Pak. J. Agri. Sci., Vol. 48(1), 11-17; 2011
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

ROOT INDUCTION IN THE AERIAL OFFSHOOTS OF DATE PALM (*PHOENIX DACTYLIFERA* L.) CULTIVAR, HILLAWI

Muhammad Afzal[1,*], Muhammad Aslam Khan[1], Muhammad Aslam Pervez[1] & Rashid Ahmed[2]

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan; [2]Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan
[*]Corresponding author's email: afzalfaran@yahoo.com

Present studies were carried out to determine the effect of some growth regulators, their application methods and environmental conditions on root induction in aerial offshoots of date palm cultivar Hillawi. For this purpose different parameters were studied after treating offshoots with growth regulators, viz. indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), 2,4-dichlorophenoxy acetic acid (2,4-D) and gibberellic acid (GA_3) each at 1000, 2000 and 3000 mg/l along with their combinations. The treatments were applied by two methods (quick dip and injection) and the treated offshoots were then planted in two environmental conditions viz., open field and plastic tunnel. All levels of IAA, IBA, NAA and some of their combinations induced rooting by both methods under these environments but GA_3 did so only @ 2000 mg/l when applied by quick-dip method in plastic tunnel. Interaction between treatment and method was significant in the offshoots in open field only. In contrast, different treatments showed variable behavior to methods of their application in plastic tunnel. Among all the growth regulators under study only IAA, IBA and NAA affected positively either individually or in combination.
Keywords *Phoenix dactylifera,* rooting, offshoot, growth regulators

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 Marshal, 2003). Its cultivation might be suitable in marginal areas owing to wider adoptability and tolerance against stress conditions. It occupies third position after citrus and mango in Pakistan with respect to area (90676 ha), production (566.494 thousand tones) and export (111.72 thousand tones) (Anonymous, 2009). 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. 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. To overcome the problem of poor or no root initiation in aerial suckers several approaches have been made with variable results. The increase in root induction is directly proportional to IBA concentration in aerial suckers when treated with 0, 1000, 2000 and 3000 mg/l with 20% or less survival after four months in the nursery. Similar trend is found in the intact offshoots by applying IBA with sphagnum moss but these intact offshoots produce 2 to 4 times more roots with 87% survival after 15 weeks of treatment before their removal from mother palms for field plantation (Gupta and Godara, 1984). IAA induces cell division, cell elongation resulting in plant growth and development, regulates the permeability of plasma membrane, stimulates pH and electrical gradients, enforces transport of auxins, sugars, amino acids and inorganic ions and induces growth (Goldsmith, 1986). Root induction in date palm offshoots depends on their size perhaps due to unknown endogenous root promoting substances while IBA (2000-8000 mg/l) injection has no role in rooting. Large (3-4 years old) offshoots of 12-20 kilogram weight or size may be preferred for successful propagation (Al-Ghamdi, 1988). Dry weight, length, number and diameter of large and small roots and number of root hairs may increase with higher concentration of NAA injection between 50 and 100 mg/l in Taaghiyaat date palm. IBA inhibits these parameters and IAA has no effect on these characters (El-Hodairi *et al*., 1992). Nasir (1996) reported that two types of date palm offshoots [one unrooted of single size, i.e., 12-20 kg and the other rooted ones of three different sizes, viz., small (1-4 kg), medium (5-11 kg) and large (12-20 kg)] were treated with 0, 500, 1000 and 2000 mg/l concentrations of IBA using quick-dip method. The results indicated supremacy of large sized rooted ones over medium and small sizes. Higher doses of IBA surpassed its lower levels in both types regarding number and length of roots, number of root hairs and leaves, length of leaves and survival percentage but root thickness declined with increasing IBA concentration. Significant modifications in metabolism of IBA are found in rooting process of date palm offshoots. Higher concentration of IBA results in more and earlier rooting in treated offshoots as compared with untreated ones. Further, the activities of IAA oxidase and peroxidase increase with time curve in similar pattern, while phenols and auxin protector levels decrease with time. Little and delayed changes in these parameters are observed in the untreated offshoots (Qaddoury and Amssa, 2004). *In vitro* propagation is also claimed for true-to-type multiplication of date palm but not tested scientifically about mutations except only one cultivar i.e., Barhi in the USA (Smith and Aynsley, 1995) according to the published reports till now. These techniques also face problems like contamination, yellowing and browning of callus as well as acclimatization of plants for transfer to *ex vitro* conditions (Al-Ghamdi, 1993). Genetic variations were detected at molecular level in Zaghloul cultivar when its plantlets were 6-12 months old (Saker *et al*., 2000). Similarly, somatic embryogenesis takes long time of 18-24 months to produce a weaned plant ready for the field. Direct organogenesis from shoot-tip portion gives a very limited number of plants due to slow growth and development. For this purpose more investigations are in progress whereas the improvement of traditional method of propagation through offshoots has almost been neglected. Further, each mother palm produces a large number of aerial/ un-rooted offshoots (about 25-90% of the total offshoots) that are useless and discarded from the commercial plantings by the farmer community.

No commercially viable method is yet available to increase the number of transplantable and true-to-type offshoots as compared with the micropropagation techniques. Present investigations were, therefore, initiated to determine the effect of hormones, their application methods and environmental conditions for root induction in aerial offshoots of date palm cultivar, Hillawi to utilize them successfully for propagation with ultimate increase in acreage and its cultivation in marginal areas.

MATERIALS AND METHODS

Aerial offshoots of uniform size (12-20 Kg) were carefully separated from mother trees and kept under shade. These offshoots were treated with five growth regulators viz. indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), 2,4-dichlorophenoxy acetic acid (2,4-D) and gibberellic acid (GA_3) each at three levels, i.e. 1000, 2000 and 3000 mg/l (prepared according to the formulae as described by Hartman and Kester, 1969) along with their selected combinations. These treatments were applied using two methods, quick-dip (M_1) by dipping the bases of selected offshoots in treatment solutions for one minute and injection (M_2**)** by adding 20-25 ml of each treatment into the offshoot bases with the help of disposable B.D. Syringes. These treated offshoots were then transplanted in respective experimental plots under two environments, open field in between citrus plantations during March-April and plastic tunnel during November-December in 2004. All other cultural practices like irrigation, hoeing, weeding and insect/pest and disease control were applied uniformly to all experimental plants. These experiments were laid out according to randomized complete block design (RCBD) with factorial arrangements by keeping treatment methods in main plots and treatments in sub-plots randomly. After one year of treatments, data were recorded and statistically analyzed using ANOVA (Steel *et al*., 1997). The significant differences among treatment results were calculated and compared by subjecting mean values to Duncan's New Multiple Range test (Duncan, 1955).

RESULTS AND DISCUSSION

Apparently there were differences in rooting response by offshoots of date palm treated with IAA, IBA, NAA, 2,4-D and GA_3. Moreover, treatment methods and planting environments also caused positive but variable responses to these treatments. Highly significant results were observed among mean values of different parameters, i.e., number of roots/offshoot, number of root hairs/root, length and thickness of roots along with interaction between treatments and methods of application and ten treatments viz., IAA and IBA (both @ 1000, 2000 & 3000 mg/l), NAA (@ 2000 mg/l), T_{16}(IAA & IBA @ 3000 & 1000 mg/l, respectively), T_{17} (IAA and IBA @ 1000 & 3000 mg/l, respectively) and T_{18} (IAA and IBA each at 3000 mg/l) showed positive response when treated offshoots were planted in open field. In contrast variable results were recorded among treatments and methods in plastic tunnel. And no interaction was found between treatments and methods in the project under study. The treatments causing root initiation in one method did not have any effect in the other and vice versa.

I. Experiment under open field

Data regarding the number of roots per offshoot indicated highly significant differences among treatments and interaction between treatments and methods of application. The effect of method was non-significant. The mean values of different treatments which induced roots in combination with method are compared in Table 1 which reveals that highest number of roots was resulted by the interaction of T6 by injection method (M_2) as 103 followed by the same treatment with quick-dip method (M_1) as 83.67. M_2T_6 and M_1T_6 remained at par with each other followed by M_2T_2, M_1T_2, M_1T_1, M_1T_3 and M_2T_5 that also remained statistically similar with each other showing mean values of 62, 53.67, 53, 44 and 41, respectively. The lowest number of 4 roots was obtained by M_2 T_{17}. Whereas, $T_{1,}$ T_8 remained successful by injection and T_{16} by quick-dip method but no rooting was seen in other method against these three treatments. Among hormones, all concentrations of IAA and IBA (individually or in combinations) remained successful except T_1 that stimulated rooting in quick-dip method only. Similarly T_8 showed positive response when applied by the injection method only. Whereas, gibberellic acid (GA_3) and 2,4-Dichlorophenoxy acetic acid (2,4- D) did not motivate root induction. As far as treatment combinations are concerned, the highest dose of IBA proved successful when combined with the lowest or the highest levels of IAA in both methods but the lowest dose of IBA in combination with highest dose of NAA gave rooting only in quick-dip method. All other treatments and combinations failed to do so regardless the method of application. Briefly the highest root number was recorded with IBA @ 3000 mg/l (T_6) in M_2 followed by the same treatment in M_1 and both were at par with each other. The resultant means revealed that the number of roots increased significantly with higher levels of IBA but all its three levels remained at par in both methods. All levels of IAA in quick-dip method remained at par with each other as well as with its medium level when applied by injection method but its lowest level did not stimulate rooting when applied through injection method (Table 1). It seems that the effect of IBA is independent of method of treatment. In contrast, IAA and NAA are method dependent. Gupta and Godara (1984) observed increase in rooting by increasing IBA level in aerial offshoots of date palm. Similarly Nasir (1996) also reported increase in number of roots with higher concentrations of IBA. Al-Ghamdi (1988) injected IBA at 2000-8000 mg/l in three cultivars, Khalas, Ruziz and Shishi and did not observe any root promotion. He linked root inhibition with improper IBA concentration or time and method of application. El-Hodairi *et al.* (1992) did not find any positive effect of IAA and IBA each at 50 and 100 mg/l. However, he reported root initiation by NAA at the same levels. Our results reveal that application of IAA and NAA is linked with method of treatment but IBA (at 3000 mg/l) behaved equally regardless of method of application.

Differences among the number of root hairs per root also remained highly significant. In this case, higher concentration of IBA produced highly significant results regardless the method of application showing same trend as in case of number of roots, i.e., the number of root hairs increased with increase in the concentration of IBA or vice versa. Similarly IAA showed the same pattern with exception of its lowest level in M_2 where there was neither any root nor root hairs. While the mean values of NAA @ 2000 mg/l (T_8) in M_2 remained at par with all the levels of IAA but remained significantly different from M_1T_{16}, M_1T_8, M_2T_1 and M_2T_{16}. The results might be relative to the root area instead of the effect of treatments. T_6 (IBA @ 3000 mg/l) surpassed all treatments in both methods (Table 1) and its impact was statistically at par followed by T_5 in the same pattern with the lowest value in M_1T_{16} (IAA@ 3000 + IBA@ 1000 mg/l) with no root induction in M_2. Increase in number of root hairs by IBA and NAA applications has been reported by El-Hodairi *et al.* (1992) and Nasir (1996), respectively. In present studies the increase in number of root hairs seems to be associated with higher levels of both IAA and IBA but method of treatment has no significant impact. Thus, more number of root hairs is produced in direct relation with more number of roots which is indirectly concerned with higher levels of IAA and IBA. Similar trend was also found in case of root length in our studies where the results remained highly significant among the mean values of different treatments. Higher levels of IBA increased root length but methods of treatment application behaved differently. The mean values of T_6, T_5 and T_2 dominated the others regardless the method of application with lowest in T_{16}. The un-predicted behavior of treatment effects as depicted by Table 1 might be due to some internal biochemical factors like proteins, protease, amylase, peroxidase, catalase and superoxide dismutase etc. other than the nutritional status of uniform sized offshoots. Ribnicky *et al*. (1996) and Gaspar *et al.* (1997) also reported that the application of auxins may induce changes in their own metabolic activities by conjugation and in other hormones like cytokinins. Adventitious rooting can also be promoted by the application of auxins in combination with phenols (Haissig, 1974; Weisman *et al*., 1988) that indicate the role of other factors in rooting.

Highly significant results were observed between mean values regarding thickness of newly induced roots only in method of application whereas treatments and interaction (MxT) were non-significant. Nasir (1996)

Table 1. Comparison of mean values for different parameters in open field

Method/ Treatment	Number of Roots Per Offshoot	Number of Root Hairs per Root	Length of root (cm)	Thickness of Roots (mm)
M_1 T_0 (Control)	0.00 h	0.00 g	0.00 h	0.00 i
M_1 T_1 (IAA @ 1000 mg/l)	53.00 bc	29.67 efg	88.67 bcde	9.40 a
M_1 T_2 (IAA @ 2000 mg/l)	53.67 bc	25.67 efg	56.67 cdefg	9.03 a
M_1 T_3 (IAA @ 3000 mg/l)	44.00 bcd	51.67 de	86.67 bcde	9.20 a
M_1 T_4 (IBA @ 1000 mg/l)	10.33 fgh	19.67 efg	30.43 fgh	6.60 cdef
M_1 T_5 (IBA @ 2000 mg/l)	29.00 def	88.67 bc	104.30 bc	7.80 abcd
M_1 T_6 (IBA @ 3000 mg/l)	83.67 a	127.70 a	123.30 ab	8.63 ab
M_1 T_8 (NAA @ 2000 mg/l)	0.00 h	0.00 g	0.00 h	0.00 i
M_1 T_{16} (T_3 + T_4)	04.00 gh	12.67 fg	8.33 gh	0.43 i
M_1 T_{17} (T_1 + T_6)	24.33 defg	20.33 efg	43.33 efgh	8.17 abc
M_1 T_{18} (T_3 + T_6)	33.67 cde	24.00 efg	53.33 cdefg	6.93 bcde
M_2 T_0 (Control)	0.00 h	0.00 g	0.00 h	0.00 i
M_2 T_1 (IAA @ 1000 mg/l)	0.00 h	0.00 g	0.00 h	0.00 i
M_2 T_2 (IAA @ 2000 mg/l)	62.00 b	42.33 def	126.70 ab	8.50 ab
M_2 T_3 (IAA @ 3000 mg/l)	10.67 fgh	71.67 cd	104.00 bc	4.63 gh
M_2 T_4 (IBA @ 1000 mg/l)	15.00 efgh	29.33 efg	49.33 defg	6.30 defg
M_2 T_5 (IBA @ 2000 mg/l)	41.00 bcd	109.30 ab	135.00 ab	5.80 efgh
M_2 T_6 (IBA @ 3000 mg/l)	103.00 a	113.00 ab	165.30 a	4.57 h
M_2 T_8 (NAA @ 2000 mg/l)	39.00 cd	44.67 def	65.67 cdef	4.92 fgh
M_2 T_{16} (T_3 + T_4)	0.00 h	0.00 g	0.00 h	0.00 i
M_2 T_{17} (T_1 + T_6)	4.00 gh	56.00 de	100.00 bcd	6.50 cdef
M_2 T_{18} (T_3 + T_6)	38.67 cd	40.33 def	69.33 cdef	6.43 cdef

reported decrease in thickness by increasing IBA concentrations. In our results, different treatments behaved in different patterns as compared to the earlier parameters but the treatments T_1, T_2, T_3, T_5, T_6 and T_{17} with M_1 revealed similar differences with each other as well as with M_2T_2 with sequence of ranking as T_1, T_3, T_2 and T_6 in M_1 followed by T_2 in M_2 and T_{17} and T_5. These results might be influenced by some unknown internal factors as discussed in the earlier parameters.

It is concluded that different concentrations and combinations of various hormones have exerted positive influence regarding induction and multiplication of roots to the aerial offshoots of date palm cultivar Hillawi. The overall results are in blended form which did not give a clear increasing or decreasing pattern of root induction along with the different concentrations of hormones. The results depict that rooting response in aerial offshoots of date palm can be substantially improved by applying IAA, IBA and NAA with results like those already observed in sequoia (Berthon *et al*., 1990), pine (Greenwood and Weir, 1994), almond (Caboni *et al*., 1997) and Eucalyptus (Fett-Neto *et al*., 2001).

II. Experiment under plastic tunnel

Different treatments in contrast with their response under open field conditions, showed absolutely variable behavior to method of application and no interaction was found between treatments and methods. Those treatments, which induced roots in one method, did not have any effect in the other and vice versa. Only five treatments remained successful in stimulating rooting in response to quick-dip method, which include T_4 (IBA @ 1000 mg/l), T_9 (NAA @ 3000 mg/l), T_{14} (GA_3 @ 2000 mg/l), T_{17} (IAA @ 1000 mg/l + IBA @ 3000 mg/l) and T_{21} (IBA @ 3000 mg/l+ NAA @ 3000 mg/l.) while three treatments, viz. T_5 (IBA @ 2000 mg/l), T_{16} (IAA @ 3000 mg/l + IBA @ 1000 mg/l) and T_{20} (IBA @ 3000 mg/l + NAA @ 1000 mg/l) responded to injection method (Table 2). All other treatments and their combinations failed to stir up the root zone in offshoots to initiate roots.

Table 2. Comparison of mean values for different parameters in plastic tunnel

Method of Application/ Treatment	No. Of Roots/ Offshoot		No. Of Root Hairs/ Root		Length of root (cm)		Thickness of Roots (mm)	
	Quick-Dip Method(M_1)	Injection Method(M_2)	Quick-Dip Method(M_1)	Injection Method(M_2)	Quick-Dip Method(M_1)	Injection Method(M_2)	Quick-Dip Method(M_1)	Injection Method(M_2)
M_1 T_0	0.00 b	-	0.00 b	-	0.00 d	-	0.00 b	-
M_2 T_0	-	0.00 c	-	0.00 c	-	0.00 c	-	0.00 c
M_1 T_4	4.33 a	-	8.92 a	-	20.36 b	-	2.33 a	-
M_2 T_5	-	5.67 b	-	9.03 b	-	21.70 b	-	3.39 b
M_1 T_9	4.00 a	-	7.00 a	-	14.33 bc	-	1.50 a	-
M_1 T_{14}	4.00 a	-	8.00 a	-	8.50 c	-	2.33 a	-
M_2 T_{16}	-	10.33 b	-	20.53 a	-	37.13 a	-	4.23 b
M_1 T_{17}	3.33 a	-	6.67 a	-	14.83 bc	-	3.53 a	-
M_2 T_{20}	-	110.00 a	-	8.37 b	-	43.20 a	-	7.07 a
M_1 T_{21}	11.67 a	-	14.93 a	-	28.52 a	-	3.76 a	-

Where T_0= Control, T_4= IBA @ 1000 mg/l, T_5= IBA @ 2000 mg/l, T_9= NAA @ 3000 mg/l, T_{14}= GA_3 @ 2000 mg/l, T_{16}= IAA @ 3000 mg/l+ IBA @ 1000 mg/l, T_{17}= IAA @ 1000 mg/l+ IBA @ 3000 mg/l, T_{20}= IBA @ 3000 mg/l+ NAA @ 1000 mg/l and T_{21}= IBA @ 3000 mg/l+ NAA @ 3000 mg/l.

In quick-dip method, the highest number of roots/ offshoot was recorded in T_{21} followed by T_4, T_9, T_{14} and T_{17} with mean values of 11.67, 4.33, 4, 4 and 3.33, respectively (Table 2). All these were at par with each other. IBA induced roots either at the lowest level or its combinations that are T_{17} and T_{21}. Similarly NAA (T_9) and GA_3 (T_{14}) were also able to induce roots. Whereas, results of injection method revealed that T_{20} surpassed other treatments significantly followed by T_{16} and T_5 but both T_{16} and T_5 were similar (Table 2). Only medium level of IBA gave very high number of roots and its other levels responded only in combinations with highest levels of IAA and lowest level of NAA. This does not correspond to the previous work even to the trend in open field as medium dose of IBA resulted in highest rank. So, it might be due to the influence of some internal biochemical factors as reported by Goldsmith (1986), and Qaddoury and Amssa (2004).

All treatments remained at par in quick-dip method when the number of root hairs/ root was compared statistically. While the results of injection method revealed significant differences among mean values of treatment effects. Their analysis shows that T_{16} leads with mean value of 20.53 hairs/ root followed by T_5 and T_{20} with values of 9.03 and 8.37 respectively (Table 2). The quick-dip method depicts that the number of root hairs/ root increases with the increase in number of roots/ offshoot or vice versa. But this pattern is not seen in case of injection method as IBA induced the highest number (110) when applied in combination with NAA and the same treatment combination produced lowest number (8.37) of root hairs/ root. El-Hodairi *et al.* (1992) concluded that IBA injection (@ 50 or 100 mg/l) inhibited different parameters including root hairs (dry weight) while NAA showed better results by increasing these parameters significantly. Nasir (1996) reported that the application of higher levels of IBA to aerial offshoots using quick-dip method, increases the number of roots and root hairs/ root. Our results show that NAA does not affect in quick-dip method but it reduces the number of root hairs when applied in combination with IBA (both at 3000 mg/l) significantly.

Highly significant results were observed in case of root length in quick-dip method. The longest roots of 28.52 cm were produced by T21 and the shortest of 8.5 cm by T14 (Table 2). The other treatments were statistically similar with each other. While in injection method, means of T_{20}, T_{16} and T_5 remained in almost same pattern as in case of number of roots (perhaps due to strong role of auxins in cell elongation) with mean values of 43.20, 37.13 and 21.70, respectively and the first two were statistically similar with each other but differ when compared with the last one (Table 2).

El-Hodairi *et al.* (1992) reported that IBA inhibited root length but NAA affected positively showing increased root length by increasing its concentration. While Nasir (1996) reported that the root length was increased by increasing IBA concentration. Our results depict different picture as the combination of IBA and NAA increased root length significantly when applied with quick-dip method. While IBA has similar impact on root length in the injection method either in combination with IAA or NAA which reveals that some other factors are affecting root length as discussed earlier in case of number of roots/ offshoot. A non-significant range of root thickness was noted from 1.50 mm to 3.76 mm in quick-dip method (Table 2). These results revealed that as root length increased, it possessed the higher number of hairs and ultimately more healthy (thick) roots were found in response to plant nutrients taken up for plant growth and development and ultimately more photosynthetic food diverted to the roots increasing their thickness. But significant differences were calculated among treatment responses in the injection method (Table 2). Again the results show similar pattern as in the previous parameter. The treatment, T_{20} surpassed others significantly which were at par with each other. But in this case last two treatments are non significant in respect to each other. El-Hodairi *et al.* (1992) concluded that root diameter (thickness) was inhibited by applying IBA @ 50 or 100 mg/l through injection at the root initiation sites of offshoots but NAA increased the root thickness significantly. Nasir (1996) observed decrease in root thickness with increasing IBA concentration applied through quick-dip method. Our results reveal that in case of number of roots/ offshoots and root hairs/ root, all treatments remained at par with each other in quick-dip method but root length showed significant differences. However root thickness seems to be partially associated with both of the earlier parameters.

Considering the above mentioned results it can be concluded that IAA @ 3000 mg/l and combination of IAA @ 1000 mg/l with IBA @ 3000 mg/l concentration were the best treatments when applied by injection method in open field while IBA @ 1000 mg/l was the most superior or at par with these two treatments when applied with quick-dip method and planted in plastic tunnel. So the aerial offshoots may be utilized for successful cultivation of true-to-type plant material throughout the year by propagation during normal season in open field as well as during winter times thus resulting in ultimate increase in acreage, production and employment etc. in the best interest of humanity.

REFRENCES

Al-Ghamdi, A. 1988. Rooting of date palm offshoots as affected by offshoot size, cultivar and indole butyric acid injection. Acta Hort 226: 379-388.

Al-Ghamdi, A.S. 1993. True to type date palm (*Phoenix dactylifera* L.) produced through tissue culture technique. I. Production and plantation of plantlets *in vitro*. Proc. 3rd Symp. on date palm in Saudi Arabia 1: 1-12. , Jan.17-20, 1993, King Fahad Uni., Ryad, Saudi Arabia.

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.

Anonymous. 2009. Area, production and export of fruit, vegetables and condiments. Fruit, Vege. and Condim. Stat. Pak . p, 1-2 , 25. 19th ed. Ministry of Food and Agriculture, Economic Wing, Islamabad, Pakistan .

Berthon, J.Y., N. Boyer, and T. Gaspar. 1990. Phenols as regulators and markers of root formation by shoots of *Sequoiadendron giganteum* raised *in vitro*. Arch. Intern. Physiol. Biochem. 98**:** 28-36.

Caboni, E., M.G. Tonelli, P. Lauri, P. Iacovacci, C. Kervers, C. Damiano, and T. Gaspar. 1997. Biochemical aspects of almond microcuttings related to *in vitro* rooting ability. Biologia Plant. 39**:** 91-97.

Duncan, D.B. 1955. Multiple Range and Multiple F-test. Biometrics. 11: 1**-** 42.

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 on the growth of taaghiyaat date palm (*Phoenix dactylifera* L). Acta Hort. 321: 326-333.

Fett-Neto, A.G., P.S. Fett, L.W.V. Goulart, G. Pasquali, R.R. Termignoni and A.G. Ferreira. 2001. Distinct effect of auxin and light on adventitious root development in *Eucalyptus saligna* and *Eucaliptus globules*. Tree Physiol. 21: 457-464.

Gaspar, T., C. Kevers and J.F. Hausman. 1997. Indissociable chief factors in the inductive phase of adventitious rooting. p. 55-63. In: A. Altman and Y. Waisel (eds.), Biology of Root Formation and Development. Plenum Press, New York.

Goldsmith, M.H. 1986. Use of membrane vesicles as a simplified system for studying auxin transport of auxin: Progress report. Sample records for indole acetic acids. [Online] avialable at http://www.etde.org/etdeweb/fieldedsearch.jsp (accessed on January 20th, 2011)

Greenwood, M.S. and R.J. Weir. 1994. Genetic variation in rooting ability of loblolly pine cuttings: effects of auxin and family on rooting by hypocotyls cuttings. Tree Phys. Vol. 15**:** 41-45.

Gupta, O.P. and N.R. Godara. 1984. Rooting in aerial suckers of date palm. Haryana Agri. Univ. J. Res. 14: 82-84.

Hartmann, H.T. and D.E. Kester. 1969. Plant propagation. p. 481. Principles and Practices. 3rd Ed. Englewood, California. N. J. Prentice Hall, Inc. New York.

Haissig, B.E. 1974. Influences of auxin synergists on adventitious root primordium initiation and development. N.Z.J. for Sci. 4**:** 311-323.

Nasir, M.J. 1996. Effect of IBA on rooted and un-rooted offshoots of date palm (*Phoenix dactylifera* L.) cv. Hillawii. M.Sc. Thesis, Dept. Hort., Univ. Agric. Faisalabad, Pakistan.

Qaddoury, A. and M. Amssa. 2004. Effect of exogenous indole butyric acid on root formation and peroxidase and indole-3-acetic acid oxidase activities and phenolic contents in date Palm offshoots. Bot. Bull. Acad. Sin. 45**:** 127-131.

Ribnicky, D.M., N. Ilic, J.D. Cohen and A.J. Cooke. 1996. The effect of exogenous auxins on endogenous indole-3-acetic acid metabolism, the implication for carrot somatic embryogenesis. Plant Physiol. 112**:** 549-558.

Saker, M.M., S.A. Bekheet, H.S. Taha, A.S. Fahmy and H.A. Moursy. 2000. Detection of somaclonal variations in tissue culture derived date palm plants using isoenzyme analysis and RAPD fingerprints. Biologia Plant. 43: 347-351.

Smith, R.J. and J.S. Aynsley. 1995. Field performance of tissue cultured date palm (*Phoenix dactylifera* L.) clonally produced by somatic embryogenesis. Principles 39: 47-52.

Steel, F.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics; A Biometrical approach. 3rd ed . McMgraw Hill, New York.

Weisman, Z., J. Riov and E. Epstein. 1988. Comparison of movement and metabolism of indole-3-acetic acid in mung bean cuttings. Physiol. Plant. 74**:** 556-560.