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SOME FACTORS CONTROLLING THE IMPROVEMENT OF SOIL MOISTURE CHARACTERISTICS AND PORE SIZE DISTRIBUTION IN NORTH NILE DELTA SOILS

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ABSTRACT

Undisturbed soil samples were taken from the surface layers of the soil of El-Serw experimental station, Domitta governorate. after the harvesting of wheat crop to demonstrate the effect of potassium fertilization and gypsum application under different irrigations water types on soil moisture characteristics and pore size distribution. The main obtained results can be summarized as follow:

Soil moisture contents as well as soil moisture constants, i.e. field capacity, available water and wilting point increased under the addition of gypsum more than under those of potassium fertilization . Total soil porosity as well as pore size distribution were affected mainly by the additions of gypsum.

Positive and high significant correlations have been established between soil moisture contents at field capacity and wilting point and either clay or organic matter contents. Otherwise , the percentages of coarse and fine sand were negatively affected at field capacity after irrigation with drainage water , such correlations were negative and significant at 1 % and 5 % between soil moisture content at wilting point and either coarse sand or silt, respectively for soil irrigated by Nile water.

Results showed that soil organic matter contents affected positively and high significantly total soil porosity, Correlation coefficients between total soil porosity and either coarse or fine sand were negative and significant. More over, the volumes of quickly and slowly drainable pores are positively and significantly correlated with clay content under drainage water irrigation. Also there was a high positive and significant correlation between fine capillary pores and organic matter content . On the other hand, negative and significant correlations established found between either slcwly drainable or fine capillary pores and silt content in soil irrigated with Nile water.

Keywords: Soil moisture, pore size distribution, Soil amendments, salt affected soils .

INTRODUCTION

The capacity of soils to receive or store available water to the growing plants is of great importance to agricultural production. Soil moisture retention is one of the limiting factors for agricultural development, particularly in arid and semiarid zones .The use of drainage water for crop irrigation crops becomes very necessary because of the shortage in good quality water resources.

Various attempts were made to improve the soil moisture characteristics and pore size distribution ,Many investigations were used different soil amendments, such as mineral fertilizers and gypsum to avoid the risk of irrigation with drainage water on some phsical properties of soils were investigated by many scientists such as Talha *et al.*(1978) who stated that soil moisture characteristic curves of alluvial soils of Egypt are affected by soil texture more than by alkalinity or salinity, Jadhovi (1978) rêported that moisture retained at 1/3 and 15.0 bar showed a significant and positive correlation with organic carbon.

Ghazy (1982) attributed the increase in soil moisture to the better flocculation of colloidal fraction by Ca^{++} ion.This also was confirmed by Lebron et al.(2002) and Abd El- Hamid et al.. (2005) they found that the volume of macrospores was increased with gypsum addition to the saline sodic soil

The present study aims to study and discuss some factors affecting soil moisture characteristics and pore size distribution of saline sodic soil at North Nile Delta.

MATERIALS AND METHODS

El-Serw experimental station (ARC), Domitta Governorate, Egypt, was chosen to demonstrate the effect of either potassium fertilization as potassium sulfate (48%K_2O) at two rates, i.e., 12 and 24 Kg K_2O/ fed^{-1} or gypsum application at 6 tons/fed^{-1} under different irrigation types i.e, Nile irrigation water and drainage irrigation water on soil moisture characteristics and pore size distribution, after harvesting wheat crop.

Undisturbed soil samples were taken from the soil surface layer (0-30 cm) by driving brass cylinders having 5 cm height and 5 cm.inside diameter into the soil representing the investigated soil. Mechanical analysis was determined using sodium hexametaphosphate as dispersing agent, Gee and Bander (1986).Estimation of soil salinity, ESP%, OM% and $CaCO_3$% were carried out according to Jackson (1967), Table 1 data show some physical and chemical analyses of irrigation water as Jackson (1967) are shown in Table 2 .

Table 1 : Some chemical and physical analysis of soil surface layer of soil under study.

Water type	Treat	E.C dSm^{-1}	$CaCo_3$ %	O.M %	Particles size distribution % C.S %	F.S %	Silt %	Clay %	Texture	ESP%
Nile water	Cont.	4.55	2.36	1.60	0.38	19.93	13.44	66.25	clay	12.00
	K_1	5.20	2.20	1.50	0.51	15.69	23.82	59.98	clay	11.50
	K_2	5.65	2.00	1.55	0.52	18.14	19.67	61.67	clay	11.75
	Gy.	3.30	2.00	1.45	1.00	17.20	18.33	63.47	clay	6.00
Drainage water .	Cont.	8.32	2.77	2.06	1.25	18.8	20.31	59.65	clay	15.30
	K_1	8.22	2.60	2.00	2.22	18.0	21.50	58.28	clay	14.00
	K_2	7.52	2.71	1.80	1.75	16.90	21.48	59.85	clay	14.20
	Gy.	6.22	2.50	1.80	3.00	17.20	18.0	61.80	clay	12.45

K_1= potassium fertilization (12 kg K_2o/fed)
K_2= potassium fertilization (12 kg K_2o/fed)
G = Gypsum amendment (6 ton/fed)

Table 2 : Irrigation water analysis

Water type	E.C dsm^{-1}	Cations mef/l Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Anions mef/l Co^{--}_3	HCo^{-}_3	Cl^{-}	So^{--}_4
Nile water	0.69	2.83	1.89	3.23	0.24	0.32	3.23	2.40	2.04
Drainage water	2.34	3.34	5.11	17.99	0.39	1.04	3.53	17.69	4.66

Undisturbed soil samples were used for determination of bulk density and soil moisture contents on weight basis at different pressures i.e. 0.1, 0.33, 0.66 and 1.00 atm, and the pressure membrane apparatus. Moisture contents on volume basis were calculated using the values of soil bulk density and soil moisture characteristics curves and obtained according to Richards and weaver (1944) and Richards (1947). Soil moisture tension was expressed according to Ascroft and Taylor (1953).Total soil porosity was calculated from the values of both real and bulk densities. Pore size distribution was calculated and classified to quickly drainable, slowly drainable, volume drainable, water holding and fine capillary pores according to De–Leenher and De–Boodt (1965).The diameters of these pores are >.28.8 μ, 28.8-8.62 μ,8.62 μ, 8.62-0.19 μ and < 0.19 μ , respectively. The obtained results were statistically analyzed and the simple correlation coefficients were calculated according to Douglas and LU (1959).

RESULTS AND DISCUSSION

I- soil moisture characteristics

The studied soil samples are almost homogenous in their textures as clay is dominate fraction, Table 1, Data in Table 3, and Fig 1 show that soil moisture contents decreases by increasing the applied pressure and this function is mainly affected by particle size distribution i.e, the higher the clay contents , the greater is moisture retained at any particular pressure and the slopes of the tention curves are gradual.Similar results were obtained by El-Tony (1982) and Heggy (1976)

Regarding the effect of different potassium fertilizer treatments and gypsum addition on soil moisture characteristics curves , data presented in Table 3 and illustrated in Fig. 1 reveal that soil moisture content at any applied pressure increased by potassium fertilization increasing from 12 to 24 Kg K_2O and gypsum addition, under different irrigation water types . This trend may be due to the balanced fertilization with potash which gives the unique opportunity to improve the roots yield of plants which enhances the aggregation process in addition, the application of gypsum led to beneficial effects on the physicochemical properties of the soil, (El-Banna *et al.* 2004)

It can also noticed that soil moisture content values at any applied pressure were higher in soil irrigated with Nile water than that irrigated with drainage water. These finding were in agreement with the findings of Laila (1993) .

Table 3 : Effect of potassium fertilizer treatment and gypsum addition on the percentage of soil moisture contents on volume bases " θ" under different water irrigation types of the studied soil

treatment	Different tension values in atm.													
	Nile water irrigation							Drainage water irrigation						
	0.00	0.10	0.33	0.66	1.00	3.00	15.00	0.00	0.10	0.33	0.66	1.00	3.00	15.00
Control	48.00	44.45	42.49	40.17	36.22	33.90	26.61	46.20	41.93	40.64	39.68	535.74	32.67	24.64
K_1	48.00	45.69	43.33	40.64	37.90	35.28	27.37	45.00	40.85	39.90	38.18	335.24	33.42	25.85
K_2	51.00	48.39	45.38	42.38	39.62	38.2[illegible]	[illegible]8.23	46.30	42.26	41.17	40.48	336.54	34.69	27.46
G	56.00	50.19	47.00	45.81	62.06	30.50	30.50	51.50	46.33	44.54	42.12	440.09	39.31	28.79

K_1 = 12 kg K_2O/fed^{-1} K_2 = 24 kg K_2O/fed^{-1} G = Gypsum 6 ton/fed^{-1}

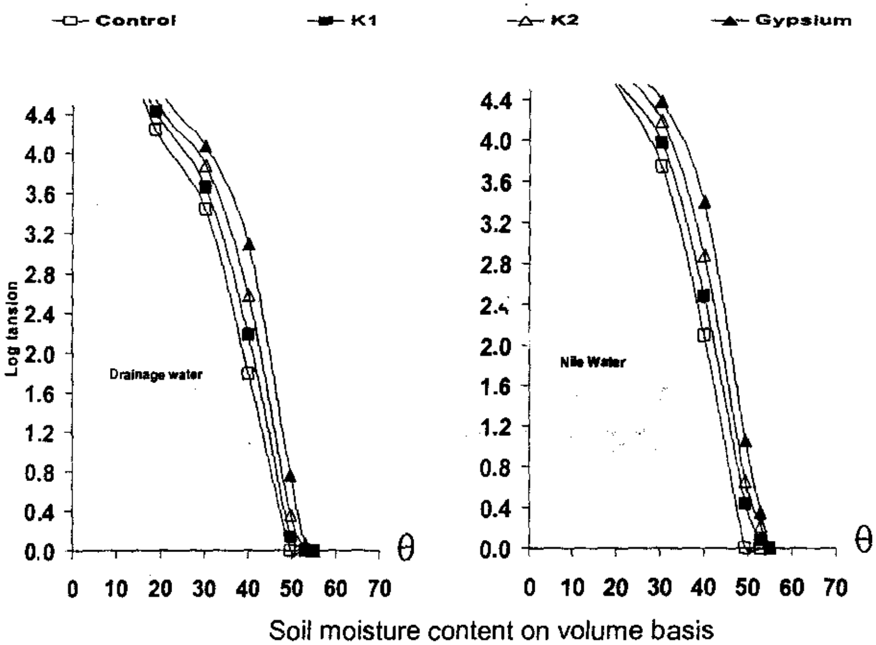

Fig 1-Effect of different fertilizer treatment and gypsum addition on soil moisture characteristic curves under different irrigation water types for studied soil samples

Field capacity, available water and wilting point are considered to be the three main aspects of soil moisture constants. These constants. could be elucidated from soil moisture characteristics curves Table 4, data show the three soil moisture constants. These constants are increased by potassium fertilization , gypsum application and irrigation by Nile water, as stated by Aly (1993) and Abou El-Defan *et al.*(2005)

The simple correlation coefficients between these three soil moister constants and particle size distribution as well as organic matter content under different irrigation water types were calculated and presented in Table 5 . Data reveal that simple correlation coefficients between field capacity and both clay and organic matter contents are positive and highly significant,

Table 4 : Effect of potassium fertilizer treatment and Gypsum addetion soil moisture constants under different irrigation types of the studied soil.

Treatment	Nile water irrigation			Drainage water irrigation		
	F.C%	A.W%	W.P%	F.C%	A.W%	W.P%
Control	42.49	15.88	26.61	40.64	16.00	24.64
K_1	43.33	15.96	27.37	39.90	14.05	25.85
K_2	45.38	17.15	28.23	41.17	13.71	27.46
G	47.00	16.50	30.50	44.54	15.75	28.79

K_1 = 12 kg K_2O/fed^{-1} K_2 = 24 kg K_2O/fed^{-1} G = Gypsum 6 ton/fed^{-1}

Table 5 : correlation coefficients and regression equations between soil moisture constants "y" and both particle size distribution and organic matter content "X" for studied soil sample under different irrigation water types.

Different characters X	Correlation coefficient "r" and regression equations					
	Field capacity %		Available water %		Wilting point	
	r	Regression equation	r	Regression equation	r	Regression equation
	Drainage irrigation					
Coars sand % X_1	-0.8750*	$y= 48.6991-3.255X_1$	-0.7728	$y= 17.7144-1.2079X_1$	-0.5671	$y= 30.8122 - 1.7662X_1$
Fine sand % X_2	-0.9490*	$y = 49.2549-0.3371 X_2$	-0.6886	$y = 18.3407-0.1600 X_2$	-0.5836	$y = 30.9142- 0.1771 X_2$
Silt % X_3	**0.5582**	$y = 32.7932 + 0.329 X_3$	0.5913	$y = 8.6620 + 0.2283 X_3$	0.2013	$y = 24.1312 + 0.3152 X_3$
Clay % X_4	0.9711**	$y = 15.5776 + 0.2191 X_4$	0.6108	$y = 6.4160 + 0.1743 X_4$	0.7203	$y = 12.7241 - 0.1621 X_4$
O.M. cont. X_5	0.7663**	$y = 38.9142 + 3.8308 X_5$	0.5688	$y = 13.6418+ 1.4844 X_5$	0.6910	$y = 23.3724 + 2.5412X_5$
	Nile water irrigation					
Coars sand % X_1	-0.5272*	$y= 31.4510 -0.1766 X_1$	-0.4433	$y= 12.3014 - 1.2357 X_1$	-0.9706**	$y= 40.0466 - 0.6381X_1$
Fine sand % X_2	-0.2061	$y = 40.8211+ 0.1857 X_2$	0.4839	$y = 13.5617 + 0.1409 X_2$	0.0519	$y = 27.2594 + 0.0441 X_2$
Silt % X_3	-0.9452*	$y = 63.6037- 0.6749 X_3$	-0.7281	$y = 209501- 0.1647 X_3$	-0.2793*	$y = 42.6556 + 0.5396 X_3$
Clay % X_4	0.9128*	$y = 4.3101 + 0.8028 X_4$	0.5152	$y = 9.1080 + 0.1432 X_4$	0.9251*	$y = -4.7979 + 0.6051 X_4$
O.M. cont. X_5	0.5217*	$y = 34.6374 + 0.4299 X_5$	0.4299	$y = 14.8252 + 1.0076 X_5$	0.9247*	$y = 34.9376 + 6.2572 X_5$

* significant at 5% level ** significant at 1% level

While they are negative and significant in the case of fine and coarse sand fractions, The simple correlation coefficients between both available water and wilting point are insignificant with either particle size distribution or organic mater for soil samples which irrigated by drainage water.

Date in Table 4 reveal also that there was a significant and positive correlation between either field capacity or wilting point and clay fraction as well as organic matter the simple correlation coefficient between field capacity and either coarse sand or silt fractions are negatively significant at 5 %.However, the correlation coefficient, was negative and significant at 1% and 5% between wilting point and either coarse sand and silt fractions. On the other hand, the simple correlation coefficients between available water and either particle size distribution or organic matter are insignificant for soil samples of soil irrigated with Nile water

II-Total soil porosity:

Concerning the effect of potassium fertilizer and application of gypsum under different irrigation water types on the values of total prosity and pore size distribution percent from total porosity. Data in Table 6 reveal that the values of total porosity (%) increased in soil surface layer of soil treated with potassium fertilizer, gypsum application, and irrigated with Nile water and also increased in soil treated with gypsum and irrigated with dranig water with untreated soil irrigated with corresponding water Nile. This finding can be attributed to the role of gypsum in enhancing aggregation process which increase the apparent soil volume and consequently increase soil porosity (Abd El–hamid *et al.* 2005)

Table 6: Total soil porosity and pore size distribution as affected by potassium fertilizer treatments and Gypsum addition under different irrigation water types

Treatment	Pore size distribution as percent from total volume											
	Nile water irrigation						Drainage water irrigation					
	Total poro.%	>28.8 μ	28.8-8.62 μ	>8.62 μ	8.62-0.19 μ	< 0.19 μ	Total poro.%	>28.8 μ	28.8-8.62 μ	>8.62 μ	8.62-0.19 μ	< 0.19 μ
Control	48.00	3.55	1.96	5.51	15.88	26.61	45..00	4.27	0.29	4.56	16.00	24.44
K_1	48.00	2.31	2.36	4.67	15.96	27.37	44.00	4.15	0.95	5.10	14.05	24.85
K_2	51.00	2.61	3.01	8.62	17.15	28.23	46.30	4.04	1.09	5.1	13.71	27.45
G	56.00	5.81	3.19	9.00	16.50	30.50	51.50	5.17	1.79	6.96	15.76	28.78

Pore size distribution as percent from total porosity										
	Nile water irrigation					Drainage water irrigation				
Treatment	>28.8 μ	28.8-8.62 μ	>8.62 μ	8.62-0.19 μ	< 0.19 μ	>28.8 μ	28.8-8.62 μ	>8.62 μ	8.62-0.19 μ	< 0.19 μ
Control	7.40	4.00	11.48	33.08	55.44	9.49	0.34	10.13	35.56	54.31
K_1	4.01	4.92	9.73	33.25	37.02	9.43	0.16	11.59	31.23	56.48
K_2	5.12	5.90	11.02	33.62	55.35	8.73	2.35	11.08	29.61	59.31
G	10.38	5.70	16.07	29.46	54.45	10.04	3.48	13.51	30.60	55.88

K_1 = 12 kg K_2O/fed^{-1} K_2 = 24 kg K_2O/fed^{-1} G = Gypsum 6 ton/fed^{-1}

Data in Table 6 also reveal that the values of pore size distribution was not affected by both potassium fertilizer treatments and water irrigation types, while there was slightly increased in pore size distribution values due to gypsum application under different irrigation water types. These results could be enhanced by those established by El–Hadidi *et al.*(2004) They found that iregular addition of farmyard manure and gypsum is rquierd to improve physical properties of heavy clay soil.

The values of simple correlation coefficient between pore size distribution ,total soil prosity and both particle size distribution and organic matter content under different irrigation water types are calculated and presented in Table 7, These values show a highly positive and significant correlations between total soil porosity and both clay and organic matter contents, while these correlation is negative and significant in the case of both coarse and fine sand fractions. Moreover, positive and significant correlations exist between quickly, slowly and volume draniable pores and clay content in the case of the soil samples irrigated with drainage water.

Regarding the simple correlation coefficients between total soil porosity or pore size distribution and both particles size distribution and organic matter contents under Nile water irrigation, date in Table 7 show high positive and significant correlation between total soil porosity and both clay and organic matter contents, Such correlations are of negative and significant behaviors with coarse sand and silt at 1% and 5% levels respectively, While the positive and significant correlation existed between both volume drainable pores and fine capillary pores with clay contents also., A high positive and significant correlation can be noticed between fine capillary pores and organic matter contents. On the other hand the simple correlation coefficients between both slowly drainable pores and fine capillary pores and silt are negative and significant in the case of soile samples irrigated with Nile water.

Thus it can be concluded that the application of gypsum to heavy clay soil has a higher significant effect on moisture characteristics and pore size distribution than potassium fertilizers

Table 7: Correlation coefficients and regression equations between pore size distribution "y" water and both particles size distribution and organic matter content "X" under different irrigation water types.

Different characters X	Correlation coefficients "r" and regression equation					
	Total porosity		>28.8 μ pores		28.8-8.62 μ pores	
	r	Regression	r	Regression	r	Regression
	Nile irrigation water					
C.sand % X_1	-0.9784**	y=77.8333-15.8333X1	-0.8077	y=13.4312-5.6298X1	-0.8202	y=6.1331-2.0774 X1
F. sand % X_2	0.0403	y=49.3078+0.0676 X2	-0.2158	y=6.7534-0.1572 X2	0.1326	y=0.9783+0.0827X2
Silt % X_3	-0.9039*	y=84.1294-1.1755 X3	-0.5545	y=12.6892-0.3.137 X3	-0.9137*	y=79135-0.1878 X3
Clay % X_4	0.9739**	y=32.3121+12.8788 X4	0.7166	y=22.6771+0.5296 X4	0.8086	y=7.6358+0.2043X4
O.M.. X_5	0.9551**	y=27.1470+1.5581 X5	0.6880	y=1.9774+4.0320 X5	0.8402	y=0.0188+1.7896X5
C.sand % X_1	-0.9428*	y=19.5643-7.7071X1	-0.4434	y=18.3814-7.7071X1	-0.9708**	y=18.3814-1.2557 X1
F. sand % X_2	**-0.0872**	**y=7.7317-0.0754 X2**	**0.4839**	**y=13.5617+0.1409 X2**	**0.0599**	**y=27.2594+0.0448 X2**
Silt % X_3	-0.7559	y=20.6027-0.5016 X3	-0.7281	y=20.9501-0.1647X3	0.7895*	y=42.6566-0.5102X3
Clay % X_4	0.8999*	y=30.3129+0.7339 X4	0.5152	y=9.1081+0.1432 X4	0.9251**	y=-4.7979+0.6596 X4
O.M.. X_5	0.8469	y=1.9586+5.8215 X5	0.4299	y=14.8252+1.0076 X5	0.9730**	y=19.8123+5.8476 X5
	>8.62 μ pores		8.62-0.19 μ pores		<0.19 μ pores	
	r	Regression	r	Regression	r	Regression
	Drainage irrigation water					
C.sand % X1	-0.9052*	y=35.9312+3.2562 X1	-0.7713	y=6.5250-1.0341 X1	-0.6671	y=2.7512-0.8218 X1
F. sand % X2	-0.9445*	y= 59.4662-0.5653 X2	-0.7987	y=6.5854-0.1019 X2	-0.6674	y=2.6811-0.0759X2
Silt % X3	0.5363	y=34.7552 +0.4627 X3	0.4122	y=1.9235+ 0.0874 X3	0.1439	y=0.1685+0.0280X3
Clay % X4	0.9785**	y=14.0610+7.0581 X4	0.8661*	y=2.9188+0.1535 X4	0.8667*	y=5.6385+0.1411X4
O.M.. X5	0.5757	y=43.1507+5.6994 X5	0.8223	y=3.4486+1.1786 X5	0.7878	y=0.2424+1.0375X5
C.sand % X_1	-0.7541	y=9.3742-1.8558 X1	0.6539	y=0.8677+5.1806 X1	-0.6345	y=31.7580-2.3248 X1
F. sand % X_2	-0.7691	y=9.2665-0.1778 X2	-0.6904	y=18.3602-0.1608 X2	-0.6497	y=31.8399-0.2267 X2
Silt % X_3	0.3005	y=2.0920+0.1154 X3	0.5917	y=8.6503+0.2288 X3	0.5638	y=21.0454+0.2108 X3
Clay % X_4	0.9176*	y=-8.5373+0.2945 X4	0.5433	y=3.1142+0.176 X4	0.6817	y=11.2168+0.3302 X4
O.M.. X_5	0.8534	y=3.6883+2.2161 X5	0.5713	y=13.6378+1.4939 X5	0.6680	y=24.8602+2.6176 X5

* significant at 5% level　　　　** significant at 1%

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بعض العوامل المؤثرة على صفات الرطوبة الأرضية والتوزيع الحجمـــى للمـــسام لأراضي شمال الدلتا

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أخذت عينات غير مثارة من أراضى محطة البحوث الزراعية بالسرو- محافظة دميــاط بغرض دراسة تأثير التسميد البوتاسى بمعدلين ١٢ و ٢٤ كجم من سماد كبريتات البوتاســيوم ٤٨ % في صورة بو٢أ وإضافة ٦ طن جبس / فدان لأراضي تروي بميــاه النيــل وكــذلك بميــاه الصرف الزراعي علي كل من صفات الرطوبة الأرضية والتوزيع النسبي للمسام ويمكن تلخيص أهم النتائج فيما يلي:

تأثرت منحنيات الرطوبة الأرضية وزادت قيم المحتوى الرطوبى (السعه الحقلية-المــاء اليسر نقطة الذبول) بإضافة الجبس مقارنه بالتسميد بالسماد البوتاسى أما المسامية الكلية والتوزيع النسبي للمسام وزادت قيمتها بإضافة الجبس فقط. وقد أظهر التحليل الإحصائي وجود علاقة موجبه عالية المعنوية بين السعه الحقلية وكل من الطين والمادة العضوية بينما كانت هذه العلاقة معنويــة سالبه مع الرمل الناعم وذلك تحت تأثير الري بمياه الصرف الزراعي . كذلك وجدت علاقة موجبه معنوية بين قيم كلا من السعه الحقلية ونقطة الذبول وكل من الطين والمادة العضوية بينما كانــت العلاقة بين السعه الحقلية وكل من الرمل الخشن والسلت معنوية سالبه على مستوى ٥ % كــذلك كانت العلاقة بين نقطة الذبول وكل من الرمل الخشن والسلت سالبه ومعنوية على مستوى ١ % و ٥% على الترتيب وذلك لعينات الأراضي المروية بمياه النيل. معامل الارتباط بين المسامية الكلية والطين والمادة العضوية كان موجب وعالي المعنوية بينما كان الارتباط معنوي وسالب مع الرمل الخشن والناعم . كذلك كانت العلاقة بين كلا من مسام الصرف الواسعة البطيئة والمسام الحجميــة معنوية موجبه مع الطين في عينات الأراضي المزوية بمياه الصرف الزراعي . وكانت العلاقة بين المسامية الكلية وكل من الطين والمادة العضوية موجبه عالية المعنوية بينما كانت سالبه معنوية مع الرمل الخشن والسلت على مستوى ١ % و٥% علي الترتيب . وكانت العلاقــة موجبــة عاليــة المعنوية علي مستوي ١% بين المسام الشعرية الدقيقة والمادة العضوية بينما كانت العلاقــة بــين مسام الصرف البطيئة والمسام الشعرية الدقيقة سالبه ومعنوية في الأراضي المروية بمياه النيل.