعة التجريبية – كلية الزراعة سابا باشا – جامعة الاسكندرية بمنطقة ابيس ١٠ خلال الموسم الشتوى ٢٠١٤ لدراسة تأثير إضافة عدد من محسنات التربة مثل السماد الحيواني- مصاصة القصب – الحبس – الكبريت – الحامض العضوي وخليط منها على الخواص الفيزيائية والكيميائية للتربة المتأثرة بالاملاح وأيضا على النمو وخصائص المحصول والمحتوى من العناصر الغذائية فى اوراق وثمار الكوسة. تم زراعة الكوسة فى أكتوبر ٢٠١٤ بزراعة البذور فى جور على ابعاد ٠.٢٥ متر داخل الخط ومسافة ٠,٦ متر بين الخطوط بطول ٣,٠ متر. بعد اكتمال النمو تم الرى بطريقة الخطوط حتى الحصاد فى ديسمبر ٢٠١٤. جميع المعاملات تم تطبيقها كما هو موصى به. أضيفت محسنات التربة (١٧ معاملة) بخلطها مع التربة السطحية لعمق ٣٠سم قبل الزراعة. تم تسجيل النمو الخضرى- المحصول ومكوناته- محتوى الاوراق والثمار من العناصر الغذائية كما تم تسجيل خصائص التربة الفيزيائية والكيميائية. أشارت النتائج الى ان خصائص النمو الخضرى (الوزن الاخضر والوزن الجاف للأوراق – المحتوى المائى للأوراق – وزن النبات الكلى – محتوى الاوراق من الكلوروفيل) لم تتأثر معنويا نتيجة إضافة المحسنات ولكن أعلى قيم تم الحصول عليها مع معاملة السماد الحيوانى (٢٤ طن/هكتار) + الجبس (٤ طن/هكتار). أعلى قيم لخصائص محصول الكوسة (قطر الثمرة – طول الثمرة – وزن الثمرة – المحصول الكلى للثمار) تم الحصول عليها من معاملة السماد الحيواني+الجبس. محصول ثمار الكوسة زاد معنويا مع إضافة محسنات التربة ووصل الى اعلى قيمة ٦٩٥٤ كجم/هكتار مع معاملة السماد الحيواني+ الجبس بما يعادل ٢٧١,٣ % مقارنة بمعاملة الكنترول. تأثر محتوى العناصر الغذائية الكبرى والصغرى فى الاوراق والثمار تأثرت معنويا باضافة محسنات التربة خاصة معاملة السماد الحيوانى+الجبس. كما تأثرت معنويا الخواص الفيزيائية للتربة مثل الكثافة الظاهرية- متوسط القطر الموزون – متوسط القطر الهندسي – معامل البناء باضافة محسنات التربة المختلفة. وقد أظهر معامل ثبات البناء – نسبة كيلي ودليل النفاذية التأثير العالى من الصوديوم فى التربة وبالتالى فان التربة تصبح مهيأة لاضرار الصوديوم ولهذا فالتربة بها مشاكل تتعلق بنفاذية المياه. كما تحسنت خواص التربة الكيميائية والتى تشمل محتوى التربة من العناصر الغذائية الميسرة كنتيجة لاضافة محسنات التربة خاصة السماد الحيوانى + الجبس . من النتائج التى تم الحصول عليها يمكن ان نقرر ان السماد الحيوانى + الجبس هى أفضل المعاملات لتحسين خواص التربة الملحية – الصودية وكذلك نمو ومحصول الكوسة.