

Rooting Light Weight Offshoots of Zagloul Date Palm Using Hydroponics Technique

¹S. El-Kosary, ¹M.A. Shaheen, ²S.A.Y. Rizk and ²A.A. Abdel-Hameed

¹Department of Pomology, Faculty of Agriculture, Cairo University, Egypt

²Pomology Unit, Desert Research Center, Mataria, Egypt

Abstract: Two experiments were carried out to evaluate the rooting possibility of different weights of Zagloul date palm offshoots as affected by plant growth regulators injection. The first was dealt with studying the effect of different offshoots weights (<2 kg, 2 to <5 kg, 5 to <8 kg, 8 to <12 kg and 12 to 15 kg) on offshoots performance under nursery condition. The second was carried out at the greenhouse to investigate the effect of IBA, NAA and IAA injection at 0, 50, 100 and 150 ppm on Zagloul date palm offshoots weighing <2 kg, 2 to <5 kg and 5 to <8 kg cultured in hydroponics system. Nursery results cleared that offshoots weighing 12 to 15 kg gave the highest percentages of survival, rooting and good parameters of growth. On the other hand, offshoots weighing less than 2 kg appeared 100% mortality after 12 months from planting. In hydroponics culture, offshoots survival percentage, number of leaves per offshoot, leaf length, rooting percentage and number of roots per offshoot were significantly increased by either offshoots weight 5 to <8 kg or IBA treatment. Also, offshoots injected by 150 ppm IBA gave the highest growth and rooting parameters. The highest percentages of survival and rooting and good performance of growth and rooting parameters were obtained with offshoots weighing 5 to <8 kg injected by 150 ppm IBA. Finally, this study is opening field to expansion advantaging from terminal products through detachment offshoots from date palm i.e., aerial offshoots, secondary offshoots and small offshoots in date palm propagation.

Key words: Date palm · Light weight offshoots · Growth regulators · Hydroponics · Rooting

INTRODUCTION

Date palm (*Phoenix dactylifera*, L.) is propagated commercially by offshoots which are mainly produced in a limited number during the early life of the tree depending on the variety and on prior fertilization treatment, irrigation and earthing up around the trunks [1-3]. Although 10 to 30 offshoots are produced by a palm, only 3 or 4 offshoots are suitable for planting out in one year. Numerous factors are considered including: offshoot weight, origin of the offshoot, the method of removal and preparation for planting, as well as treatment of an offshoot after planting [1-5].

Offshoots weighing 5 kg or less, if needed, could also be used, but their survival potential will be much lower than that of weighty offshoots [6]. Offshoots of certain age (3-4 years) and weight (12-20 kg) are commonly used in date palm propagation [2]. Sewy date palm offshoots weighing 10-15 kg gave the highest rooting percentage, number of leaves/offshoot and average leaf length followed by those weighing 15-22 kg, > 22 kg and the very small ones weighing 2 to <5 kg [7].

Using IBA at the concentration of 3000 ppm as foliar spray on offshoots of date palm trees successfully raised their rooting percentage up to 75%. In the same time, the rooting percentage was nil with the concentrations of 1000 and 2000 ppm of IBA [8]. Rooting medium was important in determining the extent of root formation of offshoots. Rooting of ground offshoots was increased by NAA and/or catechol treatments, while NAA and/or catechol treatments appeared to be essential for good root formation and development on aerial offshoots [9]. Treatment with 5 and 7% IBA resulted in the highest rooting percentage of Mejhoul and Boufeggous date palm cultivars [10].

The aim of this study is to enhance rooting ability and new shoot formation using light weights of Zagloul date palm offshoots as affected by plant growth regulators injection under hydroponics culture. Also, to magnify the ability of using light weight offshoots (that have not sufficient roots to success) as a propagation material.

MATERIALS AND METHODS

Two experiments were carried out during two successive seasons of 2004/2005 and 2005/2006 at North Sinai Governorate in North Sinai Agricultural Research station.

The First Experiment: was dealt with studying the effect of different offshoots weights (<2 kg, 2 to <5 kg, 5 to <8 kg, 8 to <12 and 12 to 15 kg) on offshoots rooting and its performance achieved in the nursery. The offshoot cut surface was covered with bitumen. Also, old roots on heaviest offshoots were pruned (if needed).

The offshoots were transplanted in the nursery at the third week of September every season. The experimental design was completely randomized including 5 treatments. Each treatment was represented by three replicates and each replicate included six offshoots.

A drip irrigation system provided water for the offshoots was used. During the first month, the soil near the offshoots was kept moist at all times [4] by light and frequent irrigation (20 liters/offshoot/day). After the first month, the offshoots received 25 liters/offshoot three times/week until the end of August, then they received 25 liters/offshoot two times/week.

The Second Experiment: was carried out at the greenhouse to investigate the effect of auxin types, i.e. indole butyric acid (IBA), naphthalene acetic acid (NAA) and indole acetic acid (IAA) and their concentrations (0, 50, 100 and 150 ppm of each) on light weight Zaghloul date palm offshoots (<2 kg, 2 to <5 kg and 5 to <8 kg). The experimental design was split plots including 36 treatments. Each treatment was replicated three times with six offshoots in each replicate.

Three ml of auxin were injected in the offshoot base before transplanting. Offshoots bases were painted with bitumen. The offshoots were established in hydroponics culture with Arnon and Hoagland, 1940 nutrient solution as shown in Table, 1 [11] at the third week of September every season for nine months. Replacing nutrient solution and fungicide addition were done every three weeks. After nine months the offshoots were transplanted in the nursery.

Zaghloul date palm offshoots were trimmed to 40, 60, 80, 100 and 120 cm (distance from the base at its widest point to the cut tip) for the weights <2 kg, 2 to <5 kg, 5 to <8 kg, 8 to <12 kg and 12 to 15 kg, respectively.

Table 1: Arnon and Hoagland, (1940) nutrient solution composition

Chemical	Formula	mg/l
Potassium dhydrogen phosphate	KH_2PO_4	230
Potassium Nitrate	KNO_3	1020
Calcium nitrate	$\text{Ca}(\text{NO}_3)_2$	492
Magnesium sulphate	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	490
Iron tartarate	$\text{FeC}_4\text{H}_4\text{O}_6$	6.00
Magnesium chloride	$\text{MgCl}_2 \cdot 4\text{H}_2\text{O}$	1.81
Zinc sulphate	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	0.05
Copper sulphate	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	0.02
Boric acid	H_3BO_3	0.05
Molybdic acid	$\text{H}_2\text{MoO}_4 \cdot \text{H}_2\text{O}$	0.01

Data Recorded as Follow: Offshoots survival percentage (%) was recorded after 6, 9 and 12 months from transplanting. After 9 months from transplanting, number of new leaves/offshoot, leaf length (cm), rooting percentage (%), number of roots/offshoot, root length (cm) and root diameter (mm) were estimated and tabulated.

Means of the obtained data were subjected to analysis of variance. The mean values were compared using LSD method at 5% level using MSTAT (1987) software package [12]. The percentages were transformed to the arcsine to find the binomial percentages according to [13].

RESULTS AND DISCUSSION

The First Experiment:

Offshoots Survival Percentage: Survival percentage was significantly increased by increasing offshoot weight. The heaviest offshoots (12 to 15 kg) recorded 77.8 and 83.3% survival percentage after 6 months, 66.7 and 77.8% after 9 months and 66.7 and 66.7% after 12 months, in the first and the second seasons, respectively (Table, 2). On the opposite, offshoots weighing <2 kg had 100% mortality after 12 months in both seasons. The other weights were in between regarding their survival percentages.

Number of New Leaves and Leaf Length: Number of new leaves and leaf length were significantly affected by offshoot weight. Offshoots weighing 12 to 15 kg gave the highest number of new leaves and leaf length comparing with other weights (Table, 3). While offshoots weighing <2 kg hadn't any response.

Rooting Percentage: Data in Table 4 show that offshoots weighing 12 to 15 kg increased significantly rooting percentage (66.7 and 72.2%) followed by 8 to <12 kg

Table 2: Effect of different offshoot weights on survival percentage of Zaghoul date palm offshoots

Offshoot weight	Survival percentage after 6 months		Survival percentage after 9 months		Survival percentage after 12 months	
	First season	Second season	First season	Second season	First season	Second season
< 2 kg	27.8	22.2	16.7	16.7	0.0	0.0
2 to <5 kg	38.9	33.3	27.8	27.8	11.1	16.7
5 to <8 kg	50.0	55.6	33.3	38.9	22.2	16.7
8 to <12 kg	61.1	66.7	55.6	61.1	38.9	44.4
12 to 15 kg	77.8	83.3	66.7	77.8	66.7	66.7
*LSD _{0.05}	14.60	24.28	17.65	24.66	20.65	8.12

*Means separation within columns

Table 3: Effect of different offshoot weights on number of new leaves and leaf length (cm) of Zaghoul date palm offshoots after 9 months

Offshoot weight	Number of new leaves		Leaf length (cm)	
	First season	Second season	First season	Second season
< 2 kg	0.0	0.0	0.0	0.0
2 to <5 kg	1.3	1.7	47.7	45.3
5 to <8 kg	2.2	2.3	87.2	89.3
8 to <12 kg	3.1	3.2	116.5	118.5
12 to 15 kg	4.1	4.1	121.2	123.8
*LSD _{0.05}	1.22	1.36	36.60	35.12

*Means separation within columns

Table 4: Effect of different offshoot weights on rooting percentage, number of roots, root length (cm) and root diameter (mm) of Zaghoul date palm offshoots after 9 months

Offshoot weight	Rooting percentage		Number of roots		Root length (cm)		Root diameter (mm)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
< 2 kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 to <5 kg	11.1	16.7	2.3	3.0	3.2	4.4	1.7	2.0
5 to <8 kg	22.2	22.2	4.8	4.7	6.2	4.2	3.1	3.4
8 to <12 kg	38.9	44.4	7.3	7.4	11.0	12.9	4.2	4.4
12 to 15 kg	66.7	72.2	11.9	12.0	22.2	25.7	5.0	4.7
*LSD _{0.05}	20.65	15.13	3.09	2.38	2.59	5.03	1.25	1.62

*Means separation within columns.

(38.9 and 44.4%), 5 to <8 kg (22.2 and 22.2%) and 2 to <5 kg (11.1 and 16.7%), in the first and the second seasons, respectively. Whereas, offshoots weighing <2 kg didn't produce any roots.

Number of Roots, Root Length and Root Diameter:

Data presented in Table 4 also show that the heaviest offshoot weight (12 to 15 kg) produced the highest number of roots, root length and root diameter comparing with other weights used in both seasons. On the other hand, offshoots weighing <2 kg didn't appear any response in regard to root formation.

These results are in agreement with Hussein *et al.* [14] who stated that the best growth and the highest survival percentage were attained when the weight of the

offshoots exceeded 15 kg. Also, Al-Ghamdi [2] found that rate of rooting was low in small offshoots and increased with increasing offshoots size. Also, the rooting capacity was correlated with presence of endogenous promoter. Rizk, [7] showed that Sewy date palm offshoots weighing 10-15 kg gave the highest rooting percentage, number of leaves/offshoot and average leaf length, while small ones (2 to <5 kg) gave the lowest values.

These findings may be due to amount of resource nutrients inside the heaviest offshoots comparing with the small ones or they may be due to pooring of the initial roots formation on offshoot when it was attached with mother tree. Finally, they may be due to accumulate amount of endogenous promoters inside the heaviest offshoots [2, 5, 7].

Table 5: Effect of different offshoot weights, auxin types and its concentrations on survival percentage of Zaghoul date palm offshoots after 6 months

		First season				Second season				
		Offshoot weight				Offshoot weight				
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean	
IBA	0 ppm	66.7	72.2	83.3	74.1	72.2	77.8	88.9	79.6	
IBA	50 ppm	72.2	77.8	94.4	81.5	77.8	83.3	94.4	85.2	
IBA	100 ppm	72.2	88.9	94.4	85.2	77.8	88.9	100.0	88.9	
IBA	150 ppm	77.8	88.9	100.0	88.9	83.3	88.9	100.0	90.7	
Mean		72.2	81.9	93.0	82.4	77.8	84.7	95.8	86.1	
NAA	0 ppm	66.7	72.2	83.3	74.1	72.2	77.8	88.9	79.6	
NAA	50 ppm	72.2	83.3	88.9	81.5	77.8	83.3	94.4	85.2	
NAA	100 ppm	72.2	83.3	94.4	83.3	77.8	83.3	94.4	85.2	
NAA	150 ppm	72.2	83.3	100.0	85.2	77.8	83.3	100.0	87.0	
Mean		70.8	80.5	91.7	81.0	76.4	81.9	94.4	84.2	
IAA	0 ppm	66.7	72.2	83.3	74.1	72.2	77.8	88.9	79.6	
IAA	50 ppm	66.7	77.8	83.3	75.9	72.2	77.8	88.9	79.6	
IAA	100 ppm	66.7	83.3	88.9	79.6	72.2	83.3	88.9	81.5	
IAA	150 ppm	72.2	83.3	88.9	81.5	77.8	83.3	94.4	85.2	
Mean		68.1	79.2	86.1	77.8	73.6	80.5	90.3	81.5	
0 ppm		66.7	72.2	83.3	74.1	72.2	77.8	88.9	79.6	
50 ppm		70.4	79.6	88.9	79.6	75.9	81.5	92.6	83.3	
100 ppm		70.4	85.2	92.6	82.7	75.9	85.2	94.4	85.2	
150 ppm		74.1	85.2	96.3	85.2	79.6	85.2	98.1	87.6	
Mean		70.4	80.5	90.3	-	75.9	82.4	93.5	-	
LSD _{0.05} for										
offshoot weight (A)					5.08					2.09
Auxin type (B)					n.s.					n.s.
Auxin concentrations (C)					5.23					5.53
A x B					7.85					8.29
A x C					9.07					8.58
B x C					9.07					n.s.
A x B x C					15.70					16.58

Table 6: Effect of different offshoot weights, auxin types and its concentrations on survival percentage of Zaghoul date palm offshoots after 9 months

		First season				Second season			
		Offshoot weight				Offshoot weight			
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean
IBA	0 ppm	27.8	38.9	50.0	38.9	44.4	50.0	55.6	50.0
IBA	50 ppm	38.9	55.6	66.7	53.7	55.6	66.7	77.8	66.7
IBA	100 ppm	50.0	61.1	66.7	59.3	61.1	72.2	83.3	72.2
IBA	150 ppm	55.6	55.6	61.1	57.4	66.7	72.2	83.3	74.1
Mean		43.0	52.8	61.1	52.3	57.0	65.3	75.0	65.7
NAA	0 ppm	44.4	38.9	50.0	44.4	44.4	50.0	55.6	50.0
NAA	50 ppm	44.4	50.0	61.1	51.9	55.6	61.1	77.8	64.8
NAA	100 ppm	50.0	50.0	61.1	53.7	61.1	66.7	77.8	68.5
NAA	150 ppm	50.0	50.0	66.7	55.6	61.1	66.7	83.3	70.4
Mean		47.2	47.2	59.7	51.4	55.6	61.1	73.6	63.4

Table 6: Continued

IAA	0 ppm	33.3	38.9	44.4	38.9	44.4	50.0	55.6	50.0
IAA	50 ppm	33.3	50.0	44.4	42.6	44.4	61.1	66.7	57.4
IAA	100 ppm	38.9	50.0	55.6	48.1	55.6	61.1	72.2	63.0
IAA	150 ppm	44.4	50.0	61.1	51.9	55.6	66.7	77.8	66.7
Mean		37.5	47.2	51.4	45.4	50.0	59.7	68.1	59.3
0 ppm		35.2	38.9	48.1	40.7	44.4	50.0	55.6	50.0
50 ppm		38.9	51.9	57.4	49.4	51.9	63.0	74.1	63.0
100 ppm		46.3	53.7	61.1	53.7	59.3	66.7	77.8	67.9
150 ppm		50.0	51.9	63.0	54.9	61.1	68.5	81.5	70.4
Mean		42.6	49.1	57.4	-	54.2	62.0	72.2	-
LSD _{0.05} for									
offshoot weight (A)					13.89	2.78			
Auxin type (B)					3.96	5.08			
Auxin concentrations (C)					4.58	5.86			
A x B					6.86	8.79			
A x C					7.93	10.15			
B x C					7.93	10.15			
A x B x C					13.73	17.58			

Table 7: Effect of different offshoot weights, auxin types and its concentrations on survival percentage of Zaghoul date palm offshoots after 12 months

Treatment		First season				Second season			
		Offshoot weight				Offshoot weight			
		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean
IBA	0 ppm	16.7	22.2	22.2	20.4	16.7	22.2	27.8	22.2
IBA	50 ppm	16.7	33.3	38.9	29.6	22.2	33.3	44.4	33.3
IBA	100 ppm	33.3	33.3	38.9	35.2	33.3	44.4	50.0	42.6
IBA	150 ppm	33.3	38.9	44.4	38.9	33.3	44.4	50.0	42.6
Mean		25.0	31.9	36.1	31.0	26.4	36.1	43.0	35.2
NAA	0 ppm	16.7	16.7	22.2	18.5	16.7	27.8	27.8	24.1
NAA	50 ppm	16.7	27.8	27.8	24.1	22.2	27.8	33.3	27.8
NAA	100 ppm	22.2	33.3	33.3	29.6	27.8	38.9	44.4	37.0
NAA	150 ppm	33.3	33.3	38.9	35.2	33.3	38.9	50.0	40.7
Mean		22.2	27.8	30.5	26.8	25.0	33.3	38.9	32.4
IAA	0 ppm	16.7	16.7	27.8	20.4	16.7	22.2	27.8	22.2
IAA	50 ppm	16.7	16.7	27.8	20.4	22.2	22.2	27.8	24.1
IAA	100 ppm	16.7	33.3	27.8	25.9	22.2	33.3	38.9	31.5
IAA	150 ppm	27.8	33.3	33.3	31.9	33.3	33.3	44.4	37.0
Mean		19.5	25.0	29.1	24.5	23.6	27.8	34.7	28.7
0 ppm		16.7	18.5	24.1	19.8	16.7	24.1	27.8	22.8
50 ppm		16.7	25.9	31.5	24.7	22.2	27.8	35.2	28.4
100 ppm		24.1	33.3	33.3	30.2	27.8	38.9	44.4	37.0
150 ppm		31.5	35.2	38.9	35.2	33.3	38.9	48.1	40.1
Mean		22.2	28.2	31.9	-	25.0	32.4	38.9	-
LSD _{0.05} for									
offshoot weight (A)					2.10	5.55			
auxin type (B)					2.99	3.75			
auxin concentrations (C)					3.45	4.33			
A x B					5.17	6.49			
A x C					5.97	7.49			
B x C					5.97	7.49			
A x B x C					10.35	12.98			

The Second Experiment:

Offshoots Survival Percentage: As shown in Tables 5, 6 and 7 offshoots weighing 5 to <8 kg increased significantly offshoots survival percentage after 6 months (90.3% in the first season and 93.5% in the second season), 9 months (57.4% in the first season and 72.2% in the second season) and 12 months (31.9% in the first season and 38.9% in the second season) comparing with offshoots weighing 2 to <5 kg. While offshoots weighing <2 kg had the lowest percentages in this respect in both seasons.

Regarding to auxin effect, injection by IBA increased significantly survival percentages followed by NAA and IAA, respectively. IBA increased significantly survival percentage after 12 months in the first season (31.0%) comparing with NAA (26.8%) and IAA (24.5%). In the second season, survival percentage after 12 months was significantly increased by either IBA (35.2%) or NAA (32.4%) comparing with IAA (28.7%).

Results indicated that the highest concentration of auxin (150 ppm) increased significantly offshoots survival percentages than other concentrations. Auxin treatment at either 150 ppm or 100 ppm increased significantly survival percentage after 12 months in the first season comparing with other concentrations. In the second season, treating offshoots with auxin at 150 ppm gave the highest value in this respect followed by 100 ppm and 50 ppm, respectively.

Treating offshoots with 150 ppm IBA gave the highest offshoots survival percentage after 6 months (88.9% in the first season and 90.7% in the second season), 9 months (57.4% in the first season and 74.1% in the second season) and 12 months (38.9% in the first season and 42.6% in the second season). Also, offshoots weighing 5 to <8 kg injected with 150 ppm IBA increased offshoots survival percentage after 6, 9 and 12 months comparing with other interactions. While those weighing <2 kg treated with free auxin gave the lowest values in both seasons.

Number of New Leaves and Leaf Length: Data presented in Tables 8 and 9 show that number of new leaves and leaf length were significantly increased by increasing offshoot weight. Using IBA increased significantly number of new leaves (4.13 in the first season and 4.14 in the second season) and leaf length (79.9 cm in the first season and 81.7 cm in the second season) followed by NAA and IAA, respectively. In addition, auxin at 150 ppm increased significantly number of new leaves and leaf length comparing to other concentrations.

The highest number of new leaves (3.24 in the first season and 3.23 in the second season) and leaf length (86.0 cm in the first season and 88.2 cm in the second season) were obtained with 150 ppm IBA treatment comparing to other interactions. Also, offshoots weighing 5 to <8 treated with 150 ppm IBA gave the highest number of leaves (4.33 in the first season and 4.20 in the second season) and leaf length (110.9 cm in the first season and 114.1 cm in the second season) comparing to other interactions. While offshoots weighing <2 kg treated with auxin at 0 ppm had the lowest values in both seasons.

Rooting Percentage: Data in Table 10 revealed that offshoots weighing either 5 to <8 kg or 2 to <5 kg increased significantly rooting percentage in the first season comparing with offshoots weighing <2 kg. In the second season, rooting percentage was significantly increased by offshoots weighing 5 to <8 kg followed by 2 to <5 kg and <2 kg, respectively.

In addition, IBA increased significantly rooting percentage (31.9% in the first season and 37.9% in the second season) followed by NAA and IAA, respectively. Also, rooting percentage was significantly increased by increasing auxin concentration.

Treating with 150 ppm IBA gave the highest rooting percentage comparing with other interactions. In addition, offshoots weighing 5 to <8 kg injected with 150 ppm IBA gave the highest rooting percentage, while offshoots weighing <2 kg treated with water free auxin showed the lowest rooting percentage. In this respect, the other interactions were in between.

Number of Roots, Root Length and Root Diameter:

Data presented in Tables 11, 12 and 13 pointed out that number of roots, root length and root diameter were significantly increased with offshoots weighing 5 to <8 kg followed by 2 to <5 kg and <2 kg, respectively.

In addition, IBA increased significantly number of roots (10.16 in the first season and 11.89 in the second season) and root diameter (4.56 mm in the first season and 4.55 mm in the second season) followed by NAA and IAA, respectively. In contrary, IAA increased significantly root length (8.61 cm in the first season and 8.82 cm in the second season) followed by NAA and IBA, respectively.

Offshoots weighing 5 to <8 kg treated with 150 ppm IBA gave the highest number of roots and root diameter comparing to other interactions, while offshoots weighing <2 kg treated with 0 ppm auxin gave the lowest values.

Table 8: Effect of different offshoot weights, auxin types and its concentrations on new leaves number of Zaghoul date palm offshoots after 9 months

		First season				Second season				
		Offshoot weight				Offshoot weight				
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean	
IBA	0 ppm	1.33	1.67	2.83	1.94	1.17	1.67	2.83	1.89	
IBA	50 ppm	1.50	2.33	3.90	2.58	1.50	2.33	3.77	2.53	
IBA	100 ppm	2.00	3.00	3.90	2.97	1.83	3.23	3.77	2.94	
IBA	150 ppm	2.17	3.23	4.33	3.24	2.17	3.33	4.20	3.23	
Mean		1.75	2.56	3.74	2.68	1.67	2.64	3.64	2.65	
NAA	0 ppm	1.33	1.83	3.00	2.06	1.17	1.67	2.77	1.87	
NAA	50 ppm	1.50	2.17	3.67	2.44	1.33	2.33	3.57	2.41	
NAA	100 ppm	1.67	2.50	3.67	2.61	1.67	2.50	3.67	2.61	
NAA	150 ppm	1.83	2.67	3.90	2.80	1.83	2.90	3.90	2.88	
Mean		1.58	2.29	3.56	2.48	1.50	2.35	3.47	2.44	
IAA	0 ppm	1.00	1.83	2.83	1.89	1.17	1.83	2.90	1.97	
IAA	50 ppm	1.33	2.00	3.33	2.22	1.50	2.00	3.50	2.33	
IAA	100 ppm	1.67	2.17	3.43	2.42	1.67	2.17	3.57	2.47	
IAA	150 ppm	1.67	2.50	3.90	2.69	1.67	2.50	3.90	2.69	
Mean		1.42	2.13	3.38	2.31	1.50	2.13	3.47	2.36	
0 ppm		1.22	1.78	2.89	1.96	1.17	1.72	2.83	1.91	
50 ppm		1.44	2.17	3.63	2.41	1.44	2.22	3.61	2.43	
100 ppm		1.78	2.56	3.67	2.67	1.72	2.63	3.67	2.67	
150 ppm		1.89	2.80	4.04	2.91	1.89	2.91	4.00	2.93	
Mean		1.58	2.33	3.56	-	1.56	2.37	3.53	-	
LSD _{0.05} for										
offshoot weight (A)					0.3311					0.2626
auxin type (B)					0.1664					0.1617
auxin concentrations (C)					0.1921					0.1867
A x B					0.2882					0.2800
A x C					0.3328					0.3233
B x C					0.3328					0.3233
A x B x C					0.5764					0.5600

Table 9: Effect of different offshoot weights, auxin types and its concentrations on leaf length (cm) of Zaghoul date palm offshoots after 9 months

		First season				Second season			
		Offshoot weight				Offshoot weight			
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean
IBA	0 ppm	49.7	71.3	90.8	70.6	51.8	71.8	91.7	71.8
IBA	50 ppm	60.2	74.8	102.1	79.0	63.7	75.0	105.7	81.5
IBA	100 ppm	63.3	81.5	106.6	83.8	65.8	81.9	108.8	85.5
IBA	150 ppm	66.8	80.3	110.9	86.0	67.2	83.2	114.1	88.2
Mean		60.0	77.0	102.6	79.9	62.1	78.0	105.1	81.7
NAA	0 ppm	48.7	72.2	89.5	70.1	51.2	71.2	91.4	72.2
NAA	50 ppm	59.8	73.3	94.2	75.8	60.8	75.8	100.1	78.9
NAA	100 ppm	61.8	76.7	102.5	80.3	62.3	77.9	104.9	81.7
NAA	150 ppm	62.2	78.5	106.4	82.4	64.7	79.6	107.7	84.0
Mean		58.1	75.2	98.2	77.1	59.8	76.1	101.0	79.0

Table 9: Continued

IAA	0 ppm	50.0	70.2	91.7	70.6	50.8	70.5	90.8	70.7
IAA	50 ppm	55.7	73.3	93.0	74.0	57.7	73.2	94.2	75.0
IAA	100 ppm	57.3	75.7	95.2	76.1	59.5	75.7	97.0	77.4
IAA	150 ppm	60.3	77.7	102.8	80.3	62.8	77.8	103.6	81.4
Mean		55.8	74.2	95.7	75.2	57.7	74.3	96.4	76.1
0 ppm		49.4	71.2	90.7	70.4	51.3	71.2	91.3	71.2
50 ppm		58.6	73.8	96.4	76.3	60.7	74.7	100.0	78.5
100 ppm		60.8	77.9	101.4	80.1	62.6	78.5	103.6	81.5
150 ppm		63.1	78.8	106.7	82.9	46.9	80.2	108.5	84.5
Mean		58.0	75.5	98.8	-	59.9	76.1	100.8	-
LSD _{0.05} for									
offshoot weight (A)					2.31	2.93			
auxin type (B)					1.42	1.40			
auxin concentrations (C)					1.64	1.62			
A x B					2.46	2.43			
A x C					2.84	2.80			
B x C					2.84	2.80			
A x B x C					4.92	4.85			

Table 10: Effect of different offshoot weights, auxin types and its concentrations on rooting percentage of Zaghoul date palm offshoots after 9 months

Treatment		First season				Second season			
		Offshoot weight				Offshoot weight			
		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean
IBA	0 ppm	16.7	22.2	27.8	22.2	22.2	27.8	33.3	27.8
IBA	50 ppm	22.2	33.3	38.9	31.5	27.8	38.9	44.4	37.0
IBA	100 ppm	33.3	33.3	38.9	35.2	33.3	44.4	50.0	42.6
IBA	150 ppm	33.3	38.9	44.4	38.9	33.3	44.4	50.0	42.6
Mean		26.4	31.9	37.5	31.9	29.1	38.9	44.4	37.5
NAA	0 ppm	16.7	22.2	27.8	22.2	22.2	27.8	33.3	27.8
NAA	50 ppm	22.2	33.3	33.3	29.6	27.8	33.3	38.9	33.3
NAA	100 ppm	27.8	33.3	33.3	31.5	27.8	38.9	44.4	37.0
NAA	150 ppm	33.3	33.3	38.9	35.2	33.3	38.9	50.0	40.7
Mean		25.0	30.5	33.3	29.6	27.8	34.7	41.7	27.8
IAA	0 ppm	16.7	22.2	27.8	22.2	22.2	27.8	33.3	27.9
IAA	50 ppm	16.7	22.2	27.8	22.2	27.8	27.8	33.3	29.6
IAA	100 ppm	16.7	33.3	33.3	27.8	27.8	33.3	38.9	33.3
IAA	150 ppm	27.8	33.3	33.3	31.5	33.3	33.3	44.4	37.0
Mean		19.5	27.8	30.5	25.9	27.8	30.5	37.5	31.9
0 ppm		16.7	22.2	27.8	22.2	22.2	27.8	33.3	27.8
50 ppm		20.4	29.6	33.3	27.8	27.8	33.3	38.9	33.3
100 ppm		25.9	33.3	35.2	31.5	29.6	38.9	44.4	37.6
150 ppm		31.5	35.2	38.9	35.2	33.3	38.9	48.1	40.1
Mean		23.6	30.1	33.8	-	28.2	34.7	41.2	-
LSD _{0.05} for									
offshoot weight (A)					5.13	2.57			
auxin type (B)					3.08	4.12			
auxin concentrations (C)					3.56	4.75			
A x B					5.33	7.13			
A x C					6.16	8.23			
B x C					6.16	8.23			
A x B x C					10.67	14.26			

Table 11: Effect of different offshoot weights, auxin types and its concentrations on roots number of Zaghloul date palm offshoots after 9 months

		First season				Second season				
		Offshoot weight				Offshoot weight				
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean	
IBA	0 ppm	3.33	5.83	8.33	5.83	3.33	8.00	13.50	8.28	
IBA	50 ppm	5.50	8.83	11.10	8.48	5.33	8.67	16.30	10.10	
IBA	100 ppm	9.17	13.67	14.93	12.59	9.33	14.73	18.67	14.24	
IBA	150 ppm	9.50	15.00	16.67	13.72	9.83	15.30	19.67	14.93	
Mean		6.88	10.83	12.76	10.16	6.96	11.68	17.03	11.89	
NAA	0 ppm	3.33	5.50	8.17	5.67	3.33	7.50	13.43	8.09	
NAA	50 ppm	4.33	7.83	9.67	7.28	4.83	10.67	15.77	10.42	
NAA	100 ppm	6.00	9.67	11.00	8.89	6.17	11.50	16.87	11.51	
NAA	150 ppm	6.67	10.33	12.23	9.74	6.67	12.17	18.43	12.42	
Mean		5.08	8.33	10.27	7.89	5.25	10.46	16.13	10.61	
IAA	0 ppm	3.33	5.83	8.17	5.78	2.33	7.67	13.43	7.81	
IAA	50 ppm	3.33	7.50	9.33	6.72	3.33	8.67	14.83	8.94	
IAA	100 ppm	3.67	8.67	10.90	7.74	3.83	9.17	15.00	9.33	
IAA	150 ppm	4.67	9.33	11.07	8.36	4.83	10.50	15.47	10.27	
Mean		3.75	7.83	9.87	7.15	3.58	9.00	14.68	9.09	
0 ppm		3.33	5.72	8.22	5.76	3.00	7.72	13.46	8.06	
50 ppm		4.39	8.06	10.03	7.49	4.50	9.33	15.63	9.82	
100 ppm		6.28	10.67	12.28	9.74	6.44	11.80	16.84	11.70	
150 ppm		6.94	11.56	13.32	10.61	7.11	12.66	17.86	12.54	
Mean		5.24	9.00	10.96	-	5.26	10.38	15.95	-	
LSD _{0.05} for										
offshoot weight (A)					0.4108					0.1075
auxin type (B)					0.3341					0.3471
auxin concentrations (C)					0.3858					0.4008
A x B					0.5787					0.6012
A x C					0.6682					0.6942
B x C					0.6682					0.6942
A x B x C					1.1570					1.2020

Table 12: Effect of different offshoot weights, auxin types and its concentrations on root length (cm) of Zaghloul date palm offshoots after 9 months

		First season				Second season			
		Offshoot weight				Offshoot weight			
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean
IBA	0 ppm	2.88	6.22	7.56	5.55	2.61	6.43	7.04	5.36
IBA	50 ppm	2.92	7.61	9.42	6.65	2.83	7.80	8.67	6.43
IBA	100 ppm	3.36	8.31	11.59	7.75	3.41	7.78	12.48	7.89
IBA	150 ppm	3.54	11.11	11.69	8.78	4.20	10.96	12.86	9.34
Mean		3.17	8.31	10.06	7.18	3.26	8.24	10.27	7.26
NAA	0 ppm	3.00	6.50	7.57	5.69	2.62	6.04	7.25	5.30
NAA	50 ppm	2.91	8.22	10.08	7.07	3.41	8.78	9.84	7.34
NAA	100 ppm	3.76	11.21	13.33	9.43	4.52	12.00	13.42	9.98
NAA	150 ppm	4.70	12.05	13.35	10.40	5.46	12.34	15.00	10.93
Mean		3.59	9.50	11.08	8.06	4.00	9.79	11.38	8.39

Table 12: Continued

IAA	0 ppm	2.61	6.57	7.64	5.61	2.60	6.54	7.18	5.44	
IAA	50 ppm	3.45	8.87	10.85	7.72	4.48	8.73	11.56	8.26	
IAA	100 ppm	3.59	12.80	14.13	10.18	4.35	12.87	14.20	10.47	
IAA	150 ppm	4.98	13.20	14.64	10.94	5.31	12.75	15.30	11.12	
Mean		3.66	10.36	11.82	8.61	4.18	10.22	12.06	8.82	
0 ppm		2.83	6.43	7.59	5.62	2.61	6.34	7.16	5.37	
50 ppm		3.09	8.23	10.12	7.15	3.57	8.44	10.02	7.34	
100 ppm		3.57	10.77	13.01	9.12	4.09	10.88	13.37	9.45	
150 ppm		4.41	12.12	13.23	9.92	4.99	12.02	14.39	10.46	
Mean		3.74	9.39	10.99	-	3.82	9.42	11.23	-	
LSD _{0.05} for										
offshoot weight (A)					0.1616					0.1224
auxin type (B)					0.1473					0.2141
auxin concentrations (C)					0.1701					0.2472
A x B					0.2552					0.3708
A x C					0.2946					0.4282
B x C					0.2946					0.4282
A x B x C					0.5103					0.7417

Table 13: Effect of different offshoot weights, auxin types and its concentrations on root diameter (mm) of Zaghloul date palm offshoots after 9 months

		First season				Second season				
		Offshoot weight				Offshoot weight				
Treatment		< 2 kg	2 to <5 kg	5 to <8 kg	Mean	< 2 kg	2 to <5 kg	5 to <8 kg	Mean	
IBA	0 ppm	2.83	3.62	3.96	3.47	2.81	3.63	4.06	3.50	
IBA	50 ppm	3.31	3.87	4.78	3.99	3.37	3.89	4.95	4.07	
IBA	100 ppm	3.42	5.70	6.71	5.28	3.49	5.41	6.61	5.17	
IBA	150 ppm	3.74	5.97	6.79	5.50	3.73	5.76	6.85	5.45	
Mean		3.32	4.79	5.56	4.56	3.35	4.67	5.62	4.55	
NAA	0 ppm	2.69	3.59	3.84	3.38	2.78	3.62	3.96	3.45	
NAA	50 ppm	3.33	3.72	4.49	3.84	3.26	3.95	4.66	3.96	
NAA	100 ppm	3.51	5.48	6.52	5.17	3.49	5.23	5.70	4.81	
NAA	150 ppm	3.51	5.62	6.55	5.22	3.50	5.37	5.86	4.91	
Mean		3.26	4.60	5.35	4.40	3.26	4.54	5.05	4.28	
IAA	0 ppm	2.73	3.57	3.91	3.40	2.78	3.54	4.01	3.44	
IAA	50 ppm	2.80	3.65	4.23	3.56	2.93	4.00	4.48	3.80	
IAA	100 ppm	3.20	5.16	5.85	4.74	3.05	5.02	5.53	4.53	
IAA	150 ppm	3.37	5.36	6.39	5.04	3.44	5.14	5.84	4.81	
Mean		3.02	4.44	5.10	4.19	3.05	4.42	4.97	4.15	
0 ppm		2.75	3.60	3.91	3.42	2.79	3.59	4.01	3.46	
50 ppm		3.14	3.75	4.50	3.80	3.19	3.95	4.70	3.94	
100 ppm		3.37	5.45	6.36	5.06	3.35	5.22	5.95	4.84	
150 ppm		3.54	5.65	6.58	5.25	3.56	5.42	6.18	5.06	
Mean		3.20	4.61	5.34	-	3.22	4.55	5.21	-	
LSD _{0.05} for										
offshoot weight (A)					0.1576					0.1075
auxin type (B)					0.0666					0.0595
auxin concentrations (C)					0.0769					0.0687
A x B					0.1153					0.1031
A x C					0.1331					0.1191
B x C					0.1331					0.1191
A x B x C					0.2305					0.2062

These observations are in accordance with those obtained by El-Hodairi *et al.* [15] who demonstrated that injection date palm cv. Taaghiyaat offshoots weighing about 15 kg with IAA at 50 or 100 ppm gave the best rooting response. Also, Rizk, [7] reported that treating Sewy date palm offshoots weighing 5-10 kg with IBA at 3000 ppm increased rooting percentage, number of leaves and number of roots/offshoot.

It is known that adventitious root induction can be stimulated by exogenously applied auxins, but the mechanism of this physiological response has not yet been clearly elucidated. Although auxins are primarily associated with the induction of adventitious roots, they are also intimately involved in such processes as cell division, cell elongation and cell differentiation [16-18].

Conclusion: From the aforementioned results, small offshoots or light weight offshoots of date palm can be used successfully in propagation using injection by either IBA or NAA at 100 or 150 ppm.

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