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EFFECT OF DIFFERENT IRRIGATION METHODS AND RATES ON GROWTH OF *CYCAS REVOLUTA*, THUNB SEEDLINGS.

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ABSTRACT

The present work was designed to study the effect of different rates of irrigation (300 , 450 , 600 and 750 ml per plant) and two irrigation methods (drip or manual irrigation) on growth of *Cycas revoluta* seedlings during two seasons (2006 and 2007) in the green-house at Antoniades Branch, Hort. Res. Inst., A.R.C. Alexandria., Egypt.

The results indicated that different irrigation rates had little effect on some plant characters of Cycas seedlings (number of leaves / plant, leaf length, number of leaflet / leaf, stem circumference and total chlorophylls content). While, the other characters revealed negligible affects in this concern. However, the high and medium rates of water 750 and 600 ml, plant recorded the same results by using the rate of 450 ml, plant while, the lowest rate (300 ml) of water gave the lowest values of all plant trials were studied. So, it could be concluded that the present study revealed great economic value in terms of rational use of water for irrigation.

Concerning the irrigation methods (drip or manual irrigation) insignificant differences were detected due to using both irrigation methods on growth of Cycas seedlings.

From the results, it could be concluded that applying 450 ml water for irrigation per seedling at four days interval in the green-house (equal 33% of F.C) was the best irrigation rate using either the drip or manual irrigation method for producing the best growth of *Cycas revoluta* seedlings.

INTRODUCTION

Cycas revoluta, family *Cycadaceae,* Sago palm is the common name. This unique plant resembles a palm tree, even though it isn't really a palm but is actually a cycad. This very symmetrical plant supports a crown of shiny dark green leaves on a thick shaggy trunk that can grow to 10-12 ft high. Japanese sago tends to produce suckers at its base forming a large multi-stem clump over time. Sago plants are dioeciously, the male structure is a yellow rod shaped cone that grows 12-18 in.

Modified leaves from the female cone which is a globe shaped yellow structure in which scale like leaves cover bright orange seeds that are about 1.5 in. in diameter. The Sago palm is native to Japans southern islands, (a subtropical area of high rain fall and worm temperature), Bailey (1960).

This is a wonderful plant for both indoor and out door uses. It looks great in the shrub border or as an expanse of loan or near the patio. Use in entryways or in rock and sand gardens. It mixes well with palms and combines well with border grass, podocarpus and camellias. Sago is an

excellent container plant; it is also used as a bonsai subject. The glassy metallic leaves are harvested for use in flower arrangements and wreaths.

Cycas revoluta is characterized with its coralloid roots, containing nitrogen fixing Cyanobacteria (Nostoc) as plant symbioses that can convert inert atmospheric nitrogen into an organic form, such as nitrate or ammonia, (Millbank, 1974 and Rai, *et al*; 2000 and Lindblad and Costa, 2002).

Very little information is available about irrigation of *Cycas revoluta* plants. So the literature on other plants seemed to be helpful in this respect. Pool and Conover (1987) found that, the irrigation frequency had no effect on *Dracaena surculesa*.

Lamhamedi *et al.* (2003) studied the effect of different irrigation regimes on the growth of black spruce seedlings to reduce the quantity of used water and the amount of mineral nutrients lost. They used four irrigation regimes (15, 30, 45 and 60%, F.C), and observed that, irrigation regime did not affect growth, root architecture or tissue nutrient contents at the end of the growing season. The losses of mineral nitrogen were 49.7, 35.9, 55.2 and 88.2% respectively, for the 15, 30, 45 and 60% irrigation regimes.

EL-Fawakhry (2004) on *Cycas revoluta* found that the different irrigation intervals had insignificant effects on growth of Cycas seedlings .however, the highest values of stem characters were observed with irrigation every 3 and 4 days after 20 months. Davis *et al.* (2008) on red oak seedling found that seedling height and root-coller diameter were not influenced by irrigation method. Tapia, *et al.* (2008) on *Ficus carica* trees stated that a good positive correlation between irrigation rate and shoot length was found, especially between the highest and lowest rates of irrigation.

The present work was carried out to study the effect of various irrigation rates and methods as well as their interaction on growth of *Cycas revoluta* plants.

MATERIAL AND METHODS

The experimental trials were carried out throughout 2006 and 2007 seasons at the nursery of Antoniades Research Branch, Hort. Res. Inst., Alexandria, Egypt. It intended to find out the effects of different irrigation rates and methods on growth of *Cycas revoluta*, seedlings.

Plant materials:

One year old seedlings (containing 4 leaves) of *Cycas revoluta* were grown in a mixture of clay, sand and peat-moss (1:1:1 v/v) in clay pots of 30 cm in diameter in a green-house (light intensity of 2500-3000 lux and relative humidity of 75-80% and average temperature of 23.4-38.6 in winter and summer, respectively). The chemical analysis of the used medium contained: (N 0.25%, P 24 ppm, K 641 ppm, Fe 7.9 ppm, Zn 3.12 ppm, Mn 9.56 ppm and Cu 1.13 ppm) with 1.25 dsm^{-1} EC and 7.1 pH. The textural class sandy loom. 1.5g of dissolved fertilizer (NPK-19:19:19) was used every 2 weeks per plant. Micro elements were added monthly as a liquid to the pot medium at the rate of 0.16 g/l.

Irrigation regime:

Four irrigation rates (300, 450, 600 and 750 ml of tap water per plant) were added every 4 days using two irrigation methods (drip irrigation or manual irrigation).

Drip irrigation system in green-house was used and organized to emit 150 ml /pot/h. All the treatments were carried out commencing from January 5th and ended after 12 months for every season.

Thus 8 treatments were arranged in three replicates with three plants per experimental unit in factorial randomized complete block design in both seasons.

The following data were recorded:

- Number of leaves per plant.
- Leaf length (cm.) (length of the tallest adult leaf). Fresh and dry weights of leaves / plant.
- Number of leaflets per the tallest leaf. Leaflet length (cm.) (length of the middle leaflet of the tallest leaf).
- Stem circumference (cm), fresh and dry weights of stem, (g/plant)
- Fresh and dry weights of roots, (g/plant)
- Total chlorophylls content mg/g fresh weight of leaf according to Moran and Porath (1980).

Duncan's Multiple Range Test was used for the comparison means among the treatments according to Sendecor, and Cochran (1974).

RESULTS AND DESCUSSION

1. Number of leaves / plant

Insignificant effects were recorded on leaf number due to using the different irrigation rates in the first season, while it was significant in the second season, as it recorded the high value with the rate of 450 ml per plant, as indicated in Table (1).

With respect to the irrigation method insignificant differences were recorded in leaves number per plant due to using drip or manual irrigation in both seasons.

Referring to the interaction between irrigation methods and rates the highest values of leaves number per plant were recorded with the rate of 450 ml in drip irrigation method.

On the other hand the lowest values were recorded with the lowest rate 300 ml in flood irrigation method.

Such effect reveals a great economic value in this concern. This result may be related to constant conditions in the green-house specially the high rate of humidity (70-80%) and thick and hard leaflets that are covered by cutin layers causing low transpiration rate resulted in low uptake rate of water.

These results are in harmony with those of EL-Fawakhry (2004) on *Cycas revoluta*, and Lamhamedi *et al.* (2003) on black spruce, and Sheikh, (1985) on rooted cuttings of poplar clones and Tapia *et al.* (2008) on *Ficus carica*.

2. Leaf length

Evidently, data in Table (1), showed significant effect on leaf length due to using the different irrigation rates in both seasons. The highest values were recorded with using 450 ml as irrigation rate, while the rate of 300 ml gave the lowest value in this respect.

On the other hand, insignificant effects were observed as a result of applying the different irrigation methods. These results are in harmony with that of *Davis et al.* (2008) on red oak seedlings.

With respect to the interaction between irrigation methods and rates the highest values of leaf length were recorded with using 450 ml of water as manual irrigation while the lowest values were recorded with 300 ml with using drip irrigation.

3. Fresh weight of leaves:

Evidently, data in Table (1), showed insignificant effect on fresh weight of leaves as a result of using the different irrigation rates in both seasons. This result may be ascribed to structural and metabolic derangement rather than direct limitation (Fogg, 1972). It is known the importance of water supply on the amount of photosynthesis. With respect to the irrigation method insignificant effect was observed in both trials.

The interaction between irrigation methods and rates showed insignificant effect, however the highest values were recorded with the rate of 600 ml using drip irrigation method.

This result was supported by the observation of Burman *et al.* (1991) on *Azadirachta indica* that average application of equal to Field capacity per plant at 2 weeks interval led to maximum growth.

Table (1): Effect of irrigation rates, methods and their interaction on number of leaves / plant, leaf length and fresh weight of leaves of *Cycas revoluta* during 2006 and 2007 seasons

Irrigation rate ml per plant	2006 season			2007 season		
	Drip irrigation	Manual irrigation	M	Drip irrigation	Manual irrigation	M
Number of leaves / plant						
300 ml	8.04	7.63	7.42	8.00bc	5.83d 8.17bc	6.92c 9.25a
450 ml	7.33	7.33	8.08	10.33a	7.33ab	8.16b
600 ml	8.83	7.50	8.00	7.00cd	7.00cd	8.17bc
750 ml	8.50	8.17	7.83	7.50c		
M	8.04	7.63		8.20	7.58	
Leaf length						
300 ml	41.66c	46.83bc	44.25c	46.83c	47.83c	46.33c
450 ml	50.16ab	54.00a	52.08a	66.33a	63.83a	65.08a
600 ml	47.75abc	48.66ab	48.20b	54.90b	54.00b	54.45b
750 ml	47.06bc	46.83bc	46.95b	55.66b	51.00b	53.33b
M	46.66	49.08 ns		55.93	54.17 ns	
Fresh weight of leaves / plant						
300 ml	60.94	49.99	60.47	91.66	61.44	76.55
450 ml	71.71	64.08	67.89	100.05	100.93	100.49
600 ml	74.76	58.76	66.76	109.28	91.50	100.39
750 ml	76.44	54.66	65.55	98.09	99.91	99.00
M	73.46	56.87		99.77	88.45	

Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

4. Dry weight of leaves /plant

Dry weight of leaves was not affected by the different irrigation rates and methods in both trials as seen in Table (2). This result may be related to little transpiration rate of the plant and other vital processes, that controlled plant production and the mineral accumulation in the leaves. This result is in accordance to that was obtained by EL-Fawakhry (2004) on *Cycas revoluta*, plants and Lamhamedi *et al.* (2003) on black spruce seedlings.

The interaction showed that little effect on dry weight of leaves was recorded and the best values were recorded with flood irrigation method at 600 and 450 ml of water irrigation.

5. Number of leaflet /leaf

It is clear from the tabulated data presented in Table (2), that irrigation rates revealed significant effect on leaflets number per leaf and the rates of 600 and 450 ml were the best as they recorded the highest values of leaflets compared with the other rates, especially with manual irrigation system. On the other hand, insignificant effects were recorded with irrigation methods.

These results are in harmony with those of EL-Fawakhry (2004) on *Cycas revoluta*, plants.

6. Leaflet length

Data in Table (2) showed insignificant effects for irrigation methods and rates on leaflet length in both experimental trials.

Table (2): Effect of irrigation rates, methods and their interaction on dry weight of leaves /plant, number of leaflet /leaf and leaflet length of *Cycas revoluta* during 2006 and 2007 seasons

Irrigation rate ml per plant	2006 season			2007 season		
	Drip irrigation	Manual irrigation	M	Drip irrigation	Manual irrigation	M
Dry weight of leaves /plant						
300 ml 450	19.10	27.26	23.18	31.50	25.65	28.57
ml 600 ml	20.83	28.14	24.48	39.83	35.20	37.51
750 ml	20.66	27.48	24.07	31.03	41.37	36.23
	21.13	26.69	23.91	32.93	36.19	34.56
M	20.43	27.39		33.83	34.60	
Number of leaflet /leaf						
300 ml 450	66.00cd	70.66bc	68.33b	72.00cd	66.00d	69.00b
ml 600 ml	74.00b	77.33a	75.67a	77.00bc	82.66a	79.83a
750 ml	73.00b	78.66a	75.83a	81.33ab	78.00abc	79.66a
	69.00bc	75.33ab	72.16ab	73.66bcd	78.00abc	5.83ab
M	70.50ns	70.50ns		76.00ns	76.17ns	
Leaflet length						
300 ml 450	12.33	13.50	12.92	13.16d	13.00d	13.08
ml	14.25	14.83	14.54	15.83a	15.41ab	15.62
600 ml	14.33	14.50	14.42	14.83bc	13.50d	14.17
750 ml	13.33	13.16	13.25	13.91cd	13.33d	13.62
M	13.56	14.00		14.43	13.31	

Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

The interaction between irrigation methods and rates showed the highest values with the rate of 450 ml in both methods of irrigation. While the lowest rate of irrigation recorded the lowest values with both methods of irrigation. This character may be controlled as the heredity behavior of this plant, more than the environmental conditions.

7. Stem circumference:

Slight effect was observed on stem circumference resulted from applying different irrigation rates in the first season, while it was significant in the second one as shown in Table (3).

Concerning irrigation methods, insignificant differences were observed throughout the two seasons. However, it could be concluded that the plants receiving 600 or 450 ml as irrigation rates with using drip or manual irrigation method were the best treatments in this concern. This might be due to the increase in metabolism process, which closely associated with the capacity of the soil to provide moisture (Mooney *et al.*, 1978 and Specht and Specht, 1989). Table (3)

8. Fresh weight of stem

It is obvious from data in Table (3) that fresh weight of stem was not significantly affected by using different irrigation treatments; however the rates of 450 ml and 600 ml gave the highest values of stem fresh weight. In this concern, Papadopol, (1982) on Poplus species found that irrigation treatments increasing stem volume growth by 12-16%. Burman *et al.*, (1991) on *Azadirachta indica* seedlings mentioned that application of field capacity per plant at 2 weeks interval led to maximum growth and biomass production. Similarly, EL-Fawakhry (2004) on *Cycas revoluta,* seedlings found that the great effect of irrigation treatment at the rate of 33% of the field capacity (at 4 days interval) on fresh weight of stem.

On the other hand, insignificant effect was recorded with irrigation methods.

The interaction between irrigation rates and methods using, drip irrigation at 450 ml as irrigation rate gave the highest values of stem fresh weight during the two seasons.

9. Dry weight of stem

Dry weight of stem was not significantly affected by the different irrigation treatments in both experimental trials as indicated in Table (3). This result may be attributed to the limited water requirements of *Cycas* plants which limit the quantity of water uptake by the plant either with high rate of water or low rate. This result is in agreement with that of EL-Fawakhry (2004) on *Cycas revoluta* plants and Poole and Conover (1987) on *Dracaena surculosa.*

Insignificant effect was recorded on the other hand, due to the interaction between irrigation rates and methods on dry weight of stem as indicated in Table (3).

Table (3): Effect of irrigation rates, methods and their interaction on stem circumference, fresh weight of stem and dry weight of stem of *Cycas revoluta* during 2006 and 2007 seasons

Irrigation rate ml per plant	2006 season			2007 season		
	Drip irrigation	Manual irrigation	M	Drip irrigation	Manual irrigation	M
Stem circumference						
300 ml	17.33	17.00	17.15	16.50c	17.00c	16.75c
450 ml	18.00	18.33	18.17	21.00a	18.66abc	19.83a
600 ml	18.08	18.08	18.08	17.25c	20.00ab	18.62ab
750 ml	17.05	18.50	17.78	17.33c	19.00abc	18.16b
M	17.62	17.98		18.02	18.66	
Fresh weight of stem / plant						
300 ml	83.98b	85.49b	84.73	73.15c	79.42b	76.28
450 ml	111.69a	84.34b	98.02	133.74a	94.45b	114.09
600 ml	95.33ab	94.70ab	85.02	91.20b	120.89a	106.05
750 ml	83.00b	103.60ab	93.30	91.20b	94.39b	94.00
M	93.50	92.03		98.18	97.28	
Dry weight of stem / plant						
300 ml	30.33	41.75	36.04	29.43	23.98	26.71
450 ml	44.26	34.01	39.14	25.52	48.29	36.90
600 ml	40.20	36.16	38.18	30.76	28.49	29.63
750 ml	37.08	38.29	37.68	23.60	31.40	27.50
M	37.97	37.55		27.33	33.04	

Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

10. Fresh weight of roots:

Data in Table (4) showed insignificant effect of different irrigation rates and methods on fresh weight of roots. However, it could be mentioned that using the rate of 450 ml was the best treatment in this concern. A relationship between root characters and vegetative growth parameter as stem weight was observed. Therefore, roots characters had the same behavior of stem characters.

This result was supported by the observation of Lamhamedi *et al.* (2003) on black spruce and Burman *et al.*, (1991) on *Azadirachta indica* seedlings and *Davis et al.* (2008) on red oak seedlings.

The interaction indicated that receiving the plants irrigation rate of 450 ml as manual irrigation had a great influence on fresh weight of roots especially in the first season.

11. Dry weight of roots

Data in Table (4) showed insignificant effect of the different irrigation rates on dry weight of roots in both experimental trials. The same result was detected by EL-Fawakhry (2004) on *Cycas* plants and Pool and Conover (1987) on *Dracaena surculosa*, and Lamhamedi *et al.* (2003) on black spruce seedlings.

Concerning the irrigation method, registered data in Table (4), revealed the superiority of using manual irrigation on dry weight of roots. This result may be due to some root elongation searching of water which goes down in the pot ground in this method.

The interaction indicated the great influence of using manual irrigation at 450 ml of water irrigation in both trials.

12. Total chlorophylls content

Applying the high and medium rates of water irrigation (750, 600 and 450 ml, respectively) revealed an increment on total chlorophylls content when compared with the lowest rate 300 ml of water irrigation. On the other hand, irrigation methods recorded non significant effect on total chlorophylls content, as shown in Table (4).

It is known that the water concentration can ever be a directly limiting factor in chlorophylls content. Water quantity is important in increasing the availability of nitrogen and other minerals and increasing its absorption by the plant, so increasing total chlorophylls content in the leaves.

Table (4): Effect of irrigation rates, methods and their interaction on fresh and dry weight of roots and total chlorophylls content of *Cycas revoluta* during 2006 and 2007 seasons

Irrigation rate ml per plant	2006 season			2007 season		
	Drip irrigation	Manual irrigation	M	Drip irrigation	Manual irrigation	M
Fresh weight of roots / plant						
300 ml	48.11c	61.57b	54.84	48.80cd	71.87bc	60.33
450 ml	58.47bc	78.09a	68.28	54.00c	84.18a	69.09
600 ml	54.08bc	68.58b	61.33	67.50b	73.85b	70.67
750 ml	53.76bc	62.14b	57.95	57.66c	76.14b	66.90
M	53.61	67.60		56.99	76.51	
Dry weight of roots / plant						
300 ml	7.41d	23.60ab	15.50	10.44ab	16.14ab	13.29
450 ml	12.34c	26.88a	19.61	12.20b	21.07a	16.64
600 ml	11.27cd	20.77bc	16.02	12.21ab	16.35ab	14.28
750 ml	9.57d	22.99ab	16.28	11.41b	18.22ab	14.82
M	10.15b	23.56a		11.57	17.95	
Total chlorophylls content						
300 ml	0.530b	0.610b	0.570b	0.54b	0.58b	0.560b
450 ml	0.770a	0.780a	0.775a	0.74a	0.75a	0.745a
600 ml	0.780a	0.770a	0.775a	0.77a	0.80a	0.785a
750 ml	0.790a	0.780a	0.795a	0.81a	0.78a	0.795a
M	0.718	0.720		0.715	0.728	

Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

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تأثير طرق ومعدلات الرى المختلفة على نمو شتلات السيكاس

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اجرى هذا البحث بهدف دراسة تأثير معدلات رى مختلفة (300 – 450 – 600 و 750 مليلتر لكل نبات) وطريقتين للرى (الرى بالتنقيط والرى العادى) والتفاعل بينهما وذلك على نمو شتلات نبات السيكاس خلال موسمى التجربة 2006 و 2007 بالصوبة بفرع بحوث الحدائق النباتية بحديقة انطونيادس. معهد بحوث البساتين الإسكندرية.

وقد أظهرت النتائج أن:

معدلات الرى المختلفة كانت قليلة التأثير على بعض صفات النبات مثل عدد الاوراق وطول الورقة وعدد الوريقات لكل ورقة ومحيط الساق والمحتوى الكلى من الكلوروفيل. بينما باقى الصفات كان تأثرها طفيفا فى هذا الخصوص. ومع ذلك فان المعدل العالى 750 مليلتر والمتوسط 600 مليلتر اظهر نفس تاثير المعدل 450 مليلتر. بينما المعدل المنخفض من مياة الرى (300 مليلتر) اعطى اقل القيم من حيث النتائج التى تم التوصل اليها بالنسبة للصفات التى تم دراستها لذلك فانه يمكن الاشارة لاهمية النتائج التى تم التوصل اليها فى هذه الدراسة لما لها من اهمية اقتصادية من حيث ترشيد استخدام مياه الرى.

اما من ناحية طريقة الرى فلم تلاحظ اى اختلافات معنوية باستخدام اى من طريقتى الرى على نمو شتلات السيكاس.

من نتائج الدراسة يمكن استنتاج ان استخدام الرى بمعدل 450 مليلتر لكل شتلة كل اربعة ايام داخل الصوبة (بما يعادل ثلث السعة الحقلية) يعتبر افضل معدل رى لشتلات السيكاس سواء باستخدام الرى بالتنقيط او العادى.