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FRUIT YIELD AND QUALITY RESPONSE OF DATE PALM CULTIVAR KHALAS TO FEMALE INFLORESCENCE RECEPTIVITY VARIED BY POLLINATION DAYS

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Abstract

This study was conducted on date palm cv. Khalas grown at Date Palm Research Center of Excellence, King Faisal University, Al-Ahsa, Kingdom of Saudi Arabia to determine the duration of female inflorescence receptivity at its cracking time and onwards to obtain optimum fruit set, yield and fruit quality. Twenty-seven uniform twelve-year-old female trees were chosen for the study, in which five spathes on each palm were selected. Female spathes were pollinated at different times *i.e.* (T_1) on the day of spathe cracking, (T_2) one day, (T_3) two days, (T_4) three days, (T_5) four days, (T_6) five days, (T_7) six days, (T_8) seven days and (T_9) eight days after female spathe cracking. The experiment was laid out on Randomized Complete Block Design with three replicates in each treatment. The findings of the study showed significant differences among different pollination days regarding fruit set percentage, parthenocarpic fruit percentage, biser fruit percentage, tamar fruit percentage, fruit drop percentage, bunch weight, yield per palm fruit fresh weight, fruit length, fruit width, fruit volume, pulp weight, pulp ratio, seed ratio and pulp : seed ratio, seed width and total soluble solids. Pollination after one to six days after spathe cracking increased fruit set percentage, tamar fruit percentage, bunch weight, fruit size, pulp weight, pulp:seed ratio and total soluble solids. Therefore, it can be concluded that the date palm cv. Khalas should be pollinated between one to six days after female spathe cracking without the expense of fruit yield and quality.

***Key words*:** Date palm, *Phoenix dactylifera*, Pollination Days, Fruit Yield and Quality.

Introduction

Pollination is the transfer of pollen grains from male anther to the female stigma, which normally precedes fertilization. Agricultural crops are either self or cross-pollinated depending on the arrangement of their floral parts. About 75% crop species rely on biotic pollination and about one-third benefit from cross-pollination by producing higher fruit quantity and quality (Aizen *et al*., 2009). The pollination process has been coordinated and perfected over the times as plants coevolved with insects in same habitats, where the insects act as pollinators or pollination agents (Muchhala *et al*., 2008). When a pollen grain settled down on a stigma, it started to germinate pollen tube. The initiation of pollen tube is precisely guided by female signals (Higashiyama and Takeuchi, 2015) and several female-secreted peptides are identified that specifically control the direction of pollen tube growth (Okuda *et al*., 2009 and Takeuchi and Higashiyama, 2012). The success of pollination process not only depends on the duration of stigma receptivity but it also depends on the environmental factors (Zaid and de Wet, 2002). Once pollen grains are discharged from anthers they become independent functional units and are subjected to the ambient environment and are more severely affected by the environmental factors than the ovules (Kakani *et al*., 2005).

Date palm (*Phoenix dactylifera* L.) is naturally a dioecious tree, the male and female flowers are borne on separate palms. It is anemophilous if left on natural cross-pollination, which reduces the fruit set and yield (Tengberg, 2012). Therefore, artificial cross-pollination is essential

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for the date palm production chain that improves fruit yield and quality and regulates annual tree bearing (Zaid and de Wet, 2002). Different artificial pollination methods have been adopted in commercial date palm plantations such as male pollen strands placement, manual or mechanical dusting and liquid pollination (Zaid and de Wet, 2002; Hajian, 2005 and Munir, 2019). It is carried out after cracking of the female spathe, which if delayed not only affect stigma receptivity but also decrease the yield by up to 70 percent (Damas, 1998 and Marzouk *et al*., 2002). The receptivity time of stigma varied from cultivar to cultivar, that is from twenty-four hours (Nasir *et al*., 1994) to more than twenty days (Rahim, 1975). Despite that, the duration receptivity of same cultivars can be varied in the following years such as date palm cvs. Sabbaka and Roushodia set highest fruits when pollinated after fourth day of spathe cracking in the first year whereas the stigma of same cultivars was receptive for only two days in the next year (Attalla *et al*., 1998). The stigma of date palm has a limited time of pollen receptivity (Ream and Furr, 1969), which is three to four days in some cultivars (Albert, 1930). In *cv*. Zaidi, the pollination practice can be done within five days after spathe opening however it can be delayed up to twenty days in cvs. Barban and Khudrawi (Rahim, 1975). In *cv.* Khalas, four days after spathe opening was reported as the best pollination time (Dowson, 1982) however, Hussain *et al*., (1984) suggested that two to four days are ideal for the same cultivar. Similarly, it was suggested that *cv.* Dhakki should be pollinated within four days after spathe cracking (Iqbal *et al*., 2004). On the other hand, they observed that pollination done on the first day of spathe splitting set more fruits and increased yield in *cv*. Gulistan however the delayed pollination time improved the fruit quality but decreased yield and increased fruit drop (Iqbal *et al*., 2017). Keeping in view the significance of the duration of female flower buds receptivity, present study was designed to reveal the most appropriate pollination days after spathe cracking of date palm *cv*. Khalas and its effect on fruit set, yield and physicochemical characteristics under the climatic condition of Al-Ahsa, Saudi Arabia.

Materials and methods

The experiment was done at the Research and Training Station, King Faisal University, Al-Ahsa, Kingdom of Saudi Arabia during 2018 and 2019 (Latitude 25° 16' 7.068" N and Longitude 49° 42' 27.522" E). Male spathes were collected from twelve-year-old palms to obtained pollen grains for pollination. Sharp bird's beak knife was used to remove the protective sheath of male spathes which were placed on Kraft brown paper sheet at ambient room temperature. After 24 hours, pollen grains were collected by shaking the strands of the spathes, were dried in glass desiccator jar (Fisher Scientific, UK) and were kept in a refrigerator at 4ºC. The pollen grains powder was mixed with plain flour (1:9) and dusted onto female spathe at 11am with soft cotton balls (Johnson and Johnson, UAE) at below time intervals:

T_1- Pollination on the day of female spathe cracking

T_2- Pollination one day after female spathe cracking

T_3- Pollination two days after female spathe cracking

T_4- Pollination three days after female spathe cracking

T_5- Pollination four days after female spathe cracking

T_6- Pollination five days after female spathe cracking

T_7- Pollination six days after female spathe cracking

T_8- Pollination seven days after female spathe cracking

T_9- Pollination eight days after female spathe cracking

Twenty-seven uniform female date palm *cv*. Khalas trees of twelve-year-old were chosen for the experiment, in which five spathes on each palm were selected and the rest were removed. The experiment was laid out on Randomized Complete Block Design with three replicates in each treatment. Kraft brown wax paper bags were used to cover the pollinated spathes to avoid any contamination, which were removed 15 days after pollination (after fruit setting). Each fruit bunch was covered with knitted polyethylene mesh bags (90×80cm) for the protection from birds and insects around mid-summer. HOBO U12-012 data logger (Onset Computer Corporation, USA) was installed in the experimental orchard to record microclimatic data after every 5 minutes. The climatic data was also recorded using on-farm wireless weather station, Model WS3083 (Aercus Instruments, West Yorkshire, UK), installed around 25 meters away from the experimental orchard (Table 1). The weather data was cross-checked with the local weather station. All the standard cultural practices were carried out uniformly. The data were recorded on the following variables: fruit set percentage, parthenocarpic fruit percentage, biser fruit percentage, tamar fruit percentage, fruit drop percentage, bunch weight, yield per palm, fruit fresh weight, fruit length, fruit width, fruit volume, pulp weight, pulp ratio, seed ratio, pulp:seed ratio, seed weight, seed length, seed width, fruit moisture content, total soluble solids, total sugar, reducing sugar, non-reducing sugar, titratable acidity and total soluble solids:titratable acidity ratio according to AOAC standard methods (AOAC, 2016). The collected data were statistically analysed according to Gomez and Gomez (1984), using Statistical Analysis Software, Release 9.4

Table 1: Climatic information of the research site during experimental years 2018-19.

Growing season	2018-19 Temperature (°C)						Relative humidity (%)		Wind speed (km/h)		Precipitation (mm)	
	Maximum		Minimum		Average							
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
March	34	37	17	9	25	21	29	38	14	11	0.00	0.00
April	35	40	21	15	28	26	32	37	18	12	2.15	0.00
May	40	47	24	21	32	34	22	21	15	9	0.84	0.00
June	45	49	30	26	38	38	13	14	20	10	0.00	0.00
July	46	48	31	28	39	38	14	16	21	11	0.00	0.00
August	46	48	29	26	38	38	17	18	18	9	0.00	0.00
September	44	47	27	24	35	35	33	25	11	8	0.00	0.00

Maximum and minimum temperatures, relative humidity, wind speed and precipitation in each cell represent the average values of year 2018 and 2019.

(SAS Institute, North Carolina, USA) and the Duncan Multiple Range Test was applied to determine the least significance difference between the means (Waller and Duncan, 1969).

Results and Discussion

Data in table 2 showed a statistically significant ($P \leq 0.05$) effect of different pollination days on the fruit set percentage, parthenocarpic (unfertilized or shees) fruit percentage, biser (unripe) fruit percentage, tamar (ripe) fruit percentage, fruit drop percentage, bunch weight and yield per palm of date palm *cv.* Khalas. Highest fruit set was recorded when the pollination practice was carried out one day to six days after female spathe cracking *i.e.* 86.65% (T_7), 86.28% (T_4), 85.94% (T_2), 85.48% (T_6), 85.20% (T_5) and 84.43% (T_3) and there was no statistical difference between them. Lowest fruit set was counted in T_1 (71.78%) and T_9 (72.62%) as both were statistically alike. The increase in the percentage of fruit set occurred by earlier pollination dates may be due to that the female ovary was mature and receptive to facilitate pollen grain to germinate, elongate and penetrate the stigma and style of the female flower resulting in better fertilization and fruit set (Ahmed *et al*., 2013). Similarly, higher fruit set was counted when the cv. Dhakki was pollinated after 1-2 days of spathe opening (Iqbal *et al*., 2004) whereas it was higher when the cv. Gulistan was pollinated on the day of spathe opening (Iqbal *et al*., 2017), which declined after the passage of time in both studies. However, the delaying pollination after female spathes cracking of date palm *cv.* Najda (Zirari, 2010) and *cv*. Rothana (Ahmed *et al*., 2013) reduced the percentage of fruit set.

Data regarding parthenocarpic fruit percentage indicated that the female bunches pollinated on the day of female spathe cracking (T_1) had maximum percentage of parthenocarpic fruits (14.90%) whereas bunches pollinated after three days of spathe cracking (T_4) produced significantly lower number of parthenocarpic fruits (7.50%) followed by T_6 (7.91%) pollination day. There are many reasons for parthenocarpic fruit development such as male or female incompatibility (Zaid and de Wet, 2002), environmental factors (Pandolfini *et al*., 2018), hormonal deregulation (Jacobsen and

Table 2: Effects of different pollination days on fruit set percentage, parthenocarpic fruits percentage, biser fruits percentage, tamar fruits percentage, fruit drop percentage, bunch weight and yield per palm of date palm *cv.* Khalas.

Treatments	Fruit set(%)	Parthenocarpic fruits (%)	Biser fruits (%)	Tamar fruits (%)	Fruit drop (%)	Bunch weight (kg)	Yield per palm (kg)
T_1	71.78^{c}(±2.29)	14.90^{a}(±1.13)	11.40^{a}(±0.48)	65.37^{c}(±1.73)	35.09^{a}(±4.56)	5.41^{b}(±0.01)	27.06^{b}(±0.05)
T_2	85.94^{a}(±1.70)	9.94^{bd}(±0.25)	5.26^{b}(±0.49)	78.13^{a}(±3.11)	14.06^{cd}(±1.70)	7.49^{a}(±0.13)	37.47^{a}(±0.65)
T_3	84.43^{a}(±1.18)	8.54^{df}(±0.34)	4.41^{b}(±0.33)	77.05^{a}(±0.57)	15.57^{cd}(±1.18)	7.36^{a}(±0.19)	36.80^{a}(±0.96)
T_4	86.28^{a}(±3.04)	7.50^{f}(±0.45)	4.61^{b}(±0.17)	81.22^{a}(±3.88)	13.72^{d}(±3.04)	7.46^{a}(±0.50)	37.29^{a}(±2.51)
T_5	85.20^{a}(±0.30)	8.58^{df}(±0.30)	4.46^{b}(±0.28)	80.29^{a}(±3.23)	14.80^{cd}(±0.30)	7.79^{a}(±0.71)	38.97^{a}(±3.56)
T_6	85.48^{a}(±1.15)	7.91^{ef}(±0.46)	4.77^{b}(±0.08)	80.65^{a}(±2.88)	14.52^{cd}(±1.15)	7.83^{a}(±0.42)	39.16^{a}(±2.11)
T_7	86.65^{a}(±1.49)	9.69^{ce}(±0.35)	4.29^{b}(±0.11)	80.03^{a}(±3.25)	13.35^{d}(±1.49)	7.04^{a}(±1.25)	35.18^{ab}(±6.27)
T_8	79.91^{b}(±1.18)	11.58^{b}(±0.72)	11.05^{a}(±1.43)	74.37^{ab}(±3.72)	20.09^{c}(±1.18)	5.69^{b}(±0.23)	28.46^{b}(±1.14)
T_9	72.62^{c}(±0.97)	11.07^{bc}(±0.56)	10.46^{a}(±1.16)	66.46^{bc}(±0.97)	27.38^{b}(±3.40)	5.53^{b}(±0.29)	27.66^{b}(±1.46)
LSD$_{(5\%)}$	5.05*	1.81*	2.07*	8.45*	6.18*	1.67*	8.33*

Similar letter(s) in a column are non-significant statistically at 5% level of probability. Figures in parentheses represent the variability within replicates. * Represents the significant statistical difference between the means of each treatment.

Table 3: Effects of different pollination days on physical characteristics of fruit of date palm *cv.* Khalas.

Treat-ments	Physical Traits of Fruit				Pulp weight (g)	Pulp ratio	Seed ratio	Pulp: Seed Ratio	Physical Traits of Seed		
	Fresh weight (g)	Length (mm)	Width (mm)	Volume (ml)					Weight (g)	Length (mm)	Width (mm)
T_1	7.68^{cd} (±0.25)	31.13^{e} (±0.37)	20.26^{c} (±0.38)	8.59^{e} (±0.13)	6.81^{cd} (±0.28)	88.58^{cd} (±0.71)	11.42^{ab} (±0.71)	7.83^{cd} (±0.57)	0.87^{a} (±0.03)	19.21^{a} (±0.41)	7.38^{b} (±0.15)
T_2	9.02^{ac} (±0.22)	33.35^{cd} (±0.17)	22.90^{a} (±0.13)	9.70^{cd} (±0.13)	8.16^{ac} (±0.24)	90.43^{ac} (±0.39)	9.57^{bd} (±0.39)	9.49^{ac} (±0.42)	0.86^{a} (±0.01)	19.41^{a} (±0.62)	7.61^{ab} (±0.02)
T_3	10.11^{a} (±0.49)	35.14^{ab} (±0.43)	23.59^{a} (±0.61)	10.19^{ac} (±0.21)	9.26^{a} (±0.48)	91.60^{a} (±0.29)	8.40^{d} (±0.29)	10.93^{a} (±0.41)	0.85^{a} (±0.02)	19.59^{a} (±0.48)	7.50^{ab} (±0.11)
T_4	9.55^{ab} (±0.74)	34.57^{bc} (±0.40)	23.11^{a} (±0.21)	10.37^{ab} (±0.30)	8.69^{ab} (±0.74)	90.85^{ab} (±0.82)	9.15^{cd} (±0.82)	10.10^{ab} (±0.99)	0.86^{a} (±0.03)	19.90^{a} (±0.37)	7.52^{ab} (±0.04)
T_5	9.55^{ab} (±0.91)	35.98^{a} (±0.33)	23.72^{a} (±0.29)	10.09^{ac} (±0.15)	8.69^{ab} (±0.90)	90.77^{ab} (±0.80)	9.23^{cd} (±0.80)	10.00^{ab} (±0.99)	0.87^{a} (±0.03)	19.51^{a} (±0.36)	7.71^{ab} (±0.08)
T_6	8.97^{ac} (±0.11)	34.50^{bc} (±0.46)	23.31^{a} (±0.69)	10.69^{a} (±0.10)	8.12^{ac} (±0.11)	90.52^{ac} (±0.09)	9.48^{bd} (±0.09)	9.56^{ac} (±0.10)	0.85^{a} (±0.01)	19.64^{a} (±0.52)	7.92^{a} (±0.14)
T_7	8.77^{ad} (±0.88)	34.51^{bc} (±0.49)	22.54^{ab} (±0.32)	9.91^{bc} (±0.10)	7.91^{ad} (±0.88)	90.01^{ad} (±1.12)	9.99^{ad} (±1.12)	9.24^{ad} (±1.03)	0.86^{a} (±0.01)	19.41^{a} (±0.24)	7.60^{ab} (±0.12)
T_8	7.24^{d} (±0.16)	32.62^{d} (±0.65)	21.50^{bc} (±0.36)	9.17^{de} (±0.33)	6.38^{d} (±0.18)	88.15^{d} (±0.48)	11.85^{a} (±0.48)	7.46^{d} (±0.35)	0.86^{a} (±0.02)	19.47^{a} (±0.44)	7.57^{ab} (±0.26)
T_9	7.91^{bd} (±0.17)	32.62^{d} (±0.65)	20.84^{c} (±0.52)	9.05^{e} (±0.41)	7.06^{bd} (±0.17)	89.24^{bd} (±0.31)	10.76^{ac} (±0.31)	8.31^{bd} (±0.27)	0.85^{a} (±0.02)	19.51^{a} (±0.55)	7.28^{b} (±0.23)
LSD$_{(5\%)}$	1.65*	1.33*	1.26*	0.65*	1.65*	1.99*	1.99*	2.03*	0.63^{NS}	1.41^{NS}	0.43*

Similar letter(s) in a column are non-significant statistically at 5% level of probability. Figures in parentheses represent the variability within replicates. * Represents the significant statistical difference between the means of each treatment whereas NS indicates the non-significant statistical difference.

Olszewski, 1993), delay or rapid growth of ovary due to the changes in regulation of gibberellin (Smith and Koltunow, 1999) and low (8-20°C) temperatures (Cohen *et al*., 2016). In present study, fruit bunches pollinated on the day of cracking or delayed it up to 7-8 days produced maximum percentage of parthenocarpic fruits that could be due to the delay or rapid ovary growth due to gibberellin regulation (Smith and Koltunow, 1999). Our results are in line with Mohammadi *et al*., (2017) who stated that the delaying in pollination time increased parthenocarpic fruits in different date palm cultivars.

Biser fruit percentage was as lowest when the pollination was done one day to six days after female spathe cracking i.e. 5.26% (T_2), 4.77% (T_6), 4.61% (T_4), 4.46% (T_5), 4.41% (T_3) and 4.29% (T_7) and there was no statistical difference between them. However, it was higher in T_1 (11.40%), T_8 (11.05%) and T_9 (10.46%), which were non-significant to each other. The trend reported in biser fruit is similar to parthenocarpic fruit, as fruit spathes pollinated on the day of cracking or delayed it up to 7-8 days produced maximum percentage of biser fruits that could be due to the internal biochemical changes, which prevented fruits to ripe. It is also affected by low ethylene synthesis, respiration rate and external temperature and inappropriate relative humidity during fruit development phases (Abbas and Ibrahim, 1996, 1998 and Awad, 2007).

Highest tamar fruit percentage was observed when the pollination was performed one day to six days after female spathe cracking *i.e.* 78.13% (T_2), 81.22% (T_4), 80.65% (T_6), 80.29% (T_5), 80.03% (T_7) and 77.05% (T_3) and these were statistically at par. However, it was lowest in T_1 (65.37%) followed by T_9 (66.46%) treatment. The ripening processes of climacteric natured date fruit are associated with a concurrent increase in the internal ethylene concentration and higher rate of respiration (Abbas and Ibrahim, 1996, 1998; Yang, 1980; Klee and Clark, 2002 and Awad, 2007) and are used as benchmarks in determining the fruit ripening. However, a few reports described the absence or reduced peak in respiration when fruits are ripened on the tree, despite a distinct rise in ethylene concentration (Saltveit, 1993 and Bower *et al*., 2002). Our results suggested that the reason of high percentage of ripened fruits (tamar fruit) when the bunches were pollinated one to six days after spathe cracking could be due to the role of matured receptive ovary cells. The matured ovary received pollen grains at an appropriate time and completed all the fruit developmental phases accordingly, which triggered the higher ethylene synthesis and rate of respiration.

Table 4: Effects of different pollination days on chemical characteristics of fruit of date palm *cv.* Khalas.

Treatments	Moisture content (%)	Total soluble solids (brix)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Titratable acidity (%)	TSS: TA ratio
T_1	18.54^{a}(±0.34)	71.95^{a}(±0.88)	57.07^{a}(±1.79)	55.01^{a}(±1.77)	2.07^{a}(±0.26)	0.19^{a}(±0.006)	380^{a}(±15.11)
T_2	18.14^{a}(±0.22)	71.31^{ab}(±0.86)	58.65^{a}(±0.65)	56.61^{a}(±1.06)	2.01^{a}(±0.55)	0.18^{a}(±0.007)	390^{a}(±10.19)
T_3	18.54^{a}(±0.34)	71.47^{ab}(±1.46)	58.40^{a}(±0.32)	56.25^{a}(±0.66)	2.15^{a}(±0.46)	0.18^{a}(±0.009)	407^{a}(±25.48)
T_4	18.14^{a}(±0.22)	70.80^{ab}(±0.78)	57.40^{a}(±1.02)	55.40^{a}(±0.89)	2.11^{a}(±0.16)	0.18^{a}(±0.003)	401^{a}(±12.01)
T_5	18.21^{a}(±0.66)	70.28^{ab}(±0.91)	57.22^{a}(±1.72)	54.81^{a}(±1.74)	2.41^{a}(±0.16)	0.17^{a}(±0.009)	408^{a}(±22.22)
T_6	18.26^{a}(±0.23)	71.28^{ab}(±0.89)	59.50^{a}(±0.79)	56.63^{a}(±0.94)	2.87^{a}(±0.23)	0.19^{a}(±0.007)	383^{a}(±17.69)
T_7	18.57^{a}(±0.30)	68.47^{bc}(±1.64)	57.07^{a}(±0.37)	54.92^{a}(±0.63)	2.15^{a}(±0.46)	0.18^{a}(±0.009)	376^{a}(±25.33)
T_8	18.54^{a}(±0.88)	66.47^{c}(±1.06)	56.73^{a}(±1.03)	54.73^{a}(±0.87)	2.00^{a}(±0.43)	0.19^{a}(±0.009)	357^{a}(±13.30)
T_9	18.60^{a}(±0.66)	68.14^{bc}(±1.45)	57.40^{a}(±1.03)	55.14^{a}(±1.15)	2.26^{a}(±0.48)	0.18^{a}(±0.006)	380^{a}(±19.34)
$LSD_{(5\%)}$	1.533^{NS}	3.449*	3.155^{NS}	3.161^{NS}	1.098^{NS}	0.022^{NS}	58.70^{NS}

Similar letter(s) in a column are non-significant statistically at 5% level of probability. Figures in parentheses represent the variability within replicates. * Represents the significant statistical difference between the means of each treatment whereas NS indicates the non-significant statistical difference.

Fruit drop percentage was minimum (13.35 and 13.72%) when female bunches were pollinated after six (T_7) and three (T_4) days of spathe cracking, respectively followed by T_2 (14.06%), T_6 (14.52%), T_5 (14.80%) and T_3 (15.57%) treatments whereas it was maximum (35.09%) in T_1 treatment. The large fruit size and shorter internodes space could be the factors playing role in the higher percentage of fruit drop (Shafique *et al*., 2011). Mohammadi *et al*., (2017) reported that pollination carried out on the day of spathe cracking produced higher percentage of fruit drop, which are similar to present results. However, the delaying in pollination days increased fruit drop in cvs. Dhakki (Iqbal *et al*., 2004) and Begum Jangi (Ahmed *et al*., 2015), which were also observed in present study when female spathes were pollinated after 7-8 days of opening.

The trend observed for bunch weight showed that it was maximum when the pollination carried out one day to six days after female spathe cracking *i.e*. 7.83 kg (T_6), 7.79 kg (T_5), 7.49 kg (T_2), 7.46 kg (T_4), 7.36 kg (T_3) and 7.04 kg (T_7) which were non-significant statistically. It was minimum in T_1 (5.41 kg), T_9 (5.53 kg) and T_8 (5.89 kg) treatments and were at par. Similar trend was noted regarding yield per palm parameter that was maximum when the pollination carried out one day to six days after female spathe cracking *i.e*. 39.16 kg (T_6), 38.97 kg (T_5), 37.47 kg (T_2), 37.29 kg (T_4) and 36.80 kg (T_3) which were non-significant statistically. However, it was minimum in T_1 (27.06 kg), T_9 (27.66 kg) and T_8 (28.46 kg) treatments and behaved alike. Similar results were found by Iqbal *et al*., (2004, 2017) in *cvs.* Dhakki and Gulistan, Ahmed *et al*., (2013) in *cv*. Rothana, Ahmed *et al*., (2015) in *cv*. Begum Jangi, Ahmed *et al*. (2016) in *cv.* Saidy and Mohammadi *et al*., (2017) in *cv.* Barhee, when delaying pollination time decreased bunch weight and yield per palm. These results may be due to the poor initial fruit set as a result of delaying pollination. However, the length of time during which the female floral buds of date palm remained receptive varied with the cultivar, temperature and humidity during flowering period.

Table 3 indicated that the effect of different pollination days was statistically significant ($P \leq 0.05$) regarding fruit fresh weight, fruit length, fruit width, fruit volume, pulp weight, pulp ratio, seed ratio and pulp:seed ratio and seed width of date palm *cv.* Khalas. However, there was non-significant effect of pollination days on seed weight and seed length. Maximum fruit fresh weight (10.11 g) was recorded in T_3 followed by T_4 and T_5 (9.55 g), T_2 (9.02 g), T_6 (8.97 g) and T_7 (8.77 g) whereas it was minimum (7.24 g) in T_8. Similarly, fruit length was maximum (35.98 mm) in T_5 followed by T_3 (35.14 mm) while it was minimum in T_1 (31.13 mm). Similarly, maximum fruit width (23.72 mm) was observed in T_5 followed by T_3 (23.59 mm), T_6 (23.31 mm), T_4 (23.11 mm) and T_2 (22.90 mm), which were statistically behaved alike whereas it was minimum in T_1 (20.26 mm) and T_9 (20.84 mm). Fruit volume was maximum in T_6 (10.69 ml) followed by T_4 (10.37 ml), T_3 (10.19 ml) and T_5 (10.09 ml) while it was minimum in T_1 (8.59 ml) and T_9 (9.05 ml). Delaying pollination up to 6-10 days increased fruit weight, length and width in *cv.* Saidy (Ahmed *et al*., 2016) whereas higher fruit weight and size recorded in *cv*. Dhakki when pollens applied up to 8 days after spathe opening (Iqbal *et al*., 2004) and in *cv*. Gulistan it was 9-12 days after spathe opening (Iqbal *et al*., 2017). Ahmed *et al*., (2015) obtained similar results in *cv*. Begum Jangi. In contrast, Shafique *et al*., (2011) reported that the different pollination days did not affect the physical characteristics of fruit of *cv*. Dhakki. In present study, pollination of 1-5 days after spathe cracking displayed the best results

therefore the difference between these studies could be due to the difference in cultivars and the effects of xenia and metaxenia of pollen source. Ahmed *et al*., (2013) observed a linear increase in fruit volume of cv. Rothana by delaying pollination up to six days, which are in agreement with our findings.

Data regarding pulp weight (9.26 g), pulp ratio (91.60) and pulp:seed ratio (10.93) were maximum when pollens were applied after two days of spathe cracking (T_3) followed by T_2, T_4, T_5, T_6 and T_7 which exhibited more or less similar results regarding the aforementioned variables. These parameters were minimum in T_8 *i.e*. 6.38 g (pulp weight), 88.15 (pulp ratio) and 7.46 (pulp:seed ratio). However, seed ratio was higher in T_8 (11.85) followed by T_1 (11.42) and T_9 (10.76) whereas it was minimum (8.40) when pollination was carried out after two days of spathe cracking (T_3). Iqbal *et al*., (2004) reported that pulp weight of *cv.* Dhakki decreased by delaying pollination time however an opposite trend was observed in *cv*. Gulistan *i.e.* delaying pollination time increased pulp weight (Iqbal *et al*., 2017). In *cv*. Rothana, a linear increase in flesh weight was reported by delaying pollination (Ahmed *et al*., 2013), which coincide with our results. Similarly, Mohammadi *et al*., (2017) reported that delaying pollination time by two days enhanced pulp:seed ratio in *cv*. Barhee, which was a pollinizer dependent response.

Data regarding seed weight and seed length are non-significant statistically, however, seed weight was maximum in T_1 and T_5 (0.87 g) while seed length was maximum in T_4 (19.90 mm). The seed width was significantly decreased in T_9 (7.28 mm) followed by T_1 (7.38 mm) while it was increased in T_6 (7.92 mm) followed by T_5 (7.71 mm), T_2 (7.61 mm), T_7 (7.60 mm), T_4 (7.52 mm) and T_3 (7.50 mm). Similar results were reported by Ahmed *et al*., (2013) in *cv.* Rothana where different pollination time did not affect seed weight. In contrast, Mohammadi *et al*., (2017) obtained significant variation in seed weight and length in *cv.* Barhee, which could be due to the effects of xenia as it was pollinated by five varied pollinizers (Beraim, Zahidi, Shahani, Fard No. 4 and Jarvis No. 1) and each one was applied at two different pollination times (day of spathe opening and two days after spathe opening).

Chemical analysis of the tamar fruits of date palm cv. Khalas revealed that apart from total soluble solids all other parameters (fruit moisture content, total sugar, reducing sugar, non-reducing sugar, titratable acidity and total soluble solids : titratable acidity ratio) were non-significant statistically (Table 4). Fruit moisture content was oscillated between 18.14% (T_2 and T_4) and 18.60% (T_9). Maximum total soluble solids were estimated in T_1 (71.95 brix) followed by T_3 (71.47 brix), T_2 (71.31 brix), T_6 (71.28 brix), T_4 (70.80 brix) and T_5 (70.28 brix) while it was minimum in T_8 (66.47 brix). However, total sugar (59.50%), reducing sugar (56.63%) and non-reducing sugar (2.87%) were higher in T_6 whereas these parameters were lowest in T_8 (56.73%, 54.73% and 2.00%, respectively). Titratable acidity was ranged from 0.17% (T_5) to 0.19% (T_1, T_6 and T_8) whereas total soluble solids:titratable acidity ratio was higher in T_5 (408) followed by T_3 (407) and T_4 (401) and it was lower (357) in T_8. The TSS:TA ratio determines the taste of the fruit. Higher the TSS:TA ratio of the fruit more will be the sweetness. Similar results were reported in cv. Rothana (Ahmed *et al*., 2013) and *cv.* Saidy (Ahmed *et al*., 2016) where delaying pollination time linearly increased TSS. In present study, the non-significant effect of different pollination days on total sugar, reducing sugar, non-reducing sugar and acidity is due the use of same pollinizer. Shafique *et al*., (2011) stated that the significant difference in sugar contents is due to the effects of pollinizer. They also obtained a significantly higher TSS:TA ratio when *cv.* Dhakki pollinated twice, which could be due to the tree age, male female compatibility and exposure of the fruit to sun light. Our non-significant results of titratable acidity are coincide with Mohammadi *et al*., (2017) who reported that it was not affected by pollination times rather it was the pollinizers.

Conclusion

The findings of this study revealed that different pollination days have significant effects on various fruit yield and its components of date palm *cv*. Khalas. Date palm trees pollinated after one to six days after spathe cracking increased fruit set percentage, tamar fruit percentage, bunch weight, fruit size, pulp weight, pulp:seed ratio and total soluble solids. Therefore, it can be concluded that the date palm *cv.* Khalas should be pollinated between one to six days after female spathe cracking without a significant decline in fruit yield and quality. Further studies are needed to investigate the effects of different pollinizers, pollen germination in relation to temperatures and the various biochemical processes involved in date palm fruit quality after post pollination scenario.

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