EFFECT OF LEACHING WITH ADDING GYPSUM AND RICE STRAW COMPOST ON IMPROVING SALT AFFECTED SOIL AND RICE YIELD

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ABSTRACT

This study was conducted to investigate the efficiency of leaching process with adding gypsum or compost and their combination on improving of poorly productive salt affected soil, the rice growth and nutrient uptake at El-Hamoul area which represent the salt affected soil in the northern part of the Nile Delta. The treatments were adding gypsum in rates of 0, 2.5, 5, and 10 (Mg fed.$^{-1}$) or compost in rates of 10 and 20 Mg fed.$^{-1}$ and combination of 2.5 gypsum with compost 10 Mg fed.$^{-1}$. Rice was transplanted after the recommended soil preparation. Three successive leachate were done with the same volume of irrigation water. The discharged water through drain's outlet and its electrical conductivity (EC_d) were measured. Soil physical and chemical properties and plant analysis were done at harvesting.

The results indicated that absolute differences in leachate volumes, due to leaching process, were relatively small for no amended soil and increased with gypsum application rates. The percolation of water through the gypsum treated soil profile was much faster than the control indicating that gypsum was the main factor to percolate process. Compost combined with gypsum treatment was more effective than compost alone. Salinity of the drained water (EC_d) values had sharply decreased until the third leaching, then a slight decrease was recorded with gypsum treatments. However, with compost treatments, the EC_d values had the same trend, but the sharp decrease was retarded until the 4th leaching. The mean value of EC_d in leachate was reduced from 32.50 to 5.17 dSm^{-1}. This decrease was a function of the number of leachings of the soil.

Consequently, leaching the soil treated with gypsum was more effective in removing the soluble salts. Leaching with adding compost reduced ESP at the end of leaching than the control. Increasing gypsum rates decreased ESP. Moreover, leaching with gypsum and compost decreased ESP value to 11.64.

The results revealed that rice shoot dry weight was increased from 1890 to 2940 kg/fed. as gypsum rates increased from zero to 10 Mg fed$^{-1.}$ The corresponding value for compost increased from 2541 to 3801 kg/fed. at 10 and 20 Mg fed.$^{-1}$, respectively. The combined effect of compost and gypsum treatment was greater than the individual one (4208 kg/fed.). Nitrogen and phosphorus content in rice dry matter was increased with compost application while they were not significantly affected by gypsum application rates. In addition, K content was not significantly affected by either gypsum or compost applications. The Na content was lower, however Ca and Mg content was higher in rice plants grown in gypsum treatments compared with compost ones. Thus, it can be said that leaching the salt affected soil with gypsum combined with compost was entirely safe. This treatment is more profitable than the leaching with water only (control).

Key words: Compost, gypsum, leaching process, salt affected soil, rice yield and componantes.

Introduction

Agricultural losses caused by salinity are difficult to assess but estimated to be substantial and expected to increase with time. Secondary salinization of agricultural lands is particularly widespread in arid and semiarid environments where crop production requires irrigation schemes. At least 20% of all irrigated lands are salt-affected, with some estimates being as high as 50%. Whereas the world's population continues to rise, the total land area under irrigation appears to have leveled off. The need for increased food production therefore needs to be met by increases in yield per land area. Most crops are sensitive to salinity caused by high concentrations of salts in the soil. The cost of salinity to agriculture is estimated conservatively to be about $US 12 billion a year, and is expected to increase as soils are further affected (Ali and Kahlown, 2001). In addition to this enormous financial cost of production there are other serious impacts of salinity on infrastructure, water supplies, and on social structure and stability of communities. Responses to salinization have been of two general kinds; engineering the environment to manage increased salt in the soil by irrigation and drainage management, or by "engineering" the plants to increase their salt tolerance. Salt tolerant plants may also ameliorate the environment by lowering the water table in salt affected soils.

Hamdi *et al.* (1996) prepared soil salinity maps for the Northern part of the Nile Delta. They found good fertile soils as well as salt affected ones having different levels of salinity. In addition, MALR, (2009) mentioned that about 5.4 percent of the land resources in Egypt represent intensive cultivated land, and about 40% of it is subjected to salinity, sodicity and waterlogging problems. Since quite a portion of the Northern part of the Nile Delta soils are saline and/or saline sodic affected to variable degree, gypsum comes into consideration. Its application ahead of rice cultivation would be better than ahead of any crop because of inundation condition. In the Nile Delta rice is the main crop and occupies annually about 0.6 million hectares, (Tantawi, 2004). Egypt has not only maintained its self sufficiency with the increasing population, it has also increased its export from 25000 Mgs in early 1980's to 35000 Mgs in 2001 (RRTC-2001).The agriculture practices in this region are to remove or burn its straw leding to air pollution and losses of nutrient elements and organic matter. Composting rice straw and applying it to the soil may increase the moisture holding capacity, maintains sufficient pore spaces to permit good air circulation and drainage of the excessive water and dilution of salt concentrations in the soil solution, (Reda, 2006 and Elsharawy *et al.* (2008).

Rice crop in many cases is used among the soil reclamation process, where it is planting with standing water. During its growth stages, this standing water could be disposed through drainage system and replaced with fresh water. This process could reduce the salinity of both soil and ground water. Incorporation of gypsum or other amendments that liberate calcium might be applied in a suitable amount to be replaced with the exchangeable sodium from exchange complex (Mohamedin *et al.,* 2004 and Moustafa 2005).

Mostafa (2000) and Mohamedin *et al.* (2005) revealed that both organic matter as composted rice straw and gypsum could ameliorate the alkali soil characteristics, but they recommended that addition of decomposed organic matter might be better than rice straw. They also found that yield of rice increased with all treatments of gypsum and manure, but the combination of gypsum and manure have more effective. On the other hand, Gharaibeh *et al.,* (2009) pointed out that reclamation of sodic soils requires passing high electrolyte water through soil profile carring added divalent ions, usually Ca^{2+}, into the soil and washing exchangeable Na^{+} ions out of the root zone. Soil macropores could be stabilized by treatments, a source of Ca^{2+}, therefore, the concentration of Ca^{2+} electrolyte would be maintained in the soil solution and thus prevents the disruption of aggregates.

The main objectives of this investigation was to study the effect of leaching with adding gypsum or rice straw compost and their combination on soil properties, the removal of soluble salts and rice growth and yield.

MATERIALS AND METHODS

The current work was carried out at a private farm adjusting to El-Hamoul area, representing the salt affected soil of the northern part of the Nile Delta. These soil surved by tile drainage with 40m space between drains and 1.25m drain depth. The soil was clay in textur (sand 32.8, silt 19.3 and Clay 44.8 %). The soil total N, OC and $CaCO_3$ content were 0.25, 0.34 and 1.33%, respectively. Saturated soil hydraulic conductivity, bulk density and total porosity percentage were 6.72 mm day^{-1}, 1.34 $g.cm^{-3}$ and 49.43%, respectively. The main soil chemical properties and irrigation water chemical analysis are given in Tables (1) and (2), respectively.

Before rice transplanting, an average gypsum requirements (10 Mg $^{fed-1}$) containing about 98% $CaSO_4.2H_2O$, was thoroughly mixed with the top 15 cm soil layer. The C/N ratio of the applied compost was a mean value of 13.2 and the total N and P contents reached 0.86 % and 21.35 ppm, respectively. All plots were subjected to two leaching process with an equal amounts of water then followed by rice transplanting which fertilized after 10 days with the recommended rate of N-P-K.

Table 1. The main soil chemical properties of the studied soil layers (0-15 and 15-30 cm).

Soil depth (cm)	pH 1:2.5,	EC dS m^{-1}	Soluble anions meq/L				Soluble cations neq/L				SAR	ESP meq/100 g soil	G.R Mg fed^{-1}
			$CO_3^{=}$	HCO_3^-	Cl^-	$SO_4^{=}$	Ca^{2+}	Mg^{2+}	Na^+	K^+			
0-15	8.48	15.98	---	6.3	94.7	50.82	37.84	23.76	87.88	2.34	15.83	33.25	8.06
15-30	8.53	18.29	---	3.27	112.57	57.95	28.65	18.85	124.63	1.66	25.57	44.47	12.00

Table (2): chemical analysis of the used irrigation water.

pH	EC dS m^{-1}	Soluble anions (meq L^{-1})				Soluble cations (meq L^{-1})				SAR
		$CO_3^{=}$	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	
7.67	1.91	--	3.36	16.52	5.56	6.29	4.17	10.19	0.33	4.46

Gypsum and rice straw compost treatments were applied either indivdewaly or in combination as it follows: T1 = Control (leaching only), T2 = 2.5 Mg gypsum fed^{-1} (25% of G.R), T3 = 5 Mg gypsum fed^{-1} (50% of G.R), T4 = 10 Mg gypsum fed^{-1} (100% of G.R), T5 = 10 Mg compost fed^{-1}, T6 = 20 Mg compost fed^{-1} and T7 = 2.5 Mg gypsum fed^{-1}+ 10 Mg compost fed^{-1}.

Rice seedlings (*Oryza sativa L.*) cv. Sakha 178 of 25day-old, were planted at rate of five seedlings per hole. Equal amounts of irrigation water (7 cm above the soil surface) were applied. The water was restricted for three days then allowed to drain from the soil for one day. The successive leaching process was five times during the experimental period. The disposed draine water was measured in a suitable respectable and expressed in volume/time (Q/t) and its electrical conductivity (EC_d) were measured.

Disturbed and undisturbed soil samples were taken in the initial and after harvesting of rice crop. The disturbed soil samples were prepared for mechanical and chemical analysis according to the standered methods. Organic carbon was determined by Walkley-Black method, and total nitrogen by macro-Kjeldahl method, exchangeable cations Ca, Mg, K and Na were determined by extraction with 1N NH_4OAc solution at pH7, soluble cations and anions as well as soil pH and EC were determined in soil baste extract according to Page *et al.* (1982). At the same time, undisturbed soil samples were taken to determine both of bulk density and hydraulic conductivity measurements (Klute, 1965). After harvesting, shoot samples of the rice plants were taken and prepared for analyzing Na, K, Ca, Mg and total N and P according to Chapman and Pratt (1961).

The amounts of salts (kg/day/fed.) removed with drainage water were calculated by using the average value of the discharges and salinity of drainage water for each lateral, according to El-Gammal *et al*., (1990):

$CS = Q \times EC_{dw} \times 0.64 \times 4.2$

Where : CS = average rate of soluble salts in (kg/day per fed.)

Q = average drain discharge rate in (mm/day)

EC_{dw} = the salinity of drainage water in (dS/m)

The experiment was statistically arranged in a complete randomized design with three replicates. The obtained data were statistically analyzed according to S.A.S (2001).

Results and discussion

The initial obtained data show that physical and chemical properties of the studied soil were poor permeability to water where, the hydraulic conductivity value was 6.72 mm day^{-1}. The EC_e and SAR values revealed that the soil is saline-alkali soil either for the surface and subsurface layers. Sodium chloride was the predominant salt in the soil solution. Table (3) and Fig. (1) show the drained water volumes as a function of leaching number of irrigation water added with different gypsum application rates. The results indicated that absolute differences in leachate volumes, due to leaching process, were relatively small in the control treatment and increased with gypsum application rates. Furthermore, the percolation of water through the gypsum treated soil was much faster than that found in the untreated plots (without gypsum). These results are in harmony with that obtained by Ali and Kahlown. (2001) and EL-Ashtar and El-Etreiby (2006) who pointed out that as gypsum rate increases the response curve occupies a higher position; indicating that gypsum was the main factor to percolate process. Data in Table (3) and Fig, (1) illustrate that the leaching process with gypsum and/or rice straw compost treatments had the same trend.

Salinity of the drained water (EC_d) and amounts of removal salts:

Electrical conductivity of drained water (EC_d) was affected by leaching with gypsum and/or rice straw compost rates (Fig.2). The EC_d values sharply decreased after the second leaching then slightly decreased after the third one with gypsum treatments. However, with compost treatments the EC_d values had the same trend, but the slight decrease was retarded until the 4^{th} leaching, (Fig. 2). After 5^{th} leaching, the mean value of EC_d in leachate was reduced from 36.82 to 6.05 dSm^{-1}.

In the type of experiments of the solute displacement, a check on the concentration of the solute is always useful. A mass balance check for TSS by use of the trapezoid rule of integration for the area under the experimental curves of Fig. (3) was done in each case. These calculations indicated that the total soluble salts (TSS) in leachate had the same trend as EC_d for all treatments. The leatchates were high concentrated in the first days of leaching. The greatest part of salts was removed at the second leaching step, after which the rate was greatly reduced in the subsequent steps. When soil layers were mixed with gypsum, the leaching was more effective in removing the soluble salts, (Table 3). Although, the applied compost retarded the amounts of soluble salts, leaching the soil treated with compost did not create a sodification hazard and ESP obtained at the end of leaching were lower than the control.

Table 3. Drain discharge (Q), EC_{dw} and the relative removed salts (RS) from the soil as affected by successive leaching combined with gypsum treatments.

Leaching No.	Control			Gypsum 2.5 Mg/fed			Gypsum 5 Mg/fed			Gypsum 10 Mg/fed		
	Q mm/day	EC dS m^{-1}	RS kg/day/fed	Q mm/day	EC dS m^{-1}	RS kg/day/fed	Q mm/day	EC dS m^{-1}	RS kg/day/fed	Q mm/day	EC dS m^{-1}	RS kg/day/fed
1	2.51	32.5	219.27	2.94	32.76	258.89	3.03	34.87	284.00	3.19	36.65	314.26
2	2.48	15.61	104.06	2.45	15.94	104.97	2.56	16.17	111.27	2.54	20.56	140.37
3	2.32	8.17	50.95	2.73	9.53	69.93	2.87	8.85	68.27	3.25	12.49	109.11
4	2.12	5.33	30.37	1.88	6.14	31.03	2.13	7.52	43.06	2.61	8.34	58.51
5	1.87	5.17	25.99	1.42	5.38	20.54	2.05	6.13	33.78	2.44	6.19	40.60

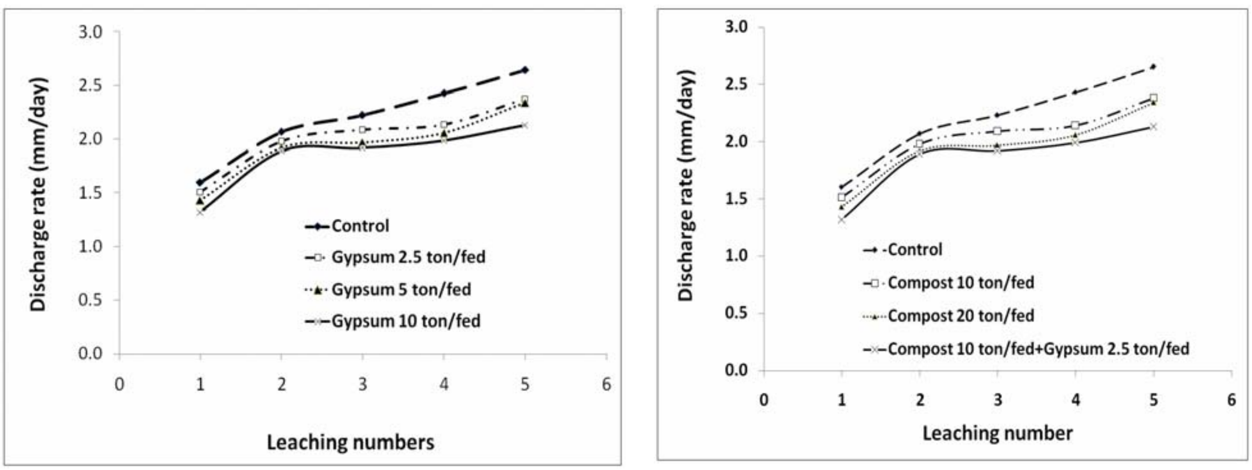

Fig. (1): Influence of leaching process combined with gypsum and compost applications rates on the discharge rate (mm/day).

Comparison between the accumulated salts removed by leaching with gypsum and/or compost, revealed that the gypsum with compost treatment was more effective in displacing the TSS. This would be an indirect effect of compost for enhancing good soil physical properties, which lead to better salt leaching processes. Similar results were found by Mostafa (2005) who suggested that the application of fresh water at amounts of 2-3 times of the field capacity was highly effective to remove the excess soluble salts.

Soil salinity ECe, SAR and ESP:

The amount of salts remaining in soil samples after rice harvesting i.e. the corresponding leaching process with different treatments are presented in Table (5). The results revealed that soil salinity (EC_e) decreased with increasing leaching water and was related to the rate of amendments. Comparison between the decreasing in the exchangeable sodium by leaching alone and accompanied by gypsum, Table (5), shows that the latter case was more effective in displacing the exchangeable sodium than the former. However, leaching process reduced the initial EC_e value from 15.98 to 5.17 $dS.m^{-1}$. These results are in agreement with that reported by Zaka *et al.* (2009) and Abdalla *et al.* (2010).

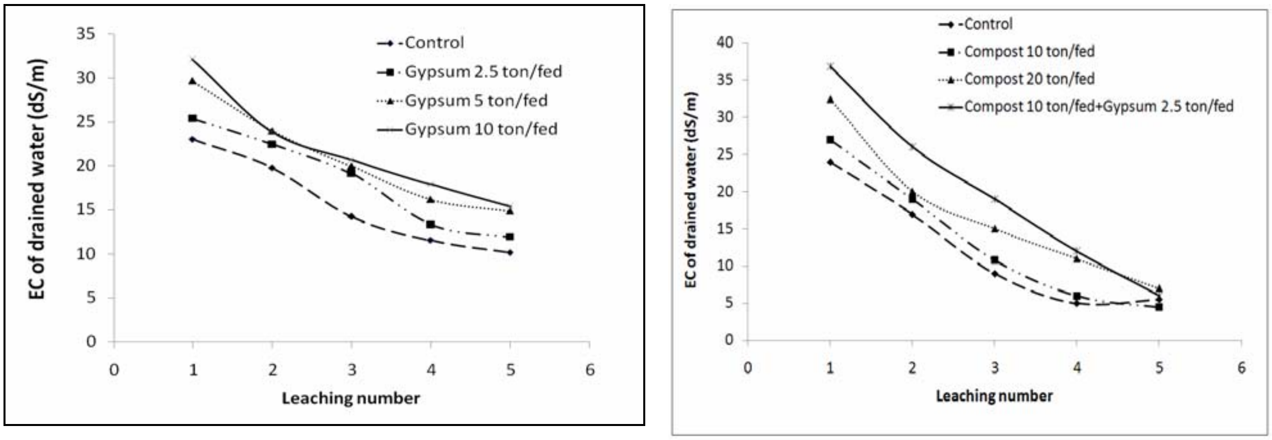

Fig. (2): Influence of leaching process combined with gypsum and compost applications rates on the salinity (EC, dS m^{-1}) of drained water.

The pronounced effect of leaching on the exchangeable sodium was higher with gypsum and rice straw compost treatments and lower with leaching alone. The corresponding ESP values were decreased to 15.66, 11.74 and 10.50 at gypsum application rates of 2.5, 5 and 10 Mg/fed., respectively. While, it reached to 22.72 and 16.50 with compost treatments at the rate of 10 and 20 Mg/fed, respectively. The greatest reduction in ESP values were observed in the combined treatment of gypsum and compost comparing with the individual ones (Table 5).

Although compost addition supplied amounts of Na, it did not create a sodification effect and ESP obtained values at the end of leaching were lower than in the control. The leaching alone was reduced the ESP from 33.25 to 26.19. Gharaibeh *et al.* (2009) showed that the soil $CaCO_3$ was more soluble under saline conditions and effectively participates in the soil actions. The exchangeable potassium was increased with compost treatments and decreased with leaching alone. This may due to compost which supplying the soil solution by additional amounts of cations. This observation is in harmony with that obtained by El-Etreiby *et al.* (1996) who reported that the composted rice straw had a highly content of K reached to 1.92 % and rendered this action to the contribution of soil $CaCO_3$ as a source for dissolved Ca.

Rice growth parameters, yield and nutrients content at harvest:

Biological yield i.e., shoot dry weight and plant height as well as the elements content of rice as affected by leaching with gypsum and/or composted rice straw amendments at harvesting are given in Table (6). Shoot dry weight was increased steadily from 1890 to 2940 kg/fed as gypsum application rates increased from 0 to 10 Mg $fed^{-1.}$ The same trend was observed for compost, where application of 10 Mg fed^{-1} increased rice dry weight to 2541 kg/fed, further application of compost to 20 Mg fed^{-1} gave higher yield of 3801kg/fed. The highest dry weight of rice was 4208 kg/fed, when the treatment consists of 2.5 Mg fed^{-1} of gypsum combined with 10 Mg fed^{-1} rice straw compost was applied to the salt affected soil. The obtained result of plant height was not significantly affected by gypsum and/or compost treatments. At the same time, rice grain yield took the same trend of shoot dry weight.

Table 4: Drained volume (Q), EC_d and removed salts (RS) from the soil columns as affected by successive leaching combined with compost and/or gypsum treatments.

Leaching No.	Compost 10 Mg/fed			Compost 20 Mg/fed			Compost 10 Mg/fed+ Gypsum 2.5 Mg/fed .		
	Q (mm/day)	EC dS m^{-1}	RS (kg/day/fed)	Q (mm/day)	EC dS m^{-1}	RS (kg/day/fed)	Q (mm/day)	EC dS.m^{-1}	RS (kg/day/fed)
1	2.99	31.55	253.57	2.45	33.57	221.08	2.87	36.82	284.05
2	2.76	16.34	121.22	2.12	16.68	95.05	2.65	18.55	132.14
3	2.54	10.11	69.03	2.43	10.45	68.26	3.37	12.77	115.68
4	2.12	8.32	47.41	2.06	8.32	46.07	3.28	8.85	78.03
5	1.96	6.28	33.09	2.36	6.19	39.27	2.85	6.05	46.35

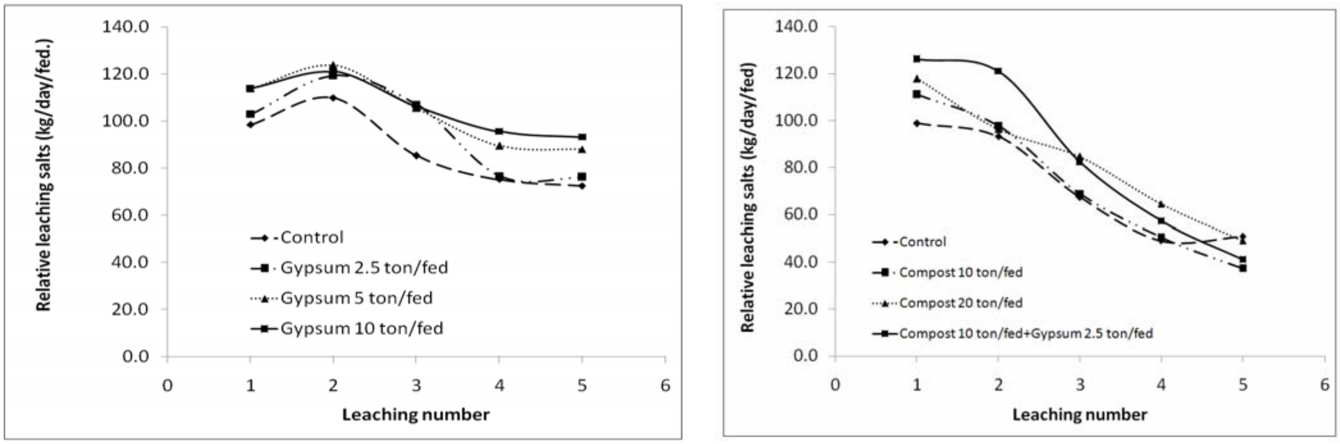

Fig. (3): Effect of leaching with gypsum and compost application rates on the relative leaching salts (kg/day/fed) of the drained water.

Table 5. Chemical characteristics of the studied soil as affected by leaching with gypsum and/or compost treatments after rice harvesting.

Treatments Mg/fed	EC dS m^{-1}	Soluble cations (mml_c L^{-1})				SAR	Exchangeable cations (meq 100 g soil)				ESP *
		Ca	Mg	Na	K		Ca	Mg	Na	K	
Control	15.98	37.84	23.76	87.88	2.34	15.83	8.70	7.22	5.81	0.45	26.19
Gypsum 2.5	9.57	22.07	12.62	54.15	2.06	13.00	9.50	6.80	3.12	0.50	15.66
Gypsum 5	10.05	35.19	16.22	42.08	1.98	8.30	10.95	6.85	2.54	0.55	12.16
Gypsum 10	10.34	38.82	18.65	39.16	1.78	7.31	12.84	6.65	2.42	0.50	10.83
Compost 10	9.56	34.14	19.43	35.15	2.12	6.79	7.90	6.84	3.81	0.62	19.87
Compost 20	8.95	30.07	11.09	41.47	2.15	9.14	8.18	6.88	2.95	0.65	15.81
Gypsum 2.5+ Compost 10	8.88	24.65	12.62	44.48	2.36	10.30	9.22	6.45	2.14	0.58	11.64

ESP in meq/100 g soil

The highest nitrogen and phosphorus content in rice dry matter was recorded at 20 Mg fed^{-1} (T6). The data indicated that N and P contents in rice were not significantly affected by gypsum application rates. In addition K content was not significantly affected by either gypsum or compost treatments. Sodium content was generally decreased by gypsum application rates. Moreover, Na content in rice was lower in gypsum treatments compared with compost ones. These results led to the conclusion that gypsum is a good source of Ca^{+2} that replaced Na^{+} on the exchange complex, which in turn leached out with drainage water. The high Na content in soil solution was reflected on its content in rice dry matter. While both of calcium and magnesium contents in rice dry matter were higher as a result of gypsum application compared with the control and and compost treatments. The same trend was observed for compost, which increased Ca and Mg content distinctly at 20 Mg fed^{-1}

Conclusion

The aforementioned results suggest that both amendments gypsum and composted rice straw helped in boosting the rice plant, which may be the results of direct nutritional effect as well as indirectly through improving soil physical and chemical properties. The combined effect of gypsum plus compost was greater than individual and leaching salt affected soils with both amendments was entirely safe, more profitable than the leaching with water only regardless of the amounts of water drained and leaching period under the experimental conditions.

Table (6): Shoot dry weight, plant height, grain yield, total N and P and some macroelements content in plant tissues.

Treatment No.	Shoot dry weight (kg/fed)	Plant height (cm)	Grain yield (kg/fed)	Total N (%)	Total P (mg/kg^{-1})	Elements content (%)			
						Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
Control	1890g	63.4	712.01d	0.18d	14.0ab	0.38d	0.21c	1.51a	1.76
Gypsum 2.5 Mg/fed	2163f	68.2	748.22d	0.20c	14.9ab	0.45cd	0.36b	0.76b	1.75
Gypsum 5 Mg/fed	2730e	71.5	789.50c	0.19c	19.3ab	0.57b	0.37b	0.57b	1.65
Gypsum 10 Mg/fed	2940b	74.8	874.58c	0.17b	13.6b	0.66a	0.52a	0.56b	1.67
Compost 10 Mg/fed	2541d	70.4	1016.91b	0.24b	30.5a	0.41cd	0.29c	1.35a	1.81
Compost 20 Mg/fed	3801c	77.8	1258.82b	0.32a	38.4a	0.48bc	0.24c	1.47a	1.84
Gypsum 2.5+ compost 10	4208a	85.7	1598.20a	0.25d	31.4a	0.48bc	0.40b	0.65b	1.85
L.S.D (0.05)	1.56	n.s	1.12	0.02	15.20	0.84	0.06	0.24	n.s

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الملخص العربى

التأثير المفيد للغسيل مع إضافة الجبس وكمبوست قش الأرز على تحسين الأراضى المتأثرة بالأملاح ومحصول الأرز

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أجريت تجربة لدراسة تأثير عملية الغسيل مع إضافة معدلات من الجبس وكومبوست قش الأرز ومخلوط منهما على تحسين أرض متأثرة بالأملاح وغير منتجة بالأضافة إلى نمو ومحصول الأرز ومكوناته بمنطقة الحامول (محافظة كفر الشيخ) لتمثل الأراضى المتأثرة بالأملاح. وتشتمل المعاملات على الغسيل بعد إضافة الجبس بمعدلات: مقارنة، 2,5، 5 و10 طن/فدان بينما كانت معدلات إضافة كمبوست قش الأرز 10، 20 طن/فدان ثم معاملة المخلوط والتى تتكون من 2,5 طن/فدان من الجبس +10 طن/فدان من كمبوست قش الأرز. تم غمر القطع التجريبية بماء الرى وشتل الأرز. وأجريت عملية الغسيل بكميات متساوية من مياه الرى. قدرت كميات مياه الصرف (التصرف) وأخذت عينات منها لتقدير ملوحتها EC_d فيه وحسبت كمية الأملاح المزالة. علاوة على ذلك، قدرت بعض الخواص الكيميائية للتربة، إلى جانب تقدير الوزن الجاف والطول لنباتات الأرز وتحليل العناصر بها عند الحصاد.

أوضحت الدراسة أن الفرق المطلق فى أحجام مياه الصرف المتحصل عليها نتيجة لعملية الغسيل كانت صغيرة نسبيا لمعاملة المقارنة ويزداد بزيادة معدلات اضافة الجبس حيث كانت كمية المياه المنصرفة أكبرفى حالة الأرض المعاملة بالجبس مقارنة بمعاملة الغسيل بالماء فقط، وكانت إضافة كمبوست قش الأرز مع الجبس أكثر فاعلية من الكمبوست بمفرده.

بينت الدراسة انخفاض كبير فى قيمة التوصيل الكهربى لماء الصرف EC_d فى بداية عمليات الغسيل حتى الغسلة الثالثة وبعدها يصبح الانخفاض صغيرا وذلك فى القطع التجريبية المعاملة بالجبس، أما القطع المعاملة بالكمبوست فتسلك نفس الاتجاة ولكن حتى الغسلة الرابعة. أنخفض متوسط قيم التوصيل الكهربى لماء الصرف EC_d من 32.83 الى 4.63 ديسيسيمنز/ م وبالتالى كان الغسيل فى وجود الجبس أكثر كفاءة فى ازالة الأملاح الذائبة الكلية من الأرض. وعلى الرغم أن كمية المياه المنصرفة فى حالة معاملة الكمبوست تقل أثناء الغسيل إلا أنه يقلل من أضرار زيادة الصوديوم حيث كانت نسبة

الصوديوم المتبادل أقل من معاملة المقارنة فى نهاية عملية الغسيل. وتحقق تحسن للأرض بدرجة كبيرة باستعمال مياه الغسيل مع اضافة معاملة الجبس+ الكمبوست حيث انخفضت قيمة ESP الى 11.64.

وأظهرت النتائج زيادة الوزن الجاف لنبات الأرز من 1890 إلى 2940 كجم/فدان عند زيادة معدلات الجبس من صفر إلى 10 طن/فدان. وكانت القيمة المقابلة مع زيادة معدل الكمبوست إلى 20 طن/فدان هي 3801 كجم/فدان. بينما كان التأثير المشترك للجبس والكمبوست أعلى من كلا منهما منفرداً (4208 كجم/فدان). أدت إضافة معاملات الكمبوست إلى زيادة محتوى عنصرى النيتروجين والفوسفور بنباتات الأرز بينما لم يكن للجبس تأثير معنوى، كما لم يتأثر البوتاسيوم معنويا. أنخفض المحتوى من عناصر الصوديوم والكالسيوم والماغنسيوم مع معاملات الجبس مقارنة بمعاملات الكمبوست. وعلى ذلك فأن عملية غسيل الأراضى المتأثرة بالأملاح مع إضافة كلا من الجبس والكمبوست كانت اكثر فاعلية مقارنة بتلك التى فى وجود المعاملات الفردية سواء للجبس أو الكمبوست وتلك التى تجرى فى وجود الماء فقط (معاملة المقارنة).