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Effect of pollination methods on pollination efficiency and fruiting of Barhy date palm

El-Salhy, A.M.[1], A.S. Abdallah[2], A.H. Salem[3] and H.M.F. El-Nagar[2]
[1]Pomology Dept., Fac. Agric., Assiut University, Assiut, Egypt.
[2]Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.
[3]Hort. Dept., Fac. of Agric. & Natural Resources, Aswan University

Abstract

Pollination is a critical process in date palms production series that affects yield and fruit quality. This study aimed to evaluate the effect of different pollination methods (dusty pollen grain powder immediately after spraying with proline plus either citric acid, ascorbic acid or sugar solution) on yield and fruit quality of Barhy date palm. This study was conducted at El- Mataana Experimental Res. Station Hort. Res. Instit., Agric. Res. Center Esna district Luxor governorate, Egypt during 2021, 2022 and 2023 seasons.

Results showed that most beneficial treatment in this concern due to dusty female spathes with 20% pollen grains powder immediately after spraying with proline plus either citric acid or sugar solution) which gave economical yield with good fruit quality. Moreover, it improves the pollination efficiency where to save time, effort, labour and cost and more practical to it is a promising technique in the future.

Key words: Barhy date palm, pollen grain suspension, pollination, fruit quality.

Introduction

Date palm is a dioecious, perennial, diploid and nano-cotyledonous plant **[1]**. It is one of the main crops to grow in arid land of most countries of the Middle East and North Africa and affects the high proportion of the economics of these countries **[2]**.

Egypt is considered among the top ten date producers. Zaghloul, Samany, Hayany are

Corresponding author E-mail: hassanmohammd2020@gmail.com

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the most economically important date palm cultivars grown in Egypt. Date palm is grown in Egypt in both Nile Valley, and desert districts. The total area and number of females reached 177102 feddans and 15710250 palms. The produced yield reached 1847629 tons, according to **[3]**.

Since the date palm is a dioecious crop, the pollination process is carried out by wind or insects, which in turn leads to low quality fruit in dioecious species like the date palm, pollination is significant for fruit setting **[4]**. It is regarded as one of the most critical processes in date production, as fruit yield and quality are dependent on the proper application of pollen [**5,6,7,8]**. Therefore, to obtain a commercial production, artificial pollination methods must be used **[9,10]**. The most imperative yield of date development is a consequence of high fruit set percentage. The achievement of this rate relies upon a blend of a few variables, i.e. the quality of the pollen source, the pollination efficiency process, the compatibility of males and females as well as environmental conditions, irrigation, soil and fertilization **[11,12,13]**.

Building up a pollination procedure and change from the traditional method of pollinator to strategy pollinated by pollen grain-water suspension spray prompted improve the fruit set is perfect degree without thinning process has likewise improved the fruit quality. The utilization of the technique to pollinate with pollen suspension with water reduce labor effort and costs of thinning process [**9,13,14,15,16]**.

Mixing pollen grains with various carriers, nutrient minerals and ascorbic acid were beneficial in establishing mechanical pollination and obtaining an economical yield with good fruit quality. Also, it is responsible for enhancing pollination efficiency [**9,10,14,15,16,17,18]**.

So, the present study was done to assess various method for pollination effects on pollination efficiency and fruiting of Barhy date palm.

Materials and Methods

This study was conducted at El- Mataana Experimental Res. Station Hort. Res. Instit., Agric. Res. Center Esna district Luxor governorate during three consecutive seasons of 2021, 2022 and 2023 in which 10 tissue culture derived off shoot of Barhy date palms were

selected for achieving this study. The palms were planted at 6 x 7 meters apart (100 palms / fed.). The texture of soil is silty clay. The selected palms were at the same age and uniform in vigour. These palms were 28 years old at the start of study, good physical conditions and free from insects, damages and diseases. The selected palms were irrigated through surface irrigation system. Pruning was performed to maintain leaf bunch ratio at 8:1. The number of female spathes per palm was adjusted to 12 spathes by removing excess earliest, latest and small bunches. Pollination of the experimental palms was uniformly performed to avoid residues of metaxenia.

The number of spathes per palm were adjusted to 12 for achieving of the following six treatments:

1- Spraying proline and citric acid at 1000 ppm, then dusting of 20% pollen grain powder.
2- Spraying proline and sugar solution at 1000 ppm, then dusting of 20% pollen grain powder.
3- Spraying proline and ascorbic acid at 1000 ppm, then dusting of 20% pollen grain powder.
4- Spraying ascorbic acid at 1000 ppm, then dusting of 20% pollen grain powder
5- Spraying ascorbic acid at 1000 ppm, then dusting of 10% pollen grain powder
6- Hand pollination by inserting 8-10 strands/spathe (traditional hand)

These treatments were applied on the same palm. pollination was uniformed in respect of source and method to avoid residues of metaxenia.

The design of the experiment was completely randomized with ten replicates, two spathe per each.

Hand pollination as well as pollination treatment dusting were applied at third day of spathe cracking. dusting of pollen powder is thoroughly applied to the spathe by small hand spreader. To prevent contamination of pollens, after the dusting of pollen grain powder, every spathe was bagged by paper bags which is removed after four weeks.

The following parameters were determined to evaluate the effects of different pollination methods on fruiting.

Yield components and fruit quality:

Initial fruit set and fruit retention percentage were evaluated one month after

pollination and at harvest time, respectively. Five female strands per bunch were randomly selected from each replication, then the percentages were calculated as following equation

$$\text{Fruit set (\%)} = \frac{\text{No. of fruit setting on the strand}}{\text{Total number of flower per strand}} \text{x } 100$$

$$\text{Fruit retention (\%)} = \frac{\text{Number of retained fruits on the strand}}{\text{Number of retained fruit} + \text{Number of flowers scars}} \text{x } 100$$

At the harvest time, bunches of each palm were picked and weighted, then the yield/palm (kg) was recorded.

Sample of 50 fruits were taken randomly from each replicate to determine some physical and chemical properties.

These characteristics included the determination of fruit weight, fruit dimension, flesh percentage and fruit moisture percentage as well as TSS, sugar content, tannins and total acidity as outlined **[19]**.

All the obtained data were tabulated and analyzed to the proper statistical analysis according **to [20,21]**. The differences between treatment means were compared by Duncan's multiple range test at 5% level of probability **[22]**.

Results

1- Yield components:

Data illustrated in tables (1 & 2) show the effect of dusting pollen grains powder different concentration (10 or 20%) and ascorbic acid at 1000 ppm. As well as dusting pollen grain powder at 20% with proline plus either citric acid, sugar solution or ascorbic acid (1000 ppm) on fruit set, fruit retention percentages and bunch weight of Barhy date palm during 2021, 2022 and 2023 seasons. It is worth to mention that the fruit set, fruit retention percentages and bunch weight reacted almost similarly in the two studied seasons.

Fruit set, fruit retention percentages and bunch weight were significantly affected by different hand pollination methods during the three studied seasons. There are insignificant differences in fruit set and fruit retention percentages as well as bunch weight due to pollination by using either pollen grains dusting at 20% (T4) or 10% (T5) plus ascorbic acid. On other hand, pollination by pollen grains dusting at 20% after spraying with proline and citric acid (T1), with sugar solution (T2) or plus ascorbic acid (T3) significantly

increased these traits and had the highest values compared to traditional hand pollination (T6).

As for spraying, either citric acid, sugar solution or ascorbic acid with proline at 1000 ppm, before dusting pollen grain powder, data show that citric acid is the more effective followed by sugar solution and ascorbic acid. There are no significant differences due to use ascorbic acid or sugar solution acid. On other hand, using 10% pollen dusting plus ascorbic acid significantly decreased these studied traits compared to using 20% pollen grain dusting and proline plus either citric acid, sugar solution or ascorbic acid.

In this respect, it seems that the reduction in fruit set percentage and bunch weight could be explained as a result of decrease in pollen grain concentration in suspension. These findings emphasized that there is a positive correlation between the pollen grain amount and initial fruit set percentage.

Moreover, pollination dusting pollen grain powder 20% (T4) failed to induce any significant on fruit retention and bunch weight compared with using grain powder at 10% (T5). Whereas, the bunch weight significantly increased as response to pollen grain powder at 20% and proline plus either citric acid (T1), solution sugar (T2) or ascorbic acid (T3) compared with traditional hand pollination (T6).

The obtained fruit retention was (58.55 57.62, 56.92, 53.92, 51.92 and 40.42 % as an av. the three studied seasons) and bunch weight was (18.81, 18.63, 18.03, 17.02, 15.83 and 14.13% as an av. the three studied seasons) due to pollinate by dusting pollen grains powder at 20% after spraying proline and citric acid at 1000 ppm (T1), by dusting pollen grains powder at 20% after spraying proline and sugar solution at 1000 ppm (T2), by dusting pollen grains powder at 20% after spraying proline and ascorbic acid at 1000 ppm (T3), by dusting pollen grains powder at 20% after spraying ascorbic acid at 1000 ppm (T4), by dusting pollen grains powder at 10% after spraying ascorbic acid at 1000 ppm (T5) and traditional pollination (T_6), respectively. Hence the increment percentage of bunch weight attained (33.12, 29.94, 27.60, 20.45 and 12.20%) as an av. the three studied seasons) due to T_1, T_2, T_3, T4, T5 compared to T_6, respectively.

Thus, it could be concluded that there is a reduction on bunch weight with reducing

the pollen grain powder concentration where reduction on bunch weight was associated with decreasing the pollen grain powder dusting from 10 to 20%.

Table (1): Effect of pollination methods on yield components:

Treatment	Fruit set (%)				Fruit retention (%)				Bunch weight (Kg)			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
T1	75.33A	77.28A	79.45A	77.35A	56.63A	60.85A	58.16A	58.55A	18.43 A	19.15A	18.85A	18.81A
T2	74.28A	76.25A	78.86A	76.46A	56.91A	59.39A	56.55A	57.62A	18.11AB	18.65AB	18.31A	18.36A
T3	71.88AB	74.55AB	76.96AB	74.46A	56.85A	58.28A	55.63A	56.92B	17.88AB	18.10AB	18.10A	18.03A
T4	67.55B	70.48B	72.79B	70.27B	53.13B	55.46B	31.18B	53.92B	16.83B	17.29B	16.93B	17.02B
T5	63.90B	68.59B	68.60B	68.83B	49.36C	52.90C	50.79C	51.92B	15.49B	16.11B	15.90B	15.83C
Control (T6)	55.31C	58.11C	60.23C	57.88C	39.25D	41.89D	40.11D	40.42C	13.68C	14.16C	14.55C	14.13D
LSD at 0.05	5.89	5.93	6.27	3.66	2.38	2.64	2.91	2.42	1.39	1.81	1.18	0.91

Table (2): Effect of pollination methods on yield/ palm and some fruit quality (weight and length):

Treatment	Yield/ palm (kg)				Fruit weight (g)				Fruit length (cm)			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
T1	221.16A	229.80A	226.20 A	225.72A	14.53A	15.66A	15.51A	15.23A	2.78A	3.08A	3.01 A	2.96A
T2	217.32A	223.80AB	219.72A	220.28A	14.36A	15.51A	15.30A	15.06A	2.75A	3.04A	2.99A	2.93A
T3	214.56A	222.0AB	217.20AB	217.92A	15.45A	15.60A	15.46A	15.50A	2.78A	3.10A	3.03A	2.97A
T4	201.96B	207.48B	203.16B	204.20B	14.50A	15.69A	15.50A	15.23A	2.80A	3.05A	3.05A	2.97A
T5	185.88C	193.32B	190.80B	190.00C	14.39A	15.58A	15.43A	15.13A	2.76A	3.05A	2.97A	2.93A
Control (T6)	164.16D	169.92C	174.60C	169.56D	12.81B	13.81B	13.65B	13.41B	2.53B	2.81B	2.77B	2.70B
LSD at 0.05	15.48	16.53	16.18	9.78	0.52	0.71	0.63	0.37	0.09	0.09	0.08	0.05

Table (3): Effect of fertilization on some fruit quality (diameter, flesh and moisture).

Treatment	fruit diameter (cm)				Flesh (%)				Fruit moisture (%)			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
T1	2.45A	2.68A	2.63A	2.59A	92.86A	93.14A	92.35A	92.78A	50.68B	52.13B	51.24B	51.35C
T2	2.40A	2.65A	2.60A	2.55A	92.68A	2.96A	92.28A	92.64A	51.11B	52.54B	51.48B	51.71BC
T3	2.44A	2.70A	2.63A	2.59A	92.91A	93.10A	92.30A	92.77A	51.43B	52.88B	51.69B	52.00BC
T4	2.46A	2.70A	2.63A	2.60A	92.53A	93.26A	92.58A	92.79A	51.82B	53.19B	52.25B	52.42BC
T5	2.43A	2.65A	2.60A	2.56A	92.61A	92.93A	92.11A	92.55A	51.96B	53.31B	52.34B	52.54B
Control (T6)	2.26B	2.50B	2.39B	2.45B	90.38B	90.25B	89.33B	89.87B	53.67A	55.22A	54.18A	54.36A
LSD at 0.05	0.08	0.07	0.08	0.05	2.08	1.98	2.28	1.28	1.65	1.79	1.80	1.10

Table (4): Effect of fertilization on some fruit quality (TSS, total and reducing sugar):

Treatment	TSS(%)				total sugar(%)				reducing sugar(%)			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
T1	41.12A	39.25A	41.52A	40.63A	34.91A	33.16A	34.90A	34.32A	26.48A	24.16A	23.63A	25.42A
T2	40.28A	39.11A	41.16A	40.36A	34.70A	32.97A	34.85A	34.17A	26.32A	24.10A	25.46A	25.29A
T3	40.34A	39.15A	41.38A	40.29A	34.59A	33.10A	34.62A	34.10A	26.40A	24.16A	25.22A	25.26A
T4	40.11A	38.85A	41.10A	40.02A	34.35A	32.78A	34.48A	33.87A	26.13A	23.97A	25.19A	25.10A
T5	39.81A	39.10A	41.50A	40.29A	34.61A	32.96A	34.80A	34.12A	23.96A	23.86A	25.53A	25.12A
Control (T6)	38.83B	37.71B	39.18B	38.52B	33.10B	31.11B	32.52B	32.24B	25.20B	23.77B	23.90B	24.10B
LSD at 0.05	0.25	1.10	1.44	0.81	0.78	0.93	1.81	0.58	0.73	0.71	0.88	0.49

Table (5): Effect of fertilization on some fruit quality (non-reducing, acidity and Tannins).

Treatment	non-reducing				acidity				Tannins			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
T1	8.23A	8.80A	9.10A	8.70A	0.288B	0.299B	0.278B	0.288C	0.133B	0.138B	0.132B	0.134C
T2	8.30A	8.87A	9.39A	8.85A	0.292B	0.307B	0.288B	0.296BC	0.138B	0.143B	0.136B	0.139BC
T3	8.19A	8.94A	9.40A	8.84A	0.298B	0.314B	0.294B	0.302BC	0.141B	0.146B	0.138B	0.142BC
T4	8.22A	8.81A	9.29A	8.77A	0.302B	0.318B	0.296B	0.305BC	0.144B	0.148B	0.141B	0.144B
T5	8.0AB	9.0A	8.77AB	8.42B	0.310B	0.325B	0.301B	0.312B	0.145B	0.151B	0.143B	0.146B
Control (T6)	7.90B	7.94B	8.62B	8.15C	0.338A	0.356A	0.336A	0.343A	0.161A	0.168A	0.158A	0.162A
LSD at 0.05	0.26	0.31	0.36	0.19	0.024	0.028	0.031	0.018	0.013	0.015	0.013	0.008

Fruit quality:

1- Physical fruit properties:

Data presented in tables (2 & 3) show the effect of dusting pollen grains powder different concentration (10 or 20%) and ascorbic acid at 1000 ppm. As well as dusting pollen grain powder at 20% with proline plus either citric acid, sugar solution or ascorbic acid (1000 ppm) on physical fruit properties of Barhy date palm during 2021 , 2022 and 2023 seasons. It is obvious that results took similar trend during the three studied seasons. It was clearly noticed that there was a positive relationship between both improving the fruit physical characteristics in terms of increasing fruit weight, fruit dimension and flesh percentage in one side and pollination by dusting pollen grains powder at 20% with spraying proline plus either citric acid, sugar solution or ascorbic acid (1000 ppm) in the other side compared with traditional hand pollination (control). The improving on these characteristics was associated with dusting the pollen grain powder immediately after spraying proline plus citric acid or sugar solutions.

Moreover, there was an increasing on the fruit weight was recorded with pollination after spraying proline plus either citric acid, sugar solutions or ascorbic acid Such increase was significantly increased with using pollen grain powder at 10 or20% with any additions compared to control. The heaviest fruit were detected on palms pollinated with pollen grain powder at 20% with any additions.

The recorded fruit weight were (15.23, 15.06, 15.50, 15.23, 15.13 and 14.41g as an av. of the three studied seasons) due to T_1 to T_6, respectively. Hence, the increment percentage of fruit weight due to use pollen grain powder over control were attained (5.69, 4.51, 7.56, 5.69 and 5.00% as an av. of the three studied seasons) due to T_1 to T_5 compared to T_6, respectively. No significant differences in fruit weight were observed due to use pollen grain powder concentration namely 10 or 20% pollen grain powder.

2- Fruit chemical constituents:

It is evident from data in tables (4 & 5) that the pollination by dusting pollen grains

powder different concentration (10 or 20%) and ascorbic acid at 1000 ppm. As well as dusting pollen grain powder at 20% with proline plus either citric acid, sugar solution or ascorbic acid (1000 ppm) significantly improved the fruit chemical constituents in terms of increasing the total soluble solids and sugar contents and reduction the moisture content percentage, total acidity and tannins content compared to pollination by traditional hand pollination.

The recorded total soluble solids were (40.63, 40.36, 40.29, 40.02, 40.29 and 38.57 % as an av. of the three studied seasons) due to T_1 to T_6, respectively. Hence the increment percentage of total soluble solids attained (5.34, 4.64, 4.46, 3.76 and 4.46%) due to T_1 to T_5 compared to T_6, respectively.

On the other hand, data in table (4 & 5) showed that using previously pollination methods significantly reduced the moisture and tannins contents and total acidity compared to use traditional hand pollination.

The improvement of these fruit traits was associated with dusting of pollen grain powder concentration at 10 or 20 % after spraying citric acid (T5 & T4), as well as, proline plus either citric acid (T1) , sugar solution (T2) or ascorbic acid (T3) . Dusting of pollen grain powder concentration 20 % after spraying, proline plus either citric acid or , sugar solution give the highest values of total soluble solids and sugar contents and lowest values of moisture and tannin contents and total acidity, whereas using traditional hand pollination gave the minimum values of total soluble solids and sugar contents and highest values of moisture and tannin contents and total acidity.

So it could be said that the pollination by dusting pollen grain powder at 20% with proline plus either citric acid, sugar solution or ascorbic acid (1000 ppm) give the highest yield with good dates as well as improve the pollination efficiency

Discussion

Pollination is considered the most important difficult and expensive practice to ensure good yield in date palms. The limited quantity of pollen grains are the basis to justify the use of mechanical pollination by sprayers and dusters. The positive action of using pollen with carriers on yield and fruit quality was mainly attributed to their important role in

enhancing the efficiency of pollination and fertilization. The mechanical pollination requires mixing the pollen grains with a bulky material to minimize the amount needed of pollen grains. This bulky material must be available, cheap, and with specific gravity close to that of the pollen grains in order to obtain homogeneous mixture **[23,24,25]**.

The protective of ascorbic acid on tissues from oxidation as well as the positive action of it on enhancing the diversion of cells and biosynthesis of carbohydrates could explain the present results **[26]**.

Amino acids are one of the most widely applied biostimulants in agriculture field. They are substances that promote plant growth, increase nutrient availability, and enhance quality attributes. Moreover, amino acids can act as precursors to produce secondary metabolites and signaling molecules in plant cell under stressed and non-stressed conditions **[27,28,29]**. In this regard, several studies reported the positive effect of amino acids on improving fruit attributes and yield **[30,31]**.

These findings were supported by the results **[17,23]** who remanded that using the combining pollen grains with boric acid, ascorbic acid or zinc suspension as spray for date palms pollination. Such pollination method increased the yield and improved fruit physical and chemical properties.

Conclusion

On the light of previous results, it could be concluded that dusting of 20% pollen grains powder immediately after spraying 1000 ppm proline either citric acid or sugar solution lead to obtain a considerable yield with good fruit quality, in additional improve the pollination efficiency

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تأثير طرق التلقيح علي كفاءه التلقيح واثمار النخيل البلح البرحى

تعتبر عملية التلقيح من العمليات البستانية الضرورية ذات التأثير المباشر على نمو الثمار وجودتها وكذلك إنتاجية نخيل البلح. ويعد تطوير عمليات التلقيح التى من شأنها الحصول على نسبة عقد مرتفعة مع جودة عالية للثمار دون الحاجة لاستخدام كميات كبيرة من حبوب اللقاح أمراً ضرورياً وفعالاً لتحسين إنتاجية نخيل البلح. ولذا أجريت هذه الدراسة خلال مواسم 2021 و 2022 و 2023على نخيل البلح البرحى النامية بالمزرعة البحثية لمحطة البحوث الزراعية في المطاعنه – أسنا – محافظه الاقصر -مصر حيث تضمنت الدراسة التلقيح تعفيرا بمسحوق حبوب اللقاح بتركيز 10 او 20 % عقب الرش بمحلول يحتوي علي حمض الستريك فقط او حمض البرولين بالاضافه الي ايا من حمض الستريك او حمض الاسكوربيك او محلول السكري بتركيز 1000 جزء في المليون. وقد أظهرت النتائج أن

التلقيح تعفيرا بمسحوق جبوب اللقاح بتركيز 20 % عقب رش النورات المؤنثه بمحلول حمض البورلين والستريك اسيد او البورلين و المحلول السكري سبب تحسينا معنويا في نسبه العقد الاولي والنهائي مما ادي الي زياده وزن السوباطه والمحصول لكل نخله اضافه الي تحسين الصفات الطبيعه للثمار من حيث زياده وزن الثمره ونسبه لحمها مع تقليل نسبه الرطوبه لها وكذلك تحسين الصفات الكيميائيه من حيث زياده محتوي الثمار من المواد الصلبه الذائبه الكليه ومحتوي السكر مع تقليل نسبه الحموضه والتانينات بالثمار مقارنه بالتلقيح التقليدي اليدوي

وعليه تعتبر هذه طريقه جيده لانتاج محصول عال ذى خصائص ثماريه جيده فضلاً عن تقليل كمية حبوب اللقاح المستخدمة حيث تقلل من تكلفة الإنتاج وتحسين كفاءة التلقيح وخصائص الثمار.