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Conditioning Effect of Composts and Acrylamide Hydrogels on a Sandy Calcareous Soil. II-Physico-bio-chemical Properties of the Soil

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ABSTRACT

A complete randomized field experiment with four replications was conducted at El-Saff (Giza overnorate) Egypt, using drip irrigated tomato (*Lycopersicum esculentum*, hybrid Wady), as the indicator plant. The treatments were: 1) un-treated sandy calcareous soil. 2 and 3) soil treated with organic compost (OM) at the rates of 1 kg/plant pit (12 tons/fed.) or 2 kg/plant pit (24 tons/fed.). 4 and 5) soil treated with 2 g plant pit (24 Kg/fed. or 4 g/plant pit (48 Kg/fed.) of a mixture of the anionic hydrogel (polyacrylamide K polyacrylate gel 30% anionicity and the cationic hydrogel polyacrylamide allylamine hydrochloride gel 20% cationicity at the ratio of 2:3 (G). 6, 8 and 9) soil treated with mixtures of OM and G at the rates of 1 kgOM + 1 gG, 1 kgOM + 2 gG, 2 kgOM + 1 gG, 2 kgOM + 2 gG/plant pit, respectively. At the end of the growing season i.e. after 150 days from plantation some physical, chemical and biological properties of the soil were determined Obtained results could be summarized as follows:

1. Applied conditioners positively affect hydrophysical properties of the soil. These include, (a) improving soil structure expressed by water stable structure units > 0.25 mm in diameter and structure coefficient, dry stable structural units > 0.84 mm in diameter and wind erosion parameter indicating high resistance of the soil against both wind and water erosion and the destruction of the soil by tillage operations, (b) decreasing soil bulk density as well as macro porosity (drainage pores) on the expense of micro ones. Therefore, water holding pores were increased, (c) increasing retained moisture in the soil at all suctions under study (from 0 - 15 atmo), because the increase in water retained in the soil at field capacity is far beyond that at wilting percentage, available water was highly increased. Decreasing mean diameterof soil pores and turn its water transmitting properties namely, infiltrationrate, hydraulic conductivity and transmissivity for vertical flow of water through soil profile.
2. Soil conditioning positively effect chemical and biological properties of the soil these effects are assembled in the following: (a) slightly decreasing soil pH, (b) increasing both CEC of the soil and its specific surface area indicating an improvement in activating chemical reactions in the soil, (c) increasing OM, organic carbon, total nitrogen % in the soil, Because the increase in total nitrogen is higher than that in organic carbon, narrower C/N ratio of treated soils were obtained indicating the mineralization of organic nitrogen compounds and hence the possibility to save and provide available forms of N to growing plants, (d) increasing N, P and K in treated soil. (c) improvingthe biological activity expressed as total count of bacteria, i.e. *Azotobacter sp.*, PDB, fungi and actinomycetes/g soil and the activity of both dehydrogenase and phosphatase.
3. Mixing both types of soil conditioners together i.e. OM and G was more efficient in improving physico-bio-chemical properties of the soil than applying each of them alone Application rate of mixtures components is considered of the important factors that highly affect soil conditioning.

Key Words: Sandy calcareous soil; Composts; Acrylamide hydrogels; Soil micro-organisms; Enzymes activity

INTRODUCTION

For the urgent need to meet food and dress demands in Egypt, more desert areas either sandy or calcareous have to be put under cultivation. Such soils are poor with respect to their physico-bio-chemical properties, soil water-plant relationships as well as their nutritional status. Reclamation and land utilization of such soils are faced by several difficulties namely: low water retention and high infiltration rate, poor structure development, low humus and clay content and loss of added nutrients via leaching or deep percolation together with the problems of wind erosion and degradation. High $CaCO_3$ content in the soil cause more difficulties i.e. surface crusting and cracking, high pH and loss of fertilizer's N, low availability of nutrients particularly P and micro-nutrients (Zn, Fe, Mn & Cu) and nutritional imbalance between some elements (K & Mg) and calcium. Under such severe conditions, desired yield levels are difficult to attain. Proper management of these soils calls for specialized approaches for sustainable productivity (Balba, 1989).

Among the natural soil conditioners, which have been used in Egypt for reclamation of sandy and sandy calcareous soils are organic manures and composts. Application rates-in addition to chemical fertilization-ranged between 10 and 20 tons/fed. (Badran, 1983; Montasser, 1987; Abo sedera, 2006) Due to the shortage that occurred in the quantities of such conditioners, particularly that organic materials are usually decomposed and needed to be added more frequently, so the need for finding substitutes has been posed. Considerable attention has been paid in the last few decades to use synthesized conditioners to prevail suitable environment for planting sandy and sandy calcareous soils. Among these conditioners are super absorbent materials i.e. hydrogels. Application rates ranged between 6 and 200 kg/fed. (Tayel & El-Hady, 1981; El-Hady & Azzam, 1983; El-Hady, 1987a, b; Rasheed *et al*., 1997; El-Hady *et al*., 2002 & 2003; Wahba, 2005a, b) It is expected that applying organic materials mixed with the proper hydrogel to the soil may be more effective and economic than using each of them alone (El-Hady *et al*., 1995a, b; 2002a, b; 2003 & 2004a, b).

The present work aims to study the conditioning effect of incorporating acrylamide hydrogels or/and compost on some physico-bio-chemical properties of sandy calcareous soil. As tomato (*Lycopersican esculentum* L.) is one of the main vegetable crops that needed to be planted under the severe conditions of Egyptian deserts it was chosen as indicator plant.

MATERIALS AND METHODS

A complete randomized field experiment with four replications for each treatment with plot area (1/100 feddan) i.e. 120 plant pits was conducted on a sandy calcareous soil at El-Saff Giza governorate (Steel & Torrie, 1980). Trickle irrigated Tomato (*Lycopersicum esculentum*, hybrid Wady), was chosen as the indicator plant. This choice was for its capability to fruit setting under severe conditions of our deserts particularly drought and salinity (El-Hady *et al*., 2002). Analyses of the soil and irrigation water are presented in (Table I & II), respectively. Fine compost produced by aerobic composting of some local organic wastes i.e. town refuse, sawdust, plant residues and organic manure at the ratio of1:1:1:!, respectively and a mixture of the anionic hydrogel (polyacrylamide K polyacrylate gel 30% anionicity) and the cationic hydrogel (polyacrylamide allylamine hydrochloride gel 20% cationicity) at the ratio of 2:3, were chosen as soil conditioners. The main constituents and properties of organic compost and hydrogel used are given in (Table III & IV), respectively.

Table I. Analytical data of El-Saff sandy calcareous soil

(a) Mechanical analysis

Sand		Silt	Clay	Soil Texture
Coarse > 200 μ %	Fine 200-20 μ %	20-2 μ%	< 2 μ %	
67.5	22.8	5.0	4.7	Sandy

(b) Chemical analysis

pH 1:2.5	EC 1:5 dSm-1	CaCO3 %	CEC cmol kg-1	OM%	Macro-nutrients ppm					
					Total			Available		
					N	P	K	N	P	K
7.4	2.2	11.95	4.48	0.06	415	738	1015	32	6	55

(c) Hydrophyslcal analysis

Bulk density kg m-3	Total porosity %	Water holding capacity* %	Field capacity* %	Wilting percentage*	Hydraulic conductivity m day-1	Mean diameter of soil pores μ
1.63	38.5	22.8	7.11	1.22	7.3	16.7

*on weight basis

Table II. Analysis of irrigation water used

Source	pH	EC dSm-1	Soluble cations (meq/I)				Soluble anions (meq/I)			
			Na+	K+	Ca++	Mg++	CO3---	HCO3-	Cl-	SO4--
Well	7.05	1.35	8.3	0.2	9.0	6.5	0.02	3.6	5.9	14.6

* Adj. SAR = 7.33 ** Fe = traces < 3 ppm.

The treatments were. Treatment no 1: non-conditioned soil (mineral fertilization only). Treatments no 2 and 3: soil conditioned with 1 and 2 kg compost (OM)/plant pit (i.e. 12 & 24 tons/fed., respectively). Treatments no 4 and 5: Soil conditioned with 2 g and 4 g hydrogel (G)/plant pit (i.e. 24 & 48 kg/fed., respectively). Treatment no 6: Soil conditioned with 1 kg OM + 1 gG/plant pit i.e. 12 tons OM + 12 kg G/fed. Treatment no 7: Soil conditioned with 1 kg OM + 2 gG/plant pit i.e. 12 tons OM + 24 kg G/fed. Treatment no 8: Soil conditioned with 2 kg OM + 1 gG/plant pit i.e. 24 tons OM + 12 kg G/fed. Treatment no 9: Soil conditioned with 2 kg OM + 2 gG/plant pit i.e. 24 tons OM + 24 kg G/fed.

The conditioning effects on some physico-bio-chemical properties of the soil either conditioned (with OM or G or their mixtures) or not were determined at the end of the growing season, i.e. after 150 days from plantation as follows:

1. Physical properties. Soil physical properties were determined according to (Dewies & Freitas, 1970; loveday, 1974; El-shafei & Ragab, 1976; El-Hady & El-sherif, 1988). The studied parameters are:

(a). Water stable structural units > 0.25 mm in diameter and structure coefficient.

(b). Dry stable structural units > 0.84 mm in diameter and wind erosion parameter.

(c). Soil bulk density, total porosity and pore size distribution.

(d). Moisture retention at different tensions and available moisture.

(e). Infiltration rate, hydraulic conductivity, mean diameter of soil pores and transmissivity for vertical flow of water through the soil profile.

(f). Adjusted evaporation.

(g). Surface area was estimated colorimetrically using

Table III. Some chemical properties of applied compost

pH (H_2O)			**7.32**
Salinity: EC dS m-1			1.3
Na+ %			0.02
Moisture: %			4.11
Mineral content	(ash %)		28.80
Organic component:	O.M %		67.09
	O.C %		38.91
	O. N %		2.09
	C:N		18.62
Macro elements:	NH4+NO3 %		0.02
	P2O5 %		0.38
	K2O %		0.48
Secondary elements	Ca2+ %		1.12
	Mg2+ %		0.36
Micro elements:	Fe	ppm	116.0
	Mn	ppm	51.0
	Zn	Ppm	45.0
	Cu	Ppm	12.5
Heavy metals:	Cd	ppm	0.40
	Co	Ppm	0.60
	Ni	Ppm	2.02
CEC	cmol kg-1		135

Table IV. Description of the main constituents and properties of hydrogels used

A. Main constituents ionicity	**Anionic**	**Cationic**
Active substance	Propeneamide propionic acid Co-polymer (K-salt)	Propeneamide Allylamine Co-polymer (Cl-salt)
Ionization degree	30 mole%	20 mole%
Cross linker	Divalent vinyl monomer	
Cross-inking ratio	1: 10-4 mole/mole	
Percentage of active substance	Greater than 88%	
Monomer content	Not higher than 300 ppm	
B. Properties:		
Appearance	white to slightly yellow grains	
Grain size	0.25-1 mm	
Bulk density	= 600 kg/m3	
Solubility	Insoluble in water and organic solvents	
PH 0.1% in distilled water	7.0±0.5	
CEC cmol kg-1	2045	2175
C. Absorption capacity in g/g hydrogel		
Deionized water	= 525	= 430
0.9% NaCl	= 44	= 35
0.4% CaCl2	= 41	= 36
Saline water (1500 ppm)	= 64	= 54
Absorption fime: Up to 50% Total absorption	Minutes 60 minutes	

orthophenanthroline adsorption method (Lowrie, 1961).

2. Chemical properties. The following determinations were carried out according to (Cottenie *et al*., 1982).

(a). Soil pH was determined in 1:2.5 soil water suspension.

(b). Electrical conductivity (dSm^{-1}) of the soil paste extract.

(c). Organic matter content.

(d). Cation Exchange capacity.

(e). Total, organic and available N.

(f). Total and available P.

(g). Total and available K.

3. Biological Properties

A. Microbial parameters. (a). Total bacterial count was determined using nutrient agar medium (Difco, 1966).

(b). Azotobacter count was determined using Ashby's medium (Allen, 1953).

(c). Phosphate dissolving bacteria count (PDB) was determined using (Bunt & Rovira, 1955) modified by Abd-El. Hafez (1966).

(d). Actinomycetes count were determined using glycerol nitrate agar medium (Szabo, 1974).

(e). Total fungal count was determined using Martins medium as described by (Marten, 1950).

B. Enzymatic activity. (a). Dehydrogenase enzymes were determined after (Skujins, 1973).

(b). Phosphatase enzymes were determined after (Katai *et al*., 1986).

RESULTS AND DISCUSSION

The conditioning effect of either compost (OM) or hydrogel (G) or their mixtures on some physico-bio-chemical properties of sandy calcareous soil was estimated at the end of the growing season (after 150 days from plantation).

Effect on hydrophysical properties. Some hydro physical properties of the soil i.e. structure stability, porosity and pore size distribution, moisture retention and transmissivity as influenced by conditioning the soil with compost or acrylamide hydrogel or their mixture are presented in Table V. Wet sieve analysis was used to determine the % of water stable fraction > 0.25 mm in diameter and this fraction was taken as a reflection of soil aggregate stability (El-Hady & El-Sherif, 1988). Data show that addition of either OM or examined G resulted in an increase in this fraction being higher with increasing the application rate of applied conditioners. Moreover 2 g/plant pit of examined G seems to be more effective in improving this property than that of 2 kg/plant pit OM. In other words, while incorporating 2 kg OM in the plant pit increased the percentage of water stable structural units > 0.25 mm in diameter by 40.2%, the increase in this fraction due to the addition of examined hydrogel was 99.1% i.e. about 2.5 times that of the higher application rate of OM. Incorporating both OM and hydrogel together into sandy soil was more efficient than applying each of them alone. Water stable structural units > 0.25 mm in diameter were about 1.7, 2.3, 1.8 and 2.5 times from that of un-treated soil by treating the plant pit with 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM +2 gG, respectively. In order to find out the aggregating capacity and to compare quantitatively between the different treatments, structure coefficient (Cr) the ratio of the percentage of the total amount of fractions greater than 0.25 mm in diameter to the percentage of fraction having the diameter less than 0.25 mm as suggested by El-Shafei and Ragab (1976), was calculated. Values of calculated (Cr) reveal a marked increase in (Cr) as a result of applying

Table V. Effect of compost and/or acrylamide hydrogel on some hydro physical properties of the soil

No. of treatment	Treatments Conditioner Used	Application rate /plant pit (Kg) compost	(g) Gel.	Water stable structural units >0.25mm (%)	Structure coefficient (Cr)	Dry stable structural units >0.84mm (%)	Wind erosion parameter	Bulk density kg m^{-3}	Total porosity %	Macro-pores (drainable pores >28.8μ)	Micro-pores (<28.8μ) Water holding pores (28.8-0.19μ)	Micro-pores (<28.8μ) Fine capillary pores (<0.19μ)	Micro: macro
1	Untreated	-	-	18.16	0.222	11.8	1.0	1.613	39.13	29.32	7.65	2.16	0.33
2	Compost	1	-	21.35	0.271	20.6	0.573	1.592	39.92	27.15	10.48	2.24	0.47
3	Compost	2	-	25.46	0.342	25.4	0.465	1.579	40.42	25.96	12.53	2.29	0.57
4	Hydrogel	-	2	36.16	0.566	32.8	0.360	1.556	41.28	22.11	16.81	2.36	0.87
5	Hydrogel	-	4	45.76	0.844	46.9	0.252	1.543	41.77	20.56	18.8	2.41	1.03
6	Compost+Hydrogel	1	1	31.18	0.453	28.1	0.420	1.529	42.30	25.76	14.1	2.44	0.64
7	Compost+Hydrogel	1	2	42.36	0.735	36.7	0.322	1.524	42.49	24.01	16.03	2.46	0.77
8	Compost+Hydrogel	2	1	33.22	0.497	33.6	0.351	1.516	42.79	24.33	15.99	2.47	0.76
9	Compost +Hydogel	2	2	45.81	0.845	45.2	0.261	1.488	43.85	23.42	17.92	2.51	0.87

No. of treatment	Treatments Conditioner Used	Application rate /plant pite (Kg) compost	(g) Gel.	Water holding capacity (WHC)*%	Filed capacity (FC)*%	Wilting percentage(WP)*	Available moisture* %	Infiltration rate (of air dry soil) cm.h^{-1}	Hydraulic cconductivity (m.day^{-1})	Mean diameter of soil pores (μ)	Transmissivity (ΣK/D) day^{-1}	Adjusted evaporation (E adj.)
1	Untreated	-	-	22.96	6.08	1.34	4.74	70.6	10.20	19.7	97.14	1.00
2	Compost	1	-	24.18	8.00	1.42	6.58	45.2	7.18	16.6	77.01	0.896
3	Compost	2	-	25.09	9.39	1.45	7.94	41.3	6.95	16.3	75.47	0.802
4	Hydrogel	-	2	26.36	12.32	1.69	10.63	36.5	5.01	13.8	62.54	0.611
5	Hydrogel	-	4	27.0	13.75	1.56	12.19	35.2	4.32	12.8	57.94	0.533
6	Compost+Hydrogel	1	1	25.44	10.82	1.60	9.22	39.4	5.76	14.8	67.54	0.707
7	Compost+Hydrogel	1	2	26.05	12.13	1.61	10.52	37.2	4.81	13.5	61.21	0.682
8	Compost+Hydrogel	2	1	26.69	12.18	1.63	10.55	38.6	5.22	14.1	63.94	0.679
9	Compost+Hydrogel	2	2	27.86	13.73	1.69	12.04	37.0	4.53	13.1	59.34	0.643

*On dry weight basis.

either OM or G or both together. Using 1 Kg and 2 Kg O.M/plant pit raised this index to 1.22 and 1.54 times that of the control. With regard to Gel treatments, Cr values were 2.55 and 3.8 times as that of the un-treated sandy soil by mixing the plant pit with 2 g and 4 gG, respectively. Applying the two techniques together for sandy calcareous soil conditioning raised the (Cr)values to be 2.0, 3.3, 2.2 and 3.8 times that of un-treated soil with the mixtures of 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG/plant pit in sequence. It is well known that the higher this index is the more stable is the soil structure.

Dry stable structure units > 0.84 mm in diameter are used as criteria to evaluate soil mechanical stability and the resistance of the structural units of sandy soil against breakdown by tillage or by wind erosion (El-Hady, 1984). Under the conditions of the research the increase in dry stable structural units > 0.84 mm in diameter were 178 and 297% with 1 g and 2 gG versus 75 and 115% with 1 kg and 2 kg OM/plant pit, respectively. Mixing OM with G raised the percentages of dry stable structural units > 0.84 mm in diameter to be 138, 211, 185 and 283% by applying 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG, respectively. In all cases, the improvement in this property was much higher than that obtained by applying the higher rate of OM, i.e. 2 kg/plant pit. Wind erosion parameter was calculated as the ratio between the percentages of the structural units > 0.84 mm in diameter of the un-treated soil and these of treated ones (Table V). The lower the calculated parameter is the more stable is the soil (El-Hady & El-Sherif, 1988). Incorporating 2 kg OM in the plant pit reduced this parameter by 53.5%, while the reduction was 64.0 and 74.8% with 2 g and 4 gG, respectively. Moreover, wind erosion parameters of sandy calcareous soil treated with mixtures of OM and G were lower than that of un-treated soil by 58, 68, 65 and 74% for the treatments 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 Kg OM + 1 gG and 2 Kg OM + 2 gG/plant pit, respectively.

Values of soil bulk density, soil porosity and macro and micro-porosity influenced by treating the soil with OM or/and G as illustrated in Table V reveal that soil conditioning decrease the bulk density of the soil as well as the macro-porosity (drainable pores having the diameter of > 28.8 μ) relative to those of un-treated soil. This decrease was calculated to be 1.3 and 2.1% for the bulk density and 7.4 and 11.5% for the macro porosity due to the application of 1 kg and 2 kg OM/plant pit, respectively. It is of interest to mention that the macro porosity was taken as the air filled porosity when the soil water system was in equilibrium with 100 cm suction (Loveday, 1974). Relevant values were 3.5 and 4.3% for the bulk density and 24.6 and 29.9% for the macro porosity when 2 g and 4 gG/plant pit, respectively applied. In regard to the effect of added conditioners on total porosity and micro porosity specially those, which hold available moisture to plants (i.e. water holding pores having the diameters of 28.8 - 0.19 μ), the data took an opposite trend to that of bulk density and macro porosity. On other words, the increase relative to those of the control that reached 2.0 and 3.3% in total porosity and 37.0 and 63.8% in water holding pores were obtained in soil when conditioned with 1 kg and 2 kg OM/plant pit, respectively.

This increase was 5.5 and 6.7% and 119.7 and 145.8% by treating the plant pit with 2 g and 4 gG, in sequence. The ratio between micro and macro pores is of great importance in revealing the rate of water retention and water movement in the soil. It is interesting to note that addition of both types of soil conditioners to the sandy calcareous soil beneficially modify this ratio. While micro: macro porosity in the un-treated soil was 0.33:1, it increased by soil conditioning to be 0.47:1 and 0.57:1 due to the addition 1 kg and 2 kg OM/plant pit, respectively and reached about 1:1 by conditioning with 4 gG to each plant pit, which indicating slow water movement and more water retention in the soil as will be presented later. Data of the combined effect of both OM and G when mixed together before addition to the soil on the aforementioned parameters, show also the decrease in bulk density and percentage of macro pores of the treated soil. It seems that mixing OM with G is more effective than applying each of them alone. The decrease in bulk density of the soil relative to that of the control treatment were 5.2, 5.5, 6.0 and 7.7% with 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG/plant pit, respectively. Similarly, the decrease in the percentages of macro pores due to the application of mixtures of OM and G were calculated to be 12.1, 18.1, 17.0 and 20.1% for the mixtures mentioned above, in sequence. On the other hand, total porosity and water holding porosity showed higher values by incorporating mixtures of OM and G in sandy calcareous soil. While applying 2 kg OM alone/plant pit increased total porosity and water holding porosity by only 3.3 and 63.8%, respectively conditioning the studied soil with only 1 kg OM + 1 gG increased soil porosity by 8.1% and soil water holding pores by 84.3%. Increasing applied OM to be 2 kg and mixed with 1 gG showed no considerable reduction in soil bulk density and macro porosity and in turn a corresponding increase in the percentages of total porosity and water holding pores indicating that the lowest rate of OM (i.e. 1 kg), may be sufficient for improving such soil properties when mixed with hydrogels. More increase in applied G to be 2 g greatly improved pore size distribution of treated soils towards high moisture retention and lower loss of water from the soil by leaching or deep percolation. This could be indicated by the modification of micro: macro porosity. Incorporating 2 kg OM mixed with 2 gG in the soil increased this ratio to be ~ 3 times that of the control treatment.

Retained moisture in the soil under different suctions as influenced by soil conditioning is shown in Table V. Data in hand refer to an increase in the percentages of retained moisture at all suctions under study due to soil conditioning being higher with increasing the application rate of either OM or G or both. At saturation (i.e. at pF = 0), the total water holding capacity (WHC) of the soil was increased by 5.3 and 9.3%, when incorporating 1 kg and 2 kg OM in the plant pit, respectively. Applying G to sandy calcareous soil increased also its WHC by 14.8 and 17.6% when 2 g and 4 gG was incorporated into the plant pit, respectively. Moreover, WHC of the soil was increased by 10.8 and 13.5% if 1 kg OM was mixed with 1 and 2 gG, in sequence. More increase in retained moisture at saturation was obtained by doubling the application rate of OM to be 2 kg/plant pit mixed with hydrogel. Under such conditions WHC values of the soil were 116.2 and 121.3% that of the un-treated soil with 1 and 2 gG, respectively. At field capacity (FC), i.e. at pF = 2.0 values of retained moisture show increases of 31.6 and 54.4% relative to that of the control by applying the same levels of OM mentioned above (i.e. 1 kg & 2 kg/plant pit, respectively). Conditioning the soil with hydrogels also raised the amounts of moisture retained into the soil at its field capacity over that of the un-treated soil by 102.6 and 126.2% for 2 and 4 gG/plant pit in sequence. Conditioning the soil with mixture of OM and G, increased also the amounts of moisture retained into the soil at its FC to be 1.78, 2.00, 2.01 and 2.26 times that of the control treatment by treating the soil with 1 kg OM + 1 gG; 1 Kg OM + 2 gG; 2 Kg OM + 1 gG and 2 kg OM + 2 gG, in sequence. Since the increase in water retained at FC is far beyond that at wilting percentage (WP) i.e. at pF = 4.2, the available water (FC-WP) increased, So incorporating 1 kg and 2 kg OM/plant pit raised available moisture to be 1.39 and 1.68 times that of un-treated soil, respectively. Moreover, applying 2 g and 4 gG/plant pit increased available moisture to be 2.24 and 2.57 times, respectively compared to control treatment. Regarding the effect of OM and G mixtures on the available water, applying 1 kg OM mixed with 1 g of the hydrogel/plant pit increased soil available water, to be 1.95 times that of un-treated control, respectively. The increase in available water over that of the control treatment due to treating the soil with 1 kg OM mixed with 2 g of the aforementioned G was 122%. Moreover, available water of sandy soil treated with 2 kg OM mixed with 1 and 2 gG/plant pit reached 2.23 and 2.54 times that of un-treated soil, respectively.

Data presented in Table V show also that conditioning the soil with either OM or G decreased the values of some water transmitting properties. Moreover, the combined effect of incorporating both OM and G together into studied soil was clear, where the values of these properties were much lower. In this regard the decrease in water transmitting properties of the soil under study due to the addition of 2 kg OM/the plant pit reached 41.5%, 31.9%, 17.3%, 22.3% and 19.8% that of un-treated control soil for the infiltration rate, hydraulic conductivity, mean diameter of soil pores, transmissivity for vertical flow of water and adjusted evaporation, respectively. With 4 gG/plant pit the decrease amounted to 50.1%, 57.6%, 35.0%, 40.4% and 46.7% that of un-treated control soil for the aforementioned properties, in sequence. The combined effect of the application of both techniques mixture for conditioning calcareous sandy soil, i.e. compost mixed with acrylamide hydrogel is more effective than using each of them alone. Incorporating 1 Kg OM mixed with 1 g of the examined G reduced the water transmitting properties of the soil under study by 44.2% for the infiltration rate, 43.5% for the hydraulic conductivity, 24.9% for the mean diameter of soil pores; 30.5% for the transmissivity for vertical flow of water through the soil profile and 29.3% for adjusted evaporation compared to control. Doubling the application rate of OM to be 2 kg mixed with only 1 g of G/plant pit caused more reduction in the studied parameters to reach 54.7%, 51.2%, 71.6%, 65.8% and 67.9% that of un-treated soil for the properties mentioned above, respectively. More decrease in the values of the studied parameters was obtained by raising the application rate of the mixture of both components, to be 2 gG and 2 kg OM/plant pit. Under these conditions, values of the studied properties were ~ 0.5 that of untreated soil for the soil infiltration rate and its hydraulic conductivity and 0.6 - 0.7 that of un-treated soil for the other properties.

Effect on chemical properties. Data presented in Table VI reveal that, some chemical properties of the studied soil were improved by varying degrees due to soil conditioning with OM and/or G.

Regarding soil pH, all examined conditioning treatments slightly decreased the pH values of the soil. The decrease in soil pH was calculated to be 0.35 and 0.39 units by applying 1 kg and 2 kg OM/plant pit, respectively. Using 2 g and 4 gG/plant pit as soil conditioner lowered soil pH by 0.45 and 0.48 units, respectively. By treating the soil with mixture of both conditioners, the decrease in soil pH was calculated to be 0.44, 0.46, 0.45 and 0.49 unit for treatments of 1 kg OM +1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG/plant pit, respectively.

One of the important limitations of soil fertility is its low CEC and subsequently its low specific surface area since many soil properties such as adsorption of water, nutrients and the attraction forces between particles are all surface phenomenon. Treating the soil with OM raises such parameters. Using 1 kg OM/plant pit as a soil conditioner raised its CEC or specific surface area by 47.7 or 38.7%. Such increase due to doubling the application rate of OM to be 2 kg/plant pit was 88.2 or 66.5% compared to control. On the other hand, CEC or specific surface area of treated soil G were, 1.8 and 2.1 times or 1.75 and 1.94 times that of the control treatment with 2 and 4 gG/plant pit, respectively. By incorporating mixtures of OM and G into the soil, the increase in both parameters in sequence were 67.3 and 60.6% with 1 kg OM + 1 gG; 99.0 and 70.5% with 1 kg OM + 2 gG; 170.5 and 106.1% with 2 kg OM + 1 gG and 192.6 and 118.0% with 2 kg OM + 2 gG/plant pit. It seems that CEC and surface area of treated soils coincide with the CEC of applied conditioners and their application rates.

With respect to soil organic matter % and accordingly its organic carbon content, treating the soil with compost raises both soil parameters being higher with the rate of applied conditioner. In other words, using 1 kg and 2 kg OM/plant pit increased organic matter and organic carbon content of the soil to be 4.1 and 8.3 times that of un-treated soil, respectively. On the other hand, organic matter and organic carbon contents of treated soil with 2 g or 4 gG/plant pit were 3.6 or 4.6 times that of the control treatment, respectively. By adding mixtures of OM and G to the soil, the increase in its organic matter and organic carbon contents over that of the control treatment were 373% with 1 kg OM + 1 gG, 427% with 1 kg OM + 2 gG; 764% with 2 kg OM + 1 gG and 800 % with 2 kg OM + 2 gG.

Similarly, total nitrogen and organic nitrogen content took the same trend of organic matter % and organic carbon contents. Compared with the control treatment values of total N were highly increased to be 9.5 and 14.5 times with 1 kg and 2 kg OM/plant pit and 6.7 and 8.7 times with 2 and 4 g of the applied hydrogel to the plant pit, respectively. Relevant values for organic N were 26.2 and 40.9 times and 17.5 and 23.0 times, in sequence. Increases in total N due to applying mixtures of OM and G to the plant pit were 745% with 1 kg OM + 1 gG, 863% with 1 kg OM + 2 gG, 1361% with 2 kg OM + 1 gG and 1471% with 2 kg OM + 2 gG. Furthermore, increases in organic nitrogen over that of un-treated soil arranged in the same manner were 2120%, 2440%, 3971% and 4275%, respectively. Because the increase in organic carbon is far beyond that of total nitrogen, carbon nitrogen ratios are much more narrower. C: N ratio of un-treated sandy soil was 10.36:1 it decreased to be 6.44:1 and 5.89:1 by treating the plant pit with 1 kg and 2 kg OM, respectively. By treating the plant pit with 2 g and 4 gG, values of C: N ratio were 5.58:1 and 5.47:1, respectively. Using mixtures of compost and hydrogels decreased C: N ratio to be 5.76:1, 5.63:1, 6.08:1 and 5.90:1 with mixtures of 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG, respectively. Such decrease in C: N ratio could be referred to the mineralization of organic nitrogen compounds and the possibility to save and provide available forms of N to growing plants.

It is well known that availability of nutrients in sandy soil is low. Under the conditions of conducted experiment and although fertilization is the same as that of other treatments, available N, P and K were 41.8, 26.4 and 201.6 mg/kg soil, respectively that refer to poor nutritional status of the soil. Considerable increase in the availability of studied nutrients was noticed due to soil conditioning. Using 1 kg/plant pit OM as a conditioner raised its nutrients availability by 38.5%, 132.2% and 105.9% for N, P and K, respectively. Doubling the application rate of OM to be 2 kg/plant pit raised the availability of the three nutrients to be 169.1, 286.4 and 295.7% that of un-treated soil, respectively. Applying the two rates of G for soil conditioning (i.e. 2 & 4 gG/plant pit), increase the availability of the aforementioned nutrients to be 50.7 and 84.4% for N, 112.9 and 174.2% for P and 43.1 and 56.8% for K, consequently over control. Availability of studied nutrients are much higher by applying the two types of soil conditioners together than that due to addition of each of them alone. Compared with un-treated soil, the combined effect of both types of soil conditioners raised the

Table VI. Effect of compost and /or acyrlamide hydrogel on some chemical properties of the soil

No. of Treatment	Treatment Conditioner used	Application rate/ plant pit Compost (kg)	Gel. (g)	pH 1:2.5 H_2O	OM%	CEC c mol kg^{-1}	Specific surface area m^2/g	Available Macronutrients N (mg/kg soil) NH_4^+	NO_3^+	NH_4^+ NO_3^-	P g/kg soil	K g/kg soil	Total N ($\mu g.g^{-1}$)	Organic C (μgg^{-1})
1	Untreated	-	-	7.75	0.11	4.84	10.09	14.2	27.6	41.8	26.4	201.6	62	638
2	Compost	1	-	7.40	0.45	7.15	13.99	18.6	39.3	57.9	61.3	415.1	588	2610
3	Compost	2	-	7.36	0.91	9.11	16.80	20.1	50.6	70.7	75.6	596.2	896	5278
4	Hydrogel	-	2	7.30	0.40	8.75	17.7	16.6	46.4	63.0	56.2	288.4	416	2320
5	Hydrogel	-	4	7.27	0.51	10.18	19.6	17.9	59.2	77.1	72.4	316.2	541	2958
6	Compost+Hydrogel	1	1	7.31	0.52	8.10	16.2	19.4	56.1	75.5	67.3	451.1	524	3016
7	Compost + Hydrogel	1	2	7.29	0.58	9.63	17.2	22.6	61.3	83.9	71.7	466.3	597	3364
8	Compost + Hydrogel	2	1	7.30	0.95	13.09	20.8	20.1	63.6	83.7	79.2	610.9	906	5510
9	Compost + Hydrogel	2	2	7.26	0.99	14.16	22.0	23.0	67.2	90.2	84.1	672.3	974	5742

Table VII. Effect of compost and /or acyrlamide hydrogel on some biological properties of the soil

No. of Treatment	Treatment Conditioner used	Application rate/plant pit compost (kg)	Gel. (g)	Total Bacterial count x 10^6	Azotobacter x 10^4	Phosphate dissolving bacteria x 10^4	Total Fungi x 10^4	Actinomycetes x 10^4	Activity of dehydrogenaseenzymes*	Activity of Phosphaas enzymese**
1	Untreated	-	-	150	20.1	15.3	19.3	18.2	5.1	20.1
2	Compost	1	-	480	28.4	40.1	28.1	28.3	29.3	35.4
3	Compost	2	-	510	32.1	48.4	30.2	29.1	39.6	45.5
4	Hydrogel\	-	2	320	25.1	29.1	22.1	21.1	18.5	29.4
5	Hydrogel	-	4	360	27.3	30.4	25.2	28.2	19.9	35.1
6	Compost +hydrogel	1	1	590	35.4	45.2	31.2	32.2	39.5	40.9
7	Compost +hydrogel	1	2	610	39.2	48.6	32.5	33.4	40.4	55.1
8	Compost +hydrogel	2	1	750	42.4	55.1	39.4	40.2	43.5	58.6
9	Compost +hydrogel	2	2	905	49.1	60.4	42.2	45.3	48.5	60.4

*ml H_2/g dry soil /24 h

* * mg P_2O_5 /100g soil /24 h

availability of studied nutrients to be 1.81, 2.01, 2.00 and 2.16 folds for N, 2.55, 2.72, 3.00 and 3.19 folds for P and 2.24, 2.31, 3.03 and 3.33 folds for K, using 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG, respectively.

Effect on biological properties. Data presented in Table VII reveal that some biological properties of the studied soil were improved by varying degrees due to soil conditioning with OM and/or G.

Microorganisms such as bacteria, fungi and actinomycetes influence profoundly the physical, chemical and especially the biological properties of soils. Activities of such organisms include the decomposition of plant residues and other organic materials and the formation of humus, the most chemically and physically active group of compounds in the soil. One result of these processes of decay is the release- from organic forms- of essential plant nutrients, such as nitrogen, phosphorus and sulfur. Subsequently still other micro-organisms can oxidize, reduce and otherwise changes the state of the nutrient elements in the soil. These changes have profound influence on plant growth and otherwise affect soil properties in addition to the role of organic fertilizers as amendement for improving physical and chemical characteristics of the soil, which in turn reflected on rhizosphere microflora; plant growth and yield (Brady, 1990; Abo-sedera, 2006). As increasing the low number of micro-organisms mentioned above i.e. bacteria, fungi and *actinomycetes* in sandy soil indicates an improvement in its biological fertility, data presented in Table VII refer to such improvement due to soil conditioning with OM or G or their mixtures. While applying 1 kg OM to the plant pit increased the number of total bacteria, *Azotobacter sp.*, phosphate dissolving bacteria (PDB), fungi and actinomycetes by 220, 41, 162, 46 and 56% in sequence, such increase were 240, 60, 216, 57 and 60%, respectively when the rate of OM was doubled to be 2 kg/plant pit. Regarding hydrogels, 2 g of examined polymer increased the aforementioned numbers by 113% for bacteria 25% for *Azotobacter sp.*, 90% for PDB, 15% for fungi and 16% for actinomycetes. Values for 4 gG/plant pit arranged in the same manner were 140, 36, 99, 31 and 55%, respectively. By incorporating both conditioners into the plant pit, total bacterial count were 393, 407, 500 and 603% that of un-treated sandy soil using 1 kg OM + 1 gG, 1 kg OM + 2 gG; 2 kg OM + 1 gG and 2 kg OM + 2 gG, respectively. Relevant values were 176, 195, 211 and 244%, for *Azotobacter sp.*, 295, 318, 360 and 395% for PDB, 162, 169, 204 and 219% for fungi and 177, 185, 221 and 250%, for Actinomycetes in sequence.

Since most of the biological reactions in the soil are enzymatic changes, enzymes activity could be considered as another parameters to characterize the biological activity of the soil. With this respect both dehydrogenase and phosphatase activities were essayed. Data indicate the increase in the activity of both enzymes by soil conditioning. Regarding OM, applying 1 kg of this conditioner to the plant pit, raised the biological activity of soil enzymes by 475% for dehydrogenase and 76% for phsophatase. More increase in enzymes activity was obtained, when higher rate of OM (2 kg/plant pit) was added to be 776% and 226% relative to that of un-treated soil for both enzymes, respectively. Conditioning the soil with hydrogels increased also enzymes activity in the soil but with lower degree. Increases in enzymes activity due to applying 2 and 4 gG/plant pit were 263 and 291% for dehydrogenase and 46 and 74% for phosphatase, in sequence. Using both conditioners together, activity of dehdyrogenase were higher than that of un-treated sandy soil by 675, 692, 753 and 851% when applying 1 kg OM + 1 gG, 1 kg OM + 2 gG, 2 kg OM + 1 gG and 2 kg OM + 2 gG, respectively. The same could be noticed for phosphatase. Its activity were 204, 274, 292 and 300% that of un-treated soil for the aforementioned soil treatments, respectively. Similar results were previously obtained (Fortun *et al*., 1997; Crecchio *et al*., 2004).

Comparing the conditioning effect of applied OM and G, it is obvious that soil hydrophysical properties related to soil structuralization and stabilization, water preservation and water movement were greatly improved using 4 gG/plant pit much more better, than that when applying even 2 kg OM/plant pit. On the other hand and with some exceptions, the effect of 1 kg OM/plant pit on some chemical properties of the soil such as organic matter %, organic carbon content and C: N are more or less the same as that in the case of applying 4 gG/plant pit. Moreover, incorporating 4 gG in the soil was more effective than that of 2 kg OM/plant pit for soil's pH, specific surface area and CEC. Really, using organic composts as conditioners for the soil greatly improve its biological activity. The improvement in both enzymes activity and micro-organisms count due to applying 1 kg OM/plant pit was more sensible than that with, 4 gG/plant pit, As expected, incorporating OM mixed with G in the plant pits was more effective than using each of them alone. The combined and interacted effects of applying both technologies for soil conditioning together on hydro-physical, chemical and biological properties of the soil were practically proved. The beneficial effect of mixing 1 kg OM with 1 gG on all the studied hydrophysical properties of the soil and most of its chemical and biological properties has exceeded that of 2 kg OM or 2 gG if each of them was solely applied to the plant pit. Although mixing 2 kg OM with 4 gG cause better improvement in soil properties, the higher moisture retention in the treated soil over the needs of the growing plants and its adverse effects on the aeration of the root zone-as a result of increasing soil micro-porosity on the expense of its macro-ones may explain, why the yield and both water and fertilizers use efficiency by growing plants did not change by an increased amount of applied conditioners. Therefore, 1 kg OM mixed with 2 gG seems to be the recommended dose to get use of the benefits of both types of soil conditioners without adverse effects on growth, water and fertilizer use efficiency by plants. Previous studies come to similar conclusions (El-Hady *et al.*, 1995a, 2000b, 2002, 2003 & 2004a; El-Hady & El-Dewainy, 2006). Moreover, using mixtures of anionic and cationic hydrogels is preferable for decreasing the loss of plant nutrients either anions (NO_3^- & $H_2PO_4^-$) or cations (NH_4^+ & K^+) by leaching and deep percolation and in the same time to improve the retaintivity of conditioned soils for these nutrients and keep them in available forms for growing plants. (El-Hady *et al*., 2001) The fast decomposition of OM if compared with the slow one of hydrogels and the need for frequent additions of OM must be considered.

Due to the effect of salinity on decreasing the efficiency of hydrogels, (El-Hady, 1993; El-Hady & Abd El-Hady, 1997) it is recommended to apply diluted fertilizer solutions to growing plants through the irrigation system. Organic materials to be mixed with hydrogels must be free of salts if possible. The lower the salt content of treated soil and irrigation water is the higher is the efficiency of applied hydrogel.

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