Zagazig J. Agric. Res., Vol. 32 No. (4) 2005 **1237 - 1255**

USING A COMPUTER MODEL TO DETERMINE SOIL CATION SORPTION – DESORPTION AND CATION SELECTIVITY COEFFICIENTS IN EL-GHARBIA GOVERNORATE SOILS

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Accepted 21 / 6 / 2005

ABSTRACT: An experiment was carried out under the laboratory conditions at El-Gemmeiza Agric. Res. Station, El-Gharbia Governorate, to study the combination effects of water solution having different ratios of Ca, Mg and Na at different salinity levels on soil sorption – desorption dynamics of these cations and the selectivity coefficient of Ca-Mg, Ca-Na and Mg-Na exchange reactions at the equilibrated clay soil, where 100 gm clay loam soil equilibrated with 100 ml distilled water contains [(0.01, 0.02, 0.03, 0.04, 0.05, 0.1 and 0.2) x soil CEC meq of the different combination of Ca, Mg and Na chloride salts].

The results were passed through a triangle diagram using special computer programme, where thirteen water solution treatments were used to cover all the possible combinations of Ca, Mg and Na salts at different salinity levels. The obtained results could be summarized as follows:-

1- **The maximum cation adsorption values for Ca, Mg and Na were generally increased with increasing its concentration in the equilibrated solutions.**

2- **The maximum cation desorption values for Ca, Mg and Na were also increased with increasing the concentrations of one or two of the other cations in the equilibrated solution.**

3- **Selectivity coefficient (Ks) for Ca-Mg exchange reaction of the equilibrated soil show preferential Ca adsorption relative to Mg was increased with decreasing salinity level specially at 0.01 soil**

CEC or by increasing Ca/Mg solution ratios specially at 100/0 ratio.

4- A similar trend was found for Ca-Na and Mg-Na selectivity coefficient (Ks) but the Ca-Na (Ks) values were higher than that of Mg-Na, this may be due to different specific cation effects for Ca, Mg and Na cations.

Key words: Sorption - desorption, selectivity coefficient (Ks), equilibrated solution.

INTRODUCTION

Irrigation water quality is one of the limiting factors facing the agricultural expansion all over the world. Ground water and surface water always contain different amounts of soluble salts which affect the chemical and physical properties of the soil, Ministry of Public works and Water Resources (1999). The cations of K, Na, Ca and Mg are adsorbed in different ratios on the colloidal fraction of the soil, and represent more than 90% of the exchangeable cations, and the last three cations influence some soil physical properties, like water flow and aggregation (Moussa, 1987).

The selectivity coefficients are essential parameters that influence cation distribution between sorbed and solution phases and their mobility in the soil profile (Thabet and Selim, 1996).

The aim of this experiment is to study the combination effects of water having different Ca : Mg : Na ratios at different salinity levels on soil sorption and desorption and selectivity coefficient of Ca-Mg, Ca-Na and Mg-Na exchange reactions of the equilibrated clay soil of El-Gharbia Governorate.

MATERIALS AND METHODS

Clay loam soil samples were taken from the surface layer (0–30cm) from Zifta, El-Gharbia Governorate. The main physical and chemical properties of the initial soil samples were presented in Table 1.

The three factors computer model (Moussa, 1987) was used in this study. The actual thirteen combined treatments are illustrated in Figs. 1 and 2 and presented in Table 2.

To study the sorption-desorption of Ca, Mg and Na of soil, seven concentrations of saline solutions were prepared on the basis of soil cation exchange capacity (CEC) to be 0.01, 0.02, 0.03, 0.04, 0.05, 0.1 and 0.2 meq/100 ml distilled water. The thirteen combination treatments of Ca, Mg and Na (chloride salts) of each above mentioned concentrations, which cover all the possible Ca, Mg and Na combinations were equilibrated with 100g soil, Table 3, with four replicates in addition to a blank

Table 1 :The main physical and chemical properties of the investigated soils

Characteristics	Value
Particle size distribution, %	
Coarse sand	0.30
Fine sand	29.80
Silt	41.20
Clay	28.70
Texture class	clay loam
EC (dSm^{-1})	1.26
pH soil suspension 1:2.5	7.35
Soluble ions in soil saturation extract, meq/l	
Ca^{++}	5.36
Mg^{++}	4.00
Na^{+}	3.72
K^{+}	0.23
HCO_3^{-}	2.80
Cl^{-}	4.49
SO_4^{-}	6.02
Exchangeable cations (meq/ 100g soil)	
Ca^{++}	34.09
Mg^{++}	9.70
Na^{+}	1.57
K^{+}	0.97
CEC (meq/100g soil)	46.74
$CaCO_3$,%	2.02

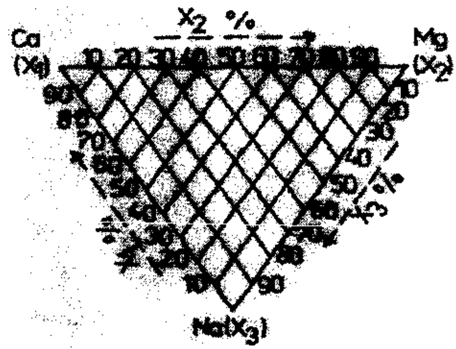

Fig. (1): Guide for the Ca(X_1), Mg(X_2) and Na(X_3) combination of each point

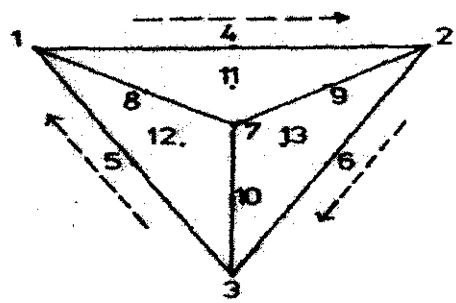

Fig. (2): Treatments sites on the triangle diagram

Table 2:The chosen combination of thirteen treatments of the computer model

Treatment No.	Relative fractional as unit			Relative concentration percentages		
	Ca (X_1)	Mg (X_2)	Na (X_3)	Ca (X_1)	Mg (X_2)	Na (X_3)
1	1	0	0	100	0	0
2	0	1	0	0	100	0
3	0	0	1	0	0	100
4	1 / 2	1 / 2	0	50	50	0
5	1 / 2	0	1 / 2	50	0	50
6	0	1 / 2	1 / 2	0	50	50
7	1 / 3	1 / 3	1 / 3	33.3	33.3	33.3
8	4 / 6	1 / 6	1 / 6	66.6	16.6	16.6
9	1 / 6	4 / 6	1 / 6	16.6	66.6	16.6
10	1 / 6	1 / 6	4 / 6	16.6	16.6	66.6
11	4 / 9	4 / 9	1 / 9	44.4	44.4	11.1
12	4 / 9	1 / 9	4 / 9	44.4	11.1	44.4
13	1 / 9	4 / 9	4 / 9	11.1	44.4	44.4

treatment. Suspensions were shaken for one hour and lift for 48 hours to equilibrate, then shaken for 10 minutes and lift for 24 hours, then shaken for 10 minutes and filtered, Moussa (1991).

Chemical analyses were carried out according to Page *et al.* (1982). Selectivity coefficient (Ks) for Ca-Mg, Ca-Na and Mg-Na exchange reactions were calculated according to Levy *et al.* (1972) as :

$$Ks_{Ca\text{-}Mg} = \frac{\text{Ca soil} + \text{Mg solution}}{\text{Mg soil} + \text{Ca solution}}$$

$$Ks_{Ca\text{-}Na} = \frac{\text{Ca soil} + \text{Na solution}}{\text{Na soil} + \text{Ca solution}}$$

$$Ks_{Mg\text{-}Na} = \frac{\text{Mg soil} + \text{Na solution}}{\text{Na soil} + \text{Mg solution}}$$

Where Ca, Mg and Na in soil and solution phases are expressed as equivalent fractions.

Table 3 : Composition of the different solutions prepared to represent the desirable cation exchange capacity levels

Solution No.	Amount of cations, meq /100 ml water from soil CEC																				
	0.01			0.02			0.03			0.04			0.05			0.1			0.2		
	Ca	Mg	Na	Ca	Mg	Na	Ca	Mg	Na	Ca	Mg	Na	Ca	Mg	Na	Ca	Mg	Na	Ca	Mg	Na
1	0.46	-	-	0.93	-	-	1.39	-	-	1.86	-	-	2.32	-	-	4.65	-	-	9.30	-	-
2	-	0.46	-	-	0.93	-	-	1.39	-	-	1.86	-	-	2.32	-	-	4.65	-	-	9.30	-
3	-	-	0.46	-	-	0.93	-	-	1.39	-	-	1.86	-	-	2.32	-	-	4.65	-	-	9.30
4	0.23	0.23	-	0.46	0.46	-	0.70	0.70	-	0.93	0.93	-	2.70	2.70	-	2.32	2.32	-	4.65	4.65	-
5	0.23	-	0.23	0.46	-	0.46	0.70	-	0.70	0.93	-	0.93	2.70	-	2.70	2.32	-	2.32	4.65	-	4.65
6	-	0.23	0.23	-	0.46	0.46	-	0.70	0.70	-	0.93	0.93	-	2.70	2.70	-	2.32	2.32	-	4.65	4.65
7	0.15	0.15	0.15	0.31	0.31	0.31	0.46	0.46	0.46	0.62	0.62	0.62	0.77	0.77	0.77	1.55	1.55	1.55	3.10	3.10	3.10
8	0.31	0.08	0.08	0.62	0.15	0.15	0.93	0.23	0.23	1.24	0.31	0.31	1.55	0.39	0.39	3.10	0.77	0.77	6.19	1.54	1.54
9	0.08	0.31	0.08	0.15	0.62	0.15	0.23	0.93	0.23	0.31	1.24	0.31	0.39	1.55	0.39	0.77	3.10	0.77	1.54	6.19	1.54
10	0.08	0.08	0.31	0.15	0.15	0.62	0.23	0.23	0.93	0.31	0.31	1.24	0.39	0.39	1.55	0.77	0.77	3.10	1.54	1.54	6.19
11	0.21	0.21	0.05	0.41	0.41	0.10	0.62	0.62	0.15	0.83	0.83	0.21	1.03	1.03	0.26	2.06	2.06	0.52	4.13	4.13	1.03
12	0.21	0.05	0.21	0.41	0.10	0.41	0.62	0.15	0.62	0.83	0.21	0.83	1.03	0.26	1.03	2.06	0.52	2.06	4.13	1.03	4.13
13	0.05	0.21	0.21	0.10	0.41	0.41	0.15	0.62	0.62	0.21	0.83	0.83	0.26	1.03	1.03	0.52	2.06	2.06	1.03	4.13	4.13

RESULTS AND DISCUSSION

1. Soil Calcium Sorption and Desorption

Data recorded in Table 4 and presented in Figs. 3 to 5 indicated that the adsorption Ca occurred when the concentration of saline equilibrated solution was more than 0.03 soil CEC meq/100ml water in case of single Ca application treatment, Fig.4, where the solution contained 100% Ca.

The maximum Ca adsorption values were generally increased with increasing its concentration in the equilibrated solution where were-0.34, 0.13 and 2.95 meq/100g soil at salinity levels 0.01, 0.03 and 0.2 of soil CEC levels, respectively. These maximum values denoted by number 10 lay in the left corner of the triangle where Ca concentration was 100% in the equilibrated solution. It is clear from Figs. 3 to 5 that the Ca adsorption decreased when the concentration of Mg or Na increased in the equilibrated solution, this decrease was more pronounced when Mg was introduced to the equilibrated solution rather than Na. Similar results were obtained by El-Nennah *et al.* (1986) and Moussa (1991).

On the other hand, the negative values which appeared in the triangle diagram referring to appearance Ca desorption from the colloidal surface complex. The maximum Ca desorption occurred when the equilibrated solution had only Mg or Na 100% where Ca desorption increased with increasing the concentration of the equilibrated solutions from -0.98 to -9.55 or from -1.28 to -5.77 meq/100g soil for the seven levels from 0.01 to 0.2 soil CEC levels, respectively. It were detected that at low concentration of the equilibrated solution, the replacing power of Ca adsorption in place of Na was very little for saline solution of 0.02 soil CEC level, meanwhile with increasing the concentration of the equilibrated solution to 0.2 soil CEC level, the relative power of Ca adsorption in place of Na was increased. However, at low concentration of the equilibrated solution, the replacing power of Ca in place of Mg was lower than Ca in place of Na. Aboulroos (1978) confirmed that the replacement of adsorbed Ca by Na depends on the relative concentration of these two ions in soil solution.

Table 4 : Calcium, magnesium and sodium sorption-desorption values as results of equilibrated with different saline concentration solutions having different combinations of Ca, Mg and Na cations

Salinity levels	Sorption - desorption of Ca (meq / 100 g soil)							Sorption - desorption of Mg (meq / 100 g soil)							Sorption - desorption of Na (meq / 100g soil)						
	0.01	0.02	0.03	0.04	0.05	0.1	0.2	0.01	0.02	0.03	0.04	0.05	0.1	0.2	0.01	0.02	0.03	0.04	0.05	0.1	0.2
Treat. No	From soil CEC (meq/100ml water)							From soil CEC (meq/100ml water)							From soil CEC (meq/100ml water)						
1	-0.34	-0.09	0.13	0.19	0.49	2.05	2.95	-0.73	-0.76	-0.86	-0.99	-1.28	-2.65	-3.19	-0.36	-0.39	-0.40	-0.63	-0.66	-0.79	-0.96
2	-0.98	-1.64	-2.33	-2.69	-2.89	-4.34	-9.55	0.12	0.87	1.84	2.02	2.25	3.84	9.33	-0.37	-0.40	-0.43	-0.70	-0.72	-0.83	-0.92
3	-1.28	-1.58	-1.84	-1.91	-2.17	-3.66	-5.77	-0.47	-0.56	-0.86	-1.19	-1.45	-1.70	-3.71	0.19	0.52	0.93	0.52	0.83	2.39	4.42
4	-0.94	-0.96	-1.08	-1.40	-1.32	-2.05	-3.65	-0.01	0.19	0.41	0.64	0.64	1.60	3.38	-0.38	-0.39	-0.43	-0.70	-0.71	-0.74	-0.93
5	-0.82	-0.83	-0.71	-0.83	-0.60	-0.09	-0.82	-0.53	-0.67	-0.97	-1.10	-1.54	-2.91	-3.52	-0.08	0.17	0.25	0.08	0.13	0.81	1.74
6	-1.08	-1.57	-1.86	-2.30	-2.62	-4.27	-7.78	-0.17	0.15	0.42	0.48	0.52	1.50	3.25	-0.09	0.13	0.22	-0.04	0.04	0.74	1.96
7	-0.60	-0.90	-1.18	-1.26	-1.82	-2.39	-4.43	-0.52	-0.27	-0.02	-0.22	0.06	0.32	1.37	-0.22	-0.04	0.07	-0.19	-0.11	0.30	0.78
8	-0.50	-0.48	-0.43	-0.74	-0.51	-0.62	0.02	-0.53	-0.61	-0.52	-0.48	-0.71	-0.67	-1.79	-0.28	-0.22	-0.13	-0.43	-0.41	-0.13	0.17
9	-0.60	-0.93	-1.46	-1.99	-2.30	-3.71	-6.99	-0.34	0.04	0.51	0.83	1.19	2.64	5.44	-0.28	-0.24	-0.14	-0.44	-0.45	-0.10	0.10
10	-0.77	-1.21	-1.50	-1.76	-1.74	-1.74	-4.19	-0.57	-0.49	-0.36	-0.59	-0.98	-1.66	-1.06	0.00	0.25	0.51	0.20	0.38	1.29	3.36
11	-0.73	-0.96	-0.90	-1.11	-1.03	-0.89	-3.30	-0.29	-0.02	0.03	0.04	0.06	-0.03	2.78	-0.31	-0.26	-0.27	-0.58	-0.36	-0.26	-0.04
12	-0.63	-0.85	-0.60	-0.31	0.18	-0.73	-1.94	-0.68	-0.62	-0.93	-1.68	-2.19	-1.94	-1.96	-0.08	0.07	0.23	-0.14	0.01	0.68	1.12
13	-0.89	-1.27	-1.27	-1.44	-2.04	-2.80	-6.16	0.32	-0.14	-0.06	-0.30	-0.52	-0.39	3.08	-0.08	0.01	0.22	-0.13	-0.25	0.61	1.13

DATA

Treatments	Replicates I	II	III	IV
1	-0.4600	-0.3300	-0.3600	-0.2300
2	-1.0100	-0.8900	-1.0000	-1.0400
3	-1.3700	-1.2600	-1.2600	-1.2400
4	-1.0000	-0.9300	-0.9200	-0.9100
5	-0.8200	-0.8800	-0.7800	-0.8000
6	-1.1000	-1.0600	-1.1000	-1.0700
7	-0.6700	-0.6700	-0.5400	-0.5400
8	-0.4800	-0.5100	-0.5000	-0.5100
9	-0.6800	-0.6100	-0.5300	-0.5900
10	-0.7900	-0.7700	-0.7600	-0.7900
11	-0.7800	-0.7700	-0.7000	-0.6800
12	-0.6300	-0.6400	-0.6200	-0.6500
13	-0.8900	-0.8900	-0.8800	-0.9000

```
AVERAGE VALUE    :

 -0.3450  -0.9850  -1.2825  -0.9400  -0.8200  -1.0825  -0.6050
 -0.5000  -0.6025  -0.7775  -0.7325  -0.6350  -0.8900

COEFF.DITER.= .9688789
  CORRELATION COEFFICINT= .9843164

CRITERION FISHER F( 12.000 39.000) 101.1808
   SOCT= 5.063079E-02
CONTROL-.7325 - 0 =-.7325         t= 22.83738
CONTROL-.635 - 0 =-.635         t= 19.79759
CONTROL-.89 --.5258334 =-.3641666         t= 11.35374

   -0.3450    -0.5080    -0.6490    -0.7680    -0.8650    -0.9400
   -0.9930    -1.0240    -1.0330    -1.0200    -0.9850

   -0.4410    -0.5112    -0.5793    -0.6452    -0.7093    -0.7708
   -0.8303    -0.8878    -0.9431    -0.9963

   -0.5365    -0.5338    -0.5488    -0.5816    -0.6321    -0.7004
   -0.7864    -0.8902    -1.0117

   -0.6315    -0.5757    -0.5576    -0.5771    -0.6342    -0.7289
   -0.8612    -1.0312

   -0.7260    -0.6371    -0.6056    -0.6317    -0.7152    -0.8563
   -1.0548

   -0.8200    -0.7178    -0.6929    -0.7454    -0.8753    -1.0825

   -0.9135    -0.8178    -0.8194    -0.9182    -1.1143

   -1.0065    -0.9373    -0.9852    -1.1502

   -1.0990    -1.0761    -1.1902

   -1.1910    -1.2343

   -1.2825

Ymax=-.345          Ymin=-1.2825

     x1   10 -14 -18 -22 -25 -27 -28 -29 -29 -29 -28   x2
           -12 -14 -16 -18 -20 -22 -24 -25 -27 -28
             -15 -15 -15 -16 -18 -20 -22 -25 -29
               -18 -16 -16 -16 -18 -21 -24 -29
                 -21 -18 -17 -18 -20 -24 -30
                   -23 -20 -20 -21 -25 -31
                     -26 -23 -23 -26 -32
                       -29 -27 -28 -33
                         -31 -31 -34
                           -34 -35
                             -37
                              x3
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Fig. 3. Sorption-desorption of Ca as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.01 meq of soil cation exchange capacity].

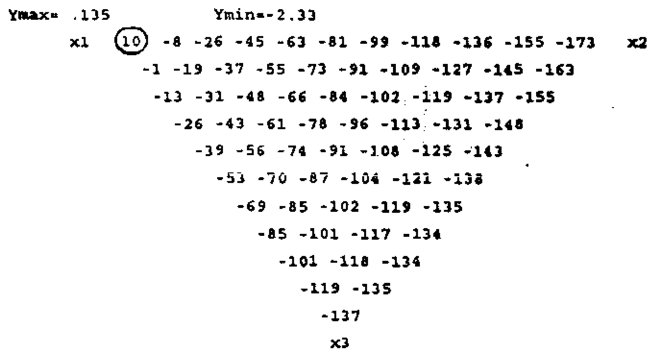

Fig. 4. Sorption-desorption of Ca as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.03 meq of soil cation exchange capacity].

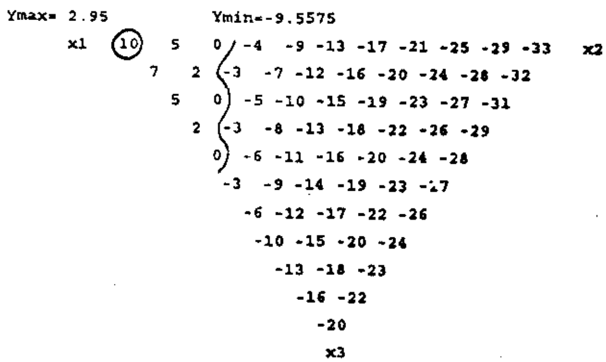

Fig. 5. Sorption-desorption of Ca as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.2 meq of soil cation exchange capacity].

2. Soil Magnesium Sorption and Desorption

Data presented in Table 4 and illustrated in Figs. 6 and 7 show that the maximum Mg adsorption values were increased with increasing its concentration in the equilibrated solutions from 0.14 to 9.33 meq/100g soil for the seven saline solutions levels from 0.01 to 0.2 of soil CEC levels respectively. These values obtained when the equilibrated solutions had only Mg, lay in the right corner of the triangle where Mg concentration was 100% in the equilibrated solution. Similar results were obtained by Yadav and Girdhar (1979), they found that adsorption of Na and Mg in the soils increased with increasing Mg/Ca ratio and electrolytes concentration of the irrigation water.

The maximum desorption of Mg obtained when the equilibrated solution had only Ca or Na 100%, these values were increased with increasing the concentration of the equilibrated solutions from -0.73 to -3.19 and from -0.47 to -3.71 meq/100g soil for the seven saline solutions levels 0.01 to 0.2 of soil CEC respectively. However, at low concentration of the equilibrated solution, the relative ability of Mg to adsorb in place of Ca was very small (-52) as shown in Fig. 6 , while increasing the concentration of the equilibrated solution resulted a relative increase of Mg ability to adsorb in place of Ca (-4) as shown in Fig. 7. Moreover, at low concentration of the equilibrated solution, the relative ability of Mg to adsorb in place of Na was very small (-34) Fig. 6, while increasing the concentration of the equilibrated solution increased the relative ability of Mg to adsorb in place of Na (-4) Fig. 7. Generally, at low concentration of the equilibrated solution, the replacing power of Mg in place of Ca was lower than that of Mg in place of Na on the clay colloidal complex. Similar results were obtained by Moussa (1987).

Moreover, it can be mentioned that zero sorption or desorption of Mg from the colloidal soil complex at 0.01 soil CEC level, Fig. 6, was obtained when the Mg concentration in the equilibrated solution was about 80% of its maximum concentration, whereas when the salinity level was increased to 0.2 soil CEC level, Fig. 7, the equilibrium points or zero number were occurred when Mg concentration was about 30% of its maximum value.

DATA

Replicates

Treatments	I	II	III	IV
1	-0.6200	-0.7700	-0.7000	-0.8600
2	0.1300	0.0200	0.1800	0.1600
3	-0.4000	-0.4900	-0.4900	-0.5200
4	0.0800	-0.0100	-0.1000	-0.0100
5	-0.5100	-0.4500	-0.6200	-0.5400
6	-0.1100	-0.2200	-0.1400	-0.2200
7	-0.4300	-0.4600	-0.5900	-0.6300
8	-0.5300	-0.5300	-0.5500	-0.5300
9	-0.2700	-0.3300	-0.4200	-0.3400
10	-0.5600	-0.5900	-0.5500	-0.5800
11	-0.2500	-0.2500	-0.3100	-0.3700
12	-0.7100	-0.6400	-0.7300	-0.6700
13	-0.3000	-0.3600	-0.3400	-0.3000

AVERAGE VALUE :

```
-0.7375   0.1225  -0.4750  -0.0100  -0.5300  -0.1725  -0.5275
-0.5350  -0.3400  -0.5700  -0.2950  -0.6875  -0.3250

COEFF.DITER.= .9528844
  CORRELATION COEFFICINT= .9761579

CRITERION FISHER F( 12.000 39.000) 65.72924
   SOCT= 6.283401E-02
CONTROL-.295 - 0 =-.295          t= 7.411066
CONTROL-.6875 - 0 =-.6875          t= 17.27155
CONTROL-.325 --.5986111 = .2736111          t= 6.873729

-0.7375   -0.5444   -0.3751   -0.2296   -0.1079   -0.0100
 0.0641    0.1144    0.1409    0.1436    0.1225

-0.6838   -0.5772   -0.4765   -0.3816   -0.2927   -0.209(
-0.1323   -0.0610    0.0045    0.0641

-0.6362   -0.5982   -0.5481   -0.4860   -0.4118   -0.3256
-0.2273   -0.1170    0.0054

-0.5947   -0.6073   -0.5900   -0.5427   -0.4654   -0.3581
-0.2208   -0.0536

-0.5593   -0.(047   -0.6021   -0.5517   -0.4533   -0.3071
-0.1129

-0.5300   -0.5902   -0.5845   -0.5130   -0.3757   -0.1725

-0.5068   -0.5638   -0.5371   -0.4266   -0.2324

-0.4897   -0.5257   -0.4600   -0.2926

-0.4787   -0.4757   -0.3531

-0.4738   -0.4139

-0.4750

Ymax= .1436          Ymin=-.7375
```

```
x1 -52 -38 -27 -16  -8  -1   4   7   9  (10)  8  x2
     -48 -41 -34 -27 -21 -15 -10  -5   0   4
       -45 -42 -39 -34 -29 -23 -16  -9   0
         -42 -43 -42 -38 -33 -25 -16  -4
           -39 -43 -42 -39 -32 -22  -8
             -37 -42 -41 -36 -27 -13
               -36 -40 -38 -30 -17
                 -35 -37 -33 -21
                   -34 -34 -25
                     -33 -29
                       -34
                        x3
```

Fig. 6. Sorption-desorption of Mg as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.01 meq of soil cation exchange capacity].

DATA

Treatments	Replicates I	II	III	IV
1	-3.2100	-3.1500	-2.9000	-3.5000
2	9.0200	9.5600	9.2200	9.5500
3	-3.2000	-3.7600	-4.0200	-3.8800
4	3.3900	3.4300	3.5400	3.1900
5	-3.0500	-3.5900	-3.7300	-3.7100
6	3.7200	3.4400	2.7800	3.0700
7	1.7600	1.3500	1.1200	1.2500
8	-1.8400	-1.5800	-1.7900	-1.9600
9	5.5100	5.4200	5.3600	5.4700
10	-0.9500	-1.1600	-1.1200	-1.0300
11	2.8200	3.0800	2.6400	2.5900
12	-1.9300	-1.9600	-1.9100	-2.0500
13	3.1200	3.1700	3.0300	3.0000

```
AVERAGE VALUE    :

 -3.1900   9.3375  -3.7150   3.3875  -3.5200   3.2525   1.3700
 -1.7925   5.4400  -1.0650   2.7825  -1.9625   3.0800

COEFF.DITER.= .9971192
  CORRELATION COEFFICINT= .9985586

CRITERION FISHER F( 12.000 39.000) 1124.928
   SOCT= .2364545
CONTROL 2.7825 - 0 = 2.7825        t= 18.57552
CONTROL-1.9625 - 0 =-1.9625        t= 13.10133
CONTROL 3.08 - 1.552222 = 1.527778      t= 10.1992

 -3.1900   -1.8243   -0.4837   0.8318   2.1222   3.3875
  4.6277    5.8428    7.0328   8.1977   9.3375

 -3.2668   -1.8385   -0.4490   0.9017   2.2136   3.4867
  4.7210    5.9165    7.0732   8.1911

 -3.3382   -1.8610   -0.4364   0.9358   2.2555   3.5227
  4.7374    5.8997    7.0094

 -3.4042   -1.8918   -0.4457   0.9343   2.2481   3.4957
  4.6772    5.7924

 -3.4648   -1.9310   -0.4770   0.8971   2.1913   3.4057
  4.5401

 -3.5200   -1.9783   -0.5303   0.8242   2.0852   3.2525

 -3.5698   -2.0340   -0.6056   0.7157   1.9296

 -3.6142   -2.0980   -0.7028   0.5714

 -3.6532   -2.1703   -0.8221

 -3.6868   -2.2509

 -3.7150

Ymax= 9.337501              Ymin=-3.715
     x1   -4  -2  -1   0   2   3   4   6   7   8  (10)  x2
            -4  -2  -1   0   2   3   5   6   7   8
              -4  -2  -1   1   2   3   5   6   7
                -4  -3  -1   1   2   3   5   6
                  -4  -3  -1   0   2   3   4
                    -4  -3  -1   0   2   3
                      -4  -3  -1   0   2
                        -4  -3  -1   0
                          -4  -3  -1
                            -4  -3
                              -4
                              x3
```

Fig. 7. Sorption-desorption of Mg as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.02 meq of soil cation exchange capacity].

3. Soil Sodium Sorption and Desorpion

Data presented in Table 4 and Figs. 8 and 9 indicate that the Na adsorption values were generally increased with increasing its concentration in the equilibrated solution, where the maximum values varied from 0.19 to 4.42 meq/100g soil for the seven saline solutions levels 0.01 to 0.2 of soil CEC levels, respectively. These values occurred when the equilibrated solution had only Na 100% where denoted by number 10 and lay in the down corner of the triangle.

On the other hand, the negative values appeared in the triangle diagram referring to appearance desorption of Na from the colloidal surface complex, where the maximum desorption of Na obtained when the equilibrated solution contained 100% Ca or Mg. These results reveal that at low concentration of the equilibrated solution (0.01 soil CEC level), the replacing power of Na adsorption in place of Ca or Mg cations was very small, while increasing the concentration of the equilibrated solution (0.2 soil CEC level), the relative power of Na adsorption in place of Ca or Mg was increased. Similar results were obtained by Aboulroos (1978).

The zero sorption-desorption of Na from the colloidal soil complex at low salinity level (0.01 soil CEC level), Fig. 8, was occurred when Na concentration in the equilibrated solution was about 70% of its maximum concentration, whereas increasing salinity level to 0.2 soil CEC level, Fig. 9, resulted a zero sorption–desorption of Na about 20% of its maximum value.

4. Selectivity Coefficient (Ks) for Cations Exchange Reaction of the Equilibrated Soils

Regarding to Ca-Mg (Ks), data recorded in Table 5 indicate that the Ca-Mg (Ks) values were generally decreased with increasing salinity levels in the equilibrated solutions, which ranged between 3.36 and 3.58 at 0.01 soil CEC level, then decreased to be between 1.78 and 2.35 at 0.2 soil CEC level.

However, increasing Ca/Mg equivalent ratio in the equilibrated solutions from 0/100 to 100/0 shows a progressive increases in Ca-Mg Ks values which ranged from 3.42 to 3.58 and from 1.78 to 2.35 at 0.01 and 0.2 soil CEC levels, respectively. Similar results were obtained by Krishnamoorthy

DATA

Replicates

Treatments	I	II	III	IV
1	-0.3700	-0.3700	-0.3700	-0.3500
2	-0.3700	-0.3700	-0.3700	-0.3700
3	0.1800	0.2000	0.2000	0.1800
4	-0.3700	-0.3700	-0.3900	-0.3900
5	-0.0800	-0.1100	-0.0800	-0.0800
6	-0.1000	-0.0700	-0.1000	-0.1000
7	-0.2200	-0.2200	-0.2200	-0.2200
8	-0.2900	-0.2900	-0.2700	-0.2700
9	-0.2700	-0.2900	-0.3100	-0.2700
10	0.0000	0.0000	0.0000	0.0000
11	-0.3200	-0.3200	-0.3000	-0.3200
12	-0.0800	-0.0800	-0.0800	-0.0800
13	-0.0800	-0.0800	-0.0800	-0.0800

```
AVERAGE VALUE   :

 -0.3650  -0.3700   0.1900  -0.3800  -0.0875  -0.0925  -0.2200
 -0.2800  -0.2850   0.0000  -0.3150  -0.0800  -0.0800

COEFF.DITER.= .9970298
  CORRELATION COEFFICINT= .9985138

CRITERION FISHER F( 12.000 39.000) 1090.968
  SOCT= 1.043874E-02
CONTROL-.315 - 0 =-.315        t= 47.63389
CONTROL-.08 - 0 =- 08        t= 12.09749
CONTROL-.08 --.1622222 = 8.222221E-02        t= 12.43353

   -0.3650    -0.3700    -0.3740    -0.3770    -0.3790    -0.3800
   -0.3800    -0.3790    -0.3770    -0.3740    -0.3700

   -0.3095    -0.3209    -0.3297    -0.3357    -0.3390    -0.3396
   -0.3375    -0.3327    -0.3251    -0.31[illegible]9

   -0.2540    -0.2702    -0.2819    -0.2893    -0.2922    -0.2907
   -0.2847    -0.2744    -0.2596

   -0.1985    -0.2177    -0.2308    -0.2377    -0.2385    -0.2332
   -0.2217    -0.2041

   -0.1430    -0.1635    -0.1762    -0.1810    -0.1780    -0.1671
   -0.1484

   -0.0875    -0.1076    -0.1182    -0.1192    -0.1106    -0.0925

   -0.0320    -0.0500    -0.0567    -0.0522    -0.0364

    0.0235     0.0093     0.0081     0.0199

    0.0790     0.0704     0.0764

    0.1345     0.1331

    0.1900

Ymax= .19          Ymin=-.38

  x1  -20 -20 -20 -20 -20 -20 -21 -20 -20 -20 -20   x2
        -17 -17 -18 -18 -18 -18 -18 -18 -18 -17
          -14 -15 -15 -16 -16 -16 -15 -15 -14
            -11 -12 -13 -13 -13 -13 -12 -11
               -8  -9 -10 -10 -10  -9  -8
                 -5  -6  -7  -7  -6  -5
                   -2  -3  -3  -3  -2
                     1   0   0   1
                       4   3   4
                         7   7
                         (10)
                          x3
```

Fig. 8. Sorption-desorption of Na as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.01 meq of soil cation exchange capacity].

DATA

Replicates

Treatments	I	II	III	IV
1	-0.9600	-0.9600	-0.9600	-0.9800
2	-0.9800	-0.8700	-0.9600	-0.8700
3	4.3500	4.5700	4.3500	4.4300
4	-0.9600	-0.8700	-0.9300	-0.9600
5	1.7400	1.7400	1.7400	1.7400
6	1.7400	2.1800	2.1800	1.7400
7	0.9100	0.7800	0.7600	0.6900
8	0.2400	0.0500	0.2000	0.2000
9	0.1700	0.1700	0.0400	0.0200
10	3.0400	3.6900	3.0400	3.6900
11	-0.0400	-0.0400	-0.0400	-0.0400
12	1.1500	1.0900	1.0900	1.1500
13	1.1300	1.1900	1.1000	1.1000

```
AVERAGE VALUE  :

 -0.9650  -0.9200   4.4250  -0.9300   1.7400   1.9600   0.7450
  0.1725   0.1000   3.3650  -0.0400   1.1200   1.1300

COEFF.DITER.= .9943671
  CORRELATION COEFFICINT= .9971796

CRITERION FISHER F( 12.000 39.000) 573.7137
   SOCT= .1376965
CONTROL-.04 - 0 =-.04          t= .4585541
CONTROL 1.12 - 0 = 1.12          t= 12.83951
CONTROL 1.13 - 1.602778 =-.472778          t= 5.419856

    -0.9650     -0.9560     -0.9480     -0.9410     -0.9350     -0.9300
    -0.9260     -0.9230     -0.9210     -0.9200     -0.9200

    -0.4224     -0.4414     -0.4525     -0.4559     -0.4513     -0.4389
    -0.4187     -0.3906     -0.3546     -0.3108

     0.1194      0.0813      0.0598      0.0551      0.0670      0.0957
     0.1410      0.2030      0.2818

     0.6604      0.6120      0.5891      0.5917      0.6199      0.6737
     0.7530      0.8578

     1.2006      1.1507      1.1352      1.1541      1.2074      1.2951
     1.4172

     1.7400      1.6975      1.6983      1.7423      1.8295      1.9600

     2.2786      2.2524      2.2782      2.3562      2.4862

     2.8164      2.8153      2.8751      2.9958

     3.3534      3.3862      3.4888

     3.8896      3.9652

     4.4250

Ymax= 4.425          Ymin=-.965

    x1   -3  -3  -3  -3  -3  -3  -3  -3  -3  -3  -3   x2

             -1  -1  -2  -2  -2  -1  -1  -1  -1  -1

                0   0   0   0   0   0   0   0   0
                ---------------------------------
                  1   1   1   1   1   1   1   1

                    2   2   2   2   2   2   3

                      3   3   3   3   4   4

                        5   5   5   5   5

                          6   6   6   6

                            7   7   7

                              8   8

                               (10)

                                x3
```

Fig. 9. Sorption-desorption of Na as affected by all the possible combinations of Ca^{2+}, Mg^{2+} and Na^{+} [Soil equilibrated with a saline solution contains 0.2 meq of soil cation exchange capacity].

and Overstreet (1950), they reported a higher affinity for exchangeable Ca than Mg.

It can be noticed that Ca preference was 3.58 at the highest Ca/Mg (100/0) ratio at the low salinity level (0.01 soil CEC), meanwhile increasing salinity level up to 0.2 soil CEC resulted a reduction of Ks to be 2.35. Meanwhile, at the lowest Ca/Mg equivalent fraction (0/100) ratio, Ca preference was 3.42 at low salinity level (0.01 soil CEC), then decreased to be 1.78 at the high salinity level (0.2 soil CEC). This means that, the Ca preference was increased with decreasing salinity level specially at 0.01 soil CEC or by increasing Ca/Mg ratio specially at 100/0 ratio. Similar results were obtained by Eisenman (1961), Beckett (1965) and Dolcator *et al.* (1968), they reported that the differences in Ca and Mg affinities are due to specific adsorption sites for Ca or Mg, while El-Nennah *et al.* (1986) found that the exchangeable affinities of Ca and Mg are nearly the same.

Concerning the Ca-Na (Ks), data in Table 5 show that the Ca-Na (Ks) values were generally decreased with increasing salinity levels of the equilibrated solutions which ranged between 18.90 and 20.21 at 0.01 soil CEC level, then decreased to be 6.27 and 3.74 at 0.2 soil CEC level, respectively. While, increasing Ca/Na equivalent fractions ratio from 0/100 to 100/0 in equilibrated solution lead to increase Ca-Na (Ks) values at low concentrations (0.01 and 0.02 soil CEC levels) to be 20.21 and 16.11, espectively, beyond these concentrations, a decrease in Ca-Na (Ks) values were detected to be 13.34, 12.24, 10.70, 6.66 and 3.74 respectively. The Ca preference was increased with decreasing salinity level. It can be recognized that the Ca-Na (Ks) values were higher than that of Ca-Mg (Ks) values, this may be due to different specific cations effect for Ca, Mg and Na, these suggest that the competition between Ca-Na is more than that of Ca-Mg and the replacing power of Ca in place of Na was higher than that of Ca in place of Mg. These results are confirmed by Amrhein and Suarez (1991), Moussa (1991) and Curtin *et al.* (1995), they mentioned that the selectivity coefficient for Na-Ca exchange was negatively correlated with organic carbon, pH and CEC.

Table 5 : Selectivity coefficient (K_S) of Ca-Mg , Ca-Na and Mg-Na of soil exchange reaction as a result of equilibrated with different saline concentration solutions having different combination of Ca, Mg and Na, equivalent fractions ratios.

Selectivity coefficient	Ks $_{(Ca-Mg)}$							Ks $_{(Ca-Na)}$							Ks $_{(Mg-Na)}$						
Salinity levels / Equivalent ratios	0.01	0:02	0.03	0.04	0.05	0.1	0.2	0.01	0.02	0.03	0.04	0.05	0.1	0.2	0.01	0.02	0.03	0.04	0.05	0.1	0.2
(0:100)	3.42	3.15	2.87	2.84	2.80	2.54	1.78	18.90	16.00	13.43	16.27	14.24	8.85	6.27	5.51	4.81	4.08	4.95	4.39	3.19	2.55
(10:90)	3.39	3.16	2.92	2.86	2.74	2.49	1.80	19.08	15.72	13.46	15.51	12.36	8.62	5.93	5.55	4.78	4.14	4.85	3.94	3.15	2.46
(20:80)	3.37	3.17	2.97	2.88	2.70	2.46	1.84	19.24	15.51	13.49	14.82	10.81	8.39	5.61	5.59	4.76	4.20	4.76	3.58	3.10	2.37
(30:70)	3.36	3.19	3.02	2.91	2.68	2.46	1.88	19.39	15.37	13.51	14.22	9.61	8.16	5.31	5.63	4.75	4.25	4.67	3.30	3.05	2.29
(40:60)	3.36	3.21	3.07	2.94	2.69	2.48	1.92	19.54	15.28	13.51	13.70	8.74	7.93	5.03	5.67	4.75	4.30	4.59	3.11	2.99	2.22
(50:50)	3.37	3.24	3.12	2.98	2.72	2.52	1.98	19.67	15.26	13.51	13.25	8.22	7.71	4.76	5.70	4.76	4.35	4.52	3.00	2.92	2.15
(60:40)	3.39	3.27	3.17	3.03	2.77	2.59	2.04	19.80	15.31	13.50	12.89	8.04	7.49	4.52	5.74	4.79	4.39	4.46	2.98	2.85	2.09
(70:30)	3.42	3.31	3.21	3.07	2.85	2.68	2.11	19.91	15.41	13.47	12.61	8.19	7.28	4.30	5.78	4.84	4.44	4.40	3.05	2.77	2.04
(80:20)	3.46	3.35	3.26	3.12	2.95	2.79	2.18	20.02	15.58	13.44	12.41	8.69	7.07	4.09	5.82	4.89	4.48	4.36	3.20	2.69	1.99
(90:10)	3.51	3.39	3.30	3.18	3.08	2.93	2.26	20.12	15.82	13.40	12.29	9.52	6.86	3.91	5.86	4.96	4.52	4.32	3.44	2.60	1.95
(100:0)	3.58	3.44	3.34	3.24	3.22	3.09	2.35	20.21	16.11	13.34	12.24	10.70	6.66	3.74	5.90	5.04	4.55	4.29	3.77	2.51	1.91

Equivalent ratios from (0:100) to (100:0) means Ca:Mg, Ca:Na and Mg:Na ratios, respectively.

Concerning the Mg-Na (Ks), data in Table 5 indicate that the Mg-Na (Ks) values were generally decreased with increasing salinity levels of the equilibrated solutions, which ranged between 5.51 and 5.90 at 0.01 soil CEC level, then decreased to be 2.55 and 1.91 at 0.2 soil CEC level. However, it can be reported that Mg preference was increased with decreasing salinity in case of high Mg/Na equivalent fractions ratio (100/0), where Mg-Na (Ks) value was equal to 5.90, meanwhile increasing salinity level to 0.2 soil CEC level resulted a decrease of Mg-Na (Ks) value to be equal 1.91. while in case of low Mg/Na equivalent fractions ratio (0/100), Mg preference was 5.51 at the low salinity level (0.01 soil CEC) decreased to be 2.55 with increasing salinity level to 0.2 soil CEC. It is worthy to mention that the Ks values of Ca-Na were higher than that of Mg-Na, this is due to the different specific cations effect and the charge density of Ca cations comparing with Mg cations, this means that the ability of Ca was higher than that of Mg on displacement of Na cations. It is obvious also that there is no wide variation in the selectivity coefficient for Mg-Na exchange reaction of the equilibrated soil, and the Mg-Na (Ks) values were nearly stable with different equivalent fractions of Mg/Na ratios. Similar results were obtained by Moussa (1991) and Babcock (1960), they mentioned that the exchange constants of Na–Ca and Na–Mg on illite are equal.

REFERENCES

Aboulroos, S. A. 1978. Sodium-Calcium and Magnesium exchange equilibrium in soils. Egypt Soil Sci. J. 18, No. 1, pp. 83-93.

Amrhein, C. and D.L. Suarez 1991. Sodium - calcium exchange with anion exclusion and weathering corrections. Soil Sci. Soc. Amer. J. 55: 698 - 706

Babcock, K.L. 1960. Evidence for Na-fixation in salt-affected soils. Soil Sci. Soc. Amer. Proc. 24, 85.

Beckett, P.H.T. 1965. The cation exchange equilibria of Calcium and magnesium. Soil Sci. 100, 118.

Curtin,D., F. Selles and H. Steppuhn 1995. Sodium - Calcium exchange selectivity as influenced by soil properties and method of determination. Soil Sci., vol. 159, No. 3, pp. 176 – 184.

Dolcator, D.L., E.G. Lotse; J.K. Syers and M.L. Jackson, 1968. Cation exchange selectivity of some clay-sized minerals and soil materials. Soil Sci. Soc. Amer. Proc., 32, 795.

Eisenman,G.1961."On Elementary Atomic Origin of Equilibrium Ionic Specificaity". Academic Press, New York.

EL-Nennah,M.E. , M.S. Foda and K.A. Abbady 1986. Ca and Mg preference on clay minerals and soil clays. Egypt. J. Soil Sci. (Special Issue) pp. 75 – 82 (1986)

Krishnamoorthy, C. and R. Overstreet 1950. An experimental evaluation of ion-exchange relationships. Soil Sci. 69, 41.

Levy,R., I. Shainberg; J. Shalheret and N. Alperovitch 1972. Selectivity coefficients of Ca exchange for three montmorillonitic soils. Geoderma 8, 133.

Ministry of Public Works and Water Resources 1999. Egypt's water policy for the 21st century. 7th Nile 2002 conference Cairo, March 15 – 19, 1999.

Moussa, K.F. 1987. A computer model on suitability of irrigation water. Soil Sci. Dept., Fac. of Agric., Zagazig Univ., Egypt J. Appl. Sci. Second Issue June (2), 1987, 892-879.

Moussa, K.F. 1991. Evaluation of the relative affinities of exchangeable cation in the alluvial soil of El-Sharkiya Governorate. Soil Sci. Dept., Fac. of Agric. Zagazig Univ., Zagazig J. Agric. Res. Vol. 18 (4) 1991, 1151-1160.

Page,A.L. , R.H. Miller and D.R. Keeney 1982. Methods of Soil Analysis. part 2. Chemical and microbiological properties. 2nd Edition.

Thabet, A.G. and H.M. Selim 1996. Determination of cation selectivity coefficients of soils: A thin disk flow method. Soil Sci., Vol. 161, No. 6 : 405- 411.

Yadav, J.S.P. and L.K. Girdhar 1979. Effect of varing Mg/Ca ratio and electolyte concentration in the irrigation water on the soil properties and growth of wheat. Inter. Symp. on Principles and Practices for reclamation and management of salt affected soils. Subcomission on salt affected soils tess. Paper 46:210-215.

استخدام نموذج للحاسب الآلي لتقدير الكاتيونات المدمصة والخارجة من التربة ومعامل الاختيارية للكاتيونات في أراضي محافظة الغربية

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اجريت تجربة تحت الظروف المعملية في محطة البحوث الزراعية بالجميزة، محافظة الغربية ، لدراسة التأثيرات المتداخلة لمحاليل مائية تحتوى علي نسب مختلفة من الكالسيوم والماغنسيوم والصوديوم عند مستويات ملوحة مختلفة علي حركة امصاص وخروج هذة الكاتيونات من التربة ومعامل الاختيارية لكل من كا – مغ ، كا – ص ، مغ – ص لفعل التبادل علي الأرض الطينية المتزنة، حيث استخدم ١٠٠ جم تربة طينية متزنة مع ١٠٠ مل ماء مقطر يحتوى علي تركيزات (٠,٠١ ، ٠,٠٢ ، ٠,٠٣، ٠,٠٤ ، ٠,٠٥ ، ٠,١ ، ٠,٢) من السعة التبادلية الكاتيونية للتربة بالمليمكافئات / لتر للتداخلات المختلفة من أملاح كلوريدات الكالسيوم والماغنسيوم والصوديوم.

تظهر النتائج في شكل مثلث متساوى الاضلاع من خلال ثلاثة عشر معاملة من المحاليل المائية تغطي كل التداخلات المحتملة لكاتيونات كا ، مغ ، ص عند مستويات الملوحة المختلفة. ويمكن تلخيص النتائج المتحصل عليها كالتالي:-

١- اعلي قيم للكاتيونات المدمصة (كا ، مغ، ص) تزداد عموما بزيادة تركيزاتها في المحاليل المتزنة.

٢- اعلي قيم لخروج اى من الكاتيونات (كا ، مغ ، ص) تزداد أيضا بزيادة التركيزات لواحد أو اثنين من الكاتيونات الأخرى في المحلول المتزن.

٣- معامل الاختيارية لفعل تبادل كا – مغ في الارض المتزنة تبين أن أفضلية امصاص الكالسيوم بالنسبة إلي الماغنسيوم تزداد بنقص مستوى الملوحة وخاصة عند مستوى ٠,٠١ من السعة التبادلية الكاتيونية للتربة أو بزيادة نسبة كا / مغ وخاصة عند نسبة ١٠٠ / ٠ .

٤- يوجد اتجاة مشابة لمعامل اختيارية كا – ص ، مغ – ص ولكن قيم معامل الاختيارية كا – ص كانت اعلي من مغ – ص ، ويعزى هذا إلي اختلاف تأثير الكاتيون النوعي لكاتيونات الكاسيوم والماغنسيوم والصوديوم.