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EFFECT OF SOIL CONDITIONERS ON SANDY SOIL PROPERTIES, GROWTH OF PLANTS AND NUTRIENTS UPTAKE

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ABSTRACT

A greenhouse experiment was carried out to study synthetic conditioner (PAM) and a natural one shale (Tafla, an old clay deposit) on maize plant growth and nutrients uptake as a result of conditioning physical and chemical properties of the loamy sand soil, collected from Ismailia, North East of Cairo.

Four kg portions of surface soil (0-30 cm) were mixed thoroughly with either PAM at rates of 0, 0.025, 0.05 and 0.1% (w/w) or Tafla at rates of 0, 1, 2 and 3% (w/w) then packed in plastic pots (25 cm and 20 cm depth). Each pot received nitrogen, phosphorus and potassium at the rate of 120 mg N , 13mgP and 40mg K per kg of soil in the forms of ammonium sulfate, calcium superphosphate and potassium sulfate, respectively. Maize was used as plant indicator and grown for 45 days.

Bulk density (BD was decreased due to the application of either PAM or Tafla. The lowest (BD) values was attained by 0.1 PAM and 3% Tafla treatments.

Hydraulic conductivity (Ks) was decreased with the application of soil conditioners. The largest decrease in (Ks) was associated with increasing the rate of soil conditioner.

Cation exchange capacity (CEC) and electrical conductivity (EC) was increased due to the application of PAM or Tafla. Treatments which received Tafla have higher EC values than those received PAM.

Dry weight of maize plants was increased due to the application of soil conditioners. The highest dry weight was obtained from PAM treatment.

The contents of maize plants from N and K were favorably affected by using the applied conditioners. Their P contents were slightly increased especially at the highest rates of application.

Results indicated that N, P, K uptake by maize plants increased due to the application of soil conditioners. The increase was dependent on the rate of application.

Keywords: Soil conditioner, Soil properties, Nutrients uptake.

INTRODUCTION

Due to the extremely rapid increase in population, agricultural demand for land and water resources necessitate more efficient use to those resources. So, reclamation and utilization of newly reclaimed land in Egypt are the major steps required to solve these problems. In fact, sandy soils are a great hope for Egyptian agricultural expansion. However, they are characterized by great water losses by deep percolation, low structure and very low fertility beside other problems. For these reasons solving the previous problems of sandy soil are depending mainly on improving their hydrophysical properties and nutrients status which will be reflected on its productivity.

The beneficial effect of certain synthetic polymers and/or natural conditioners become one of the most important particles in improving the hydrophysical properties of sandy soils as well as enhancing their productivity, De Boodt et al. (1978), Abdel Tawab (1978), El-Tokhy (1982), El-Sherif and El-Hady (1986) and Mohammad (1990).

This work was carried out to investigate the possibility of using Tafla as natural soil conditioner and polyacrylamide (PAM) as synthetic one in developing sandy soil properties as well as enhancing the productivity of this soil. Corn plant (*Zea maize*) was used as an indicator to evaluate the effect of the applied soil conditioners.

MATERIALS AND METHODS

Surface soil samples (0-30 cm) were collected from Ismailia area. Samples were air dried, crushed and passed through 2 mm sieve holes. Some soil properties were determined according to Richards (1954) and tabulated in Table (1). Polyacrylamide (PAM) as a synthetic polymer produced by ICI (Imperial Chemical Industries), molecular weight over 5 million and Tafla as a natural conditioner (supplied by Sinai Manganese Company) were used

Mineralogical, physical and chemical properties of Tafla are presented in Table (2), while x-ray diffraction pattern of the clay fraction separated from Tafla are illustrated in Fig. (1), El-Sherif and El-Hady (1986).

Greenhouse experiment:

Portions of soil, 4 kg each, were packed in plastic pots (25 cm in Φ and 20 cm in depth after being mixed with PAM at rates of 0, 0.025, 0.05 and 0.1% (w/w), or with Tafla at rates of 0, 1, 2 and 3% (w/w). Each pot received P as superphosphate at a rate of 13 mg P/kg, N as ammonium sulfate (20.5% N) at a rate of 120 mg N/kg and K as potassium sulfate at a rate of 40 mg K/kg. Each treatment was replicated three times in a randomized complete block design. Eight kernels of corn (310 three hybrid) were planted in each pot, the pots were irrigated with tap water to bring the soil water content to 70% of the field capacity. Water was added daily to maintain such moisture level. After complete germination, seedlings were thinned to uniform three plants/pot.

The plants were cut after 45 days from planting, washed, separated into shoots and roots, oven dried at 70oC for 24 hrs. Both fresh and dried weights were recorded. Plant materials were ground in a plastic mill and portions of 0.5 g was digested using a mixture of sulphuric and perchloric acids for N, P and K determinations, Jackson (1967). N was determined by the Kjeldahl method, Chapman and Pratt (1961), P was determined colorimetrically as described by Piper (1950) and K by flame photometer, Jackson (1967).

Table (1): Some physical and chemical properties of the investigated soil.

Particle size distribution					Physical properties					Chemical properties												Available nutrients (ppm)		
														Soluble cations (me/l*)				Soluble anions (me/l)*						
Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Textural Class	Field Capacity	Wilting point	Avail.. Water	Hydraulic Conductivity (cm/h)	Bulk Density (g/cm)	$CaCO_3$ (%)	Organic matter (%)	EC DS/m	CEC (me/100 g soil)	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^-	HCO_3^-	Cl^-	SO_4^{--}	N	P	K
66.01	21.33	4.53	10.13	Loamy Sand	7.09	3.05	4.04	30.53	1.75	0.40	0.13	1.35	3.29	4.22	2.33	6.35	0.78	0.00	2.13	4.42	7.13	20.30	11.19	97.0

Table (2): Mineralogical, physical and chemical analysis of Tafla.

Mineralogical composition						Particle size distribution					Chemical properties											Available nutrients (ppm)		
														Soluble cations (me/l)				Soluble anions (me/l)						
Mont menilonite (%)	Vermiculite (%)	Illite (%)	Quartz (%)	Fieldspars (%)	Interatratifield minerals (%)	Coarse sand (%)	Fine sand (%) (%)	Silt (%)	Clay (%)	Textural Class	PH	EC (dS/m tafla)	CEC (me/100 g soil)	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^-	HCO_3^-	Cl^-	SO_4^{--}	N	P	K
35.95	7.30	6.50	24.03	12.63	1.90	4.63	5.33	17.11	9.83	67.73	7.95	2.39	58.9	12.79	4.22	8.30	0.59	0.00	2.55	7.79	15.58	15.13	5.73	7.09

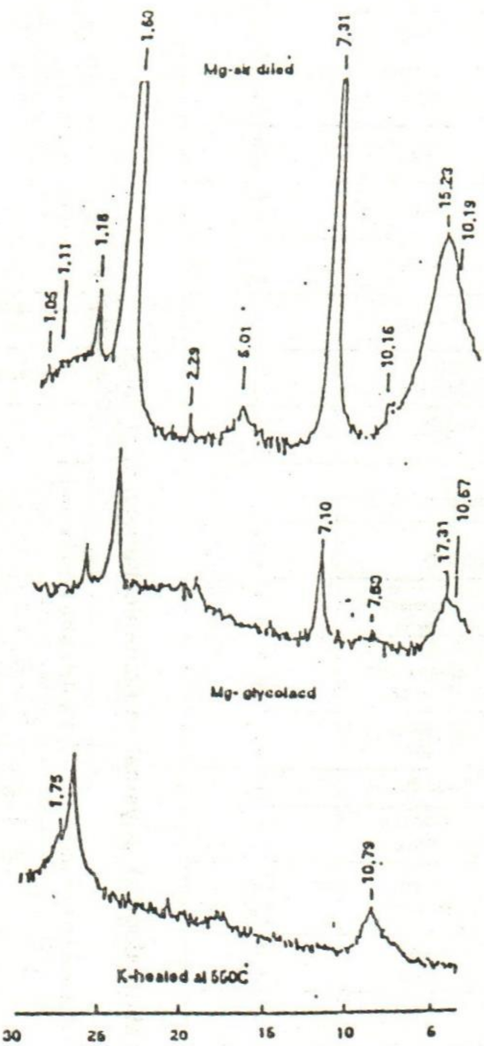

Fig (1): X-ray diffraction pattern of the clay fraction separated from Tafla

Soil analysis:

At the end of the experiment, some physical and chemical analysis were carried out as mentioned after here. Bulk density was determined for undisturbed samples as described by Richards (1954). Saturated hydraulic conductivity for the undisturbed soil samples was determined according to Klute (1982).

Total soluble salt of saturated soil extract was determined in the saturation paste extract according to Richards (1954). Cations exchange capacity (CEC) was determined according to Richards (1954). pH was determined in the soil water suspensions (1;2.5).

RESULTS AND DISCUSSION

1- Physical properties of the studied soil as affected by soil conditioners:

ha). Bulk density (BD):

Values of bulk density as influenced by PAM or Tafla are shown in Table (3). Data reveal that soil bulk density decreased as a result of applying soil conditioners. The decrease was more pronounced with increasing the rate of application. It is noticed that the studied soilwas responded by different extents to the conditioning materials, where values of bulk density averaged 1.68 and 1.67 g/cm3 for the soil treated with PAM and Tafla, respectively as compared to 1.73 g/cm3 for the control. The decrease of bulk density could be explained due to ability of the soil conditioners in improving the structure of soil through the formation of stable aggregates. This led to an increase in the avoid ratio and consequently decrease the soil bulk density. Similar explanation was suggested by Zain El-Abedin and Shawky (1974) and Fahim (1986).

Table (3): Effect of soil conditioners on some physical and chemical properties of the investigated soil.

	Rate of applied conditioner (%)	Bulk Density (g/cm3)	Hydraulic conductivity (cm/hour)	EC (dS/m-1)	CEC (me/100 g soil)
Control	0.000	1.73	30.17	1.43	3.29
PAM	0.025	1.71	29.30	1.50	3.67
	0.050	1.68	26.73	1.59	4.13
	0.100	1.66	22.51	1.65	4.80
Mean		1.68	26.18	1.58	4.20
Tafla	1	1.69	25.60	1.86	5.11
	2	1.67	21.33	1.93	5.59
	3	1.66	19.80	2.11	6.19
Mean		1.67	22.24	1.96	5.30
	Bulk density		Hydraulic conductivity		
L.S.D. 0.05	0.0237		0.5316		
L.S.D. 0.01	0.0330		0.7378		

b). Hydraulic conductivity (Ks):

Table (3) shows the effect of PAM and Tafla on Ks of the studied soil. Data reveal that Ks decreased with adding soil conditioners, specially with increasing the rat of applied PAM or Tafla. Hydraulic conductivity of the untreated sandy soil was 30.17 cm/h. It decreased for treatment with PAM to 29.30, 26.73 and 22.51 cm/h at the rates of 0.025, 0.05 and 0.10%, respectively. When Tafla was used, s decreased to 25.6, 21.33 and 19.80 cm/h at the rates of 1, 2 and 3%, respectively. These results could be attributed to the effect of PAM on blocking the wide pores between sand particles and binding this particles to form aggregates. In case of Tafla, the decrease in Ks might be attributed to the reorientation of soil particles and the partial blocking of large pathwaysdue to the probable slaking of clay particles from Tafla. Similar results were obtained by El-Tokhy (1982), Abdel-Aziz et al. (1990) and Mousa (1993).

2. Chemical properties of the studied soil as affected by soil conditioners:

a) Electrical conductivity (EC):

Table (3) shows that EC values as affected by conditioners. The EC values of the untreated soil was 1.43 dS/m. It gradually increased for treating the studied soil with PAM at the rates of 0.025, 0.05 and 0.10% to reach 1.50, 1.59 and 1.65 dS/m-1, respectively. The corresponding values when Tafla was applied at rates of 1, 2 and 3% were 1.86, 1.93 and 2.11 dS/m-1, respectively.

Table (4): Effect of soil conditioners on the fresh and dry weight of corn plants grown on sandy soil.

Treatments	Rate of applied conditioner (%)	Shoots (g/pot)		Root (g/pot)	
		Fresh weight	Dry weight	Fresh weight	Dry weight
Control	0.000	8.34	0.85	8.73	0.87
PAM	0.025	11.41	1.11	9.94	1.00
	0.050	12.11	1.20	10.71	1.09
	0.100	12.79	1.29	11.51	1.23
Mean		12.10	1.20	10.72	1.10
Tafla	1	10.31	1.06	10.23	1.05
	2	10.92	1.19	10.78	1.09
	3	11.31	1.27	11.41	1.19
Mean		10.84	1.17	10.80	1.11
L.S.D. 0.05		0.6272	0.1613	0.5175	0.0746
L.S.D. 0.01		0.8704	0.2238	0.7182	0.1036

The increase in salinity of Tafla treatment may be ascribed partially to the tendency of increasing moisture relatively at field capacity which build up soil salinity. As regard to PAM treatment, the increase in soil salinity could be related to the great ability of the hydrogel to absorb water which cause the salinity build up, Said (1994). Tafla caused higher (EC) values compared with PAM treatment. This may be attributed to the higher salt content of the Tafla material relative to the untreated soil.

Data indicated that the conditioners increased soluble ions, a trend similar to that of EC. Similar results were obtained by El-Tokhy (1982) and El-Shanawany et al. (1994).

b). Cation exchange capacity (CEC) of the soil:

Table (3) indicates that the application of conditioners increased the values of CEC from 3.29 me/100 g soil for the untreated soil to 3.67, 4 13 and 4.30 me/100 me/100 g soil as a result of applying PAM at rates of 0.025, 0.5 and 0.10%, respectively. Such increase reach 5.11, 5.59 and 6.19 me/100 g soil when Tafla was applied at rates of 1, 2 and 3%, respectively. Increasing CEC was much pronounced with Tafla than with PAM probably due to the presnence of colloidal clay materials in Tafla, especially montmorillonites which characterized by its high CEC. These results are in agreement with those obtained by El-Sebsy (1983) and Omran (1994) on PAM.

3. Plant growth and nutrient uptake as affected by soil conditioners:

a). Plant growth:

Data presented in Table (4) show the effect of applying soil conditioners on fresh and dry weights of maize shoots and roots. Both conditioners enhanced plant growth, consequently increased fresh and dry weights of shoots and roots. Such increases in fresh weight of shoots and roots were 53.4 and 31.8%, respectively in case of applying 0.10% PAM. Corresponding increases in dry weight were 51.7 and 41.3%, respectively.

When the studied soil was treated with Tafla at a rate of 3% (the highest rate) the increase in fresh weight of shoots and roots were 35.6 and 30.7%, respectively. Corresponding increases in the dry weight were 49.4 and 36.7%, respectively.

The obtained results indicate that both conditioners enhanced plant growth, while PAM being more efficient in this concern. Superiority of PAM could be attributed to the fact that the applied Tafla contains relatively higher salt content compared to PAM. Need to mention that corn is a sensitive crop to salinity and the most sensitive stage of growth to salinity is the early seedling period (Bernstein, 1974).

b). Macronutrients concentration and uptake:

Data outlined in Table (5) show the effect of conditioners on concentration and uptake of N, P and K by maize plants.

Nitrogen concentration and uptake:

Concentration of N in shoots and roots of maize plants were favorably affected by conditioning the studied soil. When the sand soil was treated with PAM at a rate of 0.1% the relative increase in N concentration reached to 18.6% in shoots and 21.5% in roots. These values when the studied soil was treated with Tafla at the rate of 3% which were 1.5 and 10.5 for shoots and roots, respectively. PAM displayed more beneficial effect on N-concentration compared to Tafla. The mean values of N-concentration due to conditioning the soil with PAM were 3.34 and 3.30 for maize shoots and roots, respectively. Corresponding values in the case of Tafla were 3.18 and

3.05%, respectively. The superiority of PAM over Tafla may be attributed to its higher content of N.

Concerning of N-uptake as affected by soil conditioners, data of Table (5) reveal that values of N-uptake in shoots and roots of maize grown on the untreated soil were 25.07 and 24.70 mg N/pot, respectively.The values of N-uptake by shoots and roots for treated sandy soil with PAM at rate of 0.025% were 35.52 and 31.60 mg N/pot, respectively. These values were increased to reach 45.15 and 42.43 mg N/pot, respectively upon treating soil with the highest rate of PAM 0.1%.

Addition of Tafla at a rate of 1% resulted in increasing the values of N-uptake in maize shoots and roots to give values at 2% Tafla treatment were 38.08 and 33.68 mg N/pot, respectively. These values increased when Tafla was applied at the highest rate (3%) to reach 41.78 and 37.36 mg N/pot for shoots and roots, respectively.

The above-mentioned results indicate that N-uptake in shoots and roots of maize plants were increased due to conditioning the sandy soil with PAM or Tafla and the increase were more obvious particularly at increasing rates of applied conditioners. PAM was more effective in increasing N-uptake. Such result is reflected by the higher plant N content compared to Tafla. Similar results were obtained by Lotfy and El-Hady (1984), Ali (1993) and Abo Srea (1994).

Phosphorus concentration and uptake:

Data presented in Table (5) reveal that P concentration in either shoots or roots remained almost constant and similar to that of the control treatment. This could be ascribed to the dilution effect since the increase uptake of P was associated with a corresponding increase in the dry matter yield.

On the other hand, values of P-uptake in the control treatment (non conditioned soil) were 1.36 and 1.21 mg P/pot for shoots and roots, respectively. Soil treated with PAM increased P-uptake. At rates of 0.025, 0.05 and 0.10% PAM, P-uptake in shoots were 1.88, 2.04 and 2.45 mg P/pot, respectively; the corresponding values in roots were 1.40, 1.52 and 1.96 mg P/pot, respectively.

Treating soil with Tafla at 1% increased P-uptake to reach 1.90 and 1.47 mg P/pot for shoots and roots, respectively. At 2% rate, P-uptake values were 2.26 and 1.47 mg P/pot, respectively. These results indicate that P-uptake was increased by the addition of Tafla or PAM and the increase was greater with increasing the rate of applied conditioner. This finding indicates the beneficial effect of these conditioners, consequently increasing plant growth. Similar results were obtained by Boutros et al. (1987) and Abo-Srea (1994) who found that PAM and Tafla increased uptake of P by corn plants.

Potassium concentration and uptake:

Data presented in Table (5) reveal that, increasing the rate of applied conditioner increased the concentrations of K in maize shoots and roots.

Tafla showed more beneficial effect on K concentration than PAM. Such trend is confirmed by the results of Abo-Srea (1994) and may be attributed to the Tafla content of K.

Data show that K-uptake was positively affected by conditioning the soil. Increasing the rate of applied PAM or Tafla was associated with increasing K-uptake by maize shoots and roots. The relative increase when soil was treated with PAM at the rate of 0.1% was 15.3 for shoots and 21.1% for roots. The corresponding value when Tafla was applied at rate of 3% was 42.8%, respectively. These results are in agreement with those obtained by Awad (1996) who reported that the addition of PAM to sandy soil increased uptake of K. Also, Abo-Srea (1994) found that addition of either PAM or Tafla to sandy soil increased uptake of K by corn plant.

As a final conclusion, physical and chemical properties of sandy soil and consequently availability and uptake of different nutrients were positively affected by addition of either PAM or Tafla. This effect was seemed to be dependent among other factors on the rate of applied conditioner as well as properties of the soil required to be conditioned.

Table (5): Effect of soil conditioners on the concentration and uptake of macronutrients in corn plants.

Treatments	Rate of applied conditioner (%)	Macronutrients											
		Nitrogen				Phosphorus				Potassium			
		Shoots		Roots		Shoots		Roots		Shoots		Roots	
		Uptake (mg/pot)	Concentration (%)	Uptake (mg/pot)	Concentration (%)	Uptake (mg/pot)	Concentration (%)	Uptake (mg/pot)	Concentration (%)	Uptake (mg/pot)	Concentration (%)	Uptake (mg/pot)	Concentration (%)
Control	0.000	25.07	2.95	24.7	2.84	1.36	0.16	1.21	0.14	16.06	1.89	15.22	1.75
PAM	0.025	35.52	3.20	31.6	3.16	1.88	0.17	1.40	0.14	26.86	2.15	21.0	2.10
	0.050	39.96	3.33	35.86	3.29	2.04	0.17	1.52	0.14	26.28	2.19	22.99	2.11
	1.100	45.15	3.50	42.43	3.45	2.45	0.19	1.96	0.16	28.38	2.20	26.07	2.12
Mean		40.21	3.34	36.63	3.30	2.12	0.17	1.62	0.14	26.17	2.18	23.35	2.11
Tafla	1	32.54	3.07	30.76	2.93	1.90	0.18	1.47	0.14	24.06	2.27	22.99	2.19
	2	38.08	3.20	33.68	3.09	2.26	0.19	1.74	0.16	29.27	2.46	26.05	2.39
	3	41.78	3.29	37.36	3.14	2.41	0.19	2.14	0.18	34.29	2.70	29.75	2.50
Mean		37.46	3.18	33.93	3.05	2.19	0.18	1.78	0.16	29.20	2.47	26.26	2.36

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تأثير محسنات التربة على خواص الأراضى الرملية – نمو النبـــات وإمتصاصـــها للعناصر

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***مركز البحوث الزراعية-الجيزة-القاهرة

إجريت تجربة أصص لدراسة تأثير المحسن التخليقى (البولى أكريل أميـــد) والمحســـن الطبيعـــى (الطفلة الممثلة لترسيبات الطين القديمة) على نمو نبات الذرة وإمتصاصه للعناصر المغذية كنتيجـــة لتحســـين الخواص الطبيعية والكيماوية للأرض الرملية التى جمعت من الاسماعيلية بشمال شرق القاهرة.

أخذ ٤ كجم من عينة أرض سطحية (٠-١٥سم) وخلطت بتجانس مع أى من البولى أكريل أميـــد (PAM) بمعدلات صفر ، ٠,٠٢٥ ، ٠,٠٥ ، ٠,١% وزنيـــة/وزنيـــة أو الطفلـــة بمعـــدلات ١ ، ٢ ، ٣% وزنية/وزنية ووضعت الوزنة فى أصيص بلاستيك قطرة ٢٥سم وعمقه ٢٠سم تلقى كل أصيص النيـــتروجين والفوسفور والبوتاسيوم بمعدل ١٢٠ مجم ن/كجم أرض ، ١٣ مجم فو/كجم أرض ، ٤٠ مجم بو/كجـــم أرض فى صورة كبريتات أمونيوم – السوبر فوسفات العادى وكبريتات البوتاسيوم على التولى ثم اســـتخدم نبـــات الذرة كدليل ونمى لمدة ٤٥ يوم. وتتلخص أهم النتائج فى الآتى:

- إنخفضت الكثافة الظاهرية نتيجة لإضافة أى من البولى أكريل أميد أو الطفلة حيث وصلـــت لأقل قيمة بإستخدام ٠,١% بولى أكريل أميد ، ٣% طفلة.
- إنخفضت قيم التوصيل الهيدروليكى بإضافة المحسنات وإزداد الإنخفاض مع زيـــادة معـــدل إضافته.
- إزدادت قيم كل من السعة التبادلية الكاتيونية والتوصيل الكهربائى بإضافة البولى أكريل أميـــد أو الطفلة إلا أن المعاملات التى أضيف إليها طفلة ارفع بها قيم التوصيل الكهربائى عن تلـــك التى عوملت بالبولى أكريل أميد.
- تأثر محتوى نبات الذرة من النيتروجين والبوتاسيوم بالمحسنات التى استخدمت فى الدراســـة بينما إزداد محتواها من الفوسفور بصورة طفيفة خاصة عند المعدلات العالية من الاضافة.
- تؤكد النتائج أن إمتصاص النيتروجين والفوسفور والبوتاسيوم بواسطة نباتات الذرة قـــد إزداد نتيجة اضافة المحسنات وتتوقف الزيادة على معدل إضافة هذه المحسنات.