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EVALUATION OF INDUSTRIAL GYPSUM WASTES AS AN AMENDMENT FOR SALT AFFECTED SOILS AND RICE PLANT GROWTH IN EL-HUSSANIA AREA, EGYPT

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ABSTRACT: *Salinity is important limitation factor for agricultural production in semi-arid region. A field experiment was conducted on a clayey saline affected soil at El-Hussania area, Egypt, during growing summer season to study of 2012 the effect of by-product gypsum (phosphogypsum and sulphugypsum) and natural one applied at two rate (15 and 30 t ha^{-1}) on some soil properties of new reclaimed soil and rice on growth, yield and yield components of rice plant (Oryza sativa L., Giza 177 cv).*

The obtained results showed that, there are some differences in bulk density, electrical conductivity (EC), pH, exchangeable Ca^{2+} and sodium adsorption ratio (SAR) among the treatments of the used gypsum sources in comparison with the control one. Among the treatments, the highest reduction in SAR (18.23 $mmol/l)^{1/2}$ and EC (7.20 dS/m) were associated the treatments of phosphogypsum, at rate of 30 t ha^{-1}.

The obtained data reveal that, the applied gypsum at different-rates significantly increased the yield attributes of rice. However, gypsum-rate of 30 t ha^{-1} resulted in relative increase percentages for grain pancle^{-1} reached 46.8% over the control treatment. With increasing added phosphogypsum levels from 15 t ha^{-1} to 30 t ha^{-1}, the yield components increased by 22.3 and 30.6% for 1000-grain weight compared with the control respectively. Among the gypsum-sources, phospho-, sulpho- and naturalgypsum gave pronounced increases in seed yield of rice reached 20.7, 58.6 and 77.2 %, respectively. This means that phosphogypsum was considered the best gypsum source from soil productivity point of view, followed by sulpho- and naturalgypsum for tested crops.

Under the current experimental conditions, it could be concluded that application of phosphogypsum at rate 30 t ha^{-1} to rice plants grown on a salt affected soil was necessary to realize an optimum productivity. As for the applied different gypsum sources, it is noteworthy to mention that although phosphogypsum was not only promising in terms of productivity and best soil properties but also it represents a better option from the applicable point of view as compared to sulpho- and naturalgypsum, this is mainly due to its relative cheap costs.

Key words: *Phosphogypsum, Sulphuregypsum, Gypsum, Salt affected soil properties and Rice yield.*

INTRODUCTION

The saline-sodic soils character zed by high sodium content are compact and generally form a hardpan on the soil surface. This compactness prevents plant root proliferation and reduces salt leaching. Thus the reclamation of such soils with simple leaching by flooding remains ineffective. The application of gypsum enhances leaching by improving soil hydraulic conductivity Ghafoor *et al.*, (1990). The gypsum application with or without organic manures for reclamation of different sodic and saline-sodic soils has proved profitable Ghafoor *et al.,* (2001). Beside gypsum, the chemical amendments followed by leaching with canal water can reclaim saline-sodic soils Biggar, (1996). The chemical amendments, being costly can be replaced successfully by organic manuring which has been found effective in increasing the crop yield and good physical health of soil Ibrahim *et al.*, (2000). Rice (*Oryza sativa* L.) is one of the most important food crops in the world. Also, rice is moderately sensitive to salinity and moderately tolerant to sodicity Aslam *et al.*, (1993) and Qadir *et al.*, (2001). It is often recommended as a desalinization and dealkalinity crop because of its ability to grow well in standing water and the above-ground parts of the rice plants could consume alkalinity in alkaline soil Van Asten *et al*., (2004). Due to its shallow rooting zone, roots are less hampered by a sodic B-horizon.

Furthermore, rice roots release organic compounds and complex energy sources Dormaar (1988), which increase partial CO_2 pressure Robbins (1986) as well as decrease soil pH through proton excretion. All these processes combined favour the increased dissolution of $CaCO_3$ in the soil and the decrease of soil alkalinity and sodicity as a function of time Ahmad *et al*., (1990). Rice cultivation may improve percolation rates even in highly sodic soils .Irrigated rice cropping is practiced to reclaim saline-sodic soils in many parts of the world Van Asten *et al*., (2004).

Phosphogypsum, a by-product of the phosphoric acid industry, containing mainly calcium sulphate and small contents of P, is largely available in many parts of the world. more than 22 million tons of phosphoric acid is produced annually worldwide, generating in excess of 110 million tons of phosphogypsum byproducts Aagli *et al*., (2005). Phosphogypsum, due to containing low phosphates and its acidic nature, has advantages over mined gypsum where it is applied to the predominantly slightly alkaline soils of the region. More importantly, fine-grained phosphogypsum contributes more than mined gypsum to soil electrolyte concentrations through ahigher dissolution rate and therefore contributes more to electrolytic control of clay dispersion in sodic soils Oster and Frenkel, (1980) and Takasu and Saigusa (2004).

Thus, it is necessary to increase knowledge on the use of phosphogypsum as a soil amendment for saline soils as an alternative to dispose of a bulky by-product of the fertilizer industry. Therefore, the present investigation was undertaken to evaluate the effect of different levels of gypsum sources application on grain yield and yield components of rice cultivar under salt affected soils.

MATERIALS AND METHODS

Site description:

This study was conducted in El-Hussania area which lies in the north-western Egypt, between longitudes 32^0 35′& 32^0 45′E and latitudes 31^0 00′& 31^0 25′ N with an average elevation of 10 meters above the sea and representing new reclaimed area, in the semi-humid and semi-arid area. The average annual precipitation is about 370-400 mm with 88% in January – December and the average temperature is 21°C. The soil of the our experimental fields is classified as saline-sodic soil.

Experimental design:

Experiment was designed as a randomized complete block in a split plot treatment (gypsum sources) arrangement, and split into subplots of two rats (50 and 100 of gypsum) requirement. A randomized complete block design with three replications. The area of experimented unit was 3 m × 5 m. Each plot was conducted with the following treatments:

(1) Saline-sodic soil (Control),
(2) Natural gypsum added at rate of 15 t ha^{-1} which equal 50 % gypsum requirement.
(3) Natural gypsum added at rate of 30 t ha^{-1} which equal100 % gypsum requirement.
(4) Phosphogypsum added at rate of 15 t ha^{-1} which equal50 % gypsum requirement.
(5) Phosphogypsum added at the rate of 30 t ha^{-1} which equal100% gypsum requirement.
(6) Sulphugypsum added at rate of 15 t ha^{-1} which equal50 % gypsum requirement.
(7) Sulphugypsum added at rate of 30 t ha^{-1} which equal100 % gypsum requirement.

Estimation of gypsum requirements

Estimation of the required gypsum was made considering the cation exchange complex of the soil, exchange efficiency and the initial and final ESP using the gypsum requirement (GR) as described in USSL Staff (1954) and Makoi (1995) as follows:

GR =Na_{exch} (Eqwt Gypsum / Eqwt Na) mg Na $mmol^{-1}$ kg^{-1}soil

Where: GR = Gypsum requirements ($g.kg^{-1}$); Na_{exch} =Exchangeable Na ($mmol.kg^{-1}$ soil); Eqwt = Equivalent weight.

The chemical characteristics and nutrients status of the applied soil amendment were determined according to the standard methods of Issam and Sayegh(2007), and the obtained data were illustrated in Table (1). Following the layout of the plots, naturalgypsum, (d from El-Salam canal (Nile water mixed with agriculture drainage water, with a ratio of 1:1) currently used in local production were grown in the field. Rice seed were sown on unsaline soil in a nearby greenhouse on May 20, 2012, .After 40-day, the seedlings were manually transplanted at a density of 4 plants/hill on June 30, 2012. All plots received nitrogen fertilizer at the rate of 240 kg N ha^{-1} as urea (46.5 % N), which were split into the basal application 7 days prior to transplanting (60% of the total N), side-dressing on 9 July (20% of the total N) and at panicle initiation on 3 August (20%). Phosphorus was added at a rate of 280 kg fed^{-1} (as single superphosphate, 12.5% P_2O_5), while K was added at a rate of 95 kg K_2O ha^{-1} as potassium sulphate (48% K_2O) during soil the preparation for cultivation. Rice was harvested at 25 September 2012. Three times horizontal flushing of standing water was taken during the rice grown stage.

Data collection: Soil analysis:-

Before planting surface soil. Sample (0-20cm) was taken from the studied soil and also from each experimental pelt after plant harvesting air-dried, ground, good mixed, sieved throng a 2mm sieve and analyzed for some physical and chemical properties as follows. Soil pH (in H_2O and 1M KCl) was measured in a 1:2.5 soil: water/1M KCl Chapman and Pratt, (1961). Removal of carbonates, OM and soluble salts were determined as reported *by* Makoi (1995). Soil OM was determined as in Walkley and Black (1934) and carbonates by volumetric calcimeter according to Allison and Moodie (1965). Electrical conductivity was determined the saturated paste as described by USDA-NRCS, (1996). Determination of soil Ca^{2+} and Mg^{2+} was done by atomic absorption spectrophotometry where sloth K^+ and Na^+ were determined by flame emission spectrophotometry. Cation exchange capacity was determined after Bower *et al*. (1952). Exchangeable Na was extracted with a buffered neutral 1M NH_4OAc solution, and Ca and Mg by 1N NaOAc solution (pH 8.2). sulphate contents and sulphur in soil were determined by using a standard turbidity method and chlorine by silver nitrate 0.01 N Issam and Sayegh, (2007). Total Na was extracted by 1M NH_4OAc solution followed by flame emission spectrophotometry. Exchangeable Na percentage was estimated by direct determination of exchangeable Na and CEC and calculated as in Richards (1954) as follows:

$ESP = Na_{exch}/ CEC \times 100$

Where: ESP = Exchangeable sodium percentage;

Na^+ = Exchangeable sodium, and

CEC = Cation exchange capacity. Sodium absorption ration (SAR) was calculated as in Sposito and Mattigod (1977) as follows:

$SAR = Na/ (Ca +Mg/2)^{1/2}$

Where: SAR = Sodium absorption ratio

Some physical, chemical and fertility properties of the investigated soil are presented in Table (2), which were determined according to the methods described by Piper (1950);Richards (1954) and Jackson (1973). *According* to the water salinity and sodicity classes undertaken by FAO (1985), data in Table (3) indicated that the used irrigation water derived from El-Salam canal (Nile water mixed with agriculture drainage water) lies in the second category C2S1, where ECiw and SAR values lay within the range < 0.75 dS/m and <6.00, respectively.

Plant analysis: Plant height per hill was measured on the main stem for fixed 30 hills in each treatment. The yield components were separated and processed from plants by hand. The data regarding plant height, 1000-grain weight, grain $panicles^{-1}$ and yield were recorded. Grain yield of all the plants from a one m^2 patch was determined in each plot after the grain was adjusted to a moisture content of water to 0.14 g g^{-1}fresh weight as described by Yoshida (1981).

Table 1: Some chemical characteristics and the nutrients status of the studied by-product materials and gypsum shale.

Character (%)	Natural-gypsum	Phosph-ogypsum	Sulphu-gypsum
SO_4^{-2}	52.8	55.5	53.2
Ca^{+2}	22.3	23.0	22.8
Cl^-	1.21	0.29	0.89
NaCl	0.22	0.12	0.15
$CaSO_4.2H_2O$	97.0	98.2	97.5
S	15.9	16.2	15.8
pH	7.70	5.31	4.45
Particle less than 2 mm	90%		
Particle less than 1mm	50%		
Purity	97%		

Table 2: Some physical and chemical properties of the experimental soil.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution%:		*Soil chemical properties:*	
Sand	14.4	pH (1:2.5 soil water suspention)	8.6
Silt	32.5	$CaCO_3$ %	3.17
Clay	53.2	Organic matter %	4.42
Textural class	Clayeyey	ECe (dS/m, soil paste extract)	14.2
		ExchangeableCa (cmol/kg)	10.98
		SAR	20.53

Table 3: Chemical characteristics of the used irrigation source El-Salam canal (Nile water mixed with agriculture drainage water, with a ratio of 1:1).

Water characteristics	Value	Water characteristics	Value
pH	7.23	Sodium absorption ratio (SAR)	6.89
Total dissolving salt (mg l^{-l})	1440	Irrigation water suitability degree	C2S1
ECiw (dS m^{-1})	2.25	Residual sodium carbonate (RSC)	0.00

Statistical analysis: The obtained data of some tested plant parameters were statistically analyzed according to Snedecor and Cochran (1980). Average values of the sampled hills in each subplot were subjected to the analysis of variance (ANOVA) to determine statistical significance of the differences among the treatment means.

RESULTS AND DISCUSSION

Effect of gypsum sources and its application rates on some soil chemical and physical characteristics cultivated by rice plants:

Soil bulk density

Data in Table (4) showed that soil bulk density (g/c m^3) generally decreased after the application of gypsum sources in comparison with control treatment ,where there are a significant differences among themselves. Continued supply of Ca^{2+} through dissolution of by-product gypsum and binding effect of the soil particles together by gypsum-sources might have improved soil structure and aggregation, which would have been the reason for decrease in bulk density in the treatments and the lowest effect was associated the treatment. The best treatment for bulk density reduction was the phosphogypsum. Calcium accumulations on the exchange sites have improved soil aggregation thus reducing the bulk density. These results are in harmony with the findings outlined by Panchaban and Ta-oun (2002).

Soil pH

Soil pH reduced to 8.40 with the treatment phosphogypsum at 100% gypsum requirement (rate of 30 t ha^{-1}) and t 8.44 for naturalgypsym added at rate of 30 t ha^{-1}, respectively Table (4). The differences between gypsum treatments and control effect on soil pH decreased treatment were significant. Lowest pH value was recorded with gypsum treatment followed by sulphugypsum and phosphogypsum treatment at rate of 15 t ha^{-1}. This might be due to water promoted phosphogypsum dissolution, expediting the reclamation reactions and due to improvement of soil Haq *et al.*, (2001). Naturalgypsum only showed a slight decrease in the pH in the range of 8.54 and 8.46. This may due to acidifying effect of acids produced during the course of reaction with water.

Soil electrical conductivity (EC).

Effect of gypsum sources application at 15and 30 t ha^{-1} shown on soil pH EC (dSm-1) in Table (4). These data she with at phosphogypsum at 100% gypsum requirement at rate of 30 t ha^{-1} was more effective in reducing soil EC of compared to naturalgypsum at the same rate. The possible reason may be the improvement in porosity and hydraulic conductivity, which resulted in enhancing the leaching of salts. Udayasoorian *et al.* (2009) suggested that application of inorganic ameliorants superior in reducing EC of soil. Sharma et al. (1982) and Akal (2010) reported decrease in EC as a result of gypsum application .Theres decreases in soil EC was resulted from excessive ions solubility and leaching improving the physical properties of soil.

Table 4: Effect of gypsum-sources and rates on some soil chemical and physical characteristics.

Gypsum treatment		soilbulk density (g cm^{-3})	soil pH (1:2.5) (soil: water)	soil electrical conductivity (dS m^{-1})	Exchangeable calcium (cmol/kg)	SAR $(mmol/l)^{1/2}$
Gypsum source	*Rate, (t ha^{-1})					
Control	Without	1.20	8.62	7.59	11.0	21.06
Naturalgypsum	15	1.10	8.54	7.56	12.4	20.46
	30	1.00	8.46	7.44	11.9	20.10
Sulphugypsum	15	1.14	8.52	7.34	13.2	19.85
	30	1.11	8.44	7.30	12.4	19.33
Phosphogypsum	15	1.12	8.50	7.22	14.5	18.83
	30	1.00	8.40	7.20	13.1	18.23

* 15 and 30 t ha^{-1} =50and 100%of gypsum requirement.

Exchangeable calcium

Table (4) shows the effect of different gypsum sources naturally or by product on the exchangeable calcium of the investigated soil. Generally, the content soil exchangeable Ca^{2+} values were clearly increased due to all amendment appli cations. This may due to addition of inorganic amendments exchanging the adsorbed Na^{+} by $Ca2^{+}$ and in the displacement of Na^{+} Soman, (1990). High level of exchangeable Ca^{2+} was observed with the treatment of phosphogypsum at 100% gypsum requirement at rate of (30 t ha^{-1}). Phosphogypsum had the highest increases of soil content of exchangeable Ca^{2+} content followed by sulphugypsum and naturalgypsum treated soil. There are at tested gypsum sources significantly different among the and the control. A similar trend was observed by Prapagar *et al.* (2012).

Sodium adsorption ratio (SAR)

A clear decrease in SAR was observed for amended soils after rice plant hanest. The decrease in SAR due to either increase in divalent cations (Ca^{2+} and Mg^{2+}), or decrease in monovalent cation (Na^{+}). The measured values of soluble cations Table(4) indicated that Na^{+} decreased while Ca^{2+} increased followed amendments applications. The relatively high mobility and leachability of Na^{+} from soil due to the applied amendments as compared with Ca^{2+}, resulted in lower values of SAR. Hence, the SAR values of the treated soil were sharply decreased with phosphogypsum treatment at 100% gypsum requirement (30 t ha^{-1}). Chaudhary and Abaidullah (1988) reported that phosphogypsum applied was more effective in reducing the SAR than an equivalent amount of $CaCl_2$.

Effect of gypsum sources and its rates on application the soil, content of available sulphur .

The status of available S in the soil at the maximum vegetative growth stage was greatly increased with the application of gypsum irrespective of its source, as shown in Table (5). However, sulphugypsum and phosphogypsum left behind more gypsum in the soil than normal gypsum . Data indicate that the relative increase percentages at the applied rate of 30 t ha^{-1} left behind a soil rich in available S, reached 128.9 and 155.5 % over the control treatment for rice plants, respectively.

Table 5: Effect of gypsum-sources and its application rates on available S- soil under rice plant cultivated andsalted affected soil

Treatment		Available sulphur (mg kg^{-1} soil)
Gypsum source (S)	Rate, t ha^{-1} (R)	
Control	0	2.97
Gypsum shall	15	3.00
	30	4.53
	Mean	3.50
Sulphugypsum	15	5.12
	30	6.80
	Mean	4.96
Phosphogypsum	15	6.33
	30	7.59
	Mean	5.63
Average	15	4.38
	30	5.47
L.S.D. at 0.05	R	0.11
	S	0.09
	R × S	0.12

This means that a more addition of gypsum source surpassed that removal by the grown plants uptake. A similar trend was also observed by Dewal and Pareek (2004). This means that a marked improvement in rice yield as a resulted of the residual S-amount could be ascribed to enhancement of SO_4^{-2} content in the soil due to gypsum-source to rice was not fully utilized by the crop leading to residual effect. This might have modified the media, especially physical properties which positively reflected on the growth and development of crop.

Effect of gypsum sources and its application rates on growth and yield of rice plants:

Plant is a sensitive indicator of the efficiency of reclamation. The influence soil by products materials as gypsum-sources added to a salt affected soil on yield and yield components of rice plants is presented in Table (6).

Rice plant growth parameters

The obtained data in Table (6) indicate that gypsum sources and its application rates markedly increased plant growth parameters (*i.e.,* plant height), yield attributes (*i.e.,* grain panicle^{-1}and 1000 grain) and seed yield of rice. Application of 15 t ha^{-1}increased the grain panicle^{-1}and 1000 grain of rice by 42.3 and 22.3 % vs 46.8 and 30.6 % for rate of 30 t ha^{-1}over the control treatment, for treatments of respectively. Also, gypsum source application exerted a significant increased in rice seeds at the rates of 15 and 30 t ha^{-1} which reached 51.2 and 66.3 % over the control treatment, respectively. These beneficial effects of applied gypsum sources and rates may be attributed to a smaller component of nitrogenase enzyme of Fe-S clusters which involved in N-biofixation achieved by either nodule bacteria or free living bacteria Lakkineni and Abrol, (1994). Further, such favored better N-fixation, thus growth, yield attributes and yield formation finally led to improve the previous plant parameters, which acts increase percentage of 36.6 and 43.8 % for plant height at the rates of 15 and 30 t ha^{-1}, the corresponding values were 27.2 and 29.2 % over the control treatment for Stalk yield, respectively.

Table 6: Effect of gypsum-sources and its application rates on growth parameters and yield of rice plants.

Treatment		Plant height (cm)	Grain panicle^{-1}	1000 grain (g)	Seed yield (t ha^{-1})	Stalk yield (t ha^{-1})
Gypsum source (S)	Rate, t ha^{-1} (R)					
Control	0	80.3	101.6	19.30	2880.5	2908.8
Gypsum shall	15	100.4	144.3	22.33	3626.8	3420.7
	30	116.4	152.3	24.41	3924.9	3658.8
	Mean	99.0	132.7	22.01	3477.3	3329.5
Sulphugypsum	15	108.0	160.1	24.54	4830.2	5115.6
	30	111.7	168.7	26.99	5995.9	5658.2
	Mean	100.0	143.5	23.60	4568.6	4560.7
Phosphogypsum	15	150.1	172.2	28.27	6079.9	5990.8
	30	152.7	174.4	30.15	6360.2	6095.5
	Mean	101.0	149.4	25.91	5106.7	4998.4
Average	15	109.7	144.6	23.61	4354.3	3698.8
	30	115.3	149.2	25.21	4790.1	3756.8
L.S.D. at 0.05	R	2.4	1.8	0.5	112.1	101.5
	S	1.1	2.1	0.3	99.6	89.9
	R × S	0.9	1.1	0.5	121.1	111.5

Thus, phosphogypsum proved a promising effect for increasing rice growth, yield and its attributes than both sulphugypsum and naturalgypsum Table (6). This is mainly due to phosphogypsum enhanced the grain panicle^{-1} and 1000 grain of rice by 8.1 & 12.5 % as well as 7.2 & 17.7 % as an improvement in seed yield of rice over the gypsum shall and sulphugypsum, respectively Barman, (2004) and Miao *et al.* (2010). The performance of sulphugypsum as a source of S to cowpea remained in between gypsum shall and phosphogypsum, and thus recorded at par yield with these two gypsum sources. Better growth and yield with phosphogypsum may be attributed to its smaller particle size that resulted in greater surface area which might enhanced its solubility as well as the oxidation of S to SO_4^{-2} (available form of S to plants). In addition, the better S-nutrition for plants could have contributed to better root and shoot growth as well as nodulation and ultimately higher yield.

Effect of gypsum-sources and its application rates on macronutrients, SO_4^{-2} and Cl^- content in rice plant:

Macronutrients content

Contents(%) of N, P and K in rice plants grains were increased significantly with successive applied rates of three gypsum sources up to 30 kg/ha, Table (7).

The increase in N, P and K content might be ascribed to the improving effect of added gypsum sources on soil physical and chemical properties and its content of available nutrient and increase in turn SO_4^{-2} contents in plant organs. However, the relative increase percentages at the applied rates of 15 and 30 t ha^{-1} were 22.2 & 30.3 % for N *vs* 45.5 & 54.5 % for P and 8.2 &10.9 % for K over the control treatment, respectively. As for gypsum- source, Phosphogypsum recorded a markedly higher N, P and K content over both Sulphugypsum and gypsum shall. In this respect Shivean, *et al.* (2000) obtained a similar resalts.

Table 7: Effect of gypsum-sources and rates on macronutrient content in rice.

Treatment		N %	P %	K %
Gypsum source (S)	Rate, t ha^{-1} (R)			
Control	0	0.99	0.11	1.92
Gypsum shall	15	1.06	0.13	2.00
	30	1.15	0.16	2.11
	Mean	1.07	0.13	2.01
Sulphugypsum	15	1.24	0.18	2.1 5
	30	1.36	0.19	2.20
	Mean	1.20	0.16	1.51
Phosphogypsum	15	1.56	0.20	2.25
	30	1.67	0.22	2.29
	Mean	1.41	0.18	1.49
Average	15	1.21	0.16	2.08
	30	1.29	0.17	2.13
L.S.D. at 0.05	R	0.04	0.02	0.10
	S	0.02	0.04	0.12
	R × S	0.05	0.03	0.15

SO_4^{-2} and Cl^- content

Total $SO_4^{-2}$and Cl^- content (%) in rice plants grains were increased significantly with successive applied ratesof added gypsum sources at 15 t ha^{-1}, as shown in Table (8).

The increase in total SO_4^{-2} and decrease in total Cl^- content might be ascribed to the greater aments of SO_4^{-2} released from added gypsum sources, where the decrease in Cl^- content was resulted from the high amounts of Cl^- leached from soil followed by gypsum application in organs. However, the relative increase percentages at the applied rates of 15 and 30 t ha^{-1} were 44.3 and 58.1 % for total SO_4^{-2} over the control treatment. As for gypsum source, phosphogypsum treatment resulted in a markedly higher total content of $SO_4^{-2}$and lower one in total Cl^- content compared with both sulphugypsum and gypsum shall. The relative increase percentages for SO_4^{-2} content for Phospho-, Sulphu- and naturalgypsum shall were 21.8, 52.5 and 63.1 % and relative decrease percentages for Cl^- content were 11.6, 12.8 and 16.4 % over the control treatment, respectively. These results are in harmony with the findings outlined by Shivean *et al.* (2000).

CONCLUSIONS

This study concluded that addition of gypsum sources at different rate acted as ameliorant to salt affected soils. Phosphogypsum was more effective in changing EC and SAR. Gypsum-sources added at 100 % gypsum requirement (30 t ha^{-1}) improved the soil chemical properties by reducing the EC, SAR and pH. Applying gypsum at 100 % gypsum requirement (30 t ha^{-1}). Among gypsum sources treatments, Phosphogypsum had a remarkable effect in reducing soil salinity/sodicity. The yield of rice grains resulted from , phosphogypsum treatment was higher compared with other treatments.

Table 8: Effect of gypsum-sources and rates on $SO_4^{-2}$and Cl^- content in rice.

Treatment		SO_4^{-2}- Content (%)			Total Cl^- (%)
Gypsum source (S)	Rate, t ha^{-1} (R)	Seed	Stalk	Total	
Control	0	0.25	1.35	1.60	1.64
Gypsum shall	15	0.30	1.59	1.89	1.50
	30	0.38	1.99	2.37	1.48
	Mean	0.31	1.64	1.95	1.45
Sulphugypsum	15	0.33	2.39	2.78	1.35
	30	0.39	2.56	2.95	1.30
	Mean	0.32	2.10	2.44	1.43
Phosphogypsum	15	0.38	2.60	2.98	1.28
	30	0.41	2.79	3.20	1.20
	Mean	0.35	2.25	2.61	1.37
Average	15	0.33	1.97	2.31	1.44
	30	0.36	2.17	2.53	1.41
L.S.D. at 0.05	R	0.01	0.10	0.03	0.04
	S	0.02	0.07	0.05	0.05
	R × S	0.01	0.05	0.06	0.07

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تقييم مخلفات الجبس من الصناعة كمحسن للأراضي المتأثرة بالاملاح ونمونبات الارز فى منطقة سهل الحسنية- مصر

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الملخص العربي

الملوحة هى عامل محدد للانتاجية الزراعية فى المناطق شبة الجافة .أجريت تجربة حقلية على أرض طميية متأثرة بالأملاح بمنطقة سهل الحسنية – مصر خلال موسم صيف عام ٢٠١٢، لتقييم إستخدام مصادر مختلفة من الجبس الزراعي (جبس – فوسفاتي، جبس طبيعي، جبس–كبريتي) أضيفت بمعدلات صفر، ١٥، ٣٠ طن/هكتار فى تحسين بعض خواص التربة وإنتاجيتها من الأرز (*Oryza sativa* L., Giza 177 cv.) .

النتائج المتحصل عليها اظهرت بعض الأختلافات في كل من الكثافة الظاهرية و التوصيل الكهربي ورقم الحموضة ونسبة الكالسيوم المتبادل ونسبة الصوديوم المتبادل للتربة وذلك لكل المعاملات تحت الدراسة باستخدام مصادر مختلفة من الجبس مقارنة بمعاملة المقارنة، كما أن هناك انخفاض في قيم الصوديوم المتبادل ١٨.٢٣ (mmol/l)1/2 والتوصيل الكهربي dS/m٧.٢٠ وذلك تحت معاملة الجبس الفوسفاتي وعند معدل اضافة ٣٠طن /هكتار.

وتشير النتائج المتحصل عليها أن معدلات الجبس المضافة أدت إلى زيادة معنوية فى مكونات محصول الأرز، حيث أن معدل الإضافة ٣٠ طن/هكتار قد أدى إلى زيادة نسبية ٤٦.٨٪ من البذور/ سنبلة مقارنة بمعاملة الكنترول. مع زيادة معدل اضافة الجبس الفوسفاتى من ١٥طن /هكتار الى ٣٠طن /هكتار فان مكونات المحصول زادت من ٢٢.٣ و٣٠.٦%لكل من المحصول ووزن ١٠٠٠حبة مقارنة بمعاملة المقارنة على التوالى . وبالنسبة لتأثير مصادر الجبس فان النتائج تشير إلى أن الجبس الفوسفاتي يليه الجبس الكبريتي و الجبس الطبيعي قد أعطت زيادات واضحة فى محصول الحبوب وصلت إلى ٧٧.٢، ٥٨.٦، ٢٠.٧ ٪ مقارنة بمعاملة الكنترول، على التوالى. وهذا يعنى أن الجبس الفوسفاتي يعتبر أفضل مصادر الجبس من وجهة إنتاجية التربة، يليه الجبس الكبريتي ثم الجبس الطبيعي بالنسبة للمحصول تحت الدراسة.

وتحت ظروف التجربة الحالية، يمكن القول بان إضافة الجبس الفوسفاتي بمعدل ٣٠ طن/هكتار لمحصول الأرزالنامى على أرض متأثرة بالملوحة كان من الضرورى للحصول على إنتاجية متميزة . أما بالنسبة لمصادر الجبس المختلفة، من الجدير بالذكر الإشارة إلى أنه بالرغم من أن الجبس الفوسفاتى هو المكون الواعد من حيث كفاءة إستخدامة كمحسن ولكنه يمثل الإختيار الأفضل من الوجهة التطبيقية الأن ولكن يمكن استخدام الجبس الفوسفاتي مقارنة بالجبس الطبيعى و الجبس الكبريتى ذلك على أساسا دراسة التكاليف.