

The conditioning effect of composts (natural) or / and acrylamide hydrogels (synthesized) on a sandy calcareous soil

1. Growth response, nutrients uptake and water and fertilizers use efficiency by tomato plants.

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Abstract: A two successive years (2003 and 2004) completely randomized field experiment with trickle irrigated tomatoes (*Lycopersicon esculentum*, hybrid Wady) as the indicator plant was conducted on a sandy calcareous soil at El-Saff area, Giza governorate, Egypt, to study the conditioning effect of hydrogels when mixed with organic composts on the growth response, production, nutrients uptake and water and fertilizers use efficiency by the plants. Examined treatments were:- (1) untreated soil, (2 and 3) soil treated with 1 and 2 kg compost (OM)/plant pit, (4 and 5) soil treated with 2g and 4g of a mixture of anionic and cationic polyacrylamide hydrogels (G)/plant pit and (6,7,8, and 9) soil treated with 1 kg OM + 1 g G; 1 kg OM + 2 g G, 2 kg OM + 1 g G and 2 kg OM + 2 g G/plant pit, respectively. Examined conditioners significantly increased the fresh and the dry weights; N, P and K uptake, marketable yield and water and fertilizers use efficiency by the plants. The beneficial effects of mixtures of OM and G exceed that of each conditioner when solely added. Under the conditions of the present study, applying 1 kg OM + 2g G to the plant pit (12 tons OM + 24 kg G/ fed*.) seems to be suitable to get use of the benefits of both types of soil conditioners without adverse effects on the production. * 1 fed. = 4200m²

Key words: composts, acrylamide hydrogels, sandy calcareous soil, nutrients uptake, water use efficiency, fertilizers use efficiency, tomato.

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 humus and clay content and loss of added nutrients via leaching or deep percolation together with the problems of wind erosion and degradation. High CaCO₃ content in the soil cause more difficulties. Of these are: surface crusting and cracking, high pH and loss of fertilizers N, low availability of nutrients particularly P and micro-nutrients (Zn, Fe, Mn and Cu) and nutritional imbalance between some elements (K and 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⁽⁴⁾.

Of the natural soil conditioners which have been used in Egypt for reclaiming sandy and sandy calcareous soils are organic manures and composts. Application rates in addition to chemical fertilization ranged between 10 and 20 tons/fed.^(3,18 and 20). 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, the problem of finding substitutes has been posed. Considerable attention has been paid in the last few decades to use synthesized conditioners to avail 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.^(7,8,16,9,19).

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.^(1,12,15,13).

The present work aims to study the conditioning effect of incorporating acrylamide hydrogels or/and composts in a sandy calcareous soil on growth, yield and water and fertilizers use efficiency by growing plants. As tomato (*Lycopersicon 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 the indicator plant.

MATERIALS AND METHODS

Two successive years (2003 and 2004) completely randomized field experiment with four replications for each treatment was conducted on a sandy calcareous soil at El-Saff, Giza governorate, Egypt, as follows:

Table 1: Analytical data of El-Saff sandy calcareous soil.

Mechanical analysis										
Sand		Silt 20-2 m%			Clay < 2 m %			Soil Texture		
Coarse > 200 m %		Fine 200-20 m %								
67.5	22.8	5.0			4.7			Sandy		
Chemical analysis										
					Macro-nutrients (ppm)					
					Total			Available		
pH 1:2.5	EC 1:5 dSm ⁻¹	CaCO ₃ %	CEC c mol kg ⁻¹	OM%	N	P	K	N	P	K
7.4	2.2	11.95	4.48	0.06	415	738	1015	32	6	55
Hydrophysical 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 m				
1.63	38.5	22.8	7.11	1.22	7.3	16.7				

* on dry weight basi

Table 2: Some chemical properties of applied compost.

pH (H ₂ O)	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:	NH ₄ +NO ₃ % 0.02
	P ₂ O ₅ % 0.38
	K ₂ O % 0.48
Secondary elements	Ca ²⁺ % 1.12
	Mg ²⁺ % 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	c mol kg ⁻¹ 135

* **Soil:** A virgin sandy calcareous soil of which more than 90% consists of particles >20m. The main analytical data of the soil are presented in Table 1.

Soil conditioners:

a. Compost (OM): Fine compost produced by aerobic composting of some local organic wastes i.e. town refuse, sawdust, plant residues and organic manure at the ratio of 1:1:1:1 respectively was applied. Table2. Presents the main chemical properties of applied compost.

b. Hydrogel(G): The absorbent material used was 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. description of the main constituents and properties of hydrogel used are given in Table 3.

Indicator plant: Tomato (*Lycopersican 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⁽¹³⁾.

Experimental design:

Size of each experimental plot: 1/100 feddan i.e. 120 plant pits.

Soil treatments:

? Treatment no 1: non-conditioned soil (mineral fertilization only).

- Treatments no 2 and 3: soil of treatment no 1 conditioned with 1 and 2 kg compost (OM)/plant pit i.e. 12 and 24 tons/fed, respectively.
- Treatments no 4 and 5: soil of treatment no 1 conditioned with 2g and 4g hydrogel (G)/plant pit i.e. 24 and 48 kg/fed., respectively.
- Treatment no 6: soil of treatment no 1 conditioned with 1 kg OM + 1 g G/plant pit i.e. 12 ton OM + 12 kg G/fed.
- Treatment no 7: soil of treatment no 1 conditioned with 1 kg OM + 2 g G/plant pit i.e. 12 ton OM + 24 kg G/fed.
- Treatment no 8: soil of treatment no 1 conditioned with 2 kg OM + 1 g G/plant pit i.e. 24 ton OM + 12 kg G/fed.
- Treatment no 9: soil of treatment no 1 conditioned with 2 kg OM + 2 g G/plant pit i.e. 24 ton OM + 24 kg G/fed.

Irrigation

System: Trickle irrigation (agro drip). Distance between laterals is 1.0 m, distance between drippers is 33.3 cm. Drippers discharge is 2 l/h. No of drippers/fed are ≈ 12000.

Table 3: 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-linking 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/m ³
Solubility		Insoluble in water and organic solvents	
PH 0.1% in distilled water		7.0±0.5	
CEC c mol kg ⁻¹		2045	2175
c- Absorption capacity in g/g hydrogel			
Deionized water		~525	~ 430
0.9% NaCl		~ 44	~ 35
0.4% CaCl ₂		~ 41	~ 36
Saline water (1500 ppm)		~ 64	~ 54
Absorption time: Up to 50%			
Total absorption		20 minutes	
		60 minutes	

Table 4: Analysis of irrigation water used

Source	pH	EC Dsm ⁻¹	Soluble cations (meq/l)				Soluble anions (meq/l)			
			Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻
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.

Irrigation water: The source of irrigation is a well, which was dug inside the farm. Regarding its quality, it was classified as no problem water ⁽²⁾. Analysis of irrigation water used is presented in Table 4.

Water requirements for the crop: Water requirements for the crop determined after Doorenbos and Pruitt⁽⁶⁾ and Vermeiren and Jobling⁽²²⁾ are 3660 m³/fed i.e. ~ 300 l/plant. Table 5. presents the water requirements for trickle irrigated tomatoes grown on a sandy calcareous soil under the agro-climatologically conditions of El-Saffare taking into consideration that.

- Date of transplanting was 22 February.
- Date of the beginning of flowering was 1st week of April
- Date of the beginning to pick fruits was 1-15 May according to the conditioning treatments.
- Date of the end of fruit picking was the last week of June.

Therefore, growing season was ~ 125 days divided into three periods i.e., 40, 55 and 30 days for vegetative growth, flowering and fruit setting and complete ripening of the fruits, respectively.

Table 5: Water requirements for trickle irrigated tomatoes grown on a sandy calcareous soil at El-Saff, Giza Governorate.

Month	F	M	A	M	J
Period	22-28	1-31	1.30	1-25	22-30
No. of days	7	31	30	25	5
Epan mm day ⁻¹	4.5	6.4	8.5	11.2	12.8
Kp	0.7	0.65	0.65	0.65	0.65
ET _o mm day ⁻¹	3.15	4.16	5.53	7.28	8.32
Kc	0.7		1.2		0.65
Kr	0.6	0.8	1.0		1.0
ET crop mm day ⁻¹	1.323	2.330	6.636	8.736	4.732
Ks				1.15 (87 %)	
Eu				1.11 (90 %)	
Lr				10 %	
IRg mm day ⁻¹	1.86	3.27	9.32	12.27	6.64
IRg l/day/plant	0.614	1.079	3.076	4.048	2.193
Irg	4.298	33.449	92.28	101.200	10.963
l/season/plant	≈ 305 l				
m ³ /season/ fed	≈ 3660 m ³				

* ET_o = reference crop evapotranspiration, Kc = crop coefficient, Kr = reduction factor for the influence of ground cover, Ks = a coefficient for the water storage efficiency of the soil, Eu = application uniformity, Lr = leaching requirements, IRg = gross irrigation requirements.

Table 6: Distribution of irrigation requirements among the growth season.

Growth stage	Time of irrigation h.	No of irrigations	Quantity of irrigation water	
			l/plant	m ³ /fed
Vegetative growth (40 days)	1.2	17	40.8	490
Flowering and fruit setting (55 days)	4.0	24	192	2304
Ripening and picking fruits (30 days)	2.75	13	71.5	858

* Drippers discharge = 2 l/h.

The soil was irrigated three-times/week i.e. Saturday, Monday and Wednesday). Table 6. presents the distribution of irrigation requirements among the growth season.

Fertilization: Super phosphate (15.5% P₂O₅) at the rate of 100 kg/fed and potassium sulphate (48-52% K₂O) at the rate of 100 kg/fed were added as a basal dose before transplanting. Ammonium nitrate (33.5% N) was applied at the rate of 50 kg/fed through the irrigation system (fertigation). Micro nutrients were sprayed twice as chelates at the rate of 100, 100 and 200 g/fed of respectively Mn (EDTA) 13% Mn, Zn (EDTA) 14% Zn and Fe (EDTHA) 6% Fe.

Other agricultural practices: The normal cultural practices for tomatoes were properly applied.

Examined parameters:

- Fresh and dry weights of the plants after 40 and 125 days from transplantation.
- Nitrogen, phosphorus and potassium uptake by the plants after 125 days from transplantation⁽⁵⁾.
- Marketable yield (total growing period was ~125 days).
- Water use efficiency by plants calculated as kg of the marketable yield produced by each m³ of irrigation water⁽¹⁷⁾.
- Fertilizers use efficiency by plants calculated as kg of the marketable yield produced by each unit of fertilizer nutrients used.

Experimental design and statistical analysis: The field experiment was designed on a completely randomized

system. Collected data were exposed to the proper statistical analysis according to Steel and Torrie ⁽²¹⁾.

RESULTS AND DISCUSSIONS

As the obtained results of both successive seasons were not significantly different, their average was taken into consideration.

1. Growth response: Plant growth expressed as the fresh and dry weights after 40 and 125 days from transplantation are presented in Table 7. Data show significant increase in the weight of the plants after 40 days from transplantation that reached 44.8 and 83.8% or 56.2 and 124.8% for the fresh weight and 38.5 and 82.3% or 54.7 and 127.6% for the dry weight over that of the control treatment by treating the plant pits with 1 and 2 Kg OM or 2 and 4 g G, respectively. The same was true after 125 days from transplantation. Increases were calculated in fresh weight to be 48.8 and 85.3% or 61.2 and 128.7% and in the dry weight to be 33.7 and 76.5% or 52.0 and 119.7% for the aforementioned treatments, in sequence. Moreover, data indicate the beneficial effect of mixing OM with G before incorporating into the soil on the fresh and dry weights of tomato plants either after 40 days or 125 days from transplantation. Under these conditions, fresh or dry weights of plants were 2.3 or 2.4, 2.6 or 2.5 and 3.1 or 3.5 times that of untreated soil (the control treatment) by treating the soil with 1 kg OM + 1g G, 1kg OM + 2g G and 2 kg OM + 1g G, respectively. Relevant values for growing plants after 125 days from transplantation were 2.4 or 2.3, 2.6 or 2.4 and 3.1 or

3.4 times, respectively. Further increase in the application rate of hydrogels to be 2 g mixed with 2 kg OM before incorporating in the plant pit of sandy soil, slightly decreased the fresh or dry weights of plants by 18.9 or 24.5% after 40 days and 12.4 or 24.4 % after 125 days from transplantation but in all cases the production was still much higher than that of control treatment. Under such conditions, the increase in the fresh weight of plants over that of the control treatment have reached 149% and 167% after 40 days and 125 days from transplantation, respectively. Relevant values for the dry weight were 162 and 159% in sequence.

Such decrease in either the fresh weights or dry weights of plants due to applying higher rates of acrylamide hydrogels in the OM-G mixture could be explained on the basis of the effect of hydrogels on modifying pore size distribution in the soil towards the finer ones (micro-pores) and increasing retained moisture in the soil to be over that needed for growing plants. But, as previously mentioned, either fresh or dry weights of the plants were still much higher than that of the untreated soil. So, it can be recommended to use lower rates of hydrogels or increasing the frequency of irrigation. Similar results were previously obtained ⁽¹⁰⁾.

2- Nitrogen, phosphorus and potassium uptake by tomato plants: Uptake of N, K and P by the plants after 40 and 125 days from transplantation are illustrated in Table 8. Data show that incorporating OM in the sandy calcareous soil led to consequent increases in the uptake of studied nutrients by the plants that amounted after 40 days from transplantation to 72 and 222% for N; 152

Table 7: Fresh and dry weights of tomato plants as influenced by soil conditioning.

No. of treatment	Conditioners used	Treatments		Fresh weight		Dry weight	
		Application /plant pit	OM (kg) G(g)	after 40 days from transplantation	After 125 days from transplantation	after 40 days from transplantation	After 125 days from transplantation
				g / plant	g / plant	g / plant	g / plant
1	Untreated	-	-	52.5	322.5	19.2	117.0
2	Compost	1	-	76.0	480.0	26.6	156.4
3	Compost	2	-	96.5	597.5	35.0	206.5
4	Hydrogel	-	2	82.0	520.0	29.7	177.8
5	Hydrogel	-	4	118.0	737.5	43.7	257.0
6	Compost + Hydrogel	1	1	121.3	762.5	45.9	270.2
7	Compost + Hydrogel	1	2	136.4	847.5	48.1	282.8
8	Compost + Hydrogel	2	1	161.5	985.0	66.5	401.3
9	Compost + Hydrogel	2	2	130.9	862.5	50.2	303.4
L. S. D. 0.05				5.5	37.5	2.2	10.2

Table 8: Nutrients uptake by tomato plants grown on a sandy calcareous soil as influenced by soil conditioning.

No. of treatment	Conditioners used	Application /plant pit		N mg / plant		P mg / plant		K mg / plant	
		OM(kg)	G (g)	after 40 days	After125 days	after 40 days	After125 days	after 40 days	After125 days
1	Untreated	-	-	157	1615	21	129	109	176
2	Compost	1	-	271	2543	53	234	173	296
3	Compost	2	-	507	4017	115	474	280	515
4	Hydrogel	-	2	330	4044	71	319	205	389
5	Hydrogel	-	4	607	5371	140	565	332	668
6	Compost + Hydrogel	1	1	666	5319	110	459	353	810
7	Compost + Hydrogel	1	2	861	7022	135	592	390	931
8	Compost + Hydrogel	2	1	1488	10707	173	1043	532	1644
9	Compost + Hydrogel	2	2	1080	8666	146	848	442	1182

Table 9: Marketable yield, water and fertilizers use efficiency by tomato plants as influenced by soil conditioning.

No. of treatment	Conditioners used	Application /plant pit		Marketable yield (kg/plant)	Water use efficiency (kgm ⁻³)	Fertilizers use efficiency (kg/ unit of added nutrients)		
		OM (kg)	G (g)			N	P ₂ O ₅	K ₂ O
1	Untreated	-	-	2.878	9.585	2062	2228	691
2	Compost	1	-	3.420	11.389	2450	2648	821
3	Compost	2	-	3.845	12.804	2755	2977	923
4	Hydrogel	-	2	3.538	11.782	2535	2739	849
5	Hydrogel	-	4	3.920	13.054	2808	3035	941
6	Compost + Hydrogel	1	1	3.740	12.454	2679	2896	898
7	Compost + Hydrogel	1	2	4.120	13.719	2952	3190	989
8	Compost + Hydrogel	2	1	4.735	15.052	3392	3666	1136
9	Compost + Hydrogel	2	2	4.740	15.784	3396	3670	1138
L.S.D. 0.05				0.330				

and 447% for P and 58 and 156% for K by applying 1 and 2Kg OM to the plant pit, respectively. When 2 and 4g of G were incorporated into the plant pit, the corresponding increases in the nutrients uptake by plants were 109, 285% ; 238, 562% and 87 and 204% in sequence. Such increases continued till the end of the growing season. After 125 days from transplantation uptake of N by the plants were 1.6 and 2.5 times and 1.9 and 3.3 times that of the non – conditioned soil by applying 1 and 2 kg OM and 2 and 4 g G to the plant pit, respectively. Similarly, uptake values arranged as mentioned above were 1.8 and 3.7 times and 2.5 and 4.4 times for P and 1.7 and 2.9 times and 2.2 and 3.8 times for K consequently.

Mixing OM with G before incorporating into the sandy calcareous soil gave higher increments in the nutrients uptake by growing plants than those obtained when applying each of them solely. In other words, uptake by the plants after 40 and 125 days from transplantation were estimated to be 4.2 and 3.3 times for N, 5.2 and 3.6 times for P and 3.2 and 4.6 times for K that of the control treatment by treating the plant pit with a mixture of 1 kg OM and 1 g G. When applying 1Kg OM + 2g G to the plant pits, the increase in nutrients uptake over that of the non conditioned soil were 447 and 335 % for N, 538 and 359% for P and 256 and 429% for K after 40 and 125 days from transplantation, respectively. More

increase in nutrients uptake were obtained to reach its maximum by doubling the rate of OM to be 2 kg and mixing with 1g G, to be after 40 and 125 days from transplantation, 9.5 and 6.6 times; 8.2 and 8.1 times and 4.9 and 9.4 times that of the control treatment for the three nutrients mentioned above respectively. More increase in applied hydrogel to be 2 g mixed with 2 kg OM / plant pit led to 20-30 % reduction in N, P and K uptake. In this case, nutrients uptake by tomato plants were only 588, 595 and 306% and 337, 557 and 575% higher than that of the non conditioned soil for N,P and K after 40 and 125 days from transplantation, in sequence.

3-Marketable yield: Data presented in Table 9. show the effect of conditioning the sandy calcareous soil with OM or G or their mixtures on the productivity of the soil. Marketable yields of tomato were significantly increased by 19 and 33.7 or 33.1 and 36.3% over that of the control treatment (non-conditioned soil) by incorporating 1 and 2 kg OM or 2 and 4 g G, in the plant pit, respectively.

More increase was obtained in the marketable yield of tomato due to mixing OM with G before incorporating into the soil. Under these conditions, marketable yields were 1.3, 1.43 and 1.65 times that of control treatment by treating the soil with 1 kg OM + 1 g G, 1 Kg OM + 2 g G and 2 Kg OM + 1g G, in sequence. It is interesting to note that, although the fresh weights or the dry weights of plants were decreased due to incorporating 2 kg OM mixed with 2 g G in the plant pit, the marketable yield was still the same as that of the treatment 2 kg OM + 1 g G indicating the previously mentioned recommendation of using the lower rate of G.

4- Water and fertilizers use efficiency by tomato plants: Values of the water or fertilizers use efficiency-which reflect the relation between the production and the total seasonal water or fertilizers used-are presented in Table 9. Data show that treating the sandy calcareous soil with examined conditioners led to an increase in water or fertilizers use efficiency by growing plants i.e. yield produced in Kg by each cubic meter of irrigation water used or each unit of added nutrients. Obtained increases were 18.8 and 33.6% for OM at the rates of 1 kg and 2 kg per plant pit, respectively. The corresponding increase for 2 and 4 g G/plant pit were respectively 22.9 and 36.2%.

Regarding the combined effect of both types of soil conditioners on the values of water or fertilizers use efficiency by tomato plants, data indicate better yields by the same quantity of water or added fertilizers. With this respect, water or fertilizers use efficiency were 1.3, 1.43 and 1.65 times that of untreated soil by incorporating 1 kg OM mixed with 1 g G; 1 kg OM mixed with 2 g G and 2 kg OM mixed with 1 g G in the plant pit, respectively.

As previously mentioned with the obtained marketable yield, when doubling the application rate of G to be 2 g and mixing them with 2 kg OM before incorporating in the soil, water or fertilizers use efficiency were still the same as that of the soil treated with 2 kg OM mixed with 1 g G. Water or fertilizers use efficiency for this treatments was calculated to be 1.65 times that of the control treatment and at the same time indicate the recommendation of using lower application rate of hydrogels when mixed with OM.

The conditioning effects of organic composts as natural soil conditioners or /and acrylamide hydrogels as synthesized ones on hydro-physical, chemical and biochemical properties of the sandy calcareous soil under study after tomato plantation were evaluated⁽¹¹⁾. Data indicate that synthetic hydrogels can be viewed as analogous to the soil organic matter. The positive effects of each of the studied conditioners on soil properties could be considered as a basis for discussing the beneficial effects that gained on crop production, nutrients uptake and both water and fertilizers use efficiency by the plants. Regarding hydro-physical and mechanical properties of the soil, the effect of both types of soil conditioners (OM or G) include: 1) Promoting good soil structure that protects the soil surface against wind and water erosion through improving soil structurization and increasing the percentages of water stable structural units. 2) Increasing soil water holding capacity and the ability the soil to retain water due to their effect on pores size distribution towards the finer ones i.e. water holding pores, from one hand and the swellability of conditioners particularly the hydrogels, on the other hand 3) Improving the dynamic soil water characteristics i.e. decreasing downward movement of water through infiltration and the upward movement of it via evaporation and 4) improving the mechanical strength of the soil i.e. decreasing both penetration resistance and compressive strength of the soil surface to be suitable for soil management practices, root growth and distribution. Concerning the bio-chemical properties of the soil, the improving effect of applied conditioners includes: 1) lowering soil pH that leads to more solubilization of nutrients and increasing nutrients availability. 2) increasing the low exchange capacity and specific surface area of the soil that raises its nutrients retention abilities and in turn minimizing the loss of such nutrients by leaching or deep percolation and 3) increasing soil microbial biomass enzymes activity indicating an improvement in the biological fertility of the soil.

As expected, incorporating OM mixed with hydrogels in the plant pits was more effective than using each of them alone. The combined and interacted effects of applying both technologies for the sandy calcareous soil

conditioning together on hydro-physical, mechanical, chemical and biological properties of the soil were practically proved. The beneficial effect of mixing 12 ton OM with 24 kg G/fed. on all the studied hydro-physical properties of the soil and most of its chemical and biological properties, has exceeded that of 24 ton OM or 48 kg G /plant pit if each of them was solely applied. Although mixing 24 ton OM with 24 kg G cause better improvement in soil properties, obtained yields did not increase. 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 the soil micro-porosity on the expense of its macro-ones-may explain why the yield, nutrients uptake and both water and fertilizers use efficiency by growing plants may decrease by an increased amount of applied hydrogel^(14, 16 and 10).

When evaluating the use of such technique for the sandy calcareous soil conditioning, one has to consider: 1) the improvement of soil properties 2) the increase in plant growth and yield and 3) savings in the prices of irrigation water and fertilizers, on one side and 1) the fast decomposition of OM if compared with the slow one of G and the need for frequent (annual) additions of OM and 2) the prices of the conditioners used and costs of the conditioning process, on the other side. Taking into consideration that the prices of applied conditioners were 100 L.E./ton OM and between 3 and 5 dollars with an average of 4 dollars i.e. about 25 L.E./kg G, estimated prices of needed conditioners for planting one feddan of the sandy calcareous soil under the conditions of our study ranges between 600 L.E. for treatment no. 4 and 3000 L.E. for treatment no. 9. Therefore, 12 ton OM. mixed with 24 kg G i.e. treatment no 7 seems to be suitable to get use of the benefit of both types of soil conditioners without adverse effects on growth, nutrients uptake, yield and water and fertilizers use efficiency by growing plants. Under such condition, conditioners needed to produce 1 ton of tomatoes costs \approx 56.4L.E.

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