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FRUIT YIELD AND QUALITY OF DHAKKI DATE (*PHOENIX DACTYLIFERA* L.) AS AFFECTED BY FRESH AND STORED POLLENS OF POTENTIAL MALE GENOTYPES

MUHAMMAD IQBAL[1], KHALID USMAN[2*], SHAKEEL AHMAD JATOI[3] AND MUHAMMAD MUNIR[4]

[1]*Department of Horticulture, Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan*
[2]*Department of Agronomy, Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan*
[3]*National Agriculture Research Center, Islamabad, Pakistan*
[4]*Department of Food Science, Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan*
[*]*Corresponding author's email: dusmangu@gmail.com*

Abstract

A maximum quantity of pollen grains at the time of pollination is helpful for higher fruit set and yield. But mostly, male flowers earlier than female. Male also shed their pollen immediately after spath opening, thus fresh pollens are not available at the time of pollination. Hence pollens are stored and used for pollination as Dhakki dates flower late in the season. An investigation was carried out in order to evaluate the impact of fresh and stored pollens of potential male genotypes on fruit yield and quality of Dhakki date palm. Twenty Dhakki trees were pollinated with fresh and stored pollens of ten different male trees (designated as M1, M2 …M10) in 2012 and 2013, respectively. Three spathes were selected on each Dhakki tree for pollination with fresh and stored pollens on the 2nd day of spath opening. The results indicated that fresh and stored pollens had a significant effect on fruit yield and quality. Fresh and stored pollens of genotype M2 induced highest fruit set (90.13 and 75.12 %), fruit weight (21.82 and 21.3 g), fruit yield (94.79 and 91.79 kg/tree), TSS (38.5 and 37.9 %), total sugar (17.8 and 17.3 %) and pollen viability (95 and 89 %), respectively. On the other hand, Fresh and stored pollens of genotype M3 brought out higher fruit weight (21.12 and 20.7 g), fruit yield (87.2 and 86.4 kg/tree), TSS (39.1 and 38.7 %) and total sugars (17.7 and 17.4 %), respectively. The results suggested that fresh and stored pollens of genotypes M2 and M3 had high potency pollens that induced higher fruit set, fruit yield and fruit quality in Dhakki date.

Key words: Pollination, Dhakki Date, Pollen viability

Introduction

Date palm (*Phoenix dactylifera* L.) is grown in arid and semi-arid regions characterized by long and hot summers, limited rainfall, and low relative humidity during the ripening period. Date plays a significant role in the economy of many countries of the world including Pakistan contributing 0.6 million tons to the world total fruit production of 7.5 million tons (FAO, 2012). Pakistan earns billion of rupees by exporting fresh (12 thousand tons) and dried (225 thousand tons) dates to other countries (Maryam *et al*., 2015). There are several high yielding varieties of date in Pakistan; however, Dhakki date is an excellent variety well-liked for outstanding yield, remarkable nutritional, health, and economic value. Dhakki is famous for fresh, dry and chauara making. Its demand is increasing day by day due to its large size and fine taste (Amin *et al*., 2007). Pakistan is one of the leading countries exporting quality date to the world market. However, the average date production of Pakistan is low due to poor pollination and high fruit dropping percentage. Being dioecious in nature, male and female flowers of date palm typically do not mature simultaneously and thus pollens are not available at the time of pollination, resulting in lower fruit yield and quality (Boughediri *et al*., 1995).For successful natural pollination, there should be 50 % male population that would reduce the crop to a considerable extent. In a favorable climate, a male can pollinate female trees in around one square mile area when male and female spaths open at the same time. But nowadays the male population is decreasing rapidly in the study area as the people are using male palm stem as a fuel for bricks factories. Male palms flower earlier than female palms and have a rather short flowering period. Owing to which a sufficient quantity of pollens is unavailable for pollination. The female palms have quite limited receptivity periods resulting in an abortive pollination process particularly if male pollen becomes unavailable or expired at that time. Moreover, climatic stresses (wind, rain, hailstorm) prevailing during February-March, being the peak pollination season badly affect fruit set and date production through natural pollination. Therefore it is time to switch to artificial pollination process in order to obtain reasonable fruit yields.

Enough research work has been conducted on pollen storage with different ways and pollen viability. The people, however, are still unaware of the causes as to how stored pollens affect fruit set, fruit yield, and fruit quality, particularly of Dhakki.There is a concern in the farming community that stored pollens result in poor fertilization which leads to lower fruit yield. However, this may be due to poor storage condition/ low viability of the stored pollens (Al-Ghamadi *et al.*, 1988). There are several factors that affect stored pollens viability; however, pollens of high potency male genotypes are much important for effective fertilization and higher fruit setting. El-Salhy *et al*., (1997), Hamid (2000), and Halail & El-Kholey (2000) reported that stored pollen can be used for pollination provided their safe storage and viability is ensured. Pollen source (male genotype) and type (fresh or stored) both can affect fruit yield and quality (Osman & Soliman, 2002; Marzouik *et al.*, 2002; El-Khosary & Soliman, 2003). Effective artificial pollination is an integral part of commercializing date palm culture (Hussein *et al*., 1979; Iqbal *et al*., 2004). Viable pollens are helpful for high fruit set (Al-Muhtaseb & Ghnaim, 2006) and fresh pollens no doubt

have the higher viability compared to stored pollens. However, fresh pollens are normally shed before the opening of the female spath and thus a commercial grower has to use stored pollens for pollination. Pollens from male genotypes of different genetic background may have variable effects on fruit yield, quality, and dropping percentage for their typical nature of fertility and compatibility (Maryam *et al*., 2015; Haider *et al*., 2013, 2014). The Dhakki date can be a world-leading, high yielding, delicious, and quality variety if pollination is carried out properly and fruit dropping is reduced. Presently, the growers who efficiently manage the pollination and do scientific processing of Dhakki date fetch attractive marketing price for their produce. The present study was therefore designed in order to screen out the potential male genotypes out of landraces which may overcome the problem of pollination and fruit dropping, and contribute significantly to the quality and quantity of fruit.

Materials and Methods

Experimental procedure: This study was conducted at Date palm Research Orchard, Main Campus Gomal University, Dera Ismail Khan in 2012 and 2013 on 25-29-year-old uniform Dhakki tree. Ten local male (designated as M1, M2, ……M10) having at least three suckers were selected. The detail of local male is given in Table 1. Male spathes were cut and protective sheaths were removed for pollen grain extraction. The inflorescence was placed on the paper sheet under the sun for 3-4 hours till the complete opening of flowers. Then pollen grains were separated and placed on paper for 2-3 hours for complete dryness. Fresh pollens were then mixed with 30 % flour and dusted with a sponge on three spathes on the second day of spath opening. Stored pollens of the previous year were also used in comparison to fresh pollens. The fresh pollens were kept in the airtight glass bottle and stored at 4^{o}C in household refrigerator for one year. Next year, the stored pollens were mixed with 30 % flour and were dusted on spathes as per previous year practice. After pollination, the spathes were covered with waxed paper to avoid contamination. The experiment was laid out in two- factor randomized complete block design having 10 male genotypes as factor A and two pollen sources (fresh and stored) as factor B with three replications. Data were recorded on the following parameters.

Table 1. Male identity number, the name of owner and location in D.I.Khan, Pakistan.

Male identity number	Name of owner	Location
M1	Ahmad Nawaz	MitthaPur Kalan
M2	Gulzar Khan	MitthaPur Kalan
M3	Malik Shakeel	MitthaPur Kalan
M4	Nawaz Khan	MitthaPur Kalan
M5	Gulsher Khan	MitthaPur Kalan
M6	Feroz Khan	MitthaPur Kalan
M7	Malik Sajid	MitthaPur Kalan
M8	Khadim Khan	MitthaPur Kalan
M9	Umar Khan	MitthaPur Kalan
M10	KhudaBakhish	MitthaPur Kalan

Pollen viability (%): Before pollination, theviability of fresh and stored pollens were determined by staining fresh and stored pollen grains with 1% acetocarmine as per procedure adopted by Moreira & Gurgel (1941) and Maryam *et al*., (2015). Pollen viability was determined by staining techniques according to the procedure. A small quantity of pollen grains was placed on slide and 1-2 drop of 1% acetocarmine solution was added. The slides were placed for a few minutes on a hot plate. The viability of pollen grains was examined with the help of a microscope at 200x magnifying power Model BHTUOSK13819. A slide was prepared from each male and pollen grains of four fields on each slide were tested. Pollen grains that stained red were considered viable whereas the colorless pollen grains were considered non-viable, and then percent viability was calculated.

Fruit set (%): After four weeks of pollination, fruit set data were recorded according to a procedure described by El Makhtun (1981). Fruit set percentage was calculated by counting normal (Fertilized) and abnormal (Un-fertilized) fruits on each spathe selected after 3 weeks of pollination. Ten strands per spathe were selected for recording perfect normal (fertilized) and imperfect abnormal (un-fertilized) fruits and percent fruit set were calculated using the following formula:

$$\frac{\text{No. of normal fruit - No. of abnormal fruit}}{\text{Total no. of fruits}} \times 100$$

Days to fruit set: The number of days to fruit set was recorded when two carpals of tricarpal ovary were abscised in each spath and then mean days were calculated.

Fruit weight (g): Twenty fruits of each tree were weighed by electric balance and the average weight of fruit was computed in grams.

Fruit size (cm): The length and width of twenty (20) fruits from each tree was measured with the help of measuring scale and mean size of fruit was calculated in centimeters.

Fruit drop (%): Percent fruit drop was calculated using the following formula (Iqbal *et al*., 2014). Ten strands per spathe were selected for the recording of percent fruit drop. The total number of fruit set was counted after fertilization. The number of fruit dropped during the season was counted. Percent fruit drop was calculated using the following formula.

$$\frac{\text{No. of fruit drops}}{\text{Total no. of fruits set}} \times 100$$

Days to maturity: The number of days to maturity was counted when 50 % fruits, color turned yellow in each tree and then mean days were calculated.

Fruit yield per tree (kg): All the fruit bunches from each treatment were weighed and finally mean yield per tree (kg) was determined.

Moisture (%): Moisture content was determined according to Anon., (2005) by using oven drying method. A 10 gram prepared sample was kept in an oven at 100ºC until successive weighing showed no further loss in weight. The sample was then cooled in desiccators and reweighed. The moisture content was determined from the loss in weight using the following formula:

$$\text{Moisture percentage} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Determination of sugars

Preparation of sample solution: Twenty gram fruit pulp was ground in a pestle and mixed with 40 ml water and two grams washed sand was added to aid rupturing of date tissue. The slurry was diluted with 150 ml of distilled water into 250 ml volumetric flask. The residue was repeatedly washed with distilled water. Five ml saturated solution of neutral lead acetate was added to the filtrate to precipitate the unwanted materials and then 5 ml of saturated potassium oxalate solution was added to precipitate the residual lead. A Final volume of solution was made to 250 ml with distilled water and the solution was filtered.

Preparation of standard sugar solution: Reducing sugars, non-reducing sugars and total sugars were determined by Lane and Eynon as given in Anon., (2005).

Determination of reducing sugars: For the determination of the reducing sugars, 5ml of each Fehling's "A" and Fehling's "B" solutions freshly prepared and standardized with standard Dextrose solution was taken in 250 ml conical flask. It was titrated with the sample. The contents of the flask were mixed thoroughly, heated to boiling and boiled moderately for two minutes. Then two drops of methylene blue were added, taking care not to touch the sides of the flask. The titration was completed within one minute by adding sugar solution drop wise as 5-10 seconds intervals until the indicator was decolorized completely. At the end point, the boiling liquid assumed brick red color of precipitated cuprous oxide. The percent reducing sugar was calculated by using the following formula:

$$\% \text{ Reducing sugars} = \frac{\text{Fehling's solution equivalent (0.5 gms Dextrose)} \times 250}{\text{ml sample solution used} \times 50} \times 100$$

Estimation of non-reducing sugars: Non-reducing sugars (sucrose) was calculated from the data obtained for reducing sugars and total sugars by using the following formula:

% Non Reducing sugars = (%Total sugar - % Reducing sugar) x 342/360

Total soluble solid (Brix): Total soluble solid was determined by hand refractometer as per Anon., (1995). Determinations were made in triplicate. 4 g each was taken from the slurry and was transferred to a 250 ml volumetric flask. Now the distilled water was added up to the mark. The content of the flask was allowed to stand for eight hours with rigorous shaking. It was then allowed to stand for another 16 hours without shaking and then filtered. From the filtrate, 50 ml was pipetted to a flat-bottomed disk and dried at 100ºC to constant weight. It was then cooled in desiccators and weighed. Total soluble solids were determined by multiplying this reading by the factor i.e., 125.

Total sugars: Total sugars were determined by Lane and Annon method as described by Anon., (1995). For the estimation of total sugars, 50 ml of the sample solution was put into a 250 ml beaker through a pipette, 5 g citric acid and 50 ml of the distilled water was added. The solution was boiled very gently for five minutes to invert the sucrose. It was cooled and transferred to the 250 ml volumetric flask and was neutralized with 20 % NaOH solution using phenolphthalein as an indicator. The volume was made up to the mark with distilled water. The solution was titrated with Fehling's solution as for reducing sugar. The total sugar was calculated by using the following formula:

$$\text{Total sugars (\%)} = \frac{\text{Feh. solution Equivalent (0.5 g Dextrose)} \times 250 \times 250}{\text{ml of sample solution used} \times 50 \times 50} \times 100$$

Statistical analysis: The data collected were compiled and analyzed statistically using computer software MSTATC. The method of Analysis of Variance (ANOVA) was applied and means were separated using Least Significant Difference (LSD) test (Steel *et al*., 1997).

Results and Discussion

Fruit set (%): The data regarding fruit set percentage was given in Table 2. The results showed a significant effect of male genotypes and pollen source on fruit set percentage. The genotype M2 caused higher fruit set (82.6%) followed by M3 (77.1%) compared to all other genotypes. Similarly, fresh pollens resulted in comparatively higher fruit set (65.3%) than stored pollens (52.7%). Genotypes × pollens interaction had also a significant effect on fruit set percentage (Fig. 1). The results indicate that pollination of date palm (cv. Dhakki) with fresh and stored pollens of M2 and M3 resulted in higher fruit set than all other combinations. The higher fruit set obtained from fresh pollen pollination than stored pollen of M2 may be due to more pollen viability percentage because stored pollen viability decreases in storage with the passage of time (Table 4). In fresh pollen, more pollen viability might be due to the higher moisture content that caused rapid pollen germination, pollen tube development, penetration into the style and ovary of pistillate flower for fertilization. The fruit set behavior of date palm may be dependent on climatic factors and male - female compatibility which can affect cell number in

early cell division stage of fruit set, cell multiplication, and normal fruit setting. The results indicate that the genotypes M2 and M3 were perhaps more compatible with the female genotype under the agro-climatic condition of Dera Ismail Khan in addition to their more pollen viability and thus resulted in more fruit set than all other genotypes. Analogous results were reported by other researchers (Iqbal *et al*., 2004, 2009; Hani *et al*., 2006). They noted maximum fruit set in those males possessing higher viable pollen percentage. Al-Hamoudi *et al*., (2006) had also similar findings who reported that more viable pollens produced more fruit set percentage. It is evident from the results that genotype M2 showed highest fruit set percentage among all other genotypes probably due to more viable pollens, higher germination percentage and genetic makeup which eventually retained more fruit after fertilization (Iqbal *et al*., 2011; Omar & El-Abd, 2014; Djerouni *et al*., 2015; Kadri *et al*., 2016; Shahid *et al*., 2017; Islam *et al*., 2017 and Soliman *et al*., 2017).

Table 2. Fruit set, days to fruit set, fruit weight, and fruit length as affected by date palm genotypes and pollens (fresh and stored) during 2012-2013.

Genotypes	Fruit set (%)	Days to fruit set	Fruit weight (g)	Fruit length (cm)
M1	36.5i	18.8a	19.9d	4.1bcd
M2	82.6a	17.0e	21.6a	4.7a
M3	77.1b	17.2de	20.9b	4.7a
M4	46.2g	17.9bc	18.9e	4.0e
M5	42.9h	18.5a	19.9d	4.2b
M6	51.2f	17.9b	20.5c	4.0de
M7	68.7d	17.6c	18.9e	4.1bcd
M8	75.0c	17.3d	17.9f	4.2bc
M9	43.2h	17.9bc	19.9d	4.1bcd
M10	66.6e	17.9b	18.9e	4.1cd
LSD	0.737	0.274	0.192	0.098
Pollens				
Fresh	65.3a	18.1a	19.9a	4.3a
Stored	52.7b	17.5b	19.5b	4.1b
LSD	0.038	0.127	0.099	0.049
Interactions (genotype × pollens)	**	**	NS	NS

**, Highly significant at $p \leq 0.01$. LSD = Least significant difference at $p \leq 0.05$, NS = Not significant at $p \leq 0.05$. Means sharing no letter differ significantly at $p \leq 0.05$

Days to fruit set: From the perusal of data given in Table 2, the genotypes M1 and M5 took more days (18.8, 18.5) to fruit set than the rest of the genotypes, respectively. On the other hand, M2 and M3 took fewer days (17.0, 17.2) to fruit set than other genotypes, respectively. Regarding pollens effect, stored pollens took fewer days to fruit set than fresh pollens. Interactive effect of genotype and pollens revealed that M1 and M5 with both fresh as well as stored pollens took more days to fruit set than all other treatment combinations (Fig. 2). Unlike this, M2 and M3 with fresh and stored pollens caused fruit set earlier (17.0, 17.2) than all other genotypes, respectively. The variation in days to fruit set may be attributed to genetic characters of pollen physiology, male and female incompatibility and receptivity of female flowers that were responsible for early or late fruit set. These results are in line with the findings of Iqbal *et al.,* (2012) and Shahid *et al*., (2017) who reported that pollen sources had a significant effect on days to fruit set in Dhakki date palm.

Fruit weight (g): The data regarding fruit weight was given in Table 2. The results showed significant effect of genotypes and pollen source on fruit weight. The genotype M2 caused higher fruit weight (21.6 g) followed by M3 (20.9 g) than all other genotypes. Similarly, fresh pollens resulted in comparatively higher fruit weight (19.9 g) than stored pollens (19.5 g). Genotypes × pollens interaction had no significant effect on fruit weight. Higher fruit weight with M2 and M3 pollens may be due to the reduced number of retained fruits which in turn increased the reserve food in fruit that lead to higher fruit weight. The variation in fruit weight might be due to differences in pollen quality, pollen viability, and pollen tube growth as reported by Shafique *et al*., (2011). Other researchers also reported a significant effect of pollen source on fruit weight (El-Makhtoun *et al*., 1995; Rahmdil *et al*., 2014 & Omaima *et al.,* 2014). This might be due to the hormones released by growing endosperm and embryo tissues that diffused into the ovary tissue and stimulated fruit growth.

Fruit length (cm): Data regarding fruit length had a similar trend as reported for fruit weight. Both genotypes and pollens had significantly affected fruit length (Table 2). The lengthier fruits were produced when date palm was pollinated with pollens of M2 (4.7 cm) and M3 (4.7 cm). Likewise, fresh pollens caused lengthier fruit (4.3 cm) than stored pollens (4.1 cm). Genotype × pollen interaction was not significant. Higher fruit length recorded was perhaps due to pollen source. Observance of shorter fruit length (4.0) in M4 and M6 may be mainly due to a genetic character and partially due to an environmental factor that caused competition for food partitioning among fruits which lead to shorter fruit length. Iqbal *et al.,* (2), 008Omar *et al.,* (2014) and Shahid *et al*., (2017) had analogous results who reported that pollen sources significantly affected fruit length. However, these results disagreed with the findings of Muhtaseb & Ghnaim (2006) who reported that pollen sources had no significant effect on fruit length. However, there had been partial agreement with the results of Omaima *et al.,* (2014) who reported significant and non-significant in second year. results in one year.

Fruit width (cm): The data for fruit width were given in Table 3. Genotypes and pollens had significant effects on fruit width; however, genotype × pollen interaction was not significant. Genotypes M2 and M3 caused higher fruit width (2.20 cm, 2.26 cm) than all other male genotypes. Fresh pollens caused wider fruit production (2.16 cm) than stored pollens (2.07 cm). The genotypes M6, M9, and M10 caused fruit production comparatively thinner in size. Variation in fruit width may be due to the genetic makeup of pollen sources. Similar results were communicated by Iqbal *et al*., (2011 & 2012) who reported that pollen sources had a significant effect on fruit width of different date cultivars. These results partially agreed with the previous findings of Omaima *et al.,* (2014) who observed the significant response in year 1 and non-significant effect in year 2. Pollen source directly affects fruit width of date palm (*Phoenix dactylifera* L.) through the process known as 'metaxenia'(Rezazadeh *et al*., 2013).

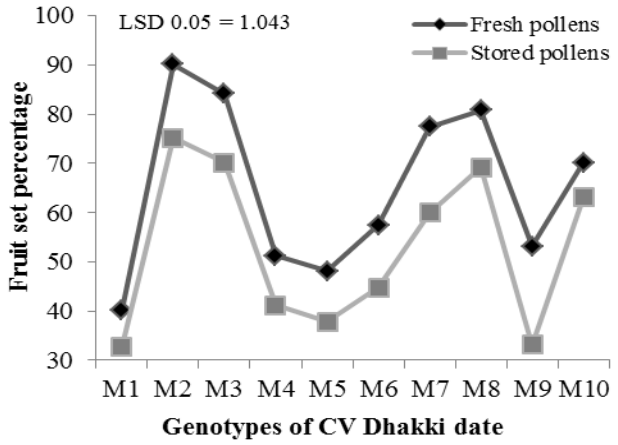

Fig. 1. Interactive effects of genotypes and pollens (fresh and stored) on fruit set percentage.

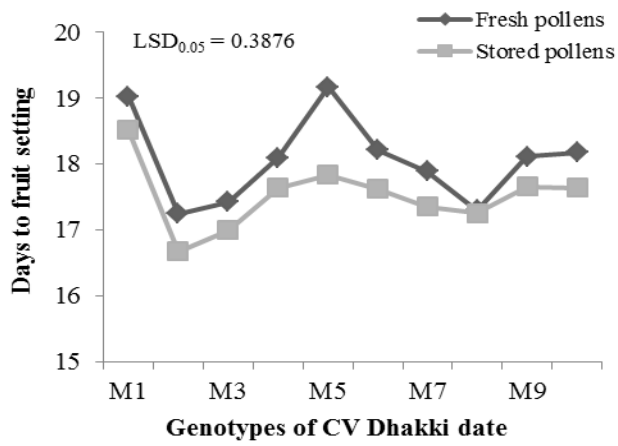

Fig. 2. Interactive effects of genotypes and pollens (fresh or stored) on days to fruit setting.

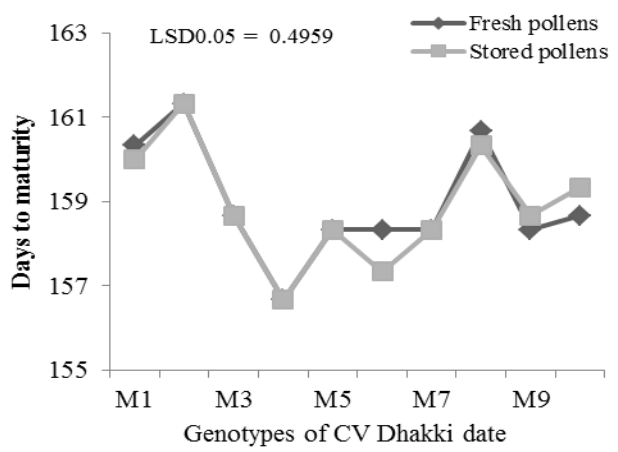

Fig. 3. Interactive effects of genotypes and pollens (fresh and stored) on days to maturity.

Fruit drop (%): Data recorded for fruit drop percentage revealed significantly highest fruit drop in case of pollination with pollens of M4 (40.8%), M5 (40.9%), and M6 (40.8%) (Table 3). Likewise, fresh pollens caused more dropping percentage (39.52%) than stored pollens (38.36%) probably due to more fruit set percentage and competition between fruits for resources. Genotype by pollen interaction did not influence fruit dropping percentage. Fruit dropping starts from fruit setting and continues till harvesting and usually more than 40 percent fruits drop, which consequently reduce total yield. Fruit dropping immediately after pollination may be due to the shedding of unfertilized ovules. The other possible reason for more dropping may be higher fruit fresh weight that induced dropping. The results showed that different pollinizers played a vital role in fruit retention and reduced the development of abscission layer in fruit stalk during fruit growth and development. The results are in conformity with the findings of Iqbal *et al.,* (2011), Shafique *et al.,* (2011) and Shahid *et al.,* (2017) who reported that fruit drop could be reduced by pollinizers due to the genetic behavior of the male plant.

Days to maturity: Data regarding days to maturity were significantly affected by male genotypes, pollens, and genotype x pollen interaction (Table 3). Genotype M2 took maximum days to maturity (161) while M4 took minimum days to maturity (157). The genotypes M3, M5, M7, and M9 matured earlier and took almost similar days to maturity. Similarly, fresh and stored pollens also took alike days to maturity. The genotype x pollen interaction revealed that genotype M2 took maximum days to maturity irrespective of the pollen source due to maximum fruit set, fruit weight, and fruit size. In such bunches with heavy fruit load, light approaches less and thus fruit ripening is delayed as reported by Shahid *et al.,* (2017) who communicated that pollen source significantly affected date maturation. Conversely, M4 took minimum days to maturity due to less fruit set, and fruit size. In such bunches, more air and light can approach to the fruit and thus mature earlier (Fig. 3). Variation in days to maturity may be due to climatic as well as genetic factors. These findings are in conformity with that of AL-Khalifa (2006) and Iqbal *et al.,* (2011) who reported that pollen sources had a significant influence on fruit ripening time. Zirai (2012), Maryam *et al.,* (2015) and Shahid *et al.,* (2017) also reported similar findings.

Yield (kg/tree): Fruit yield had a significant response to genotypes, pollens, and genotype x pollen interaction (Table 3). The genotype M2 caused the highest fruit yield (93.3 kg/tree) followed by M3 (86.8 kg/tree) compared to all other genotypes. All other genotypes had lower fruit yield. Pertaining to pollen effect, fresh pollen caused higher fruit yield (73.8 kg/tree) than stored pollen (70.8 kg/tree). Interactive effect of genotype x pollen revealed that genotype M2 in combination with either fresh pollen/stored pollen had the highest fruit yield followed by M3 (Fig. 4). Results indicated that M2 produced the highest yield which was perhaps due to maximum fruit setting, maximum fruit weight, size and less fruit dropping and highest moisture content.

Fresh and stored pollens of M2 and M3 had perhaps high potency pollen sources that resulted in higher fruit yield. These results are in accordance with the findings of Iqbal *et al.,* (2008), Omer *et al.,* (2014), Omamia *et al.,* (2014) and Shahid *et al.,* (2017), who reported that fruit yield was significantly affected by various pollens sources, and were contradictory with the findings of Muhtaseb & Ghanim (2006), Shafique *et al.,* (2011) and Iqbal *et al.,* (2012) who reported that pollen sources did not influence fruit yield significantly.

Table 3. Fruit width, fruit yield, fruit dropping and days to maturity as affected by date palm genotypes and pollens (fresh and stored) during 2012-2013.

Genotypes	Fruit width (cm)	Fruit dropping (%)	Days to maturity	Fruit yield (kg/tree)
M1	2.16b	35.8f	160b	85.6c
M2	2.20ab	35.9f	161a	93.3a
M3	2.26a	38.9d	159cd	86.8b
M4	2.11b-e	40.8a	157f	61.7g
M5	2.15bc	40.9a	158d	58.8hi
M6	2.05def	40.8a	158e	63.1f
M7	1.99f	39.6c	158d	83.1d
M8	2.13bcd	38.6d	161b	59.3h
M9	2.06c-f	40.2b	159d	58.5i
M10	2.04ef	37.9e	159c	72.5e
LSD	0.09053	0.3964	0.3506	0.6518
Pollens				
Fresh	2.16a	39.52a	159	73.8a
Stored	2.07b	38.36b	159	70.8b
LSD	0.0453	0.1773	NS	0.3201
Interactions	NS	NS	**	**

**, Highly significant at $P \leq 0.01$. LSD = Least significant difference at $p \leq 0.05$, NS = Not significant at $p \leq 0.05$. Means sharing no letter differ significantly at $p \leq 0.05$

Table 4. Moisture (%), TSS (%), total sugar and pollen viability as affected by date palm genotypes and pollens (fresh and stored) during 2012-2013.

Genotypes	Moisture (%)	TSS (%)	Total sugar (%)	Pollen viability (%)
M1	67.1c	36.6f	16.6e	78.0c
M2	68.5a	38.2b	17.6a	91.8a
M3	68.3b	38.9a	17.5a	85.0b
M4	64.5i	37.3cd	16.9cd	53.6g
M5	64.3 j	37.1de	17.0bc	48.4i
M6	65.5g	36.7f	16.9cd	54.0g
M7	66.6e	36.7f	16.7de	74.2d
M8	65.6f	37.6c	16.7de	50.8h
M9	64.5h	36.6f	17.2b	54.5f
M10	66.7d	36.9ef	16.9cd	70.2e
LSD	0.01198	0.2887	0.2424	0.5482
Pollens				
Fresh	66.6a	37.8a	17.4a	69.8a
Stored	65.7b	36.8b	16.6b	62.3b
LSD	2.086	0.1323	0.1090	0.2760
Interactions	**	**	NS	**

**, Highly significant at $P \leq 0.01$. LSD = Least significant difference at $p \leq 0.05$, NS = Not significant at $p \leq 0.05$. Means sharing no letter differ significantly at $p \leq 0.05$

Moisture (%): Moisture is one of the essential components of fruit which impacts its quality.The moisture content of date is ranged from 64.3- 68.5% (Table 4). Genotype M2 (68.5%) and M3 (68.3%) produced higher moisture contents than all other genotypes. Fresh pollens, fruits had higher moisture content (66.6%) than stored pollens (65.7%). Genotype by pollen interaction revealed that fresh pollens of M2 outyielded all other combinations followed next by M3, however, stored pollens of M2 and M3 had similar moisture content (Fig. 5). Genotype M5 in combination with fresh or stored pollen resulted in lowest moisture content. Results revealed that fruit moisture is closely related with fruit weight. The results indicated that higher fruit moisture of M2 and M3 was due to their higher fruit weight. These results were supported by the findings of Omer *et al.,* (2014), Rahmdel *et al.,* (2014) and Abdelha *et al.,* (2016) who reported that pollen sources had a significant effect on fruit moisture.

Total soluble solids (TSS): Data recorded on total soluble solids percentage had an almost similar pattern as reported for moisture content except M3 which had more TSS (38.9%) than all other genotypes in this case (Table 4). Genotype M1, M6, M7, M9, and M10 had the lowest TSS value. Fresh pollens produced higher TSS (37.8%) than stored pollens (36.8%). Genotype x pollen interaction revealed significantly higher TSS for M3 in combination with fresh or stored pollens compared with all other combinations (Fig. 6). The results suggested that genotypes M2, M3, and M8 in combination with either fresh pollens or stored pollens produced higher TSS than all other combinations. Analogous results were reported by Shafique *et al.,* (2011) who reported that different pollinizers had significantly different effects on fruit TSS. Pollens from different male genotypes showed variable effects on TSS probably due to differences in genetic makeup, growth, health, vigor and spathe characteristics (Nasir *et al*., 1986; Abdel-Hatef *et al.,* 2016; Aashish *et al.,* 2017 and Siyahsar *et al*., 2018).

Total sugars (%): Sugar content is an important quality and quantity attribute of date. Data presented in Table 4 indicated that genotypes M2 (17.6%) and M3 (17.5%) produced the highest percentage of total sugar while lowest value of total sugar was recorded with genotype M1 (16.6%). Fresh pollens caused higher total sugar production (17.4%) than stored pollens (16.6%). Genotype x pollen interaction did not influence total sugar significantly. These findings are in accordance with the findings of Omer & Abdel (2014), Rahmdel *et al.,* (2014) and Aashish *et al.,* (2017) who reported that total sugars were significantly affected with male pollinizers. Variable effects of pollen sources on total sugar might be due to enzymatic activities initiated by the metaxenic effect and afterward passed into extracellular sites, got dissolved readily into water and inverted the sugar. Likewise, the hydrolytic enzymes, such as polygalacturonase and cellulose might also be involved in these biochemical changes by solubilizing the pectin and cellulose of cell wall as reported by Muhtaseb & Ghanim (2006). However, Helail & El-Kholey, (2000), El-Ashry (2009) and Omar *et al*., (2014) reported that pollen source effect on the physiology and biosynthesis of sugars is still under consideration and not fully known.

Pollen viability (%): Pollen viability showed a significant response to genotypes, pollens, and genotypes x pollens interaction (Table 4). Maximum pollen viability was recorded with M2 (91.8%) followed by M3 (85.0%)

while the minimum was recorded with M5 (48.4%). Fresh pollens were more viable (69.8%) than stored pollens (62.3%) perhaps due to more moisture content. Stored pollens lose moisture with the passage of time during storage. Genotypes x pollens interaction revealed that M2 with fresh pollens had the highest viability among all other treatment combinations (Fig. 7). Similarly stored pollens of M2 also outyielded all other genotypes. M3 in combination with fresh pollens as well as stored pollens showed next higher viability after M2. The results suggested that fresh pollens were more viable than stored pollens probably due to fluctuation in storage condition during the experimentation period. These results agreed with the findings of Nasr *et al.,* (1986), Marzouk*et al.,* (2002), Iqbal *et al.,* (2004 & 2009), Djerouni *et al.,* (2015), Kadri *et al.,* (2016), Shahid *et al.,* (2017) , Islam *et al.,* (2017) and Aly (2018) who reported that pollen sources differed in pollen viability percentage. Pollen viability has already been evaluated by several researchers under different storage conditions (Maryam *et al*., 2015); however, the important aspect of this study is the impact of fresh and stored pollen of different potential genotypes on fruit yield and quality of Dhakki date under filed condition.

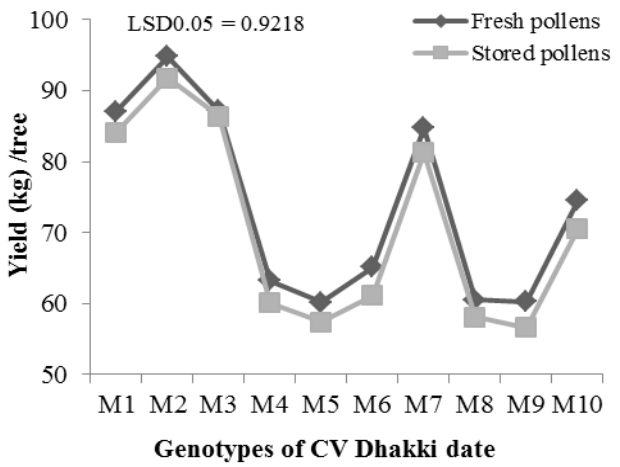

Fig. 4. Interactive effects of genotypes and pollens (fresh and stored) on fruit yield (kg/tree).

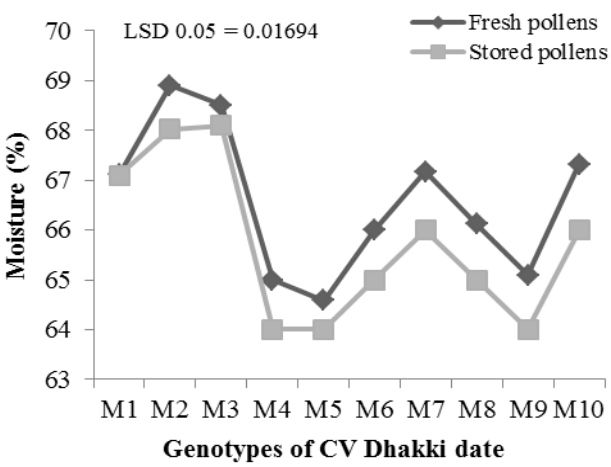

Fig. 5. Interactive effects of genotypes and pollens (fresh and stored) on moisture (%).

Conclusion

On the basis of higher fruit set, fruit yield, pollen viability and less dropping percentage, the local male (M2) fresh and stored pollens are recommended to be used for pollination in Dhakki date for enhanced yield and quality in D.I. Khan. On the other hand, M3-another local male (M3) produced higher fruit weight, fruit length, fruit width, moisture (%), total sugar contents, TSS, pollen viability, and matured earlier with lesser fruit dropping is recommeded for producing a quality date.

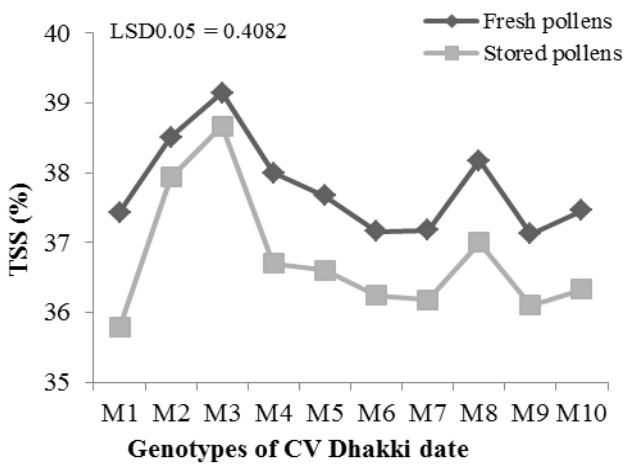

Fig. 6. Interactive effects of genotypes and pollens (fresh and stored) on TSS (%).

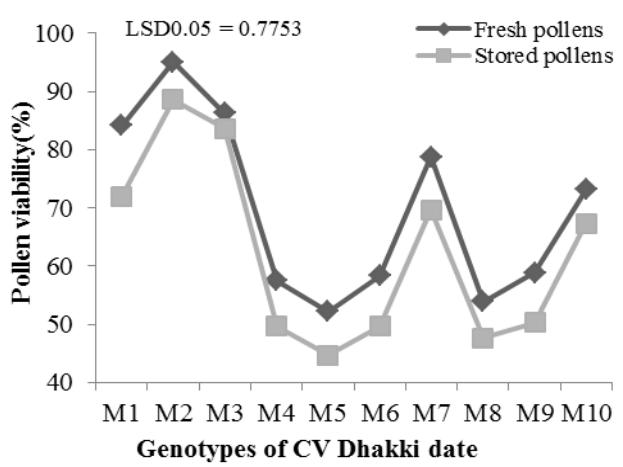

Fig. 7. Interactive effects of genotypes and pollens (Fresh and stored) on pollen viability (%).

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