International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Chemical composition of pollen grains and its effect on yield and fruit quality of Barhee date palm

*Samy EL-Kosary, Ayman Shaban and Abdelrahman Hasseb**

Pomology Department, Faculty of Agriculture, Cairo University, Giza, Egypt

Abstract

The field experiment was designed to evaluate some date palm male pollinizers (Jarvis, Ghanamy, and Maghal) for recommendation of the best pollinizer for Barhee date palm trees grown at private orchard located near El-Sadat city, Egypt. Chemical composition of tested pollen grains was moisture (6.9 - 9.6%), ash (5 - 5.2%), fats (1.87 - 2.21%), and protein (15.8-17.5%). Minerals content such as calcium was (0.26 - 0.37%), zinc (57.5 – 76.1 mg/kg) and boron (11.5 - 12.3 mg/kg). Pollen grains of Jarvis recorded the highest viability and germination. The obtained data revealed that Jarvis was superior in the yield components (Bunch weight, retained fruits, fertilized fruits, fruit weight, and yield/palm) followed by Ghanamy and Maghal pollinizer, respectively. Also, Jarvis gave the highest fruit physical properties i.e, length, diameter, shape index, seed weight. The highest fruit chemical properties were obtained by using Jarvis as a pollinizer especially for fruit Tss, Tss/Acidity ratio, total sugars and total carotenoids content. Jarvis and Ghanamy are considered a promising pollen source for Barhee date palm cultivar.

Keywords: Pollen chemical analysis; Jarvis; Ghanamy; Pollinizers; Date palm; Pollination.

Full length article **Corresponding Author*, e-mail: abdelrahman.m.mahmoud@agr.cu.edu.eg

1. Introduction

The date palm (*Phoenix dactylifera* L.) belongs to the genus Phoenix of the palm family (Arecaceae) distributed in the subtropical and tropical region of the ancient world [1]. It thrives in hot conditions and can stand a certain degree of soil salinity as long as the roots receive a regular content of water, mostly provided by irrigation [2-3]. In 2020, the global production volume of dates amounted to about 9.45 million metric tons. Egypt recorded the first rank among other countries in dates production with 1,747,714 tons in 2021 as18% of the world production [4]. Date palm pollination naturally occurs by the action of wind. But it is not sufficient for commercial production. So, it is necessary to do the artificially pollination for commercial production. Artificial pollination practices should be applied to female spathes to ensure satisfying yielding traits usually by maintaining male strands between female strands [5, 6]. Nowadays, with palm derived from tissue culture incompatibility or partial incompatibility between different female and male cultivars is common but poorly understood. Only one ovule in each flower is fertilized and producing a single fruit [7]. The yield of date palms is mainly determined by the fruit set percentage **(**FSP) of the racemes. This relies on numerous factors such as the date palm pollen (DPP) source and quality, pollination time, pollination technique, and female-male compatibility [7]. In commercial plantations, the female palms are artificially pollinated (hand or mechanical pollination) with pollen from male palms. Different sources of pollen grains can lead to many variations in fruit set, color, size, shape, fruit-weight, seed-weight, percentage of flesh, and seedless fruit formation is referred to metaxenia effect [8]. In earlier studies, various researchers investigated the floral characteristics of male palms and their pollen effects on yield components [9,8,10]. It is a well-known fact that some males are highly potent as compared to others which contribute to an increase in fruit set and yield due to vegetative and floral characteristics [11,12]. Pollinating "Barhee" date palms with “Boyer” and “Dayyat1” male palms gave the highest fruit set. Also, the highest fruit weight was recorded when female palms were pollinated with “Mejhool” and “Aqaba” males [13]. Using Ghanamy as pollen source, the most significant fruit set and bunch weights were recorded. While, Fard pollen produced the highest fruit weight, length, diameter, flesh weight and thickness, and flesh percentage when compared to Boyer and Sewy pollens [14]. Date palm Barhee cultivar has many problems in the pollination, which cause an unsatisfied production economic yield, and production of a big amount of the “seedless” or “shees” fruits (non-economic fruits) [15]. Low fruit set was found widely among tissue culture-produced Barhee palms of Barhee cultivar with most flowers, in such trees, turn into parthenocarpic fruitlets having three carpels [16].

Therefore, the present investigation aimed to study the effect of different pollen sources to overcome the pollination problems and optimize Barhee date palm yield and fruit quality.

2. Materials and Methods

2.1. Experimental location and plant material

This experiment was conducted on seven years old Barhee date palm cultivar during 2020 and 2021 seasons. The chosen palms were produced through a tissue culture procedure. They were uniform in size and grown in a private orchard located near El-Sadat city, Egypt (30°15'47.0"N 30°40'19.3"E).

2.2. Collection of pollen grains from different sources

The strands of Ghanamy, Jarvis and Maghal (which are commonly used in pollination from Fayoum region) were detached and spread in a thin layer on paper sheets 4-5 days till drying under shadow place.

2.3. Pollination method

Pollen grains were collected during flowering time from the tested pollinizers (Ghanamy, Jarvis and Maghal) and prepared for conducting the pollination process. Nine female Barhee dates were selected as three female palms for each pollen source, one palm for each replicate. The quantity of bunches was fixed to be eight for each palm. The pollination process was done just after spathe cracking (during March and April in the studied seasons). 10 male strands were inserted inside the female spathe. Then, the pollinated spathes were covered with perforated paper bags (60x30cm). Thereafter, the bags were removed after four weeks of pollination.

2.4. Measurements

2.4.1 Pollen viability

Aceto-carmine test (2%): Carmine shows the presence of cytoplasm. The pollen nucleus is rich in chromatin material and viable pollen stains pink to deep red with aceto-carmine. While sterile (mostly shriveled) pollen does not accept any stain and thus remains mainly white and transparent [17].

2.4.2. Pollen germination

Pollen germination test was done according to [18]. The germination medium which contains 5% sucrose, 0.20 g/L boric acid, 0.42 g/L calcium nitrate, 0.1 g/L potassium nitrate and 0.22 g/L magnesium sulfate was solidified by adding 1% agar. Then, the medium was autoclaved for 15 mins at 120°C. The germination medium was poured into the petri dishes and was allowed to cool for 30 mins, then the pollen grains dusting process was done for the tested pollinizers and incubated in dark area for 24 hours. The examination of pollen germination percentage was calculated by observing 5 random fields for each petri dish as one replicate. The percentage was calculated for each pollinizer with three replicates.

2.4.3. Pollen grains chemical composition

Moisture content, ash, crude fat, and crude protein were determined for tested pollen grains of selected pollinizers according to the Official Methods of Analyses. Concentrations of calcium and zinc (Ca, Zn) of pollen grains were determined using Atomic Absorption Spectrometry as described in [19]. Boron was measured by ICP spectrometer (Agilent 8800, CA, USA). Total phenolic content was determined using Folin–Ciocalteu reagent using gallic acid as the standard [20].

2.4.4. Fruiting parameters

Ten strands were randomly chosen from each replicate of each treatment for determining the percentage of fertilized fruits, unfertilized fruits and fruits retained as the following equations, at Khalal stage:

$$\text{Fertilized fruit (\%)} = \frac{no.of Fertilized\ fruits/strand}{Total\ scares\ no.per\ strand} \times 100$$

$$\text{Unfertilized fruit (\%)} = \frac{no.of seedless\ fruits/strand}{Total\ scares\ no.per\ strand} \times 100$$

$$\text{Retained fruit (\%)} = \frac{no.of retained\ fruits/strand}{Total\ scares\ no.per\ strand} \times 100$$

2.4.5. Bunch weight

Barhee date palm trees were harvested at maturity stage at the end of khalal stage (at full color stage). Each bunch was weighted individually to determine the bunch's weight. Then, the yield per palm was estimated and tabulated

2.4.6. Fruit physical characteristics

Fifteen fruits were picked from each bunch (replicate) per each treatment to determine the following fruit physical characteristics:

• Fruit weight: The average fruit weight (g) was determined by weighing 10 fruit samples from each replicate, by using a digital balance.

• Flesh weight and seed weight: After separation of the seeds from fruit samples, the flesh and seed weight (g) were determined by weighing each of them separately and the average weight was estimated.

• Flesh/seed ratio: It was determined by dividing the flesh weight by seed weight.

• Fruit dimensions: Fruit length (L) and diameter (D) were measured by cm using Vernier caliper.

• Shape index (L/D): Shape index was calculated by dividing length by diameter.

2.4.7. Fruit Chemical characteristics

• Total Soluble Solids (TSS Brix): A sample of 5 fruits flesh from each replicate was collected and minced. The collected paste was squeezed. The TSS was measured using a hand refractometer according to [21].

• Total acidity (%): It was estimated by titration 5 fruit juice samples from each replicate. The titratable acidity was done by titrating the known volume of juice with NaOH using phenolphthalein as indicator then calculated as malic acid according to [22].

• TSS/Acid ratio: It was calculated by dividing TSS percentage by acidity percentage.

• Total sugars: Total sugars (mg/g) were determined as described by Dubois [23].

• Total Carotenoids: Total carotenoids content was calculated according to Jensen [24] as µg /g of fresh weight by using the following formulae:

Total Carotenoids (µg/g) = 7.6 (OD480) – 1.49 (OD510) x (V/1000) x (W), where OD = optical density, V = final volume of 80 % acetone, W = sample weight.

2.5. Statistical analysis

This experiment was designed as a Randomized Complete Block Design (RCBD). It contained three treatments and each treatment contained three replicates as one palm tree for each replicate. The experimental data were analyzed by analysis of variance (ANOVA) using the general linear models ‘‘GLM’’ procedure. Statistical analyses were performed using SAS software (version 9.0; SAS Institute, Cary, NC). For all analyses, significant differences between treatments ($p \leq 0.05$) were assessed by means of multiple Duncan range tests [25].

3. Results and Discussion

3.1. Pollen viability – germination tests

Pollen viability and germination of the tested pollinizers showed that there were significant differences between them. Jarvis recorded the highest viability and germination followed by Ghanamy and Maghal recorded lowest values (Fig. 1).

3.2. Chemical composition of pollen grains

Results in Table 1 showed that Jarvis pollen grains contained the highest moisture percentage followed by Ghanamy and Maghal pollens, respectively. Concerning ash%, the highest values were found with Jarvis pollen grains, while Ghanamy and Maghal recorded lower and similar values. Total phenols and fats were the highest in Jarvis pollen grains followed by Maghal then Ghanamy which recorded the lowest values. Regarding protein %, Maghal pollen grains contained the highest value followed by Jarvis and Ghanamy. Mineral content of pollen grains differed between the tested pollinizers as shown in Table 1. The highest values of calcium were detected in Ghanamy pollen grains followed by Jarvis. On the contrary, Maghal pollen grains ranked the lowest in this concern. The highest zinc content was concomitant to Jarvis and Ghanamy pollen grains, respectively. The reverse was true with Maghal, which led to the poorest grains in their zinc content. Boron content was the highest in Maghal followed by Jarvis pollen grains. Meanwhile, the lowest boron content was detected in Ghanamy pollen grain**.**

3.3. Fruiting and yield components

Results in Table 2 showed that the highest fertilized fruit percentage was recorded with using Jarvis and Ghanamy pollen grains respectively. While using Maghal pollen grains recorded the lowest fertilized fruit percentage. Regarding unfertilized fruit percentage, it was significantly increased with using Maghal pollen grains. While, using Jarvis and Ghanamy pollen grains decreased unfertilized fruits. About retained fruit percentage, it could be observed that using Jarvis pollen grains showed the highest retained fruit percentage followed by Ghanamy. Meanwhile, the lowest retained fruit percentage was obtained by using Maghal pollen grains. The effect of different pollen grain sources significantly affected yield (kg/palm), bunch weight (kg) and fruit (g) of Barhee date palm as shown in Table 2. Concerning palm yield, Barhee bunch weight was the heaviest with using Jarvis followed by Ghanamy pollen grains. While the lightest ones were detected with Maghal pollen grains. The obtained data regarding bunch weight is considered as indicator for palm yield. Thus, Barhee palm yield had the same trend of result affecting by different pollen grain sources as resulted from bunch weight. Concerning the effect of pollen grain sources on fruit weight, the data revealed that using Jarvis pollen grains gave the highest fruit weight followed by Ghanamy. Whereas, using Maghal pollen grains recorded the lowest fruit weight. The enhancement date palm yield by different pollen grains sources were in agreement with earlier findings reported by [26] who reported that, fruit weight of Barhee was induced by Jarvis pollen grains compared to the other pollen grains sources. Also, Jarvis pollinizer recorded higher yield of Barhee than Shahani and Fard No. 4, Barhee palms pollinated with "Ghanamy" pollen grains produced the heaviest fruits and recorded when compared to any pollen grains sources the greatest values of fruit set % [27], using Ghanamy as pollinizer gave a higher fruit set and bunch weight when compared to Sabad and Sewy male pollinizers [5]. The highest significant fruit set percent and bunch weight of Barhee were recorded by Ghanamy pollen grains. On the other hand, the lowest bunch weight was found with Sewy and Fard pollen grains [14].

3.4. Fruit physical characteristics

Results in Table 3 showed the effect of different pollen grains sources on fruit length, diameter, fruit length/diameter, flesh weight, seed weight and flesh seed ratio of Barhee date palm. Regarding fruit length, the highest value was exhibited significantly by using Jarvis followed by Maghal and Ghanamy pollen grains. The same trend was noticed in fruit length/diameter. With regard to fruit diameter, the highest value was recorded with Jarvis followed by Ghanamy pollen grains. On the other side, Maghal pollen grains gave the lowest fruit diameter. Concerning flesh weight, the greatest values were found with Jarvis followed by Ghanamy pollen grains. On the contrary, Maghal pollen grains ranked statistically the lowest in this concern. Regarding seed weight, the differences were not relatively pronounced to be taken into consideration from the statistical standpoint. Flesh seed ratio enhanced with Ghanamy and Jarvis pollen grains compared to Maghal pollen grains. These results dealing with the enhancement of fruit physical properties due to pollen grains source went in line with the results of many studies.

It was found that pollen sources had significant effect on physical characteristics of dates such as flesh weight [28], seed weight [9], and fruit dimensions [29]. [12] reported that Ghanamy pollen grains recorded the higher fruit weight, length, diameter, flesh weight, flesh % compared to control. Barhee palms pollinated with Ghanamy pollen grains exhibited statistically the heaviest fruits and the highest values of pulp and seed weight as compared to any pollen grains sources. Also, Ghanamy pollen grains had significantly a positive effect on fruit length. However, pollen grains sources recorded similar values with no significant differences in fruit shape index [27]. Jarvis pollen is considered as the most suitable pollen source to benefit metaxenic effects on Barhee dates with a direct effect on the morphology and other characteristics of seed and fruit tissues. The highest value of pulp to seed ratio of Barhee dates was obtained with Jarvis pollen grains [27].

3.5. Fruit chemical characteristics

Fruit chemical characteristics for Barhee date palm significantly differed according to tested pollen grains sources were presented in Table 4. Fruit TSS was markedly

coupled with Jarvis pollen grains. Moreover, Ghanamy ranked statistically the second in fruit TSS. The reverse was true with Maghal, which induced significantly the poorest fruit in their TSS content. Concerning fruit juice acidity (%) of Barhee date palm as influenced by pollen grains source, it was quite evident that the highest value was detected with Maghal followed by Ghanamy. On the contrary, Jarvis ranked statistically the lowest in this concern. TSS/Acid ratio was influenced by the differential pollen grains source. Jarvis was statistically the superior and showed the greatest values in this concern followed by Ghanamy pollen grains. On the contrary, Maghal pollen grains recorded the lowest TSS/Acid ratio. Such trend of response could be logically explained depending upon the paralleled rates of changes exhibited in fruit juice TSS.

Regarding total sugars, the highest values were recorded with Jarvis and Ghanamy pollen grains. The reverse was true with Maghal pollen grains which ranked statistically the lowest values in this concern. Results in Table 4 indicated that carotenoids followed to great extent the same trend previously detected with total sugars percentage. Hence, the highest value in carotenoids was statistically concomitant to Jarvis and Ghanamy, respectively. As contrasting with using Maghal pollen grains led significantly to the poorest fruit in their carotenoids content.

The Previously illustrated results which demonstrate the enhancing effect of different pollen grains sources on chemical characteristics of Barhee date fruit were in agreement with the findings of [14] on Barhee [30] on Sabbaka and Nabbut-Ali; [31] on Zaghloul and [32] on Dhakki. However, other studies indicated low impact of pollen grains source on key chemical constituents of date fruits [7,15]. The highest value of TSS content was obviously recorded by the Barhee palms pollinated with "Ghanamy" pollen grains [27].

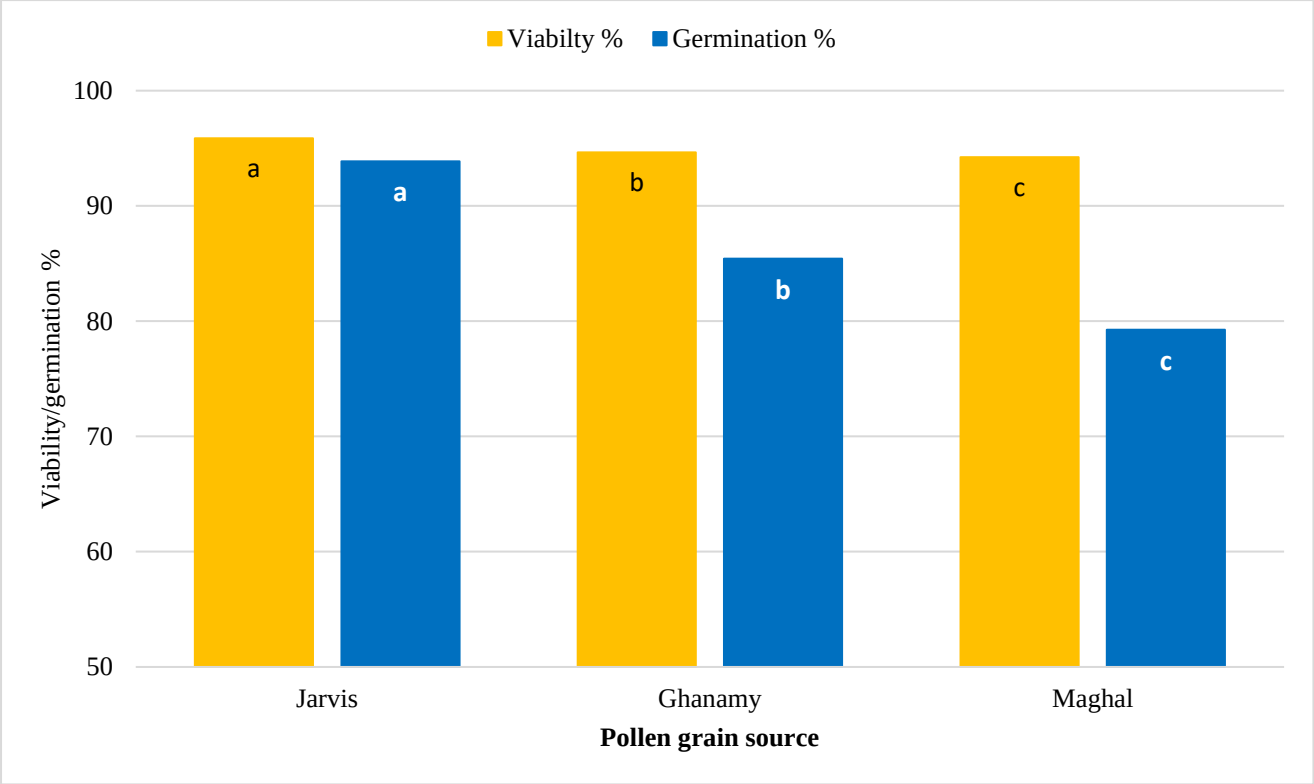

Fig. 1: Viability and germination percentages of the tested pollen grains.

Table 1: Chemical composition of pollen grains for Jarvis, Ghanamy and Maghal date palm

Chemical composition	Pollen Grain Sources		
	Jarvis	Ghanamy	Maghal
Moisture (%)	9.6a	7.6b	6.9c
Ash (%)	5.2a	5.0a	5.0a
Total Phenols (ppm)	1575.9a	683.6c	941.6b
Protein (%)	16.3b	15.8c	17.5a
Fats (%)	2.21a	1.87c	2.01b
Calcium (%)	0.33b	0.37a	0.26c
Zinc (mg/kg)	76.1a	63.1b	57.5c
Boron (mg/kg)	11.6b	11.5b	12.3a

*Values shown are means, within each row, different letters indicate significant differences according to means of multiple Duncan range tests ($P < 0.05$).

Table 2: Effect of different pollen grains sources on fruiting and yield components of female Barhee date palm (Average of the two seasons)

Parameters	Pollen Grain Sources		
	Jarvis	Ghanamy	Maghal
Fertilized fruits (%)	46.96^{a}	39.47^{b}	18.46^{c}
Seedless fruits (%)	2.05^{b}	1.58^{b}	17.52^{a}
Retained fruits (%)	52.39^{a}	40.86^{b}	36.10^{b}
Fruit weight (g)	19.51^{a}	18.72^{b}	18.15^{c}
Bunch weight (Kg)	16.22^{a}	12.90^{a}	5.64^{b}
Yield (Kg/ palm)	162.28^{a}	129.06^{a}	56.93^{b}

* Values shown are means, within each row, different letters indicate significant differences according to means of multiple Duncan range tests ($P < 0.05$).

Table 3: Effect of different pollen grains sources on fruit physical characteristics of female Barhee date palm (Average of the two seasons)

Parameters	Pollen grain sources		
	Jarvis	Ghanamy	Maghal
Fruit length (mm)	36.62^{a}	34.38^{c}	35.48^{b}
Fruit diameter (mm)	29.29^{a}	28.61^{a}	28.54^{a}
Fruit length/diameter	1.25^{a}	1.20^{a}	1.24^{a}
Flesh weight (g)	15.45^{a}	14.99^{a}	14.13^{b}
Seed weight (g)	4.07^{a}	3.73^{b}	4.02^{a}
Flesh/seed ratio	3.79^{ab}	4.02^{a}	3.51^{b}

* Values shown are means, within each row, different letters indicate significant differences according to means of multiple Duncan range tests ($P < 0.05$).

Table 4: Effect of different pollen grains sources on fruit chemical characteristics of female Barhee date palm (Average of the two seasons)

Parameters	Pollen Grain Sources		
	Jarvis	**Ghanamy**	**Maghal**
TSS (%)	26.58[a]	23.40[b]	18.33[c]
Acidity (%)	0.13[a]	0.15[a]	0.18[a]
TSS/Acid ratio	199.06[a]	167.11[b]	111.89[c]
Total sugars (mg/g)	47.61[a]	41.07[b]	30.93[c]
Carotenoids (mg/g)	47.93[a]	36.79[b]	26.26[c]

* Values shown are means, within each row, different letters indicate significant differences according to means of multiple Duncan range tests ($P < 0.05$).

4. Conclusions

It is admitted according to the results of the current study, Jarvis showed the highest values of yield components, physical and chemical characteristics of the resulting fruits. Thus, the selected pollinizers gave superior results compared to Maghal. Then, Jarvis and Ghanamy are considered a promising pollen source for Barhee date palm cultivar.

References

[1] A. Henderson. (2009). Palms of southern Asia (Vol. 50). Princeton University Press.

[2] A.A.M. Abd, D. A. Taain & E.A.A.M. Al-Thahab. (2019). Morphological study (vegetative and floral) of twelve date palm male cultivars. Plant Archives, 19, 1349-57.

[3] M. Tengberg. (2020). Date palm: origins and development. In Encyclopedia of Global Archaeology (pp. 3125-3128). Cham: Springer International Publishing.

[4] FAO. (2021). Food and Agriculture Organization of the United Nations.

[5] N. Ortiz-Uribe, R. Salomón-Torres & R. Krueger. (2019). Date palm status and perspective in Mexico. Agriculture, 9(3), 46. https://doi.org/10.3390/agriculture9030046.

[6] A. Gupta, R.K. Godara, V.K. Sharma & A.K. Panda. (2017). Artificial pollination: a tool for improving fruiting traits in date palm (*Phoenix dactylifera* L.). Chemical Science Review and Letters, 6: 1312-1320.

[7] A. Zaid & P. F. de Wet. (2002). Date palm cultivation. Abdelouahhab Zaid (ed.) Chapter II. FAO Plant production and protection.

[8] N.S. Al-Khalifah. (2006). Metaxenia: Influence of pollen on the maternal tissue of fruits of two cultivars of date palm (*Phoenix dactylifera* L.). Bangladesh Journal of Botany, 35(2), 151-161.

[9] A.S. Al-Ghamdi, G.M. Al-Hassan & M. Jahjah. (1988). Evaluation of eight seedling date palm (*Phoenix dactylifera* L.) males and their effects on fruit character of three female cultivars. Arab Gulf journal of scientific research: B: Agricultural and biological sciences, 6(2):175–187

[10] O.M. Hafez, M.A. Saleh, E.A.M. Mostafa, M.M. Naguib & N.E. Ashour. (2014). Effect of pollen grain sources on yield and fruit quality of Samany date palm. International Journal of Agricultural Research, 9(3), 164-168. https://doi.org/10.3923/ijar.2014.164.168.

[11] M. El-Nawam, Safaa. (2018). Metaxinic Effect of Some Male Date Palms on Zaghloul and Samany Fruits. Assiut Journal of Agricultural Sciences, 49(1), 96-109.

[12] E.E.G. Gadalla, A. Mohamed, H. Mahdy & S. Hosny. (2021). Effect of some male date palms on yield and fruit quality of Barhee cultivar. Egyptian International Journal of Palms, 1(1), 1-9. https://doi.org/10.21608/ESJP.2021.233431.

[13] J.A. Al-Muhtaseb & H.D. Ghnaim. (2006). Effect of pollen source on yield, quality and maturity of "Barhi" date palm. Jordan Journal of Agricultural Sciences, 2(2), 9-14.

[14] A.H. Al-Hamoudi, A.M. El-Hammady, I.M. Desouky & A. Abdel-Hamid (2006). Evaluation of some male types as pollinators for Barhi date palm cv. grown in Egypt. Arab Universities Journal of Agricultural Sciences, 14(1), 365-377. https://doi.org/10.21608/ajs.2006.15573

[15] E.M.A. Zaen El–Daen, S. El-Merghany & A. El-Rahman. (2017). Improving fruit set and productivity of Barhee date palm under heat stress conditions. Journal of Plant Production, 8(12), 1403-1408. https://doi.org/10.21608/jpp.2017.42017.

[16] Y. Cohen, R. Korchinsky & E. Tripler. (2004). Flower abnormalities cause abnormal fruit setting in tissue culture-propagated date palm (*Phoenix dactylifera* L.). The Journal of Horticultural Science and Biotechnology, 79(6), 1007-1013. https://doi.org/10.1080/14620316.2004.11511853.

[17] M.A. McKellar & K.H. Quesenberry. (1992). Chromosome-Pairing and Pollen Viability in *Desmodium ovalifolium* Wall× *Desmodium heterocarpon* (L) DC. Hybrids. Australian journal of botany, 40(2), 243-247. https://doi.org/10.1071/BT9920243.

[18] M. Mesnoua, M. Roumani, M.K. Bensalah, A. Salem & A. Benaziza. (2018). Optimization of conditions for in vitro pollen germination and pollen tube growth of date palm (*Phoenix dactylifera* L.).

Journal of Fundamental and Applied Sciences, 10(1), 158-167. https://doi.org/10.4314/jfas.v10i1.11.

[19] AOAC. (2010). Officials Methods of Analysis. Association of Official Analytical Chemists. (17th Ed.). Washington DC.

[20] V.L. Singleton, R. Orthofer & R.M. Lamuela-Raventós. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In Methods in enzymology (Vol. 299, pp. 152-178). Academic press. https://doi.org/10.1016/S00766879(99)99017-1.

[21] AOAC. (1995). Official methods of analysis (16th ed.). Association of Official Analytical Chemists. Washington, DC, USA.

[22] AOAC. (2005). Official Methods of Analysis (18th ed.). Association of Official Analytical Chemists; Arlington, VA, USA.

[23] M. Dubois, K.A. Gilles, J.K. Hamilton, P.T. Rebers & F. Smith. (1956). Colorimetric method for determination of sugars and related substances. Analytical chemistry, 28(3), 350-356. https://doi.org/10.1021/ac60111a017.

[24] A. Jensen. (1978). Chlorophylls and carotenoids. In Handbook of Phycological Methods: Physiological and Biochemical Methods; Hellebust, J.A., Craigie, J.S., Eds.; Cambridge University Press: Cambridge, UK, pp.59–70.

[25] D.B. Duncan. (1955). Multiple range and multiple F tests. Biometrics, 11(1), 1-42. https://doi.org/10.2307/3001478

[26] N. Mohammadi, S. Rastgoo & M. Izadi. (2017). The strong effect of pollen source and pollination time on fruit set and the yield of tissue culture-derived date palm (*Phoenix dactylifera* L.) trees cv. Barhee. Scientia Horticulturae, 224, 343-350. https://doi.org/10.1016/j.scienta.2017.06.031.

[27] A.E. Atawia, T.A.M. El-Akkad & H. Hassan. (2020).T. M. Effect of different sources of pollen grains on some physical and chemical fruit characters of barhy date palm cultivar. Annals of Agricultural Science, Moshtohor. 58(2), 331 – 338. https://doi.org/10.21608/ASSJM.2020.114891.

[28] M. Iqbal, A. Ghaffar & M. Munir. (2008). Effect of different date male pollinizers on fruit characteristics and yield index of date palm (*Phoenix dactylifera* L.) cultivars Zahidi and Dhakki. Pakistan Journal of Agricultural Research. 21 (1/4), 79-85.

[29] M. Rahemi. (1998). Effects of pollen sources on fruit characteristics of shahani date. Iran Agricultural Research, 17(2), 169-174.

[30] M.A. Awad & A.D. Al-Qurashi. (2012). Partial fruit set failure phenomenon in 'Nabbut-Ali'and 'Sabbaka'date palm cultivars under hot arid climate as affected by pollinator type and pollination method. Scientia Horticulturae, 135, 157-163. https://doi.org/10.1016/j.scienta.2011.12.0

[31] K.M. Farag, A.S. Elsabagh, & H.A. ElAshry. (2012). Fruit characteristics of "Zaghloul" date palm in relation to metaxenic influences of used pollinator. American-Eurasian Journal of Agricultural & Environmental Sciences, 12(7), 842-855. https://doi.org/10.5829/idosi.aejaes.2012.12.07.1803

[32] M.U.H.A. Shafique, A.S. Khan, A.U. Malik, M.U.H. Shahid, I.A. Rajwana, B.A. Saleem, M. Amin & I. Ahmad. (2011). Influence of pollen source and pollination frequency on fruit drop, yield and quality of date palm (*Phoenix dactylifera* L.) cv. Dhakki. Pakistan Journal of Botany, 43(2), 831-839.