Menoufia J. Plant Prod., Vol. 4 December (2019): 489 - 503

RESPONSE OF *CONOCARPUS ERECTUS* L. PLANTS GROWN ON SANDY SOIL TO HYDROGEL APPLICATION UNDER DEFICIT WATER CONDITIONS

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Received: Sep. 18 , 2019 Accepted: Oct. 2 , 2019

ABSTRACT: ***Water deficit is a main factor of limiting the growth of plants, particularly in arid and semi-arid regions. So this study was conducted in order to assess the influence of applying hydrogel polymers to minimize the negative effects caused by deficit water. Hence, An experimental pots was carried out during 2017 and 2108 seasons at the nursery of Sakha Horticultural Research Station, Horticultural Research Institute, Agricultural Research Center to study the effect of tow irrigation intervals (4 and 8days) and four hydrogel rates (0.0, 0.2, 0.4 and 0.6 % g/g) and their interactions on the growth traits and nutrition status of Conocarpus erectus L. plants as well as some soil properties were investigated. The obtained results point out that, growth parameters (plant height, number of shoots and leaves/plant and stem thickness, shoot fresh and dry weight and total green color) as well as the leaf mineral contents were significantly increased when buttonwood seedlings were watered every four days than when they were watered every eight days in both season. Conversely, leaf proline content was increased under irrigation every 8 days. in addition, adding hydrogel at 0.4 or 0.6 caused a significant increase in the previous growth aspects but decreased leaf proline content compared to the control. Both low irrigation period (4 days) or high of hydrogel rate (0.6% w/w) and their interaction gave the highest values of leaf total and free water contents as well as bound water and osmotic pressure were reduced. Finally, the largest rates of the hydrogel amendment (0.4 and 0.6%) under irrigation every 4 or 8 days extended the loss of soil water, increased the plant ability reflected in the accessible soil water and thus enhanced the growth parameters of the seedlings.***

Key words: ***Water absorbing soil amendments, Conocarpus erectus L. plants, growth, water saving***

INTRODUCTION

Conocarpus erectus **L. is a multi-trunked, evergreen plant (1-4 m high) that can grow into a tree up to 20 m. It belongs to the family of Combretaceae and is frequently referred to as buttonwood and grows in tropical and subtropical districts. The root system consists of lateral and fine roots. The bark is fibrous and moderately thin. The leaves are spirally arranged, somewhat fleshy, with petioles. Inflorescences are terminal and small flowers in spheroidal heads are grouped. The bark and leaves have been used in tannery. Its timber is commonly used for high-grade charcoal and housing. (Al-Humaid and Moftah, 2007 and Hegazy *et al.*, 2008).**

Due to the growing demand for wood products and bio-energy biomass, efforts are presently being made to boost the output of timber throughout the globe. New desert lands are areas that may be accessible for this purpose, where water shortages are generally the limiting factor for planting.

Under climatic changes and water resource limitations facing Egypt, we should do our best to efficiently renationalize orchard-level irrigation water. Water is one of the most critical crop production factors in Egypt. Rainfall is small, so most agricultural output depends on irrigation for the most part. Water resources on the Nile River are restricted and focused (El-Kady and Borham, 2013).

Minimizing water losses can be implemented with soil modifications that enhance the physical characteristics of the soil and boost the effectiveness of water irrigation and rationalization of water irrigation (Esteban *et al.*, 2011). One of the latest soil modifications applied in this regard is the use of water-saving modifications, i.e. hydrogel polymers to enhance water and nutrient effectiveness, which become more essential over time, especially in arid and semi-arid areas with limited water sources. Under water circumstances, soil water and nutrients stored in hydrogel are gradually released for plant growth (Yazdani *et al.*, 2007). Hydrogel is sometimes referred to as "Root watering crystals" or "water retention granules" because it swells like sponges to be as many times the initial size when it comes into contact with water, thus increasing the ability of soil water retention and decreasing irrigation frequency (Huttermann *et al.,* 1999, Ghasemi and Khoshkhoe, 2007). The primary objectives of this research were therefore to explore the impact of irrigation intervals at distinct hydrogel rates on the growth of *Conocarpus erectus* L. seedling as well as soil properties in the form of a pot experimental research.

MATERIALS AND METHODS

Experimental site and plant material

During the 2017 and 2018 seasons, an experimental pot was conducted in the nursery of Sakha Horticultural Research Station, Horticultural Research Institute, Agricultural Research Center, North Middle Nile Delta, Egypt (31° 77 ' N latitude and 30° 57 ' E longitude at an altitude of approximately 6 meters above sea level) to study the effect of hydrogel rates and on the growth of *Conocarpus erectus* L. under irrigation intervals. The study period meteorological information were provided in Table 1.

Table (1): Average of the monthly meteorological data during the two growing seasons.

Month	T (C^o)*		RH%		W_S	Pan Evap.
	Max	Min	Max	Min	m/sec	mm/day
April.	27.2	20.8	80.2	47.4	81.7	497.7
May	30.9	24.8	76.7	44.8	101.2	646.5
June	32.6	26.7	77.8	49.7	100.5	740.2
July	34.2	27.2	83.5	54.3	58.2	690.6
Agus.	33.9	26.8	84.2	43.4	73.1	623
Sep.	32.7	24.7	84.7	49.3	77.2	517.3
Oct.	29.1	22.3	81.8	52.2	65.6	325.2

T: temperatures, RH: relative humidity, Ws: wind speed

*Source: Meteorological Station at Sakha, Kafr EL-Sheikh Governorate.

Conocarpus erectus L. seedlings were obtained from a commercial nursery and transplanted to plastic pots (30 x 21cm about 6kg/ pot) filled with a washed sand. On the second week of April in both seasons (beginning of the study), healthy seedlings of uniformly height were selected (average height was 20±5cm). The soil mixture was then prepared from the previous washed sand and hydrogel in dry form.

Experimental soil analysis

The physical and chemical properties as well as soil moisture content of the soil used before beginning the experimental were determined according to Jackson (1967) and Black *et al*. (1965) and are given in Table (2). Pots were immediately watered after placing the hydrogel levels. All seedlings were fertilized according to recommendation rates with NPK (1:1:1) at 20g/pot.

Experimental design and treatments:

Seventy two uniform seedlings were selected and arranged in a factorial randomized complete block design. The combinations between the two factors; the irrigation intervals (A) and the hydrogel rates (B) in addition to their interactions resulting eight treatments (2 irrigation intervals x 4 rates of hydrogel) each treatment were replicated three times with three seedlings for each replicate (3 replicates x 3 seedlings). as follow:

I. Factor A was assigned in two irrigation intervals as, irrigation every 4 and 8 days

The quantity of irrigation water applied (l/plant/year) and number of irrigations in the different irrigation treatments during each growing season were showed in Table (3).

II. Factor B was aranged for four soil applications of hydrogel at rates of 0.0 as control, 0.2,0.4 and 0.6% (g/g)

Hydrogel polymer known "Aquagool" (40% Hydro polymer, 6.5%N, 4.8%P, 8.2%K and hold capacity at 300-500%) produced by Lucky Star TG., Egypt

Table (2): Some chemical, physical properties and soil moisture constant of the soil used.

Ec (dSm^{-1})	O.M (%)	pH	Soluble catine (*meq/l*)			Soluble anions (*meq/l*)			
			Ca^{++}	Mg^{++}	K^{+}	Na^{+}	So_4^{--}	HCO_3^{-}	Cl^{-}
2.03	0. 06	7.80	5.7	3.5	0.2	10.9	6.7	5.3	8.3

Particle size divisions (%)			Textural class	Soil moisture properties (%)		
Sand	Silt	Clay		FC*	WP*	AW*
98.2	1	0.8	Sandy	8.4	2.8	5. 6

*= FC: Field capacity, WP: wilting point, AW: available water

Table (3): The quantity of irrigation water applied (l/plant/y.) and number of irrigations in the different irrigation treatments (average of two seasons).

Irrigation intervals	Number of irrigations	Water applied (l/plant/season)
4 days	46	46
8 days	23	23

The following data were recorded:

1-Vegetative growth traits:

On 20th and 25th October in 2017 and 2018 seasons, respectively, after 6 months of planting, eight plants per treatment were randomly sampled. Plant height and root length (cm) were measured, also number of shoots and leaves /plant were counted. As well as chlorophyll index (total green color) was estimate according to Yadava (1986) by using chlorophyll meter (A Minolta SPAD). Afterwards, seedlings were cut at the cotyledon insertion point and separated into shoots (main stem+ branches+ leaves) and roots., in addition to determining shoots and roots fresh and dry weights (g). Roots fresh samples were carefully thoroughly washed with tap water in order to get rid of the remaining soil mixture then dried on filter papers and immediately weighed. The seedling parts dry weights were determined by drying samples at 70 ^{o}C to a constant weight for approximately 48hr. The shoot: root ratio (g/g) was calculated from the obtained dry weights.

2-Nutritional status:

Leaf mineral content:

At the end of November 20 mature leaves/ plant were sampled in both seasons, washed, dried at 70°C to a constant weight ground and digested for determination leaf mineral content. Nitrogen was determined by Micro-kjeldahl method as outlined by Chapman and Pratt (1978). Phosphorus was determined using spectrophotometer according to Murphy and Riely (1962). Potassium determined by flame photometer according to Jackson (1967).

Leaf proline content (µ mole/g). was determined conferring to Bates *et al.,* (1973).

3-Water Relation:

Total and free water contents in leaf tissues, also bound water content and osmotic of the cell sap of leaves were determined according to the method described by Koshirinko *et al.* (1970).

4- Soil properties

Physical characteristics of the studied soil such as soil field capacity (FC), permanent wilting point (PWP) and available water were determined according to Klute (1986)

Statistical analysis

Data were analyzed by MSTATC computer software program (Bricker, 1991). The obtained data were subjected to analysis of variance according Snedecor and Cochran (1990). Duncan's multiple range test (Duncan, 1955) at 5% level was used to compare the means.

RESULTS AND DISCUSSION

1- Vegetative growth parameters:

Data presented in Tables (4 and 5) show the impacts of irrigation intervals, hydrogel rates and their interaction on buttonwood seedlings growth characteristics during the 2017 and 2018 seasons. By reducing irrigation intervals and increasing hydrogel rates relative to control, growth characteristics were generally enhanced.

a. Plant height, number of shoots and leaves/plant and stem thickness

Results presented in Table (4) showed that plant height, number of shoots and leaves/plant and stem thickness were significantly increased when buttonwood seedlings were watered every four days than when they were watered every eight days in both season. The reduction in vegetative growth under watering every 8 days (watering regime) could be attributed to minimal availability of assimilation by decreasing net photosynthesis under water stress (Mpelascoka *et al.*, 2001) In addition, drought stress prompted the development of abcisic acid (ABA) in the root and vegetative parts and enhanced consistency of reactive oxygen species (ROS) to reduce vegetative growth. (Atkinson *et al.,* 2000). These results agree with the findings of El-Kady and Borham (2013) on buttonwood plants and Kargar *et al.,* (2017) on silver maple, who indicated that, under water deficit, the values of vegetative growth parameters were significantly decreased. Seedlings grown in soil amended with hydrogel exhibited higher values of former mentioned growth parameters than those grown in soil without hydrogel. The highest values were obtained from soil amended with 0.6% (g/g) hydrogel more than the other rates in both seasons. The increment in vegetative growth parameters due to hydrogel applications may be due to improvement of water holding capacity and physical properties of the soil, better absorption of irrigation water and its storage in the soil and so, prevent the moisture stresses which reflected on vegetative growth (Sheikh *et al.,* 2010). In addition, Andry *et al.,* (2009) confirmed the effects of superabsorbent polymers in density and growth of the root due to improvement in physical condition of the soil. This growth increase is caused by indirect role of amendment materials increase N, P and k uptake by the plant, appropriate aeration and available water by increasing the water holding capacity of the soil which reduce water stress of plants resulting in increased growth and plant performance. However. Al-Humaid and Moftah (2007), Orikiriza *et al.,* (2009) and Hassan *et al.,* (2017), reported that incorporation of hydrogel in sandy soil significantly increased the growth parameters.

Table (4): Effect of irrigation intervals, hydrogel rates and their interaction on plant height, No. of shoots and leaves/plant and stem thickness of *Conocarpus erectus* L. plants in 2017 and 2018 seasons.

Treatments		Plant height (cm)		No. of Shoots/plant		No. of leaves/plant		Stem thickness(cm)	
		2017	2018	2017	2018	2017	2018	2017	2018
Irrigation intervals									
4 days		71.25a	72.92a	27.67a	28.17a	399.4a	395.8a	1.18a	1.16a
8 days		66.58b	68.58b	23.75b	24.75b	338.8b	341.9b	1.01a	1.01b
Hydrogel rates (%)									
0.00 (Cont.)		61.50d	63.17d	19.83de	20.83d	297.2d	304.2d	0.92d	0.92c
0.2		66.17c	68.83c	24.50c	25.00c	352.3c	349.0c	1.07c	1.00c
0.4		70.00b	72.00b	27.50b	28.50b	400.0b	395.8b	1.15b	1.13b
0.6		78.00a	79.00a	31.00a	31.50a	426.8a	426.3a	1.25a	1.28a
Interaction (I x H)									
4 days	0.00(Cont.)	65.00d	66.33e	22.33d	23.67d	319.7e	325.3e	1.03de	1.00cde
	0.2	69.00c	71.00c	27.00c	26.67c	403.3c	394.7c	1.13bc	1.10bc
	0.4	71.00c	73.67bc	29.00b	29.67b	424.3b	411.7b	1.20b	1.20ab
	0.6	80.00a	80.67a	32.33a	32.67a	450.3a	451.3a	1.37a	1.33a
8 days	0.00(Cont.)	58.00e	60.00f	17.33e	18.00e	274.7g	283.0g	0.80f	0.83e
	0.2	63.33d	66.67de	22.00d	23.33d	301.3f	303.3f	1.00e	0.90be
	0.4	69.00c	70.33cd	26.00c	27.33c	375.7d	380.0d	1.10cd	1.07bcd
	0.6	76.00b	77.33ab	29.67b	30.33b	403.3c	401.3c	1.13bc	1.23ab

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

Table (5): Effect of irrigation intervals, hydrogel rates and their interaction on shoot fresh and dry weight, root length and total green color of *Conocarpus erectus* L. plants in 2017 and 2018 seasons.

Treatments		Shoot fresh weight (g)		Shoot dry weight (g)		Root length (cm)		Total green color (SPAD)	
		2017	2018	2017	2018	2017	2018	2017	2018
Irrigation intervals									
4 days		116.02a	115.8a	37.62a	37.07a	43.08a	42.67a	109.17a	82.48a
8 days		88.05b	74.08b	29.70b	24.78b	38.75b	40.33b	90.00b	66.62b
Hydrogel rates (%)									
0.00 (Cont.)		75.87b	67.87d	26.03b	23.37d	36.50c	38.33c	89.20d	59.65c
0.2		86.20c	84.52c	29.37c	28.67c	40.50b	41.50b	94.60c	73.63b
0.4		109.08b	100.32b	37.68b	32.38b	41.66b	42.67a	105.02b	76.05b
0.6		136.98a	127.23a	41.55a	39.27a	45.00a	43.5a	109.52a	88.85a
Inter action (I x H)									
4 days	0.00(Cont.)	95.90cd	96.07c	32.33e	29.47c	37.66cd	39.67e	93.13cd	64.17c
	0.2	102.33c	109.7b	33.33e	38.33b	42.33bc	42.66bc	100.37b	82.30b
	0.4	125.13b	121.23b	40.27b	39.20ab	43.66b	44.00ab	119.87a	83.17b
	0.6	140.7a	136.53a	44.53a	41.27a	48.66a	44.33a	123.30a	100.26a
8 days	0.00(Cont.)	55.83f	39.67f	19.73g	17.27e	35.33d	37.00f	85.27e	55.13d
	0.2	70.07e	59.33e	25.40f	19.00e	38.67cd	40.33de	88.83de	64.97c
	0.4	93.03d	79.40d	35.10d	25.57b	39.67bcd	41.33cd	90.17cde	68.93c
	0.6	133.27ab	117.93b	38.57c	37.27b	41.33bc	42.67bc	95.73bc	77.43b

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

With regard to the interaction between irrigation intervals and hydrogel rates the results show that the highest values of growth parameters were recorded for seedlings irrigated every 4days and grown in sandy-amended soil with 0.6% hydrogel for both seasons.

b. Shoot fresh and dry weight, root length and total green color (SPAD)

The peak values of the previously listed growth parameters were achieved at a 2-day irrigation interval, whereas the minimum values were attained by seedlings subjected to deficit irrigation (irrigation every 8 days) in both seasons (Table, 5). These results are in agreement with those of Afsharmanesh, (2009) and Kamal and El-Shazly (2013).

For hydrogel treatments (Table, 5), the results showed that, soil application of 0.6% g/g hydrogel gave the higher values of the growth parameters than the other hydrogel rates, compared with the least growth parameters obtained with control. Hydrogel had a beneficial impact on the aspects of vegetative growth owing to the implementation of hydrogel at distinct concentrations, the rooting medium can absorb and store large amounts of water during both irrigation periods and then gradually release water when required (Shi *et al.,* 2010). This hydrogel characteristic helps to improve the root development and thus the entire plant growth traits. Similar results were noticed by Arbona *et al.,* (2015) on young citrus plants Chirino *et al.,* (2011) on Cork oak plants.

There was a significant interaction between irrigation periods and hydrogel rates on the vegetative aspects (Table, 5). Under irrigation every 4 days and hydrogel concentration (0.4 or 0.6%) the growth values were pronouncedly higher than those irrigated every 8 days without hydrogel (deficit irrigation treatment).

2-Nutritional status:
Leaf mineral and proline content:

Table (6) displayed that leaf N, P and K responded specifically to irrigation intervals. Hence, irrigated seedlings every 4 days had statistically the highest mineral (%) in leaves, while the reverse was true with those watered every 8 days (watering regime). The positive effects of irrigation every 4 days on mineral uptake could be due to its enhancing effect on transport of dissolved nutrients by mass flow also, the suitable balance of moisture in plant creates favorable conditions for photosynthesis and metabolites translocation, which accelerate the rate of nutrients uptake. On the other hand, the uptake of nutrients was retarded under irrigation deficit circumstances and this may be due to reducing active rooting. Analogous noting has been reported Mostafa (2017) on *Conocarpus erectus* L. plants, who found that irrigation transplants every 2 days gave the highest N, P and K (%) in leaves, while irrigation every 4 days gave the lowest values .In the same line, Zoghdan, and Abo El-Enien(2019) on Citrus trees found that the percentage of mineral nutrition in the leaves were decreased under deficit irrigation treatments. Adding the hydrogel polymer at rate 0.6 or 0.4%(g/g) was the best treatment for increasing leaf N, P and K content compared to the control. According to the previous results, it could be concluded that application of hydrogel enhances leaf mineral contents because hydrogel enables absorbing and retaining considerable amount of water and nutrients that would be slowly released into tree roots. This may be due to the increase in the nutrient use efficiency of soil treated with treatments and improving in physio-chemical conditions of soil and affecting the trees response to mitigate drought (Buchholz and Graham, 1998). These results are in harmony with those reported by Anupama *et al.,* (2007), Chirino *et al.,* (2011), Kamran and Chamheidar (2014) on *Pyracantha coccinea* plants. With regard to, the effect of interaction (irrigation intervals x hydrogel rates), data of both seasons showed that, irrigation every 4 days treatment combined with the highest rates of hydrogel (0.6%) resulted the highest values of leaf mineral content.

Irrigation intervals treatments showed significant variations in leaf proline content. The highest values in this respect (0.47 and 0.46µ mole/g fw) were recorded with deficit irrigation treatment (irrigation every 8 days), but the lowest values (0.35 and 0.35 µ mole/g fw) were recorded under irrigation interval every 4 days in both seasons, respectively (Table, 6). These results negatively exposed the correlation between irrigation rates and proline content as this means that under water stress the hydrolysis of proteins increases which increases accumulation of proline content in the leaves. Leaf proline content was increased with decreasing hydrogel rates from 0.0 up to 0.6%. The highest values in this respect were recorded by the control (0.0%) meanwhile the least values were obtained with the high rates (0.6% g/g) in both seasons. The maximum and minimum values of leaf proline content belonged to the combined treatment of irrigation every 8 days x hydrogel at 0.0% and irrigation every 4 days x hydrogel at 0.6%, respectively. In the same line, Ennab and El-Sayed (2014) and Abo El-Enien *et al.,* (2019) stated that proline content in the leaves was increased under deficit irrigation conditions.

Table (6): Effect of irrigation intervals, hydrogel rates and their interaction on leaf mineral and proline contents of *Conocarpus erectus* L. plants in 2017 and 2018 seasons.

Treatments		N (%)		P (%)		K (%)		Proline (µmole/gFW)	
		2017	2018	2017	2018	2017	2018	2017	2018
Irrigation intervals									
4 days		1.80a	1.74a	0.35a	0.33a	1.41a	1.42a	0.35b	0.35b
8 days		1.62b	1.52b	0.24b	0.23b	1.33b	1.32b	0.47a	0.46a
Hydrogel rates (%)									
0.00 (Cont.)		1.50d	1.50c	0.26d	0.25d	1.35c	1.35c	0.46a	0.45a
0.2		1.60c	1.53c	0.29c	0.26c	1.36bc	1.36c	0.43b	0.42b
0.4		1.82b	1.68b	0.30b	0.30b	1.37b	1.37b	0.39c	0.39c
0.6		1.93a	1.80a	0.34a	0.32a	1.40a	1.41a	0.36d	0.35d
Inter action (I x H)									
4 days	0.00(Cont.)	1.58de	1.59de	0.31d	0.29d	1.39b	1.39c	0.41d	0.39d
	0.2	1.67cde	1.61d	0.34c	0.31c	1.40b	1.40bc	0.38e	0.38e
	0.4	1.90b	1.83b	0.35b	0.35b	1.41ab	1.42b	0.33f	0.33f
	0.6	2.06a	1.91a	0.40a	0.38a	1.43a	1.47a	0.30g	0.30g
8 days	0.00(Cont.)	1.42f	1.40f	0.20h	0.21g	1.30e	1.30f	0.51a	0.50a
	0.2	1.53ef	1.45f	0.23g	0.22g	1.32de	1.31ef	0.48b	0.47b
	0.4	1.73cd	1.53e	0.25f	0.24f	1.33d	1.32e	0.46c	0.45c
	0.6	1.81bc	1.70c	0.29e	0.27e	1.36c	1.35d	0.42d	0.40d

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

3-Water relation:

Results presented in Table (7) revealed that, total and free water contents in leaf tissues were markedly increased by decreasing irrigation periods from 8 up to 4 days. Deficit irrigation treatment (irrigation every 8 days) recorded the signeficantly least values in 2017and 2018 seasons. The decrease in the total and free water content under deficit irrigation (irrigation every 8 days) could be resulted from the reduction of water absorption by the roots. In contrast, the highest values of bound water content and osmotic pressure were recorded with the lower irrigation rate (irrigation every 8 days). These results are in partial agreement with teh findings obtained by Helalya *et al.,* (2017) and Abo El-Enien *et al.,* (2019) on fruit trees. They found that, total and free water contents in leaf tissues were significantly decreased while bound water content and osmotic pressure were increased with deficit irrigation.

Table (7): Effect of irrigation intervals, hydrogel rates and their interaction on some water relation parameters in leaves of *Conocarpus erectus* L. plants in 2017 and 2018 seasons.

Treatment		Total water content (%)		Free water content (%)		Bound water content(%)		Osmotic pressure(atm)	
		2017	2018	2017	2018	2017	2018	2017	2018
Irrigation intervals									
4 days		60.37a	61.18a	45.62a	44.37a	14.76b	16.82b	15.42b	14.82b
8 days		51.73b	52.80b	34.73b	33.29b	17.01a	19.52a	17.52a	17.37a
Hydrogel rates (%)									
0.00 (Cont.)		53.22d	54.20d	37.18d	35.35d	16.60a	18.53a	17.62a	17.50a
0.2		54.73c	56.06c	39.52c	37.53c	15.67bc	18.85a	17.87a	16.52b
0.4		56.42b	57.30b	40.75b	39.58b	15.22c	17.60b	15.95b	15.63c
0.6		59.83a	60.42a	43.25a	42.87a	16.05ab	17.72b	14.45c	14.73d
Inter action (I x H)									
4 days	0.00(Cont.)	56.43d	58.07d	43.17d	40.13d	17.03b	16.17d	12.60f	13.13f
	0.2	58.83c	59.76c	44.80c	43.07c	14.67c	16.50d	14.87e	14.00e
	0.4	60.83b	61.57b	46.17b	45.07b	14.03cd	19.03b	17.23bc	15.13d
	0.6	65.37a	65.33a	48.33a	49.23a	16.67b	17.93c	17.00cd	17.00b
8 days	0.00(Cont.)	50.63g	50.33g	31.20h	30.57h	18.80a	20.37a	18.73a	17.90a
	0.2	50.00g	53.03f	35.33f	32.00g	16.17b	19.77ab	18.00ab	18.00a
	0.4	52.00f	52.35f	34.23g	34.10f	16.40b	18.93b	17.03cd	16.33c
	0.6	54.30e	55.50e	38.17e	36.50e	13.30d	16.70d	16.30d	17.26b

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

Total and free water contents in leaf tissues were increased with increasing the rates of hydrogel, and the greatest values were obtained with hydrogel at 0.6% comparing with the lowest values recorded with control (hydrogel at rate 0.0%). On the contrary, hydrogel at 0.0 and 0.2% raised bound water content and osmotic pressure compared with the other rates of hydrogel in both 2017 and 2018 seasons. Improving relative water content under water saving substances treatments may be due to maintaining enough available water for trees to overcome drought stress injuries. In this line, Fernando *et al.,* (2013) found that, hydrogel amendment significantly increased the plant available water (PAW) in sandy soil compared to the control. Also, Arbona *et al.,* (2015) and Barki *et al.,* (2018) found that, hydrogel treatment enhance the capacity to avoid drought damages of trees and improve leaf relative water content.

The interaction between irrigation intervals and hydrogel applications was significant in both seasons. The highest values of total and free water contents in leaf tissues belonged to irrigation every 4 days x hydrogel at 0.6% combination treatment comparing with the lowest values achieved by irrigation every 8 days x hydrogel at 0.0%.Conversely, the highest values of bound water content and osmotic pressure were achieved by irrigation every 8 days x hydrogel at 0.0% in both seasons.

4- Soil properties

Soil moisture characteristic

Results illustrated in Figures (1,2 and 3) indicate the impact of combining irrigation intervals with hydrogel rates on the characteristic soil moisture during the 2017 and 2018 seasons. Generally, all measured soil moisture characteristics were favorably impacted by irrigation periods and rates of hydrogel compared to soil control. Increasing the irrigation intervals from 4 to 8 significantly increased the soil FC (17.10 and 16.50%) and WP (6.90 and 6.00%) and decreased the AW (10.20 and 10.40%), respectively for the first and second seasons. Soil amended with high rate of hydrogel, were able to store much more water than those amended with low rates (the control). The FC, WP, and AW of pots amended with 0.6% hydrogel were increased compared to the lowest values recorded with control (0.0% hydrogel). The interaction of irrigation every 8 days and hydrogel rate at 0.6% presented the highest FC and WP values in both seasons (25.3 and 8.8% in the first season and 25.7 and 9.0 in the second one, respectively) while, the highest AW was presented from the irrigation intervals every 4 days and hydrogel rate at 0.6% during the two seasons. The alteration of sandy soil physical properties indicates that adding hydrogel, even at small levels, to the soil increases the period of time at which the soil remains moistned than the control soil. This allows the irrigated water not to be wasted after irrigation, but stored in the soil and released under the mechanism controlled by plant roots absorption and evaporation (Al-Humaid and Moftah, 2007 and Sannino, 2008). In addition, the application of the amendment also encouraged formation of soil aggregates that, in turn, decreased the soil bulk densities. The results submitted are in line with the findings of Koupai *et al.,* (2008), Bhat *et al.,* (2009) and El-Kady and Borham (2013), who recorded the positive effect of absorbent polymers on soil density, compactness, texture, aeration, water retention and available water.

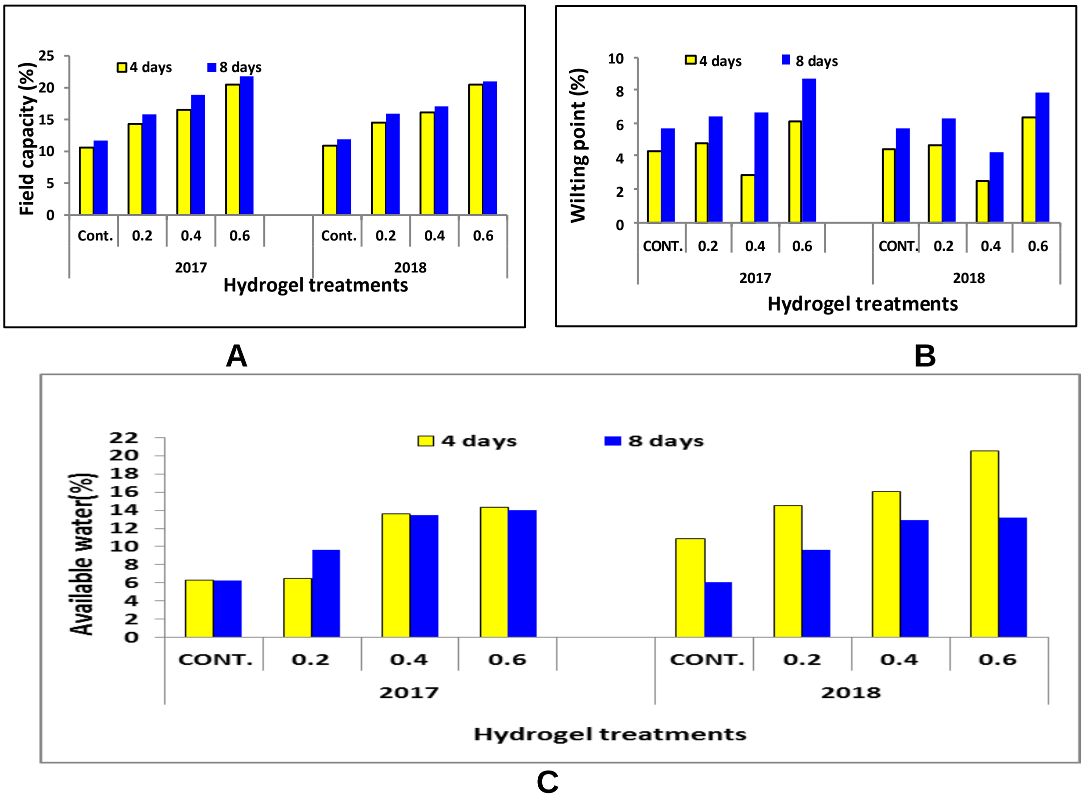

Fig. 1: Effect of irrigation intervals, hydrogel rates and their interaction on some soil properties, (A) field capacity (B)wilting point (C) available water during 2017 and 2018 seasons.

CONCLUSION

Based on the results obtained from this study, it is recommended to add 0.4 or 0.6% (g/g) hydrogel polymer amended sandy soil for the establishment of *Conocarpus erectus* plants under the two irrigation intervals (every 4 and 8 days) which is considered the best treatment in the ability to improve the growth parameters, and rationalize the amount of irrigation water in sandy soil under the experimental conditions.

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استجابة نباتات الكونوكاربس النامية في التربة الرملية للمعاملة بالهيدروجيل تحت ظروف النقص المائي

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الملخص العربى

يُعد نقص مياه الري من أحد العوامل الرئيسية التي تحد من نمو النباتات وخاصة في المناطق الجافة وشبه الجافة لذلك أجريت هذه الدراسة لتقييم تأثير اضافة الهيدروجيل بوليمر لتقليل الآثار السلبية الناتجة عن نقص مياه الرى، حيث تم اجراء تجربة اصص خلال عامي 2017 و 2018 بالمزرعة البحثية محطة بحوث البساتين بسخا– معهد بحوث البساتين مركز البحوث الزراعية و ذلك لدراسة تأثير فترات الرى (الرى كل 4 و 8 ايام) واضافة الهيدروجيل بأربعة معدلات (g/g) % 0.0, 0.2, 0.4 and 0.6 على النمو وبعض الصفات الطبيعية للتربة والعلاقات المائية لشتلات الكونوكاربس المنزرعة في تربة رملية.

أوضحت النتائج التي تم الحصول عليها ان هناك زيادة معنوية فى قياسات النمو الخضرى (ارتفاع النبات وعدد الاوراق والفروع/نبات وكذلك الوزن الجاف والطازج للفروع والجذور) وكذلك المحتوى المعدنى للأوراق عند ري شتلات الكونوكاربس المنزرعة فى تربة رملية كل 4 ايام فى كلا موسمى الدراسة فى حين زاد محتوى الاوراق من البرولين مع الرى كل 8 ايام

سجلت الدراسة زيادة معنوية فى معظم قياسات النمو الخضرى ومحتوى الاوراق من العناصر عند اضافة الهيدروجيل بمعدل 0.4 او % 0.6 ، حسنت معاملات الرى كل 4 او 8 ايام والمعدل العالي من الهيدروجيل والتداخل بينهم من خصائص الصفات الطبيعية للتربة (السعة الحقلية والماء الميسر) وكذلك سجلت اعلى القيم للماء الكلى والمرتبط للأوراق.

وفقًا للنتائج التي تم الحصول عليها في ظل ظروف الدراسة ، يمكن التوصية بإطالة فترات الرى لشتلات الكونوكاربس المنزرعة في التربة الرملية من 4الى 8 ايام مع اضافة الهيدروجيل بمعدل 0.4 او% 0.6 مما يؤدى إلى تحسين النمو الخضري ، بجانب زيادة كفاءة استخدام المياه مع توفير مياه الري عن طريق تقليل كمية المياه المضافة مقارنة بالري بدون اضافة الهيدروجيل.

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