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Land Reclamation Using Compost, Agricultural Gypsum and Sugar Beet Mud.

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ABSTRACT

In Egypt, the improvement of degraded soils is considered as an important issue in the agricultural security program. Large amounts of sugar industrial wastes such as sugar lime mud is producing annually causing some issues to the environment if not exploited. So, a pot trial was carried out to evaluate the influence of some soil amendments on enhancing some chemical and physical characteristics of some degraded soils of Egypt. Three soil types (saline, sandy and sodic soils) were used and treated with three soil amendments *i.e.* compost, agricultural gypsum and sugar beet mud which were applied to the three studied soils (two weeks before sowing) at three rates (0.5, 1 and 1.5%, equivalent to 2.5, 5 and 7.5 g pot^{-1}, respectively) and moisted after addition to the saturation limit. Soils were cultivated with barley**.** At the end of the trail, undisturbed soil samples were taken from each treatment .The findings show that barley seeds did not succeed in germination under sodic soil conditions, while seeds succeed in germination under saline and sandy soils. Generally, soil addition of all studied amendments at all rates pronouncedly improved all studied chemical and physical characteristics of saline, sandy and sodic soils compared to control treatment (without soil addition), but the improvement increased with the increase of adding rate of all soil amendments under study, where the best values were recorded due to the soil addition rate of 1.5% followed by 1% and 0.5%, respectively for all soil characteristics. Also, the results confirm that sugar beet mud as a new soil amendment in Egypt is beneficial for improving degraded soils due to its high content from organic matter and calcium.

***Keywords*:** Gypsum, compost, sugar beet mud, saline, sandy and sodic soils.

INTRODUCTION

In Egypt, salt-affected soils represent about 30 % of the total cultivated region (FAO, 2005). The North Delta contains the biggest area of saline and saline-sodic soils (46%). Poor drainage, as well as irrigation with saline drainage water, supports the buildup of sodicity and salinity (Amer and Hashem, 2018). Saline and sodic soils are originated mainly in the semi-arid regions where the evaporation rate is precipitation (Qadir *et al.* 2008). Soil salinity has a great influence on declining yield potentials of the cultivated crops, where crop yields start declining when soil EC goes above 4.0 dSm^{-1} (Mohamed, 2016). Sandy soils represent about 96% of Egypt's total area and suffer from low nutrients, which are washed away by irrigation as well as it is light, warm and dry (El-Hadidi *et al.* 1998).

Gypsum is commonly used for the reclamation of saline and sodic soils and for reducing the harmful influences of high sodium irrigation water sin agricultural regions due to its solubility, availability, low cost and ease of handling. It has a sulfur content of 19% and a calcium content of 23%. The calcium in the applied gypsum enables Na+ displacement on the cation exchange sites of the soil (Abdel-Fattah, 2012 and Bello, 2012). Organic fertilizers such as compost play an important role in improving the chemical and physical characteristics of degraded soils and supplying macro and micronutrients (Ilupeju *et al.* 2015). Sugar beet factory lime is generally produced and stockpiled close to sugar factories during sugar beet juice purification process (Seleiman and Kheir, 2018). The sugar beet mud is one of the lowest cost sorbents and considered an organic amendment, contains a high content of total Ca, Mg, N, P and K (Kheir and Kamara, 2019). However, using it in improving degraded soils properties not extensively studied before, favouring its importance in the current study.

The objective of this study is to evaluate the effect of different rates of compost, agricultural gypsum and sugar beet mud on reclaiming some degraded soils (*i.e.* saline, sandy and sodic soils) in Egypt.

MATERIALS AND METHODS

To achieve the goal of this investigation, a pot experiment was conducted outdoor at the Experimental Greenhouse of the Faculty of Agriculture, Mansoura University, Egypt, during the winter season of 2019. It was aimed at assess the influence of compost, gypsum and sugar beet mud (By-product in a sugar beet manufacturing process) as reclamation materials on some physical and chemical properties of different degraded soils (saline, sandy and sodic soils) in Egypt.

The investigated soils (saline, sandy and sodic) were analyzed before planting according to Dewis and Fertias (1970), Tables 1 and 2 show their some chemical and physical characteristics.

Plant compost (70%ric straw +30% other plant residues) was prepared at Temi El-Amdid, Agricultural Research Station, El-Dakahlia Governorate, Egypt according to El-Hammady *et al.* (2003). Chemical analysis of the compost (plant residues) used are presented in Table 4. The treatments in this study included natural minerals *i.e.* gypsum and sugar beet mud. Sugar beet mud was obtained from Dakahlia sugar beet Factory, Egypt. While gypsum was obtained from Agric. Res., Center, Giza, Egypt. Table 5 being describing some characteristics of the used mineral amendments.

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Plastic pots (15 cm diameter and 15 cm depth) were filled with air-dry soils equaled to 500 g oven-dry soil of the studied three soils types (saline, sandy and sodic). The compost, gypsum ($CaSO_4.2H_2O$) and sugar beet mud were applied to the three studied soils (two weeks before sowing) at three rates (0.5, 1 and 1.5%, equivalent to 2.5, 5 and 7.5 g pot^{-1}, respectively) and moisted after addition to saturation limit. On 13th of November, 2019; ten seeds of barely per pot were sown. Throughout the experiment, soil moisture was kept at field capacity by watering to the constant weight. Seeds of barley didn't germinate under sodic soil conditions.

At the end of the experiment, soil samples were taken from each treatment to determine some soil physical properties. Another part of soil samples was air-dried, ground and sieved through 2mm then stored in plastic bags to evaluate some soil chemical properties.

Table 1. Some chemical properties of investigated soils.

Soil chemical properties		Saline	Sandy	Sodic
pH		8.100	7.91	8.77
EC, dS m^{-1}		5.500	0.90	3.20
$CaCO_3$ %		2.900	1.00	2.29
OM%		2.010	0.30	1.10
ESP%		9.300	7.90	32.0
Soluble Cations (meq 100g soil $^{-1}$)	Ca^{++}	5.630	0.92	3.27
	Mg^{++}	4.220	0.69	2.45
	K^+	1.420	0.23	0.85
	Na^+	16.89	2.76	9.81
Soluble Anions (meq 100 soil $^{-1}$)	CO_3^{--}	0.000	0.00	1.57
	HCO_3^-	8.440	1.38	4.41
	Cl^-	13.56	2.25	7.84
	SO_4^{--}	6.160	0.97	2.56
Available macro-nutrients (mg Kg soil^{-1})	Nitrogen (N)	65.59	12.1	45.5
	Phosphorus (P)	9.550	0.30	7.75
	Potassium (K)	230.9	39.3	280.3
Available boron (mgKg^{-1})		0.450	0.09	0.20

* Soil pH was determined in soil suspension (1: 2.5).

Table 2. Some physical properties of investigated soils.

Soil physical properties		Saline	Sandy	Sodic
Particles size distribution	Sand %	8.990	90.50	14.50
	Silt %	29.96	4.700	35.50
	Clay%	54.64	4.800	51.00
	Texture Class	Clay	Sandy	Clay
Saturation percentage (SP)%		89.06	34.44	68.00
Field capacity (FC)%		44.53	11.22	34.80
Wilting point (WP)%		22.30	5.610	17.00
Available water (AW)%		22.30	5.610	17.80
Bulk Density (Mg cm^{-3})		1.240	1.590	1.430
Total Porosity%		58.49	39.00	61.00

Table 3. Chemical analysis of the used plant compost.

Characteristics		Values
pH 1:5		5.970
EC (1:10) (dSm^{-1})		3.160
OM%		39.48
Organic carbon%		22.90
C/N ratio		14.22
Available micronutrients (mg kg^{-1})	Iron	54.70
	Manganese	12.50
	Copper	3.510
	Zinc	19.70
Macro-nutrients (%)	Nitrogen	1.610
	Phosphorus	0.380
	Potassium	0.820

Data recorded: 1- Physical analysis: Soil bulk density (Mg cm^{-3}) was determined using core method, klute and Dirksen (1986).Real density was determined using pycnometer method described by (Black, 1965).Total soil porosity (p %) was calculated using both real and bulk density values. 2- Chemical analysis: Soil pH was determined in (1:2.5) soil water suspensions, while Electrical conductivity (dS m^{-1}) was determined in the saturated soil paste extract according to Jackson (1973).Organic matter content (%) was determined according to (Hesse, 1971).Total carbonate was determined as calcium carbonate using Collin`s calcimeter (Piper, 1947).Soluble cations and anions were determined in saturated soil paste extract according to Jackson (1973).Exchangeable sodium percentage (ESP) and exchangeable calcium percentage (ECaP) were determined by Page *et al.* (1982).

Table 4. Sugar beet mud and gypsum components.

Characteristics	values
Sugar beet mud	
$CaCO_3$%	92.80
OM%	7.200
Gypsum ($CaSO_4 . 2H_2O$)	
Purity (%)	98.8
pH (1: 5 gypsum : water)	7.80
EC [1: 5]	2.56
Ca [g Kg $^{-1}$]	230
S [g Kg $^{-1}$]	175

RESULTS AND DISCUSSION

Data illustrated in Tables 5, 6 and 7 show the effect of some soil amendments such as compost, agricultural gypsum and sugar beet mud (by-product in a sugar beet manufacturing process) on some soil chemical properties (pH , EC, O.M, ESP, ECaP, total $CaCO_3$ and soluble cations and anions) and some physical properties (bulk and real density and total porosity) after barley harvest.

1. Saline Soil Condition.

The effect of treatments *i. e.* compost, agricultural gypsum and sugar beet mud, on improving salt affected soil characteristics (pH , EC, O.M, ESP, ECaP, total $CaCO_3$, soluble ions, bulk and real density and total porosity), that was cultivated with barley after reclamation with the above mentioned conditions, are presented in Table 5. The most values of soil characteristics in salt affected soil treated with the different treatments (compost, agricultural gypsum and sugar beet mud) were decreased due to applications of these conditions. The decrease in values varied from a treatment to another.

Soil chemical properties.

Soil Electric conductivity (EC).

Regarding to soil electric conductivity (EC) as affected by different soil amendments after barley harvest, data in Table 5 demonstrate a significant decrease of saline soil EC values as affected by applying compost at rates of 0.5,1 and 1.5% and sugar beet mud at rate of 1.5% only compared to control. While, applying agricultural gypsum at all rates caused raising EC values compared to control treatment. Under different rates of compost, the soil EC values were pronouncedly decreased as the rates of compost were increased. Under sugar beet mud treatments, the soil EC values increased with the first rate of sugar beet mud (0.5%) compared to control and then decreased with raising sugar beet mud to 1.5%, where the soil EC values were pronouncedly decreased as the amount of organic matter in sugar beet mud were increased with increasing addition rate. The treatments sequence from less EC to top EC value under both compost and sugar beet mud was as follows: 1.5% > 1% > 0.5%. On the contrary, a remarkable increase in soil EC values was found with any increase in gypsum rate compared to control treatment (without soil amendments).Sugar beet mud is superior to gypsum in reducing EC values of saline soil used because it contains 7% O.M. These results suggest that some treatments led to increase of soil salinity, where others decreased it. Generally, compost added at any rate and sugar beet mud at a rate of 1.5% positively affected EC value of salt affected soil. The decrease in EC was attributed to the improving action of the used conditioners (compost and sugar beet mud) on the total porosity (Table 5), which enhanced in the leaching of salts out of the soil root zone improving hydraulic conductivity and total porosity which contributes to the decrease in salts concentration as well as decrease the osmotic potential of the root zone and improving plant growth. Similar results were reported by Abualamaim (2012), who found that the EC value of the salt affected soils after application of compost at a rate of 20 m^3/fed (47.6m^3ha^{-1}), sharply was decreased by about 30%. Mohamed (2012) showed that addition of compost to a salt affected soil reduced the electrical conductivity (EC) and ESP compared to the control. Beside, Ali and Kahlown (2001) stated that addition of gypsum initially increases the EC of the soil. Beside, Sanchary *et al.* (2019) who stated that the application of higher doses of processed sugar mill mud caused improving the soil properties. Also, Kheir and Kamara, (2019) found that the application of sugar beet factory lime caused an improvement of the soil properties.

Soil reaction (pH)

Soil pH is an important parameter for soil fertility; it controls soil nutrients solubility and availability for barley plants and affects soil microorganisms. The pH numerical values are always within range of 7.6 to 8.4 under normal soil conditions in Egypt. The decrease in soil pH always results in favorable soil medium and productivity by land management process and technique. Soil pH as shown in Table (5) is ranged between 7.90 and 8.14 as affected by the different soil amendments (compost, agricultural gypsum and sugar beet mud) whereas control recorded 8.05. The minimum value was obtained with the application of compost at rate of 1.5%, which recorded 7.90, while the maximum pH value was (8.14) resulted from application of sugar beet mud at rate of 1.5%. Generally, under compost and gypsum treatments, the pH value decreased gradually with increasing application rate. On the contrary, under sugar beet mud treatments, the pH value increased gradually with increasing application rate due to its content of 92.8%$CaCO_3$. These results revealed the useful effect with application of the compost and gypsum, where these amendments decreased soil pH compared to control. Also, the positive effect of compost on saline soil reaction (pH) is more than gypsum. The relationship between organic matter content and soil reaction may exist, this may due to CO_2 and organic acids produced in considerable amounts during decomposition of organic material. Many workers reported that organic manure affected the soil pH. Fouda *et al.* (2020) and El-Hadidi *et al.* (2020) reported that increasing the applied compost rates resulted in an increase of soil organic matter content as well as a decrease of soil pH. Anas *et al.* (2005) added that increasing rate of FYM applied to soil led to a decrease in soil pH from 7.79 to 7.45. Prapager *et al.* (2012) indicated that gypsum application caused reducing pH value but gypsum application in combination with organic amendments improved the soil chemical properties by reducing the EC and pH values, than applying gypsum alone.

Organic matter (OM)

Data in Table 5 indicate that, application of different studied soil amendments at rates of 0.5, 1 and 1.5% increased organic matter (OM) in soil compared to the control except agricultural gypsum, which did not cause an increasing in soil organic matter. Also, the data elucidated that organic matter increased progressively with increasing the application rates of compost and sugar beet mud. The increase with compost is higher than that with sugar beet mud at the same added rate. This attributes to that O.M content in compost is higher than sugar beet mud (Tables 3 and 4).The values of OM% content as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud)ranged between 0.91to 3.12%, whereas control recorded 1.12 %. The highest OM contents were obtained with the application of compost at rate of 1.5%. In fact, application of compost and sugar beet mud to soil may be improved some chemical properties of the salt affected soils and this consequently encouraged the plant to have a good growth. In this respect, El-Hadidi *et al.* (2020) reported that the use of compost can be beneficial to improve organic matter status, due to compost is rich source of nutrients with high organic matter content. Also, Fouda *et al.* (2020) investigated that the probable effects of compost on soil condition; they found that the organic matter content was increased in the soil. They added that, the addition of compost alone or in combination with biofertilizer enhanced significantly organic matter status after tomato crop. Similar results were also obtained by Abualamaim (2012) who observed that OM and CEC values of salt affected soil cultivated with Sudan grass and treated with compost were increased.

ESP, ECaP and total $CaCO_3$

The effect of treatments *i. e.* compost, agricultural gypsum and sugar beet mud, on improving Exchangeable Sodium Percentage (ESP), Exchangeable calcium Percentage (ECaP) and total CaCO3 of salt affected soil, that was cultivated with barley are presented in Table 5. Under compost treatments, the values of ESP and total CaCO3 in investigated salt affected soil were pronouncedly decreased as the rates of compost were increased, while ECaP % values were pronouncedly increased as the rates of compost were increased. This may be attributed to CO2 and organic acids which produced in considerable amounts during decomposition of organic material and lead to dissolution of CaCO3 in a soluble form (Ca(HCO3)), thus soluble calcium in soil solution will increase and replace exchangeable sodium on soil colloids surface. Under gypsum and sugar beet mud treatments, the values of ESP in investigated salt affected soil were pronouncedly decreased as the rates of gypsum and sugar beet mud were increased, while ECaP and total CaCO3 values were pronouncedly increased as rates of gypsum and sugar beet mud were increased. This may be attributed to chemical reactions resulted from adding gypsum to the saline soil, where calcium replace exchangeable sodium on soil colloids, thus sodic clay becomes calcic clay. Also, gypsum may interact with sodium carbonate and turn into sodium sulfate. On the other hand, the positive effect of sugar beet mud in decreasing ESP and increasing ECaP may be attributed to its content of O.M.

Soil physical properties.

Soil bulk density (BD)

Soil bulk density (BD) is considered as a good indicator for the improvement of the main physical properties; the decrease in its value means that the different structure parameters are desirable for different chemical and biological processes in soil. Obtained results were ranged between 1.05 to 1.19 $Mgcm^{-3}$ for different amendments as compared to control treatment which recorded 1.21 $Mgcm^{-3}$. Soil bulk density (BD) values were significantly decreased as the content of organic matter was increased. Under different compost rates, applying compost to the soil before sowing at rate of 0.5, 1.0 and 1.5 % pronouncedly decreased the BD. Soil bulk density (BD) values remarkably decreased with the increase of adding compost rate, where the lowest values were obtained from addition of compost as soil application at rate of 1.5% followed by 1% and 0.5%, respectively. Under different sugar beet mud rates, it could be observed that the best addition rate of sugar beet mud conditioner for realizing the lowest values of BD was recorded when the addition of sugar beet mud material was added at a rate of 1.5% followed by1% and lately 0.5%.Under different agricultural gypsum rates, the trend of BD looks just like the trend under both compost and sugar beet mud rates, where the efficiency of gypsum treatments was as follows:

1.5% gypsum> 1% gypsum > 0.5% gypsum > control treatment.

Generally, Table 5 revealed that individual application of compost, agricultural gypsum and sugar beet mud at different rates led to reducing soil bulk density. These results suggest the vital role of compost and sugar beet mud in reducing soil bulk density due to their content from calcium and organic matter, while agricultural gypsum causes increasing soil aggregates due to its calcium content, thus reducing BD. Many researchers have identified the influence of different combinations of amendments on soil physical properties. The effect of different amendments on plant behaviors is not only a matter of nutrients supply but it has also an influence on the physical, chemical and biological characteristics of soil, which in turn, influence plant growth and development. Abdel Hady (2005) found that decrease in soil bulk density is generally associated with the low particle density of organic matter, when mixed with the mineral fractions of soils caused greatly improvements in both aggregation and porosity. Mandal *et al.* (2013) stated that soil bulk density decreased linearly, up to 42% with 40% compost. According to Rego *et al.* (2017), the use of agricultural gypsum is one of the alternatives to reduce soil density. The performance of the agricultural gypsum on this property is explained by the fact that it is a soil conditioner and when added to the soil solution acts as a binder by the provision of cations, such as calcium and sulfur itself, which act to neutralize soil loads. Abualamaim (2012) found that some physical properties such as bulk density of the salt affected soils after application of compost at a rate of 20 m3/fed decreased by about 18% than that of the control.

Table 5. Effect of compost, gypsum and sugar beet mud on some physical and chemical properties of saline soil.

Soil conditioner	EC (1:5) $dS.m^{-1}$	PH (1:2.5)	Soluble ions (meq.100g^{-1} soil)								ESP (%)	ECaP (%)	O.M (%)	T. $CaCO_3$ (%)	Porosity (%)	Real density (Mgcm^{-3})	Bulk density (Mgcm^{-3})
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	$HCO_3^{=}$	Cl^{-}	$SO_4^{=}$							
Compost (0.5 %)	4.38	7.93	3.20	3.09	13.32	2.81	-	8.1	11.21	3.12	8.5	21.2	2.43	1.63	56	2.68	1.15
Compost (1 %)	4.21	7.92	3.04	2.64	13.28	2.59	-	6.56	11.83	3.16	8.1	22.6	2.85	1.48	58	2.61	1.10
Compost (1.5 %)	3.91	7.90	2.05	1.82	11.68	4.46	-	4.87	10.45	4.69	7.7	23.1	3.12	1.25	59	2.56	1.05
Gypsum (0.5 %)	5.54	7.96	5.05	3.62	15.59	4.1	-	8.56	14.03	5.77	7.1	25.9	0.98	2.09	56	2.73	1.19
Gypsum (1 %)	5.63	7.95	5.80	4.06	16.42	2.54	-	8.32	14.82	5.86	6.7	26.7	0.99	2.56	58	2.72	1.17
Gypsum (1.5 %)	5.75	7.92	5.34	4.27	17.33	2.44	-	7.88	15.06	6.44	5.9	30.8	0.97	3.53	58	2.70	1.16
Sugar beet mud (0.5 %)	5.48	8.08	4.67	4.13	15.62	3.63	-	6.54	13.92	7.59	6.2	29.4	1.43	4.36	56	2.70	1.16
Sugar beet mud (1 %)	5.32	8.11	4.46	3.95	15.13	3.69	-	6.42	13.04	7.77	5.6	32.5	1.64	4.86	56	2.62	1.14
Sugar beet mud (1.5 %)	5.17	8.14	4.56	3.67	14.70	3.54	-	5.79	12.86	8.09	5.2	35.6	1.95	5.21	57	2.63	1.12
Control	5.20	8.05	5.32	3.99	15.98	1.33	-	2.67	13.31	10.64	8.9	20.4	1.12	1.74	55	2.74	1.21

Soil real density (RD)

Soil real density (RD) is considered a soil parameter, which is unable to be easily changed. Data in Table 5 show soil RD as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud),where obtained results were ranged between 2.56 to 2.73 Mgcm^{-3} for different soil amendments as compared to control treatment that recorded 2.74 Mgcm^{-3}. Scanning the different treatments it can detected that the application of 0.5, 1.0 and 1.5 % of compost, agricultural gypsum and sugar beet mud resulted in a reduction of soil real density. Under both compost and sugar beet mud, the reduction of the soil real density was associated with the O.M application. Under agricultural gypsum treatments, the trend of RD looks just like the trend under both compost and sugar beet mud rates, where agricultural gypsum causes little decreasing weight of particles for volume unit, thus reducing RD. Also, it could be clearly noticed that there was a very little change in soil real density, even when investigated soil amendments were applied by its maximum dose. For example, under gypsum treatments, the change in soil real density was only in the second decimal number.

Total soil porosity

Total soil porosity is a result of the relationship between real and bulk density, Table 5 shows that the total soil porosity values as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud) were ranged between 56 and 59 %, meanwhile control recorded 55%. Our finding is in harmony with those obtained by Abualamaim (2012) who found that some physical properties such as total porosity of the salt affected soils after application of compost at a rate of 20 m^3 fed^{-1} was increased by 26% as a result of compost application as compared with the control.

2. **Sandy Soil Condition.**

The effect of treatments *i. e.* compost, agricultural gypsum and sugar beet mud, on improving some chemical and physical properties of the sandy soil *i.e.* electric conductivity (EC), organic matter (OM), soil reaction (pH), ESP, ECaP, total $CaCO_3$, soluble ions, bulk and real density and total porosity after barley crop harvesting have been presented in Table 6. The results appeared that application of different soil amendments remarkably affected sandy soil properties.

Soil chemical properties.

Soil solution electric conductivity (EC).

Regarding to soil solution electric conductivity (EC) of sandy soil as affected by different soil amendments after barley harvest, data in Table 6 demonstrate that some treatments lead to an increase in soil salinity, where others decreased it. A significant decrease was found for EC values of sandy soil as affected by applying compost at rates of 0.5, 1.0 and 1.5% and sugar beet mud at rate of 1.0 and 1.5% compared to control. While, applying agricultural gypsum at all rates caused raising EC values compared to control treatment. Under different rates of both compost and sugar beet mud, the soil EC values were pronouncedly decreased as the rates of soil amendments were increased. On the contrary, a remarkable increase in soil EC values was found with any increase in gypsum addition rate compared to control treatment (without soil amendments). Sugar beet mud is superior to gypsum in reducing EC values of sandy soil because it contains 7% O.M.Obtained data are in agreement with those obtained by Beheiry *et al.* (2007) who found that increasing rate of FYM applied to soil from 5 to 15 ton fed^{-1} led to a decrease in the EC value of this soil from 4.17 to 3.41 dS m^{-1}. Also, Ali and Kahlown (2001) stated that addition of gypsum initially increased the EC value of the soil. On the contrary, Dahdouh *et al.* (2004) found that a significant increase in soil EC value was obtained by increasing the organic matter addition rate. Also, Kheir and Kamara (2019) stated that applying sugar beet factory lime to sandy soil at a rate of 10 t ha^{-1} significantly increased soil organic matter, Meanwhile, soil bulk density and hydraulic conductivity values were decreased subjected to sugar beet factory application, confirming their suitability in improving sandy soil properties for sustainable agriculture.

Soil reaction (pH)

Data in Table 6 show the effect of different rates of soil amendments (compost, agricultural gypsum and sugar beet mud) on soil pH of sandy soil after barely harvest. It could be observed that; the values of pH were slightly affected due to the application of different rates of aforementioned soil amendments where the change in soil pH value was only in the second decimal number. The pH value was decreased gradually with increasing application rate of both compost and gypsum treatments. On the contrary, under sugar beet mud treatments, the pH increased gradually with increasing application rate due to its content of 92.8% $CaCO_3$. These results revealed that the useful and effective application of the compost and gypsum, where these amendments decreased soil pH to some extent compared with control. Also, the positive effect of compost on sandy soil reaction (pH) is higher than gypsum. As previously mentioned, the promotive effect of composting on reducing soil pH is mainly due to the releasing of organic acids through the decomposition of compost (Mohamed *et al.* 2020). Similar findings were reported by (Kheir and and Kamara, 2019) who found that sugar beet factory lime slightly increased sandy soil pH due to its higher content of calcium carbonate. Beside of Prapager *et al.* (2012) who indicated that gypsum application caused reducing pH value.

Organic matter (OM)

Data in Table 6 indicate that, application of different studied amendments to sandy soil at rates of 0.5, 1.0 and 1.5% increased organic matter (OM) content in soil compared to the control, except agricultural gypsum, which did not cause increasing soil organic matter. Also, the data elucidated that organic matter content was increased progressively with increasing the application rates of compost and sugar beet mud. The increase with compost is higher than that with sugar beet mud at the same added rate. As previously mentioned, this attributes to that O.M content in compost is more than sugar beet mud (Tables 3 and 4). Also, the increase in soil organic matter due to increasing compost addition level could be explained by the residual part after decomposition of organic materail contained in compost (Mohamed *et al.* 2020). These results suggest that application of compost and sugar beet mud to sandy soil is very important to increase their OM content. Similar findings were reported by (Sarwar *et al.* 2008; El-Hadidi *et al.* 2020 and Fouda *et al.* 2020).

ESP, ECaP and total $CaCO_3$content.

The effect of treatments *i. e.* compost, agricultural gypsum and sugar beet mud on some soil chemical properties, e.g. exchangeable sodium percentage (ESP), exchangeable calcium percentage (ECaP) and total $CaCO_3$ content of sandy soil, that was cultivated with barley are given in Table 6. Under different treatments, the values of ESP in investigated sandy soil were slightly decreased as rates of soil amendment were increased, while ECaP values were slightly increased as rates of soil amendment were increased. This may be attributed to increasing soluble calcium in soil solution and then it replaced exchangeable sodium on surface of soil colloids.Under gypsum and sugar beet mud treatments, the values of total $CaCO_3$ content were increased as rates of gypsum and sugar beet mud were increased, while the values of total $CaCO_3$ in investigated sandy soil were decreased as the rates of compost were increased under compost treatments. Generally, the calcium ions causes soil aggregates, these results come in the same line with other findings of (Shainberg *et al.*1989) who found that increasing soil aggregates due to gypsum application lead to increasing water storage in deeper rooting zone.

Table 6. Effect of compost, gypsum and sugar beet mud on some physical and chemical properties of sandy soil.

Soil conditioner	EC (1:5) $dS.m^{-1}$	PH (1:2.5)	Soluble ions ($meq.100g^{-1}$ soil)								ESP (%)	ECaP (%)	O.M (%)	T. $CaCO_3$ (%)	Porosity (%)	Real density	Bulk density
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	$HCO_3^{=}$	Cl^{-}	$SO_4^{=}$						($Mgcm^{-3}$)	
Compost (0.5 %)	0.80	7.93	0.83	0.53	2.56	0.17	-	0.95	1.98	1.16	6.8	16.6	1.61	1.08	42	2.71	1.58
Compost (1 %)	0.78	7.91	0.81	0.49	2.21	0.48	-	0.88	1.91	0.94	6.5	17.5	1.73	0.81	47	2.70	1.44
Compost (1.5 %)	0.73	7.91	0.63	0.42	1.95	0.73	-	0.85	1.81	1.07	6.2	18.2	1.85	0.55	47	2.69	1.42
Gypsum (0.5 %)	0.91	7.95	0.67	0.52	2.58	0.88	-	1.05	2.07	1.53	6.0	19.1	0.19	1.32	44	2.79	1.57
Gypsum (1 %)	0.93	7.94	0.71	0.57	2.66	0.82	-	1.1	2.09	1.57	5.7	19.8	0.20	1.58	44	2.77	1.54
Gypsum (1.5 %)	0.96	7.93	0.85	0.62	2.33	1.11	-	0.93	1.96	2.02	5.3	21.4	0.19	1.85	44	2.77	1.51
Sugar beet mud (0.5 %)	0.88	7.98	0.75	0.66	2.24	0.85	-	0.91	1.89	1.7	5.4	20.5	0.86	2.14	42	2.72	1.56
Sugar beet mud (1 %)	0.86	8.00	0.86	0.67	2.44	0.43	-	1.09	1.74	1.57	5.1	22.2	0.89	2.37	43	2.70	1.53
Sugar beet mud (1.5 %)	0.83	8.05	0.83	0.64	2.40	0.37	-	1.02	1.68	1.54	4.9	22.9	0.93	2.62	46	2.69	1.48
Control	0.87	7.96	0.89	0.66	2.68	0.22	-	1.16	2.28	1.01	7.2	15.2	0.28	1.33	42	2.80	1.60

Soil physical properties.

Soil bulk density (BD)

Soil bulk density (BD) values were slightly decreased as the addition levels of organic materials were increased. Under different investigated soil amendments , applying compost, gypsum and sugar beet mud to the soil before sowing at rate of 0.5, 1 and 1.5 % pronouncedly decreased the BD compared to control treatment. Soil bulk density (BD) values remarkably decreased with the increase of adding soil amendments rate, where the lowest values were obtained from addition of compost, gypsum and sugar beet mud as soil application at rate of 1.5% followed by 1% and 0.5%, respectively, where the rates sequence from less BD to top BD was as follows:1.5%> 1% > 0.5% for all soil amendments ,but the compost was more positive on sandy soil BD then sugar beet mud and lately gypsum. Improvement of BD of sandy soil may be due to the decomposition of added organic materials, forming humus material that are responsible for increasing soil aggregates (Six *et al.* 2004). As mentioned above, the decrease in soil bulk density is generally associated with the producing humus materials which join with the soil mineral fractions causing a greatly improves in both aggregation and porosity. Moreover, compost had a positive effect on improving soil bulk density, where decreased bulk density and increased total porosity. The high organic content in added compost is a good explanation of its effect on bulk density (Kunda, 2006).

Soil real density (RD)

As mentioned above soil real density (RD) is considered a soil parameter, which is unable to be easily changed. Data in Table 6 show soil RD as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud).Scanning the different treatments it can detected that the application 0.5, 1 and 1.5 % of compost, agricultural gypsum and sugar beet mud resulted in reduction of soil real density. Under both compost and sugar beet mud, the reduction of the soil real density was associated with the organic materials addition which have a low density, while, under agricultural gypsum treatments, the reduction of the soil real density was also associated with low density of gypsum compared to soil particles. Also, it could be clearly noticed that there was a very little change in soil real density, even when investigated soil amendments were applied at its maximum rate under experiment.

Total soil porosity

Table 6 shows the soil total porosity as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud). All treatments cause an incasing in soil total porosity compared to the control treatment, but there is no difference between the applied three rates of the gypsum.Such primitive effects of organic (compost and sugar beet mud (7.2 % O.M)) or inorganic (gypsum) application may be related to the increase of storage micro-pores in the studied sandy soil, which can be regarded as an index for of an improved soil structure. In addition, a thin coat of translocated fine particles of colloidal organic (active organic acids) and inorganic (fine clays) materials partially covered the walls interconnected vughs, which are usually the most common pores in this soil. In this connection, Mohamed *et al.* (2020) reported that compost is often viewed as a way to improving soil fertility by improving soil physical properties as well as increasing soil organic carbon and nutrient availability.Our finding is in a harmony with those obtained by; Wahdan *et al.* (2009) who studied the effect of the applied treatments of compost and gypsum on some hydrophysical properties. They found that the solely and combined treatments showed positive and significant effects for improving the values of soil bulk density, total porosity, hydraulic conductivity and available water content.

3.Sodic Soil Condition.

Despite using the different studied soil amendments before sowing, barley seeds did not succeed in germination under sodic soil conditions, but there are changes in chemical and physical properties of sodic soil treated with these studied soil amendments as shown in Table 7.

Soil chemical properties.

Soil solution electric conductivity (EC).

Data of Table 7 reveal that application of compost, agricultural gypsum and sugar beet mud at rates of 0.5, 1.0 and 1.5% affected soil solution EC compared to control. After 45 days from sowing (seeds did not succeed in germination), gypsum treatments recorded the highest value of EC (3.05,3.18 and 3.34 dS m^{-1} at rate of 0.5, 1.0 and 1.5%,respectively) compared to control treatment(2.80 dS m^{-1}).The differences among various treatments were clear when compared with control. Electrical conductivity of soil solution is a soil parameter that indicates indirectly the total concentration of soluble salts and subsequently measurement of soil salinity. A decrease in EC value of sodic soil was observed under all investigated rates of compost and sugar beet mud compared to control treatment. The EC value of this soil was not already beyond the critical limit of 4.0 dS m^{-1}. The main reason for this decrease in soil EC value may be attributed to high organic matter inputs which occupied cation-exchange sites and coated soil particle surfaces, limiting Na adsorption and enhancing leaching of Na and salts through soil profile (Kheir and Kamara, 2019).Furthermore, high concentrations of basic cations in compost may affect the potential of compost to alter extractable Na and salinity level of soil and considered responsible for up to 90% adsorbing power of the soils. Also, application of gypsum improves soil structure (Sarwar *et al.* 2011). The improved soil structure provided a better environment for root development and aeration. Soil aggregation is quite often improved, which is attributed to the action of gum compounds, polysaccharides and fluvic acid components of organic materials. Such an improvement helps in leaching of soluble salts present in excessive quantities in the soil solution. Sarwar *et al.* (2011) reported the improvement in EC value of saline-sodic soil with the application of compost and gypsum to the desired levels. Ahmed (2011) showed that addition of organic material to sodic soils led to accelerate the leaching of Na thus, decrease electrical conductivity (EC), increase water infiltration, water holding capacity, and aggregate stability. Generally, the improvement of the EC value of this soil owing to addition of soil amendments was insufficient to obtain successful seed germination.

Soil reaction (pH)

Soil pH elucidates an overall picture of the medium for plant growth including the trend of nutrient supply and the fate of applied nutrients, soil aeration, soil salinity and sodicity status, and ultimate weather conditions of the region. It was observed that application of compost, gypsum, sugar beet mud at different rats (0.5, 1.0 and 1.5%) lowered the pH of sodic soil after 48 days from application compared to control (Table 7). The lowest pH value of 8.05 was observed when compost was added to sodic soil at rate of 1.5% against the highest value of 8.85 in control treatment (without applying soil amendments). Under compost and gypsum treatments, the pH value decreased gradually with increasing application rate. On the contrary, under sugar beet mud treatments, the pH value increased gradually with increasing application rate due to its high content of 92.8% $CaCO_3$. Generally, the application of all soil amendments reduced the soil pH as compared to control, but the improvement of soil reaction (pH) of studied sodic soil owing to soil amendments was insufficient to obtain successful seed germination. Decrease in soil pH value may be attributed to the production of organic acids during mineralization of organic materials by heterotrophs and nitrification by autotrophs which have caused this decrease in soil pH value (Anas *et al.* 2005; Prapager *et al.* 2012; Fouda *et al.* (2020) and El-Hadidi *et al.* 2020).

Organic matter (OM)content.

Data in Table 7 indicate that, application of both compost and sugar beet mud at rates of 0.5, 1 and 1.5% increased organic matter (OM) content in soil compared to the control, while agricultural gypsum did not causes increasing soil organic matter. Also, the data elucidated that organic matter was increased progressively with increasing the application rates of compost and sugar beet mud. Under the same rate of both compost and sugar beet mud, this increase with compost is higher than that with sugar beet mud. As mentioned above, this attributes to that O.M content in compost is higher than sugar beet mud Tables 3 and 4. Application of compost and sugar beet mud to sodic soil may improve O.M. content of sodic soil, but the improvement of organic matter content in studied sodic soil owing to soil amendments was insufficient to obtain successful seed germination.

ESP, ECaP and total $CaCO_3$

The effect of treatments *i. e.* compost, agricultural gypsum and sugar beet mud, on improving exchangeable sodium percentage (ESP), exchangeable calcium percentage (ECaP) and total $CaCO_3$ content of sodic soil are presented in Table 7. Under all investigated treatments, the values of ESP of investigated sodic soil were pronouncedly decreased as application rates of soil amendments were increased, while ECaP values were pronouncedly increased as addition rates of soil amendments were increased. This is due to increasing soluble calcium from used soil amendments in soil solution, thus it replaces exchangeable sodium on sodic soil colloids. Under compost treatments, the values of total $CaCO_3$ in investigated sodic soil were pronouncedly decreased as rates of compost were increased, while under gypsum and sugar beet mud treatments; total $CaCO_3$ values were pronouncedly increased as rates of gypsum or sugar beet mud were increased. This may be attributed to chemical reactions resulted from adding gypsum to the sodic soil, where calcium replace exchangeable sodium on soil colloids, thus sodic clay becomes calcic clay. Also, gypsum may interact with sodium carbonate and turn into sodium sulfate. On the other hand, the positive effect of sugar beet mud in decreasing ESP value and increasing ECaP value may be attributed to its content of O.M. Generally, the organic matter have a great role in reducing ESP of sodic soil. Although all investigated soil amendments led to reducing ESP value of sodic soil, this reduction was not sufficient to success seed barley germination. Generally, all soil amendments at all added rates could not reclaim perfectly, but if the added rates of soil amendments increased, the efficiency may be improved. Similar results were found by Rao and Pathak, (1996) who stated that the application of compost to sodic soils was found to reduce ESP values.These findings are in harmony with the previous results of Abo-Ogiala and Khalafallah (2019) who stated that application of gypsum at higher rates to saline- sodic soils following by irrigation resulted an increase in sodium, chloride, potassium, manganese and zinc in leached water but decreased pH value, exchangeable sodium. Beside of Fisher (2011) reported that gypsum lead to aggregation which happened due to similarly charged ions accumulated at the same site and connect in stable aggregates such as Ca^{2+} and Mg^{2+}.Therefore, improving soil aggregation resulting salt leaching as a result of gypsum application and this leads to enhancing infiltration rate (IR). On the other hand, Abbas *et al.* (2012) reported that soil aggregates were enhanced with compost and soil structure showed higher stability under application of compost. Also, Ahmed (2011) showed that addition of organic material to sodic soils can accelerate the leaching of Na and subsequently decrease the ESP, as shown below Fig1.

Soil physical properties.

Soil bulk density (BD)

Data in Table 7 revealed that application of compost, agricultural gypsum and sugar beet mud at different rates led to reducing soil bulk density compared to control. Soil bulk density (BD) values were decreased as the level of organic matter content was increased. Under different compost rates, applying compost to the soil before sowing at rate of 0.5, 1 and 1.5 % pronouncedly decreased the BD. Soil bulk density (BD) values remarkably decreased with the increase of adding compost rate, where the lowest values were obtained from addition of compost as soil application at rate of 1.5% followed by 1% and 0.5%, respectively. Under different sugar beet mud rates, it could be observed that the best addition rate of sugar beet mud conditioner for realizing the lowest values of BD was recorded when the addition of sugar beet mud material was added at a rate of 1.5% followed by1% and lately 0.5%.Under different agricultural gypsum rates, the trend of BD looks just like the trend under both compost and sugar beet mud rates, where the treatments sequence from less BD to top BD was as follows:1.5% gypsum> 1% gypsum > 0.5% gypsum .

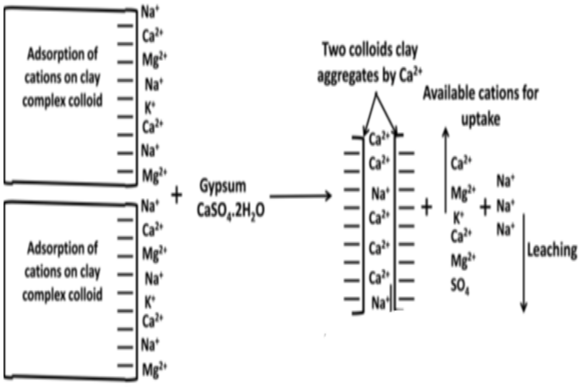

Fig. 1. Model explains gypsum effect on soil properties, Abo-Ogiala and Khalafallah (2019).

Our finding is in agreement with Hussain *et al.* (2001) who stated that physical properties as bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved, when FYM (10 t ha^{-1}) was applied in combination with chemical amendments, resulting enhanced rice and wheat yields in sodic soil.

Soil real density (RD)

Data in Table 7 show soil RD as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud),where obtained results were ranged between 2.59 to 2.76 $Mgcm^{-3}$ for different soil amendments as compared to control treatment that recorded 2.78 $Mgcm^{-3}$. The application rate 0.5, 1 and 1.5 % of compost, agricultural gypsum and sugar beet mud resulted in a reduction of soil real density compared to control treatment, but it could be noticed that there was a very little change in soil real density. Under both compost and sugar beet mud, the reduction of the soil real density was associated with its O.M content. Under agricultural gypsum treatments, the trend of RD looks just like the trend under both compost and sugar beet mud rates, where agricultural gypsum causes an addition of light particles weight, thus reducing RD.

Total soil porosity

Data in Table 7 reveal that application of compost, agricultural gypsum and sugar beet mud at different rates led to an increase in total soil porosity compared to control. The total soil porosity % of investigated sodic soil as affected by different soil amendments (compost, agricultural gypsum and sugar beet mud) ranged between 45 and 50 %, meanwhile control recorded 50%.Our finding is in harmony with those obtained by Hussain *et al.* (2001) who reported the improvement in soil physical properties such as total soil porosity with the application of farmyard manure

(10 Mg ha^{-1}) integrated with chemical amendments and also resulted in enhancing rice and wheat yields under sodic soil conditions. Application of gypsum and organic matter also improved soil structure (Abo-Ogiala and Khalafallah, 2019).

Table 7. Effect of compost, gypsum and sugar beet mud on some physical and chemical properties of sodic soil.

Soil conditioner	EC (1:5) $dS.m^{-1}$	PH (1:2.5)	Soluble ions (meq.$100g^{-1}$ soil)								ESP (%)	ECaP (%)	O.M (%)	T. $CaCO_3$ (%)	Porosity (%)	Real density (Mgcm⁻³)	Bulk density (Mgcm⁻³)
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	$HCO_3^{=}$	Cl^{-}	$SO_4^{=}$							
Compost (0.5 %)	2.43	8.20	2.42	1.82	7.65	0.55	1.50	2.13	5.88	2.93	26.3	21.3	1.32	2.56	45	2.67	1.47
Compost (1 %)	2.31	8.12	2.32	1.74	7.22	0.54	1.10	2.09	5.73	2.90	25.6	22.9	1.40	2.43	48	2.62	1.35
Compost (1.5 %)	2.18	8.05	2.18	1.64	6.82	0.52	1.31	1.96	5.21	2.68	25.1	26.4	1.54	2.25	49	2.59	1.33
Gypsum (0.5 %)	3.05	8.31	3.16	2.31	9.38	0.76	0.98	3.01	7.69	3.93	23.2	29.5	1.09	3.36	47	2.76	1.46
Gypsum (1 %)	3.18	8.26	3.28	2.43	9.78	0.79	0.15	3.42	8.31	4.40	19.6	33.1	1.05	3.75	50	2.74	1.43
Gypsum (1.5 %)	3.34	8.22	3.46	2.53	10.30	0.81	0.85	3.29	8.54	4.42	17.5	36.5	1.05	3.94	48	2.73	1.38
Sugar beet mud (0.5 %)	2.87	8.36	3.08	2.26	8.60	0.75	2.06	2.49	6.79	3.35	14.8	34.9	1.13	4.96	46	2.71	1.45
Sugar beet mud (1 %)	2.84	8.42	2.76	2.03	9.17	0.58	1.6	2.56	7.15	3.23	14.6	38.7	1.15	5.19	47	2.63	1.40
Sugar beet mud (1.5 %)	2.78	8.48	3.84	1.85	8.12	0.42	2.85	2.19	6.17	3.01	13.3	41.2	1.18	5.63	48	2.64	1.36
Control	2.80	8.58	2.86	2.14	8.62	0.71	1.09	3.94	6.89	2.41	28.2	20.6	0.95	2.35	45	2.78	1.52

CONCLUSION

Results obtained from this investigation increase our knowledge regarding the efficacy of some soil amendments such as compost and agricultural on the improvement of degraded soils properties. Also, the results confirm that sugar beet mud which may cause problems to the environment, is beneficial for improving degraded soils as anew soil amendment in Egypt due to its high contents from organic matter and calcium

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استصلاح الأراضي باستخدام الكومبوست والجبس الزراعي وطين بنجر السكر

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في مصر، يعتبر تحسين الأراضي المتدهورة قضية مهمة في برنامج الأمن الزراعي. كميات كبيرة من المخلفات الصناعية للسكر مثل طين السكر والجير الذي ينتج سنويا يسبب بعض المشاكل للبيئة إذا لم يتم استغلالها. لذلك تم إجراء تجربة أصص لتقييم تأثير بعض محسنات التربة على تحسين بعض الخصائص الكيميائية والفيزيائية لبعض أنواع الاراضي المتدهورة في مصر. تم استخدام ثلاثة أنواع من التربة (ملحية ورملية و صودية) ومعاملتها بثلاثة محسنات تربة وهي الكومبوست والجبس الزراعي وطين بنجر السكر والتي تم اضافتها الي الاراضي الثلاثة المدروسة (قبل الزراعة بأسبوعين) بثلاث معدلات (0.5%، 1%، 1.5 ٪، أي ما يعادل 2.5، 5.0، 7.5 جرام /أصيص على التوالي) والترطيب حتي التشبع، تمت زراعة الاراضي بالشعير. في نهاية التجربة، تم أخذ عينات من التربة من كل معاملة، وأظهرت النتائج عدم نجاح إنبات بذور الشعير تحت ظروف التربة الصودية ، بينما نجحت البذور في الإنبات تحت ظروف الأراضي الملحية والرملية. بشكل عام، أدت الإضافة الأرضية لجميع المحسنات المدروسة عند جميع المعدلات إلى تحسن واضح في جميع الخصائص الكيميائية والفيزيائية للتربة الملحية والرملية والصودية مقارنة بالمعاملة الكنترول (بدون إضافة)، لكن التحسن زاد مع زيادة معدل إضافة جميع محسنات التربة المدروسة حيث تم تسجيل أفضل القيم بسبب الإضافة الارضية بنسبة 1.5٪ تليها 1٪ و0.5٪ على التوالي لجميع خصائص التربة. كما تؤكد النتائج أن طين بنجر السكر كمحسن جديد للتربة في مصر مفيد في تحسين الاراضي المتدهورة بسبب محتواها العالي من المواد العضوية والكالسيوم.