J. Agric. Sci. Mansoura Univ., 34 (4): 4131 - 4139, 2009

COMBINED IMPACT OF NATURAL AND SYNTHITIC CONDITIONRS ON EL-ARISH SANDY SOIL PROPERTIES AND PRODUCTIVITY

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ABSTRACT

Completely randomized field experiments were conducted at El-Arish Agricultural Research Station, North Sinai, during the winter season of 2005/2006 and the summer one of 2006. The effect of Super Absorbent Polymers (SAPs) combined with local bentonite in the ratio of 1:20 (w/w), was studied on soil chemical and hydro-physical characteristics and some morphological growth parameters as well as the yield production of faba bean (*Vicia faba* L.) and corn (Zea maiza) grown under drip irrigation system and natural drainage conditions. Soil conditioner was applied in the rate of 0, 1.5, 2.0 and 2.5 ton/fed.

Obtained results reveal that soil chemical properties, i.e., EC, pH, soluble cations and anions as well as SAR values are directly affected by increasing conditioner application rate. Modification in soil textural class from sandy to sandy loam was existed with the increase in clay content. Bulk density, macro-pores and saturated hydraulic conductivity values were markedly decreased, while the values of total porosity, water holding capacity, field capacity and available moisture were progressively increased. The greatest improvement in these soil characteristics is pronounced under the highest rate of conditioner doses. Moreover, growth parameters of the two crops as well as their seed yields were beneficially increased with increasing the rate of applied conditioner. This reveals to the highly magnitude of combining synthesized and natural conditioners in a proper amount to improve El-Arish sandy soils properties and enhancing their productivity.

Keywords: Sandy soil, Bentonite, Synthetic soil conditioners, Super Absorbent Polymers (SAPs), Chemical and hydro-physical properties, Productivity.

INTRODUCTION

Sandy soils widely exist in arid and semi-arid regions such as the east and west desert areas of Egypt. Increasing the productive lands is one of the major targets of the agricultural policy. The productivity of sandy soils is mostly limited by several agronomic obstacles. Their very low specific surface area caused its inert chemical and biological conditions. The fertility level of such soils is very poor and is controlled by their fine fractions, i.e. clay and organic matter contents. In this respect, Abd El-Kader (1999) showed that nutrients applied to raise the low fertility of sandy soils were subjected to loss by leaching. Due to low water retention of such soil, it needs frequent irrigations at short intervals.

Several applications of natural and synthesized soil conditioners were carried out to improve some physico-bio-chemical properties of sandy soils and their productivity (Abou-Gabal *et al.,* 1990 and Arafat and El-Hady, 2002). In this concern, Afifi (1986) mentioned that the addition of clay deposits (Bentonite) to the sandy soil increased the retention and availability of soil moisture, reduced the velocity of downward water movement and restricted the deep percolation and leaching out nutrients. At the same time, El-Sherif and El-Hady (1986) postulated that mixing sandy soil with local bentonite improved soil mechanical, hydrophysical and chemical properties, and consequently increasing water use efficiency. Sallam *et al.* (1995) concluded that mixing shale deposits (clay content 72% dominated by smectite) with sand improved the physico-chemical properties and in particular the soil moisture characteristics and cation exchange capacity. In addition, El-Hady *et al.* (2004) stated that synthesized absorbent polymers (hydrogels) were effective in modifying the pore size distribution towards the increase in water holding pores on the expense of drainable ones. Moreover, the available water for plants increased up to more than two times that of the original sandy soil. The effect of hydrogels on improving plant-soil water relations in sandy soil was very near to that of bentonitic clay and much better than that of farmyard manure. Similar results were obtained by Ouchi *et al.* (1989), Helalia *et al.* (1992) and Moustafa *et al.* (1995). Moreover, Sivapalan (2001) indicated that the additional amount of water retained by the soil due to the presence of a synthetic anionic copolymer (ALCOSORB 400) was completely available to soybean plants. Consequently there were substantial increases in water use efficiency by plants grown in soils treated with different application rates of the polymer.

The present work aims to highlight the favorable effect of applying natural local bentonite in combining with a synthesized conditioner, i.e., Super Absorbent Polymers (SAPs) at different rates on some sandy soil properties at El-Arish, North Sinai, and its productivity.

MATERIALS AND METHODS

The current study was carried out at El-Arish Agricultural Research Station, which prolongs to the Agricultural Research Center (A.R.C). The soil is light in texture with deep groundwater (more than 6m). Faba bean (Giza 843) as a winter crop (2005/2006) and corn (Zea maize) as a summer one (2006) under drip irrigation system were chosen as the indicator crops. Before faba bean cultivation, the natural local bentonite obtained from Cairo-Ismailia Desert Road was added and mixed with the soil of each pit, and then two successive irrigations were applied to leach and reduce the high soluble salts content of bentonite. After that, Super Absorbent Polymers (SAPs), with the same major component (polyacrylic acid), i.e. Arasoubu S-107, Arnon T-121, Bargas-700, Diawet-A and IPC-01, were applied to the plant pits previously treated with bentonite. The ratio between the synthesized and natural conditioners was 1:20 (w.w). , i. e., the combined conditioner additives was at the rate of 0.0, 1.5, 2.0 and 2.5 ton/fed (0, 75, 100 and 125 g/pit). Some physical and chemical characteristics of the used bentonite are presented in Table (1). The statistical design was completely randomized with four replicates for each treatment. The recommended doses of N and K fertilizers for each crop were applied through the irrigation system, while phosphorus was added manually to each pit after planting. At maturity and harvesting time of both crops, some growth parameters and the seed yields (kg/fed.) were recorded. Representative soil samples (0-30 cm) were collected to determine some soil chemical and hydro-physical properties. Soil salinity, soluble cations and anions were measured according to Page (1982). Particle size distribution was carried out as described by Dewis and Freitas (1970). Soil bulk density was determined by core method (Page, 1982). Total soil porosity was calculated using the data of bulk density. Soil moisture characteristics were carried out for each treatment over the range from 0 to 15 atm. using the pressure cooker for the pressures of 0.1 and 0.33 atm., and the pressure membrane apparatus for the pressures >1 atm., Available water and pores size distribution were computed (Loveday, 1974). The hydraulic conductivity was measured under constant head after Klute (1965). The obtained results were statistically analyzed as described by Gomez and Gomez (1984).

Table (1): Some physical and chemical properties of Cairo-Ismailia Desert Road bentonite

Physical properties		Chemical properties	
Particle size distribution %		Electrical conductivity (EC) dS/m	17.15
Coarse sand 2000-200*u*	0.5	pH (1: 2.5) soil: water suspension	7.68
Fine sand 200-20*u*	4.5	Soluble cations meq/1:	
Silt 20-2*u*	23.1	Ca^{2+}	15.3
Clay <2*u*	71.9	Mg^{2+}	22.6
Bulk density g/cm^3	1.25	K^+	0.2
Total porosity %	52.8	Na^+	149.0
Pore size distribution as % of total porosity		Soluble anions meq/1:	
Macro (drainable) pores (>28.8*u*)	44.7	CO_3^{2-}	Nil
Micro pores (<28.8*u*)	55.3	HCO_3^-	2.7
Water holding capacity (WHC)*	82.7	Cl^-	153.6
Field capacity (FC)*	45.7	SO_4^{2-}	30.9
Wilting percentage (WP)*	27.0	Total $CaCO_3$ %	0.2
Available moisture (FC-WP)*	18.7	Organic matter %	0.3
Hydraulic conductivity m/day	0.146		

*** % on weight basis**

RESULTS AND DISCUSSION

1- Soil chemical properties as influenced by the conditioner additives:

Several soil chemical properties were affected by soil conditioner additives. Although bentonite has a very high salinity level (17.15 dS m^{-1}), the treated soil by the combined SAPs and bentonite were less saline than the untreated ones (Table 2). These low salinity levels were achieved by adding a considerable amount of irrigation water at the beginning of planting process. In this concern, previous studies implied the possibility to decrease salt content of sandy soils treated with bentonite through leaching (El-Sherif and El-Hady, 1988 and Hefny, 2003). There are an increase in the values of both pH and sodium adsorption ratio (SAR). As previously mentioned, the hazards of soil salinity and/or alkalinity can be possibly declined by taking leaching requirements into account.

Table (2): Some chemical properties for the surface layer (0-30cm) of El-Arish soil as influenced by SAPs and bentonite applications

Treatment Ton/fed	pH	EC ds/m	Soluble cations meq/1				Soluble anions meq/1			SAR
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3	Cl^{-}	SO_4^{2-}	
Control	8.75	1.73	4.15	4.65	8.00	0.69	2.88	6.49	8.12	3.81
1.5	8.80	1.54	3.55	3.16	8.25	0.49	2.30	6.37	6.64	4.51
2.0	8.86	1.51	3.30	2.37	8.84	0.35	2.59	3.82	8.59	5.26
2.5	9.02	1.53	3.18	1.43	10.25	0.34	2.73	3.68	8.79	6.74

2. Soil hydro-physical properties as influenced by the conditioner additives:

1-Soil texture:

Data in Table (3) show that the values of coarse sand were reduced on the expense of fine sand, silt and clay fractions which increased as the conditioner application rate increased. In fact, the increase in the finest fractions (silt and clay) can be attributed to the addition of bentonitic clay deposits (Al-Omran *et al.,* 2002). Moreover, soil texture in consequence, was slightly turned from sandy in the untreated soil to loamy sand with increasing the conditioner additives. These modification in soil textural class took similar trend with those observed by El-Hady and El-Sherif (1988-a and b) and pointed out by Hefny (2003) who emphasized that mixing sandy soils with bentonitic clays changed their textural class towards the finer ones and in turn their hydro-physical and chemical properties may be improved.

2-Bulk density and total porosity:

Table (3) reveals to a good improvement in both soil bulk density and total porosity status due to the increase in the SAPs-bentonite conditioner application rates. The values of bulk density were slightly decreased by 3.0, 4.2 and 7.2%, while the values of total porosity were increased by 5.1, 7.0 and 12.2% under 1.5, 2.0 and 2.5 ton/fed of the conditioner, respectively as compared with the untreated one. These results can be attributed to the redistribution of soil particles, the increase in bulk soil volume and the binding action of SAPs which assess to improve soil structure, mainly in aggregate formation. These findings are very close to that obtained by Al-Omran *et al.* (2002).

Table (3): Some hydro-physical properties as affected by the combined SAPs+ bentonite application rates at El-Arish sandy soils

Soil properties		SAPs + bentonite treatments (ton/fed)			
		Control	**1.5**	**2.0**	**2.5**
Particle size distribution %					
- Coarse sand		66.64	62.94	62.48	61.45
- Fine sand		19.23	20.34	20.64	20.35
- Silt		8.24	8.84	8.19	8.81
- Clay		5.89	7.88	8.69	9.39
Texture class		Sandy	L.S	L.S	L.S
Bulk density	g/cm^3	1.67	1.62	1.60	1.55
Total porosity	%	37.0	38.9	39.6	41.5
Water holding capacity*	%	21.94	23.8	24.66	26.66
Field capacity*	%	6.31	8.29	10.5	12.17
Wilting percentage*	%	1.16	1.50	1.83	2.02
Available water*	%	5.15	6.79	8.67	10.15
Hydraulic conductivity	cm/h	6.11	4.13	3.39	2.64

***On weight basis** **L.S. = Loamy sand**

3- Soil moisture retentions:

The influence of combining the polymer with bentonite on soil moisture retentions, i.e., total water holding capacity (WHC) at pF=0, field capacity (FC) at pF=2 and wilting percentage (WP) at pF=4.2 as well as the available water (FC-WP) of sandy soil is shown in Table (3). Obtained data show that the increase in soil (WHC) reached 8.5, 12.4 and 21.5% for the treated soils as compared to untreated one. Moreover, the amount of water held by amended soil was greater than that held by untreated one at both FC and WP. The increase in moisture retained at field capacity achieved 31.4, 66.4 and 92.9%, while such increase in available water become 31.8, 68.4 and 97.1% after mixing sandy soil with 1.5, 2.0 and 2.5 ton/fed of bentonite+ SAPs, respectively.

This increase in soil moisture retention parameters is considered as the greatest goal in the reclamation of sandy soils, where water deficit is occurred. These may be rendered to the increase in fine particles content (clay fraction) resulted from bentonite additives and the binding action of the super absorbent polymers (SAPs) (Helalia *et al.,* 1992). The highly magnitude of these results is saving a lot of irrigation water which can be used to reclaim, cultivate new areas and to enhance water use efficiency of most crops.

4-Pore size distribution:

Pore size distribution of El-Arish sandy soil as affected by SAPs and bentonitic clays are demonstrated in Fig. (1). It is obvious that micropores (<28.8μ) especially those responsible for the available moisture i.e. water holding pores (W.H.P, 28.8-0.19μ) are progressively increased on the contrary of the macro ones which represents the total drainable pores (T.D.P, >28.8μ). On the other hand, fine capillary pores (F.C.P) which retain soil moisture at the wilting percentage, are slightly increased. These results may be attributed to the redistribution of solid particles after the existing of bentonite and the swelling and bending action resulted from the applied polymers.

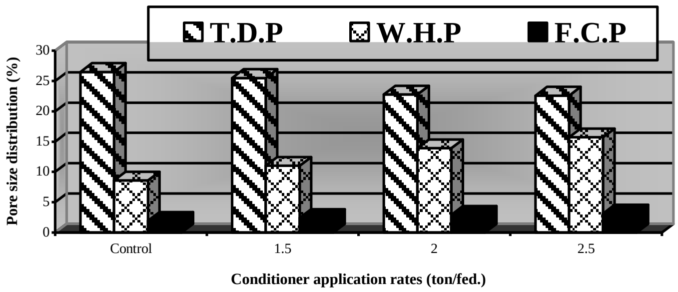

Fig. (1): Pore size distribution of Al-Arish sandy soil as affected by SAPs and bentonite application rates.

In this case, soil aggregates can be established, hence the water holding pores increased and consequently available moisture in the treated soils. Similar trend were observed by El-Hady *et al.* (2003) who pointed out that increasing available moisture for plants elongates irrigation frequencies and in turn decrease the quantities of irrigation water needed and costs of irrigation process.

5- Saturated hydraulic conductivity "K":

Data in Table (3) show that the values of saturated hydraulic conductivity measured for the surface layer, were sharply decreased with the increase in the soil conditioner application rate. The greatest decrease in "K" values (56.8%) was recorded at the plots treated by 2.5 ton/fed of the conditioners compared with the untreated ones. Similar results were shown by Choudhary *et al.* (1995).

2) Effect on growth parameters and grain yields of faba bean and corn plants:

Data presented in Table (4) show the increase percentage of the morphological vegetative growth parameters and seed yield of faba bean (Giza 3) due to soil conditioning. Plant height, number of branches/plant, number of pods/plant, number of seeds/pod, weight of 100 seed in grams (seed index) as well as the seeds yield of faba bean had significant increases with increasing the conditioner application rates.

Table 4: The increase percentage in faba bean growth parameters and yield compared to control as affected by conditioner additives

Treatment	Plant height cm	No. of branches/plant	No. of pods/plant	No. of seed/plant	Seed Index	Seed yield ton/fed
Control	**64.6**	**3.0**	**15.0**	**43.0**	**69.05**	**3.09**
The increase percentages compared to control (%)						
1.5 ton/fed	6.04	66.67	13.3	20.93	12.31	44.98
2.0 ton/fed	15.33	66.67	20.0	39.53	22.23	56.98
2.5 ton/fed	23.53	100.0	40.0	83.72	35.99	84.50
L.S.D at 0.05	3.01*	0.598*	2.19*	1.44*	3.30*	0.36*

*** Significant**

In addition, results of corn shown in Table (5) reveal that the growth parameters as well as the grain yield were clearly affected by the conditioner additions. Moreover, there is a significant increase in cob length, number of rows/cob, total cob weights and cob diameter with the different treatment of studied conditioner. While the weight of 100-grains (g) and the grains yield were significantly increased by increasing the conditioner rates.

Table 5: The increase percentage in corn growth parameters and yield compared to control values as affected by conditioner additives.

Treatments ton/fed.	Cob length (cm)	No. of rows/ cob	Total cob weight (g)	Grains weight/ cob (g)	Cob diameter (cm)	Grain yield (ton/fed)	Grain Index
Control	**14.9**	**12.0**	**123.6**	**94.9**	**3.62**	**2.184**	**26.16**
The increase percentages compared to control (%)							
1.5	8.72	3.33	8.58	14.86	2.49	3.13	22.68
2.0	35.57	6.67	70.71	74.29	11.05	8.18	47.42
2.5	36.91	10.00	95.23	109.06	11.60	37.16	69.07
L.S.D at 0.05	3.47*	1.27*	49.02*	40.14*	0.316*	1.736*	0.026*

*** Significant,**

The modification existed in soil chemical and hydro-physical properties by combining the synthesized polymers and bentonite as conditioners for El-Arish sandy soils caused an increase in their productivity. These results are in harmony with those found by Arafat and El-Hady (2002) who revealed that using hydrogels and organic composts as conditioners for sandy calcareous soils in Egypt caused an increase in both water and fertilizers use efficiency by plants and increased cotton yield.

It can be concluded that favorable modifications in soil properties were clearly obtained by applying the synthesized hydrogel (SAPs) combined with bentonitic clay deposits to El-Arish sandy soil. Consequently, growth parameters of indicator crops, as well as their yields were increased. Obtained results are promising to enhance the horizontal and/or vertical expanding agriculture in such problematic soils. The improve in agricultural status may modify the level of population life by increasing farmers income.

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الأثر المشترك للمحسنات الطبيعية (البنتونيت) و الصناعية (الهيدروجيل) على خواص وإنتاجية أراضى العريش الرملية

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أجريت تجربتين حقليتين بتصميم تام العشوائية بأرض محطة البحوث الزراعية بالعريش، محافظة شمال سيناء خلال عامى ٢٠٠٥و ٢٠٠٦ بغرض دراسة تأثير إضافة بوليمرات عالية الأمتصاص SAPs مع البنتونيت بنسبة ١:٢٠ وزناً، على خواص التربة الكيميائية والطبيعية و المائية وبعض مقاييس النمو الخضرية و الإنتاجية لمحصولى الفول البلدى (صنف جيزة ٨٤٣) (كمحصول شتوى) و الذرة الشامية (كمحصول صيفى) المنزرعة تحت ظروف الرى بالتنقيط والصرف الطبيعى. وقد أضيفت محسنات التربة بمعدلات صفر و ١,٥ و ٢ و ٢,٥ طن/فدان.

أشارت النتائج المتحصل عليها تأثر خواص التربة الكيميائية مثل التوصيل الكهربى ودرجة الحموضة وكمية الكاتيونات و الأنيونات الذائبة ومعدل إدمصاص الصوديوم مباشرة بزيادة معدل إضافة المحسن. أما الخواص الطبيعية فقد حدث تعديل فى قوام التربة من الرملية إلى الرملية طميية مع زيادة نسبية فى المحتوى الطينى. وقد انخفضت بوضوح قيم كل من الكثافة الظاهرية و المسام الواسعة ودرجة التوصيل الهيدروليكى، بينما أرتفعت قيم كل من المسامية الكلية، السعة التشبعية بالماء، السعة الحقلية، ومسام حفظ الماء. وقد ظهر أعلى تحسن فى خواص التربة باستخدام أعلى معدل إضافة.

علاوة على ذلك، أثرت الزيادة فى معدلات إضافة المحسنات تأثيراً إيجابياً على مقاييس النمو الخضرية لكل من نباتات الفول البلدى و الذرة الشامية. وتبعاً لذلك فقد زاد محصول الحبوب لكلا المحصولين.

هذه النتائج تشير إلى أهمية استخدام المحسنات الصناعية مع تلك الطبيعية بمعدلات مناسبة لتحسين خواص الأراضى الرملية بمنطقة العريش وزيادة إنتاجيتها.