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INFLUENCE OF POLLEN SOURCE AND POLLINATION FREQUENCY ON FRUIT DROP, YIELD AND QUALITY OF DATE PALM (*PHOENIX DACTYLIFERA* L.) CV. DHAKKI

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Abstract

The study was undertaken to determine the influence of pollen sources and pollination frequency on fruit drop, yield and quality of date palm cv. 'Dhakki'. Three 'Dhakki' female trees and three different male trees (M-1, M-2 and M-3) were selected for the experiment. On each female tree six spathes were chosen and were pollinated with pollens collected from one of the selected male parent. Out of six, three spathes were pollinated once and other three were pollinated twice (second pollination was done two days after first pollination). Data were collected for physico-chemical characteristics of the fruit including fruit drop, fruit weight, flesh weight, seed weight, total soluble solids (TSS), titratable acidity (TA), TSS: TA ratio, sugars, level of ascorbic acid and total phenols. The results indicated that pollen source significantly affected the fruit drop percentage as minimum fruit drop was observed from the tree pollinated with M-3. Physical properties of the fruit like fruit weight, flesh weight and seed weight were significantly improved with pollination from M-1 compared to other male trees. After harvest chemical quality parameters like TSS and TSS: TA ratio, ascorbic acid contents, and reducing sugars were highest in fruit pollinated with M-3 and M-2 respectively. Whereas lowest level of TA was recorded in fruits pollinated with M-3. Pollen source and number of pollinations did not significantly affect the level of total phenols in the date palm fruit. Total and non-reducing sugars were significantly higher in the fruit pollinated twice. In conclusion, the pollen source had significant impact on the physico-chemical properties of date palm cv. 'Dhakki'. The results suggested that best pollen source (male trees) should be selected for their respective female trees to get most desired characteristics.

Introduction

For centuries, the date (*Phoenix dactylifera* L.) has been an important crop in the desert regions of Arabian countries and has formed the basis of survival for many ancient nomads (Mohammed *et al*., 1983). At present more than 2000 cultivars of date palm are known to exist all over the world with variation in their genetic makeup (Askari *et al.,* 2003), but only a few important ones have been evaluated for their agronomic performance and fruit quality (Al-Hooti *et al*., 1997).

In Pakistan, date palm is considered to be the third major fruit crop after citrus and mango. Pakistan is the fifth largest date producer in the world, with an area of 81.7 thousand ha and production of 426.8 thousand tons. Balochistan is the major date producing province providing 225 thousand tons of dates from an area of 46.1 thousand ha and contributes 53% to the total national output (Anon., 2006). Pakistan exports both fresh (12 thousand tons) as well as dried (255 thousand tons) dates to many countries of

the world. Fresh dates markets include Bangladesh, Canada, Denmark, Germany, India, Indonesia, Malaysia, South Africa, Sri Lanka, USA and UK, whereas dried dates are exported to Afghanistan, Bangladesh, Canada, Denmark, Germany, India and Japan (Amin *et al.,* 2007).

Date fruit is consumed intensively all over the world due to its high nutritional value as it is rich in certain nutrients and a good source of rapid energy due to its high carbohydrates content (70-80%). Most of the carbohydrates in the dates are in the form fructose and glucose, which are easily absorbed by the human body (Al-Farsi *et al.,* 2005). Apart from high nutritional status, the medicinal value of the date fruits can never be neglected. The date fruits being exceptionally rich in potassium and extremely low in sodium are desirable food for hypersensitive persons who are assumed to consume low sodium diets (Sawaya *et al.*, 1983).

Date palm is dioecious and naturally cross pollinated. For commercial cultivation artificial pollination is required using compatible pollen source. Pollen source has been reported to effect fruit set, ripening and quality (AI-Obeed & Abdul-Rahman 2002; Monselise, 1986). The direct effect of pollen on fruit physical and chemical characteristics is known as metaxenia, which effects time of fruit ripening (Al-Delamiy & Ali, 1970), fruit size (Abdelal *et al*., 1983), fruit colour (Al-Delamiy & Ali, 1970), weight of fruit and seed (El- Ghayaty, 1982). Gasim (1993) reported that the direct effect of male parent on date fruit qualities varies according to the male parent used in female pollination.

The 'Dhakki' is one of the important date palm cultivar being grown in Pakistan. It is well known for its meritorious characters i.e. large fruit size and high sweetness. Being protandrous in nature. It faces shortage of pollen grains at the time of stigma receptivity. Due to difference in pollen availability and stigma receptivity, ultimately the fruit setting is affected resulting in poor yield which may lead towards 50% reduction in the potential yield (Khan & Ghafoor, 1993). At present very little is known about the role of pollen source and numbers of pollination on yield and quality of date palm cv. 'Dhakki'. Hence, the study was conducted to elucidate the effects of different pollen sources and numbers of pollination on the fruit drop, yield, and physio-chemical fruit quality characteristics of date palm cultivar 'Dhakki'.

Materials and Methods

Plant materials: To determine the influence of pollen source and numbers of pollination on fruit drop, yield and quality, three date palm (*Phoenix dactylifera* L.) cv. 'Dhakki', female trees and three different male trees [M-1 and M-2 were 25th and 24th trees planted respectively in the line coinciding the Guava block situated North-West direction, whereas M-3 was the 3rd tree situated North-West direction in the line coinciding the Kinnow block adjacent to root stock block in the Experimental Fruit Orchard, Square-9, Institute of Horticultural Sciences, University of Agriculture, Faisalabad] were selected for the experiment. On each female tree six spathes were chosen and were pollinated with pollens collected from one of the selected male parent. Out of six, three spathes were hand pollinated once and other three were pollinated twice (second pollination was done two days after first pollination). After harvest, fruit were cured with standard procedure by treating them with sodium chloride and acetic acid. Data were collected regarding fruit drop, yield and physico-chemical quality [fruit weight, flesh weight, seed weight, total soluble solids (TSS), titratable acidity (TA), TSS: TA ratio, sugars, ascorbic acid and total phenols] parameters.

Fruit drop (%): Fruit drop was determined by measuring the number of scars per strand (at three week interval for each tree), then average fruit drop was calculated as percent (%).

Yield at harvest (kg): To determine the total yield at harvest, each spathe was weighed separately using weighing balance and was expressed in kilogram (kg).

Physical quality characteristics: After harvest the physico-chemical characteristics of the fruits were analyzed for quality determination.

Fruit weight (g): To determine fruit weight, 10 fruit were selected randomly from each strand per replication. Average fruit weight was calculated and was expressed in gram (g).

Flesh weight (g): Flesh of the same 10 representative fruit as a replicate was weighed and average flesh weight was calculated in gram (g).

Seed weight (g): Seeds of the same selected fruit were weighed on an electronic balance and the average seed weight was calculated in gram (g).

TSS, TA, and TSS: TA ratio: Digital refractometer (RX 5000, Atago, Japan) was used for the determination of TSS and was expressed as ^{o}Brix. The TA of the juice was determined by titrating it against 0.1 N NaOH, using phenolphthalein as an indicator, and was expressed in % malic acid. TSS: TA ratio was determined by dividing TSS with respective TA values.

Sugars: Reducing, non-reducing sugars and total sugars were determined by using the method described by Hortwitz (1960).

Ascorbic acid: Ascorbic acid contents were determined by the method reported earlier by Ruck (1969). Ten ml of juice was diluted with 0.4% oxalic acid solution and 5 ml of filtered aliquot was titrated against 2, 6-dichlorophenol indophenol dye to light pink colour end point and were determined as mg 100 ml^{-1} FW.

Total phenols: Total phenols were determined by the method described by Ainsworth & Gillespie (2007) and were expressed as mg GAE g^{-1} FW

Statistical analysis: Data were subjected to analysis of variance using SPSS® Software (SPSS, Illinois, and USA) and treatment means were compared with the help of Duncan's New Multiple Range Test (Steel *et al.,* 1997).

Results and Discussion

Effect on fruit drop (%): Pollen source significantly affected the fruit drop percentage. Minimum fruit drop (48.6%) was recorded with M-3 and maximum with M-2 which was 1.4-fold less than M-2 (Fig. 1A). However, pollination frequency did not affect fruit drop significantly (Table 1). Different males vary in their pollen viability, germination percentage and genetic makeup which ultimately affect the retention of the fruit with the tree. The results mentioned above show that different males cause variation in fruit drop percentage in 'Dhakki' trees which is in line with the findings of Ghalib *et al.,* (1987) who reported that different male pollinators have significant effect on the fruit drop of 'Sayer' and 'Hallawy' dates.

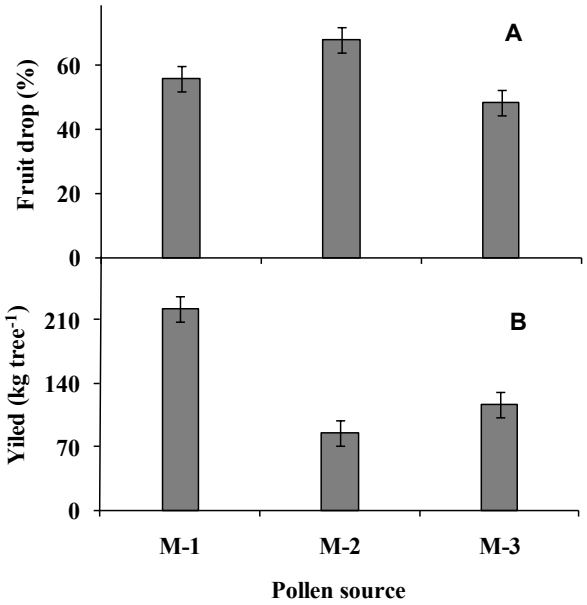

Fig. 1. Effects of pollen source on the fruit drop (A) and yield (B) of date palm cv. 'Dhakki'. Vertical bars indicate ± SE of means. n = 3 replicate.

Table 1. Effects of pollination frequency on physical characteristics of date palm cv. Dhakki fruit.

Pollination frequency	Fruit drop (%)	Yield (Kg tree^{-1})	Fruit weight (g)	Flesh weight (g)	Seed weight (g)
Once	53.9a	130.8a	32.2 a	28.8 a	3.2a
Twice	60.9a	152.5a	32.8 a	28.7 a	3.1a
	NS	*NS*	*NS*	*NS*	*NS*

NS = not significant at $p \leq 0.05$.

Effect on fruit yield (%): Significant differences were found regarding the effects of different pollen sources on the fruit yield. The tree pollinated by M-1 exhibited highest yield (222 Kg per tree), which was 2.6 and 1.9 times higher than M-2 and M-3 respectively (Fig. 1B). However, in this study pollination frequency did not affect the yield significantly. Slightly (non-significant) higher yield was obtained from the spathe which were pollinated twice in contrast to the spathes which were pollinated once (Table 1). The variation in yield refers to the differences in pollen source, viability, male and female compatibility (Al-Ghamdi *et al*., 1988). The differences in yield could be due to variation in pollen quality, percentage germination and pollen tube growth. Therefore, the pollen source (male trees) has significant effect on the ultimate fruit yield. Similarly, positive impact of pollen sources have been reported on the yield of 'Siwi' and 'Ahmadi' (El-Ghayaty 1983), 'Zaidi' (Ghaffar & Iqbal 2003), 'Shahani' (Rahemi 1998), 'Hallawy' and 'Khadrawy' (Helail & Kholey 2000), and 'Hayyani' (Muhtaseb & Ghnaim 2007) cultivars of date palm.

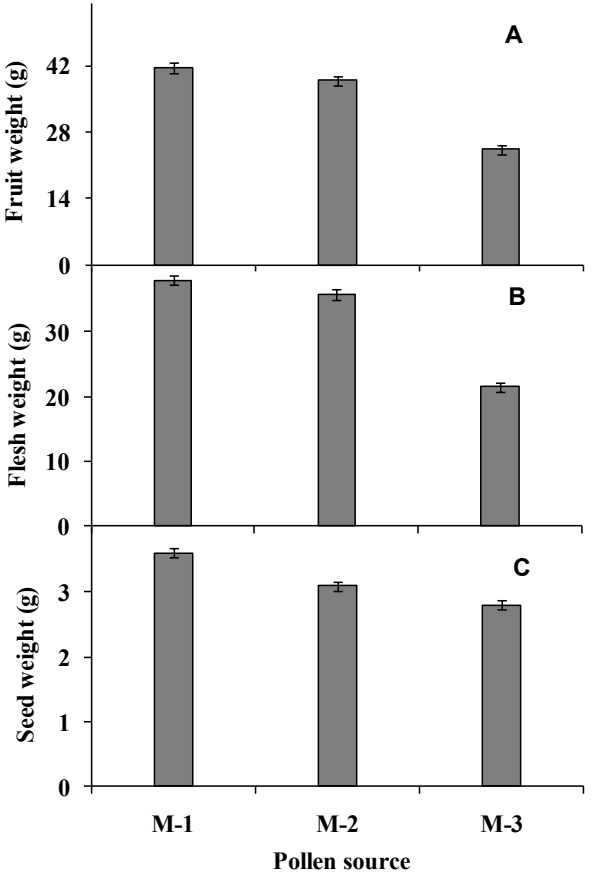

Fig. 2. Effects of pollen source on average fruit weight (A), flesh weight (B), and seed weight (C) of date palm cv. 'Dhakki' fruit. Vertical bars indicate ± SE of means. n = 3 replicate.

Effect on fruit quality

Fruit, flesh and seed weight (g): Pollen source significantly affected fruit weight, flesh weight and seed weight. Fruit from the trees pollinated with M-1 exhibited higher fruit weight, flesh weight flesh and seed weight as compared to the trees pollinated from other male trees (Fig. 2). This may be due to the metaxenial effect in date palm. The pollen source affects the growth of ovarian tissues with respect to hormones released by growing endosperm and embryo tissues, which diffuse into the ovarian tissue and exert specific effect on the fruit growth. Earlier similar kind of results have been found by El-Makhtoun & Abdel-Kader, (1993) and Nixon (1951) who reported significant effect of pollen source on fruit weight, flesh weight, and seed weight of date palm fruit. However pollination frequency did not reveal any significant differences for these characteristics (Table 1), which clearly depicted that repetition of the pollination does not affect the physical fruit quality characteristic of date palm.

Table 2. Effects of pollen source on biochemical characteristics of date palm cv. Dhakki fruit.

Pollen source	TSS (°Brix)	TA (%)	TSS:TA (Ratio)	AA (g 100 mL^{-1})	RS (%)	NRS (%)	TS (%)	TPC (mg GAE g^{-1})
M-1	40.3a	0.135b	298b	6.4ab	12.5b	20.0a	31.9a	15.9
M-2	39ab	0.159a	245b	4.3b	14.7a	22.0a	35.9a	15.1
M-3	36.3b	0.101c	359a	8.3a	9.3c	22.4a	31.2a	15.1
LSD	3.025	0.029	72.07	2.923	1.782	NS	NS	NS

LSD = Least significant difference at $p \leq 0.05$, TSS = Total soluble solids, TA = Titratable acidity, AA = Ascorbic acid, RS = Reducing sugars, NRS = Non-reducing sugars, TS = Total sugars, NS = Not significant at $p \leq 0.05$. Means not sharing any letter differ significantly at $p \leq 0.05$

Table 3. Effects of pollination frequency on biochemical characteristics of date palm cv. Dhakki fruit.

Pollination frequency	TSS (°Brix)	TA (%)	TSS:TA (Ratio)	AA (g 100 mL^{-1})	RS (%)	NRS (%)	TS (%)	TPC (mg GAE g^{-1})
Once	38.6a	0.13a	297b	5.97 b	12.9a	19.4 b	31.7b	15
Twice	39.3a	0.12a	327.5a	7.7 a	11.5a	25.6 a	36.6a	15.6
LSD	NS	NS	43.27	1.249	NS	2.575	2.623	NS

LSD = Least significant difference at $p \leq 0.05$, TSS = Total soluble solids, TA = Titratable acidity, AA = Ascorbic acid, RS = Reducing sugars, NRS = Non-reducing sugars, TS = Total sugars, NS = Not significant at $p \leq 0.05$. Means not sharing any letter differ significantly at $p \leq 0.05$

TSS, TA and TSS: TA ratio: The data regarding TSS exhibited significant differences among all pollen sources. Highest TSS was recorded with M-1 (40.3%) followed by M-2 (39%) and M-3 (36.3%) (Table 2). Pollens from M-1 increased the TSS percentage by 1.1-fold as compared to M-3. The results support the previous findings of Abdelal (1983) who reported significant effect of pollen source on the TSS of the date palm fruit. In addition, these effects might be due to differences in genetic makeup, growth, health, vigour, and spathe characteristics (Nasir *et al.,* 1986), and tree age (Ibrahim *et al.,* 1994). However, pollination frequency had no significant effect on the TSS values of the fruit (Table 3).

Pollen source significantly affected the TA and TSS: TA ratio of the fruits as TA was lowest in the fruit of tree pollinated by M-3 (0.10%) as compared to M-1 (0.135%) and M-2 (0.159%). TA of the fruit pollinated with M-3 were 1.3- and 1.6-fold less than M-1 and M-2 respectively. Similarly, the TSS: TA ratio was also higher in the fruit pollinated with M-3 (446.7) followed by M-1 (316.5) and M-2 (258.9) respectively which was 1.4 and 1.7 times higher than M-1 and M-2 (Table 2). As far as pollination frequency is concerned, it had non-significant effect on the TA of the fruits. On the other hands TSS: TA ratio was significantly higher in the fruit that were pollinated twice (Table 3). The TSS: TA ratio actually determines the taste of the fruit. Higher the TSS: TA ratio of the fruit more will be the sweetness. Difference in TA and TSS: TA ratio could be due to the tree age, male female compatibility and exposure of the fruit to sun light. However, further investigations are required to find out the scientific basis for the difference in the TSS: TA ratio of date palm fruit as influence by the pollination frequency.

Ascorbic acid and total phenoles: The effect of different pollen sources and pollination frequency was significant on the ascorbic acid contents of the 'Dhakki' fruit. Ascorbic acid contents were 2-fold higher in the fruits obtained from the trees pollinated by M-3 (8.3 mg 100 ml^{-1} FW) than M-2 (4.3 mg 100 ml^{-1} FW) (Table 2). Similarly, ascorbic contents were 1.3-fold higher in the fruit harvested from trees pollinated twice (7.7 mg 100 ml^{-1} FW) as compared to those pollinated once trees (5.9 mg 100 ml^{-1} FW) (Table 3).

However, total phenols were not significantly affected by pollen source and as well as numbers of pollination. Slightly higher amount of total phenols were found in M-1 (15.9 mg GAE g^{-1} FW) than M-2 and M-3 (15.1 mg GAE g^{-1} FW), respectively (Table 2). Fruit pollinated twice also showed slightly higher amount of total phenols (15.6 mg GAE g^{-1} FW) than pollinated once (15 mg GAE g^{-1} FW) (Table 3). The variation in ascorbic acid contents of fruits pollinated by different pollen sources could be due to the metaxenial effect (Helail & Kholey 2000). Although light is not necessary for ascorbic acid synthesis but the amount of light has been found to induce positive impact on the level of on the ascorbic acid concentration in date palm fruit. Sugars used during photosynthesis are responsible for ascorbic acid synthesis (Harris 1975). However, the role of pollination frequency on the ascorbic acid synthesis in date palm in not clear and needs further investigation.

Reducing, non-reducing and total sugars: Pollen source and pollination frequency affected the sugar level of the date palm fruit in different ways. Fruit pollinated with M-2 exhibited significantly highest reducing sugar contents (14.7%) about 1.7- and 1.6-fold higher in the fruit harvested from the tree pollinated by M-1 (12.5%) and lowest in M-3 (9.3%) respectively (Table 2). The non-reducing and total sugar contents showed non-significant response to the pollen sources (Table 2). However, non-reducing and total sugars were higher in the fruit obtained from the trees pollinated twice than pollinated once (Table 3). Sugar contents of the fruit affected by pollen source might be due to the activities of enzymes system initiated by the metaxenial effect and later on that passed into extra cellular sites, get dissolved readily into water and invert the sugars. Similarly the hydrolytic enzymes like polygalacturonase and cellulose may also be involved in these biochemical changes by solubilizing the pectin and cellulose in date palm fruit (Hasegawa & Smolensky, 1971). The involvement of different pollen sources in the physiology of different biochemical reactions involved in the biosynthesis of sugars is still not fully understood and needs further studies.

Conclusions

The results of this study suggested that pollen source and pollination frequency have significant effects on fruit drop, yield and quality of date palm cv. 'Dhakki'. Pollen source was found more effective as compared to the pollination frequency. Overall, it is suggested that for better yield and fruit quality, compatible pollinizers should be selected. The application of pollens more than once has little impact on the fruit yield and quality. Further studies are needed to investigate the effects of different pollen sources on the various biochemical processes related to of date palm fruit quality. Moreover, the physiological and molecular phenomenon involved in the differential response of different pollen sources also need to be explored.

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