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EFFECT OF DIFFERENT DRAIN DEPTHS ON SOME SOIL CHEMICAL PROPERTIES, WATER USE EFFICIENCY AND PRODUCTIVITY OF MAIZE AND WHEAT UNDER NEWLY RECLAIMED SALINE SOIL.

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ABSTRACT

Two field experiments were conducted on a the clay saline sodic soil in El-Rowad Village Farm in Sahl El-Hossinia, El-Sharkia Governorate, Egypt, during summer 2014 and winter season 2014/2015 to study the effect of two different drains type (open drain and covered drain system) with different depths of 50, 70 and 90 cm from surface soil on some soil chemical properties , maize , wheat productivity and water use efficiency (WUE) under sodic saline soil condition to select the best drain system with the best drain depth.

Results showed that using open and covered drains decreased soil pH and EC of soil with drain depth (50 and 70 cm from surface soil) more than drain depth 90 cm. In addition, the effect of applying open drain system with drain depth of 50 and 70 cm show that positive increase in available N, P, K, Fe, Mn and Zn in saline sodic clay soil compared with depth 90 cm under open drain system.

Concerning the weight of straw yield, grain yield (Mg/fed) and weight of 1000 grain (g) for both maize and wheat were significant increase with open drain for 50 cm depth more than 70 and 90 cm depth.

Finally, the using of open drain system with lowest depth treatment produced maximum yield and WUE value with cultivation both maize and wheat crops.

The using of open drain system with 50 cm depth lead to improve the soil chemical properties of clay saline sodic soil and increase the yield productivity and water use efficiency (WUE) of maize and wheat crops.

Keywords:Saline sodic soils, drain system, drain depth, maize and Wheat productivity, water use efficiency (WUE).

NTRODUCTION

In Egypt, improving salt affected soils is considered as an important part in the agricultural security program. Management of the salt affected soils requires a combination of agronomic practices depending on chemical amendments, water quality and local conditions including climate as well as crop economic policy, (El-Etr *et al.*, 2013). Soil salinization process can be either natural or may be imposed by human activities. The latter is usually arises from irrigation in areas with low rainfall and high evaporation. In such conditions, the necessary steps are conducting leaching practices and/or performing a desirable drainage system (Kapourechal *et al.*, 2013).

The main problem at Sahl El-Hossynia soil is related to high salinity conditions. Soil degradation caused by salinizations and sodication were of universal concern. Saline >4 dSm^{-1} at 25 °C, or salt affected soil is a major environmental issue, as it limits plant growth and development, causing productivity losses (Qadir *et al.*, 2008).

Open drainage should be considered as an option for reducing salinity levels and lowering the level of subsurface water. In this system, water begins to accumulate at the surface when the irrigation rate exceeds the soil infiltration rate. This situation is common in most clay soils given their low K values and infiltration rates. The main types of surface drainage are bedding, furrow, and ditch systems. All these types have been evaluated in the Nile Delta and are being used in heavy soils, (Abdel–Hafez 2011).

Subsurface drainage is usually based upon a system of buried perforated pipes (tile drains) which control groundwater levels. The buried pipes have the advantage of not hindering mechanized farming. Furthermore, they require less maintenance than open ditches and do not lead to loss of land. When the soil profile allows the movement of water, the K value is more than 0.1 m/day and the soils are highly responsive to conventional tile drainage. The major problem associated with tile drainage of heavy clay soils with K values of less than 0.1 m/day is that the tiles usually need to be closer together to be effective, which may be uneconomical. In practice, the spacing is often determined using local experience and varies between 10 and 20 m in heavy clay soils of medium K values, Abdel–Hafez (2011). The introduction of drainage systems (open and tile drainage) has direct and indirect effects. These indirect effects which can be physical, chemical, biological and hydrological can be positive, (Nasralla, 2009). Drainage maintains the productive capacity of soil by removing excess water, improving the soil moisture, improving the air circulation and reducing salt content and erosion (Chahar and Vadodaria, 2008). Mohammad (2012) reported that the (maximum amount of drain discharge change into the initial discharge was 78% and related to the 68% decreasing bottom depth of layer below soil surface and 89 % and related to 30 % decreasing depth of water level in drain blow soil surface into the initial. As, well as , the maximum amount of drain discharge change into the initial discharge was 44% and related to the 150% increasing depth of drain bottom below soil surface into the initial. Prasad *et al.*, (2007) also reported positive results with open sub surface drainage system in reducing the salinity of problematic soils. Sub surface drainage treatment carried out in salt affected area along with the water and soil analysis, it is observed that the treatment is quite effective and it shows satisfactory results. Leaching of salts in the form of ions is good to reduce soil salinity. Leaching can decrease soil salinity effectively by improving the quality of irrigation water (Fard *et al.*, 2007). Padalkar *et al.*, (2012) indicated that the reduction in soil pH observed from 8.7 to 7.27 and in EC (dSm^{-1}) from 4.5 to 2.81 dSm^{-1} after sub-surface drainage treatment. Christen and Ayars (2001) stated that the design of drainage systems for irrigated agriculture should support efficient water management, irrigation water savings, and reduced salt discharge. Zhonghua *et al.*, (2006) showed that for rice in China (the major water use crop), controlled drainage could reduce subsurface discharge through field ditches up to 94%. For wheat and corn, the benefit of controlled drainage is negligible, since the major drainage discharge is directly through the main ditch system. Jodhao *et al.*, (2009) suggested that the soil pH and EC soil (dSm^{-1}) decreased with decreasing drain spacing system 15 m for 60 cm depth followed by 90 cm depth. Jung *et al.*, (2010) showed that the tile drainage system had helped in increasing crop yields as well as improving soil productivity and consequently total economic value of such a production.

Maize is one of the most important cereal crop in Egypt and it is sown as a summer crop for human consumption, animal feeding and industrial purpose especially for oil and starch production. The local production of maize did not cover the local consumption. Maize is an important crop in temperate climatic region as well as in semi-arid climatic region, because of the increasing demand for food and livestock feed. The widespread application of agrochemicals to intensify crop cultivation is known to severely impact arable soils Kozdro *et al.*, 2004).

Wheat (*Triticum aestivum,* L.) is one of the most important cereal crops in Egypt and over the entire world used in human food and animal feed. Wheat provides 37 % of the total calories for the people and 40 % of the protein in the Egyptian diet. The total production of wheat in Egypt reached 8184 million tons in 2006, produced from an area of 3.004 million feddan, Zaki *et al.*, (2007). Wheat is the most important nutritional cereal crop in Egypt .The local production is not sufficient to meet local requirements. Egyptian production is about 7.4 million tons of wheat grain with an average production of 18.12 ardab per feddan (Anonymous, 2007).

This investigation was carried out in saline soil with the objectives to study the impact of different depths of drain types systems on some chemical properties of saline soil to study the performance of different crops (Maize and Wheat) productivity under various drain type system with different drain depths.

MATERIALS AND METHODS

The experimental work was carried out at El-Rowad Village Farm in Sahl El-Hossinia , El-Sharkia Governorate , Egypt , during the two successive summer and winter seasons 2014/2015 to study the evaluation of two drains type (open drain and covered drain system) with different depths on some soil chemical properties and maize , wheat productivity and water use efficiency (WUE) under sodic saline soil condition. The location is at 31° 8' 12.461" N latitude and 31° 52' 15.496" E longitude, El-Etr *et al.*, (2013).

Experimental layout: The experimental field was divided into six plots. The dimension of the plot was 10 m X 50 m. Each plot was considered for one specified treatment as follows: open drains (surface drainage system) with three depths (50, 70 and 90 cm from soil surface) and sub-surface drains (covered drain) with three depths (50, 70 and 90 cm from soil surface). The both drainage systems were the beginning with a slope of 0. 1%, taking into accounts the consideration of the water level in the main drain.

Design of the network drains: Three open drains were excavated at depths of 50 , 70 and 90 cm below the soil surface for each one. The slope of these laterals was 0.1 %. Parallel lateral drains of 12.5 m drain spacing were connected at right angles into the collector in the drainage layout. Open ditch collector was used at a depth of 2 m from the soil surface at the beginning with a slope of 0.05 %., taking into account the consideration of the water level in the main drain of the studied area.

Subsurface drains were installed in three plots only as an auxiliary system coinciding with open drains to accelerate the leaching process. In each of the three plots, drain tubes of 10 cm diameter, perforated, polyethylene with synthetic materials were installed 50 ,70 and 90 cm below soil surface on a grade of 0.1 % and 50 m long. The diameter of the slot was 4 mm, the number of slots was 350 per m pipe length and the total open area was approximately 4400 mm^2 per m pipe length. The covered drains were spaced 12.5 m apart.

Spacing of the drains: The design of closed subsurface drainage system involves determination of depth, spacing and diameter of drains. Pipe spacing is roughly proportional to the permeability of sub-surface soil. A soil with low permeability requires close spacing and vice versa. Lateral drain spacing calculation in this flow condition is mainly dependent on steady state formula (Hooghoudt, 1940):

$$P = \left[\frac{4K(H^2 - h^2}{Q} \right]$$

Where: P = drain spacing (m), K = hydraulic conductivity (m/day), h = hydraulic head or water table elevation above drain level midway between two laterals (m), Q = discharge rate per unit surface area (m/day). The hydraulic conductivity was 1.62 cm/day; the obtained value of K is low due to the high percentage of clay content which is approximately 40.81 % of the soil.

The drainage discharge criteria (q) used in the Nile Delta is 1 mm/day, depth of dewatering zone to reduce capillary salinization for heavy clay soil as recommended by FAO (1980) is 1.2 m and consequently design of hydraulic head (h) is 0.3 m. Applying the Hooghoudt's equation and substituting the values of k, h, q and d; using trial and error procedure; the lateral drain spacing was 6.25 m. According to the previous results, in the current study, the lateral drain spacing was designed as recommended by FAO (1980) by using the calculated lateral drain spacing (P = 6.25 m) and double spacing (P = 12.5 m).

Soil sampling and analyses: Surface (0- 30 cm) soil sample was taken from each experimental plot before planting and after plants harvesting. Each soil sample was air–dried separately and analyzed for some physical, chemical properties and also for its content of some available macro-micronutrients according to the methods described by Cottenie *et al.,* (1982), Page *et al.,* (1982) and Klute (1986). Some physical and chemical properties of the experimental soil shown in Table (1).

Table (1) Physical and Chemical properties of soil under study before cultivation.

Course sand (%)	Fine sand (%)	Silt (%)		Clay (%)	Texture	O.M (%)	ESP (%)	$CaCO_3$ (%)
2.36	25.98	30.85		40.81	Clay	0.56	19.59	8.93
Bulk density (g/m^3)		F.C. (%)			W.P. (%)		A.W. (%)	
1.47		20.75			11.63		12.97	
Chemical analysis								
pH (1:2:5)	EC (dS/m)	Cations (meq/l)				Anions (meq/l)		
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}
8.12	12.59	14.26	25.10	85.75	0.79	10.67	70.66	44.57
Macronutrients (mg/kg)			Micronutrients (mg/kg)					
N	P	K	Fe		Mn		Zn	
38.22	3.19	195	5.19		1.07		0.66	

Irrigation and drainage water: Irrigation water from El-Salam canal (1:1) Nile water mixed with agriculture drainage water at each application samples of irrigation water were taken as well as samples from the drainage ducts. The chemical analysis of irrigation water and drainage water were determined during maize and wheat planting according to same methods of soil analysis.

Experimental procedure: Irrigation unit consists of gasoline engine 4.1 kW (5.5 hp) and pump 3/3"with discharge rate of 25 m^3/h followed by flow meter 3 inches was used to measure the discharge of water. Application rate of irrigation adding by 15 cm of water depth (75 m^3/plot) one irrigation per two weeks intervals. Surface drainage is used after each rotation to remove visible crusts of salt on the surface of salt affected soils and the excess water is drained.

The application of gypsum was mixed thoroughly in soil with plough during soil preparation before 25 days of maize planting at the rate of 5 $Mg.fed^{-1}$. The experimental plots units are subjected to some pretreatments processes as follows: a) leveling the soil surface by using lazar technique. b) Deep sub-soiling plough. c) Drainage water flow towards the main collectors of 2 m in depth and d) establishment of an irrigation canal in the middle part of the experimental pilot unit.

In both seasons, each experiment was carried out in a split plot design with three replicates. The used two drains types system was a ranged randomly as main plot, where the levels of depths were distributed randomly as sub plot.

The two tested crops (maize and wheat) which obtained from Crop Institute Agriculture Research Center, Giza, Egypt.

Grains maize (Zea mays L) cultivar was variety single hybrid 10 was sown on 15^{th} May 2014 and harvest in 25 September 2014. Wheat grains (Masr 2) were sown on 25^{th} of November 2014/2015 and harvest on 5 may 2015. Mineral fertilizer used as urea (46 % N) at application at rate of 100 kg N/fed where it's applied in three doses after 21, 45 and 60 days after sowing. Super phosphate (15.5% P_2O_5) was added at 200 kg /fed during soil tillage. Potassium sulphate (48 % K_2O) was added on two equal doses after 21 and 45 days from planting.

Annual rainfall approximately 50 mm. Maximum temperatures during July-August is 41 to 46 ^oC and minimum temperature during December–January is 10 to 22 ^oC.

Actual water consumptive use (CU):

Actual water consumptive use (CU) of wheat crop was determined. Gravimetric soil samples, from soil surface down to 60 cm depth, were collected after sowing, before and after each irrigation and at harvest time to determine water consumptive use values. The CU value was calculated according to Israelsen and Hansen, (1962) as follows:

$$CU = \sum_{i=1}^{i=4} \frac{(\theta_2 - \theta_1)}{100} \times \rho_b \times D \quad ....(1)$$

Where:

CU = seasonal water consumptive use (cm),

θ_2 = soil moisture content after irrigation (on mass basis, %),

θ_1 = soil moisture content before irrigation (on mass basis, %),

ρb = Soil bulk density (g/cm^3),

D = Depth of soil layer (15 cm each), and

i = Number of soil layer.

Water Use Efficiency "WUE"

Water use efficiency (WUE) was determined according to Awady et al. (1976) and Bos (1980) using the following equation:

$$WUE = \frac{Average\ yield\ \ kg/fed}{Amount\ of\ applied\ \ water\ \ m^3/fed} \quad kg/m^3 \quad ......(2)$$

Obtained results were subjected to statistical analysis according to Snedecor and Cochran (1980) and the treatments were compared by using the least significant difference (L.S.D. at 0.05 level of probability).

RESULTS AND DISCUSSION

Chemical characteristics of irrigation and drainage water during the two seasons:

Electrical Conductivity (EC):

Total soluble salts of the studied irrigation water and drainage water are presented in Tables (2, 3, 4 and 5). The data obtained reveal that EC values are more affected by both irrigation water and drainage water during two seasons, where the recorded values ranged between 1.73 and 1.99 (dSm^{-1}) for irrigation water while drainage water recorded 5.63 and 7.04 (dSm^{-1}) for open drain system and 6.83 and 7.52 (dSm^{-1}) for covered drain during maize planting in summer season. Also, the electrical conductivity in irrigation water and drainage water from drain types recoded values ranged between 1.28 and 1.69 (dSm^{-1}) for irrigation water, while drainage water for open drain was 3.40 and 4.58 (dSm^{-1}) and 3.83 and 5.02 (dSm^{-1}) for covered drain during wheat planting in winter season. The corresponding relative increases of mean values of EC (dSm^{-1}) in drainage water for two types drains and different depths of drain were 199.47, 234.57 and 274.47 % for open drain with depth 50, 70 and 90 cm respectively, compared with mean values of EC (dSm^{-1}) irrigation water, while the mean values EC (dSm^{-1}) of covered drain were 263.30, 275.00 and 300.00 % for drain depths 50, 70 and 90 cm respectively , compared with mean values of EC (dSm^{-1}) irrigation water during maize planting in summer season. On the other hand, the relative increases of mean values drainage water was 122.2, 170.59 and 199.35 % for open drain and 150.33, 197.39 and 228.10 % for covered drain with depths 50, 70 and 90 cm, respectively compared with EC (dSm^{-1}) in irrigation water during wheat planting in winter season. The EC (dSm^{-1}) in irrigation water and in drainage water increase in summer season than winter season. These results are in agreement with Ahmed (2013) reported that the values of EC drainage water increased in summer season in comparison with other seasons and this may be because high temperature and high evaporation in the summer season. Shaban(2005) , found that the ECiw values were increased or decreased according to the seasonal variations for the different cultivated crops.

Table (2) Chemical analysis of irrigation water from El-Salam Canal during maize planting.

Properties	El-Salam Canal				Mean
	May	June	July	September	
PH	8.00	8.03	8.04	8.02	
EC ($dS\ m^{-1}$)	1.85	1.96	1.99	1.73	1.88
$NO_3(mgL^{-1})$	19.67	22.45	20.97	17.63	20.18
$NH_4(mgL^{-1})$	9.85	10.67	13.22	11.88	11.41
P (mgL^{-1})	5.47	6.99	7.15	6.22	6.46
K (mgL^{-1})	7.88	8.60	9.14	8.37	8.50
Fe (mgL^{-1})	3.49	3.69	4.02	3.94	3.79
Mn (mg^{L-1})	1.98	2.14	2.88	2.71	2.43
Zn (mgL^{-1})	0.58	0.63	0.69	0.72	0.66

Table (3). Chemical analysis of irrigation water from El-Salam Canal in during wheat planting.

Properties	El-Salam Canal				Mean
	December	February	March	April	
PH	7.98	7.99	8.02	8.01	
EC ($dS\ m^{-1}$)	1.65	1.28	1.48	1.69	1.53
$NO_3(mgL^{-1})$	14.52	18.63	19.22	15.37	16.94
$NH_4(mgL^{-1})$	7.26	9.41	12.67	10.85	10.05
P (mgL^{-1})	4.29	5.14	5.88	4.93	5.06
K (mgL^{-1})	7.26	8.43	9.10	8.52	8.33
Fe (mgL^{-1})	2.85	2.89	2.93	2.98	2.91
Mn (mg^{L-1})	0.99	1.06	1.18	1.34	1.14
Zn (mgL^{-1})	0.60	0.63	0.68	0.71	0.66

pH of irrigation water and drainage water:

Regarding the pH values of the studied irrigation water and drainage water, data presented in Tables (2,3,4 and 5) show that the pH values ranged between 8.00 and 8.02 for irrigation water during maize planting in summer season, while , the pH values of irrigation water during wheat planting in winter season was 7.98 and 8.02. As well as, the pH values in drainage water values ranged between 8.08 to 8.04 for open drain and 8.34 to 8.19 for covered drain during maize planting. On the other hand, the pH in drainage water during wheat planting ranged 8.07 to 8.03 for open drain, while pH value ranged 8.19 to 8.34 for covered drain. It is clear that pH value of the different water (irrigation water and drainage water) falls in the normal range of limitation as described by Ayers and Westcot (1985). Bauder et al. (2006) found that the normal pH range for irrigation water varied from 6.5 to 8.4.

Table (4). The mean values of pH, EC, Macro-Micronutrients contents in drainage water during maize planting

Drain depth (cm)	pH	EC (dSm^{-1})	Macronutrients (mg/L)				Micronutrients (mg/L)		
			NO_3-N	NH_4-N	P	K	Fe	Mn	Zn
	Open drain								
50	8.04	5.63	20.98	9.78	6.96	7.85	4.40	2.86	1.27
70	8.05	6.29	19.46	9.38	6.46	7.56	4.21	2.69	1.21
90	8.08	7.04	18.50	8.67	6.11	7.25	3.97	2.52	1.16
Covered drain									
50	8.19	6.83	21.71	12.76	6.27	7.39	3.72	2.50	1.02
70	8.25	7.05	21.05	11.69	5.71	6.91	3.47	2.33	1.00
90	8.34	7.52	20.53	10.69	5.04	6.59	3.30	2.18	0.85

Table (5). The mean values of pH, EC, Macro-Micronutrients contents in drainage water during wheat planting

Drain depth (cm)	pH	EC (dSm^{-1})	Macronutrients (mg/L)				Micronutrients (mg/L)		
			NO_3-N	NH_4-N	P	K	Fe	Mn	Zn
	Open drain								
50	8.03	3.40	24.09	15.04	4.71	8.54	3.25	1.77	0.83
70	8.05	4.14	21.94	13.73	4.16	8.33	3.10	1.64	0.78
90	8.07	4.58	20.76	11.45	3.91	7.85	2.91	1.52	0.70
Covered drain									
50	8.09	3.83	22.71	12.76	4.17	6.39	3.12	2.45	0.72
70	8.15	4.55	21.65	11.69	3.83	5.95	3.07	2.37	0.71
90	8.14	5.02	20.72	10.69	3.55	5.35	2.68	2.29	0.65

Macronutrients content in irrigation and drainage water during maize and wheat planting.

The concentrations of NO_3-N and NH_4-N in the studied irrigation water and drainage water at various sampling depths during maize and wheat cultivation are presented in Tables (2, 3, 4 and 5). The data obtained show that the NH_4-N content in irrigation water ranged between 9.85 and 13.22 (mgL^{-1}), while, the ranged between during wheat planting 7.26 to 12.67 (mgL^{-1}). The highest NH_4-N values 13.22 (mgL^{-1}) in July month during maize planting, while, 12.67 (mgL^{-1}) in March month during wheat planting. Nitrate leaching is one of the processes concern for common reasons that impact on groundwater quality, where nitrate is the most common high found in groundwater. The NH_4-N concentration was increased in drainage water during wheat planting than maize planting for both type drain systems. The reasons for the geographical different in NH_4-N content in irrigation and derange water may be primarily due to nitrification.

Concerning NO_3-N concentrations in the irrigation and drainage water during maize and wheat planting presented in Tables (2, 3, 4 and 5). Data indicated that its values ranged between 17.63 and 22.45 (mgL^{-1}) in irrigation water during maize planting, while values ranged between 15.52 and 19.22 (mgL^{-1}) contents in irrigation water during wheat planting. Also, NO_3-N values ranged between 18.50 and 20.98 (mgL^{-1}) contents in drainage water for open drain and 20.53 and 21.71 (mgL^{-1}) contents in drainage water for covered drain during maize planting. On the other hand, the NO_3-N values content in drainage water was ranged between 20.76 and 24.90 (mgL^{-1}) for open drain and the values ranged between 20.53 and 20.71(mgL^{-1}) for covered drain. The NO_3-N concentration in irrigation water increase in summer seasons these the winter season , while the NO_3-N content in drainage water in both drain types systems increase in winter season than summer season (wheat planting than maize planting) . Abd Alrahman et al (2011) found that the nitrate (NO_3-N) in irrigation water often occurs at higher concentrations than ammonia in irrigation water. Nitrate in irrigation water and water table are generally associated with usage of nitrogen fertilizer. The NO_3-N and NH_4-N contents in drainage water were increase with decreasing depth of drain system. These results are in agreement by (Moriasi et al, 2013) suggested that the nitrogen dissolve into surface and groundwater as it passes through the soil column show that a decrease in drain depth from 1.5 to 0.9 meters decreased nitrogen losses by 14%. There was little change resulting from drains placed deeper than 1.2 meters. At this depth, most of the water has naturally drained from the soils. Skaggs (2003) indicated that the increasing the drain spacing or decreasing the drain depth reduced nitrate nitrogen drainage losses and net mineralization and at the same time increased denitrification and runoff losses.

Phosphorus content in irrigation water and drainage water during maize and wheat planting.

Data presented in Tables (2,3,4 and 5) show that the P content in irrigation and drainage water at various period during maize and wheat cultivation ranged between 5.47 and 7.15 (mgL^{-1}) for irrigation water during maize planting, while the P ranged between 4.29 and 5.88 (mgL^{-1}) for irrigation water during wheat planting. The highest value was found in summer season than winter season. On the other hand, the P content in drainage water value ranged between 6.11 and 6.96 (mgL^{-1}) for open drain and 5.04 and 6.27 (mgL^{-1}) for covered drain during maize planting , while the P content in drainage water value ranged between 3.91 and 4.71 (mgL^{-1}) for open drain and 3.55 and 4.17 (mgL^{-1}) for covered drain during wheat planting. The P content was increase in drainage water during maize planting than wheat planting. Shaban (2005) found that the P concentration in drainage water or El-Salam Canal greatly variations according to sampling period, where it increases in the summer seasons than winter season. Abd Alrahman et al (2011) indicated that the P in irrigation water often occurs at higher concentrations. Phosphate in irrigation water and water table are generally associated with usage of phosphorus fertilizers.

In general the P content tend to increase in irrigation water periods according to the following July > June > September > May during maize planting, while March > February > April > December during wheat planting. It is noticed that the P concentration in drainage water showed greatly variation according to samples depth drain, where it increases during maize and wheat planting 50 > 70 > 90 cm for open and covered drain. The P increase content in drainage water for open drain than covered drain in both seasons.

Potassium content in irrigation water and drainage water.

The content of K in irrigation water and drainage water as drains type and depth (50 - 70 and 90 cm) during maize and wheat planting are presented in Tables (2, 3, 4 and5). Data show that K content in irrigation water ranged between 7.88 and 9.14 (mgL^{-1}) during maize planting and 7.26 and 9.10 (mgL^{-1}) during wheat planting. The highest value of K increase in irrigation water July and March months. On the other hand, The K concentration in drainage water values ranged between 7.25 and 7.85 (mgL^{-1}) for open drain and 6.59 and 7.85 (mgL^{-1}) for covered drain during maize planting, while the K content in drainage water value ranged between 7.85 and 8.54 (mgL^{-1}) for open drain and 5.35 and 6.39 for covered drain during wheat planting. The highest values of K concentration in drainage water were 9.78 (mgL^{-1}) for open drain depth 50 cm and 6.27 (mgL^{-1}) for covered drain during maize planting. Also, the highest value of K content in drainage water 4.71 and 4.17 (mgL^{-1}) for open and covered drain depth 50 cm during wheat planting. These results are in agreement by Shaban (2005).

Micronutrients content in irrigation water and drainage water.

Data in Tables (2, 3, 4 and 5) show that the concentration of Fe, Mn and Zn in all water, i.e. irrigation and drainage water as affected by the two type's drains of different depths was increased in summer season than winter season. On the other hand, the concentration of Fe, Mn and Zn in drainage water from open drain and covered drain increased with at the lowest depth of drain during both seasons (maize and wheat planting). The concentration of Fe, Mn and Zn in irrigation water or drainage water are presented within safe or permissible limits. These obtained data are in agreement with those obtained by FAO (1992) and Farag and Mehana (2000).

Also, the recommended limits of trace elements (Table 6) in irrigation and drainage water show relatively low contents.

Table (6): Trace element limits after National Academy of Engineering (1972).

Element	Symbol	Long – term use (mg/L)*	Short - term use (mg/L)**
Iron	Fe	5.0	15 .0
Manganese	Mn	0.2	10.0
Zinc	Zn	2.0	1.0

*** For water used continuously on all soils.**

**** For water used a period of up to 20 years fine – textured neutral or alkaline soils.**

Effect of different drains types and depths on some soil properties:

Electric conductivity EC (dSm^{-1}):

Drainage system (open and covered drain) helps reclaiming salt affected soils by lowering water-table and consequently leaching down salts and creating aerobic conditions to sustain agriculture and decrease of EC soil around the root zone. The results in Table (7) shows that the EC in different depths indicated that there was a decrease in soil salinity. The corresponding relative decrease of mean values of soil salinity (EC) was 42, 39 and 36 % for drains depth (50, 70 and 90 cm) after maize harvest compared with initial soil. The relative reduced in mean values of soil salinity after wheat harvest was 54, 51 and 49 % for drains depth (50, 70 and 90 cm) compared with initial soil. The decrease in EC in this drain depth 50 cm is possibility due to leaching down of salts from upper depth (30 cm). The increase of soil salinity after maize harvest reflected to saline groundwater areas, even if leaching occurs, salts enter the top soil evaporation during the summer season (maize crop) compared with winter season (wheat crop). On the other hand, the EC (dSm^{-1}) values decreased in the winter season from 6.47 and 5.77 dSm^{-1} when the wheat was irrigated with El-Salam Canal (agriculture drainage water mixed with Nile water 1:1) for soil treated with open drain, while the EC values decrease in the first season summer from 8.30 and 7.11 dSm^{-1}, when the maize was irrigated with El-Salam Canal in soil treated with covered drain. These results are in agreement by Jodhao *et al.,* 2009 indicated that the soil salinity reduction was 28, 24 and 10 % with 20, 60 and 120 cm drain depth respectively. Kale (2012) reported that the impact of subsurface drainage on soil salinity after wheat harvest were decrease in soil salinity. The depth of the water table decreased rapidly to 68 cm for wheat after installing proper drainage system. The installation of drainage system helps maintaining the salt balanced and improvement in the salinity status of various fields, Raza and Chaudhry, 1998).

Table (7). Effect of drain type and depth on pH, EC (dSm-1) and macro-micronutrients content in soil after maize and wheat harvest.

Treatments	Drain depth (cm)	pH (1:2.5)	EC (dSm^{-1})	Available macronutrients ($mg\ kg^{-1}$)			Available micronutrients ($mg\ kg^{-1}$)		
				N	P	K	Fe	Mn	Zn
Summer (2014) after Maize harvest									
Open Drain	50	7.93	6.94	46.85	3.99	220.00	6.39	1.82	0.86
Covered Drain		8.00	7.61	44.45	3.82	212.25	6.11	1.61	0.79
Open Drain	70	7.98	7.51	44.80	4.02	211.25	6.28	1.71	0.81
Covered Drain		8.02	7.96	42.25	3.69	207.75	6.07	1.51	0.75
Open Drain	90	8.02	7.94	43.52	4.02	208.50	6.21	1.61	0.75
Covered Drain		8.02	8.30	40.81	3.85	204.75	6.07	1.42	0.73
LSD. 5% drain depth			Ns	Ns	Ns	9.5	Ns	0.19	0.091
Drain type			Ns	Ns	Ns	Ns	Ns	Ns	Ns
Interaction			Ns	Ns	Ns	Ns	Ns	Ns	Ns
Winter 2014 /2015 after wheat harvest									
Open Drain	50	7.87	5.77	54.15	3.70	219.25	6.72	1.77	0.84
Covered Drain		7.99	5.89	46.45	3.46	217.75	6.32	1.70	0.82
Open Drain	70	7.94	6.18	48.07	3.59	213.25	6.65	1.71	0.80
Covered Drain		8.02	6.17	45.60	3.36	213.00	6.22	1.64	0.78
Open Drain	90	7.97	6.47	44.52	3.50	211.00	6.54	1.63	0.76
Covered Drain		8.03	6.40	43.54	3.34	209.75	6.18	1.59	0.74
LSD. 5% drain depth			Ns	3.23	Ns	Ns	Ns	Ns	0.077
Drain type			Ns	Ns	Ns	Ns	Ns	Ns	Ns
Interaction			Ns	Ns	Ns	Ns	Ns	Ns	Ns

It can be stated in a general way that the more increase of the drainage depth (90cm) is the higher electrical conductivity of soil in both seasons. These results indicate the possibility of further improvements in soil salinity and soil properties, which indicating that open and covered drain systems is important of the decrease for groundwater levels.

Soil pH:

Results revealed that the values of pH in soil have decreases, as affected by the studied treatments compared with control. Application of gypsum combined with different depths of drains type system led to decreases of the pH values in winter (wheat) than summer season (maize). On the other hand, the soil pH was reduced due to the addition of gypsum under different drains type systems the reduction pronounced of decrease depth drain type system where the pH dropped from 8.02 to 7.93 for open drain depth 90 cm and 50 cm, while the value of soil pH ranged between 8.02 to 8.00 for covered drain depth at 50 and 90 cm after maize harvest. Concerning, that the soil pH in the soil irrigated with El-Salam Canal, data showd that pH values fluctuate in an arrow range for different depth drain during winter season ranged between 7.97 to 7.87 for open drain with 90 and 50cm, while the soil pH ranged between 8.03 and 7.99 for covered drain after for wheat harvest. It is also found that soil pH tends to increase slightly after the two crops harvest. The soils of all experimental pilot units are characterized by slightly to moderately alkaline conditions. These results are in agreement by Wahdan et al (1999). Joachim and Hubert (2010) indicated that the application of gypsum ($Ca_2SO_4.2H_2O$ in saline-sodic and sodic soils led to reducing of pH. Ayub et al. (2007) reported that the gypsum reduced soil pH slowly from (8.5 – 7.5) in about 20 weeks. Through the process of decomposition, the reaction of CO_2 with H_2O forms both organic (H_2CO_3) and inorganic acids (H_2SO_4, HNO_3) which are potential suppliers of hydrogen ions in the soil encouraging the development of acidic cations. There is a generally decreasing trend in soil pH with increasing number of years in cultivation as soils tend to be slightly leached and become acidic in reaction (Jaiyeoba, 2003). Emiru and Heluf (2012) indicated that the increasing clay percentage with depth also has the tendency to furnish hydrogen ions from clay colloidal surfaces to the soil solution again reducing which finally reduce soil pH.

Macronutrient content in soil:

The obtained data in Table (7) indicated also that using of open and covered drainage system under different depths in N, P and K available contents in soil after both maize and wheat were increase with all treatments after wheat harvest than maize harvest. The effect of drain depth on available of K content in soil was significant, while the N and P were no significant after maize harvest. The interaction between drain type and drain depth on N, P and K contents in soil were no significant. On the other hand the available N content in soil was significant increase as affected by drain depth and drain type alone or the interaction between drain type and drain depth, while the P and K no significant with all treatments after wheat harvest. As well as, the interaction between types of drain system and drain depths were no significantly effect on N, P and K content in soil.

The corresponding relative increase of values available N content in soil was 22.58, 17.22 and 13.87 %for open drain depths 50, 70 and 90 cm respectively after maize harvest compared with N content in initial soil, while the relative increase of values available N content in soil was 16.30, 10.54 and 6.78 % for covered drain depths 50, 70 and 90 cm respectively after maize harvest compared with N content in soil initial. As, well as, the relative increase of P content in soil values was 25.08, 26.02 and 26.02 % for open drain depths 50, 70 and 90 cm respectively after maize harvest compared with P content in initial soil, while the relative increase of P content in soil values as affected by covered drain was 19.75, 15.67 and 20.69 % for drain depths 50, 70 and 90 cm respectively after maize harvest compared with P content in initial soil. The corresponding relative increases of K content in soil reached 12.82, 8.33 and 6.92 % for open drain depths 50, 70 and 90 cm respectively, while the relative increases of K content in soil values was 8.85, 6.54 and 5.00 % for covered drain respectively after maize harvest, than K content in initial soil. Corresponding relative increases of N, P and K available content in soil after wheat harvest were 41.68, 25.77 and 16.48 % for N ; 15.99, 12.54 and 9.72 for P and 12.44, 9.36 and 8.21 for K in soil as affected by open drain depths 50, 70 and 90 cm respectively compared with N, P and K content in initial soil. On the other hand, the relative increases of values were 21.53, 19.31 and 13.92 % for N ; 8.46, 5.33 and 4.70 % for P and 11.67, 9.23 and 7.56 % for K content in soil as affected by covered drain respectively after wheat harvest compared with N, P and K content in initial soil. This is a true, since open drain is directly with depth (50 cm) which is more enrichment N, P and K content in soil during both seasons, than other treatments. These results are in agreement by Sharma et al (2000) reported that the increase of available N, P and K content in soil differently in the three drain spacing (20- 50 and 75 m). El-Shal et al. (2015) reported that the increase of macronutrients available in soil under low space drain system after wheat harvest. Jodhao et al (2009) found that the maximum increase in potassium content was recorded with 15 m drain spacing and 60 cm depth.

Available of micronutrients in the studied soil:

Data presented in Table (7) show that the pronounced increases in soil available micronutrients contents Fe, Mn and Zn (mg kg^{-1}) as affected by two drain types and different drain depths were achieved as a result of open and covered drains for depth 50 cm. This is more related may be attributed to the increase of organic matter, biochemical and chemical changes, which led to released more available micronutrients in surface layer. The highest values of Fe, Mn and Zn were open and covered drains for depth 50 cm all studied and tend to decrease with drain increase depth. This is manly due to their surface accumulations from the irrigation water used, as well as, soil management practices and micro-organisms activities in topsoil's, which positively affected the availability of these elements in the soil. The corresponding relative increases of values were 23.12; 21.00 and 19.65 % for Fe ; 70.09 ; 59.81 and 50.47 % for Mn and 30.30, 22.73 and 13.64 % for Zn content in soil treated with open drain depths 50, 70 and 90 cm respectively after maize harvest, compared with soil initial. Concerning, the relative increases of values were 17.73, 16.96 and 16.96 % for Fe; 50.47; 41.12 and 32.71 % for Mn and 19.70; 13.64 and 10.61 % for Zn respectively in soil treated with covered after maize harvest than initial soil. As for the change in the available contents of Fe, Mn and Zn in soil as affected by type drains and different depth under wheat cultivation, data presented in Table (7) show that using the open and covered drains for depth 50 cm led to increases of available Fe, Mn and Zn in soil after wheat harvest than other drain depths. The corresponding, relative increases of values were 29.48, 28.13 and 26.01% for Fe; 65.42, 59.81 and 52.34 % for Mn and 27.27, 21.21 and 15.15 % for Zn in soil treated with open drain depths 50, 70 and 90 cm respectively , compared with initial soil. Also, the relative increases of values were 21.77, 19.85 and 19.08 % for Fe; 58.88, 53.27 and 48.60 % for Mn and 24.24, 18.18 and 12.12 % for Zn in soil treated with covered drain of depth 50, 70 and 90 cm respectively after wheat harvest compared with initial soil.

In general, the positive effect of the used two drain types system and different drain depths under both maize and wheat crops on available Fe, Mn and Zn in soil. The highest relative increase of Fe (%) content in soil treated with open drain after wheat harvest, while the relative increases of Mn and Zn (%) were increase in soil after maize harvest. The relative increases of Fe, Mn and Zn percentage in soil treated with covered drain after wheat harvest than maize harvest. The increase or decrease in available micronutrient concentrations in the studied soil attributed to increasing rates of gypsum, type drain depths and decreased of soil pH.

Finally , from the obtained data it can be concluded that , a) the tested type drains can be used El-Salam canal irrigation water and leaching process of saline soil also, its can be used the irrigation theses soil especially after wheat planting. b) These irrigation water contents of micronutrients were safe limits, c) The accumulation of micronutrients in soil followed by irrigation water of soil were high where their increased with decrease the drain depth and d) The accumulation of micronutrients related to El-Salam canal used drains type, drain depths and soil depth during maize and wheat cultivated . These results are in agreement by Shaban (2005) found that the soil available Fe, Mn and Zn increased by irrigated with El-Salam canal after rice and wheat planting. El-Shikh (2003) and Abou Hussien and Shaban (2008) they also observed that, the content of these trace elements was decreased with the increase of soil depth.

Effect of type and depth of drains on maize and wheat productivity:

The results obtained of different depths of type drains system used in saline soil status positive or negatively reflected on plants growth and turn their yields of straw and grains. Directly an effect of drain depths and type drains system on growth of maize and wheat yields. Data presented in Table (8) show that the values of straw yield (Mg fed^{-1}) and grain yield (Mg fed^{-1}) of both studied crops increased with decreasing drain depth, due to rapidly of leaching and more reduction in soil salinity around root zone. The yields of maize and wheat straw and grains tend to increase as a result of reduction of soil salinity and increase of nutrients stability in root zone. As well as, the effect of drains type and different depth on straw, grains yield (Mg fed^{-1}) and 1000 grain (g) of maize were increased significantly with decreasing depth of both drains type.

The interaction between drains type and depths of drain on straw, grain yield of maize and 1000 grains were significant increase with decreasing depth and type of drains. While the effect of different depth drain and drains type on straw and grains yield (Mg fed^{-1}) and 1000 grains (g) were significant increase expect straw yield was no significant as affected depth drains. The interaction between drains type and depth drains were significant increase. Also, the relative increases in straw yield of maize and wheat for soil treated with open drain were 5.65 and 2.33 %, while the relative increases in straw yield of wheat were 22.18 and 2.39 % for drain depths 50 and 70 cm compared with drain depth of 90 cm. Also, the relative increases in straw yield of maize and wheat in soil treated with covered drain were 2.69 and 1.01 % of maize straw yield, while the relative increases in straw yield of wheat were 32.27 and 15.45 % for drain depths 50 and 70 cm compared with drain depth of 90 cm.

Table (8) yield straw, yield weight and weight of 1000 grains for maize and wheat plants.

Treatments	Drain depth (Cm)	Weight of straw yield (Mg/fed)	Weight of grains yield (Mg/fed)	Weight of 1000 grains (g)
Summer (2014) after Maize harvest				
Open Drain	50	3.180	1.359	85.420
Covered Drain		3.050	1.275	80.970
Mean		3.120	1.320	83.20 0
Open Drain	70	3.080	1.320	82.970
Covered Drain		3.000	1.2530	79.220
Mean		3.040	1.290	81.100
Open Drain	90	3.010	1.250	76.820
Covered Drain		2.970	1.1820	78.590
Mean		2.990	1.22 0	77.71 0
LSD. 5% drain depth		0.079	0.051	0.418
Drain type		0.064	0.042	0.341
Interaction		0.111	0.073	0.591
Winter 2014 /2015 after wheat harvest				
Open Drain	50	3.58	2.85	26.89
Covered Drain		2.91	1.66	24.98
Mean		3.25	2.26	25.94
Open Drain	70	3.00	2.60	25.88
Covered Drain		2.54	1.50	24.20
Mean		2.77	2.05	25.04
Open Drain	90	2.93	2.40	24.35
Covered Drain		2.20	1.49	23.18
Mean		2.57	1.95	23.77
LSD. 5% drain depth		ns	0.048	0.540
Drain type		0.329	0.039	0.441
Interaction		0.570	0.068	0.763

On the other hand, the relative increases in grains yield of maize and wheat under open drain conditions were 8.72 and 5.6 % of grain maize yield, while the relative increases of grain yield of wheat under open drain conditions were 18.75 and 8.33 % for drain depths 50 and 70 cm compared with drain depth 90 cm. Concerning the relative increases in grain yield of maize and wheat under covered drain were 7.87 and 6.01 % for grain yield of maize , while the relative increases of grain yield of wheat values were 11.41 and 0.67 % for covered drain depths 50 and 70 cm compared with depth drain 90 cm. These results are in agreement by Asad and Ahmed (2015) reported that the wheat yields will be increased to 1.10 to 2.00 ton ha^{-1} at groundwater decrease with increasing depth. As, well as, the maize yields obtained under existing irrigation and drainage conditions are far below than the potential of 3 ton ha^{-1}. Kale (2012) indicated a significant increase in wheat yield due to the subsurface drainage system. These results indicate the possibility of further improvements in soil salinity, soil properties, and crop yields in ensuing years, indicating that open and subsurface drainage system is a viable management option for waterlogged saline soil and high ground water level. The significant increase in crop yield and cropping intensity can be attributed to the direct effects of the introduction of open drainage system, which in turn lowered the water table and decreased the soil salinity by leaching out the soluble salts from the root zone, there by not only creating the favorable conditions in root zone but also making the nutrients available to the plants resulting in optimum plant growth and yield.

Actual water consumptive use (CU):

All treatments using surface irrigation system with constant application rate with maize and wheat cultivation and in the end of the experiment clear that actual water consumptive use (CU) was about 4250 m^3 for all treatments with maize and about 2500 m^3 with wheat crop because there was no difference between irrigation treatments.

On the other hand, the data in Table (9) shows the effect of different treatments drain type system and drain depth on yield. Data indicated that highest yield of maize crop (1359 kg/fed) was obtained by using open drain system with 50 cm drain depth. While the lowest value (1182 kg/fed) was obtained with the covered drain and 90 cm drain depth treatment. Also data indicated that, drain system and depth of drain had a significant effect on yield. Increasing depth of drain decreases yield, while also using open drain system in clay saline sodic soil increases yield. On the other hand, the same trend obtained with wheat crop yield, the highest yield (2850 kg/fed) was obtained by using open drain system with 50 cm drain depth. While the lowest value (1490 kg/fed) was obtained with the covered drain and 90 cm drain depth.

Water use efficiency (WUE):

Data in table (9) shows the water use efficiency (WUE) for the different treatments. WUE values with maize cultivation varied between 0.28 and 0.32 kg/m^3. The highest value was obtained with using open drain system with 50 cm drain depth; while the lowest value was obtained with the covered drain and 90 cm drain depth treatment. It has been noticed that drain depths and drain type systems had strong effect on yield and WUE. Increasing drain depths decreases yield and WUE. On the other hand the same trend obtained with wheat crop yield, the highest WUE value (1.14 kg/m^3) was obtained by using open drain system with 50 cm drain depth. While the lowest value (0.60 kg/m^3) was obtained with the covered drain and 90 cm drain depth. Finally the using of open drain system with lowest depth treatment produced maximum yield and WUE value with cultivation both maize and wheat.

Table (9): The effect of different treatments on yield and water use efficiency (WUE)

Treatments	Drain depth (Cm)	Yield, kg/fed	WUE, kg/m^3
Summer (2014) after Maize harvest			
Open Drain	50	1359	0.32
Covered Drain		1275	0.30
Open Drain	70	1320	0.31
Covered Drain		1253	0.29
Open Drain	90	1250	0.29
Covered Drain		1182	0.28
Winter 2014 /2015 after wheat harvest			
Open Drain	50	2850	1.14
Covered Drain		1660	0.66
Open Drain	70	2600	1.04
Covered Drain		1500	0.60
Open Drain	90	2400	0.96
Covered Drain		1890	0.60

Statistical analysis:

The regression analysis for the effect of drain type, and drain depths on maize and wheat crops yield cleared the high significant effect between the studied parameters interactions in crop yield. Also the analysis explain that the drain type and depths has the inversely proportion to the maize and wheat crop yield while the drain depth has a directly proportion. From the regression analysis the drain depth is the high effect on the maize and wheat crop yield then the drain type system.

CONCLUSION

In the experiment type drains treatment carried out in salt affected area along with water and soil chemical analysis, it is observed thus that open drain can be one of the most effective treatments for reclamation of saline soil if the El-Salam canal used for irrigation purpose is of good quality. The treatment with drains different depth was quite affectivity and it shows satisfactory results. The increase in straw and grains yield for soil treated with drains type decreased depth because leaching and remove of salt around in root zone and lower water table. Open drainage system is one of the best tools for permanent reclamation of water logged and saline soils. Drainage system helped to overcome the excessive remove the harmful salts are brought in by the irrigation water there by creating favorable conditions in the soil root zone to establish maize and wheat successfully in the second season. Open drainage system is technically feasible to reclaim water logged and saline soils and to sustain agricultural production in irrigated commands. Further, the Open drainage System needs frequent desalting of drains during summer months for effective functioning of the system. Thus, Open drainage system is one of the best tools for permanent reclamation of water and saline soils and the best system for increase water use efficiency (WUE) in sodic saline soil.

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تاثير اعماق الصرف المختلفة على بعض خصائص التربة الكميائية وانتاجية محصولى الذرة والقمح وكفاءة استخدام المياه فى الاراضى الملحية المستصلحة حديثا

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اجريت تجربتان حقليتان فى ارض طنية ملحية صودية فى قرية الرواد بسهل الحسينية – محافظة الشرقية اثناء الموسم الصيفى والشتوى ٢٠١٥/٢٠١٤ ، لدراسة تاثير نوعين مختلفين من نظم الصرف (الصرف المكشوف والصرف المغطى) مع اعماق صرف مختلفة وهى (٥٠ – ٧٠ - ٩٠ سم من سطح التربة) على بعض الخصائص الكيميائية للتربة وانتاجية محصولى الذرة والقمح و كفاءة استخدام المياة تحت ظروف ارض طينية ملحية صودية وذلك لاختيار افضل نظام صرف مع افضل عمق للمصرف.

اظهرت النتائج ان استخدام المصرف المكشوف والمغطى يودى الى انخفاض فى درجة حموضة التربة ودرجة ملوحة التربة مع العمق ٥٠ و٧٠ سم اكثر من العمق ٩٠ سم من سطح التربة بالاضافة الى استخدام المصرف المكشوف مع العمق ٥٠ و٧٠ سم ادى الى زيادة فى تيسر عناصر النتروجين – الفوسفور- البوتاسيوم- الحديد- المنجنيز – الزنك فى التربة الطينية الملحية الصودية بالمقارنة مع العمق ٩٠ سم للمصرف المكشوف.

كذلك وزن محصول القش والحبوب بالميجاجرام لكل فدان لكلا المحصولين (الذرة والقمح) ووزن الف حبة زاد زيادة معنوية مع المصرف المكشوف والعمق ٥٠ سم اكثر من العمق ٧٠ و٩٠ سم. وفى النهاية استخدام نظام المصرف المكشوف مع العمق الاقل يعطى اعلى انتاجية لمحصولى الذرة والقمح.

التوصيات، استخدام نظام المصرف المكشوف بعمق ٥٠ سم تحت سطح التربة مع اضافة الجبس الزراعى يودى الى تحسين صفات الأرض الطنية الملحية الصودية وزيادة الانتاجية وزيادة كفاءة استخدام المياة لمحصولى الذرة والقمح.