SOIL HYDROPHYSICAL PROPERTIES AS AFFECTED BY KIND OF ADDED POLYMER

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ABSTRACT

Laboratory experiments were carried out to clarify the impact of different types of natural and synthetic polymers on some hydrophysical properties (soil hydraulic parameters) of a sandy soil. Adding 0.5% (w/w) of each treatment to soil significantly increased water retention at saturation, field capacity, total available water and readily available water. This treatment decreased the value of inflection point on water retention curve as result of enhancing water behavior in the soil. The obtained results revealed that soil water storage significantly increased from 0.271 in control treatment (without adding polymer) up to 0.414 in treatment [T_{10}] (Acrylic acid + Xanthan) while, field capacity increased significantly from 0.078 in control up to 0.242 of the abovementioned treatment (T_{10}). Regarding the effects of polymer application in total available water and readily available water, data revealed significant increases in the above mentioned parameters. Total available water increased from 0.044 in control treatment up to 0.153 in T_{10} and readily available water increased from 0.057in control treatment up to 0.185 in T_{10}. Concerning values of inflection point on soil water retention curve, the obtained results revealed that, inflection point of control treatment (1000 mbar) decreased to 590 mbar, as a result of adding a mixture of polymer acrylic acid + xanthan (T_{10}). Soil depletion rate decreased as due to polymer application by 25% up to 75% depending on type of polymer and wether it was added individually or in combination with another polymer. This effect led to significant differences among control treatment (control) and the other treatments. Generally, there were significant effects of all polymers on the concerned hydrophyical properties of the studied sandy soil, i.e. storage capacity of soil water**,** depletion rate of soil water, soil field capacity, soil available water, readily available water and inflection point on the soil water retention curve. Acrylic acid recorded the best results concerning soil water behavior if it was added individually to the sandy soil (Treatment 2) or in combination with Xanthan (Treatment 10) or with Lignosulphonate (Treatment 11).

Keywords: Soil hydrophysical properties, Available water, Readily available water, Inflection point, Field capacity, Natural polymer, Synthetic polymer

INTRODUCTION

Scarcity of irrigation water is one of the major problems of agricultural production particularly in light textured soils. Sandy soils are characterized with low water retention and high drainage of irrigation water below the root zone leading to poor crop water and fertilizer use efficiencies. Therefore, development of new technologies to conserve water is becoming important to achieve a sustainable growth in agricultural production. Polymers, especially those of hydrophilic properties, known as superabsorbent polymers (SAP's) can improve water retention in soil and may increase plant growth (**Zhang et al 2006**).This is an important issue in arid and semi-arid regions for improving the water management of coarse-textured soils as mentioned by **Abedi-Koupai et al (2008)**. **Zhang and Wang (2006)** indicated that hydrogel soil conditioners have the ability to absorb water in quite a hundred times its original weight within short

period of time and desorbs the absorbed water under stress conditions. The hydrogel soil conditioners retain water up to 400 times their weight and release 95% of the retained water to growing plants, **(Bowman and Evans, 1991)**. Furthermore, the hydrogels soil conditioners markedly affects soil permeability, soil density, soil structure, soil texture, and evaporation and water infiltration rate. Hydrogel soil conditioners also increase the amount of available water in the root zone, resulting in increased irrigation intervals **(El-Hady et al 2009)** However, there is much need to explore some different types of polymers to enhance the soil water retention capacity and water balance on root zone and consequently improve crop yield and its quality as mentioned by **Dorraji et al (2010)**.Several investigations were conducted in the last two decades particularly in regions which suffer from scarcity in water resources to find out the effect of the application of synthetic hydrogel soil conditioners on promoting aggregate stability by gluing particles together within aggregates as well as by coating the aggregate surfaces, (**Shainberg et al 1990**). **Abedi-Koupai et al (2008**) found that the water storage at different tensions was improved significantly particularly in sandy soil treated with synthetic hydrogel soil conditioners. They added that the application of hydrogel soil conditioners can result in significant reduction in the required irrigation frequency particularly for coarse textured soils. It was observed that the application of hydrogel soil conditioners to sandy soils improved water availability to plants by increasing the water holding pores and reducing saturated hydraulic conductivity by decreasing the drainage pores **(El-Hady and Abo-Sedera, 2006).** **Bhardwaj et al (2007)** found that mixing hydrogel soil conditioners with sandy soils may decrease water percolation rates and increase water availability to crops.

On the other hand, some investigations reported that the application of hydrogel soil conditioners in sandy soils significantly increased the water retention capacity **(Abedi-Koupai and Sohrab, 2004). Andry et al (2009)** studied the effects of two hydrophilic polymers named carboxyl methyl cellulose (CMC) and isopropyl acrylamide (IPA) on water holding capacity of sandy soil, and found that this hydrophilic polymers can swell by absorbing large volumes of water and consequently improve water retention in sandy soils. **Chen et al (2016)** investigated the influence of some polymers soil conditioners representing different side-chain charges, molecular weights, and degree of cross-link on water and nutrient retention in soils and indicated that the

tested SAP's (Super Absorbent Polymer) possess high degree of cross-link help the soil retain water best. **Liao et al (2016)** concluded that the SAP's had a great effect on water retention in soil with suction pressure ranged between -100 and -800 cm, because these areas appeared the greatest increases in water content compared to the control.

Milani et al (2017) mentioned that, the hydrogel particles are also taken as miniature water reservoir in the soil and water will be released from these reservoirs by roots through osmotic pressure difference. When the hydrogel soil conditioners is mixed with the soil, it forms an associate amorphous gelatin-like mass on hydration and is great of absorption and desorption for an extended time, thus acts as a slow release supply of water within the soil. However, in different types of soils, the effect of hydrogel application on soil water retention and release characteristics must be fully investigated before recommending hydrogel for further commercial use in the agriculture **Abobatta, (2018)**.

Generally, agricultural uses with polymers can change the different soil characteristics through the following different mechanisms Implement water-holding capacity of the soil, increasing soil permeability, improving water retention on different soil types, increasing the water use efficiency, increasing irrigation intervals due to increasing the time to reach a permanent wilting point, minimizing soil erosion and water run-off, implement soil penetration and infiltration, decrease soil compaction tendency and improving soil drainage **Abobatta, 2018).**

MATERIALS AND METHODS

Laboratory experiments were conducted to investigate the influences of adding different types of polymers on soil hydrophysical properties, i.e. hydraulic parameters and water retention properties of a sandy soil. Soil sample was collected from 0-30 cm soil depth, Pivot No.14 of a farm located at 85 km from Cairo along Cairo-Alex. Desert Road. Disturbed and undisturbed soil samples were collected to determine some physical and chemical properties using the standard methods described by **Klute (1986) and Page (1982)**.Results obtained are presented in **Tables (1 and 2)**.

This experiment included 15 polymer soil conditioner treatments with 0.5% (w/w) as recommended application rate, besides of the control treatment (without adding any polymer) as shown in **Table (3)**. Therefore, the air-dried soil was sub - divided into 16 parts. Each part of soil received the calculated amount of the proper polymer (polymers) treatment and then mixed thoroughly.

Table 1. Some physical properties of the used soil sample

* Particle size distribution %				Textural class	ρ_b g/cm^3	ρ_s g/cm^3	f %
Coarse Sand	Fine Sand	Silt	Clay				
16.2	54.2	20.2	9.4	loamy sand	1.65	2.58	36.04

* According to scheme of ISSS (International soil science society)

ρ_b ... Soil bulk density ρ_s ... Soil particle density f ... Soil porosity

Table 2. Some chemical properties of the used soil sample

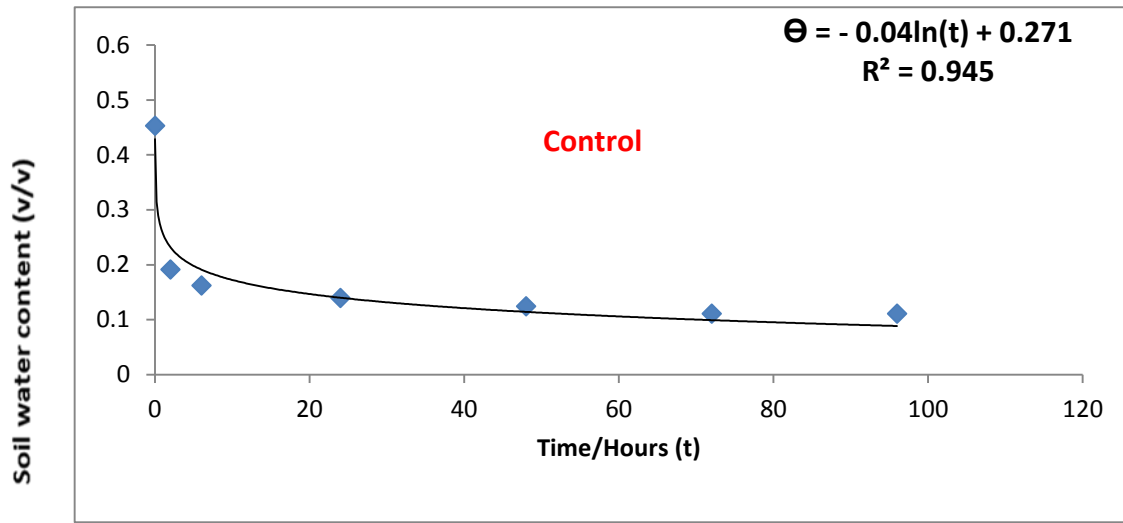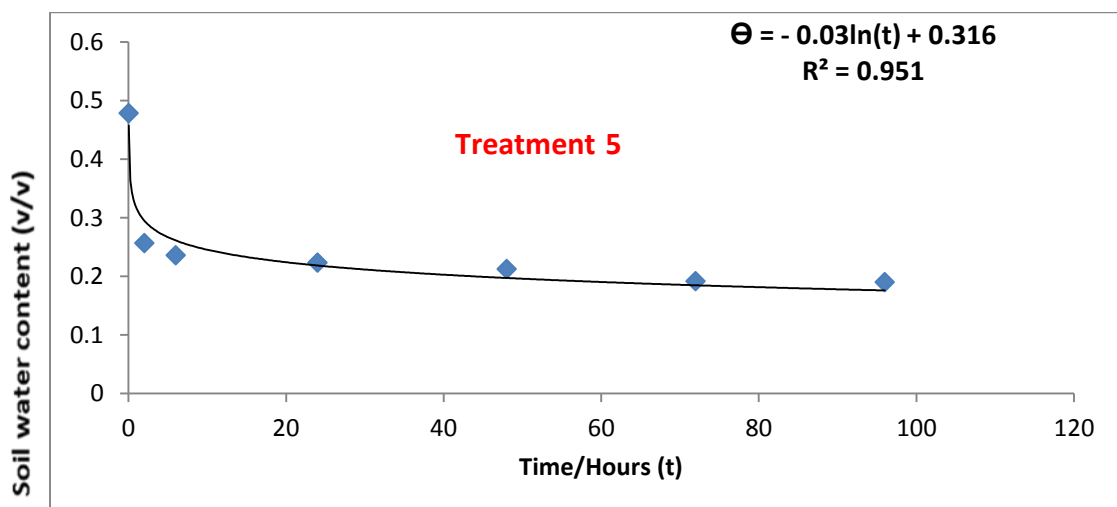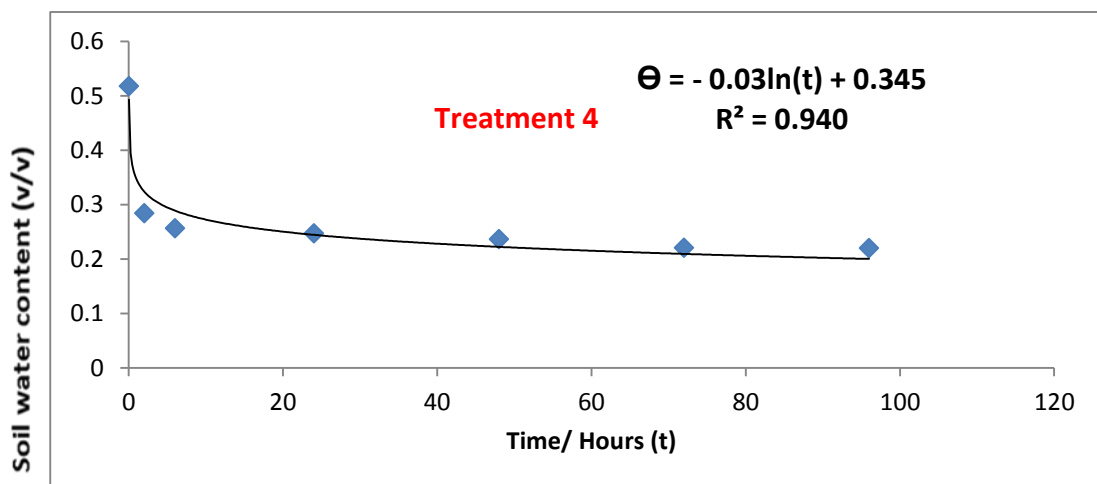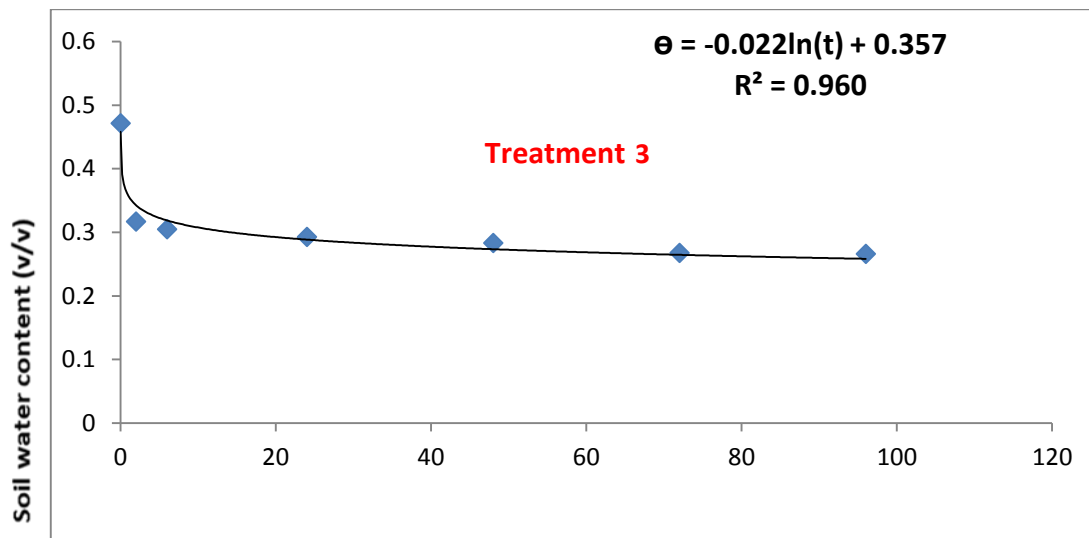| EC$_e$ dS/m	pH	CaCO$_3$%	OM %	Water soluble cations meq/l				Water soluble anions meq/l			
				K$^+$	Na$^+$	Mg^{++}	Ca^{++}	Cl$^-$	SO$_4^-$	HCO$_3^-$	CO$_3^=$
1.86	7.67	9.56	1.38	0.10	9.55	4.23	4.72	10.9	4.11	3.59	nd

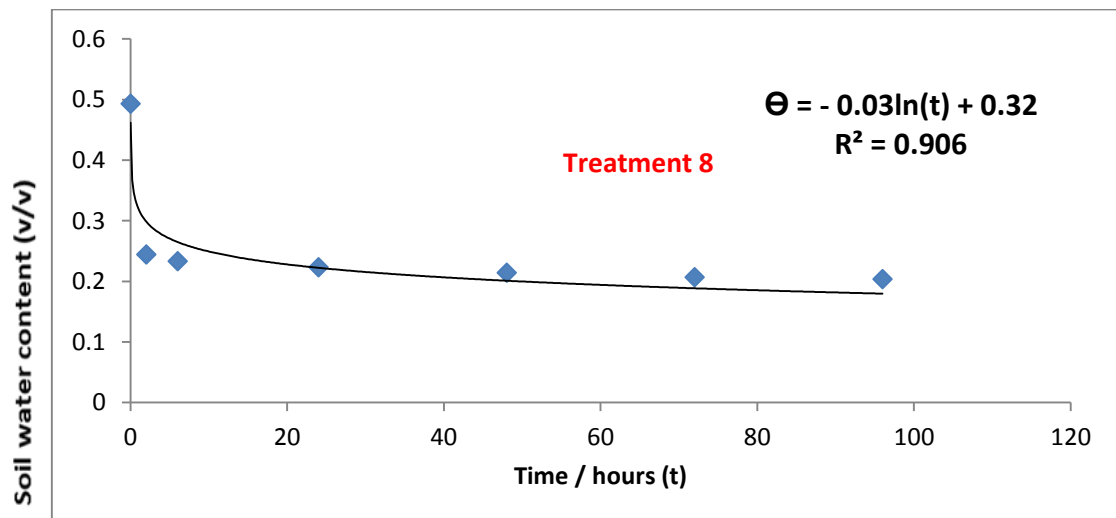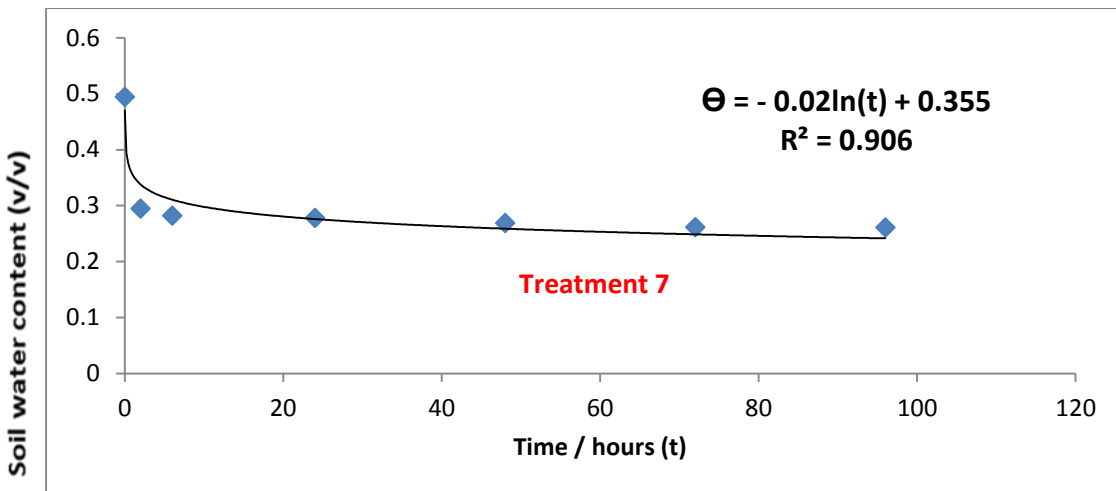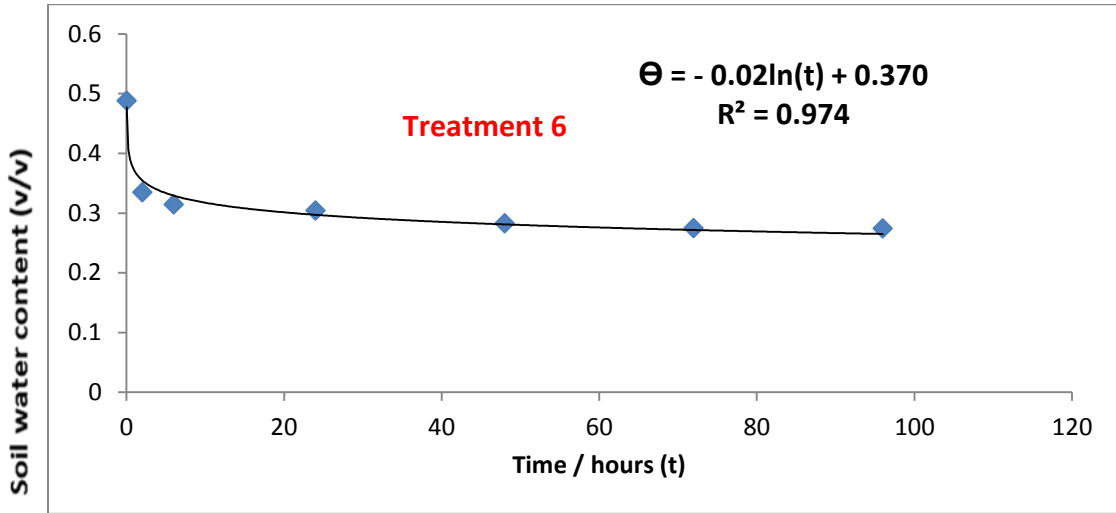nd .... Non detected

Table 3. Characterization of used treatments

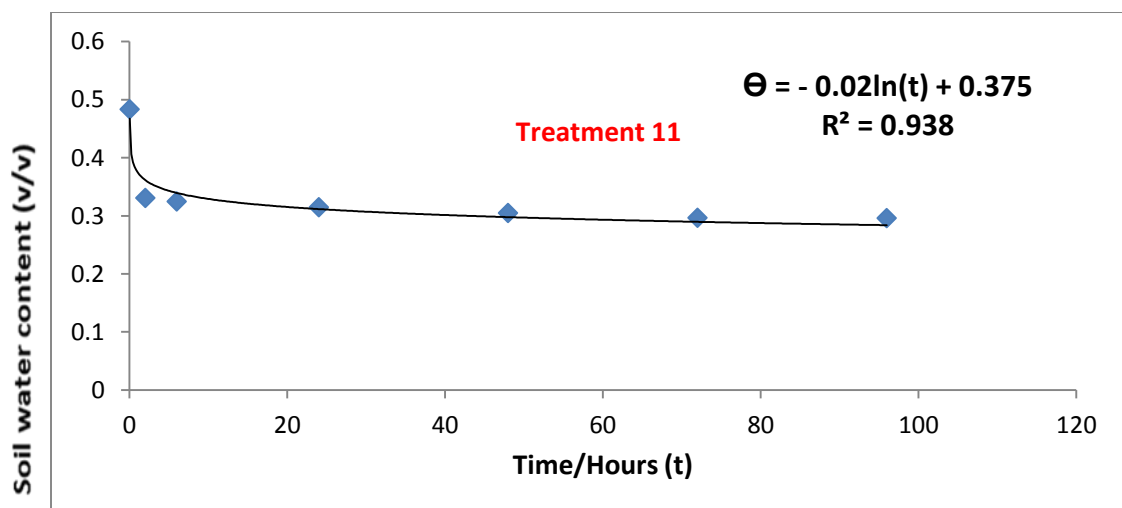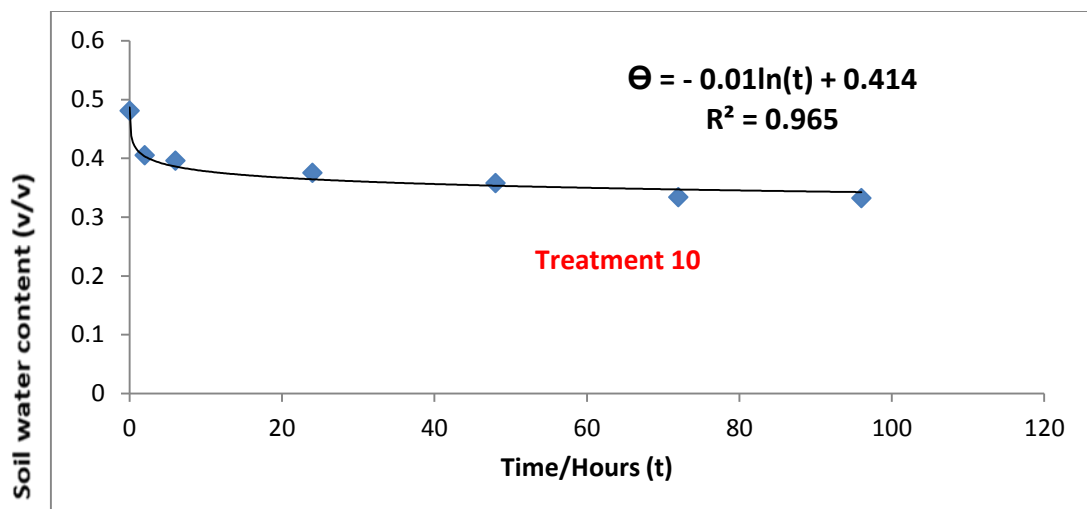| Treatment	Used polymer	Polymer type	Polymer classification
Control	Without any polymer	--	--
Treatment 1	Acrylamide (bis)	Synthetic	Hydrophilic linear polymers
Treatment 2	Acrylic acid	Synthetic	Hydrophilic linear polymers
Treatment 3	Xanthan	Natural	Hydrophilic linear polymers
Treatment 4	Lignosulphonate	Natural	Hydrophilic linear polymers
Treatment 5	1,3,6Beta glucan	Natural	Hydrophilic linear polymers
Treatment 6	Acrylamide + Acrylic acid		
Treatment 7	Acrylamide +xanthan		
Treatment 8	Acrylamide +Lignosulphonate		
Treatment 9	Acrylamide +1,3,6 Beta glucan		
Treatment 10	Acrylic acid+ Xanthan		
Treatment 11	Acrylic acid+ Lignosulphonate		
Treatment 12	Acrylic acid +1,3,6 Beta glucan		
Treatment 13	Xanthan +Lignosulphonate		
Treatment 14	Xanthan+1,3,6 Beta glucan		
Treatment 15	Lignosulphonate +1,3,6 Beta glucan		

The treated soil samples and control one were packed in plastic cups of 5 cm height and 10 cm upper diameter, 8 cm lower diameter (pored base) up to compose a bulk density = 1.65 g / cm^3 with 4 replicates.

Soil cups were saturated with tap water, leaved to drain the excess water through the pored base. After equilibrium, no drain water from plastic cups, each cup was covered with a lid and its weight was recorded after 1, 6, 12, 24, 48, 72 and 96 hours to obtain soil depletion data, **Table (4) and Fig. (1)**.

Θ = - 0.04ln(t) + 0.271
R² = 0.945
Control

Θ = - 0.03ln(t) + 0.320
R² = 0.910
Treatment 1

Θ = - 0.01ln(t) + 0.371
R² = 0.94
Treatment 2

$Ө = -0.022\ln(t) + 0.357$

$R^2 = 0.960$

Treatment 3

$Ө = -0.03\ln(t) + 0.345$

$R^2 = 0.940$

Treatment 4

$Ө = -0.03\ln(t) + 0.316$

$R^2 = 0.951$

Treatment 5

$\Theta = - 0.02\ln(t) + 0.370$

$R^2 = 0.974$

Treatment 6

$\Theta = - 0.02\ln(t) + 0.355$

$R^2 = 0.906$

Treatment 7

$\Theta = - 0.03\ln(t) + 0.32$

$R^2 = 0.906$

Treatment 8

$\Theta = - 0.03\ln(t) + 0.328$

$R^2 = 0.908$

Treatment 9

$\Theta = - 0.01\ln(t) + 0.414$

$R^2 = 0.965$

Treatment 10

$\Theta = - 0.02\ln(t) + 0.375$

$R^2 = 0.938$

Treatment 11

Treatment 12
$$\Theta = -0.02\ln(t) + 0.380$$
$$R^2 = 0.983$$

Treatment 13
$$\Theta = -0.02\ln(t) + 0.319$$
$$R^2 = 0.948$$

Treatment 14
$$\Theta = -0.02\ln(t) + 0.347$$
$$R^2 = 0.943$$

$$\Theta = -0.03\ln(t) + 0.315$$
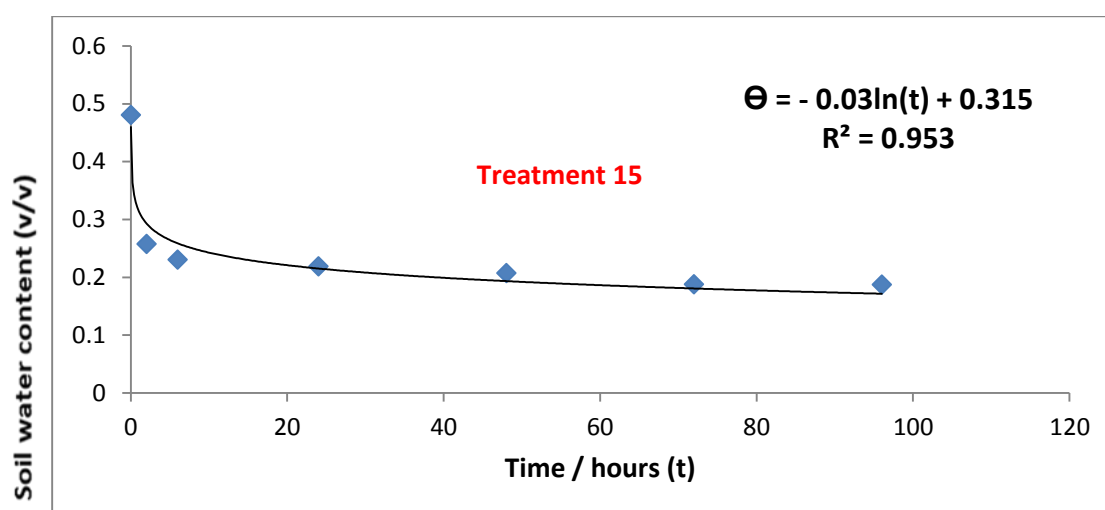$$R^2 = 0.953$$

Treatment 15

Fig. 1. Soil water depletion curve as affected by the investigated treatments

Table 4. Depletion rate and storage capacity of soil water as affected by the investigated treatments

Treatment	Fitted equation	Intercept	Slope	R^2
Control	$\Theta = -0.04\ln(t) + 0.271$	0.271	- 0.04	0.945**
Treatment 1	$\Theta = -0.03\ln(t) + 0.320$	0.320	- 0.03	0.910**
Treatment 2	$\Theta = -0.01\ln(t) + 0.371$	0.371	- 0.01	0.940**
Treatment 3	$\Theta = -0.02\ln(t) + 0.357$	0.357	- 0.02	0.960**
Treatment 4	$\Theta = -0.03\ln(t) + 0.345$	0.345	- 0.03	0.940**
Treatment 5	$\Theta = -0.03\ln(t) + 0.316$	0.316	- 0.03	0.951**
Treatment 6	$\Theta = -0.02\ln(t) + 0.370$	0.370	- 0.02	0.974**
Treatment 7	$\Theta = -0.02\ln(t) + 0.355$	0.355	- 0.02	0.906**
Treatment 8	$\Theta = -0.03\ln(t) + 0.320$	0.320	- 0.03	0.906**
Treatment 9	$\Theta = -0.03\ln(t) + 0.328$	0.328	- 0.03	0.908**
Treatment 10	$\Theta = -0.01\ln(t) + 0.414$	0.414	- 0.01	0.965**
Treatment 11	$\Theta = -0.02\ln(t) + 0.375$	0.375	- 0.02	0.938**
Treatment 12	$\Theta = -0.02\ln(t) + 0.380$	0.380	- 0.02	0.983**
Treatment 13	$\Theta = -0.02\ln(t) + 0.319$	0.319	- 0.02	0.948**
Treatment 14	$\Theta = -0.02\ln(t) + 0.347$	0.347	- 0.02	0.943**
Treatment 15	$\Theta = -0.03\ln(t) + 0.315$	0.315	- 0.03	0.953**

t ... Elapsed time (h)   **Ө ...** Soil water content (v/v)

Intercept refers to water storage capacity of soil
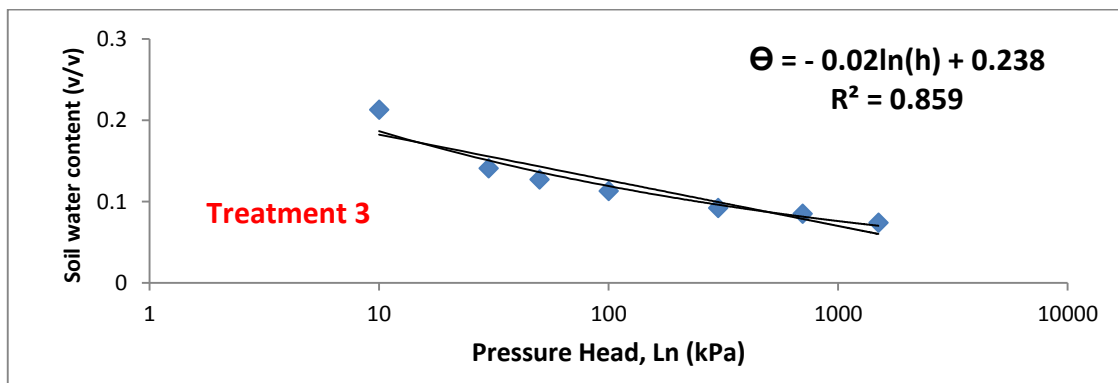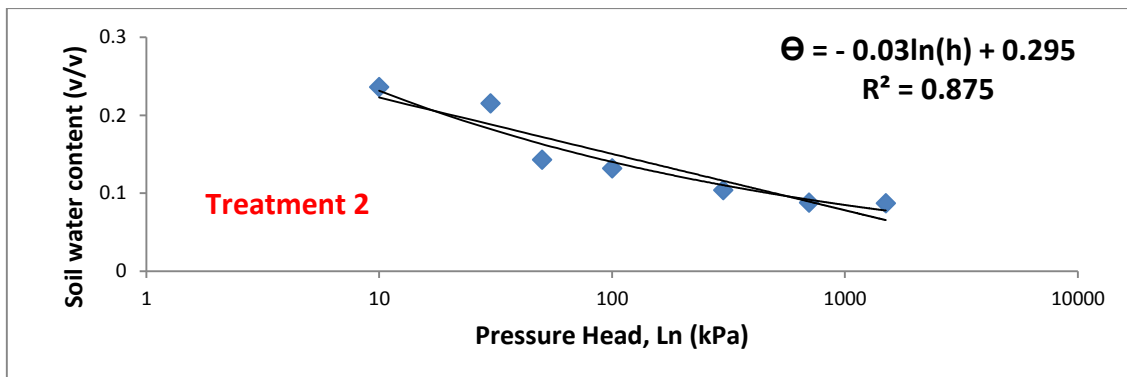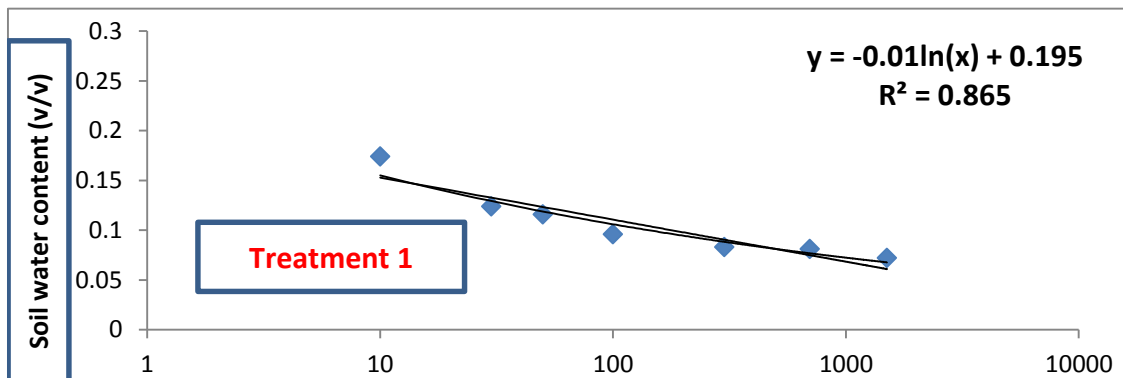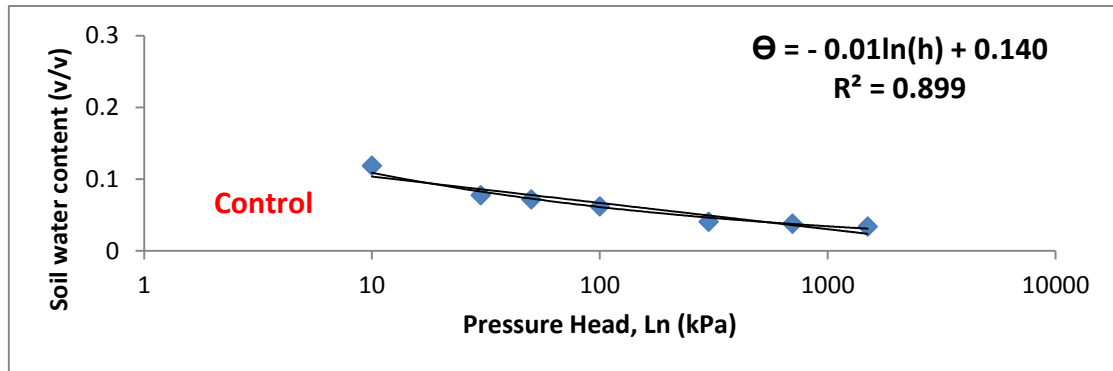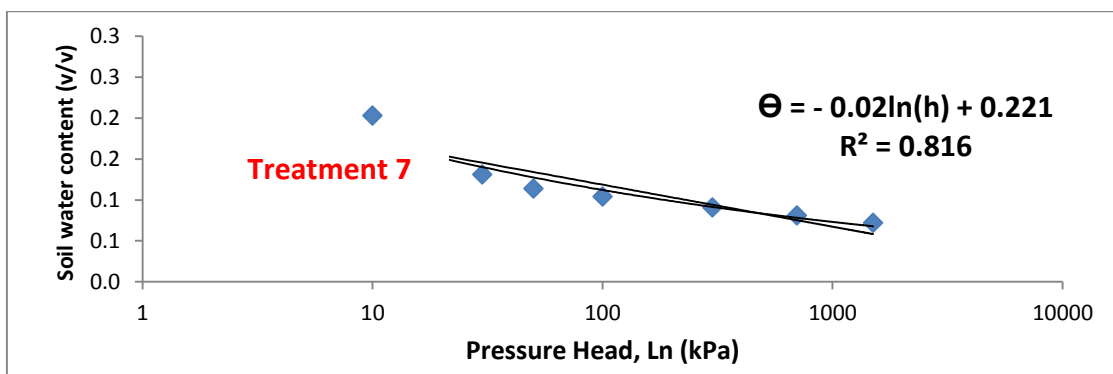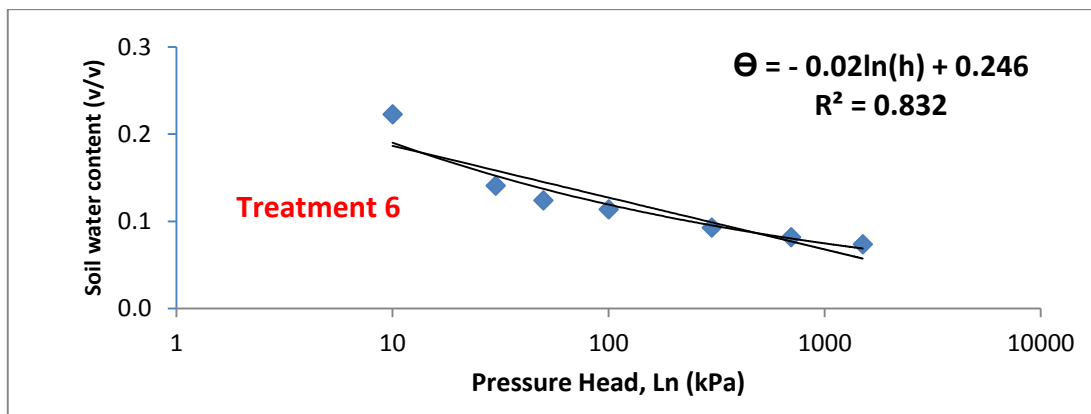
Slope refers to water depletion rate

R² Coefficient of determination

*Significant at 0.05 **Highly significant at 0.01

Soil water retention curve are determined using treated soil sample and control one as described by **Klute (1986)**, then data were presented in Table (5) and illustrated in **Fig. (2)**.

Inflection point of soil water retention curve was calculated from soil water retention data that occur where the second derivative of fitted equation is zero **Bronshtein, (2004).**

The obtained data were subjected to the analysis of variance (ANOVA). The F-test and T-test were used to identify the significance of differences among the control on one side and each other treatment on the other one, (**Steel and Torrie, 1980).** The data were also subjected to simple linear and non-linear regression analyses. The coefficients of determination (R^2) were verified.

Treatment 4

$\Theta = -0.02\ln(h) + 0.212$
$R^2 = 0.921$

Treatment 5

$\Theta = -0.01\ln(h) + 0.196$
$R^2 = 0.927$

Treatment 6

$\Theta = -0.02\ln(h) + 0.246$
$R^2 = 0.832$

Treatment 7

$\Theta = -0.02\ln(h) + 0.221$
$R^2 = 0.816$

Treatment 8

$\Theta = -0.01\ln(h) + 0.186$
$R^2 = 0.855$

Treatment 9

$\Theta = -0.01\ln(h) + 0.199$
$R^2 = 0.906$

Treatment 10

$\Theta = -0.03\ln(h) + 0.343$
$R^2 = 0.807$

Treatment 11

$\Theta = -0.03\ln(h) + 0.319$
$R^2 = 0.819$
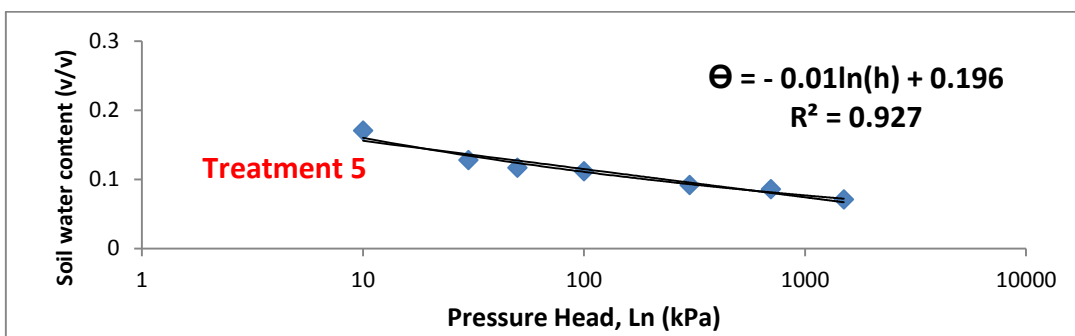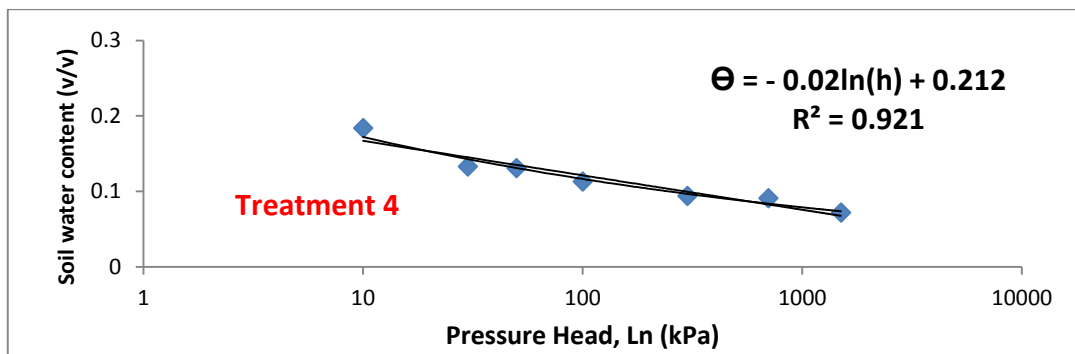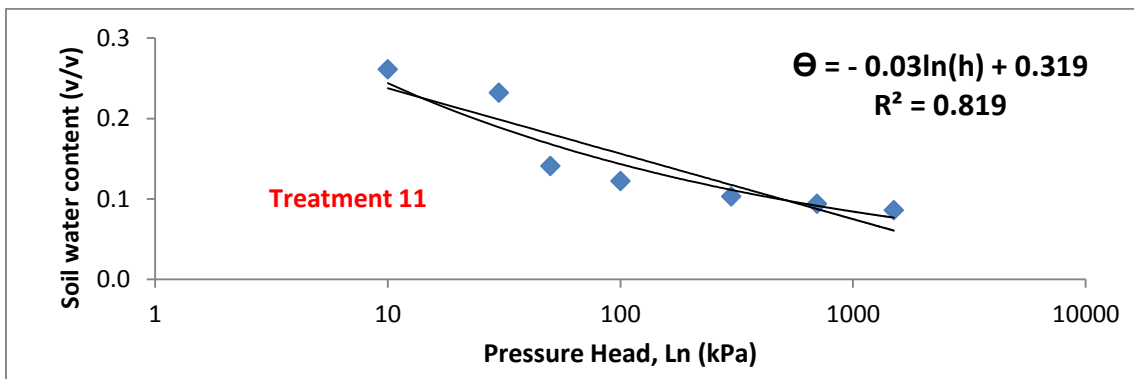
Fig 2. Soil water retention curve as affected by the investigated treatments and their fitted equations

Table 5. Soil water retention equations as affected by the investigated treatments

Treatment	Fitted equation	Intercept	Slope	R^2
Blank	$\Theta = -0.01\ln(h) + 0.140$	0.14	-0.01	0.899**
Treatment 1	$\Theta = -0.01\ln(h) + 0.195$	0.195	-0.01	0.865**
Treatment 2	$\Theta = -0.03\ln(h) + 0.295$	0.295	-0.03	0.875**
Treatment 3	$\Theta = -0.02\ln(h) + 0.238$	0.238	-0.02	0.859**
Treatment 4	$\Theta = -0.02\ln(h) + 0.212$	0.212	-0.02	0.921**
Treatment 5	$\Theta = -0.01\ln(h) + 0.196$	0.196	-0.01	0.927**
Treatment 6	$\Theta = -0.02\ln(h) + 0.246$	0.246	-0.02	0.832**
Treatment 7	$\Theta = -0.02\ln(h) + 0.221$	0.221	-0.02	0.816**
Treatment 8	$\Theta = -0.01\ln(h) + 0.186$	0.186	-0.01	0.855**
Treatment 9	$\Theta = -0.01\ln(h) + 0.199$	0.199	-0.01	0.906**
Treatment 10	$\Theta = -0.03\ln(h) + 0.343$	0.343	-0.03	0.807**
Treatment 11	$\Theta = -0.03\ln(h) + 0.319$	0.319	-0.03	0.819**
Treatment 12	$\Theta = -0.02\ln(h) + 0.244$	0.244	-0.02	0.833**
Treatment 13	$\Theta = -0.01\ln(h) + 0.195$	0.195	-0.01	0.888**
Treatment 14	$\Theta = -0.02\ln(h) + 0.208$	0.208	-0.02	0.896**
Treatment 15	$\Theta = -0.01\ln(h) + 0.178$	0.178	-0.01	0.815**

h ... Pressure head (kPa)   **Θ** ...Soil water content (v/v)
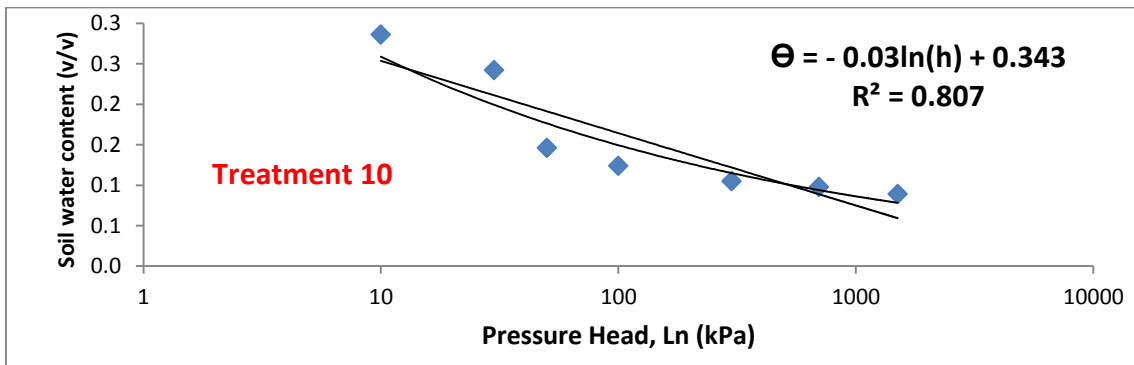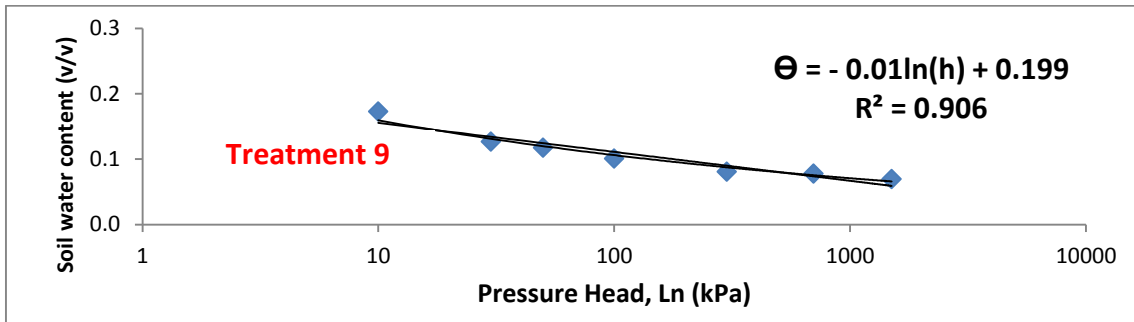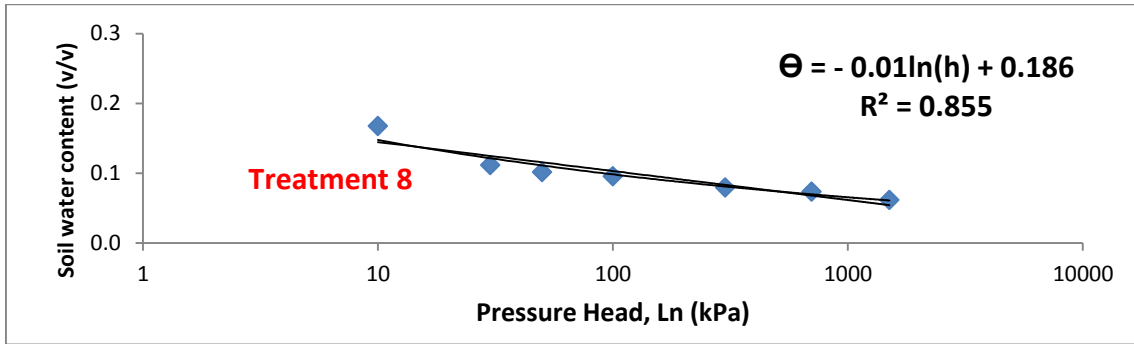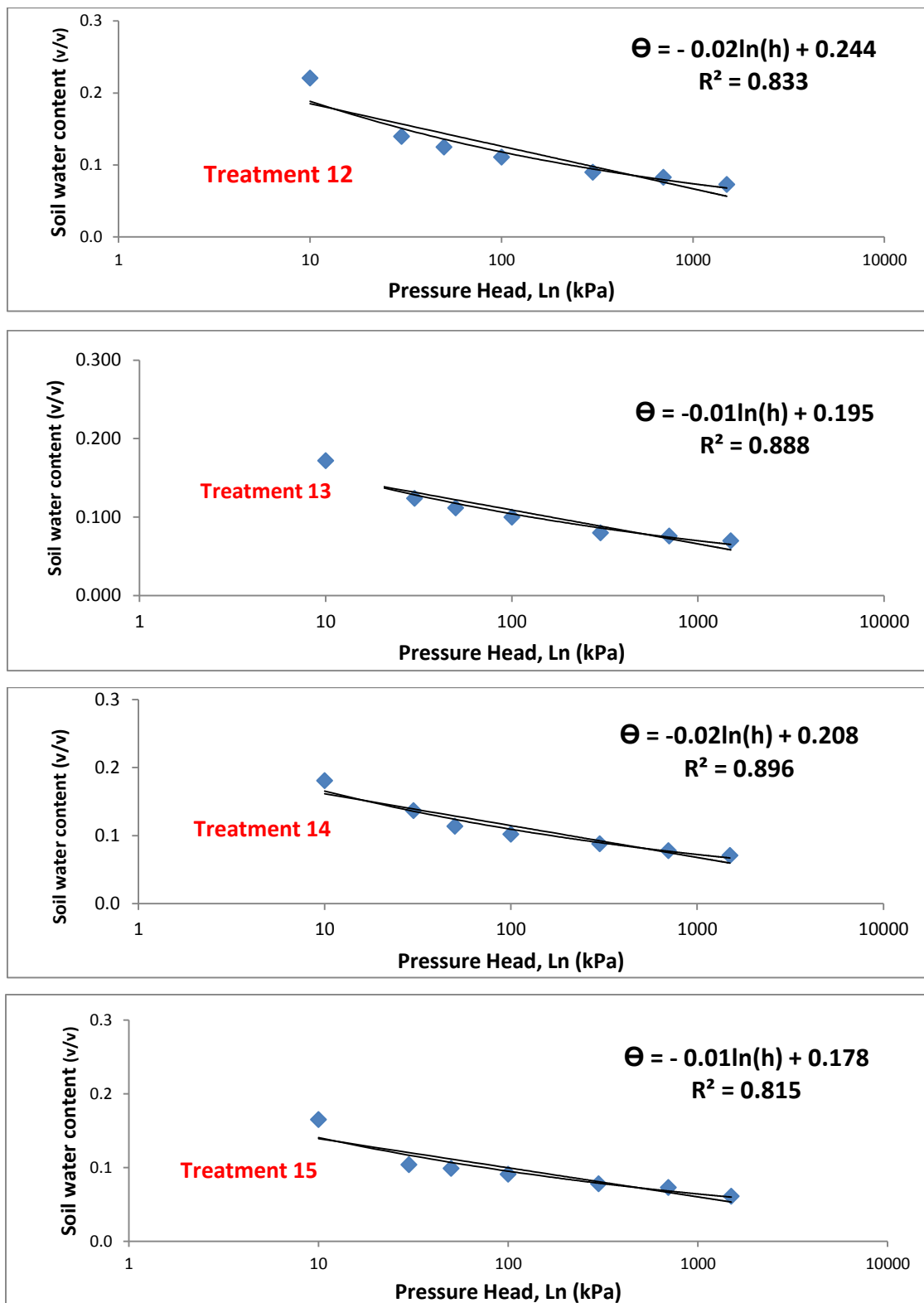* Significant at 0.05   ** Highly significant at 0.01

Table 6. Inflection point at soil water retention curve, field capacity and available water (v/v) of the studied soil sample as affected by the investigated treatments

Treatment	Inflection point (mbar)	Field capacity (v/v)	Available water (v/v)	Readily Available water (v/v)
Control	1000	0.078	0.044	0.057
Treatment 1	775*	0.124*	0.052	0.078*
Treatment 2	665*	0.215**	0.128**	0.104**
Treatment 3	750*	0.141*	0.067*	0.100**
Treatment 4	750*	0.133*	0.061*	0.071*
Treatment 5	900*	0.128*	0.057*	0.059*
Treatment 6	750*	0.141*	0.067*	0.109**
Treatment 7	888*	0.131*	0.059*	0.099**
Treatment 8	666*	0.112*	0.05	0.072*
Treatment 9	777*	0.127*	0.057*	0.077*
Treatment 10	590**	0.242**	0.153**	0.185**
Treatment 11	595**	0.232**	0.146**	0.150**
Treatment 12	830*	0.14*	0.067*	0.110**
Treatment 13	777*	0.124*	0.054*	0.072*
Treatment 14	777*	0.137*	0.066*	0.079*
Treatment 15	666*	0.104*	0.063*	0.074*

Field capacity = θ_{330} .... Soil water content (v/v) at P (mbar)
Available water = $\theta_{330} - \theta_{15000}$ .... Soil water content (v/v) at P (mbar)
Readily available water = $\theta_{100} - \theta_{1000}$ .... Soil water content (v/v) at P (mbar)
* Significant deference at 0.05   ** High significant deference at 0.01

RESULTS AND DISCUSSION

Concerning the effect of adding polymers to the used sandy soil, on soil water storage capacity, **Table (4)** shows this relation with different polymers. The intercepts of the fitted equations that, represent water storage capacity are arranged in the following descending order: $T_{10}>T_{12}>T_{11}> T_2 > T_6> T_3 >T_7 > T_{14}> T_4 >T_9 >T_8 >T_1 > T_5 > T_{15}$.

This finding reveals that the treatments T_{10}, T_{11}, T_{12}, are of the most significant effects on water storage capacity. However, the acrylic acid (Treatment 2) was the polymer of the highest significant effect on retaining water in the soil under atmospheric pressure with high significant. This finding is in harmony with that of **Andy et al (2009)** who found that, using hydrophilic polymers can retain large volume of water exceeds water holding capacity and consequently improve water retention in sandy soils. Data in **Table (4)** reveal also that, water depletion rate which represent with the slope of fitted equation confirmed the aforementioned finding.

Water depletion rate was -0.04 for the control treatment (without adding any polymer) followed by T_1, T_4, T_5, T_8, T_9 and T_{15} whose corresponding value was -0.03 then T_3, T_6, T_7, T_{11}, T_{12}, T_{13} and T_{14} with a value of -0.02.

Finally, T_2 and T_{10} showed the lowest value of water depletion rate, which was 0.01, T_2 (Acrylic acid) was the most effective polymer retaining water in sandy soil.

Inflection point on soil water retention curve divided this curve into two parts; each one of them differs from the other concerning water behavior. Readily available water is found between 10-100 kPa (100-1000 mbar), which represents the available range of soil water. So, if the value of inflection point is more than or equal 100 kPa it means low amount of available water, **(Narjary 2012)**.

Soil water changes in the (0-10 kPa) range (unavailable to plants) occurred due to the soil sample which was not treated with a polymer, (**Narjary et al 2012**).

Water release per unit suction change in the 10-100 kPa range (available to plants) in soil sample not treated with polymer were significantly lower compared to that in soil samples treated with polymers.

Data in **Table (6)** revealed that the highest value of suction at the inflection point was found in the control treatment (not treated soil sample). This value i.e., 1000 mbar (100 kPa) represents the lower limit of readily available water while, T_{10} and

T_{11} recorded the lowest values of suction at inflection point 590, 595 mbar, respectively. Consequently, this means that, T_{10} and T_{11} have the most effective action in retaining water in availability range (10-100 kPa). Concerning the effect of each polymer, **Table (5)** reveals that, the acrylic acid was the most effective polymer whether it was added individually or combined with others.

Data of **Table (6)** reveal that, field capacity increased from 0.078(v/v) (Control) to 0.215, 0.242 and 0.232 (v/v) for T_2, T_{10} and T_{11}. Respectively, while available water increased from 0.044 (v/v) (Control) to 0.128, 0.153 and 0.146 (v/v) for T_2, T_{10} and T_{11}, respectively.

Also, readily available water, increased from 0.057 (v/v) to 0.104, 0.185 and 0.150 (v/v) for T_2, T_{10} and T_{11}, respectively and the difference among these increments were highly significant.

These findings are in agreement with those of **Zhang et al (2006), Andry et al (2009), Dorraji et al (2010), Narjary et al (2012) and Nada & Blumenstein (2015).**

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الصفات الهيدروفيزيقية للأراضى الرملية وتأثرها بنوع البوليمر المضاف

[26]

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الموجـــــــز

أجريت عدة تجارب معملية لتوضيح تأثير أنواع طبيعية وصناعية من البوليمرات على بعض الخواص الهيدروفيزيقية (المعايير الهيدروليكية) للأرض الرملية. أدى إضافة 0.5 % (وزناً) من البوليمر(أو خليط البوليمرات) فى كل معاملة الى تحسن سلوك إحتجاز الماء فى التربة معنوياً عند التشبع بالماء وعند السعة الحقلية والماء الميسر والماء جاهز التيسر، وكذلك أدى الى إنخفاض قيمة نقطة الإنقلاب على منحنى الشد الرطوبى كنتيجة لتحسن سلوك الماء فى التربة.

أوضحت النتائج المتحصل عليها أن السعة التشبعية العظمى للتربة قد ازدادت زيادة معنوية من 0.271 (حجماً) فى معاملة الكنترول الى 0.414 فى المعاملة العاشرة والتى تتكون من خليط متساوى من Acrylic acid+ Xanthan، بينما ازدادت قيم السعة الحقلية زيادة معنوية من 0.078 (حجما) فى معاملة الكنترول الى 0.242 فى المعاملة العاشرة سالفة الذكر. وبخصوص تأثير إضافة البوليمر على كل من الماء الميسر والماء الجاهز التيسر فإن النتائج أظهرت زيادة معنوية لكل منهما، حيث زادت نسبة الماء الميسر من 0.044 حجماً (فى معاملة الكنترول) الى 0.153 حجماً (فى المعاملة رقم 10)، بينما فى حالة الماء جاهز التيسر فقد ازداد من 0.057 حجماً – فى معاملة الكنترول – الى 0.185 حجما فى المعاملة العاشرة

أيضاً. بخصوص قيمة الشد الرطوبى عند نقطة الانقلاب على منحنى احتجاز الماء فإن النتائج أظهرت أن قيمة نقطة الانقلاب فى المعاملة رقم (10) قد تناقصت بفرق معنوى جداً من 1000 ملليبار فى معاملة (الكنترول) إلى 590 ملليبار فى حالة المعاملة العاشرة. إنخفض معدل الإستنزاف الرطوبى من التربة بنسبة تتراوح ما بين 25 – 75 % كنتيجة لإضافة البوليمرات حسب نوع البوليمر وحالته اذا أضيف منفردا أو كخليط مع بوليمر أخر. أدى هذا التأثير إلى وجود فرق معنوى بين تجربة الكنترول والمعاملات المختلفة.

وقد أظهرت النتائج تأثيرات معنوية لكل البوليمرات المستخدمة على الصفات الهيدروفيزيقية المقصود بها البحث مثل سعة حفظ الماء بالتربة ومعدل الإستنزاف منها وكذلك السعة الحقلية والماء الميسر والماء جاهز التيسر ونقطة الإنقلاب على منحنى إحتجاز الماء بالتربة. بينما أظهر Acrylic acid أفضل النتائج بالنسبة لسلوك الماء فى الأرض الرملية سواء أضيف منفرداً (Treatment 2) أو كخليط مع Xanthan (Treatment 11) Lignosulphonate. أو كخليط مع (Treatment 10).

الكلمات االمفتاحية: الخصائص الفيزيائية للتربة، الماء المتاح، الماء الميسر، نقطة الانحراف، السعة الحقلية، بوليمرات طبيعية، بوليمرات صناعية