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EFFECT OF SOME AMELIORATION PROCESSES ON NUTRIENTS AVAILABILITY AND UPTAKE IN SALT AFFECTED SOILS

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ABSTRACT

Salt affected soils in Egypt are located, mostly, at North Delta. Reclamation processes of such soils are commonly using chemical amendments as gypsum (*G*) or phosphogypsum (*PG*) and/or organic amendments as farmyard manure (*FYM*), in addition to deep ploughing using sub-soiler. The current study was carried out for two seasons (2000 and 2000/2001) to study the effect of some amelioration processes on macro and micronutrients availability, elemental uptake and yield productivity of salt affected soil at North Delta. Amelioration treatments (*FYM* and/or *PG* application) have a significant effect on increasing the available N, P, and K contents in the sequent layers of soil profile especially in the surface layers. Also, amelioration treatments resulted in a significant increase in the available Fe, Mn, Zn and Cu contents in the surface layers.

Moreover, amelioration processes have a highly significant effect on sorghum and barley yields. *PG* has a highly significant effect on the yield of both crops. These results may be attributed to that *PG* affected the soil properties such as porosity, *ESP*, *pH* and nutrients availability, which enhance plant growth. Regarding subsoiling and *FYM*, it could be noticed that subsoiling and *FYM* as well have a highly significant effect on the yield of both crops

In addition, the uptake of the determined macronutrients (N, P, K) and micronutrients (Fe, Mn, Zn and Cu) were increased, while Na was decreased under the different amelioration processes.

INTRODUCTION

Salt affected soils are scattered allover the world, especially in arid and semi-arid regions like Egypt. It is located, mostly, in Egypt at North Delta. Soil salinity and alkalinity affect soil properties and availability of plant nutrients and hence soil productivity. Reclamation processes of such soils are commonly using chemicals (as gypsum or phosphogypsum) and/or organic amendments (as farmyard manure), in addition to deep ploughing using sub-soiler.

Gypsum ($CaSO_4$, xH_2O) is used in the agriculture either as sources of Ca and S for crops or as soil conditioners to improve certain physical properties of problem soils. They are available as mined gypsum or as industrial by-products; such as: phosphogypsum (*PG*). They, likewise, can be used as source of Ca and S for crops, soil ameliorants for sodic dispersed soils, soil conditioners for hard setting clay soils and hardpans, bulk carriers for micronutrients (Alcordo, 1993) and/or in modifying Ca ratios in soil (Alva and Gascho, 1991) and in reducing NH_3-H losses from urea fertilizers and farm manure (Da Gloria et al. 1991,C.F.Rechcigl 1995). *PG* is produced during phosphoric acid production from rock phosphate according to the following reaction:

$$Ca_{10}(PO_4)_6F_2 + 10\,H_2SO_4 + 20\,H_2O \longrightarrow 6\,H_3PO_4 + 10\,CaSO_4.2H_2O + 2HF\uparrow$$

Many countries produce *PG*, e. g. USA, Russia, Canada, etc. (Novikov *et al.*1990 and Collings, 1980). *PG* is highly acidic with *pH* in water ranging from 2.0 to 5.0 while mined gypsum ranged from 6.7 to 7.4. *PG* solubility is 2.6 g/l in water while that of mined gypsum is 2.41 g/l in water (Weast, 1981).

The availability of macro and micro- nutrients is affected by amendments application so that the highest nitrogen content of the soil was achieved with gypsum application combined with sandy mole, while the highest phosphorus content was detected with gypsum application combined with sub-soiling. (Shams El-Din *et al.,* 2000). The availability of micro-nutrients (e.g. Zn, Mn, Fe, Cu, ...etc.) is increased with increasing the amounts of applied gypsum (Abd El-Fattah *et. al.*, 1987; Mahmoud *et al.*, 1996; and Youssef, 1992). Macro and micro- nutrients uptake, such as N, P, K, Ca, Mg, Zn, Mn and Fe as well as Na is increased by increasing rates of gypsum application, (El-Fakharani, 1997; Sonbol *et al.*, 2001; *Gazia*, 2001; Genaidy *et. al.*, 1989 and Ismail *et. al.*, 1991). Moreover, it is stated that gypsum addition leads to an increase in the yield of many crops such as rice and wheat (Abrol and Bhumbla, 1975; and Gazia *et al.,* 1996), wheat and berseem (*Hussain et al.*, 1988), bean and barley (Ghowail *et al.* 1978) and wheat and broad bean (*Dora*, 1996).

On the other hand, the availability of macro and micro- nutrients (e.g. N, P, K, Fe or Zn ...etc) in the soil is affected by organic manure application (Mahmoud, 1994; Nadia *et al.*, 2000; El-Gala *et al.*, 1998; *Gazia*, 2001; Rechcigl, 1995; and Swarup, 1982). Moreover, it is stated that organic manure application leads to an increase in the yield of many crops such as rice (Thakur *et al.*, 1995), maize (Hamoud, 1992), berseem, sorgum and barley, (Ghazy, 1994), barley (Abdel Karim, 1989), and (El-Sherief, 1997) and wheat (*El-Koumey*, 1998). Consequently, organic matter application increased macro and micro- nutrients uptake (e.g. N (*Kaloosh et. al.*, 1989), P (Nafady *et al.*, 1993) and K, Fe, Cu and Zn (*El-Koumey*, 1998).

The current study was carried out to study the effect of some amelioration processes on macro and microelements availability, elemental uptake and yield productivity of salt affected soil at North Delta.

MATERIALS AND METHODS

A field experiment was conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh, Egypt for two successive seasons; summer of 2000, where sorgum was cultivated and winter of 2000/2001, where barley was cultivated to study the effect of some amelioration processes on some soil properties, some elements availability, and productivity of salt affected soil at North Delta. Area of 2100 m^2 of deteriorated bared soil was chosen to implement these processes. A split-split plot design with four replicates. Plot area was $24m^2$. The main plots were occupied by phosphogypsum (*PG*) treatment with three levels namely: PG_0, PG_1 and PG_2 to represent zero, 50% and 100% of correspondence gypsum requirements (10 ton/fed, 80% purity). The sub plots were occupied by subsoiling treatment namely: without subsoiling (So) and with subsoiling (S_1) (with 2-m spacing and 50cm depth). Sub-sub plots were assigned to farmyard manure (*FYM*) treatment namely: FYM_0 and FYM_1 to represent without and with $20m^3$ *FYM* /fed application respectively. Soil texture was clayey with 46.92% clay and 28.94% silt in average. Chemical properties of the experimental soil and its content of macro and micronutrients are given in Tables' (1and 2). Chemical composition of *FYM* is given in Table (3). Chemical analyses were done according to Jackson, 1973. Micronutrients were determined according to Cotteine *et al.* (1982a). Statistical analyses were done according to Cochran and Cox, (1960).

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

Soil depth cm	PH 1:2.5S.W. sus.	EC dS/m (soil paste)	Soluble ions (meq/l)							O.M. %	CaC₃ %	CEC meq/100g soil	SAR	ESP
			Cations				Anions							
			Ca	Mg	Na	K	Cl	HCO_3	SO_4					
0 – 15	8.87	17.3	22.8	21.6	152	3.7	153.8	2.1	44.2	1.4	3.6	33.8	32.4	31.7
15-30	8.85	15.2	20.2	14.9	116	1.3	116.3	2.0	34.1	1.2	3.2	41.6	27.7	28.4

Table (2): Macro and micronutrients content in soil (ppm).

Soil depth cm	N		P		K		Fe		Mn		Zn		Cu	
	Total	Avail-able	Total	Avail-able	Total	Avail-able	Total	Avail-able	Total	Avail-able	Total	Avail-able	Total	Avail-able
0– 15	160.4	8.9	25.3	1.3	8240	864	3214	10.5	621	2.5	52	0.8	51	.95
15-30	153.0	8.1	19.5	0.9	7560	845	3977	7.0	447	1.8	84	0.4	45	0.8

Table (3) chemical composition of FYM.

Properties	Values	
PH (1:2.5)	6.30	
O.M. %	33.02	
O. C. %	19.12	
C:N ratio	13.2	
Macronutrients		
Total N %	1.45	
Total P %	1.60	
Total K %	2.00	
Micronutrients	Total	Available
Fe ppm	6608	158.1
Mn ppm	3561.3	519.9
Zn ppm	33.37	5.55
Cu ppm	11.60	1.00

RESULTS AND DISCUSION

A - Effect of amelioration processes on the availability of macro and micronutrients.

1 – Nitrogen (N):

Application of *PG* and/or *FYM* have a significant effect on increasing the available N content in the sequent layers of soil profile especially in the surface layer as shown in Table (4). But subsoiling has no significant effect on N availability. This result may be due to the improvement in physical and biological conditions that led to activation of microorganisms, consequently enhanced organic nitrogen mineralization and nitrogen fixation. This result is in agreement with Mohammed *et al.*, (1993), Nadia *et Al.*, (2000) and Shams El-Din *et al.* (2000).

Table (4): Effect of amelioration processes on some macronutrients availability in soils.

Treatment	N ppm		P ppm		K ppm	
	0.0 – 15 Cm	15 – 30 cm	0.0 – 15 cm	15 – 30 cm	0.0 – 15 cm	15 – 30 Cm
Phosphogypsum(PG):						
PGo	15.662	15.516	2.71	1.68	1418.9	1003.4
PG_1	17.908	15.780	2.91	2.02	1751.6	1269.3
PG_2	21.204	16.650	2.66	1.78	1889.9	1342.3
F-test	*	ns	ns	ns	**	Ns
LSD.05	4.446	-	-	-	234.25	-
0.01	-		-	-	354.90	-
Subsoiling (S):						
S_o	15.931	16.18	1.19	0.75	1510.6	1203.1
S_1	16.585	15.77	4.33	2.91	1862.9	1207.0
F-test	ns	ns	**	**	**	Ns
Farmyard manure (FYM):						
FYM_o	17.285	14.53	2.35	1.51	1662.9	1188.5
FYM_1	19.231	1744	3.166	2.147	1686.5	1221.6
F-test	*	*	**	*	*	Ns
Interactions:						
PGxS	*	ns	*	*	*	Ns
PGxFYM	*	ns	*	*	*	**
SxFYM	Ns	ns	*	*	ns	Ns
PGxSxFYM	ns	ns	ns	ns	ns	Ns

2 – Phosphorus (P):

Data in Table (4) show that the available P in the plots treated with both FYM and subsoiling was greater than those found in the control plots. This may be attributed to that the phosphorus released from the added organic manure and also to the increase in the biological activity (Dora, 1996 and Nadia *et al.* 2000). On the other hand, addition of *PG* especially PG_2 treatment decreased the available P. this may be due to an enhancement of P fixation (Chhabra *et al.* 1981). Similar results were obtained by Swarup, (1982) And Dora, (1996). In addition, available P decreased with the soil depth. This result may be attributed to decreasing of organic matter with the depth.

3 - Potassium (K):

Data in Table (4) show that *PG* application and subsoiling treatment as well as *FYM* application resulted in an increase in available K. The highest content of available K was recorded under the combination treatment of $PG_2S_1FYM_1$, while the lowest one was obtained by the control treatment ($PG_oS_oFYM_o$). Moreover, data show that the available K decreased with soil depth. These results are in agreement with those obtained by Mahmoud *et al.* (1996), Nadia *et al.* (2000) and Shams El-Din *et al.* (2000).

4 – Iron (Fe):

Data in Table (5) show that all amelioration treatments resulted in a significant increase in the available Fe at the surface layer, but the increase was not significant in the subsurface layer except with *FYM*, which was highly significant. This may be attributed to the beneficial effect of *FYM* on soil physical and chemical properties that make more suitable conditions for Fe availability. These results are in harmony with those obtained by Dora (1996) and Shams El-Din *et al.* (2000). Fe availability was distinctly affected by phosphogypsum application. This result may be due to the negative effect of phosphogypsum on the soil *pH*. This result is in agreement with that of Sharma and Yadov (1989) and Shams El-Din *et al.* (2000).

5 – Manganese (Mn):

Data in Table (5) show that all amelioration treatments resulted in a significant increase in the available Mn in the surface layer (0 – 15 cm) and subsurface layer (15 – 30 cm). *PG* and *FYM* caused a significant increase in available Mn. This may be due to the resultant decrease in soil *pH*. The highest values of available Mn were obtained with both the combined treatments of $PG_1S_1FYM_1$ and $PG_2S_1FYM_1$. These results are in harmony with that obtained by Sharma and Yodav (1989) and Shams El-Din *et al.* (2000).

Table (5): Effect of amelioration processes on some micronutrients availability.

treatment	Fe (ppm)		Mn (ppm)		Zn (ppm)		Cu (ppm)	
	0 - 15	15 – 30	0 - 15	15 – 30	0 - 15	15 – 30	0 - 15	15 – 30
Phosphogypsum(PG):								
PG_0	12.926	11.513	5.878	4.443	0.694	0.387	0.951	0.612
PG_1	14.294	11.722	12.536	8.306	1.034	0.465	1.424	0.789
PG_2	15.469	12.231	14.571	9.959	1.507	0.578	1.634	0.945
F-test	**	Ns	**	**	**	*	**	**
LSD.05	0.776	-	2.182	1.971	0.334	0.124	0.167	0.102
0.01	1.172	-	3.305	2.986	0.475	-	0.209	0.145
Subsoiling (S):								
S_0	13.556	11.878	9.600	6.887	0.975	0.360	1.203	0.781
S_1	14.103	11.765	12.390	8.252	1.182	0.527	1.470	0.783
F-test	**	Ns	**	*	*	*	**	Ns
Farmyard manure (FYM):								
FYM_0	13.384	11.528	9.038	6.042	1.002	0.428	1.087	0.771
FYM_1	14.276	12.116	12.952	9.097	1.115	0.459	1.586	0.793
F-test	**	**	**	**	*	*	**	Ns
Interactions:								
PGxS	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
PGxFYM	*	Ns	Ns	Ns	Ns	Ns	**	Ns
SxFYM	Ns	Ns	Ns	Ns	Ns	Ns	*	Ns
PGxSxFYM	ns	ns	ns	ns	ns	ns	ns	Ns

6 – Zinc (Zn):

Data in Table (5) show that all the amelioration treatments resulted in a significant increase in the available Zn especially in the surface layer. The highest values of available Zn were achieved with both the combined treatments of $PG_1S_1FYM_1$ and $PG_2S_1FYM_1$. Similar results were obtained by Abd El-Fattah *et al.* (1987) and Dora (1996).

7 – Copper (Cu):

Data in Table (5) show that all the amelioration treatments resulted in a significant increase in the available Cu in the surface layer (0 – 15 cm) and subsurface layer (15 – 30 cm).The highest values of available Cu were achieved with the combined treatments of $PG_1S_1FYM_1$ and $PG_2S_1FYM_1$. These results may be due to the improving effect of the the amelioration treatments on soil physical and chemical properties particularly *pH* and *ESP*. Similar results were obtained by Shams El-Din *et al.* (2000) and Abd El-Fattah *et al.* (1987).

It could be concluded that the tested amelioration treatments (*PG*, Subsoiling and *FYM*) have a positive effect on the availability of micronutrients (Fe, Mn, Zn and Cu). This effect diminishes with the soil depth.

B - Effect of amelioration processes on sorghum and barley yield:

Data in Table (6) show that the three amelioration processes have a highly significant effect on sorghum and barley yield. Phosphogypsum (*PG*) has a highly significant effect on the yield of both crops. These results may be attributed to that *PG* improved the soil properties such as porosity, *ESP*, *pH* and nutrients availability, which enhance plant growth.

Table (6): Effect of amelioration processes on sorghum and barley grain yield

Treatment	Sorghum (ton/fed.)	Barley (ton/fed.)
Phosphogypsum(PG):		
PG_0	0.613	1.082
PG_1	1.185	2.309
PG_2	1.277	2.647
F-test	**	**
LSD 0.05	0.044	0.079
0.01	0.066	0.110
Subsoiling (S):		
S_0	0.867	1.545
S_1	1.183	2.481
F-test	**	**
Farmyard manure (FYM):		
FYM_0	0.920	1.598
FYM_1	1.130	2.428
F-test	**	**
Interactions:		
PGxS	**	**
PGxFYM	**	*
SxFYM	**	Ns
PGxSxFYM	**	Ns

Regarding subsoiling and *FYM*, it was noticed that subsoiling and *FYM* as well have a highly significant effect on both yields. Moreover, all possible combinations of interaction between the three treatments are highly significant with respect to sorghum yield. But for barley, only the paired interaction between *PG* and the other two treatments (Subsoiling or *FYM*) were significant.

C-Effect of amelioration processes on elements Uptake by sorghum plants:

Data in Table (7) show the average uptake (g/plot) of N, P, K and Na by sorghum plants for two cuts. Data show that the uptake of the determined macronutrients was increased under the different amelioration processes. The highest increase occurred when the combination of the three amelioration processes were included, while the lowest increase was in the case of single process. It was noticeable that the opposite direction was observed with Na uptake, since the lowest values of Na uptake was occurred with the combination treatments of $PG_1S_1FYM_1$ and $PG_2S_1FYM_1$, while the highest values were occurred with the control *PGoSoFYMo*. This may be due to the high level of salinity. These results are in agreement with those of Abdel-Rahman and Mikkelson (1986).

Regarding micronutrients, Table (8) shows Fe, Mn, Zn and Cu uptake. It was observed that the more combination the more increase in the uptake, i. e. the effect of each individual process on micronutrients uptake by sorghum plants was less than that of double or triple combination. These results are in agreement with those of Mohammed et al. (1993) and Dora (1996).

Table (7): Effect of amelioration processes on macronutrients (N. P, K) and Na uptake by sorghum.

Treatment	N Gr/plot	P Gr/plot	K Gr/plot	Na Gr/plot
Phosphogypsum(PG):				
PG_0	30.428	7.264	35.241	7.693
PG_1	65.722	20.796	85.199	9.825
PG_2	74.245	24.015	89.644	10.199
F-test	**	**	**	**
LSD.05	7.467	2.802	10.797	1.033
0.01	11.265	4.239	16.261	1.505
Subsoiling (S):				
S_0	45.857	13.937	56.951	9.431
S_1	67.73	20.780	83.106	9.047
F-test	**	**	**	**
Farmyard manure (FYM):				
FYM_0	45.073	14.005	61.447	9.064
FYM_1	68.523	20.711	78.610	9.414
F-test	**	**	**	**
Interactions:				
PGxS	**	**	**	**
PGxFYM	**	*	*	*
SxFYM	Ns	Ns	*	*
PGxSxFYM	Ns	Ns	Ns	Ns

Table (8): Effect of amelioration processes on micronutrients (Fe, Mn, Zn and Cu) uptake by sorghum.

Treatment	Fe Mg/plot	Mn Mg/plot	Zn Mg/plot	Cu Mg/plot
Phosphogypsum(PG):				
PG_o	610.59	78.244	72.191	6.058
PG_1	1889.30	180.142	162.535	17.653
PG_2	2125.76	200.336	182.623	19.944
F-test	**	**	**	**
LSD.05	315.36	19.280	28.822	1.729
0.01	477.67	28.870	43.543	2.602
Subsoiling (S):				
S_o	1222.01	121.168	113.201	11.832
S_1	1861.76	184.647	165.031	17.271
F-test	**	**	**	**
Farmyard manure (FYM):				
FYM_o	1246.08	129.516	119.847	11.358
FYM_1	1837.68	176.299	158.385	17.746
F-test	**	**	**	**
Interactions:				
PGxS	**	**	**	**
PGxFYM	**	**	**	**
SxFYM	**	Ns	Ns	Ns
PGxSxFYM	ns	*	ns	Ns

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تأثير بعض عمليات تحسين الأراضي على صلاحية وامتصاص المغذيات في الأراضي المتأثرة بالأملاح

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تنتشر الأراضي المتأثرة بالأملاح في مصر في منطقة شمال الدلتا، وإن تحسين مثل هذه الأراضي عادة يكون باستخدام مصلحات كيماوية (مثل الجبس أو الجبس المفسفر) أو باستخدام الأسمدة العضوية، بالإضافة الى استخدام الحرث العميق تحت التربة.

وقد نفذت هذه الدراسة على مدى موسمين زراعيين متتاليين (٢٠٠ و ٢٠٠٠/٢٠٠١) في أراضي بور ومتأثرة بالأملاح لدراسة تأثير عمليات التحسين (إضافة الجبس المفسفر – الحرث العميق تحت التربة – و/أو السماد البلدي) على صلاحية العناصر الكبرى والصغرى وامتصاصها بواسطة نبات الذرة الرفيعة (السورجم)، الى جانب تأثير عمليات التحسين على إنتاجية هذه الأراضي ومحصولي الذرة الرفيعة (السورجم) والشعير.

وقد أوضحت الدراسة أن عمليات التحسين المستعملة (إضافة الجبس المفسفر – الحرث العميق تحت التربة – و/أو السماد البلدي) أدت الى زيادة صلاحية كل من العناصر الكبرى (النيتروجين – الفوسفور – البوتاسيوم) والصغرى (حديد – منجنيز – زنك – نحاس) خصوصا في الطبقة السطحية .

بالإضافة الى ذلك ، فإن لهذه العمليات تأثير عالي المعنوية على كل من محصولي الذرة الرفيعة (السورجم) والشعير. فضلا عن أن هذه العمليات قد أدت الى زيادة كمية العناصر الكبرى والصغرى الممتصة بواسطة نبات الذرة الرفيعة (السورجم) ما عدا عنصر الصوديوم الذي تناقص امتصاصه بسبب إضافة الجبس المفسفر والحرث العميق تحت التربة.