J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 14 (5):143 - 150, 2023

Journal of Soil Sciences and Agricultural Engineering

Journal homepage & Available online at: www.jssae.journals.ekb.eg

Improving Salt-Affected Soils for Enhanced Fodder Beet Productivity: Effects of Soil Conditioners and Tillage Techniques

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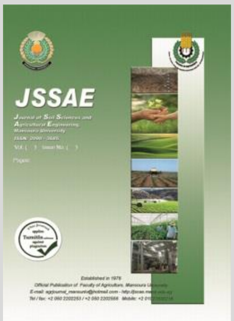

ABSTRACT

Due to the importance of improving salt-affected soils in Egypt's agricultural security policy, a field experiment was conducted in the winter of 2021/2022 at Kom Abou-Khallad village, Nasser district, Beni-Suef Governorate, Egypt, aiming to determine the impact of various amendments with various two-tillage systems on certain properties of salt-affected soils, as well as the growth and productivity of fodder beet (Beta vulgaris L.). Different amelioration techniques were applied using soil conditioners (natural gypsum, cement dust modified, phosphogypsum, and filter mud) that were carried out under two tillage systems, namely, shallow and deep (subsoil). The results show that subsoil tillage decreases bulk density and penetration resistance by about 7.75 and 13.6% and increases total porosity and hydraulic conductivity by about 7.31 and 7.7% over shallow tillage, respectively. increase available water by about 1.51 %, reduce pH, decrease ECe by about 12.47 %, decrease ESP by about 10.44 %, and increase soil organic matter by about 6.25 %, as well as increase the fresh yield of roots and shoots by about 22.75 and 34.32 %, respectively. The corresponding increases for dry roots and tops yields were 21.75 and 22.45%, respectively, for the nutrient uptake of fodder beet plants. The relative increment in total N, P, and K uptake reached 28.58, 29.27, and 30.87%, respectively. Treated fodder plants cultivated in salt-affected soil with soil conditioners, especially filter mud, at a rate of 18 mg ha^{-1} resulted in a decreased hazardous effect of salinity by improving soil properties, which consequently increased its productivity.

Keywords: Amelioration; deep tillage; gypsum; filter mud; fodder beet.

INTRODUCTION

Salinity is a global phenomenon that reduces arable land and has an effect on agricultural production, posing a danger to food security. According to Rahneshan *et al.*, (2018), the presence of salt in the rhizosphere causes an osmotic impact that restricts root water absorption. Salinity reduces the amount of chloroplasts in leaf cells and harms the structure of roots and leaves (Hasana and Miyake, 2017). Salinity and sodicity, on the other hand, have a harmful impact on the physical characteristics of the soil. It is a form of chemical deterioration of soil. It is one of the biggest problems restricting crop productivity in arid and semi-arid regions, which are characterized by low and inconsistent yearly rainfall, protracted dry periods, and high levels of evaporation, leading to salt buildup in the soil's top layer (FAO and ITPS, (2015) and Trabelsi *et al.*, 2019). Rising sea levels, an imbalance between groundwater withdrawal and yearly recharge, an increase in groundwater salinity used for irrigation, and salt accumulating in the soil might all be directly threatened by climate change (Mukhopadhyay *et al.*, 2021). About 1 billion hectares of land are affected by salts overall, and the tendency is rapidly rising (Ivushkin *et al.*, 2019). But nevertheless, sodicity issues present a hazard to 40–60% of these soils too though (Wicke *et al.*, (2011) and Tanji and Wallender, 2011). Eastern, western, and northern-central regions of the Nile Delta are where you may find the majority of Egypt's salt-affected soils. However, 25% of the soils in upper Egypt, 20% of those in the southern Delta and Middle Egypt, and 55% of those in the northern Delta have soils that are influenced by salt (Mohamed, 2017). In Egypt, saline soils are frequently improved as part of the agricultural strategy. Several solutions have been put into practice to lessen the issues with salt-affected soils, such as leaching, which is not only challenging but also costly and time-consuming. Also, it is unprofitable and makes the farmer maintain his property uncultivated for an extended period of time. A careful choice of various treatments and unique management techniques to reduce salinity may enhance and make soils suitable for farming. Gypsum, a common single-inorganic amendment, provides abundant Ca^{2+}, which replaces exchangeable Na^{+} in saline-sodic soils (Ahmad *et al.*, 2016). The improvement of saline-sodic soil through physical techniques like plowing, sub-soiling, or chemical supplements like gypsum is regarded as a useful technology (Hafez *et al.*, 2015). Additionally, because of their solubility, cheap cost, availability, and simplicity of handling, gypsum and organic matter are utilized to lessen the impacts of high sodium irrigation water in agricultural areas. In this concern, Wang *et al.*, (2019) stated that tillage at 20-50 cm depth, soil bulk density, and soil compaction were decreased, while it improved each macro aggregation (> 0.25 cm), the structure stability, and soil water storage, consequently increased maize yield. As a consequence of its long-term ameliorative effects on soil's physical, chemical, and biological qualities, the application of organic treatments may improve sustainability Taha and Abd Elhamed, (2021). In comparison to the addition of gypsum alone, the combination of gypsum plus organic matter to the topsoil will limit spontaneous dispersion and EC

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DOI: 10.21608/jssae.2023.202488.1156

down to the subsurface. In addition, it was discovered that phosphogypsum application decreased hydraulic conductivity, total porosity, EC, ESP, and pH. Additionally, it was discovered that phosphogypsum application reduced bulk density, pH, EC, ESP, and total porosity while increasing hydraulic conductivity, mean weight diameter of soil aggregates, geometric mean diameter, and water-stable aggregates Abdel-Fattah *et al.,* (2015). Additionally, (Alzamel *et al.,* 2022) the use of organic waste as a soil conditioner (filter mud) is thought to be environmentally suited for growing recovered soil that has been impacted by salt under difficult conditions in Egypt.

Fodder beet (*Beta vulgaris L.)* is Egypt's new winter forage crop. Due to its tolerance for high soil and water salinities, it is a particularly productive crop in salt-affected soils. The entire output, including the above- and below-ground components, is what may be directly fed to animals, particularly dairy cows, or it can be made into high-quality silage. Moreover, it has been claimed that the fodder beet plant may be used to produce silage. One of the most promising feed crops is fodder beet, which is advised for seeding in marginal regions like salty soil in addition to being a rich source of energy for dairy cows. A useful source of forage is fodder beet, particularly amid serious forage shortages like the summer in Egypt.

The major goals of this research were to enhance the growth of fodder beet (*Beta vulgaris*) and reduce the negative effects of salt stress. Additionally, this study seeks to evaluate how natural gypsum, cement dust, phosphogypsum, and filter mud under two tillage treatments might improve several physical and chemical aspects of salt-affected soil.

MATERIALS AND METHODS

Experimental work

This research was done in the 2021–2022 growing season in Kom Abou-Khallad village, Nasser district, Beni-Suef Governorate, Egypt (Latitude 29°12' N, Longitude 31° 2' E, and 24.1 m above sea level). The standard techniques described specified by A.O.A.C. (1990) were used to determine some of the physical and chemical characteristics of the selected soil, which are illustrated in Table (1).

Table 1. Some chemical and physical properties of the studied soil.

Soil characteristics	Values	Soil characteristics	Values
Particle size distribution (%)		Soluble cations (soil paste, m molcl^{-1})	
Sand	11.7	Ca^{2+}	15.65
Silt	25.5	Mg^{2+}	13.85
Clay	62.8	Na^{+}	47.79
Textural class	Clay	K^{+}	0.67
Soil chemical properties:		Soluble anions (soil paste, m molcl^{-1})	
Soil pH (soil paste)	8.61	CO_3^{2-}	---
ECe (dS/m. soil paste extract)	9.79	HCO_3^{-}	4.15
$CaCO_3$ %	8.64	Cl^{-}	57.32
Organic matter %	1.61	SO_4^{2-}	16.49
CEC cmolc k.g^{-1}	37.56	ESP %	14.62
Soil physical properties		Available macronutrients (mg kg^{-1})	
P.D Mg m^{-3}	2.70	N	16.46
B.D Mg m^{-3}	1.34	P	11.24
T.P %	48.13	K	184
Moisture % (w/w)			
Field capacity	43.45	Total soil N %	0.068
Wilting point	22.63	Gypsum requirement (Mg ha^{-1})	15.5
Available water	20.82	Hydraulic conductivity cm h^{-1}	0.13

The irrigation water resource used for the experiment was drainage saline water (C3-S1) ECe = 2.18 & SAR = 7.12.

The Experimental soil was planted with fodder beet, (*Beta vulgaris* C.V Brigadier) on 15 October 2021. All fodder beet plots received fertilizers according to the recommended dose of the Agricultural Ministry where nitrogen was applied at a rate of 286 kg N ha^{-1} as urea (46 % N) in three equal doses during the growing period (after 45 and 80 and 120 days) from planting, whereas P was applied at rates of 71 kg P_2O_5 ha^{-1} as superphosphate (15.5 % P_2O_5) before planting and K applied at a rate of 171 kg K_2O ha^{-1} as potassium sulphate (48 % K_2O) in two equal dosed, 114 kg K_2O ha^{-1} before planting and 57 kg K_2O ha^{-1} at three months later. A fodder beet was harvested on 25 May 2022.

Experimental design

The experimental design was a split-plot design in randomized complete block design in four replicates. The tillage treatments were arranged in the main plots, while gypsum as well as substitute material gypsum, i.e., cement dust, phosphogypsum, filter mud treatments were arranged in subplots as follows:

Main plots tillage system:

- No-tillage
- Tillage subsoil (50 cm)

Sub-plots (soil conditioners treatments as substitute or replacement natural gypsum):

T_1 = C = Control (without natural gypsum)
T_2 = NG= natural gypsum (100 G.R %, 15.50 Mg ha^{-1})
T_3 = CD1= cement dust (100 G.R %, 10.8 Mg ha^{-1})
T_4 = CD2= cement dust (50 G.R %, 5.4 Mg ha^{-1})
T_5 = PG1= phosphogypsum (100 G.R %, 13.2 Mg ha^{-1})
T_6 = PG2= phosphogypsum (50 G.R %, 6.6 Mg ha^{-1})
T_7 = FM1= filter mud (100 G.R %, 18 Mg ha^{-1})
T_8 = FM2= filter mud (50 G.R %, 9 Mg ha^{-1})

Natural gypsum

The Natural gypsum ($CaSO_4.2H_2O$, particles 1-2 mm) for agricultural gypsum requirements were received from the Agricultural Ministry. The Natural gypsum was added to plots and mixed with the surface layer (0-30 cm) during soil preparation processes at the rate NG (100 G.R %, 15.5 Mg ha^{-1}).

Cement dust (by-pass)

Cement dust (by-pass) is a highly soluble and reactive byproduct of the cement industry; kiln dust is also obtainable in limited quantities locally. Cement manufacturing is one of Egypt's greatest essential industries. Egypt manufactures approximately 48 million tons per annum annually discards approximately 3 million tons of cement dust. Cement dust was received from Wadi El Nile Cement Company from Beni-Suef governorate. Some characteristics of the used cement dust are presented in Table (2).

The Cement dust modified with commercial sulfuric acid (H_2SO_4) 98% (4 cement dust * 1 sulfuric acid 98% (w/w)) added to plots at rates CD1= Cement dust (100 G.R %, 10.8 Mg ha^{-1}) and CD2= Cement dust (50 G.R %, 5.4 Mg ha^{-1}) and thoroughly mixed with soil at the depth (0-30 cm) during soil preparation processes.

Table 2. The main chemical constituents of cement by-pass.

Constituent	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Cl
Conc. (%)	11.88	2.97	2.60	47.81	0.68	12.13	2.28	4.38	4.81

Phosphogypsum

Phosphogypsum is a waste byproduct of the phosphate rock processing used to make phosphoric acid and phosphate fertilizers such as superphosphate. The chemical solution phosphoric acid treatment method, often known as the 'wet process,' involves the digestion of phosphate ore with sulfuric acid to produce phosphoric acid and calcium sulphate, primarily in dihydrate form ($CaSO_4.2H_2O$). The phosphogypsum was added to plots at rate PG1= phosphogypsum (100 G.R %, 13.2 Mg ha^{-1}) and PG2= phosphogypsum (50 G.R %, 6.6 Mg ha^{-1}). Some chemical constituents in phosphogypsum are listed in Table (3).

Table 3. Some chemical constituents of phosphogypsum:

Constituents	Concentration %	
	Impure PG	Treated PG using H_2SO_4
CaO	28.31	33.81
SO_3	40.45	48.31
SiO_2	8.29	4.33
Al_2O_3	0.17	0.03
Fe_2O_3	0.31	0.02
MgO	0.21	0.005
P_2O_5	1.98	0.026
F	0.26	0.002
Na_2O	0.29	0.002
K_2O	0.02	0.003

Filter mud (press mud)

Filter mud waste by-products for sugar factories in Abu-Qurqas Centre located in the Minia Governorate of Egypt were used in this study at two levels (100 G.R %, 18 Mg ha^{-1}) and (50 G.R %, 9 Mg ha^{-1}). It is a soft, spongy, lightweight material of dark brown or dark gray. The Filter mud wastes were added to plots and thoroughly mixed with soil at the depth (0-30 cm) during soil preparation processes. Some chemical characteristics of the studied filter mud are determined in 1:5 water suspension according to A.O.A.C. (1990) and listed in Table (4).

Table 4. Some characteristics of filter mud (press mud):

Composition and characteristics	Filter mud (F.M)
Density (g cm^{-3})	0.26
SP (%)	324
pH (1: 5)	6.65
EC (1: 5) dS m^{-1}	5.07
Organic Carbon (%)	27.75
Organic matter (%)	47.84
C/N Ratio	12.50
Total nitrogen (%)	2.52
Total Phosphorous (%)	0.95
Potassium (%)	0.64
Total Ca (%)	5.14

Methods of analysis

Soil analysis

After harvesting soil samples from each plot were taken for physical and chemical analysis according to A.O.A.C. (1990).

Soil penetration resistance (SPR) was determined by a hand penetrometer device (Herrick and Jones, 2002).

The available water was calculated as follows: Available water (%) = field capacity (%) – wilting point (%).

Gypsum requirements were calculated using the Schoonover method (1952).

Plant analysis

Subsamples of fodder beet were ground in a stainless-steel mill and digested with H_2SO_4 and H_2O_2 and then the digested samples were analyzed for N, P, K, content according to A.O.A.C. (1990).

Some soil measurements:

Sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) were calculated using the following equation as reported by Richards (1954).

$$\boldsymbol{SAR} = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}} \quad \text{and} \quad \boldsymbol{ESP} = \frac{100(-0.01216+0.01475\,SAR)}{1+(-0.01216+0.01475\,SAR)}$$

Statistical analysis

The data obtained were subject to statistical analysis according to Snedecor and Cochran (1981) and the treatments were compared by using L.S.D. at 0.05 level of probability.

RESULTS AND DISCUSSION

Physical properties:

Data listed in Table (5) present the effect of some different amelioration techniques on some physical soil properties after fodder beet harvest. As for the main effect of tillage, the data clearly show that the studied physical properties, namely, bulk density, total porosity, hydraulic conductivity and penetration resistance were affected by the tillage system, where subsoil tillage improved these parameters more than shallow ones. Using subsoil tillage decreases bulk density and penetration resistance by about 7.75 and 13.6 % and increases total porosity and hydraulic conductivity by about 7.31 and 7.7 % over shallow tillage, respectively. The positive effect of deeper tillage on physical soil properties may be due to its effect on breaking soil clods and bigger granular to smaller ones besides cracking the hard pans, resulting to encourage the formation of large soil aggregates (Antar *et al.,* (2008) and Ordoñez-Morales *et al.,* 2019). These results are similar to those obtained by Gendy, (2011) and Deshesh, (2021). Regarding the main effect of the studied soil conditioners, the data in Table (5) show the addition of studied soil conditioners. In general, it could be arranged the effect of soil conditioners on the improvement of soil physical properties in descending order as follow: FM1>FM2>PG1>G>CD1>PG2>CD2>Control. It is obvious to notice that filter mud at 18 Mg ha^{-1} is the most effective conditioner for decreasing both bulk density and soil penetration resistance as well as increasing total porosity and hydraulic conductivity. The beneficial effect of soil conditioners on physical soil properties, especially filter mud may be attributed to the decomposition of the conditioners, consequently increasing exchangeable calcium, resulting to enhance aggregation formation, finally, improve the soils physical properties (Abd El-Hamid *et al.,* 2005). These results agree with those obtained by Mansour *et al.,* (2014) and

Abbady, (2022). Respecting the interaction effect, the data reveal that the physical soil properties after harvest was significantly affected by the interaction between the tillage system and soil conditioners, where using deep tillage enhanced the effect of soil conditioners on the physical properties.

Table 5. Effect of different amelioration techniques on some physical properties of soil after harvest:

Different amelioration technique		Fodder beet			
Tillage	**Soil conditioners**	**BD**	**TP**	**HC**	**SPR**
Shallow tillage (15 cm)	Control	1.35	50	0.150	3.98
	G	1.28	52.59	0.273	3.72
	CD1	1.29	52.22	0.272	3.75
	CD2	1.33	50.74	0.264	3.86
	PG1	1.27	52.96	0.275	3.69
	PG2	1.32	51.11	0.266	3.83
	FM1	1.22	54.81	0.285	3.54
	FM2	1.25	53.7	0.279	3.63
	Mean	1.29	52.27	0.26	3.75
Subsoil tillage (50 cm)	Control	1.24	54	0.211	3.48
	G	1.18	56.39	0.293	3.2
	CD1	1.19	56.04	0.291	3.23
	CD2	1.22	54.68	0.284	3.33
	PG1	1.17	56.73	0.295	3.18
	PG2	1.21	55.02	0.286	3.3
	FM1	1.12	58.43	0.304	3.05
	FM2	1.15	57.41	0.299	3.13
	Mean	1.19	56.09	0.28	3.24
Mean of soil conditioners	Control	1.30	52.00	0.181	3.73
	G	1.23	54.49	0.283	3.46
	CD1	1.24	54.13	0.282	3.49
	CD2	1.28	52.71	0.274	3.60
	PG1	1.22	54.85	0.285	3.44
	PG2	1.27	53.07	0.276	3.57
	FM1	1.17	56.62	0.295	3.30
	FM2	1.20	55.56	0.289	3.38
LSD 0.05	A	0.01	1.16	0.012	0.15
	B	0.01	0.22	0.011	0.02
	AB	0.01	0.31	0.015	0.03

C = Control (without natural gypsum)
NG= Natural gypsum (100 G.R %, 15.50 Mg ha^{-1})
CD1= Cement dust (100 G.R %, 10.8 Mg ha^{-1})
CD2= Cement dust (50 G.R %, 5.4 Mg ha^{-1})
PG1= Phosphogypsum (100 G.R %, 13.2 Mg ha^{-1})
PG2= Phosphogypsum (50 G.R %, 6.6 Mg ha^{-1})
FM1= Filter mud (100 G.R %, 18 Mg ha^{-1})
FM2= Filter mud (50 G.R %, 9 Mg ha^{-1})
BD = Bulk density (Mg m^{-3})
TP= Total porosity % **HC = Hydraulic conductivity mm h^{-1}**
SPR = Soil penetration resistance (MPa) at soil moisture contents (50%)

In general, the best values of soil physical properties were obtained for the treatment of the application of 18 Mg ha^{-1} filter mud under subsoil tillage. On the other hand, the treatment without the application of soil conditioners under sallow tillage exhibited the lowest effectiveness on the soil's physical properties. These results are in line with those obtained by Tabiehzad *et al.,* (2017) and Deshesh, (2021).

Chemical soil properties:

The effect of the tillage system and some soil conditioners on some chemical soil properties after fodder beet harvest was presented in Table (6). As the main effect of the tillage system, the data reveal that all studied soil chemical properties were significantly affected by the tillage system, whereas deeper tillage positively improved chemical soil properties. Compared with shallow tillage, subsoil tillage led to significantly decreasing soil pH, EC and ESP (%), while it increasing soil organic matter. The positive effect of deep tillage on improving chemical soil properties may be attributed to the effect of subsoil tillage on decreasing soil compaction (Thomas *et al.,* 2007). In addition, Sasal *et al.,* (2006) reported that increasing soil porosity due to deep tillage resulted in increasing the leaching processes, consequently enhancing plant growth, in turn increasing soil organic matter and decreasing soil salinity. These results are similar to those obtained by Sharma *et al.,* (2016) and Taha *et al.,* (2021). As for the primary impact of soil conditioners, the findings indicate that adding gypsum, modified cement dust, phosphogypsum, and filter mud to the fodder beet soil considerably improved soil pH, EC, ESP, and soil organic matter. As more conditioners were used, the effectiveness of those conditioners increased. Comparing with control added G, CD1, CD2, PG1, PG2, FM1, and FM2 decreased soil pH by 2.2, 1.1, 0.6, 1.3, 0.24, 1.1, and 0.85 %, respectively.

Table 6. Effect of different amelioration techniques on some chemical properties of soil after harvest:

Different amelioration technique		Fodder beet			
Tillage	**Soil conditioners**	**pH$_s$**	**EC$_e$ dS m^{-1}**	**ESP**	**OM %**
Shallow tillage (15 cm)	Control	8.32	8.77	14.20	1.45
	G	8.11	7.20	10.23	1.79
	CD1	8.19	7.25	12.32	1.77
	CD2	8.24	6.94	11.79	1.73
	PG1	8.18	7.09	12.04	1.80
	PG2	8.28	7.17	12.18	1.74
	FM1	8.20	6.47	10.99	1.95
	FM2	8.21	7.53	12.79	1.82
	Mean	8.22	7.30	12.07	1.76
Subsoil tillage (50 cm)	Control	8.22	7.63	13.26	1.47
	G	8.07	5.72	9.72	1.90
	CD1	8.16	6.19	10.32	1.89
	CD2	8.20	6.20	10.93	1.85
	PG1	8.14	6.05	10.28	1.91
	PG2	8.22	6.07	10.91	1.86
	FM1	8.16	5.95	10.11	2.12
	FM2	8.18	6.45	10.96	1.93
	Mean	8.20	6.28	10.81	1.87
Mean of soil conditioners	Control	8.27	8.20	13.73	1.46
	G	8.09	6.46	9.98	1.85
	CD1	8.18	6.72	11.32	1.83
	CD2	8.22	6.57	11.36	1.79
	PG1	8.16	6.57	11.16	1.86
	PG2	8.25	6.62	11.55	1.80
	FM1	8.18	6.21	10.55	2.04
	FM2	8.20	6.99	11.88	1.88
LSD 0.05	A	0.05	0.59	0.74	0.07
	B	0.02	0.18	0.32	0.05
	AB	0.04	0.26	0.46	0.07

C = Control (without natural gypsum)
NG= Natural gypsum (100 G.R %, 15.50 Mg ha^{-1})
CD1= Cement dust (100 G.R %, 10.8 Mg ha^{-1})
CD2= Cement dust (50 G.R %, 5.4 Mg ha^{-1})
PG1= Phosphogypsum (100 G.R %, 13.2 Mg ha^{-1})
PG2= Phosphogypsum (50 G.R %, 6.6 Mg ha^{-1})
FM1= Filter mud (100 G.R %, 18 Mg ha^{-1})
FM2= Filter mud (50 G.R %, 9 Mg ha^{-1})
pHs = pH in soil saturated paste
ECe= Electrical conductivity in soil-saturated paste extract
ESP%= Exchangeable sodium percentage
O.M % = Organic matter

Some trends were obtained for EC and ESP, while it increased soil organic matter by about 26.7, 25.3, 22.6, 27.4, 23.3, 39.7 and 28.7% in the abovementioned respect. The beneficial effect of soil conditioners on chemical soil properties may be due to the application of these materials increased the infiltration ratio of the soil, consequently increasing soil porosity that led to reducing soil salinity (Bairagi *et al.,* 2017). In addition, the studied conditioners were considered acid-forming substances, hence decreased soil pH and ESP (Stamford *et al.,* 2015). Moreover, Taha and Abd Elhamed, (2021) mentioned that the positive effect on soil organic matter may be due to soil conditioners improved soil properties, which in turn enhanced root growth, resulted to increased residues. These results are in harmony with those obtained by Sarwar *et al.,* (2011) and El-Sheref *et al.,* (2019). With regard to the interaction effect, the data show that soil chemical properties after fodder beet harvest were significantly responded to the interaction between the tillage system and soil conditioners. In general, using subsoil tillage enhanced the positive effect of the studied conditioners on improving soil chemical properties. These results agree with those obtained by El-Saady, (2004) and Gendy, (2011).

Moisture parameters:

Data in Table (7) represents the effect of the tillage system and different amelioration on moisture parameters, namely, field capacity, wilting point and available water. Results show that these moisture parameters were significantly increased due to subsoil tillage than shallow one. The positive effect of deep tillage on water retention may be due to the deep tillage formed many lines with large cracks extent from the surface to subsoil depth as well as formed many capillary cracks (Antar *et al.,* 2014).

Table 7. Effect of different amelioration techniques on available water in soil after harvest:

Different amelioration technique		Fodder beet		
Tillage	**soil conditioners**	**FC**	**WP**	**AW**
Shallow tillage (15 cm)	Control	44.87	19.61	25.26
	G	46.16	20.17	25.98
	CD1	45.82	20.03	25.80
	CD2	45.18	19.75	25.44
	PG1	46.49	20.32	26.17
	PG2	45.17	19.74	25.43
	FM1	47.11	20.59	26.52
	FM2	46.81	20.46	26.35
	Mean	45.95	20.08	25.87
Subsoil tillage (50 cm)	Control	45.54	19.90	25.64
	G	46.85	20.48	26.37
	CD1	46.51	20.33	26.18
	CD2	45.86	20.04	25.82
	PG1	47.19	20.62	26.56
	PG2	45.85	20.04	25.81
	FM1	47.82	20.90	26.92
	FM2	47.51	20.76	26.75
	Mean	46.64	20.39	26.26
Mean of soil conditioners	Control	45.21	19.76	25.45
	G	46.51	20.33	26.18
	CD1	46.17	20.18	25.99
	CD2	45.52	19.90	25.63
	PG1	46.84	20.47	26.37
	PG2	45.51	19.89	25.62
	FM1	47.47	20.75	26.72
	FM2	47.16	20.61	26.55
LSD 0.05	A	0.28	0.12	0.15
	B	0.16	0.07	0.09
	AB	0.24	0.10	0.12

C = Control (without natural gypsum)
NG= Natural gypsum (100 G.R %, 15.50 Mg ha^{-1})
CD1= Cement dust (100 G.R %, 10.8 Mg ha^{-1})
CD2= Cement dust (50 G.R %, 5.4 Mg ha^{-1})
PG1= Phosphogypsum (100 G.R %, 13.2 Mg ha^{-1})
PG2= Phosphogypsum (50 G.R %, 6.6 Mg ha^{-1})
FM1= Filter mud (100 G.R %, 18 Mg ha^{-1})
FM2= Filter mud (50 G.R %, 9 Mg ha^{-1}) FC = Field capacity (%)
WP = Wilting point (%) AW = Available water (%)

In addition, Abdel-Mawgoud, (2004) reported that the deep tillage led to an increase in macro-pores than micro-ones. These results are in good agreement with those obtained by Antar *et al.,* (2008) and Antar *et al.,* (2014). Considering soil conditioners, the data reveal that moisture parameters were positively affected by applying the different soil conditioners, where filter mud is the most effective one. It is worth noticing that the effects on moisture parameters were increasing as its level increased. The relative increasing of field capacity, wilting point and available water due to added 18 Mg ha^{-1} filter mud were 4.99, 5.01, and 4.99 % over control, respectively. It could be observed that soil conditioners application led to increasing field capacity at rate higher than the rate of increasing wilting point, consequently increasing available water. The positive effect of soil conditioners on physical soil properties, especially bulk density and total porosity is a good explanation for its effect on moisture parameters. These results are in line with those obtained by Abd El-Hamid *et al.,* (2005) and Reda, (2007). The results show that moisture parameters were significantly affected by the interaction between the tillage system and soil conditioner application. In general, added filter mud at a high rate with subsoil tillage yielded favorable moisture parameters. On the other hand, shallow tillage with no conditioner application exhibited the lowest values of moisture parameters. These results agree with the finding of Antar *et al.,* (2014).

Fresh and dry yield:

The data of fodder beet yield in terms of fresh and dry yield for roots and tops as affected by tillage system and different soil conditioners and their interactions are given in Table (8).

Table 8. Effect of different amelioration techniques on fresh and dry yield after harvest:

Different amelioration technique		Fodder beet (Mg ha^{-1})			
Tillage	**Soil conditioners**	**Fresh Root**	**Dry Root**	**Fresh Top**	**Dry Top**
Shallow tillage (15 cm)	Control	86.02	14.43	7.36	0.93
	G	113.33	19.26	10.19	1.21
	CD1	111.43	18.95	10.02	1.21
	CD2	108.57	18.45	9.76	1.17
	PG1	112.07	19.05	10.10	1.21
	PG2	109.05	18.55	9.81	1.17
	FM1	121.12	20.60	10.90	1.31
	FM2	109.83	18.67	9.88	1.19
	Mean	110.71	18.50	9.76	1.17
Subsoil tillage (50 cm)	Control	103.71	16.52	8.88	1.12
	G	140.57	23.90	12.64	1.52
	CD1	135.24	23.00	12.17	1.45
	CD2	130.57	22.19	11.76	1.40
	PG1	137.52	23.38	12.38	1.48
	PG2	133.14	22.64	11.98	1.43
	FM1	148.95	25.33	13.40	1.62
	FM2	136.00	23.12	12.24	1.48
	Mean	135.90	22.52	11.93	1.43
Mean of soil conditioners	Control	94.88	15.48	8.12	1.02
	G	126.95	21.60	11.43	1.38
	CD1	123.33	20.98	11.10	1.33
	CD2	119.57	20.33	10.76	1.29
	PG1	124.81	21.21	11.24	1.36
	PG2	121.10	20.60	10.90	1.31
	FM1	135.05	22.98	12.17	1.48
	FM2	122.93	20.90	11.07	1.33
LSD 0.05	A	2.43	0.83	0.45	0.05
	B	1.10	0.50	0.29	0.02
	AB	1.71	0.76	0.33	0.05

C = Control (without natural gypsum)
NG= Natural gypsum (100 G.R %, 15.50 Mg ha^{-1})
CD1= Cement dust (100 G.R %, 10.8 Mg ha^{-1})
CD2= Cement dust (50 G.R %, 5.4 Mg ha^{-1})
PG1= Phosphogypsum (100 G.R %, 13.2 Mg ha^{-1})
PG2= Phosphogypsum (50 G.R %, 6.6 Mg ha^{-1})
FM1= Filter mud (100 G.R %, 18 Mg ha^{-1})
FM2= Filter mud (50 G.R %, 9 Mg ha^{-1})

In terms of the primary effect of the tillage system, the findings show that deep tillage yielded fresh roots and tops yield exceeded than due to shallow one by about 22.75 and

34.32 % respectively. The corresponding increases for dry roots and tops yields were 21.75 and 22.45 % in the abovementioned order. The beneficial effect of deep tillage on fodder yield can be explained by its promotive effect on improved soil properties as discussed before. These results are in accordance with those obtained by Abdel-Mawgoud *et al.,* (2006) and Antar *et al.,* (2014) for sugar beet roots and shoots. Concerning the soil conditioners, the data reveal that, irrespective of the tillage system effect, fresh and dry yields of fodder beet roots and shoots were positively affected by added the different soil conditioners when compared with control, where filter mud at a high rate followed by gypsum at rate of 15.5 Mg ha^{-1} gave the highest both fresh and dry yields for roots (135.05 and 12.17 Mg ha^{-1}) and shoots (22.98 and 1.48 Mg ha^{-1}), respectively, followed by gypsum at rate 15.5 Mg ha^{-1} which produced 126.95 and 11.43 Mg ha^{-1} and 21.60 and 1.38 Mg ha^{-1} in the same respect.

The beneficial effect of such conditioners on fodder beet yield can be attributed to their effect on soil properties, in turn plants will have favourable environmental conditions to grow better. Similar results were obtained by Reda, (2007).

The results of the interaction reveal that fodder yields were significantly affected by the interaction between the two studied factors. The highest values of fresh and dry roots and tops (148.95 and 13.4 and 25.33 and 1.62 Mg ha^{-1}, respectively) were recorded under the treatment of subsoil tillage and added 18 Mg ha^{-1} filter mud. On the other hand, the treatment of shallow tillage without soil conditioners exerted the lowest fodder beet yields. These results are in line with those obtained by Aiad *et al.,* (2012) and El-Sanat *et al.,* (2012).

Nutrient status

The data listed in Table (9) show the influence of the tillage system and some soil conditioners as well as their interaction on N, P and K status of fodder beet roots and shoots in terms of N, P and K uptake in roots and/or in shoots. And as far as the significant determinants of tillage, the obtained results demonstrate a certain nutrient uptake by roots or shoots as well as total uptake were significantly responded to the tillage system where, plants under deep tillage uptake N, P, and K more than under shallow tillage. The superiority of subsoil over shallow tillage may be due to deep tillage improved soil pH and salinity as discussed in Table (6), consequently, increased nutrient availability which enhanced the nutrient absorption by plants.

Table 9. Effect of different amelioration techniques on N, P, and K uptake of roots and/or top (kg ha^{-1}):

Different amelioration technique		Fodder beet (kg ha^{-1})								
Tillage	Soil conditioners	Root uptake N	Root uptake P	Root uptake K	Top uptake N	Top uptake P	Top uptake K	Total uptake N	Total uptake P	Total uptake K
Shallow tillage (15 cm)	Control	161.6	57.7	174.6	13.74	2.33	14.31	175.3	60.0	188.9
	G	236.9	102.1	443.0	19.90	4.50	34.48	256.8	106.6	477.5
	CD1	240.7	102.3	445.4	20.52	4.62	35.33	261.2	107.0	480.7
	CD2	219.6	94.1	415.2	18.67	4.19	32.43	238.3	98.3	447.6
	PG1	264.8	112.4	476.2	22.33	5.10	37.88	287.1	117.5	514.1
	PG2	243.0	103.9	443.3	20.31	4.55	34.64	263.3	108.4	477.9
	FM1	294.5	125.6	525.2	24.76	5.64	41.79	319.3	131.3	567.0
	FM2	250.1	108.3	455.5	21.31	4.76	36.31	271.5	113.0	491.8
	Mean	238.9	100.8	422.3	20.19	4.45	33.40	259.1	105.3	455.7
Subsoil tillage (50 cm)	Control	190.0	71.0	201.6	17.00	3.02	18.69	207.0	74.1	220.3
	G	308.4	133.9	590.5	28.64	5.95	46.48	337.0	139.8	636.9
	CD1	305.9	131.1	579.6	28.02	5.81	45.45	333.9	136.9	625.1
	CD2	279.6	119.8	537.0	25.71	5.33	41.86	305.3	125.2	578.9
	PG1	341.4	147.3	626.6	31.00	6.50	49.45	372.4	153.8	676.1
	PG2	310.2	133.6	581.9	28.43	5.86	45.71	338.6	139.5	627.6
	FM1	380.0	164.7	694.1	34.81	7.29	55.52	414.8	172.0	749.7
	FM2	326.0	141.0	608.0	30.12	6.36	48.26	356.1	147.4	656.3
	Mean	305.2	130.3	552.4	27.98	5.76	43.93	333.1	136.1	596.4
Mean of soil conditioners	Control	175.8	64.4	188.1	15.38	2.67	16.50	191.2	67.0	204.6
	G	272.6	118.0	516.7	24.29	5.21	40.48	296.9	123.2	557.2
	CD1	273.3	116.7	512.5	24.29	5.21	40.40	297.6	121.9	552.9
	CD2	249.6	107.0	476.1	22.19	4.76	37.14	271.8	111.7	513.2
	PG1	303.1	129.8	551.4	26.67	5.81	43.67	329.7	135.6	595.1
	PG2	276.6	118.7	512.6	24.36	5.21	40.19	301.0	123.9	552.8
	FM1	337.3	145.1	609.7	29.79	6.45	48.64	367.0	151.6	658.3
	FM2	288.0	124.6	531.7	25.71	5.55	42.29	313.8	130.2	574.0
LSD 0.05	A	28.05	11.95	39.52	3.07	0.57	3.21	31.12	12.52	42.74
	B	6.48	3.19	16.90	0.67	0.12	1.21	7.14	3.31	18.12
	AB	9.17	4.52	23.33	0.95	0.17	1.71	10.12	4.69	25.05

C = Control (without natural gypsum) **NG= Natural gypsum (100 G.R %, 15.50 Mg ha^{-1})**
CD1= Cement dust (100 G.R %, 10.8 Mg ha^{-1}) **CD2= Cement dust (50 G.R %, 5.4 Mg ha^{-1})**
PG1= Phosphogypsum (100 G.R %, 13.2 Mg ha^{-1}) **PG2= Phosphogypsum (50 G.R %, 6.6 Mg ha^{-1})**
FM1= Filter mud (100 G.R %, 18 Mg ha^{-1}) **FM2= Filter mud (50 G.R %, 9 Mg ha^{-1})**

Also, the increase in roots and shoots dry weight (Table 6) and N, P and K concentration in roots and shoots due to deep tillage is a good explanation of its beneficial effect on nutrient uptake, since nutrient uptake calculates by multiplying the dry yield by nutrient concentration. The relative increment of fodder beet under deep tillage total N, P, and K uptake reached 28.58, 29.27, and 30.87 %, respectively. Similar results were obtained by Alam *et al*., (2014) and Taha *et al.,* (2021). As for the effect of some soil conditioners, the data reveal that comparing with the control, all studied soil conditioners enhanced N, P and K uptake, whether in roots and/or tops of fodder beet plants. The plants treated with a high level of filter mud followed by phosphogypsum at a higher rate gave the highest values of nutrient uptake. The relative increment in total N, P and K uptake due to added 18 Mg ha-[1] reached to (91.95, 126.27, 221.75) % over control. The promotive effect of these conditioners on nutrient uptake may be due to their positive effect on soil properties and fodder beet yield as discussed before. These findings are in line with those obtained by Genedy *et al.*, (2018) and El-Sheref *et al.*, (2019). The results of the interaction reveal that nutrients uptake were significantly affected by the interaction between tillage and soil conditioners. The plants treated with 18 Mg ha^{-1} filter mud under subsoil tillage uptakes higher amounts of N, P and K (414.8, 172, 749.7 kg ha^{1}), while the plants without soil conditioners under shallow one exhibited the lowest values (319.3, 131.3, 567 kg ha^{-1}).

CONCLUSION

Based on the obtained results, it can be concluded that the use of soil conditioners in combination with deep tillage is an effective method for improving the physical, chemical, and moisture properties of the soil, as well as increasing the growth and productivity of fodder beet. The application of filter mud at a rate of 18 Mg ha^{-1} showed the highest positive impact on the studied parameters. By implementing these improvement techniques, the hazardous effects of salinity on the soil can be reduced, resulting in increased agricultural productivity and improved food security in Egypt. Therefore, it is recommended to promote the use of soil conditioners and deep tillage practices in salt-affected soils to enhance agricultural production in Egypt.

ACKNOWLEDGMENT

I would want to show Prof. Dr. Safwat Ahmed Ismail Emeritus Professor of Soil Science Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt, my admiration and my gratitude (providing language help, statistical analysis, etc.).

REFERENCES

A.O.A.C. (1990). Official Method of Analysis "*Association Official Analytical Chemists" 10th Ed.*, Washington, D.C., USA.

Abbady, F. A. (2022). Amelioration of newly reclaimed soil under some stress conditions in Upper Egypt. (Doctoral dissertation, Ph.D. thesis, Faculty of Agriculture, Sohag University, Sohag, Egypt).

Abd El-Hamid, Azza, R., El-Maghraby, T.A., El-Banna, I.M.M., Mansour, S.F. (2005). Effect of gypsum application and potassium fertilization on sugar beet (Beta vulgaris L.) yield and some physical properties of soil at north Nile delta. *Egypt. J. of Appl. Sci., 20*: 656-668.

Abdel-Fattah, M. K., Fouda, S., & Schmidhalter, U. (2015). Effects of gypsum particle size on reclaiming saline-sodic soils in Egypt. *Communications in Soil Science and Plant Analysis*, *46*(9), 1112-1122.

Abdel-Mawgoud, A. S. A. (2004). Subsoiling to conserve rootzone stratum of heavy clay soil. *Minufiya J. Agric. Res*, *29*(6), 1456-1478.

Abdel-Mawgoud, A. S. A., Gendy, A.A.S. & Ramadan, S. A. (2006). Improving root zone environment and productivity of a salty clay soil using subsoiling and gypsum application. *Assiut Journal of Agricultural Sciences*, *37*(2), 147-164.

Abou Youssef, M. F. (2001). Use phosphogypsum fortified as a soil amendment for saline-sodic soil in El-Salhiya plain. *Zagazig J. Agric. Res*, *28*, 889-911.

Ahmad, S., Ghafoor, A., Akhtar, M. E., & Khan, M. Z. (2016). Implication of gypsum rates to optimize hydraulic conductivity for variable-texture saline–sodic soils reclamation. Land degradation & development, 27(3), 550-560.

Aiad, M. A. F., Abd El-Aziz, M. A., Zamil, B. A. A., & Antar, A. S. (2012). Combating of soil deterioration at north delta, Egypt. *J. Agric. Res. Kafr El-Sheikh Univ*, *38*(2), 322-341.

Alam, M. D., Islam, M., Salahin, N., & Hasanuzzaman, M. (2014). Effect of tillage practices on soil properties and crop productivity in wheat-mungbean-rice cropping system under subtropical climatic conditions. *The Scientific World Journal*, *2014*.

Alzamel, N. M., Taha, E. M., Bakr, A. A., & Loutfy, N. (2022). Effect of organic and inorganic fertilizers on soil properties, Growth yield, and physiochemical properties of sunflower seeds and oils. Sustainability, 14(19), 12928.

Antar, S. A., El-Henawy, A. S., & Atwa, A. A. E. (2008). Improving some properties of heavy clay salt affected soil as a result of different subsurface tillage. *Journal of Soil Sciences and Agricultural Engineering, 33*(10), 7675-7687.

Antar, S. A., El-Sanat, G. M. A., & Khafagy, H. A. (2014). Improving heavy clay salt affected soil and its production using some amendments application in north delta. *Journal of Soil Sciences and Agricultural Engineering, 5*(12), 1717-1730.

Bairagi, M. D., David, A. A., Thomas, T., & Gurjar, P. C. (2017). Effect of different levels of NPK and gypsum on soil properties and yield of groundnut (Arachis hypogea L.) var. Jyoti. *International Journal of Current Microbiology and Applied Sciences*, *6*(6), 984-991.

Deshesh, T. H. M. A. (2021). Amelioration of salt-affected soils and its productivity using soil amendments and tillage system. *Menoufia Journal of Soil Science*, *6*(2), 31-47.

El-Saady, A.S.M. (2004). Response of soybean to phosphogypsum and superphosphate application under the Egyptian soil's conditions. *J. Agric. Sci. Mansoura Univ. 29*(7): 4337-4348.

El-Sanat, G. M. A. (2012). Effect of some soil management practices and nitrogen fertilizer levels on some soil properties and its productivity at North Delta. *Journal of Soil Sciences and Agricultural Engineering, 3*(12), 1137-1151.

El-Sheref, G., Awadalla, H., & Mohamed, G. (2019). Use of gypsum and sulphur for improving rock p efficiency and their effect on wheat productivity and soil properties. *Alexandria Journal of Soil and Water Sciences*, *3*(2), 50-67.

FAO and ITPS. (2015). Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy. ISBN 978-92-5-109004-6.

Gendy, A. A. S. (2011). Response of Some Field Crops to Proper Tillage under Salt Affected Soils in North Nile Delta. *Journal of Soil Sciences and Agricultural Engineering*, *2*(5), 441-453.

Genedy, M., Ewis, A., & Genaidy, S. (2018). Importance of gypsum, organic manure application and nitrogen, zinc fertilization for wheat crop in saline-sodic soils. *Journal of Productivity and Development*, *23*(2), 343-356.

Hafez, E. M., Abou El Hassan, W. H., Gaafar, I. A., & Seleiman, M. F. (2015). Effect of gypsum application and irrigation intervals on clay saline-sodic soil characterization, rice water use efficiency, growth, and yield. *Journal of Agricultural Science*, *7*(12), 208-219.

Hasana, R., & Miyake, H. (2017). Salinity Stress Alters Nutrient Uptake and Causes the Damage of Root and Leaf Anatomy in Maize. *KnE Life Sciences*, *3*, 219-225.

Herrick, J. E., & Jones, T. L. (2002). A dynamic cone penetrometer for measuring soil penetration resistance. *Soil Science Society of America Journal*, *66*(4), 1320-1324.

Ivushkin, K., Bartholomeus, H., Bregt, A. K., Pulatov, A., Kempen, B., & De Sousa, L. (2019). Global mapping of soil salinity change. *Remote sensing of environment*, *231*, 111260.

Mansour, S. F., Reda, M. M. A., Hamad, M. M. H., & Khafagy, E. E. E. (2014). Utilization efficiency of different industrial byproducts in amelioration of saline-sodic soils. *Journal of Soil Sciences and Agricultural Engineering*, *5*(7), 997-1015.

Mohamed, N. N. (2017). Management of salt-affected soils in the Nile Delta. *The Nile Delta*, 265-295.

Mukhopadhyay, R., Sarkar, B., Jat, H. S., Sharma, P. C., & Bolan, N. S. (2021). Soil salinity under climate change: Challenges for sustainable agriculture and food security. *Journal of Environmental Management*, *280*, 111736.

Ordoñez-Morales, K. D., Cadena-Zapata, M., Zermeño-González, A., & Campos-Magaña, S. (2019). Effect of tillage systems on physical properties of a clay loam soil under oats. *Agriculture*, *9*(3), 621-14.

Rahneshan, Z., Nasibi, F., & Moghadam, A. A. (2018). Effects of salinity stress on some growth, physiological, biochemical parameters and nutrients in two pistachio (Pistacia vera L.) rootstocks. *Journal of plant interactions*, *13*(1), 73-82.

Reda, M. M. A. (2007). Amelioration techniques for saline-sodic soils in north Nile delta and its impact on sunflower productivity. *J. Biol. Chem. Environ. Sci*, *2*(1), 139-155.

Richards, L. A. (Ed.) (1954). Diagnosis and improvement of saline and alkali soils. *US Salinity Laboratory Staff, US Department of Agriculture Handbook 60*, Washington, DC, USA.

Sarwar, G., Ibrahim, M., Tahir, M. A., Iftikhar, Y., Haider, M. S., Noor-Us-Sabah, N. U. S., ... & Zhang, Y. S. (2011). Effect of compost and gypsum application on the chemical properties and fertility status of saline-sodic soil. *Korean Journal of Soil Science and Fertilizer*, *44*(3), 510-516.

Sasal, M. C., Andriulo, A. E., & Taboada, M. A. (2006). Soil porosity characteristics and water movement under zero tillage in silty soils in Argentinian Pampas. *Soil and Tillage Research*, *87*(1), 9-18.

Schoonover, W. R. (1952). Examination of soils for alkali. *Berkeley: University of California. Extension Service*.

Sharma, P., Abrol, V., Sharma, K. R., Sharma, N., Phogat, V. K., & Vikas, V. (2016). Impact of conservation tillage on soil organic carbon and physical properties–a review. *International Journal of Bio-resource and Stress Management*, *7*(1), 151-161.

Snedecor, G. W., & Cochran, W. G. (1980). Statistical methods. 7th. *Iowa State University USA*, 80-86.

Stamford, N. P., Figueiredo, M. V., da Silva Junior, S., Freitas, A. D. S., Santos, C. E. R., & Junior, M. A. L. (2015). Effect of gypsum and sulfur with Acid thiobacillus on soil salinity alleviation and on cowpea biomass and nutrient status as affected by PK rock biofertilizer. *Scientia Horticulturae*, *192*, 287-292.

Tabiehzad, H., Cayci, G., & Afshar Pour Rezaeieh, K. (2017). The effects of tillage methods on soil aggregation and crop yields in a wheat-corn rotation under semi-arid conditions. Solid Earth Discussions, 1-20.

Taha, M. B., & Abd Elhamed, A. S. (2021). Some agricultural practices for improving the productivity of moderately sodic soil I: soil properties and wheat vegetative growth. *Science Archives Vol. 2*(4), 287-297.

Taha, M. B., Salleh, A. M., & Abd Elhamed, A. S. (2021). Some agricultural practices for improving the productivity of moderately sodic soil II: wheat yield, nutrient status, and economic potentiality. *Science Archives Vol. 2*(4), 298-311.

Tanji, K.K., Wallender, W.W. (2011). Nature and extent of agricultural salinity and sodicity. In *Agricultural Salinity Assessment and Management*, 2nd ed.; American Society of Civil Engineers: Reston, VA, USA, pp. 1–26.

Thomas, G. A., Dalal, R. C., & Standley, J. (2007). No-till effects on organic matter, pH, cation exchange capacity and nutrient distribution in a Luvisol in the semi-arid subtropics. *Soil and Tillage Research*, *94*(2), 295-304.

Trabelsi, L., Gargouri, K., Hassena, A. B., Mbadra, C., Ghrab, M., Ncube, B., ... & Gargouri, R. (2019). Impact of drought and salinity on olive water status and physiological performance in an arid climate. *Agricultural water management*, *213*, 749-759.

Wang, S., Guo, L., Zhou, P., Wang, X., Shen, Y., Han, H. & Han, K. (2019). Effect of subsoiling depth on soil physical properties and summer maize (Zea mays L.) yield. *Plant, Soil and Environment*, *65*(3), 131-137.

Wicke, B., Smeets, E., Dornburg, V., Vashev, B., Gaiser, T., Turkenburg, W., & Faaij, A. (2011). The global technical and economic potential of bioenergy from salt-affected soils. *Energy & Environmental Science*, *4*(8), 2669-2681.

تحسين الاراضي المتأثرة بالأملاح وإنتاجيتها من بنجر العلف: تأثير محسنات التربة وتقنيات الحرث

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الملخص

أجريت تجربة حقلية في أرض طينية متأثرة بالأملاح بقرية كوم أبو خلاد/ مركز ناصر/ محافظة بنى سويف/ مصر فى موسم النمو الشتوى 2022/2021 لتقييم تأثير بعض محسنات التربة وطريقة الحرث على صفات التربة ومحصول بنجر العلف وكان التصميم المتبع في التجربة هو القطع المنشقة بأربع مكررات وقد وضع نظام الحرث (عميق وسطحى) في القطع الرئيسية بينما وضعت محسنات التربة (بدون ،جبس طبيعى بمعدل 15.5 طن/ هكتار ، تراب الإسمنت بمعدل 10.8 طن/هكتار، تراب الإسمنت بمعدل 5.4 طن/هكتار ، فوسفوجبس بمعدل 13.2 طن/هكتار ، فوسفوجبس بمعدل 6.6 طن/هكتار ، طين المرشحات بمعدل 18 طن/هكتار ، طين المرشحات بمعدل 9 طن/هكتار) فى القطع المنشقة. ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي:-أدى الحرث العميق الى تحسين خواص التربة الطبيعية (الكثافه الظاهرية ، المسامية الكلية ، التوصيل الهيدروليكي ، اختراق التربة) والخواص الكيمياوية (الحموضه ، الملوحة ، الصوديوم المتبادل ، المادة العضوية) والعلاقات المائية (السعة الحقلية ، نقطة الذبول ، الماء الميسر) وكذلك محصول بنجر العلف (الجذور والأجزاء الخضرية) وإمتصاصة للعناصر ، وقد أدى إضافة طين المرشحات بمعدل 18 طن/هكتار الى أعلى القيم. أظهرت نتائج التداخل أن الحرث العميق مع إضافة 18 طن/هكتار طين مرشحات إلى تحسين خواص الأرض المتأثرة بالأملاح وزيادة إنتاجيتها من محصول بنجر العلف لذا ينصح في حالة إستزراع و استصلاح الأراضي الطينية المتأثرة بالأملاح إلى الحرث العميق قبل الزراعة مع إضافة محسنات التربة مثل الجبس الطبيعي أو بدائلة وبالأخص طين المرشحات.