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Fruit Characteristics of "Zaghloul" Date Palm in Relation to Metaxenic Influences of Used Pollinator

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Abstract: Field experiment of this investigation was carried out on date palm (*Phoenix dactylifera* L.) Zaghloul cultivar growing in Edco district, El-Behera Governorate, Egypt during the two successive seasons 2007 and 2008. Two previously studied pollinators were used in this study, named here (A) and (B). The experiment was designed as randomized complete blocks with four replicates (each spathe as one replicate) in addition to the control (non-pollinated spathe). Furthermore, Physical and chemical characteristics of the pollinated fruits and non-pollinated ones were assessed. Regardless the time, results proved that pollinator (A) caused a significant increase in fruit weight, flesh weight, rag weight, fruit size, total soluble solids, reducing and non-reducing sugars, anthocyanin, vitamin C content, crude fibers content and a significant decrease in chlorophyll a, b contents as compared with pollinator (B). Meanwhile, pollinated spathes had remarkably greater fruit weight, flesh weight, rag weight, fruit size, total, reducing and non-reducing sugars, anthocyanin content, vitamin C and higher crude fibers content as compared with the non-pollinated spathes. As the fruit progressed from the kimri to the khalal stage, there was a continuously significant increase in fruit weight, flesh weight, rag weight, fruit size, TSS, total sugars, reducing, non-reducing sugars and crude fibers from one sampling date to another until harvest. Non-pollinated spathes had significantly greater tannin contents, higher acidity and higher chlorophyll a, b contents in their fruits as compared with those on pollinated spathes. However, either pollinator (A) or (B) did not make a significant difference in tannins and acidity content of fruits on pollinated spathes. The time factor data indicated that there was a significant decrease in tannin content, titratable acidity and chlorophyll a, b contents in the fruit until the period preceding maturity (after 186 days of pollination).The time factor data indicated that there were different trends for both vitamin C and anthocyanin increments between the two seasons since in the first one, vitamin C and anthocyanin ceased to increase after 174 and 186 days of pollination, respectively, while in the second season, this vitamin and anthocyanin continued to increase in a significant manner until harvest. In conclusion pollinators have their metazenic effects especially on fruit weight, size and flesh weight and pollinator (A) was superior to pollinator (B) in this regard.

Key words: Date palm (*Phoenix dactylifera* L.) · Pollination · Metaxenic effects · Physical and chemical characteristics

INTRODUCTION

Artificial pollination of date palm spathes is one of the major practices that are necessary for successful fruiting. It has been documented and reported that there is a direct effect for the type of pollens on some fruit characteristics outside the embryo and the endosperm. Such effect is known as the metaxenia. The metaxenia effects were reported on fruit size by Swingle [1], El-Ghayaty [2], Abdelal *et al*. [3] and Shaheen *et al.* [4], on fruit color and the time of ripening by Al-Delamiy and Ali [5], on fruit and seed weight by El-Ghayaty[2] and Abdelah *et al*. [3],Al-Hamoudi *et al.* [6] and Abd El-Zaher [7] on TSS by Al-Hamoudi *et al.* [6]. Many researchers

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reached to the conclusion that there is a direct effect for the used male parent on date palm qualities even the flavor or aroma of the fruit [8]. It has been reported that the metaxenic influence on accelerating fruit maturity was considerable in the marginal areas since in arid regions high temperature was the dominant factor influencing the time of fruit maturity and ripening [9]. The interest in the metaxenic effects was extended to study such possibility on the mineral contents of the fruit [4]. Even accelerating the time of ripening is very important in some areas that have been threatened by frost or rain or even the relatively short period of warm temperature during the season of date palm growth and development. The increasing demand to the organic production systems of main fruit crops including date palm emphasizes the need for more research on the metaxenic effects of used pollens and their explanations. Thus, the objectives of this study were to investigate the metaxenic effects of some date palm male pollens on physical and chemical properties of Zaghloul date palms (*Phoenix dactylifera* L.).

MATERIALS AND METHODS

This study was conducted during two successive seasons 2007 and 2008 on "Zaghloul" date palms (*Phoenix dactylifera* L.) of about 15years old grown in Edco district, El-Behera Governorate, Egypt. In both seasons, four uniform vigorous female palms were selected according to their bearing of the same number of female spathes. Regular agricultural practices were applied to all investigated palms. On each selected palm in both seasons, twelve female spathes of nearly equal size were chosen and labeled. Four of the twelve female spathes on each palm received pollens from one of the two male parents, that were selected from Balteem district, Kafr El-Sheikh Governorate and evaluated by Omar [10] designated as 14 and 19. Four female spathes for each palm were not pollinated (as pollinator's control). The experiment consisted of 3 treatments, where each treatment was replicated 4 times with 4 female spathes for each palm in a complete randomized design. Hand pollination was carried out by placing desired male pollen strands within female spathe. After pollination, all spathes were bagged, each in a large paper bag which was tied at the base of the spathe to prevent contamination from air or other surrounding pollinating treatments. Thereafter, the bags were removed out after two weeks following pollination.

Pollen Viability and Fruit Set Percentage: Pollen viability was tested using aceto-carmine staining technique. Moreover, the germination (%) of pollens that were collected from two males was determined. The hanging drop technique was utilized for culturing the pollen grains in Albert [11] media. The cultures were stored at 30°C temperature and data was recorded after 4 hrs. For each germination test, random readings (counts) of 100-200 grains from different microscopic fields on the slide were made. The average results of pollen germination were recorded for each male. Total number of retained fruits scars was counted and fruit set was determined as recommended by El-makhtoun [12]. Fruit set was calculated every two weeks (during May and June months) using the following equation:

$$\text{Fruit set (\%)} = \frac{\text{No. of retained fruits on the strand}}{\text{No. of retained fruits + No. of flowers scars on the same strand}} \times 100$$

Physical and Chemical Fruit Characteristics: Zaghloul fruit periodical samples were taken after 144, 175, 187 and 199 days following pollination in the two successive seasons. The samples of 40 fruits were picked randomly from each treatment (10 fruits per each replicate) per each tree in order to determine the following: Fruit weight (gm) and volume (cm^3) by using volume trice method. TSS (%) was determined by a hand refractometer in the juice extracted from ten fruits [13]. Total sugars of each fruit sample were extracted from 10 g ground fresh material using distilled water [14]. Reducing sugars content was determined by the method of Shaffar and Hartman [15]. Non-reducing sugars were calculated by difference between total sugars and reducing sugars. Samples of fruits were taken to determine tannins content as "gallactronic" acid [13]. Tannins content was determined using Indigo carmine indicator; titration was carried out using 0.1 N potassium permanganate solution. Tannins per 100 gm fresh weight of the flesh according to the following: 1ml oxalic acid (0.1N) =0.00416 g. Vitamin C content was determined by 2, 6-dichlorophenol indophenols blue dye according to A.O.A.C [13] and expressed as mg V.C /100 ml fruit juice. The acidity was colorimetrical based on estimated malic acid according to A.O.A.C [13]. The results of these titrations were converted to percent of malic acid (as the dominant organic acid in the fruit) using the following equation:

$$\text{Percent of titratable acidity} = \frac{\text{N. } N_aOH \text{ x ml. } N_aOH \text{ x } 0.067}{\text{ml. Juice used}}$$

Anthocyanin pigment was determined by taking 0.5 g fruit peel and anthocyanin was extracted by using 25 milliliters of ethanolic HCl (980 ml ethanol 95% + 20 ml concentrated HCl), the extract solution was filtered and the optical densities of the filtrates was measured by Spectrophotometer at 530 nm. Anthocyanin was expressed as mg/100 g fruit peel, according to Rabino *et al.* [16] with the following equation:

$$\text{Anthocyanin mg/100g fruit peel} = \frac{\text{100 x extraction solution volume x Optical density}}{\text{Sample weight x 98.2}}$$

Chlorophylls were determined by N, N-dimethylformamide according to Rami [17] according to the following equation:

$$\text{Chl a} = 12.92\ A664 - 2.12\ A647 - 3.85\ A603$$
$$\text{Chl b} = -4.93\ A664 + 26.09\ A647 - 12.79\ A603$$

Crude fiber content was determined according to the procedure described by the A.O.A.C [13] according to the following equations:

$$\text{Crude Fiber} = \frac{\text{100 x (W3- (W1 x C1)}}{\text{W2}}$$

Where: W1 =Bag tare weight, W2=Sample Weight, W3=Weight of organic matter (Loss of weight on ignition of bag and fiber), C1=Ash corrected blank bag factor (running average of loss of weight on Ignition of blank bag/original blank bag). Data were statistically analyzed according to two ways ANOVA. Comparisons among means were made via the least significant differences multiple range tests according to Snedecor and Cochran [18]. The data were analyzed using SAS (2000) program.

RESULTS AND DISCUSSION

The Initial Status of the Pollinators: Results in Tables 1 and 2 revealed that both pollinators (A) and (B) had remarkable viability that exceeded 97% while the germination test proved that they were similar in this aspect.

Viability test proved that both pollinators had superior vigor and their germination percentage did not vary but was almost identical (Tables 1 and 2). In a similar manner, fruits in spathes pollinated with different pollinators (A) & (B) had similar fruit set when compared in both seasons (Tables 3 and 4).

Table 1: The initial status of used pollinators (A and B) in terms of their percentages during 2007 season

Pollinator No	Viability % ±SD	Germination % ±SD
A	98.29±1.33	30.93±3.88
B	97.02 ±2.6	31.43±3.82

Table 2: The initial status of used pollinators (A and B) in terms of their percentages during 2008 season

Pollinator No	Viability % ±SD	Germination % ±SD
A	97.74±1.66	26.69±4.72
B	98.22 ±1.74	27.41±4.89

Table 3: Final fruit set (%) of Zaghloul date fruits as influenced by the used pollinators (A and B) during 2007 season

	Male	
Female	Pollinator (A)	Pollinator (B)
1	35.97±2.38	37.67±3.475
2	37.18±2.96	38.08±3.23
3	34.95±3.68	37.06±3.51
4	37.55±3.18	39.8±3.32

Table 4: Final fruit set (%) of Zaghloul date fruits as influenced by the used pollinators (A and B) during 2008 season

	Male	
Female	Pollinator (A)	Pollinator (B)
1	34.09±3.55	35.45±2.84
2	36.70±2.45	38.97±3.28
3	34.67±3.33	37.85±2.63
4	38.49±3.75	39.37±3.39

Physical Characteristics

Fruit Weight: Data presented in Table 5 revealed that fruit weight of "Zaghloul" date was significantly influenced by the type of used pollinator regardless the time, since pollinator (A) caused a significant increase in fruit weight as compared with pollinator (B) in both seasons. Meanwhile, pollinated spathes had remarkably greater fruit weight as compared with the non-pollinated spathes. As the fruit progressed from the kimri to the khalal stage, there was a continuous increase in fruit weight from one sampling date to another until harvest. With regard to the effect of the interaction between pollinator type and the time factor on fruit weight (Table 5). Data indicated that at each sampling date whether at the Kimri or Khalal stages, the two pollinators performed equally in terms of their influence on fruit weight during 2007 and 2008 seasons, except when using

Table 5: Fruit weight (gm) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	28.07 de	25.26 e	8.01 g	20.41 c
15 Sept 175 (DAP)	32.93 abc	30.14 cd	9.98 fg	24.35 b
27 Sept 187 (DAP)	33.58 ab	31.86 bc	11.27 f	25.57 ab
9 Oct 199 (DAP)	35.55 a	33.20 abc	11.88 f	26.88 a
Mean	32.51 a	30.12 b	10.28 c	--
		2008 season		
1 Sept 144 (DAP)	26.53 d	25.98 d	7.74 g	20.08 d
2 Oct 175 (DAP)	31.72 bc	30.21 c	9.22 fg	23.72 c
14 Oct 187 (DAP)	35.76 a	32.59 bc	11.09 ef	25.96 b
26 Oct 199 (DAP)	36.15 a	34.19 ab	13.41 e	28.44 a
Mean	32.15 a	31.13 b	10.36 c	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 6: Flesh weight (gm) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	23.97 d	21.01 d	7.19 f	17.39 c
15 Sept 175 (DAP)	30.41 abc	27.79 c	9.61e f	22.60 b
27 Sept 187 (DAP)	31.38 ab	29.21 bc	10.38e f	23.66 b
9 Oct 199 (DAP)	33.22 a	30.95 abc	11.56 e	25.24 a
Mean	29.75 a	27.24 b	9.68 c	--
		2008 season		
1 Sept 144 (DAP)	23.01 e	21.58 e	7.06 g	17.22 d
2 Oct 175 (DAP)	28.41 cd	26.97 d	7.01 g	20.79 c
14 Oct 187 (DAP)	33.26 ab	30.37 bc	9.81f g	24.04 b
26 Oct 199 (DAP)	33.97 a	31.94 ab	12.84 f	26.69 a
Mean	29.33 a	28.04 b	9.18 c	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 7: Rage weight (gm) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	1.84 b	2.09 a	0.085 c	1.34 b
15 Sept 175 (DAP)	2.10 a	2.22 a	0.10 c	1.47 a
27 Sept 187 (DAP)	2.12 a	2.24 a	0.10 c	1.49 a
9 Oct 199 (DAP)	2.19 a	2.18 a	0.17 c	1.51 a
Mean	2.06 b	2.185 a	0.12 c	--
		2008 season		
1 Sept 144 (DAP)	1.832 b	1.86 ab	0.09 d	1.26 b
2 Oct 175 (DAP)	2.02 ab	2.02 ab	0.13 d	1.39 a
14 Oct 187 (DAP)	2.05 ab	2.15 a	0.11 d	1.44 a
26 Oct 199 (DAP)	1.95 ab	1.91 ab	0.49 c	1.45 a
Mean	1.968 a	1.987 a	0.21 b	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 8: Size (cm^3) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	25.98 bc	24.50 c	8.00 d	23.75 c
15 Sept 175 (DAP)	31.25 a	30.00 ab	10.00 d	23.75 b
27 Sept 187 (DAP)	33.25 a	31.25 a	10.25 d	24.91 b
9 Oct 199 (DAP)	33.75 a	33.00 a	11.50 d	26.08 a
Mean	31.05 a	29.69 a	9.94 b	--
		2008 season		
1 Sept 144 (DAP)	26.25 e	24.10 e	6.65 h	19.00 d
2 Oct 175 (DAP)	31.45 cd	29.45 d	7.97 gh	22.95 c
14 Oct 187 (DAP)	33.62 abc	32.17 bcd	10.52 fg	25.44 b
26 Oct 199 (DAP)	35.49 a	35.15 ab	12.70 f	27.78 a
Mean	31.70 a	30.21 b	9.46 c	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

pollinator (A) that resulted in greater fruit weight after 187 days after pollination than that found with the (B) pollinator. Moreover, non-pollinated spathes gave much lighter weight than those pollinated spathes throughout the sampling periods. Variations in the type of pollinator and the response of fruit weight to non-pollination are in agreement with those reported by Ben Salah and Hellali [8], Gasim [19], El-Makhtoun and Abd-El-Kader [20] and Desoukey *et al.* [21].

Fruit-flesh Weight: The effect of the treatments represented by the type of pollinator regardless the time factor Table 6 on flesh weight of Zaghloul date fruits revealed that pollinator (A) caused a significant increase in flesh weight as compared with pollinator (B) in both seasons. Furthermore, both pollinators (A) and (B) led to a remarkable increase in flesh weight relative to non-pollinated spathes. With regard, to the effect of the time factor, regardless the treatments on flesh weight, the data in the same tables showed that the fruit continued to increase in a significant manner through the period of sampling in the kimri stage until maturity (the khalal stage) except during the period between 175 and 187 days after pollination in the first season. The interaction between the pollinators (as the treatments) and the time factor (Table 6) indicated that the two pollinators did not vary on their effect on flesh weight at each sampling time in both seasons. Moreover, at each sample, flesh weight of pollinated palms was much greater than that of non-pollinated spathes, furthermore, within each pollinator flesh weight did not significantly increase in the last 24 and 12 days in the two seasons, respectively which could be due to reaching the maturity. The reported data regarding the effect of changing the pollinator type on flesh weight of date fruit are in agreement with those obtained by Omar [10], El-Makhtoun [12] and Higazy *et al*. [22].

Rag Weight: Results in Table 7 revealed that rag weight of "Zaghloul" date fruits resulted from pollinator (A) was greater than that of pollinator (B) in a significant manner only in the first season while such weight was markedly lower in the non-pollinated spathes as compared with those pollinated with either pollinator (A) or (B), meanwhile, the time factor data, regardless the treatments, showed that there was no significant change over the last 24 days before harvest in both seasons (between 175 days after pollinator to 199 after pollination). Thus, the only significant increase in rag weight occurred at the kimri stage during the period between 144 to 175 days after pollination. Furthermore, the interaction between the pollination type and the time factor revealed that at each sampling, time in the last 24 days before harvest (the last three samples), there was no significant alteration in rag weight in both seasons when the two pollinators were compared. The rag weight of fruits in non-pollinated spathes was significantly lower than those of pollinated ones over the sampling periods in both seasons. Even within each pollinator, there was no significant change in rag weight in the last 24 days prior harvest. The above results are in agreement with those obtained by Attalla *et al.* [23], Sharaan [24] and Al-Hooti *et al.* [25].

Fruit Size: Data of fruit size as influenced by the pollinator type, regardless the time, was recorded in Table 8. Data indicated that using pollinator (A) led to

increasing fruit size with a significant manner in the second season as compared with those resulted from using pollinator (B). Non-pollinated spathes had much smaller fruit size in both seasons relative to pollinated palms. With regard to the changes in fruit size over time, it was found that there was a general trend for increasing fruit size from the end of the kimri stage (144 days after pollination) to the khalal stage. This increase in fruit size was significantly until the harvest sample (199 days after pollination). The interaction between treatments (the pollinators A and B) and the time factor was also reported in Table 8. At each sampling date, there was no significant difference between fruit size of spathes pollinated by pollinator (A) and those with pollinator (B) whether early at the kimri stage (144 days after pollination) or at the harvest sample (199 days after pollination). It was obvious that at each sampling date pollinated palms possessed much larger fruit size than non-pollinated ones in both seasons. Within each pollinator, the significant increase in fruit size during both seasons occurred between 144 days after pollination and 175 after pollination. Furthermore, no significant increase in fruit size was found in non-pollinated spathes over time. This trend of fruit size is agreement with the findings of Hussein *et al*. [26] and Aly [27].

Chemical Characteristics

Total Soluble Solids (TSS): Response of total soluble solids in "Zaghloul" date fruits to the variation in pollination type was reported in Table 9. Data showed that fruits produced with pollinator (A) tended to posses more soluble solids as compared with those on spathes pollinated with pollinator (B). This difference however, was not significant in the first season regardless the time factor. On the other hand, there was a significant increase in TSS from one sample to another until harvest in the two seasons (regardless the pollination type). The interaction between the treatments (The pollination type) and the time factor was also reported in Tables 9-. It was evident that there was no significant difference between the two pollinators (A) and (B) in their effect on TSS after 143 and 175 days after pollination in the two seasons. However, TSS of Zaghloul dates on spathes pollinated with pollinator (A) were greater than those resulted from palms pollinated with pollinator (B) whether after, 187 or 199 days after pollination. It was obvious that all pollinated spathes had greater TSS values over the sampling periods when compared with non-pollinated spathes in both seasons. Furthermore, under each pollinator, there was a significant increase in the TSS values between 144 and 175 days and then such increase was not generally significant between 187 and 199 days in TSS which coincided with reaching fruit maturity. The obtained results are in line with those reported by Al-Delamy and Ali [5], Omer [10], El-Makhtoun [12], Higazy *et al*. [22] and El-Hamady *et al*. [28].

Total Sugars: Total sugars data of "Zaghloul" date fruits as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons was recorded and reported in Table 10. Data revealed that total sugars were significantly altered by conducting the pollination when compared with non-pollinated spathes. However, the difference in total sugars tended to increase by using pollinator (A) when compared with pollinator (B) but the significant difference was only in the first season. Moreover, the time factor (regardless the pollinator treatments) indicated that there was a significant increase in total sugar between 144 and 175 days samples after pollination in both seasons. However, the total sugars ceased to increase between 187 and 199 days after pollination in both seasons that could ascribed to reach the maturity stage (Table 10). Furthermore, the interaction between treatments (the pollinator type) and the time factor at each sampling time, pollinated spathes were superior in their total sugars in the fruit as compared with those of non-pollinated spathes. Moreover, at each sampling time, there was no significant difference in total sugars of "Zaghloul" fruits between both used pollinators in a consistent manner. Mean while, total sugars in "Zaghloul" fruits continued to increase between 144 and 175 days following pollination with each used pollinator in both seasons which coincided with fruit growth and development during the kimri stage. However, no further increase in total sugars of the fruit was recorded between those samples taken after 187 and 199 following pollination with either of the used pollinator (A) or (B). Obtained results and trends are in agreement with those reported by Shaheen *et al*. [4] and El- Makhtoun [12].

Reducing Sugars: The effect of the pollinator type, regardless the time, on reducing sugars of "Zaghloul" date fruits was shown in Table 11. Data indicated that fruits of pollinator (A) had higher reducing sugars than those of pollinator (B) especially in the first season. Furthermore, pollinated spathes had significantly more reducing sugars in their fruits as compared with non-pollinated spathes in both seasons (Table 11). With regard to the effect of the time factor on the content of

Table 9: Total soluble solids (%) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	8.75 f	8.70 f	5.80 g	7.75 d
15 Sept 175 (DAP)	12.45 e	11.37 e	8.87 f	10.90 c
27 Sept 187 (DAP)	21.30 b	16.77 cd	12.75 e	15.89 b
9 Oct 199 (DAP)	23.42 a	18.15 c	15.60 d	20.11 a
Mean	15.69 a	14.54 b	10.75 c	--
		2008 season		
1 Sept 144 (DAP)	8.55 e	8.60 e	5.80 f	7.65 d
2 Oct 175 (DAP)	11.85 d	11.35 d	7.20 ef	10.13 c
14 Oct 187 (DAP)	22.10 a	16.55 b	10.75 d	14.85 b
26 Oct 199 (DAP)	23.15 a	17.25 d	14.40 c	19.88 a
Mean	15.20 a	14.65 a	9.54 b	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 10: Total Sugars (%) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	43.19 d	41.30 d	20.97 f	35.15 b
15 Sept 175 (DAP)	61.22 c	62.27 bc	26.50 e	51.9 a
27 Sept 187 (DAP)	67.21 ab	62.78 abc	27.45 e	52.48 a
9 Oct 199 (DAP)	67.99 a	66.95 ab	27.57 e	52.26 a
Mean	61.33 a	56.89 b	25.62 c	--
		2008 season		
1 Sept 144 (DAP)	43.48 d	42.83 d	19.12 f	35.14 c
2 Oct 175 (DAP)	60.84 bc	58.29 c	24.35 e	47.83 b
14 Oct 187 (DAP)	65.30 ab	63.31 ab	25.76 e	51.71 a
26 Oct 199 (DAP)	66.06 a	64.80 ab	27.10 e	52.40 a
Mean	58.92 a	57.31 a	24.08 b	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 11: Reducing Sugars (%) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	37.63 c	35.68 c	19.14 e	30.81 b
15 Sept 175 (DAP)	47.29 ab	46.64 b	24.19 d	40.26 a
27 Sept 187 (DAP)	50.68 a	47.70 ab	24.90 d	41.09 a
9 Oct 199 (DAP)	50.40 a	49.95 ab	25.12 d	40.94 a
Mean	47.16 a	44.33 b	23.34 c	--
		2008 season		
1 Sept 144 (DAP)	37.09 b	36.48 b	16.91 d	30.16 b
2 Oct 175 (DAP)	48.25 a	47.12 a	21.74 c	39.04 a
14 Oct 187 (DAP)	49.49 a	47.80 a	23.05 c	40.11 a
26 Oct 199 (DAP)	47.82 a	47.72 a	24.65 c	40.06 a
Mean	45.66 a	44.78 a	21.59 b	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 12: Non-reducing Sugars (%) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	5.56 d	5.63 d	1.83 e	4.34 c
15 Sept 175 (DAP)	16.44 abc	15.07 c	2.31 e	11.38 b
27 Sept 187 (DAP)	17.00 ab	15.62 bc	2.55 e	11.64 ab
9 Oct 199 (DAP)	17.58 a	16.52 abc	2.45 e	12.16 a
Mean	14.17 a	13.19 b	2.28 c	--
		2008 season		
1 Sept 144 (DAP)	6.38 c	6.34 c	2.21 d	4.98 c
2 Oct 175 (DAP)	12.58 b	11.17 b	2.61 d	8.79 b
14 Oct 187 (DAP)	17.07 a	15.51 a	2.71 d	11.59 a
26 Oct 199 (DAP)	17.47 a	16.55 a	2.40 d	12.31 a
Mean	13.25 a	12.53 a	2.48 b	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 13: Tannins (as "gallactronic" acid %) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	1.37 b	1.42 b	1.84 a	1.54 a
15 Sept 175 (DAP)	0.78 c	0.81 c	1.74 a	1.11 b
27 Sept 187 (DAP)	0.09 d	0.081 d	1.62 ab	0.59 c
9 Oct 199 (DAP)	0.048 d	0.054 d	1.40 b	0.50 c
Mean	0.57 b	0.592 b	1.65 a	--
		2008 season		
1 Sept 144 (DAP)	1.38 c	1.42 c	1.78 a	1.528 a
2 Oct 175 (DAP)	0.97 d	0.99 d	1.65 ab	1.205 b
14 Oct 187 (DAP)	0.088 e	0.083 e	1.48 bc	0.55 c
26 Oct 199 (DAP)	0.052 e	0.05 e	1.42 c	0.51 c
Mean	0.622 b	0.638 b	1.585 a	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

reducing sugars in "Zaghloul" fruits, it was found that such sugars significantly increased between 144 and 175 days after pollination then reducing sugars ceased to increase until the harvest day (199 days after pollination) and this trend was consistent in both seasons. On the other hand, the interaction between treatments (the pollinator type) and the time also shown in Table 11 revealed that at each sampling date, the pollinated spathes had greater reducing sugars in their fruits than those of non-pollinated spathes, while such sugars were not significantly different between fruits of pollinator (A) and (B) at each time after pollination. Moreover, under each pollinator, reducing sugars only increased significantly between 144 and 175 days after pollination then there was no further increase in such sugars until the harvest day which could be ascribed to reach fruit maturity. The above findings regarding the influence of changing the pollination type on fruit reducing sugars are in line with those found by Omar [10] and El-Makhtoun [12].

Non-Reducing Sugars: Changes in non-reducing sugars of "Zaghloul" date fruits as influenced by the type of pollinator, regardless the time, were recorded in Table 12. Data indicated a similar trend to that found in reducing sugars since there was a significant increase in non-reducing sugars of fruits belonging to palms pollinated with pollinator (A) as compared with those pollinated with pollinator (B). However, this increase was only significant in the first season. However, pollinated spathes produced fruits with much higher non-reducing sugars when compared with non-pollinated spathes in both seasons.

Furthermore, the time factor data revealed that there was a significant increase in non-reducing sugars between 144 and 175 samples after pollination in both seasons. However, there was no significant change in such sugars between samples of 187 and 199 days after pollination in a consistent manner which might be coinciding with reaching to fruit maturity. With regard to the interactions between pollinator treatments and the time factor, it was evident from Table 12 that at each sampling time fruits produced from pollinated spathes was superior in their non-reducing sugars relative to those of non-pollinated spathes. However, the non-reducing sugars, at each sampling time, of pollinated spathes fruits did not significantly vary whether with pollinated (A) or (B) in both seasons. Moreover, the significant change in such sugars under each pollinator was again found between samples of 144 and 175 days after pollination. This trend was also true in the second season when non-reducing sugars were compared between 175 and 187 days after pollination under both used pollinators. Similar results were reported by El-Makhtoun [12] and Hussien and Hassan [29].

Tannins: The effect of the pollinator type regardless the time on tannin contents of "Zaghloul" date fruits was reported in Table 13. Data revealed that using either pollinator (A) or (B) did not make a significant difference in terms of their influence on tannins content in both seasons. However, non-pollinated spathes had significantly greater tannin contents in their fruits as compared with those of pollinated spathes in a consistent manner. The time factor data indicated that there was a significant decrease in tannin content in the fruit during the period ranging from 144 to 175 days after pollination. There after tannin content did not vary when samples taken after 187 and 199 days after pollination when compared with reaching to fruit maturity. With regard to the effect of the interaction between the type of pollination and the time factor (Table 13), it was evident that at each sampling time, pollinated fruits had similar tannin contents but was smaller in amounts than that found in fruits of non-pollinated trees in both seasons since these later fruits were much slower in their development. Furthermore, under each pollinator, the significant reduction in tannin content occurred between 144 and 175 days and between 175 and 187 day after pollination then tannins ceased to significantly change between 187 and 199 days after pollination. On the other hand fruit tannin contents of non-pollinated tree showed a marked reduction in the last sample (after 199 days from pollination). The above findings regarding the effect of changing the type of pollinator on the tannin contents of the fruit agreed with those reported by Al-Hooti *et al.* [25] and Musa [30].

Fruit Acidity: Titratable acidity of "Zaghloul" date fruits as influenced by the type of pollinator was recorded in Table 14. The pollinator treatment factor, regardless the time factor, showed that changing the type of pollinator did not affect fruit acidity whether the used pollinator (A) or (B). Moreover, non-pollinated fruits had significantly higher acidity than fruits of pollinated spathes in both seasons. Data of the time factor in the same table revealed that there was a significant decline in titratable acidity between 175 and 187 days after pollination then afterward acidity ceased to change until the harvest sample. This was a consistent trend in both seasons. The interaction between type of pollination and the time factor was also reported in Table 14. Data indicated that at each sampling time, fruit acidity did not vary between those of pollinator (A) or (B) in both seasons. However, the last two samples taken after 187 and 199 after pollination had similar acidity in the fruit whether under pollinator (A) or (B) or in the fruits of non-pollinated spathes. Meanwhile, acidity of fruits after 175 days from pollination was higher in non-pollinated spathes as compared with fruits of pollinated ones. Moreover, under each pollinator, there was no significant difference in fruit acidity in the last three samples. The effect of changing the pollinator on fruit acidity of date fruit is in line with those findings of Musa [30] and Mawlood [32].

Vitamin C Content: Vitamin C content of "Zaghloul" date fruits as influenced by various used pollinators were reported in Table 15. The data revealed that vitamin C in the fruits of pollinated spathes tended to be higher than in non-pollinated ones especially in the first season. Moreover, fruits of pollinator (A) had greater amount of vitamin C than those of pollinator (B) in a significant manner only in the first season. The time factor data indicated that vitamin C content was significantly increased between 144 and 175 days after pollination and then there was a further increase over time but in a significant manner in the second season. Thus, there was no specific trend of vitamin C content in the fruit over the sampling time when the data of the two seasons were compared. The interaction between the treatments (pollinators) and the time factor proved that at each sampling time after 144, 175 and 187 there was significant difference in vitamin C content of fruits under pollinator

Table 14: Acidity (%) of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	0.16 b	0.168 b	0.21 a	0.178 a
15 Sept 175 (DAP)	0.069 de	0.079 d	0.108 c	0.086 b
27 Sept 187 (DAP)	0.046 e	0.055 de	0.071 de	0.057 c
9 Oct 199 (DAP)	0.045 e	0.054 de	0.069 de	0.056 c
Mean	0.0798 b	0.089 b	0.114 a	--
		2008 season		
1 Sept 144 (DAP)	0.17 b	0.17 b	0.20 b	0.182 b
2 Oct 175 (DAP)	0.084 b	0.086 b	0.86 a	0.345 a
14 Oct 187 (DAP)	0.051 b	0.052 b	0.095 b	0.066 bc
26 Oct 199 (DAP)	0.046 b	0.046 b	0.073 b	0.055 c
Mean	0.088 b	0.090 b	0.31 a	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 15: Vitamin C (mg/100 g) content of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	0.58 f	0.55 f	0.51 f	0.546 b
15 Sept 175 (DAP)	1.39 abc	1.34 abcd	1.10 e	1.278 a
27 Sept 187 (DAP)	1.51 ab	1.38 abc	1.18 de	1.359 a
9 Oct 199 (DAP)	1.53 a	1.32 bcd	1.22 cde	1.36 a
Mean	1.25 a	1.15 b	1.00 c	--
		2008 season		
1 Sept 144 (DAP)	0.55 e	0.55 e	0.54 e	0.548 d
2 Oct 175 (DAP)	0.97 cd	0.74 de	0.93 d	0.880 c
14 Oct 187 (DAP)	1.35 ab	1.39 ab	1.21b c	1.317 b
26 Oct 199 (DAP)	1.51 a	1.42 ab	1.41 ab	1.45 a
Mean	1.096 a	1.026 a	1.024 a	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 16: Anthocyanin (mg/100g) content of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	3.65 d	3.46 d	2.36 f	3.16 c
15 Sept 175 (DAP)	5.67 b	5.49 b	2.87 e	4.68 b
27 Sept 187 (DAP)	8.63 a	8.43 a	4.334 c	7.13 a
9 Oct 199 (DAP)	8.71 a	8.52 a	4.43 c	7.22 a
Mean	6.66 a	6.476 b	3.50 c	--
		2008 season		
1 Sept 144 (DAP)	3.67 de	3.59 e	2.31 f	3.12 d
2 Oct 175 (DAP)	6.57 c	6.39 c	3.47 e	5.54 c
14 Oct 187 (DAP)	7.76 b	7.50 b	4.42 d	6.56 b
26 Oct 199 (DAP)	8.62 a	8.49 a	3.93 de	7.01 a
Mean	6.636 a	6.464 a	3.582 b	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 17: Chlorophyll (a) (mg/100 g) content of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	0.086 bcd	0.107 b	0.15 a	0.116 a
15 Sept 175 (DAP)	0.076 d	0.083 cd	0.10 bc	0.087 b
27 Sept 187 (DAP)	0.032 e	0.043 e	0.072 d	0.049 c
9 Oct 199 (DAP)	0.031 e	0.042 e	0.067 d	0.047 c
Mean	0.057 c	0.069 b	0.098 a	--
		2008 season		
1 Sept 144 (DAP)	0.095 bc	0.103 b	0.164 a	0.121 a
2 Oct 175 (DAP)	0.080 de	0.083 cd	0.098 b	0.087 b
14 Oct 187 (DAP)	0.069 ef	0.0689 ef	0.095 bc	0.077 c
26 Oct 199 (DAP)	0.036 g	0.036 g	0.065 f	0.046 d
Mean	0.070 b	0.073 b	0.105 a	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

Table 18: Chlorophyll (b) (mg/100 g) content of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	0.072 d	0.097 bc	0.12 a	0.096 a
15 Sept 175 (DAP)	0.067 d	0.074 d	0.11 ab	0.083 b
27 Sept 187 (DAP)	0.059 d	0.078 cd	0.11 ab	0.082 b
9 Oct 199 (DAP)	0.057 d	0.076 cd	0.10 bc	0.077 b
Mean	0.064 c	0.081 b	0.11 a	--
		2008 season		
1 Sept 144 (DAP)	0.089 abc	0.091 abc	0.096 ab	0.093 a
2 Oct 175 (DAP)	0.073 abc	0.078 abc	0.10 a	0.084 ab
14 Oct 187 (DAP)	0.066 bc	0.068 abc	0.094 ab	0.076 bc
26 Oct 199 (DAP)	0.059 c	0.060 c	0.087 abc	0.069 c
Mean	0.072 b	0.074 b	0.094 a	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

(A) and (B), in both seasons. Furthermore, under each pollinator there was a significant increase in vitamin C as the fruit progressed toward maturity especially during the period between 144 and 175 days after pollination. The above trends are in line with that found by Sawaya *et al*. [32].

Anthocyanin Content: The effect of used pollinators on anthocyanin content of "Zaghloul" fruits during the two seasons was reported in Table 16. Data revealed that fruits of pollinated spathes had significantly higher anthocyanin content than those of non-pollinated spathes in both seasons. Moreover, spathes pollinated with pollinator (A) tended to have greater amount of anthocyanin in the fruit relative to those fruits of pollinator (B). The time factor data indicated that anthocyanin content in the fruit, regardless the pollination type, was increasing over time from one sample to another especially during the period between 144,175 and 187after pollination. The interaction between the type of pollinator and the time factor indicated that anthocyanin content in the fruit at each sampling time did not significantly vary whether the used pollinator was (A) or (B) in both seasons. However, fruits of pollinated trees had consistently greater amount of anthocyanin as compared with those of non-pollinated trees at each sampling time. Under each pollinator, anthocyanin content from one sample to another was significantly increased then ceased to change significantly between 187 and 199 after pollination in the first season. Meanwhile, the increase in anthocyanin content in the fruit continued from one sample to another until the harvest sample in the second

season. In non-pollinated palms, the increase in anthocyanin over time continued until 187 days after pollination then did not have any further alteration between 187 and 199 days after pollination. The above data regarding the effect of pollination on anthocyanin content in the fruit as compared with fruits of non-pollinated could be explained on the basis that seeds as a source of auxins promote the biosynthesis of ethylene which enhances anthocyanin formation in the fruit. This conclusion could be supported by comparing IAA content of fruits in pollinated spathes with those of non-pollinated spathes. Moreover, no considerable variations in anthocyanin contents were found between fruits of pollinator (A) or (B). This could be attributed to the similarity in ABA content that important for enhancing anthocyanin production [33].

Chlorophyll (a) Content: Chlorophyll (a) content of "Zaghloul" date fruit as influenced by the type of pollinator was recorded in Table 17. Data indicated that there was lower chlorophyll a content in fruits produced under pollinator (A) when compared with those produced by spathes pollinated with pollinator (B). However, the difference between both was significant in the first season. Moreover, non-pollinated spathes had fruits with higher chlorophyll a content than pollinated spathes whether by pollinator (A) or (B) in both seasons. With regard to the time factor, it was evident that there is a continuous decline in chlorophyll (a) content over time as the fruit progressed from the kimri stage to the Khalal stage. Such reduction was significant among the samples taken after 144,175 and 187 from pollination in both seasons. The interaction between the type of pollinator and the time factor also revealed that chlorophyll (a) content in the fruit did not vary between fruits of both used pollinators at each sampling time. Meanwhile, fruits of non-pollinated spathes had higher chlorophyll (a) content at each sampling date than those of pollinated spathes. Under each pollinator, there was no well defined trend in chlorophyll (a) data when values were compared over time from sample to another. However, there was a significant decline in chlorophyll (a) when 144 days sample (at the kimri stage) was compared with 199 days sample (at maturity) in both seasons, Results of chlorophyll (a) obtained in this study are in line with Nasr *et al.* [34] and Shaheen and Al-Quarashi [35].

Chlorophyll (b) Content: The data regarding the changes in chlorophyll (b) in response to the used pollinator are presented in Table 18. Data showed that chlorophyll (b) content in the fruits of pollinated spathes was significantly lower than those of non-pollinated spathes, regardless the time factor. However, more chlorophyll (b) content was found in fruits produced on spathes pollinated with pollinator (B) when compared with pollinator (A) especially in the first season. Data of the time factor, regardless the treatments (pollinator type) revealed that the major change in chlorophyll (b) was found over the period ranging from 144 to 175 days after pollination. However, the difference in chlorophyll (b) between samples taken after 144 and 199 days from pollination was significant in both seasons. The interaction between the type of pollinator and the time factor indicated that, at each sampling time, the difference between chlorophyll b content of pollinators (A) and (B) was not significant. Furthermore, non- pollinated plams had fruits with higher chlorophyll (b) than pollinated ones in samples taken after 144, 175 and 187 days after pollination in the first season. In addition, under each pollinator chlorophyll (b), in general, did not alter from one sample to another in a significant manner. Trends of chlorophyll (b) obtained in this study are in agreement with those of Nasr *et al.* [34] and Shaheen and Al-Quarashi [35].

Crude Fiber Content: Crude fiber data of "Zaghloul" date fruits as influenced by the type of pollinator were reported in Table 19. Data revealed that crude fibers of pollinated spathes did not vary in the first season but was significantly greater than of non-pollinated spathes. In the second season, spathes pollinated with pollinator (A) had significantly greater crude fibers than those pollinated with pollinator (B). However, pollinated spathes maintained their higher crude fibers content when compared with non-pollinated spathes. Data of the time factor in the same tables indicated a significant-progressive increase in crude fibers of the fruits in both seasons, regardless the pollinator treatments. Furthermore, the interaction between treatments (the pollination type) and the time factor was also reported in Table 19. At each sampling date, fruits in pollinated spathes did not significantly vary in their crude fibers whether with pollinator (A) or (B) except with the 199 days after pollination sampling in the second season. Meanwhile, crude fiber content of pollinated spathes in the first season was superior to that obtained in fruits of non-pollinated spathes. This, however, was not the case in the second season even though pollinated spathes tended to have higher crude fibers as compared with non-pollinated spathes. Moreover, under each pollinator

Table 19: Crude fiber (%) content of "Zaghloul" date fruit as influenced by the type of pollinator, the time factor and their interaction throughout the kimri stage until maturity during 2007 and 2008 seasons.

	Type of pollinator			
Days after pollination (DAP)	Pollinator (A)	Pollinator (B)	Without pollination	Mean
		2007 season		
14 Aug 144 (DAP)	1.22 f	1.24 f	1.04 g	1.167 d
15 Sept 175 (DAP)	1.69 bcd	1.62 cd	1.50 e	1.61 c
27 Sept 187 (DAP)	1.79 b	1.77 b	1.59 de	1.72 b
9 Oct 199 (DAP)	1.95 a	1.91 a	1.73 bc	1.86 a
Mean	1.664 a	1.637 a	1.467 b	--
		2008 season		
1 Sept 144 (DAP)	1.18 de	1.14 e	1.14 e	1.155 d
2 Oct 175 (DAP)	1.31 d	1.29 d	1.26 de	1.288 c
14 Oct 187 (DAP)	1.66 c	1.67 c	1.62 c	1.65 b
26 Oct 199 (DAP)	2.18 a	1.92 b	1.68 c	1.944 a
Mean	1.58 a	1.507 b	1.44 c	--

Values followed by the same letter(s) are not statistically different at 5% level of probability.

in both seasons, there was a consistent increase in crude fibers in the last two sampling dates (after 187 and 199 days from pollination). The trend of crude fibers data obtained in this study is in agreement with that found by Selim *et al*. [36], Kamel *et al.* [37] and Rizk [38].

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