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Characteristics of Four Barhee Dates Strains as Affected by Pollen Source and Pollination Time

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Abstract: This study was carried out during two successive seasons (2005 and 2006) at the Experimental Research Station, Fac. Agric. Giza, Egypt. Pollen grains used in this trial were collected from three regions (Fayoum, Kerdasa and Maraziek) to pollinate four strains of Barhee seedling palms at three times (2, 4 and 6 days of spathe cracking). Results indicated that all studied fruit characters were significantly differed between Barhee strains. Fayoum pollen source gave the highest fruit retained and bunch weight with low fruit quality (fruit and flesh weights, fruit dimensions and fruit contents of TSS, total soluble and reducing sugars) comparing with other pollen sources. While, Kerdasa pollen source gave the highest fruit quality in both seasons with decreasing in fruit retained and bunch weight comparing with other pollen sources. In addition delaying pollination time from 2 to 6 days after spathe cracking reduced fruit retained percentage and bunch weight, whereas, it enhanced fruit quality in both seasons. The interaction between pollen grain source and pollination time significantly affected fruit characters under study in the two seasons.

Key words: Date palm · Pollen source · Pollination time · Barhee · Strains

INTRODUCTION

Date palm (*Phoenix dactylifera L.*) is one of the oldest cultivated trees in the world. In Egypt, date palm is one of the most important fruits which is widely distributed in different districts. Also, date palm is a dioecious plant in which artificial pollination is essential for economic crop. It is generally known that pollen grains from different male of date palms affect the yield and fruit quality "Metaxinia" [1]. Therefore, the effect of different pollen sources on different female date palm cultivars was studied by many workers [2-9]. They proved that fruit set, yield and fruit quality were affected by different sources of pollen grains.

The receptivity of female flowers are differed according to the cultivar of female date palm and environmental conditions [10]. However, pollination is usually done within the first 2-6 days after spathe cracking [4, 11, 12]. Moreover, it was found that receptivity was ranged within 12-15 days according to different countries, cultivars and different inflorescences of the same cultivar [13-15].

The main objective of this study is to maximize the fruit retained and yield as well as to improve the fruit quality of four strains of Barhee seedling palms by selected pollination time and most suitable pollen source.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2005 and 2006) at the Experimental Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. Four strains of Barhee seedling palms were used in this trial. Mother's female palms were propagated by seeds. These female palms produced 3-5 offshoots that arrived to commercial fruiting since 15 years. All palms of each strain (group) received the normal agricultural practice. In this study, the groups were numbered from one to four. The palms of each strain under investigation were nearly similar in growth and production, which pruned at 8:1 leaf/bunch ratio [16]. Three sources of pollen grains were used for this study. The selected male palm trees were grown at different regions; Fayoum, Kerdasa and Maraziek. The mature male spathes were collected and dried at room temperature for 24 hour to reduce the humidity within the individual strands which 10 of them were used for pollinating one of each female inflorescence during the two studied seasons. All pollen grain sources were tested before using in this work.

Experimental Design: Three female palms of each strain were used in this work. Nine bunches were left on each female palm. Bunches were divided into three groups,

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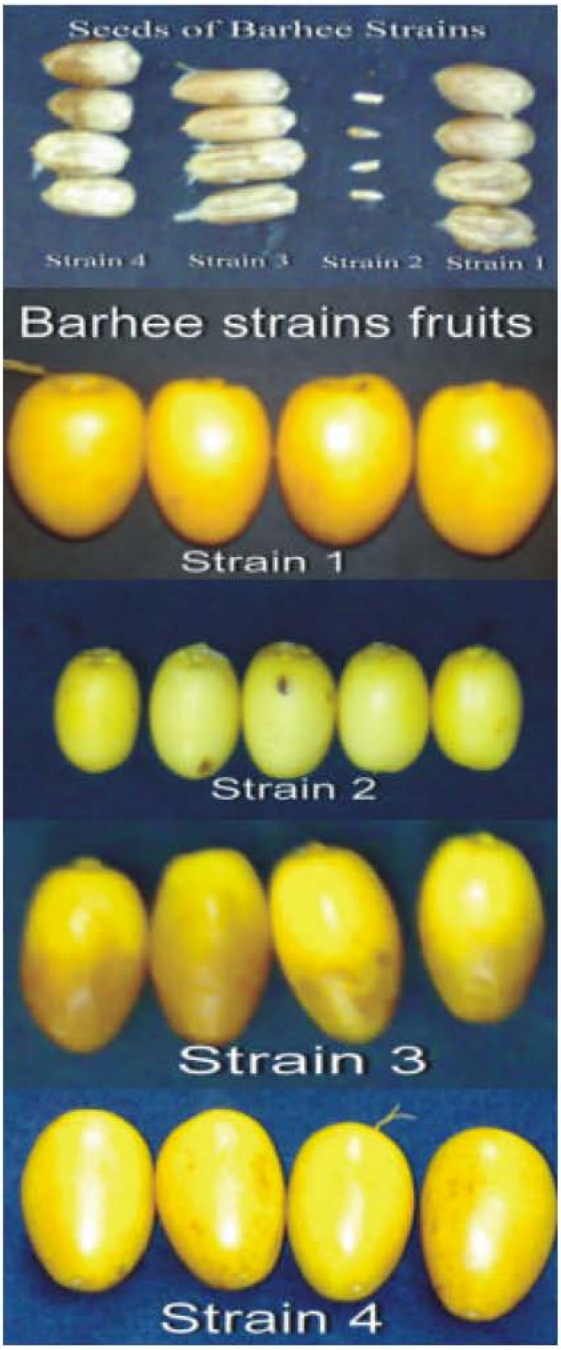

Fig. 1: Four Barhee strains seeds and fruits photos of date seedling palms

each contains three bunches. Each group was pollinated by one pollen grains source. As one bunch of each group was pollinated at 2, 4 and 6 days after inflorescence cracking. The individually pollen source, however, was replicated three times on different palms. Pollination was begot at the 3rd week of March in both seasons. The female inflorescences were covered with paper bags before cracking and after pollination to avoid the mixing between times of pollination and pollen sources used.

Statistical Analysis: The obtained data were subjected to analysis of variance. The mean values were compared using LSD method at 5% level. The data were tabulated and statistically analyzed according to the randomized complete blocks design method [17]. The percentages were transformed to the arcsine to find the binomial percentages according to [18].

The fruit yield of this experiment was harvested at maturity stage during 3rd week of September in the two seasons [19]. Figure 1 distinguish the fruit and seed shapes of different Barhee strains under study.

The Following Data Were Recorded:

- Fruit retained percentage was calculated at harvest using this equation:

$$\text{Fruit retained} = \frac{\text{Total number of retained fruits per bunch}}{\text{Total scares number per bunch}} \text{X } 100$$

- Bunch weight was estimated as Kg.
- Fruit physical properties: Samples of 25 fruits from each replicate were taken randomly to determine fruit, flesh and seed weights, fruit length and fruit diameter.
- Fruit moisture content percentage was calculated as described in A.O.A.C. [20].
- Total soluble solids content (TSS) percentage was determined in juice fruit as described in A.O.A.C. [20].
- Total soluble sugars were determined according to Smith *et al.* [21] in the methanol extract using the phenol sulfuric acid method and the concentration was calculated as g /100 g fresh weight.
- Reducing soluble sugars were determined in the methanol extract according to Nelson and Somogy [22] as described in A.O.A.C. [20] and the percentage was calculated as g /100 g fresh weight.

RESULTS

Fruit Retained Percentage (%): Data presented in Table 1 exhibited that fruit retained percentage of Barhee strains had affected significantly by different pollen sources, time of pollination after spathe cracking and interactions between them in both seasons. Barhee strain 2 produced the highest fruit retained percentage followed by strains 3, 4 and 1, in the first and second seasons,

Table 1: Effect of pollen source and pollination time on fruit retained percentage of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	38.53	40.14	37.32	38.37	38.59	36.55	37.52	34.99	35.79	36.21
	4 days	30.50	37.10	33.43	32.97	33.50	26.78	34.62	30.89	30.23	30.63
	6 days	28.98	35.32	32.43	32.07	32.20	26.14	33.18	30.00	29.00	29.58
Mean		32.67	37.52	34.39	34.47	34.76	29.82	35.11	31.96	31.67	32.14
Kerdasa	2 days	36.89	39.71	37.13	36.16	37.47	35.77	34.60	35.28	35.16	35.20
	4 days	29.48	34.41	32.30	31.07	31.81	22.87	32.00	30.61	28.36	28.46
	6 days	27.73	33.23	32.47	31.01	31.11	25.80	30.60	29.94	28.55	28.72
Mean		31.37	35.78	33.97	32.75	33.47	28.15	32.40	31.94	30.69	30.79
Maraziek	2 days	35.75	38.00	32.33	36.40	35.62	32.43	34.85	30.64	33.22	32.78
	4 days	27.25	32.19	29.15	27.26	28.96	25.29	30.25	27.51	24.89	26.98
	6 days	26.63	29.37	27.25	26.55	27.45	24.00	27.54	26.08	24.93	25.64
Mean		29.88	33.19	29.58	30.07	30.68	27.24	30.88	28.08	27.68	28.47
2 days		37.06	39.28	35.59	36.98	37.23	34.92	35.66	33.64	34.72	34.73
4 days		29.08	34.57	31.63	30.43	31.43	24.98	32.29	29.67	27.83	28.68
6 days		27.78	32.64	30.72	29.88	30.25	25.31	30.44	28.67	27.49	27.98
Mean		31.31	35.50	32.65	32.43	32.97	28.40	32.80	30.66	30.01	30.47

LSD at 5% level for:	First season	Second season
Strain (A)	= 0.44	= 0.38
Pollen source (B)	= 0.38	= 0.33
A X B	= 0.77	= 0.67
Pollination time (C)	= 0.37	= 0.33
A X C	= 0.77	= 0.67
B X C	= 0.67	= 0.58
A X B X C	= 1.34	= 1.16

respectively. In addition, fruit retained percentage was the highest by Fayoum pollen source followed by Kerdasa and Maraziek sources in both seasons. Moreover, It was clearly noticed that fruit retained percentage had decreased when pollination was done within 6 days after spathe cracking in both seasons.

The interaction between Barhee strain and pollen source cleared that highest fruit retained percentage was obtained by strain 2 which pollinated by Fayoum pollen source comparing with other interactions in the two seasons. Also, pollination at two days after spathe cracking produced the highest percentage of the second strain fruit retained comparing with other interactions in the two seasons. In addition, pollinating by pollens from Fayoum region within 2 days after spathe cracking produced the highest fruit retained percentage comparing with other interactions in both seasons.

The interaction between strains, pollen source and pollination time showed that pollination at 2 days after inflorescence cracking by pollens imported from Fayoum region raised significantly the fruit retained% in the first and second seasons, respectively. Whereas, the lowest fruit retained percentage was recorded with Barhee strain one pollinated by Maraziek pollens within 6 days after spathe cracking during the two seasons. Whatever, Barhee strain number two produced the highest values of fruit retained percentages when interacted with either pollen source or pollination time in both seasons.

Bunch Weight (Kg): Bunch weight was significantly affected by Barhee strains, pollen source, pollination time and interactions between them in both seasons (Table 2). Whoever, strain number two produced the heaviest bunch weight followed by strains number 3, 4 and 1 in the first and second seasons, respectively. The weightiest bunches were resulted by using pollens imported from Fayoum or Kerdasa regions comparing with Maraziek source in both seasons. Also, the heaviest bunch was recorded when pollination was done at two days from inflorescence cracking in both seasons.

The interaction between strain and pollen source cleared that highest values of bunch weight were observed on strain 2 which was pollinated by Fayoum pollen source in the two seasons comparing with other interactions used. Moreover, the highest bunch weight was detected with strain 2 that pollinated within two days after spathe cracking comparing with other interactions in this field during both seasons. In addition, pollination by Fayoum pollen source at two days from spathe cracking enhanced weight of bunches comparing with other interactions in this respect during both seasons.

Table 2: Effect of pollen source and pollination time on bunch weight (kg) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	10.650	17.750	13.467	12.423	13.572	10.083	16.817	12.367	11.593	12.715
	4 days	9.803	15.583	11.417	10.750	11.888	9.117	14.583	10.667	9.750	11.029
	6 days	8.750	13.667	11.750	11.250	11.354	8.033	12.667	11.283	10.502	10.621
Mean		9.734	15.667	12.211	11.474	12.271	9.078	14.689	11.439	10.615	11.455
Kerdasa	2 days	11.500	16.083	14.583	12.083	13.562	10.500	14.267	12.950	11.667	12.346
	4 days	10.833	16.217	12.867	10.383	12.575	9.883	14.267	12.683	9.317	11.537
	6 days	10.713	12.667	11.900	9.867	11.287	9.250	11.517	10.667	8.833	10.067
Mean		11.015	14.989	13.117	10.778	12.475	9.878	13.350	12.100	9.939	11.317
Maraziek	2 days	9.633	15.883	13.567	11.600	12.671	8.417	14.017	12.523	10.250	11.302
	4 days	9.017	15.583	11.783	10.217	11.650	7.667	14.500	10.567	9.250	10.496
	6 days	8.633	12.333	11.500	9.550	10.504	7.283	11.083	10.833	8.433	9.408
Mean		9.094	14.600	12.283	10.456	11.608	7.789	13.200	11.308	9.311	10.402
2 days		10.594	16.572	13.872	12.035	13.268	9.667	15.034	12.613	11.170	12.121
4 days		9.884	15.794	12.022	10.450	12.308	8.889	14.450	11.306	9.439	11.021
6 days		9.365	12.889	11.717	10.220	11.048	8.189	11.756	10.928	9.256	10.032
Mean		9.948	15.085	12.537	10.902	12.118	8.915	13.747	11.616	9.955	11.058
LSD at 5% level for:					First season						Second season
Strain (A)					= 0.334						= 0.436
Pollen source (B)					= 0.292						= 0.374
A X B					= 0.585						= 0.753
Pollination time (C)					= 0.292						= 0.374
A X C					= 0.585						= 0.753
B X C					= 0.505						= 0.648
A X B X C					= 1.019						= 1.307

Table 3: Effect of pollen source and pollination time on fruit weight (g) of four Barhee strains seedling during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	15.27	7.07	10.37	13.77	11.62	16.30	8.30	11.40	14.93	12.73
	4 days	15.50	7.47	11.30	14.00	10.07	16.47	8.73	12.47	15.37	13.26
	6 days	15.73	7.53	10.87	14.87	12.25	17.51	8.83	11.93	16.27	13.63
Mean		15.50	7.36	10.85	14.21	11.98	16.76	8.62	11.93	15.52	13.21
Kerdasa	2 days	16.00	7.87	12.43	14.60	12.72	16.97	8.97	13.40	15.23	13.64
	4 days	18.00	8.77	14.17	16.23	14.29	19.07	9.57	14.87	17.47	15.24
	6 days	18.00	9.27	14.90	16.80	14.74	19.17	10.14	16.07	17.97	15.84
Mean		17.33	8.64	13.83	15.88	13.92	18.40	9.56	14.78	16.89	14.91
Maraziek	2 days	14.90	5.93	12.13	14.53	11.87	16.17	7.23	13.47	15.80	13.17
	4 days	17.43	7.60	13.77	14.93	13.43	18.53	8.37	15.43	16.37	14.67
	6 days	16.57	8.03	13.53	15.40	13.38	18.60	9.21	15.58	17.93	15.33
Mean		16.30	7.19	13.14	14.95	12.89	17.77	8.27	14.83	16.70	14.39
2 days		15.39	6.96	11.64	14.30	12.07	16.48	8.17	12.76	15.32	13.18
4 days		16.98	7.95	13.08	15.05	13.26	18.02	8.89	14.26	16.40	14.39
6 days		16.77	8.28	13.10	15.69	13.46	18.43	9.39	14.53	17.39	14.93
Mean		16.38	7.73	12.61	15.01	12.93	17.64	8.82	13.85	16.37	14.17
LSD at 5% level for:					First season						Second season
Strain (A)					= 0.30						= 0.37
Pollen source (B)					= 0.26						= 0.32
A X B					= 0.52						= 0.64
Pollination time (C)					= 0.26						= 0.32
A X C					= 0.52						= 0.64
B X C					= 0.45						= 0.56
A X B X C					= 0.90						= 1.12

Table 4: Effect of pollen source and pollination time on flesh weight (g) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	13.52	6.47	8.49	11.91	10.10	14.44	8.21	9.50	13.09	11.31
	4 days	13.68	7.38	9.48	12.10	10.66	14.64	8.64	10.54	13.57	11.85
	6 days	13.96	7.45	9.07	13.07	10.89	15.68	8.74	10.06	14.47	12.24
Mean		13.72	7.10	9.01	12.36	10.55	14.92	8.53	10.03	13.71	11.80
Kerdasa	2 days	14.12	7.78	10.53	12.71	11.28	15.10	8.88	11.53	13.36	12.22
	4 days	16.20	8.68	12.28	14.46	12.90	17.25	9.49	13.00	15.64	13.84
	6 days	16.18	9.19	13.07	13.07	12.88	17.30	10.06	14.15	16.07	14.40
Mean		15.50	8.55	11.96	13.41	12.35	16.55	9.48	12.89	15.02	13.49
Maraziek	2 days	13.09	5.85	10.32	12.70	10.49	14.34	7.15	11.67	13.96	11.78
	4 days	15.52	7.52	11.97	13.05	12.01	16.72	8.28	13.66	14.50	13.29
	6 days	14.71	7.94	11.67	13.44	11.94	16.87	9.12	13.75	16.00	13.94
Mean		14.44	7.10	11.321	13.06	11.48	15.98	8.18	13.03	14.82	13.00
2 days		13.58	6.70	9.78	12.44	10.62	14.63	8.08	10.90	13.47	11.77
4 days		15.13	7.86	11.24	13.20	11.86	16.20	8.80	12.40	14.57	12.99
6 days		14.95	8.19	11.27	13.19	11.90	16.62	9.31	12.65	15.51	13.52
Mean		14.55	7.58	10.76	12.94	11.46	15.82	8.73	11.98	14.52	12.76

LSD at 5% level for:	First season	Second season
Strain (A)	= 0.31	= 0.38
Pollen source (B)	= 0.27	= 0.33
A X B	= 0.54	= 0.66
Pollination time (C)	= 0.27	= 0.33
A X C	= 0.54	= 0.66
B X C	= 0.47	= 0.57
A X B X C	= 0.94	= 1.15

Concerning the interaction between Barhee strain, pollen source and pollination time, Strain number two that pollinated by Fayoum pollens at two days of spathe cracking produced the highest bunch weight comparing with other interactions in both seasons.

Fruit Weight (G): Barhee fruit weight was significantly affected by strain, pollen source, pollination time and the interaction between them during both seasons (Table 3). The heaviest fruit was detected by strain one, or when pollination was done within 6 days after spathe cracking, or when pollens were imported from Kerdasa in both seasons.

The interaction between two factors that conducted in this trial exhibited that highest values of fruit weight were recorded on bunches of strain one that pollinated by Kerdasa pollen source, or strain one that pollinated within 6 days after inflorescence cracking, or when Kerdasa pollen source was used in pollination within 6 days of spathe cracking in the two seasons.

Regarding the interaction between strain, pollen source and pollination time, the heaviest fruits were obtained from strain one which was pollinated within 4 or 6 days after spathe cracking when pollens from Kerdasa region were used comparing with other interactions in this respect in the two seasons. Whatever, the lowest fruit weight in this respect was recorded with Barhee strain number 2 that pollinated within 2 days after spathe cracking using pollens from Fayoum in the first season and Maraziek regions in the second season during study.

Fruit Flesh Weight (G): Data presented in Table 4 cleared that fruit flesh weight was significantly affected by strain, pollen source, pollination time and interaction between them in both seasons. The highest fruit weight was obtained with strain number one comparing with other strains in the first and second seasons, respectively. Also, using pollens from Kerdasa region produced the highest fruit flesh weight comparing with other pollen sources used. Whatever, pollination within 6 days after spathe cracking produced the heaviest fruit flesh weight comparing with other pollination time in both seasons.

The interaction between Barhee strain and pollen source reflected that using pollens from Kerdasa region in pollination Barhee strain 2 gave the heaviest fruit flesh weight comparing with other interactions. Also, the interaction of strain with pollination time cleared that heaviest fruit flesh weight was obtained from strain

Table 5: Effect of pollen source and pollination time on seed weight (g) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	1.75	0.09	1.88	1.86	1.39	1.86	0.09	1.90	1.84	1.42
	4 days	1.82	0.09	1.82	1.90	1.41	1.83	0.09	1.93	1.80	1.41
	6 days	1.77	0.09	1.79	1.80	1.36	1.83	0.09	1.87	1.80	1.39
Mean		1.78	0.09	1.83	1.85	1.39	1.84	0.09	1.90	1.81	1.41
Kerdasa	2 days	1.88	0.08	1.90	1.89	1.44	1.87	0.09	1.87	1.87	1.42
	4 days	1.80	0.08	1.88	1.78	1.38	1.82	0.08	1.87	1.83	1.40
	6 days	1.82	0.08	1.83	1.73	1.36	1.87	0.08	1.92	1.90	1.44
Mean		1.83	0.08	1.87	1.80	1.39	1.85	0.08	1.89	1.87	1.42
Maraziek	2 days	1.81	0.08	1.81	1.83	1.38	1.83	0.08	1.80	1.84	1.39
	4 days	1.92	0.08	1.80	1.88	1.42	1.81	0.09	1.77	1.87	1.38
	6 days	1.86	0.09	1.87	1.96	1.44	1.73	0.09	1.83	1.93	1.39
Mean		1.86	0.08	1.83	1.89	1.41	1.79	0.09	1.80	1.88	1.39
2 days		1.81	0.08	1.86	1.86	1.40	1.85	0.09	1.86	1.85	1.41
4 days		1.85	0.08	1.83	1.85	1.40	1.82	0.09	1.86	1.83	1.40
6 days		1.82	0.09	1.83	1.83	1.39	1.81	0.09	1.87	1.87	1.41
Mean		1.83	0.08	1.84	1.85	1.40	1.83	0.09	1.86	1.85	1.41

LSD at 5% level for:	First season	Second season
Strain (A)	= 0.18	= 0.17
Pollen source (B)	= N.S.	= N.S.
A X B	= 0.32	= 0.29
Pollination time (C)	= N.S.	= N.S.
A X C	= 0.32	= 0.29
B X C	= N.S.	= N.S.
A X B X C	= 0.56	= 0.51

one pollinated at 4 days in the first or at 6 days in the second season of spathe cracking comparing with other interactions during study. In addition, interaction between pollen sources with pollination time gave the highest fruit flesh weight by using pollens imported from Kerdasa region within 4 days in the first season and 6 days in the second season of spathe cracking comparing with other interactions.

Concerning the interaction between Barhee strain, pollen source and pollination time. It was clearly observed that strain number one produced the highest values of fruit flesh weight when it was pollinated at 4 or 6 days after spathe cracking by Kerdasa pollen source comparing with other interactions in the two seasons.

Seed Weight (G): Results of seed weight are tabulated in Table 5. It appeared that Barhee strain number 1, 3, 4 produced nearly the same seed weight which differed significantly with that of strain 2 which shoed aborted seeds in the two seasons. Referring to pollen source, pollination time and the interaction between them on seed weight, cleared that no significant effect was recorded in both seasons in this regard. On the other hand, seed weight had differed significantly by different strains according to pollen source in the two seasons.

Also, the interaction between strains and pollination time showed significant differences in seed weight in the two seasons. But all these differences were in between strains number 1, 3, 4 comparing with strain number 2 in respect to the interaction between Barhee strains and pollen source or pollination time during the two seasons.

The interaction between strain, pollen source and pollination time showed significant differences on seed weight during the two seasons. The highest seed weight was recorded with strain number four that pollinated by Fayoum pollen source at 6 days of spathe cracking in the first season. While in the second season, strain number 3 that pollinated by Maraziek pollen source at 4 days of spathe cracking or number 4 pollinated by Fayoum pollen source at 6 days from spathe cracking produced the highest seed weight comparing with other interactions.

Fruit Length (Cm): Table 6 clear that fruit length increased significantly with Barhee strain three comparing with other strains in the first and second seasons, respectively. Also, it was increased significantly when pollination was done by pollens from Kerdasa region comparing with other pollen sources in the first and second seasons, respectively. In addition pollination at 4 days in the first season or 6 days in the second season

Table 6: Effect of pollen source and pollination time on fruit length (cm) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	3.37	2.90	3.50	3.20	3.24	3.57	2.90	3.70	3.47	3.41
	4 days	3.60	3.07	3.67	3.37	3.58	3.90	3.10	3.73	3.57	3.57
	6 days	3.33	3.10	3.67	3.40	3.37	3.90	3.10	3.77	3.83	3.65
Mean		3.43	3.02	3.61	3.32	3.40	3.79	3.03	3.73	3.62	3.54
Kerdasa	2 days	3.37	2.87	3.73	3.73	3.42	3.47	2.90	3.77	3.86	3.50
	4 days	3.43	3.13	4.10	3.77	3.61	3.57	2.93	4.17	3.77	3.61
	6 days	3.73	2.93	4.30	3.50	3.61	3.86	2.97	4.35	3.77	3.74
Mean		3.51	2.98	4.04	3.67	3.55	3.63	2.93	4.10	3.80	3.62
Maraziek	2 days	3.33	2.87	3.63	3.07	3.22	3.43	3.13	3.97	3.33	3.46
	4 days	3.40	2.83	4.10	3.30	3.41	3.63	3.15	4.23	3.66	3.67
	6 days	3.27	2.87	3.73	3.17	3.26	3.40	3.16	4.33	3.67	3.64
Mean		3.33	2.86	3.82	3.18	3.30	3.49	3.15	4.18	3.55	3.59
2 days		3.36	2.88	3.62	3.33	3.29	3.49	2.98	3.81	3.55	3.46
4 days		3.48	3.01	3.96	3.48	3.53	3.70	3.06	4.04	3.67	3.62
6 days		3.44	2.97	3.90	3.36	3.41	3.72	3.08	4.15	3.76	3.68
Mean		3.43	2.95	3.83	3.39	3.42	3.64	3.04	4.00	3.66	3.59
LSD at 5% level for:					First season						Second season
Strain (A)					= 0.28						= 0.32
Pollen source (B)					= 0.24						= 0.28
A X B					= 0.48						= 0.56
Pollination time (C)					= N.S.						= N.S.
A X C					= 0.48						= 0.56
B X C					= N.S.						= N.S.
A X B X C					= 0.84						= 0.97

from spathe cracking increased fruit length without significant differences comparing with other pollination times.

The interaction between strain and pollen source appeared that fruit length had significantly increased with strain number three when it was pollinated by Kerdasa pollen source in the first season or by Maraziek pollen source in the second season comparing with other interactions in this respect. Also, strain three produced the tallest fruit when it was pollinated at 4 days in the first season or at 6 days in the second season with significant differences with other interactions in this regard. Moreover, the interaction between pollen source and pollination time reflected that pollination using Kerdasa pollen source at 4 or 6 days of spathe cracking produced the tallest fruit comparing with other interactions in the first season. Whereas, in the second season, the highest value in this respect was detected by Maraziek pollen source when pollination was done at6 days of spathe cracking comparing with other interactions.

The interaction between strains, pollen source and pollination time showed significant effect on fruit length during the two seasons. The highest fruit length was recorded with Barhee strain number three when it was pollinated by Kerdasa pollen source at 6 days from spathe cracking comparing with other interactions in the first and second seasons, respectively.

Fruit Diameter (Cm): Fruit diameter was significantly affected by different Barhee strains, interaction between strain and pollen source or with pollination time as well as the interaction between strains, pollen source and pollination time in the two seasons (Table 7). Whereas, pollen source and pollination time or the interaction between them did not show any significant effect on fruit diameter in both seasons. Whatever, there is no significant differences between fruit diameter of Barhee strain number 1 and 4 during both seasons which were the widest comparing with strain 3 and 2, respectively. Also, Kerdasa pollen source increased fruit diameter comparing with Maraziek and Fayoum pollen sources in both seasons.

The interaction between strain and pollen source cleared that highest fruit diameter was recorded from the interaction between strain four with Kerdasa pollen source comparing with other interactions in the two seasons. Also, the highest fruit diameter was obtained from the interaction between strain four when it was

Table 7: Effect of pollen source and pollination time on fruit diameter (cm) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	2.40	1.87	2.07	2.27	2.15	2.57	1.93	2.17	2.33	2.25
	4 days	2.43	1.93	2.20	2.50	2.26	2.53	2.17	2.30	2.53	2.38
	6 days	2.60	2.07	2.30	2.43	2.35	2.53	2.17	2.40	2.56	2.41
Mean		2.48	1.96	2.19	2.40	2.25	2.54	2.09	2.29	2.47	2.35
Kerdasa	2 days	2.63	1.93	2.23	2.77	2.39	2.70	1.93	2.23	2.80	2.41
	4 days	2.77	2.10	2.20	2.80	2.47	2.80	2.10	2.40	2.87	2.54
	6 days	2.77	2.17	2.30	2.77	2.50	2.90	2.27	2.57	2.90	2.66
Mean		2.72	2.07	2.24	2.78	2.45	2.80	2.10	2.40	2.86	2.54
Maraziek	2 days	2.47	2.00	2.23	2.70	2.35	2.70	2.00	2.27	2.73	2.42
	4 days	2.43	1.87	2.00	2.63	2.23	2.83	2.00	2.40	2.80	2.51
	6 days	2.43	1.87	2.20	2.53	2.26	2.97	2.00	2.47	2.93	2.59
Mean		2.44	1.91	2.14	2.62	2.28	2.83	2.00	2.38	2.82	2.51
2 days		2.50	1.93	2.18	2.58	2.30	2.66	1.95	2.22	2.62	2.36
4 days		2.54	1.97	2.13	2.64	2.32	2.72	2.09	2.37	2.73	2.48
6 days		2.60	2.04	2.26	2.58	2.37	2.80	2.15	2.48	2.80	2.55
Mean		2.55	1.98	2.19	2.60	2.33	2.73	2.06	2.36	2.72	2.46

LSD at 5% level for:	First season	Second season
Strain (A)	= 0.24	= 0.28
Pollen source (B)	= N.S.	= N.S.
A X B	= 0.43	= 0.49
Pollination time (C)	= N.S.	= N.S.
A X C	= 0.43	= 0.49
B X C	= N.S.	= N.S.
A X B X C	= 0.74	= 0.86

pollinated at 6 days in the first season or strains one and four with pollination at 6 days in the second season comparing with other interaction in this field. Moreover, the highest fruit diameter was noticed by Kerdasa pollen source when it was used in pollination at 6 days of spathe cracking comparing with other interactions in this concern during both seasons.

On the other side fruit diameter was the biggest with strain four when it was pollinated by Kerdasa pollen source within 4 days of spathe cracking comparing with other interactions in this concern in the first season. Whereas, the biggest diameter was confirmed with the interaction between strain one pollinated by Maraziek pollen source at 6 days of spathe cracking in the second season.

Fruit Moisture (%): Tabulated date in Table 8 clear that all results of fruit moisture content were significantly affected by strain, pollen source, pollination time and interaction between them during both seasons. Barhee strain number two produced fruits that had the highest fruit moisture content followed by strains number 3, 1 and four in the first and second seasons, respectively. Maraziek pollen source increased fruit moisture content comparing with Fayoum and Kerdasa pollen sources in the two seasons, respectively. Also, pollination at 2 days of spathe cracking increased the values of fruit moisture content comparing with other pollination times in the two seasons.

Barhee strain number two which was pollinated by Maraziek pollen source produced the highest fruit moisture content comparing with other interaction in this respect. Also, Barhee strain two which was pollinated at 2 days from spathe cracking gave the highest fruit moisture content comparing with other interactions in the two seasons. Moreover, using pollens from Fayoum in the first season or Maraziek in the second season produced the highest fruit moisture content when it was applied at two days of spathe cracking.

Referring to the interaction between strain, pollen source and pollination time, the highest fruit moisture content was recorded with strain two which was pollinated by Maraziek pollen source at two days of spathe cracking comparing with other interactions in the two seasons. Whereas, strain four pollinated by Kerdasa pollen source at 6 days after spathe cracking produced the lowest fruit moisture content in this respect during both seasons.

Table 8: Effect of pollen source and pollination time on fruit moisture (%) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	67.65	67.48	68.42	65.51	67.26	66.39	67.40	66.79	65.55	66.53
	4 days	66.17	66.40	65.62	63.48	65.42	66.07	66.48	65.55	63.22	65.33
	6 days	65.49	66.00	65.21	60.89	64.40	65.78	65.60	65.44	63.03	64.96
Mean		66.44	66.63	66.42	63.29	65.69	66.08	66.49	65.93	63.93	65.61
Kerdasa	2 days	66.48	68.00	67.61	64.28	66.59	65.81	68.22	67.33	64.55	66.48
	4 days	63.63	66.54	66.53	60.65	64.34	62.93	66.19	66.52	60.42	64.01
	6 days	63.58	66.55	64.37	60.00	63.62	61.25	66.00	64.33	60.03	62.90
Mean		64.56	67.03	66.17	61.64	64.85	63.33	66.80	66.06	61.67	64.46
Maraziek	2 days	66.00	68.58	67.59	64.67	66.71	66.03	68.23	67.36	64.56	66.54
	4 days	65.00	68.45	67.28	64.53	66.31	65.32	67.90	66.29	64.34	65.96
	6 days	64.86	67.50	65.56	63.51	65.36	64.88	67.59	65.43	63.36	65.31
Mean		65.29	68.18	66.81	64.24	66.13	65.41	67.91	66.36	64.09	65.94
2 days		66.71	68.02	67.87	64.82	66.85	66.08	67.95	67.16	64.89	66.52
4 days		64.93	67.13	66.48	62.89	65.36	64.77	66.86	66.12	62.66	65.10
6 days		64.64	66.68	65.05	61.47	64.46	63.97	66.40	65.07	62.14	64.39
Mean		65.43	67.28	66.47	63.06	65.56	64.94	67.07	66.12	63.23	65.34

LSD at 5% level for:	First season	Second season
Strain (A)	= 0.84	= 0.89
Pollen source (B)	= 0.72	= 0.77
A X B	= 1.45	= 1.54
Pollination time (C)	= 0.72	= 0.77
A X C	= 1.45	= 1.54
B X C	= 1.26	= 1.33
A X B X C	= 2.52	= 2.67

Table 9: Effect of pollen source and pollination time on fruit TSS (%) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	30.77	20.33	30.77	33.40	28.82	30.97	20.27	31.23	33.57	29.01
	4 days	33.47	20.43	34.57	34.00	30.62	33.63	20.67	35.70	34.60	31.15
	6 days	34.53	22.80	34.93	34.47	31.68	35.90	23.33	35.73	34.73	32.42
Mean		32.92	21.19	33.42	33.96	30.37	33.50	21.42	34.22	34.30	30.86
Kerdasa	2 days	32.13	21.10	32.43	32.10	29.44	32.67	22.43	33.53	33.47	30.52
	4 days	35.27	21.73	35.63	35.47	32.02	36.10	24.27	36.37	36.50	33.31
	6 days	36.90	23.83	36.90	36.20	33.46	37.90	24.33	37.76	37.03	34.25
Mean		34.77	22.22	34.99	34.59	31.64	35.56	23.68	35.89	35.67	32.69
Maraziek	2 days	33.73	20.73	32.90	32.60	29.99	33.77	20.73	33.10	33.83	30.36
	4 days	36.70	22.50	34.64	35.93	32.45	36.83	22.67	36.17	36.90	33.14
	6 days	36.73	22.53	36.80	36.50	33.14	37.93	22.67	37.67	37.03	33.82
Mean		35.72	21.92	34.78	35.01	31.86	36.18	22.02	35.65	35.92	32.44
2 days		32.21	20.72	32.03	32.70	29.42	32.47	21.14	32.62	33.62	29.96
4 days		35.15	21.55	34.95	35.13	31.70	35.52	22.54	36.08	36.00	32.53
6 days		36.05	23.05	36.21	35.72	32.76	37.24	23.44	37.05	36.26	33.50
Mean		34.47	21.77	34.40	34.52	31.29	35.08	22.37	35.25	35.29	32.00

LSD at 5% level for:	First season	Second season
Strain (A)	= 0.61	= 0.68
Pollen source (B)	= 0.53	= 0.59
A X B	= 1.06	= 1.18
Pollination time (C)	= 0.53	= 0.59
A X C	= 1.06	= 1.18
B X C	= 0.92	= 1.02
A X B X C	= 1.84	= 2.05

Table 10: Effect of pollen source and pollination time on fruit total sugars (%) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	25.58	16.47	23.30	26.40	22.94	25.71	16.73	24.20	26.97	23.40
	4 days	27.43	17.37	24.70	27.47	24.24	29.57	17.60	25.03	27.94	25.03
	6 days	28.13	17.33	25.47	28.34	24.82	29.29	17.70	26.51	29.43	25.73
Mean		27.05	17.06	24.49	27.40	24.00	28.19	17.34	25.25	28.11	24.72
Kerdasa	2 days	26.53	17.67	26.47	26.20	24.22	27.07	17.76	27.37	27.30	24.87
	4 days	28.96	17.83	27.27	27.17	25.31	28.68	17.96	28.10	28.23	25.74
	6 days	29.53	18.23	28.67	28.64	26.27	29.77	18.33	29.56	29.66	26.83
Mean		28.34	17.91	27.47	27.34	25.27	28.51	18.02	28.34	28.40	25.81
Maraziek	2 days	27.65	17.87	26.91	27.77	25.05	28.73	17.98	26.93	27.82	25.36
	4 days	29.07	18.47	27.97	28.27	25.94	29.96	18.52	28.21	29.17	26.46
	6 days	29.60	18.93	28.37	28.83	26.43	29.94	18.93	29.87	29.77	27.13
Mean		28.77	18.42	27.75	28.29	25.81	29.54	18.48	28.34	28.92	26.32
2 days		26.59	17.34	25.56	26.79	24.07	27.17	17.49	26.17	27.36	24.54
4 days		28.49	17.89	26.65	27.64	25.16	29.40	18.03	27.11	28.45	25.74
6 days		29.09	18.16	27.50	28.60	25.84	29.67	18.32	28.65	29.62	26.56
Mean		28.06	17.80	26.57	27.68	25.02	28.75	17.95	27.31	28.48	25.61
LSD at 5% level for:					First season						Second season
Strain (A)					= 0.55						=0.53
Pollen source (B)					= 0.47						=0.46
A X B					= 0.95						=0.92
Pollination time (C)					= 0.47						= 0.46
A X C					= 0.95						= 0.92
B X C					= 0.83						=0.80
A X B X C					= 1.66						=1.60

Fruit Total Soluble Solids% (TSS): Fruit soluble solids content (TSS) was varied significantly affecting by strain, pollen source, pollination time and different interactions between them during both seasons (Table 9). Barhee strain number 4 produced the highest TSS fruit content followed by strains 1, 3 and 2 in the first season, respectively. Whereas, Barhee strain 4 had the highest value in this respect followed by strains number 3, 1 and 2 in the second season, respectively.

Using pollens from Maraziek in the first season or from Kerdasa in the second season increased TSS fruit content comparing with other pollen sources in the two seasons. Moreover, pollination at 6 days increased TSS fruit content comparing with that done at 4 or 2 days of spathe cracking in the two seasons, respectively. The highest TSS fruit content was also detected from the interaction between Barhee strain three with Maraziek pollen source comparing with other interactions in the two seasons. Also, strain 3 which was pollinated at 6 days after spathe cracking produced the highest TSS fruit content comparing with other interactions in this field during both seasons. In addition, pollination using Kerdasa pollen source at 6 days of spathe cracking increased TSS fruit content comparing with other interactions in this field during both seasons.

The interaction between strains, pollen source and pollination time revealed that highest TSS content was noticed with strain number 1 which was pollinated by Kerdasa pollen source at 6 days of spathe cracking in the first season. In the second season, the highest value of TSS content was observed with the interaction between strain number 1 pollinated by Maraziek pollen source at 6 days after spathe cracking. Whatever, strain number 2 is characterized by lower content of TSS affecting by all factors and interactions between them comparing with the other three strains which had higher TSS content during two seasons.

Fruit Total and Reducing Sugars (%): Fruit total and reducing sugars content was significantly differed affecting by strains, pollen source, pollination time and interactions between them during both seasons (Tables 10 and 11). Barhee strain one produced the highest fruit total and reducing sugars content comparing with other Barhee strains. Also, Maraziek pollen source increased fruit total and reducing sugars content comparing with other pollen sources used in the two seasons. In addition, pollination at 6 days of spathe cracking increased fruit total and reducing sugars content in the first and second seasons comparing with other pollination times.

Table 11: Effect of pollen source and pollination time on fruit reducing sugars (%) of four Barhee seedling strains during 2005 and 2006 seasons

		First season 2005					Second season 2006				
Pollen source	Pollination time after spathe cracking	Strain 1	Strain 2	Strain 3	Strain 4	Mean	Strain 1	Strain 2	Strain 3	Strain 4	Mean
Fayoum	2 days	17.98	12.07	16.90	20.27	16.80	18.08	12.10	17.80	20.64	17.15
	4 days	20.16	12.97	18.02	19.90	17.76	22.07	12.93	18.50	20.47	18.49
	6 days	20.65	13.20	18.30	20.77	18.23	21.66	14.03	18.54	21.63	18.96
Mean		19.60	12.75	17.74	20.31	17.60	20.60	13.02	18.28	20.91	18.20
Kerdasa	2 days	20.40	13.24	19.87	19.43	18.23	20.40	13.23	20.64	19.86	18.53
	4 days	21.36	13.56	20.57	19.87	18.84	21.04	13.68	21.22	20.68	19.15
	6 days	22.83	14.23	20.80	19.87	19.43	22.90	14.23	21.64	20.79	19.89
Mean		21.53	13.68	20.41	19.72	18.83	21.45	13.71	21.17	20.44	19.19
Maraziek	2 days	21.22	14.00	20.71	21.10	19.26	22.33	14.28	21.06	21.72	19.85
	4 days	21.24	14.07	21.24	20.84	19.35	22.13	14.32	21.11	21.84	19.85
	6 days	22.83	14.86	20.40	21.26	19.84	23.17	14.87	21.81	22.15	20.50
Mean		21.76	14.31	20.78	21.07	19.48	22.54	14.49	21.33	21.90	20.07
2 days		19.87	13.10	19.16	20.27	18.10	20.27	13.20	19.83	20.74	18.51
4 days		20.92	13.53	19.94	20.20	18.65	21.75	13.64	20.28	21.00	19.16
6 days		22.10	14.10	19.83	20.63	19.17	22.58	14.38	20.66	21.52	19.78
Mean		20.96	13.58	19.64	20.37	18.64	21.53	13.74	20.26	21.09	19.15
LSD at 5% level for:					First season					Second season	
Strain (A)					= 0.58					= 0.57	
Pollen source (B)					= 0.50					= 0.49	
A X B					= 1.01					= 0.98	
Pollination time (C)					= 0.50					= 0.49	
A X C					= 1.01					= 0.98	
B X C					= 0.87					= 0.85	
A X B X C					= 1.75					= 1.71	

Barhee strain one which was pollinated by Maraziek pollen source produced the highest fruit total and reducing sugars content comparing with other interactions in this field during both seasons. In addition, Barhee strain one that pollinated at 6 days of spathe cracking developed fruits that contained the highest content of total and reducing sugars comparing with other interactions in the two seasons. Moreover, pollination by pollens from Maraziek region at 6 days after spathe cracking increased fruit total and reducing sugars comparing with other interaction in the two seasons.

Concerning the interaction between strain, pollen source and pollination time, the highest content of fruit total and reducing sugars was obtained from strain one that pollinated by Maraziek pollen source at 6 days of spathe cracking. Whatever, Barhee strain number two is characterized by inferior content of total and reducing sugars comparing with other strains in the two seasons.

DISCUSSION

The obtained results indicated that selection of the suitable male pollinators and pollination time is great importance for improving the productivity and fruit quality of different date palm cultivars. Fruit quality (fruit and flesh weight, fruit length and diameter, fruit size, fruit TSS and fruit sugars content) was affected significantly by pollen source and pollination time [3, 4, 6, 8, 9, 11, 12]. All the above fruit properties were increased by delaying pollination from 2 to 6 days after spathe opening [4, 7, 14]. The receptivity of female flowers reaches its optimum within three to four days after spathe cracking [11]. Whatever, the increasing in fruit quality when pollination was done at 6 days might due to the decreasing fruit retained; thus there is low competition between fruits comparing with the highest fruit retained percentage. Kerdasa pollen source had increased the most of fruit properties under study in the two seasons comparing with other pollen sources (Maraziek and Fayoum).

On the other hand, the differences in fruit retained and quality between different Barhee strains under study are also affected by strain genotypes of Barhee palm [23]. Barhee strains number one and four produced the highest fruit and flesh weights, TSS and total sugars contents. There fruits were the nearly similar in shape (spherical to ovate) and the most of fruit properties. Whereas, fruit of Barhee strain number three was tended to looks like semi dry fruits, however, its shape had the elongate shape. On the other hand, strain number two

produced the lowest fruit weight, length and its contents of TSS and total sugars. It is tended to produce fruits of aborted seeds (Fig. 1). Finally, the interaction between pollen source and pollination time had affect significantly all studied fruit characters for all Barhee strains fruits.

In conclusion: it is admitted according to the results of the previous study that strains number one and four produced fruits having nearly the characteristics of Barhee cv. Fruits. However, strain number three developed fruits had the characteristics of semi dry date palms. While strain number two need more investigation aiming to increase fruit weight and dimensions as it produce aborted seed (seedless fruits). Regarding to pollen source and pollination time, Kerdasa pollen grains is the best source for pollination of the studied Barhee strains. Also, the suitable pollination time is existed within 4-6 days of spathe cracking.

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