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ROOTABILITY GROUND AND AERIAL OFFSHOOTS OF SOME DATE PALM CULTIVARS GROWN IN NORTH SINAI USING METAL NANOPARTICLES AND NAA

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ABSTRACT: This investigation was carried out during 2016 and 2017 seasons in the greenhouse of the Experimental orchard, Faculty of Environmental and Agricultural Sciences, Arish University, North-Sinai Governorate, Egypt. Offshoot bases of ground and aerial Amry, Khudary and Hayany cvs. date palm were soaked in distilled water for 24 hr., then subjected to five treatments: 1) Untreated offshoot bases (control); 2) Soaking offshoot bases in 0.5% nanoparticles of $FeSO_4$ alone for 10 minutes; 3) Soaking offshoot bases in 0.5% nanoparticles of $FeSO_4$ + 8% NAA for 10 minutes; 4) Soaking offshoot bases in 0.5% nanoparticles of $ZnSO_4$ alone for 10 minutes; 5) Soaking offshoot bases in 0.5% nanoparticles of $ZnSO_4$ + 8% NAA solution for 10 minutes. The experiment was laid out following randomized complete block design (RCBD) included 15 treatments and statistically analyzed using ANOVA, each treatment was replicated five times. The best results in terms of main root length, total root weight, small root number and weight, large root number and weight and survival offshoots percentages were obtained generally by treating offshoots bases with 0.5% nanoparticles of $FeSO_4$ + 8% NAA and 0.5% nanoparticles of $ZnSO_4$ + 8% NAA. Ground and aerial offshoots of "Amry" and "Hayany" cvs. could be considered to be “easy- to root”, since the rooting occurred during the first three and four months from the onset of the initial treatment time (January), respectively. On the other hand, rooting of ground and aerial offshoots of "Khudary" cultivar could be considered as “difficult- to root”, since the rooting occurred after three and four months later, respectively. Results of both seasons revealed that the 0.5% nanoparticles of $FeSO_4$ + 8% NAA and 0.5% nanoparticles of $ZnSO_4$ + 8% NAA treatments achieved the highest total root weight in the three tested cultivars. Positive correlation ships in "Amry" cv. were found between the percentage of survival ground offshoots and the mean root length, total root weight and both weight and number of small and large roots with values of 0.321*, 0.423*, 0.425*, 0.521** and 0.421*, respectively. Also, positive correlation was noticed in "Hayany" cultivar between the percentage of survival aerial offshoots and each of the mean root length (r = 0.456*), total root weight (r = 0.589*), number and weight of small roots(r = 0.632*, and 0.453*), respectively and large root number (r = 0.357*).

Key words: Date palm, nanoparicles, NAA, rootabilty, survival offshoots percentage, ground and aerial offshoots.

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is an income generating source having potential of staple food qualities as its fruit is enriched with higher mineral contents **(Al-Shahib and Marshall, 2003)**. Date palm is generally propagated by offshoots **(Hartmann *et al.,* 1997; Zaid and Wet, 2002)**. Due to dioecious in nature and cross pollination, it cannot be propagated sexually for commercial fruit production. So the commercial propagation has strictly been confined to the use of only asexual means by using offshoots. offshoots produced at the base of the mother stem have a high survival rate due to the well-developed root system and

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they are usually produced being close to the ground. Offshoots grown at high position on the mother stem (*i.e.* aerial offshoots) lack such root system and their survival is very low **(Gupta, and Godara, 1992; Al-Mana *et al.,* 1996).** However, reduced number (*i.e.*, each tree produces 2-3 offshoots/year thus giving 15-30 offshoots in a period of 12- 15 years), variation in their age, size and weight on a single mother tree, slow growth and very high mortality rate of the transplanted rooted suckers are the major constraints **(Afzal *et al.,* 2011).** It is common practice to get rid of the aerobic branches of date palms and waste them because of their inability to form their own roots **(Jamro *et al.,* 2018)**. In fact, offshoots grown at high position on the mother stem (*i.e.* aerial offshoots) lack such root system and their survival is very low **(Al-Mana *et al.,* 1996)**. Rooting capacity has been correlated with some endogenous substances such as carbohydrate content **(Rahmana and Rahkhodaei, 2013)** and rooting inhibitors which are found in a number of species. The upper offshoots have fewer carbohydrates than the lower offshoots. These inhibitors are suggested to be principal reasons for rooting failure in certain difficult-to-root cuttings **(Fadl *et al.,* 1979)**. Development of the root structure plays critical role in survival and growth of the date palm. Most of the palm species produce adventitious roots that originate from the root initials present on trunk **(Day *et al.*, 2009).**

Nanoparticles (NPs), also known as particulate nanomaterials (NMs), are particle materials with at least one dimension in the nanoscale between 1–100 nm **(Stampoulis *et al.,* 2009**; **Wang *et al.,* 2016). Masarovicova and Kral'ova (2013)** characterized nanoparticles and specially metal nanoparticles in detail. Thus, nanoparticles (NPs) are atomic or molecular aggregates can drastically modify their physico-chemical properties compared to the bulk material **(Heller and Atkinson, 2007).** Coming nanotechnologies in the agricultural field seem quiet promising **(Mousavi and Rezaei, 2011; Ditta, 2012).** Try to use nanoparticles in an attempt to further stimulate the rooting of aerial of offshoots of date palm and raise the efficiency of growth hormones **(Roshdy and Refaai, 2016)**. **Karakecili *et al.* (2019)** investigated the use of zinc oxide nanoparticles (nZnO) as nanocarriers for plant auxins indole-3-acetic acid (IAA) and indole-3-butyric acid (IBA) and determine the effects on rhizogenesis in micro cuttings of different *Pyrus* species. Auxin loaded nanoparticles (IAA-nZnO and IBA-nZnO) were characterized for particle size, morphology, thermal behavior and chemical structure. In this genotype, the highest rooting percentage was achieved for IBA-nZnO and IAA-nZnO at 400 $mg.l^{-1}$ concentration as 50.0% and 41.7%, respectively. Thus, auxin loaded ZnO nanoparticles could be used as efficient nanocarriers in agricultural applications **(Monica and Cremonini, 2009)**.

Synthetic hormones like Naphthalene Acetic Acid (NAA) are commonly used to promote root development in asexual propagation **(Jamro *et al.,* 2018)**. **Al-Mana *et al.* (1996)** showed that aerial offshoots treated with NAA (as a rooting co-factor) resulted in good root formation and development. Large sized offshoots were found to contain greater qualities of endogenous root promoting substances or smaller quantities of rooting inhibitors **(Dawson and Pansiot, 1985). El-Hodairi *et al.* (1992)** found that injecting bases of date palm (cv. Taaghiyaat) offshoots with NAA gave the best rooting response. NAA increased the number, length and dry weight of root hairs, small roots (1-1.5mm long) and large roots (>1.5mm). Aerial offshoots of Segie and Khalas date cultivars produced well developed root system, while Succary and Seleg produced poor roots after 6 months of applying commercial Naphthalene Acetic Acid powder (Radicante, 0.8% NAA) applications **(Al-Obeed, 2005).**

The aim of the present study was to evaluate the effect of two nanoparticles ($FeSO_4$ and $ZnSO_4$) alone or in combination with NAA growth regulator on the rooting system of ground and aerial offshoots of three date palm cultivars grown at North-Sinai Governorate, Egypt.

MATERIALS AND METHODS

This investigation was carried out during 2016 and 2017 seasons in the greenhouse of the Experimental orchard of the Faculty of Environmental and Agricultural Sciences, Arish University, North-Sinai Governorate, Egypt to evaluate the effect of two nanoparticles ($FeSO_4$ and $ZnSO_4$) alone or in combination with NAA growth regulator on the rooting system of ground and aerial offshoots of three date palm cultivars. Ground and aerial offshoots of uniform size (12-20 Kg) were carefully separated from mother trees and kept under shade. Amry, Khudary and Hayany cultivars which are commonly grown in Al-Arish region were selected for this study. These offshoots were prepared for the treatments during the first week of January 2016 and 2017 seasons. Offshoot bases were cleaned by removing the old leaf bases and the fibers surrounding the stem then were surface sterilized for 20 seconds in a 0.5% aqueous solution of sodium hypochlorite (Plat 1-A). Offshoot bases of ground and aerial Amry, Khudary and Hayany cvs. date palm were soaked in distilled water for 24 hr. then treated with five treatments as follow:

1. Untreated offshoot bases (control).
2. Soaking offshoot bases in 0.5% NPs-$FeSO_4$ alone for 10 minutes.
3. Soaking offshoot bases in 0.5% NPs-$FeSO_4$ + 8% NAA solution for 10 minutes.
4. Soaking offshoot bases in 0.5% NPs-$ZnSO_4$ alone for 10 minutes.
5. Soaking offshoot bases in 0.5% NPs-$ZnSO_4$ + 8% NAA solution for 10 minutes.

This experiment was laid out following randomized complete block design (RCBD). Experiment included 15 treatments which were the combination with three cultivars and five NPs treatments. Each treatment was replicated five times (*i.e.,* 5 NPs treatments × 3 cultivars × 5 replicates = 75 offshoots for each ground and aerial offshoots).

Measurements

The offshoots were planted in black plastic pots (30 × 25 cm in diameter) filled with a mixture of perlite: peat moss: sand (1: 1: 1 *V/V*) (Plate 1-B). At the end of the experiment (April and May for ground and aerial offshoots for both Amry and Hayany cultivars, respectively and July and August for the considered offshoots for Khudary cultivar), the number of survived offshoots was counted. The formed roots were cut from the offshoot base, and divided into two groups: large diameter (diameter >0.5 cm) and small diameter roots (diameter <0.5 cm) according to **Liu *et al.* (2018)**. Roots of each size were then counted, weighed and the length of 10 main roots was measured.

Statistically Analysis

These experiments were laid out according to randomized complete block design (RCBD). Data obtained in this study were recorded and statistically analyzed using ANOVA **(Steel *et al.,* 1997)**. Duncan´s multiple range test was used to separate treatment means to found significantly different in the analysis of variance **(Duncan, 1955)**. and correlation coefficients among variables were analyzed using **SAS (1988)**.

RESULTS AND DISCUSSION

Regarding the time required for root formation in the ground and aerial offshoots (untabulated data), it was noticed that the time of root formation differed according to the cultivar, offshoot type and concentration of growth regulators. Ground offshoots of "Amry" and "Hayany" cultivars developed their root system within three months (April) from the onset of the initial treatment time (January 2016 and 2017). At this mentioned date, signs of primordial roots were noticed in the ground offshoots "Khudary" cultivar. Thus, ground offshoots of "Amry" and "Hayany". could be considered to be “easy- to root” cultivars, since the rooting occurred during the first three months. On the other hand, "Khudary" cultivar ground offshoots, which developed its root system three months later (July), could be considered as “difficult - to root”. In this respect, the same trend was found for aerial offshoots with one month later than the ground offshoots in the three date palm cultivars *i.e.,* May for both "Amry" and "Hayany and August for "Khudary" cultivars. The same trend was found by **(Reuveni and Adato, 1974)**. They reported that date palm cultivars exhibited a wide range of differences in their ability of rooting time as affected by different treatments.

Effects of Metal Nanoparticles and NAA on Ground Offshoots

Small roots number and weight

Concerning, the specific effect of $FeSO_4$ and $ZnSO_4$ nanoparticles, results in Table 1 revealed that soaking ground offshoots in 0.5% NPs-$FeSO_4$ + 8% NAA caused a high significant

Plat 1. (A) The surface sterilization offshoot bases. (B) The media mixture which offshoots were planted in pots

increase in small roots number and weight (105.05 and 99.13) and (54.81 and 50.41 g), in both seasons, respectively. As for specific effect of cultivars, results showed that Amry cultivar had the highest value for each of small root number and weight (133.30 and 130.07) and (69.03 and 65.00 g) compared to the other two cultivars in both seasons, respectively. Meanwhile, Hayany cultivar produced the least significant effect in this respect. Regarding, the interaction effects between nanoparticles and date palm cultivars, it is clear that the ground Amry offshoots bases treating with solutions containing 0.5% $FeSO_4$ nanoparticles (NPs) + 8% NAA induced the highest number and weight of small roots (diameter <0.5 cm), followed by Amry offshoots bases treating with $ZnSO_4$ (NPs)+ 8% NAA treatment as compared to the other treatments. While, untreated ground offshoots of Hayany had the least value for each of small root number and weight in both seasons. Significant differences in the small root number were noticed among all treatments in both seasons. These findings are in agreement with those obtained by **Lavee *et al.* (1994), Al-Obeed (2005) and Jamro *et al.* (2018).**

Large root number and weight

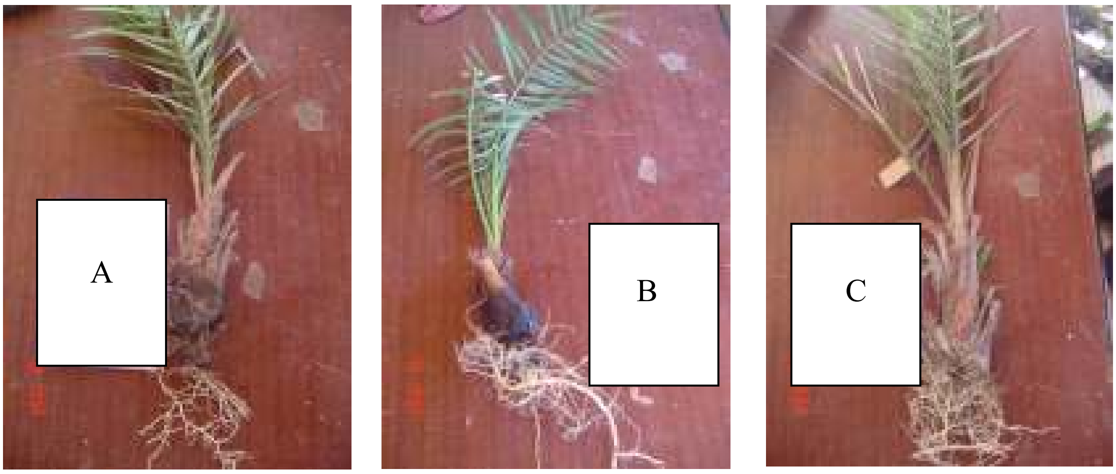
Results in Table 1 indicated that large root number and weight of ground offshoots were affected significantly by $FeSO_4$ and $ZnSO_4$ nanoparticles. Soaking in 0.5% NPs-$FeSO_4$ + 8% NAA was induced more simulative effect in large root number and weight (58.06 and 48.14) and (163.69 and 150.03 g) in both seasons, respectively. On the other hand, untreated ground offshoots (control) gave the lowest values in both experimental seasons. Concerning, the specific effect of date palm cultivars, the highest large roots number and weight were recorded with Amry ground offshoots (62.36 and 50.43) and (155.41 and 154.60 g), followed by Hayany cv. (39.09 and 35.24) and (120.23 and 114.26 g) in both seasons, respectively. On the other hand, the Khudary ground offshoots cv. gave the least values (29.52 and 31.17) and (92.64 and 94.29g) in this respect. Regarding the interaction effect between different nanoparticles and cultivars, results presented in Table 1 revealed that, treating the ground offshoots of Amry cv. with 0.5% nanoparticles of NPs-$FeSO_4$ + 8% NAA gave the highest number and weight of large roots (78.99 and 62.13) and (201.26 and 189.74 g) in the 1st and 2nd seasons, respectively, followed by Amry cv. with 0.5% nanoparticles of NPs-$FeSO_4$ alone compared to other interactions. While, untreated "Khudary" ground offshoots gave the lowest values in both experimental seasons. Significant differences were found, in number and weight of large roots, between all treatments as compared with the control in 2016 and 2017 seasons. These results are in line with those obtained by **El-Hammady *et al.* (1992), Lavee *et al.* (1994) and Thangavelu *et al.* (2018).**

Mean root length

Results presented in Table 2 and Plat 2 indicated that, treated ground offshoots with 0.5% NPs-$FeSO_4$ + 8% NAA gave significantly higher mean root length (Average length of 10

Table 1. Effect of cultivars, some metals nanoparticles with Naphthalene acetic acid and their interactions on roots number and weight of ground offshoots of date palm during 2016 and 2017 seasons

Treatment	Roots number								Roots weight (g)							
	Small roots (<0.5 cm)			Mean of T.	Large roots (>0.5 cm)			Mean of T.	Small roots (<0.5 cm)			Mean of T.	Large roots (>0.5 cm)			Mean of T.
	Amry	Khudary	Hayany		Amry	Khudary	Hayany		Amry	Khudary	Hayany		Amry	Khudary	Hayany	
2016 season																
Control	112.52 e	55.29 l	55.12 l	**74.31 D**	45.31 f	18.40 l	33.15 i	**32.29 D**	62.19 e	28.90 j	28.10 j	**39.73 D**	121.25 f	61.26 k	96.75 hi	**93.09 D**
0.5% NPs-$FeSO_4$	135.23 c	75.40 h	68.34 jk	**92.99 B**	65.23 b	23.52 k	41.22 g	**43.32 B**	71.12 c	39.72 gh	37.44 h	**49.43BC**	189.78 b	74.18 j	123.54ef	**129.17 B**
0.5% NPs-$FeSO_4$ + 8% NAA	154.28 a	85.43 f	75.45 h	**105.05A**	78.94 a	42.14 fg	53.10 e	**58.06A**	75.47 a	49.14 f	39.83gh	**54.81A**	201.26 a	128.49 e	161.32 c	**163.69A**
0.5% NPs-$ZnSO_4$	123.11 d	72.15 i	66.55 k	**87.27 C**	59.86 d	28.45 j	33.24 i	**40.52 C**	63.83 d	37.41 h	36.32 i	**45.85 C**	132.53 d	84.13 i	101.11 h	**105.92 C**
0.5% NPs-$ZnSO_4$ + 8% NAA	141.37 b	81.13 g	71.33 j	**97.94 AB**	62.48 c	35.11 h	34.72 hi	**44.10AB**	72.54 b	42.12 g	36.51 i	**50.39B**	132.25 d	115.12 g	118.42fg	**121.93BC**
Mean of cultivars	**133.30A**	**73.88 B**	**67.36 C**		**62.36 A**	**29.52 C**	**39.09 B**		**69.03A**	**39.46 B**	**35.64 C**		**155.41A**	**92.64 C**	**120.23B**	
2017 season																
Control	98.86 e	47.32 k	45.33 l	**63.84 D**	32.55 g	21.19 i	22.35 hi	**25.36 D**	45.82 c	25.40 h	22.35 i	**31.19 C**	100.20fg	65.86 i	71.25 h	**79.10 D**
0.5% NPs-$FeSO_4$	123.25 d	56.43 i	52.16 j	**77.28 C**	55.29 b	23.71 h	36.51 f	**38.50 C**	62.51 b	29.73 g	26.13gh	**39.46BC**	165.72 b	69.51 hi	124.53 e	**119.92CD**
0.5% NPs-$FeSO_4$ + 8% NAA	154.23 a	76.77 f	66.38 g	**99.13 A**	62.13 a	41.18 d	41.12 d	**48.14 A**	75.83 a	41.14 d	34.27 ef	**50.41 A**	189.74 a	128.54de	131.82 d	**150.03 A**
0.5% NPs-$ZnSO_4$	132.22 c	61.28 h	61.29 h	**84.93 BC**	48.74 c	31.22 h	37.27 e	**39.08BC**	65.37 b	33.18 efg	32.15 fg	**43.57 B**	157.12 c	95.23 g	112.54 f	**121.63 C**
0.5% NPs-$ZnSO_4$ + 8% NAA	141.81 b	65.29 gh	65.30gh	**90.80 B**	53.45 bc	38.57 de	38.96 de	**43.66 B**	75.48 a	35.11 e	35.29 e	**48.63AB**	160.23bc	112.29	131.15 d	**134.56 B**
Mean of cultivars	**130.07A**	**61.42 B**	**58.09C**		**50.43 A**	**31.17 C**	**35.24 B**		**65.00A**	**32.91B**	**30.04 B**		**154.60A**	**94.29 C**	**114.26B**	



Plat 2. Effects of metal nanoparticles and NAA on mean root length of ground offshoots (A) Amry cv. (B) Khudary cv. (C) Hayany cv.

main roots) than when compared with the control, followed by 0.5% NPs-$ZnSO_4$ + 8% NAA treatment in both seasons. As for the specific effect of different cultivars, results in Table 2 show that Hayany cultivar produced the longest main root length (small and large) compared with other cultivars in both experimental seasons. Regarding, the interaction effect between nanoparticles practices and cultivars on longest main root length, results in Table 2 indicate that Hayany cultivar treating the ground offshoot's bases with 0.5% NPs-$FeSO_4$ + 8% NAA produced the longest root length compared with the other treatments. The untreated Khudary ground offshoot's treatment showed a significant reduction in the longest main root length (small roots), while the untreated Amry ground offshoot's treatment gave the least value of the longest main root length (large roots) in both seasons. These results are in line with those obtained by **El-Hammady *et al.* (1992), Lavee *et al.* (1994) and Al-Obeed (2005)** who concluded that, a positive effect of the NAA treatment on Khalas, Succary and Seleg offshoots for rooting length. **Al-Mana *et al.* (1996)** reported that the highest rooting in aerial offshoots of Shish cultivar was achieved with 8% NAA treatment followed by those treated with 8% NAA+50 ppm catechol.

Survival percentages of ground offshoots

As regards to the specific effect of nanoparticles (NPs) practices on survival percentages of ground offshoots, it is clear from Table 2 that all the nanoparticles treatments increased the survival percentages of ground offshoots as compared with the untreated ones in both seasons. Soaking the base of ground offshoots of cultivars in solution containing 0.5% of nanoparticles NPs-$FeSO_4$ + 8% NAA produced the highest survival percentages (88.11 and 87.05%) in both seasons, respectively, while the least values were observed with the untreated ground offshoots (control) in this respect. Concerning the specific effect of cultivars, results showed that Khudary cultivar recorded the highest values of survival percentages of ground offshoots in both seasons with no significant differences with Amry cultivar in the 2nd season. Regarding the interaction effect between nanoparticles treatments and date palm cultivars on survival percentages of ground offshoots, results in the same table revealed that soaking the base of ground offshoots of Amry and Khudary in solution containing 0.5% NPs-$FeSO_4$ + 8% NAA produced the highest survival percentages (94.45 and 93.44 %) for Amry c.v. and (95.29 and 91.2%) for Khudary c.v. in both seasons, respectively. Moreover, the statistical analysis revealed that all treatments significantly increased the survival percentages of ground offshoots as compared with the control during both seasons, while, untreated Hayany cv. treatment gave the least values in this concern during both seasons. These results are in line with those obtained by **Al-Mana *et al.* (1996),**

Table 2. Effect of cultivars, some metals nanoparticles with Naphthalene acetic acid and their interactions on mean roots length and ground offshoots survival of ground offshoots of date palm during 2016 and 2017 seasons

Treatment	Mean roots length (Average length of 10 main roots cm)								Ground offshoots survival (%)			
	Small roots (<0.5 cm)			Mean of T.	Large roots (>0.5 cm)			Mean of T.	Amry	Khudary	Hayany	Mean of T.
	Amry	Khudary	Hayany		Amry	Khudary	Hayany					
					2016 season							
Control	32.13 gh	29.20 h	41.11 e	**34.15 D**	6.45 l	9.33 k	20.48 e	**12.09 E**	65.32 f	72.52 de	54.14 h	**63.99 E**
0.5% NPs-$FeSO_4$	38.25 efg	33.44 g	51.26 b	**40.98BC**	15.56 h	14.45 i	31.22 ab	**20.41 C**	68.44 e	80.25 bc	62.43 g	**70.37 D**
0.5% NPs-$FeSO_4$ + 8% NAA	45.16 c	42.55 de	56.29 a	**48.00 A**	29.15 b	23.11 d	34.12 a	**28.79 A**	94.45 a	93.44 a	76.45 cd	**88.11 A**
0.5% NPs-$ZnSO_4$	36.42 fg	39.47 ef	43.23 cde	**39.71C**	12.12 j	19.73 f	26.56 c	**19.47 D**	72.86 de	78.47 bcd	68.47 e	**73.27 C**
0.5% NPs-$ZnSO_4$ + 8% NAA	44.21 cd	36.72 fg	45.62 c	**42.18B**	26.08 c	17.81 g	28.93 bc	**24.27 B**	86.47 ab	84.10 b	73.54 cde	**81.37 B**
Mean of cultivars	**39.23 B**	**36.28 C**	**47.50 A**		**17.87 B**	**16.89 B**	**28.26 A**		**77.51 B**	**81.76 A**	**67.01 C**	
					2017 season							
Control	36.42 g	28.60 h	44.24 d	**36.42 D**	10.27 k	12.63 j	20.52 g	**14.47 D**	63.28 fgh	69.43 efg	57.11 h	**63.27 E**
0.5% NPs-$FeSO_4$	38.45 f	35.43 g	56.35 ab	**43.41BC**	19.48 gh	18.12 h	37.52 b	**25.04BC**	67.44 fg	74.56 de	62.43 gh	**68.14 D**
0.5% NPs-$FeSO_4$ + 8% NAA	44.27 d	46.52 c	59.36 a	**50.05 A**	24.11 f	30.49 cd	41.68 a	**32.09 A**	95.29 a	91.20 ab	74.65 de	**87.05 A**
0.5% NPs-$ZnSO_4$	37.54 fg	38.74 f	45.17 cd	**40.48 C**	16.82 i	23.55 fg	29.35 d	**23.24 C**	73.40 e	76.48 d	69.47 efg	**73.12 C**
0.5% NPs-$ZnSO_4$ + 8% NAA	42.13 e	42.51 e	49.88 b	**44.84 B**	23.18 fg	27.26 e	32.68 c	**27.71 B**	89.51 b	82.43 c	71.88 ef	**81.27 B**
Mean of cultivars	**39.76 B**	**38.36 B**	**51.00 A**		**18.77 C**	**22.41 B**	**32.35 A**		**77.78 A**	**78.82 A**	**67.11 B**	

Table 3. Correlation coefficient of some root characteristics in ground offshoots of date palm cultivars (average of two seasons)

Root character		Roots number		Roots weight		Mean root length	Offshoots survival (%)
		Small roots number	Large roots number	Small roots weight	Large roots weight		
		Amry cv.					
Roots number	Small roots number	------	-0.012NS	0.523*	-0.021NS	0.267NS	0.425*
	Large roots number		------	-0.0541*	0.531**	-0.125NS	0.521**
Roots weight	Small roots weight			------	-0.0213NS	0.424*	0.321NS
	Large roots weight				------	0.428*	0.421*
Mean root length						------	0.321*
Survival offshoots (%)							------
		Khudary cv.					
Roots number	Small roots number	------	-0.068NS	0.321NS	-0.035NS	0.388*	0.535*
	Large roots number		------	0.632**	0.621**	-0.134NS	0.564**
Roots weight	Small roots weight			------	0.032NS	0.512**	0.421*
	Large roots weight				------	0.532**	0.512*
Mean root length						------	0.428*
Survival offshoots (%)							------
		Hayany cv.					
Roots number	Small roots number	------	-0.012NS	0.523*	-0.021NS	0.131NS	0.533*
	Large roots number		------	-0.057NS	0.635**	0.324*	0.454*
Roots weight	Small roots weight			------	-0.058NS	0.231NS	0.345*
	Large roots weight				------	0.531*	0.547*
Mean root length						------	0.429*
Offshoots survival (%)							------

Afzal *et al.* (2011) and Mohammadi and Khezri (2018) they concluded that the application of zinc chelate provide growers with a tool to increase offshoots survival (> 85%).

The correlation coefficients among the different root characteristics of ground offshoots

The correlation coefficients among the different root characteristics of ground offshoots of Amry, Khudary and Hayany cvs. are presented in Table 3. Regarding Amry c.v., results revealed that positive correlations were found between the percentage of ground offshoots survival and each of the mean root length, total root weight, number of small roots and both number and weight of large roots with values of 0.321*, 0.423*, 0.425*, 0.521** and 0.421*, respectively. Also, high correlation was noticed between weight of large roots and both of total root weight and number of large roots. On the other hand, no correlation was found between the mean root length and total root weight and also between number of small and large roots. Concerning the ground offshoots in Khudary cultivar, results showed that positive and significant correlation was found between the mean root length and number and weight of small roots, weight of large roots and percentage of ground offshoots survival. Moreover, positive and highly significant correlation was found between weight of large roots and total root weight and number of large roots. Regarding Hayany cv., results in the same table illustrated that positive correlation was found between the percentage of offshoots survival and the mean root length (r = 0.429*), total root weight (r = 0.423*), number and weight of small and large roots (r = 0.533*, 0.345*, r = 0.454* and 0.547*, respectively). Also, positive and high correlations were obtained between the weight of large roots and total root weight (r = 0.589**) and number of large roots (r = 0.635**). Moreover, total root weight correlated significantly with the number of large roots (r = 0.459*) and the percentage of offshoots survival (r = 0.423**). These results are in line with those obtained by **Abdullatif and Al-Khateeb (2015).**

Effects of Metal Nanoparticles and NAA on Aerial Offshoots

Small roots number and weight

Results of 2016 and 2017 seasons clearly showed that the 0.5% nanoparticles of $FeSO_4$ (NPs) + 8% NAA soaking treatment encouraged inducing the highest number and weight of aerial offshoot's small roots, followed by 0.5% nanoparticles of $ZnSO_4$ + 8% NAA treatment as compared with the remained treatments including the control in both experimental seasons (Table 4). As for specific effect of cultivars, results showed that Hayany cultivar had the highest value for each of small root number and weight (62.56 and 64.89) and (32.47 and 35.04 g) compared to other aerial offshoots in both seasons, respectively. Meanwhile, Khudary cultivar produced the least significant effect (43.76 and 51.45) and (23.40 and 27.27 g) in this respect. Respecting, the interaction effect between nanoparticles and date palm cultivars, the results in Table 4 show that the highest number and weight of aerial offshoot's small roots were noticed with the aerial Hayany offshoots bases soaking in solutions containing 0.5% NPs-$FeSO_4$ + 8% NAA in both seasons. In the meantime the least values were given by untreated Khudary treatment in both seasons. On the other hand, the other interactions revealed in between effect. In accordance to these results, those previously reported by **Isaid *et al.* (2018)** working on Mejdool, Deglet Noor and Barhi. They found that aerial auxin concentration especially NAA, promoted root initiation.

Large roots number and weight

The present results in Table 4 revealed that the aerial offshoots treated with 0.5% nanoparticles of $FeSO_4$ (NPs) + 8% NAA surpassed other treatments in both number and weight (37.94 and 33.66) and (117.25 and 106.89 g) of large roots during both seasons, respectively, while the untreated aerial offshoots treatment gave the least values in this concern during 2016 and 2017 seasons. In relation to the specific effect of date palm cultivars on large root number and weight, results in Table 4 indicate that Hayany cv. showed to be the most effective treatments in large number and weight (37.77 and 37.13) and (119.98 and 112.43 g) in both seasons, respectively. On the contrary, aerial offshoots of Khudary cv. caused a significant reduction in this respect. With reference to the interaction effect between nanoparticles treatments and date palm cultivars on large root number and weight, results showed that Hayany cv. with 0.5% NPs-$ZnSO_4$ + 8% NAA induced more simulative effect in large root number and weight (51.18 and 46.32) and (157.83 and 151.26 g) in the both seasons. In the meantime, results of both experimental seasons clarified that the different nanoparticles and growth regulator treatments significantly increased the number and weight of large roots of aerial offshoots comparing with the control in 2016 and 2017 seasons. The obtained results are in harmony with those previously reported by **El-Hammady *et al.* (1992) and Thangavelu *et al.* (2018).**

Mean root length

Results in Table 5 reveal that, in both study seasons, the nanoparticles of $FeSO_4$ (NPs)+ 8% NAA treatment gave the longest roots (small and large), while untreated aerial offshoots (control) gave the lowest values in both seasons. Concerning the specific effect of date palm cultivars, the results in the same table show that the longest roots (small and large) were given by Amry cv., followed by Khudary cv. in both seasons. In the meantime, Hayany cv. had the shortest roots (small and large) in both seasons. Regarding the interaction effect of treating bases of aerial offshoots of "Amry, Khudary and Hayany" cultivars, results in Table 5 show that all nanoparticles of $FeSO_4$ and $ZnSO_4$ with or without NAA treatments gave significantly longer large and small roots as compared with the control in the both seasons. Amry cv. with nanoparticles of 0.5 % NPs-$FeSO_4$ + 8% NAA treatment gave the longest root, while untreated Hayany cv. aerial offshoots gave the lowest values in both seasons. These results are in line with those obtained by **Al-Obeed (2005).** They found that the aerial est rooting in ten aerial (aerial and unrooted) offshoots of each of four date palm (*Phoenix dactylifera* L.) cultivars namely Succary, Seleg, Segie and Khalas was achieved with 8 % NAA treatment. **Rui *et al.* (2016)** reported that Fe_2O_3 NPs increased root length in peanut plant.

Survival percentages of aerial offshoots

As for the effect of nanoparticles treatments on survival percentages of aerial offshoots, results in Table 5 show that the 0.5% NPs-$ZnSO_4$ + 8% NAA treatment showed to be the most effective on survival percentages of aerial offshoots as compared to the other treatments and untreated aerial offshoots in both seasons. The highest values of survival percentages of aerial offshoots in the both seasons were recorded by Khudary cv., followed by Hayany cv. On the contrary, the least values were detected in Amry cv. in both seasons. Regarding the interaction effect on the survival percentages of aerial offshoots, the obtained results showed greater offshoots survival percentages with the 0.5% nanoparticles of $ZnSO_4$ (NPs) + 8% NAA in Khudary cv. (78.54 and 78.52 %) in 2016 and 2017 seasons, respectively. In the second rank came the 0.5% nanoparticles of $FeSO_4$ (NPs)+ 8% NAA in Khudary cv. (75.43 and 77.10 %) in the first and second seasons, respectively. The least survival percentages came from the untreated aerial offshoots (control) in Hayany cv. (41.24 and 45.42%) in both seasons, respectively. It is worthy to mention that the differences were statistically significant between the 0.5% nanoparticles of $FeSO_4$ + 8% NAA and 0.5% nanoparticles of $ZnSO_4$ + 8% NAA treatments on one hand and the remained treatments on the other hand in most cases. Results obtained herein are in agreement with those of **Anjarne and Zaid (1993)** and to somewhat extend with **Waifong (2001)** and **Afzal *et al.* (2011)**.

The correlation coefficients among the different root characteristics of aerial offshoots

The correlation coefficients among the different root characteristics of aerial offshoots of "Amry, Khudary and Hayany" cvs. are presented in Table 6. Regarding Amry cv., results revealed that positive correlation ships were found between the survival percentage of aerial offshoots and the mean root length, total root weight, number and weight of small roots and number and weight of large roots with values of 0.459*, 0.658*, 0.324*, 0.421*, 0.628* and 0.596* respectively. On the other hand, no correlation was noticed among the mean root length, both small root number and weight and large roots number. Regarding the aerial offshoots of "Khudary" cultivar, results in Table 6 show that, positive and significant correlation was found between the mean root length and weight of large roots and survival percentage of aerial offshoots. In the meantime, positive and significant correlation was found between the survival percentage of aerial offshoots and each of the mean root length (r = 0.547**), total root weight (r = 0.452*), number of small roots (r = 0.541*) and number and weight of large roots (r = 0.478* and 0.658* respectively). At the same time, results revealed no significant correlation between the number and weight of both small and large roots. Concerning Hayany cv., results illustrated in Table 6 revealed positive correlation between the percentage of survival aerial offshoots and each of the mean root length (r = 0.452*), total root weight (r = 0.589*), number and weight of small roots (r = 0.632*, and 0.453* respectively), and large roots number (r = 0.357*). Also, positive correlations were obtained between the weight of large roots and each of the total root weight (r = 0.532*) and the number of large roots (r = 0.489*). Moreover, total root weight correlated significantly with both the number and weight of large roots (r = 0.452* and r = 0.532*, respectively) and the survival percentage of

Table 4. Effect of cultivars, some metals nanoparticles with Naphthalene acetic acid and their interactions on mean roots length and ground offshoots survival of aerial offshoots of date palm during 2016 and 2017 seasons

Treatment	Roots number								Roots weight (g)							
	Small roots (<0.5 cm)			Mean of T.	Large roots (>0.5 cm)			Mean of T.	Small roots (<0.5 cm)			Mean of T.	Large roots (>0.5 cm)			Mean of T.
	Amry	Khudary	Hayany		Amry	Khudary	Hayany		Amry	Khudary	Hayany		Amry	Khudary	Hayany	
2016 season																
Control	35.31 i	21.34 k	45.17 g	**33.94D**	22.23 gh	11.21 j	18.66 i	**17.37D**	18.53 f	12.11 h	23.44 e	**18.03 D**	71.22 g	35.26 j	58.46 i	**54.98 D**
0.5% NPs-$FeSO_4$	42.52 h	32.26 j	62.39 d	**45.72C**	28.64 f	21.10 h	45.65 b	**31.80B**	22.14 ef	17.80g	29.45cd	**23.13 C**	91.35 f	63.43 hi	151.29 a	**102.02B**
0.5% NPs-$FeSO_4$+8% NAA	56.36 e	52.13 f	75.45 a	**61.31A**	31.36 ef	31.27 ef	51.18 a	**37.94A**	27.52 d	27.43 d	41.23 a	**32.06 A**	98.26def	95.65 ef	157.83 a	**117.25A**
0.5% NPs-$ZnSO_4$	54.48 ef	63.52cd	65.24bc	**61.08B**	33.18 d	21.38gh	41.24 bc	**31.93B**	26.46 de	33.34 c	35.12 b	**31.64AB**	111.29d	65.32 h	131.11 b	**102.57B**
0.5% NPs-$ZnSO_4$+8% NAA	66.10 b	49.54fg	64.53bcd	**60.06B**	38.52 c	22.29 g	32.13 e	**30.98C**	34.57 bc	26.32de	33.11 c	**31.33 B**	121.31c	71.11 g	101.21de	**97.88 C**
Mean of cultivars	**50.95 B**	**43.76 C**	**62.56 A**		**30.79 B**	**21.45 C**	**37.77 A**		**25.84 B**	**23.40 C**	**32.47 A**		**98.69B**	**66.15 C**	**119.98A**	
2017 season																
Control	45.22 g	32.27 i	42.15 h	**39.88D**	12.36 h	18.14 g	19.81 f	**16.77D**	23.55 f	17.51 g	22.34 f	**21.13D**	37.81 g	61.22 f	62.12 f	**53.72 E**
0.5% NPs-$FeSO_4$	53.29 ef	54.24e	75.43 ab	**60.99B**	18.63 fg	18.26 fg	38.43 b	**25.11C**	27.82 e	27.83 e	42.58 a	**32.74B**	61.24 f	73.55 e	105.94cd	**80.24 D**
0.5% NPs-$FeSO_4$+8% NAA	53.48 ef	61.26c	76.57 a	**63.77A**	22.32 e	32.33 c	46.32 a	**33.66A**	28.14 de	33.14 c	41.63 a	**34.30A**	71.15 ef	98.26 d	151.26 a	**106.89A**
0.5% NPs-$ZnSO_4$	51.21 f	53.17ef	68.98 b	**57.79C**	31.15 d	21.36 ef	42.34 ab	**31.62B**	26.12 ef	29.16cde	36.46 b	**30.58C**	96.16 d	68.44 ef	131.27 b	**98.62 B**
0.5% NPs-$ZnSO_4$+8% NAA	66.27bc	56.32d	61.34 c	**61.31AB**	32.17 c	22.38 e	38.76 b	**31.10B**	35.53 bc	28.73 de	32.18cd	**32.15B**	101.21cd	61.17 f	111.58 c	**91.32 C**
Mean of cultivars	**53.89 B**	**51.45C**	**64.89 A**		**23.33 B**	**22.49 C**	**37.13 A**		**28.23 B**	**27.27 C**	**35.04 A**		**73.51B**	**72.53B**	**112.43A**	

Table 5. Effect of cultivars, some metals nanoparticles with Naphthalene acetic acid and their interactions on mean roots length and ground offshoots survival of aerial offshoots of date palm during 2016 and 2017 seasons

Treatment	Mean roots length (Average length of 10 main roots cm)								Aerial offshoots survival (%)			
	Small roots (<0.5 cm)			Mean of T.	Large roots (>0.5 cm)			Mean of T.	Amry	Khudary	Hayany	Mean of T.
	Amry	Khudary	Hayany		Amry	Khudary	Hayany					
					2016 season							
Control	6.45 f	5.11 fg	4.08 g	**5.21 D**	10.24 ij	9.22 k	8.25 l	**9.24 E**	53.20 e	52.19 e	41.24 f	**48.88 D**
0.5% NPs-$FeSO_4$	11.80 de	11.26 de	9.11 e	**10.72 C**	22.13 d	18.74 g	12.32 i	**17.73 D**	62.55 d	62.56 d	58.45 de	**61.19 C**
0.5% NPs-$FeSO_4$ + 8% NAA	19.52 a	18.34 ab	14.58 c	**17.48 A**	28.26 a	22.47 d	19.58 f	**23.44 A**	69.50 bc	75.43 ab	68.38 c	**71.10 AB**
0.5% NPs-$ZnSO_4$	16.83 bc	16.55 bc	12.27 d	**15.22 B**	23.27 c	21.31 e	15.69 h	**20.09 C**	68.36 c	65.72 cd	62.44 d	**65.51 B**
0.5% NPs-$ZnSO_4$ + 8% NAA	17.34abc	14.69 c	13.42 cd	**15.15 B**	27.68 b	19.82 f	18.35 g	**21.95 B**	71.12 abc	78.54 a	71.24abc	**73.63 A**
Mean of cultivars	**14.39A**	**13.19 B**	**10.69 C**		**22.32 A**	**18.31 B**	**14.84 C**		**64.95 AB**	**66.89 A**	**60.35 B**	
					2017 season							
Control	7.45 i	7.44 i	7.34 i	**7.41 C**	9.22 i	12.14 h	11.4 hi	**10.92 D**	49.33 g	56.44 f	45.42 h	**50.40 E**
0.5% NPs-$FeSO_4$	16.34 f	17.02 e	12.59 h	**15.32 BC**	18.94 f	22.25 d	16.34 g	**19.18 C**	56.14 f	68.18 cd	62.54 e	**62.29 D**
0.5% NPs-$FeSO_4$ + 8% NAA	23.15 a	19.11 d	17.44 e	**19.90 A**	32.55 a	25.36 c	22.16 d	**26.69 A**	68.45 cd	77.10 ab	65.20 de	**70.25 B**
0.5% NPs-$ZnSO_4$	21.56 c	12.18 h	14.61 g	**16.12 B**	31.18 b	16.87 g	18.97 f	**22.34 B**	62.38 e	72.54 bc	66.41cde	**67.11 C**
0.5% NPs-$ZnSO_4$ + 8% NAA	22.08 b	17.38 e	16.68 f	**18.71 AB**	31.59 ab	23.19 cd	20.19 e	**24.99 AB**	71.49 c	78.52 a	74.13 b	**74.71 A**
Mean of cultivars	**18.12 A**	**14.63 B**	**13.73 C**		**24.70 A**	**19.96 B**	**17.81 C**		**61.56 B**	**70.56 A**	**62.74 B**	

Table 6. Correlation coefficient of some root characteristics in aerial offshoots of date palm cultivars (average of two seasons)

Root character		Roots number		Roots weight		Mean root length	Offshoots survival (%)
		Small roots number	Large roots number	Small roots weight	Large roots weight		
		Amry cv.					
Roots number	Small roots number	------	-0.054NS	0.487*	-0.058NS	-0.135NS	0.324*
	Large roots number		------	-0.0541NS	0.487*	0.425*	0.628*
Roots weight	Small roots weight			------	-0.0213NS	-0.035NS	0.421*
	Large roots weight				------	0.523*	0.596*
Mean root length						------	0.459*
Offshoots survival (%)							------
		Khudary cv.					
Roots number	Small roots number	------	-0.054NS	0.489*	0.187NS	0.267NS	0.541*
	Large roots number		------	0.369NS	0.452*	0.278NS	0.478*
Roots weight	Small roots weight			------	-0.026NS	0.215NS	0.124NS
	Large roots weight				------	0.587*	0.658*
Mean root length						------	0.547**
Offshoots survival (%)							------
		Hayany cv.					
Roots number	Small roots number	------	-0.025NS	0.421*	-0.058NS	0.287NS	0.632*
	Large roots number		------	-0.087NS	0.489*	-0.028NS	0.357*
Roots weight	Small roots weight			------	-0.089NS	0.514*	0.453*
	Large roots weight				------	0.574*	0.214NS
Mean root length						------	0.456*
Offshoots survival (%)							------

aerial offshoots (r = 0.589*). The obtained results are in agreement with those of **Al-Mana *et al.* (1996)**. They stressed the importance of large number of leaves to root formation in the attached offshoot, and this could be attributed to the carbohydrates food reserve and/or the hormonal balance leading to rooting.

DISCUSSION

Physiological parameters including large and small roots number and weight, mean roots length, as well as survival percentages of ground and aerial offshoots of date palm cultivars suggested that the additions of both $FeSO_4$ (NPs), $ZnSO_4$ (NPs) and NAA growth regulator could elevate the date palm rootability at the certain concentration (0.5% for $FeSO_4$ and $ZnSO_4$ NPs and 8% for NAA in this study). The observations revealed that $FeSO_4$ and $ZnSO_4$ (NPs) promoted the rooting of ground and aerial offshoots of date palm alone or with adding NAA. Previous studies have demonstrated that metal-based NPs can accumulate and biotransform to other forms in plants. Due to their nano-effects, NPs is able to penetrate plant cell, which is different from the bulk NPs (in micrometer), and accumulate in plant tissues. Further study should focus on differentiation the Fe and Zn status, which can provide more information for Fe bio availability to plants **(Rui *et al.,* 2016)**.

Conclusion

Generally, from this study we can conclude that the best results in terms of mean root length, total root weight, small roots number and weight, large root number and weight and survival offshoots percentages were obtained generally by treating offshoots bases with 0.5% nanoparticles of FeSO4 (NPs) + 8% NAA and 0.5% nanoparticles of ZnSO4 (NPs) + 8% NAA treatments. Ground and aerial offshoots of "Amry" and "Hayany" cvs. could be considered to be "easy- to root", since the rooting occurred during the first three and four months from the onset of the initial treatment time (January), respectively. On the other hand, rooting of ground and aerial offshoots of "Khudary" cultivar could be considered as “difficult- to root”, since the rooting occurred after three and four months later, respectively.

REFERENCES

Abdullatif, A.A. and S.A. Al-Khateeb (2015). Effect of different combinations of growth hormones and its interaction on callogenesis. Res. J. Biotechnol., 10 (11): 83 -88.

Afzal, M., M.A. Khan, M.A. Pervez and R. Ahmed (2011). Root induction in the aerial offshoots of date palm (*Phoenix dactylifera* L.) cultivar, Hillawi. Pak. J. Agri. Sci., 48 (1): 11-17.

Al-Mana, F.A., M.A. El-Hamady, M.A. Bacha, and A.O. Abdelrahman (1996). Improving root development on ground and aerial date palm offshoots. Res. Bult, Agric Res. Cent., Saudi Univ., 60: 5-19.

Al-Obeed, R.S. (2005). Rooting of aerial offshoots of four date palm (*Phoenix dactylifera* L.) cultivars by air layering method using polyethylene Bags. Pak. J. Biol. Sci., 8 (7): 978-981.

Al-Shahib, W. and R.J. Marshall (2003). The fruit of the date palm: its possible use as the best food for the future? Int. J. Food Sci. Nutr., 54: 247-59.

Anjarne, M. and A. Zaid (1993). The effects of various growth regulator levels on early rooting in date palm (*Phoenix dactylifera* L.). Al Awamia, 82: 197-210.

Dawson, V.H. and A.P. Pansiot (1985). Improvement of date Palm growing. FAO Agric. Study, 1 : 112.

Day, S.D., G. Watson, P.E. Wiseman and J.R. Harris (2009). Causes and consequences of deep structural roots in urban trees: From nursery production to landscape establishment. Arboriculture and Urban Forestry, 35: 182 - 191.

Ditta, A. (2012). How Helpful is nanotechnology in Agricultural. Adv. Nat. Sci.: Nanoscience and Nanotechnol., 3 (10): 1-10.

Duncan, B.D. (1955). Multiple Range and Multiple F-tests. Biometrics, 11: 1– 42.

El-Hammady, M., F.A. Al-Mana and M.A. Bacha (1992). Greenhouse rooting of date palm offshoots using an inverted mist system. Ann. Agric. Sci., Ain Shams Univ., Cairo, 37: 523 - 529.

El-Hodairi, M.H., A.S. El-Fagih and A.A. Amer (1992). The effects of indole acetic acid (IAA), indole butyric acid (IBA) and naphthalene acetic acid (NAA) on the growth of Taaghiyaat date palm (*Phoenix dactylifera* L). Acta Hort., 321: 326-333.

Fadl, M.S., A.S. El-Deen and M.A. El-Mahdy (1979). Physiological and chemical factors controlling adventitious root initiation in carob (*Ceratonia siliqua* L.) stem cuttings. Egypt. J. Hort., 6: 55-68.

Gupta, O.P. and N.R. Godara (1992). Rooting in aerial suckers of date palm. Haryana Agric. Univ. J. Res., 14: 82 - 84.

Hartmann, H.T., D.E. Kester, Jr.F.T. Davie and R.L. Genever (1997). Plant Propagation, Principles and Practices, 6th Ed., Prentice-Hall at India Private Limited, New Delhi, India.

Heller, H. and B. Atkinson (2007). Agricultural Nanotechnology Nanotech. Intervention in Agricultural science sand their technical implications, 260 ppm Knut H. Heller and Bill Atkins on Dominant Eds, 10-20.

Isaid, H.M.A., A.Sh.M. Arar and T.A.S. Abu Baker (2018). Evaluation of aerial offshoots rooting of three international date palm Variety. J. Al-Quds Open Univ. Res. and Studies, 43 (2):29- 34.

Jamro, M.M., A.N. Shah and F.Kh. Nizamani (2018). Effects of IBA and NAA on integrated root development in aerial offshoots of *Phoenix dactylifera* L. Bangladesh J. Bot., 47(2): 287-292.

Karakecili, A., S. Korpayev, H. Dumanoğlu and S. Alizadeh (2019). Synthesis of indole-3-acetic acid and indole-3-butyric acid loaded zinc oxide nanoparticles: Effects on rhizogenesis. J. Biotechnol., 303: 8-15.

Lavee, S., N. Avidan, R.L.M. Pierik, M. Geibel, D. Treutter and W. Feucht (1994). Chlorogenic acid-an independent morphogensis regulator or a cofactor. Acta-Hort., 381: 405 - 412.

Liu, Y.; G. Wang; Y. Kunxia; L. Peng; X. Lie and L. Guobin (2018). A new method to optimize root order classification based on the diameter interval of fine root. Scientific Reports. 8, 2960 (1), UR - https://doi.org/10.1038/s41598-018-21248-6.

Masarovicova, E. and K. Kraľova (2013). Metal nanoparticles and plants. Ecol. Chem. Eng. S., 20 (1): 9-22.

Mohammadi, H. and M. Khezri (2018). The influence of foliar application of urea, zinc chelate and boric acid on growth characteristics, photosynthesis and survival of date palm offshoots (*Phoenix dactylifera* cv. Mazafati). Europ. J. Hort. Sci., 83 (11): 114 – 120.

Monica, R.C. and R. Cremonini (2009). Nanoparticles and higher plants. Caryologia., 62: 161–165.

Mousavi, S.R. and M. Rezaei (2011). Nanotechnology in agriculture and Food production. J. Appl. Environ. Boo1 Sci., 1 (1): 414-419.

Rahmana, A. and E. Rahkhodaei (2013). Offshoots weight and disinfection on Mejdool date palm survival rate. Int. J. Agric. and Crop Sci., 5: 1784- 1788.

Reuveni, O. and I. Adato (1974). Endogenous carbohydrates, root promoters and root inhibitors in easy and difficult - to - root date palm (*Phoenix dactylifera* L.) offshoots". J. Ame. Soc. Hort. Sci., 99: 361-363.

Roshdy, Kh.A. and M.M. Refaai (2016). Effect of nanotechnology fertilization on growth and fruiting of Zaghloul date palms. J. Plant Prod., Mansoura Univ., 7 (1): 93-98.

Rui, M., Ch. Ma, Y. Hao, J. Guo, Y. Rui, X. Tang, Q. Zhao, X. Fan, Z. Zhang, T. Hou and S. Zhu (2016). Iron oxide nanoparticles as a potential iron fertilizer for Peanut (*Arachis hypogaea*). Frontiers in Plant Science. https://www.frontiersin. Org /article /10.3389/fpls. 2016.00815.

SAS (1988). Institute. Sas/Stat. User's guide". Release 6.03 ed. Cary. NC: SAS Inst., 630.

Stampoulis, D., S.K. Sinha and J.C. White (2009). Assay-dependent phytotoxicity of nanoparticles to plants. Environ. Sci. Technol., 43: 9473–9479.

Steel, F.G.D., J.H. Torrie and D.A. Dickey (1997). Principles and procedures of statistics; a biometrical approach. 3rd Ed. Mc Mgraw Hill, New York.

Thangavelu, R.M., D. Gunasekaran, M.I. Jesse, M.S. Riyaz, D. Sundarajan and K. Krishnan (2018). Nanobiotechnology approach using plant rooting hormone synthesized silver nanoparticle as ‘‘nanobullets” for the dynamic applications in Horticulture-An *in vitro* and *ex vitro* study. Arab. J. Chem. King Saud Univ., 11: 48-61.

Waifong, A.V. (2001). Evaluation of peach palm heart production. Planter, 97 (900): 123-134.

Wang, X., X. Yang, S. Chen, L. Qianqian, W. Wang, H. Chunjiang, G. Xiao, L. Wang and W. Shucai (2016). Zinc oxide nanoparticles affect biomass accumulation and photosynthesis in arabidopsis. front. plant sci., https://doi.org/ 10.3389/fpls.2016.01243.

Zaid, A. and P.F. Wet (2002). Date palm propagation. FAO plant production and protection, 156:73-105.

إمكانية تجذير فسائل ورواكيب بعض أصناف النخيل النامية فى شمال سيناء باستخدام المعادن النانوية ونفثالين حامض الخليك

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تم دراسة تأثير كل من مركبات الحديد والزنك النانوية منفردة أو مع إضافة هرمون نفثالين حامض الخليك "NAA" على تجذير الفسائل والرواكيب لثلاثة من أصناف نخيل البلح النامية في شمال سيناء وهى "العمري" و"الخضيري" و"الحياني"، تم نقع قواعد الفسائل والرواكيب فى الماء لمدة ٢٤ ساعة ثم معاملتها بخمس معاملات كالتالي:١) فسائل لم تعامل قواعدها بمحلول النانو ونفثالين حامض الخليك "معاملة المقارنة"، ٢) نقع قواعد الفسائل في محلول يحتوى على ٠,٥% من $FeSO_4$ النانوي منفرداً لمدة ١٠ دقائق ، ٣) نقع قواعد الفسائل في محلول يحتوى على ٠,٥% من $FeSO_4$ النانوي + ٨% نفثالين حامض الخليك لمدة ١٠ دقائق، ٤) نقع قواعد الفسائل في محلول يحتوى على ٠,٥% من $ZnSO_4$ النانوي منفرداً لمدة١٠ دقائق ، ٥) نقع قواعد الفسائل في محلول يحتوى على ٠,٥% من $ZnSO_4$ النانوي + ٨% نفثالين حامض الخليك لمدة ١٠ دقائق، تم تصميم التجربة بنظام القطاعات كاملة العشوائية (RCBD) ذات العاملين لخمسة عشر معاملة (خمسة معاملات من المركبات النانوية × ثلاثة أصناف نخيل، كل معاملة ممثلة بخمسة مكررات)، وتم تحليل البيانات إحصائيا باستخدام ANOVA، وقد أظهرت النتائج أن معاملتي نقع قواعد الفسائل في محلول يحتوى على ٠,٥% من $FeSO_4$ النانوي + ٨% نفثالين حامض الخليك سجلت أعلى القيم من حيث طول الجذر، و أعداد وأوزان الجذور الصغيرة والكبيرة والنسبة المئوية للفسائل الأرضية والهوائية الحية المتبقية ، يليها معاملة ٠,٥% من $ZnSO_4$ النانوي + ٨% نفثالين حامض الخليك في كلا موسمي الدراسة، كما أظهرت النتائج تفوق صنف العمري والحياني عن صنف الخضيري من حيث عدد ووزن الجذور الصغيرة والكبيرة للفسائل الأرضية والهوائية، بينما كان لصنف الحياني التفوق في صفة طول الجذور الكبيرة والصغيرة، وكان للصنف الخضيري أعلى نسبة بقاء للفسائل الأرضية والهوائية، كذلك يمكن إعتبار صنفي العمرى والحياني سهلة التجذير نظرا لحدوث التجذير بفسائلها الأرضية والهوائية بعد٣ و ٤ شهور على التوالي لكل من الصنفين من بداية المعاملات، كذلك وجدت علاقة ارتباط موجبة بين النسبة المئوية للفسائل الحية وكل من متوسط طول الجذر، الوزن الكلى للجذور، أعداد وأوزان الجذور الصغيرة وكذا أعداد الجذور الكبيرة لصنف الحياني، كذلك أظهرت النتائج وجود علاقة ارتباط موجبة بين متوسط طول الجذر, الوزن الكلى للجذور، وزن الجذور الصغيرة، أعداد وأوزان الجذور الكبيرة لصنف العمرى، من ناحية أخرى يمكن إعتبار الفسائل الأرضية والهوائية لصنف الخضيري صعبة التجذير نظرا لتأخرها فى التجذير لمدة ٣ و ٤ شهور أخرى عن الصنفين السابقين على التوالى.

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