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A COMPARATIVE STUDY OF SOME SOIL AMENDMENTS AND THEIR APPLIED METHODS ON THE AMELIORATION OF SALINE-SODIC SOILS

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ABSTRACT: *Two field experiments were conducted in a private farm located at South-El-Hussynia Plain Port Said Governorate, during four successive seasons of, 2011/2012 and 2012/2013 to evaluate the profitability of industrial byproducts sugar lime, By-pass, a mixture (1) and a mixture (2) using efficiency as soil amendments, on improving some soil properties and its productivity of barley plants, comparing with gypsum under two techniques of application i.e. surface alone method and the combination method (surface+ subsurface) with intermittent leaching cycles.*

The obtained results can be summarized as follows:

1- Reduction in the values of ECe, ESP and bulk density. On the contrary, H.C. and WTD were increased under the two methods of application either surface alone or in combination (surface +subsurface).

2- The combination application method (surface +subsurface) was bearing more effective than surface application method.

3- Either mixture (1) or mixture (2) was bearing more effective than the applied gypsum in both two techniques surface or (surface +subsurface).

4- Crop yield (grain and straw) of barley was significantly increased by using soil amendment treatments particularly, in the presence of (surface +subsurface) technique.

***Key words**: Saline - sodic soils, Amelioration, Soil amendments, Sugar lime, Vinasse.*

INTRODUCTION

Sodicity (sodium rich) and salinity are soil characteristics responsible for soil degradation and affect agricultural production in several ways. The problem of salt affected soils has become a global issue because of poor land and water management practices as well as insufficient reclamation operations in many parts of the world.

Egypt has 3.4 million fed. of saline-sodic soils, affecting productivity and livelihoods are notable in the north of Nile Delta .Most of these areas suffers from the major soil twin problems salinity/ sodicity and water logging. It is estimated that the world as a whole is losing at least 3 hectares of fertile land every minute due to salinization/sodification (Abrol *et al.*,1988.). According to estimates by FAO and UNESCO nearly 50% of the irrigated lands in the arid and semi-arid regions of the world have some degree of soil Stalinization and codification problems. Today the availability of new land is limited, due to over irrigation, high water tables, poor water management practices, fertile and productive soils are turning into non-productive saline / sodic and water logged soils, which result in less crop production and eventually abandonment of the land. Thus, reclamation of existing salt affected soils is of primary importance.

Gypsum applications followed by leaching, and biological methods such as growing salt –tolerant crops, were founds successful in reclamation of a number of sodic and saline –sodic soils having good drainage conditions (Ahmed *et al.*, 1990, Oster *et al.*, 1996 and Reda, 2006). Abdalla *et al.*, (2010) concluded that tile drainage installation is the most important tool to conserve or reclaim the harmful effect of salty clayey soils to a feasible one. This process must be under taken with gypsum requirements. The most common reclamation amendment for this purpose is gypsum because of its low coast, commercial availability and ease of handling. The application of gypsum enhances leaching by improving soil hydraulic conductivity. Mansour (2002) showed that adding sugar lime to saline sodic soils increased total porosity, water holding capacity, quickly drainable and water holding pores, consequently soil hydraulic conductivity increased. On the other hand, soil bulk density and fine capillary pores were decreased by increasing application rate.

(Parnaudea *et al*. 2008 and Habib *et al*., 2009). Tejada *et al*., (2007) found that beet vinasse was a positive effect on soil's physical structural stability increased and bulk density decreased with respect to control. Cement Kiln dust (CKD)"By-pass" is a fine grained material generated as a by-product of cement manufacturing. Raw materials are fed into cement Kiln and heated to temperatures ranging between 1400 and 1550 °C. The main raw material used to produce cement is lime stone ($CaCO_3$) with approximately ten percent of the raw mix made up of a silica source (*e.g.,* sand or clay), an alumina source and an iron source. Abd El-Hamid *et al*., (2011) concluded that the usage of any amendments gypsum, sugar lime, By-passe, mixture (1) and mixture (2) could be positively affect on about reclamation of saline clay soil in Shall El-Tina district.

Mansour *et al.,* (2011) concluded that using suitable amendments mixtures under suitable application method (surface +subsurface) with intermittent leaching cycles, were the pest for the led to short time for reclamation of clay saline sodic soils. Dahlya *et al.*, (1981) observed that leaching intermittently allowed more time for the movement of water through pores and improved the leaching efficiency Al-Sibai *et al.,* (1997) worked on the movement of solute through porous media under intermittent leaching and reported that under intermittent leaching, 25% of water savings were possible under their laboratory conditions. Therefore they concluded that intermittent leaching could improve leaching efficiency.

The aim of this experiment was improving the efficiency of some industrial byproducts i.e. Sugar lime and by-pass as a soil amendments in saline sodic soils, comparing with gypsum under two techniques of application, of evaluate their effect on improving some chemical and physical properties.

MATERIALS AND METHODS

Two field experiments were conducted on a private farm located at South-El-Hussynia Plain Port Said Governorate, during four successive seasons of 2011/2012 and 2012/2013. Soil characteristics were determined according to Cottenie *et al* (1982) and the obtained data are presented in Table (1).

Table (1): Some physio-chemical properties of the experimental soil

Soil properties and units	Value	
	0-20 cm	20-40 cm
Particle size distribution %		
Coarse sand	0.7	0.6
Fine sand	14.3	11.1
Silt	29.3	29.2
Clay	55.7	59.1
Texture class	Clay	Clay
Chemical analysis		
pH (1:2.5)	8.5	8.9
EC $dS.m^{-1}$	17.6	14.6
ESP %	22.6	27.0

The chemical composition of Sugar lime, Vinasse and By-pass were carried out according to Page *et al* (1982) and the obtained data are tabulated in Table (2).

The experiment was established in a split plot design with three replicates. The plot area of 10×5 m^2. The main plot was divided into two techniques of application surface alone method and the combination method (surface + subsurface). The sub main plot was divided into six soil amendments treatments i.e. untreated (T1), gypsum (T2), sugar lime (T3), By-pass (T4), mixture 1 (T5) and mixture 2 (T6) were used at a rate of 4.0 Mg $fed.^{-1}$ for each soil amendments treatments. The composition and chemical properties of the two mixtures of amendments used are presented in Table (3)

In the surface application method, the soil amendments were applied over the soil surface and then tillage by cultivator (conventional tillage),while, in the combination method, half dose of different soil amendments were applied over the soil surface and tillage by turning plow then the second half dose was applied and tillage using deep plowing (40 cm depth).

Table (2): Chemical composition of Sugar lime, Vinasse and By-pass used.

Characteristics	Sugar lime	Vinasse	Cement kiln dust (By-pass)
Density (Mg m^{-3})	0.74	1.14	0.63
pH (1:2.5)	8.30	4.50	12.0
EC (dSm^{-1})	15.3	10.0	17.5
SP	70.0	--	209
$CaCO_3$ (%)	51.3	0.12	30.9
Total elements (%)			
Nitrogen	0.94	0.20	0.02
Potassium	0.06	0.71	1.36
Calcium	28.5	0.65	4.51
Phosphorus	0.28	0.21	0.09
Manganese	3.42	0.60	0.35
Iron	0.007	0.0006	0.011
Copper	0.21	0.0073	2.02
Zinc	0.003	0.0024	0.003

Table (3): Composition and chemical properties of the two mixtures of soil amendments used.

Mixtures of amendments	Mixtures composition percent				Chemical properties		
	S.L	B.P	V	A	pH	EC dS m^{-1}	$CaCO_3$ %
M_1	3	3	1	1	7.11	14.70	14.3
M_2	8	-	2	1	7.07	24.6	17.6

S.L: Sugar lime **V:** Vinasse **B.P**: By-pass
A: Concentrated sulphuric acid

The experimental layout:

The experimental comprised 36 plots, each 10×5 m.Laid out narrow beside both of drainage ditches,1.25m. deep, and installed at intervals of 5 m. Fig. (1). One split was tillage by turning plow while another split was tillage by cultivator. Each basin was surrounded by a low earthen embankment which service to contain the pounded water. The leaching water was supplied from irrigation canal lie between two drains, which measured by flow meter, staff gauges in stalled within each basin leaching. Intermittent leaching in which pounded water application is interrupted with rest periods allowing redistribution of the salts held in micro pores.

Barley grains (Giza 123) were sown at November after the soil was leaching, Before sowing, all plots were fertilized by super phosphate (15.5% P_2O_5) at rate of 120 Kgfed^{-1} and mixed with soil during the seed bed preparation. After 21 and 42 days of sowing were fertilized by ammonium nitrate (33%) and potassium sulphate (48 %) at rates 200 and 50 Kgfed^{-1} in two equal doses, respectively.

Water table depth:

Observation wells were inserted in the midpoint of each plot, 1.5 m. depth from soil surface to measure the fluctuation of water table before each leaching cycle, Luthin (1966). Disturbed and undisturbed soil samples were taken at the end of the experiment from each plot through two depths i.e. 0-20 and 20-40 cm. These samples were prepared for different physical and chemical properties according to the standard methods mentioned in Table (4).

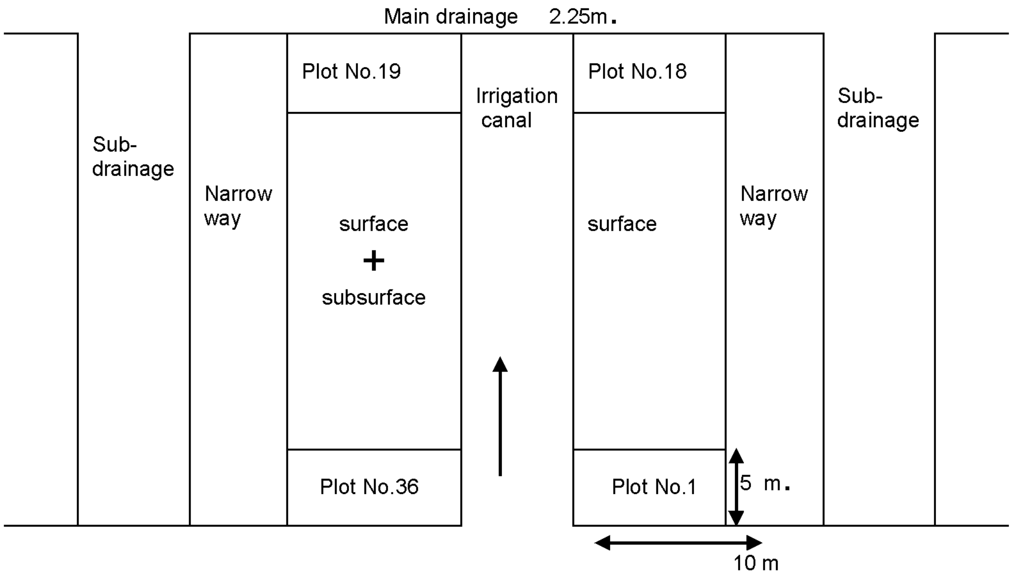

Fig. (1): Layout of the experimental plots in split plot design.

Table (4): Soil properties as determined by the standard methods described by the different publishers.

Soil properties		References
Chemical analysis		Cottenie *et al.,* 1982
Particle size distribution	(%)	Gee and Bauder, 1986
Bulk density	(Mg m^{-3})	Vomocil, 1965
Hydraulic conductivity	(Cm h^{-1})	VanBeers,1958 (Auger hole method)
Ground water levels		Luthin 1966.
Soil pH and electrical conductivity	(dS m^{-1})	Page *et al.,* 1982.
Gypsum requirement	(Mg fed^{-1})	Oster and Frenkel 1980.

RESULTS AND DISCUSSION

Salt leaching and exchangeable sodium percent (ESP) at the end leaching cycles.

The movement of soluble salts in the soil depends mainly on its texture, structure, total porosity and permeability. Reclamation processes play an active role in improving salt movement and leaching process. Data in Table (5) showed the effect of the application methods for soil amendment treatments i.e. gypsum, Sugar lime, By-pass, mixture (1) and mixture (2) on ECe and ESP of saline sodic soil under leaching cycles. Data indicated that, the mean values of both soil ECe and ESP after the end of leaching cycles were decreased with the different amendment treatments either surface addition or combination (surface and subsurface) method as compared with control (untreated soil)

The relative decrease (%) in soil salinity (ECe) was increased in both two application methods. The best treatments were found to be mixture 1(T5) in both surface and sub surface, particularly the combination application method. These results may be attributed to the tillage using turning plow followed by deep plowing which have increased the total porosity, infiltration rate and helped more in leaching the salts, as compared with the surface addition alone. (Sadiq *et al.,* (2003).The same trend was observed with exchangeable sodium percent (ESP) in both surface and subsurface layers (0-20 and 20-40 cm). These results may be due to higher soluble Ca^{2+}, and consequently increasing exchangeable Ca^{2+} which encourage decreasing of both soluble and exchangeable sodium hence decreasing the ESP values (Ghazy, 1994 and Abd El-Hamid *et al.,* 2011)

Table (5): Effect of different soil amendment treatments and application methods on final Salinities (ECe), exchangeable sodium percent (ESP) and relative decrease (R.d %) for soil depths (0-20 and 20-40cm.).

Application methods	Soil amendment treatments	Soil depth							
		0-20cm				20-40cm			
		EC (dSm^{-1})	*R.d (%)	ESP	R.d (%)	EC (dSm^{-1})	R.d (%)	ESP (%)	R.d (%)
Surface	T1	14.70	----	21.00	----	15.00	--	20.00	--
	T2	10.00	31.97	13.50	35.71	11.00	26.67	13.80	31.00
	T3	11.00	25.17	14.00	33.33	12.20	18.67	15.70	21.50
	T4	10.50	28.57	13.80	34.29	11.50	23.33	14.30	28.50
	T5	9.20	37.41	10.10	51.90	9.80	34.67	10.60	47.00
	T6	9.00	38.78	9.80	53.33	10.10	32.67	11.40	43.00
Surface+ subsurface	T1	14.40	--	20.60	--	14.60	--	19.40	--
	T2	9.00	37.50	9.30	54.85	9.80	32.88	9.70	50.00
	T3	8.50	40.97	10.60	48.54	10.50	28.08	11.20	42.27
	T4	8.00	44.44	10.20	50.49	10.00	31.51	10.80	44.33
	T5	7.30	49.31	8.10	60.68	8.40	42.47	8.80	54.64
	T6	7.50	47.92	8.30	59.71	8.60	41.10	8.90	54.12

* R.d = Relative decrease (%) =cont. - treatment / treatment × 100

Water table depth (WTD):

Water table depth fluctuations during leaching cycles are illustrated in Fig. (2).The data showed that a deeper water table increased with increasing leaching cycles and develops more rapidly in the present of the applied amendment treatments than the control, particularly the combination method of application.

WTD fluctuated between 60 to 72 cm and 80 to 110cm and 78 to 106 cm at the end of leaching period (16^{th} leaching cycles) for gypsum , mixture (1) then mixture (2) for surface and combination (surface and subsurface) application, respectively. These results may be attributed to the increasing exchangeable Ca^{+2} which encourage flocculation of soil particles leading to the formation of large soil aggregates with void volume which increased the efficiency of leaching processes.

Bulk density:-

It is well known that bulk density is mostly affected by soluble salts content as a result of the effect of any one of gypsum, sugar lime, by-pass, mixture (1) and mixture (2) under the different application methods as shown in Table (6). Higher value of bulk density means more weight per unit volume. So, when more soil was packed in the same volume, the soil became more compact and defective from agriculture point of view. Due to less pore space. These soils were impermeable to water. The value of soil bulk density, become more porous and effective for root respiration and water permeability. Data in Table (6) indicated that soil bulk density was improved as a result of the different application of soil amendment treatments. The most effective treatment was the combination application method was more effective under soil amendments than the surface application method alone. The value of bulk density in surface application method was decreased from 1.55 Mg m^{-1}in the control treatment, to 1.44, 1.47, 1.45, 1.40 and 1.38 in soil application of gypsum, sugar lime, by-pass, mixture (1) and mixture (2) respectively. While, in the combination application method, these values were 1.4, 1.43, 1.41, 1.33 and 1.3 with the same amendments. Generally, the found data results that the lowest values of B.D or the high efficiency of the terted treatments were recorded with mixture (1) followed mixture (2), respectively, in the combination method.

These results may be attributed to the decomposition amendments and increasing exchangeable calcium which enhance aggregation process and consequently increase apparent soil bulk density volume and decrease soil bulk density which increased the efficiency of leaching processes (Ghazy, 1994 and Abd El-Hamid, 2011)

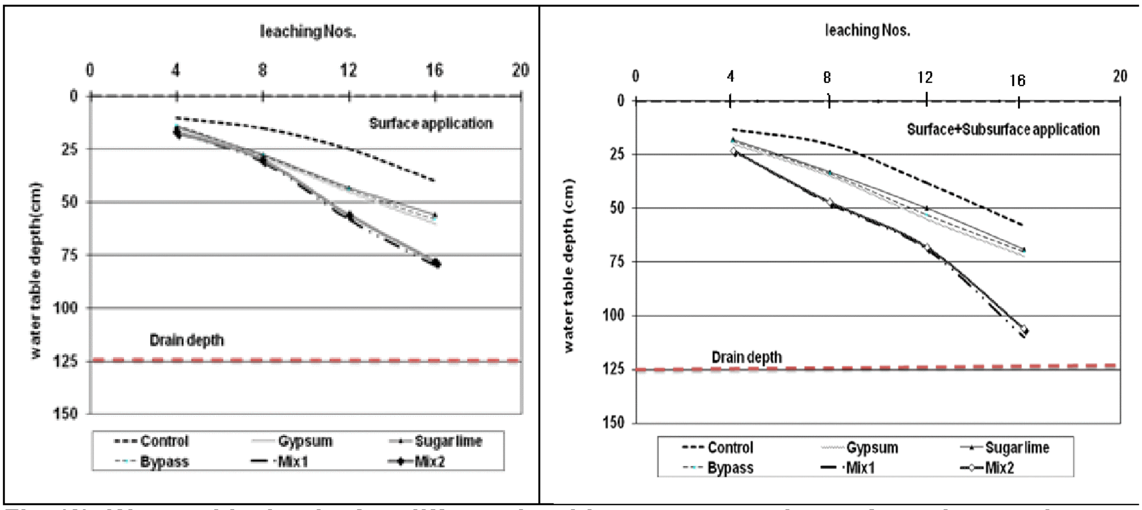

Fig. (2): Water table depth after different leaching process under surface alone and surface +subsurface application methods of soil amendments treatments.

Table (6): Effect of different soil amendment treatments and application methods On water table depth, soil bulk density and hydraulic conductivity.

Application method	Soil amendment treatments	WTD (cm)	B.D (Mgm^{-3})	H.C ($cm\ h^{-1}$)
Surface	T1	40	1 55	2.4
	T2	60	1.44	3.8
	T3	56	1.47	3.6
	T4	58	1.45	3.7
	T5	80	1.38	4.2
	T6	78	1.4	4
Surface + Subsurface	T1	58	1.49	3.1
	T2	72	1.4	7.8
	T3	69	1.43	7.6
	T4	70	1.41	7.5
	T5	110	1.3	9.5
	T6	106	1.33	9.3

B.D: Bulk density. **H.C**: Hydraulic conductivity .**WTD**: Water table depth.

Hydraulic conductivity (HC):

The effect of different treatments of the tested soil amendments under leaching cycles, on hydraulic conductivity (cmh^{-1}), the obtained data were studied and represented in Table (6) data reveal that the most effective treatments were the combination more than surface addition alone. Data in Table (6) showed that the changes of H.C. connected to WTD, bulk density and applied method. It is clear that the highest value of H.C and WTD are found with the combination (surface and subsurface) addition as compared with the surface addition and the control (untreated soil).This result may be attributed to the decreased ESP, ECe and bulk density values in the treated soil which were lower than those in the untreated soil, On the other hand, this could be due to the presence of amendments, which enhanced the soil aggregates which increase both of total porosity and drainable pores. These results were similar to that reported by Mansour (2012)

Crop yield:

The yield of barley (Giza 123) was used to evaluate the impact of soil amendment treatments under two application methods. Barley is moderately of salinity and sodicity (Barros, *et al.,* 2004).The yield of barley 2012/2013 are presented in Table (7). Data indicated that the grain and straw yields of barley plants significantly increased as a result of soil amendment application, either surface or combination (surface + subsurface). The yield of barley plants either grain or straw shows the superiority of combination treatments over the surface individually treatments. Furthermore, the relative increase of both grain and straw yields show that the efficiency of the studied amendments could be arranged in the following descending order: mixture (1) >mixture (2)>gypsum > By-passe > sugar lime, either addition surface or combination. These results may be attributed to improvement in both soil physical and chemical properties as well as increasing the availability of soil macro and micro-nutrients for plant and both water and fertilizers use efficiencies (El-Masry, 1995).Moreover, the decrease in ECe and ESP consequently decreasing the uptake of sodium by plant comparing with the untreated (El-Maghraby, 1992) The maximum reclamation efficiency of the mixture (1) treatment may be increased supply of Ca^{2+} in the soil ameliorates the salt effect through enhanced K^{+}/Na^{+} selectivity (Wahadan *et al.*, 1999 and Hanay *et al.*, 2004).

Table (7): Effect of different soil amendment treatments and application methods on the barley yield parameters (average two seasons)

Application methods	Amendment treatments	Grain Yield (Mg fed^{-1})	R.I (%)	Straw yield (Mg fed^{-1})	R.I (%)
Surface	T1	0.77	-	1.5	--
	T2	1.18	34.75	2.32	35.34
	T3	1.04	25.96	2.05	26.83
	T4	1.1	30.00	1.98	24.24
	T5	1.41	45.39	2.79	46.24
	T6	1.37	43.80	2.69	44.24
L.S.D. 0.05		0.43		0.38	
Surface + subsurface	T1	0.9	-	1.78	-
	T2	1.58	43.04	3.1	42.58
	T3	1.45	37.93	2.88	38.19
	T4	1.5	40.00	2.95	39.66
	T5	1.75	48.57	3.4	47.65
	T6	1.68	46.43	3.34	46.71
L.S.D. 0.05		0.45		0.41	

*R.I=Relative increase

CONCLUSION

From the above mentioned results and discussion it could be concluded that using a suitable amendments mixture (1) or mixture (2) under suitable application method (surface +subsurface) with intermittent leaching cycles, were the pest for the led to short time for reclamation and improving the properties of clay saline sodic soils. In addition, this method may encourage the horizontal expansion of the most marginal agriculture soils in Egypt and increasing the farmer's livelihood and national incomes.

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دراسة مقارنة لبعض المصلحات وطرق اضافتها لتحسين الاراضى الملحية الصودية

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الملخص العربى

أقيمت تجربتان حقليتان بمزرعة خاصة بمنطقة جنوب سهل الحسينية بمحافظة بورسعيد خلال عامين متتاليين ٢٠١٢/٢٠١١ و٢٠١٣/٢٠١٢ بهدف تعظيم الاستفاده و تقييم تاثيرخمس مصلحات (الجبس- جير السكر-الباى باس- مخلوط ١- مخلوط٢) تحت طريقتى إضافه إلى التربة (سطحية فقط - سطحية وتحت سطحية معا) مع إتباع طريقة الغسيل المتقطع و ذلك على تحسين إستصلاح الاراضى الملحية الصودية وزيادة انتاجيتها من محصول الشعير

وقد اشارت النتائج المتحصل عليها على:

١- انخفاض قيم كل من نسبة الصوديوم المتبادل وملوحة التربة والكثافة الظاهرية وعلى العكس زادت قيم كل من التوصيل الهيدروليكى ومنسوب الماء الارضى.

٢- معاملة الاضافة السطحية والتحت سطحية معا أعطت نتائج أفضل من معاملة الاضافة السطحية فقط.

٣- نتائج إضافة المخلوط ١ أو ٢ أفضل من نتائج إضافة المصلحات الاخرى (الجبس- جير السكر- الباى باس) سواء كانت الاضافة سطحية فقط او سطحية و تحت سطحية معا .

٤- زيادة محصول الشعير النامى (حبوب وقش) زياده معنويه عند إستخدام أى من المصلحات فى التربة خاصة عند معاملة الإضافة السطحيه وتحت السطحيه معا مقارنة بالاضافة السطحية فقط.