

Effects of Different Pollination Methods on Fruit Quality and Yield of Date Palm Candidate Line Hillawi

Muti Ullah¹, Fayyaz Ahmad^{1,*}, Javed Iqbal², Muhammad Imtiaz³, Muhammad Kashif Raza⁴

¹Date Palm Research Sub-station, Jhang, Punjab, Pakistan

²Cotton Research Sub-station, Jhang, Punjab, Pakistan

³National Institute for Biotechnology and Genetic Engineering, Faisalabad, Punjab, Pakistan

⁴Institutue of Horticultural Science, University of Agriculture, Faisalabad, Punjab, Pakistan

Edited by:

Mehdi Maqbool,
University of Poonch,
Rawalakot, Azad Kashmir,
Pakistan

Reviewed by:

Sajid Mehmood,
Guangzhou University,
Guangzhou, China

Asif Sajjad,
Islamia University,
Bahawalpur, Pakistan

Muhammad Khilil-ur-
Rehman,
Nanjing Agricultural
University, Nanjing, China

Received

November 9, 2018

Accepted

December 12, 2018

Published Online

December 31, 2018

Abstract: A mechanized way of date production in changing climatic scenario and ever-increasing population dynamics is needed. Therefore, refinement in pollination techniques may aid in achievement of higher fruit yield. Present investigation was planned to evaluate the effect of different pollination methods on fruit setting percentage, bunch weight, fruit length, fruit size, fruit weight, stone weight, yield per plant and total soluble salts (TSS) in date palm candidate line ‘Hillawi’. This study was conducted at Date Palm Research Sub Station, Jhang, Pakistan during the year 2015 and 2016 (mid-February to end July, respectively). Five pollination methods which include natural (control), placement, manual dusting, dusting with pollinator and dried pollen + talcum powder was implied on female spath. All the pollination techniques significantly influenced the expression of studied traits. Maximum fruit set percentage (61.3%), bunch weight (8.4 kg), fruit length (4.1cm) fruit width (3.5cm), fruit weight (12.45 g) stone weight (1.7g), yield per plant (87.70 kg) and TSS (38.43°Brix) were recorded when pollen dusting was done with pollinator, as compared to other techniques. Characters association study revealed that fruit yield per plant had a positive and significant relationship with fruit setting percentage, bunch weight, fruit length, fruit width, fruit weight and TSS. Therefore, selection of sucker from mother plant with improved mentioned characteristics could produce date orchards with higher fruit yield. Pollen dusting with pollinator emerged as the most effective pollination technique for improving the quantity and quality of fruit in date palm candidate line ‘Hillawi’.

Keywords: Date palm, Hillawi; Pollination; Pollinator, Methods of pollination; Fruit quality.

*Corresponding author: Fayyaz Ahmad: datepalmjg@gmail.com

Cite this article as: Ullah, M., F. Ahmad, J. Iqbal, M. Imtiaz and M.K. Raza. 2018. **Effects of different pollination methods on fruit quality and yield of date palm candidate line Hillawi.** Journal of Environmental and Agricultural Sciences. 17: 55-62.



This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium provided the original author and source are properly cited and credited.

1 Introduction

Date is one of the most popular fruit worldwide with an impressive list of essential nutrients, vitamins, and minerals which are required for normal human growth and development (Al-Farsi and Lee, 2008; Assirey, 2015; Hamad et al., 2015). It is a historic plant and reported to be cultivated for more than 6000 years ago (Abdolvand et al., 2018; Chandrasekaran and Bahkali, 2013; Weber, 2010).

Date flesh contains carbohydrates (73.5%), ash (1.5%), fat (0.2%), protein (2.3%), also contain unsaturated fatty acids (palmitoleic, oleic, linoleic, and linolenic acids) and vitamins (A, C, B1, B2, folic

acid and nicotinic acid). Moreover, dates fruit is a rich source of several minerals including calcium, magnesium, iron, phosphorus, potassium, sodium, zinc, copper, manganese and selenium (Al-Shahib and Marshall, 2003), which differ with varying climatic conditions and management practices (Alhamdan et al., 2016). It is a rapid source of glucose and fructose (70-80%), easily available to human beings (Haider et al., 2018). Date fruit contain anthocyanins, phenolics, sterols, carotenoids and flavonoids with numerous health benefits. Therefore it is considered as best food for human nutrition (Al-Shahib and Marshall, 2003). Preclinical investigations have revealed that the date fruit consist of free radical scavenging, antioxidant, antimicrobial, anti-

inflammatory, gastro-protective and anticancer element (Baliga et al, 2011; Huertas et al., 2011; Mohamed et al., 2014; Vayalil, 2012).

Date is the important fruit crop globally (Johnson et al., 2015) with annual production of 7.5 million tons. Pakistan contribute only 0.6 million tons in it (FAO, 2012). Pakistan exports (225 thousand tones) dried dates to India, Canada, Afghanistan, Bangladesh, Germany and Denmark and 12 thousand tons of fresh dates to India, Denmark, Germany, Indonesia, Canada, Sri Lanka, Malaysia, South Africa and USA (Amin et al., 2007). It performs well in arid and semi-arid conditions and considered as the most appropriate choice for small as well as large scale farming (Abdolvand et al., 2018; Gros-Balthazard et al., 2018; Mlih et al., 2015). It is the third major fruit crop in Pakistan that occupied an area of 97.1 thousand hectares with total production of 467.7 thousand tones. In Punjab it is grown on an area of 5.7 thousand hectares with production of 42.9 thousand tones (Government of Pakistan, 2016).

Around 3000 cultivars of date palm have been reported in world with different genetic makeup (Khierallah et al., 2017). Hillawi is reported to have unique characteristics (best at khalal stage consummation, uniform maturity, earliness and out of 150 promising strains grown in Punjab (Nazri, 1995). It is the most popular strain of date palm in Punjab due to its taste, color and consumption at Khalal stage. Being dioecious in nature, male and female plants grow separately (Kharb and Mitra, 2017). Natural pollination takes place by wind, insects and bees (Bashir et al., 2018; Bashir et al., 2019). However, fruit set percentage by natural means is very low, as female spath after opening need to be pollinated within 2 to 4 days (Iqbal et al., 2018; Lemlem et al., 2018). For commercial production of dates maximum fruit setting is pre-requisite, while through natural pollination up to 50 percent yield reduction is observed due to obstacles in stigma receptivity and pollen availability (Shafique et al., 2011; Shahid et al., 2017). Artificial pollination is crucial for profitable date palm production and also good quality dates (Iqbal et al., 2018).

Taking into consideration the importance of artificial pollination in date palm, present study was planned to evaluate the impact of different artificial pollination techniques on date fruit yield and quality characters. The ultimate objective was to develop an appropriate technique which could be farmer friendly and economical.

2. Materials and Methods

An experiment was conducted during the year 2015 and 2016 (mid-February to end July, respectively) at Date Palm Research Sub-station, Jhang, Pakistan (31.2655° N, 72.3124° E). A randomized complete block design (RCBD) was used with three replications. Two Hillawi plants of uniform age (20 years) and vigor were selected from each treatment for data collection.

Five treatments (Table 1) including Control (in which spathes were left open for natural pollination by air, wind and insect), Placement (spikelets were taken from the male palm spathes and spikelet put into female spathes in central and round farm). Manual Dusting (male spathes were harvested and dusting was done on spathes of female plants). Dusting with pollinator (males spathes were harvested; their protective covering was removed and was put under sunlight on newspaper for releasing pollen grains.

These pollen grains were put into pollinator chamber and sprayed on open female spathes by Animator pumping. Pollinator is a device (up to 15 feet long), locally invented at DPRSS, Jhang, with help of this device a single man can pollinate approximately 150-200 plants in a day. Dried Pollen + Talcum Powder (dried pollen grains were mixed with talcum powder and sprayed on open female spath) were used. Female spaths were bagged properly after pollination in all treatments except in the control. Data regarding the fruit set percentage was calculated as described by Sarrway et al., (2012). Single fruit weight (g) was calculated by weighing 20 fruits on electrical weighing balance (Model DQE-Sartorius GW6202) and mean fruit weight was calculated. Physical parameters of fruits (length (cm), width (cm), thickness (cm) and seed weight (g)) were recorded for 20 fruits using vernier caliper and then mean values calculated. TSS was expressed in °Brix and measured as per A.O.A.C., (1995).

Table 1. Different pollination methods used in this study

Treatments	Details
T ₁	Natural/Control
T ₂	Placement
T ₃	Manual dusting
T ₄	Dusting with Pollinator
T ₅	Dried Pollen + Talcum Powder

Table 2. Mean Squares corresponding to various source of variation for fruit yield and related parameters in date palm strain Hillawi.

SOV	DF	FS (%)	BW	FL	FW	FWt.	SWt.	Yield	TSS	
REPLICATION	2015	2	2.672	0.113	0.014	0.039	0.414	0.062	4.420	0.089
	2016		0.941	0.312	0.072	0.072	0.187	0.033	7.680	0.326
TREATMENT	2015	4	446.2	8.77	0.381	0.312	11.49	0.287	1233	0.701
	2016		265.0	1.864	0.254	0.273	11.80	0.111	558.0	24.68
ERROR	2015	8	11.07	0.12	0.038	0.008	0.208	0.014	4.040	0.099
	2016		1.973	0.062	0.030	0.144	0.030	0.060	6.105	0.300
P VALUE	2015		0.000	0.001	0.003	0.000	0.000	0.000	0.000	0.009
	2016		0.000	0.000	0.007	0.190	0.000	0.010	0.000	0.000

Where FS(%)= Fruit setting(% age), BW=Bunch Weight (kg), FL=Fruit Length (cm), FW= Fruit Width (cm), FWt.=Fruit Weight (g), SWt.=Stone Weight (g), Y=Yield per plant(kg)TSS=Total Soluble Salts.

To determine total yield at harvest, each bunch was weighed separately using weighing balance and was expressed in kilogram (kg). Analysis of variance was computed according to Steel et al., (1997). A computed generated program (STATISTIX 8.1) was used for data analysis.

3. Results and Discussion

A little research work has been done on date palm pollination techniques in Pakistan. Plenty of room is still available for the improvement of fruit yield and related traits in dates. Taking into consideration these facts, present study was planned to investigate most appropriate pollination techniques for obtaining a better date fruit yield. A candidate date palm variety 'Hillawi' was used for the purpose. For producing an authenticated data, the studies were carried out for two consecutive years (2015-2016). Mustafa et al., (2014) reported that pollination in date palm can significantly affect various yield attributing components. The objective of the investigation was to study the impact of different pollination techniques

on the expression of various fruit characteristics of said date palm strain.

3.1. Fruit set percentage (%)

Results presented in Table 2 showed that different pollination techniques significantly affect fruit set percentage in date palm strain during studied years. Iqbal et al., (2010) computed the same while working on different pollination techniques (dusting of pollens, placement of male spath, liquid spraying of pollens and natural pollination) in date palm (strain Sukkri) Maximum fruit set percentage (61.3 and 60.1%) was observed in T₄ (dusting with pollinator) in year 2015 and 2016, respectively. While, Iqbal et al. (2010), noted the highest fruit setting with the help of placement method, whereas lowest fruit setting was observed in control (natural pollination). The differences in results could be attributed to use of latest technique (dusting with pollinator) in this study. While, the minimum fruit set percentage (30.2 and 34.6%) was found in T₁ (control) in year 2015 and 2016, respectively.

Table 3. Influence of various pollination techniques on pomological, yield and quality parameters on date palm strain Hillawi during the year 2015.

Treatment	2015							
	FS(%)	BW	FL	FW	FWt.	SWt.	Yield	TSS
T ₁	30.42d	3.567d	2.70bc	1.963b	7.340e	1.700b	41.43d	36.43a
T ₂	51.34b	5.333c	3.667b	3.530a	10.42b	1.367b	87.70a	35.77bc
T ₃	43.59c	6.000b	4.100a	2.250b	9.433c	1.133b	77.90b	36.23ab
T ₄	61.37a	8.467a	3.333bc	3.301a	12.45a	1.167a	87.57a	38.43c
T ₅	36.46e	6.467b	3.200c	1.600c	8.420d	1.400b	57.93c	36.60a
cv (%)	6.87	5.66	5.16	6.85	5.19	10.96	2.88	2.51
C Value	6.267	0.632	0.368	0.167	0.858	0.281	3.784	0.591

Where FS(%)= Fruit setting(% age), BW=Bunch Weight (kg), FL=Fruit Length (cm), FW= Fruit Width (cm), FWt.=Fruit Weight (g), SWt.=Stone Weight (g), Y=Yield per plant(kg)TSS=Total Soluble Salts. T₁ = Natural, T₂= Placement, T₃= Manual Dusting, T₄= Dusting with Pollinator, T₅= Dried Pollen + Talcum Powder.

Table 4. Influence of various pollination techniques on pomological, yield and quality parameters on date palm strain Hillawi during the year 2016.

2016								
TREATMENT	FS (%)	BW	FL	FW	FWt.	SWt	YIELD	TSS
T ₁	34.63e	3.033d	2.400a	2.253b	7.683e	1.780b	51.10d	32.20c
T ₂	52.53b	6.333b	3.366b	2.330b	10.75b	1.300b	78.93ab	36.13b
T ₃	48.30c	6.666b	3.133b	3.473a	9.567c	1.366a	77.23b	37.73b
T ₄	60.16a	7.867a	4.180b	3.683a	12.78a	1.233a	83.17a	38.23c
T ₅	45.40d	5.833c	3.180b	1.866b	8.620d	1.333b	60.93c	32.00a
CV(%)	2.925	4.200	5.282	16.11	3.702	9.096	3.522	1.560
C. value	2.651	0.489	0.336	0.704	0.688	0.240	4.650	1.030

Where FS(%)= Fruit setting(%age), BW=Bunch Weight (kg), FL=Fruit Length (cm), FW= Fruit Width (cm), FWt.=Fruit Weight (g), SWt.=Stone Weight (g), Y=Yield per plant(kg)TSS=Total Soluble Salts. T₁ = Natural, T₂= Placement, T₃= Manual Dusting, T₄= Dusting with Pollinator, T₅= Dried Pollen + Talcum Powder.

Contrary results were observed by [Awad, \(2010\)](#), who noted lower fruit set percentage (75.6, 86.8, and 87.8%) with the application of pollen grains-water suspension (0.5, 1, 1.5 g/l, respectively) compared to natural pollination (90.0%) in *Lalu* cultivar. It may be due to different agro climatic condition, variety and application of different techniques.

3.2. Bunch Weight

Bunch weight is an important characteristic of date palm and could play a pivotal role in improving the yield. All studied five treatments varied significantly with reference to their impact on bunch weight (Table 2). Dusting with pollinator (T₄) had a highly significant impression towards increasing the bunch weight. The maximum value of bunch weight (8.4 and 7.06 kg) was achieved during the year 2015 and 2016, respectively when T₄ was applied to the strain 'Hillawi'. While, minimum bunch weight of 3.5 and 3.0 was recorded in control (T₁) during year 2015 and 2016, respectively.

Contrasting results were obtained by [Samouni et al., \(2016\)](#) who obtained non-significant differences in fruit weight per bunch due to dusting of pollen grains powder at 50 or 25% compared to control. Contrasting results observed in both studies could be due to different agro-climatic condition, use of different cultivar and pollination techniques.

3.3. Fruit Length

Result revealed that different pollination techniques significantly affect the fruit length. However, [Iqbal et al., \(2010\)](#) observed non-significant impact of pollinations techniques on fruit length. The differences in results may be attributed due to change in environment and use of different variety for experimentation. The maximum fruit length (4.1 cm) in the studied years (2015 and 2016),

was noted when pollen dusting was done with pollinators (T₄), followed by the manual dusting (T₃). Minimum fruit length of 2.7 and 2.4 cm was noted in control (T₁) in year 2015-16 respectively. [Refaey and Dengawy \(2017\)](#) worked on 'Hayany' date palm cultivar and also found that most pollination techniques (natural pollination and dusting of pollen mixture (5, 10 and 20%)), have improved the physical characteristics (Fruit length, width and size and yield per plant) of dates.

3.4. Fruit Width

During 2015, maximum fruit width of 3.3 and 2.5 cm was observed in 'Hillawi' when pollinated through placement method followed by manual dusting, respectively. Both treatments showed non-significant differences between them regarding the mentioned characteristic. Dusting with pollinator (T₄) and manual dusting (T₃) were the best techniques during 2016, both have improved the fruit width (2.68 and 2.47cm, respectively). These findings corroborated with [Refaey and Dengawy \(2017\)](#) who worked on 'Hayany' date palm cultivar and found that different pollination techniques (traditional pollination and dusting with pollen mixture at 5%, 10% and 20%) have improved physical characteristics (fruit size, length, width and yield per plant) of fruit.

3.5. Fruit Weight

Highly significant differences were observed among all treatments for fruit weight in both studied years (Table 2). The results showed that pollination methods have worth noting impact on fruit size and weight development. Maximum single fruit weight of 12.45 and 12.78 (g), was recorded during year 2015 and 2016 respectively, when T₄ (dusting with pollinator) was applied. The findings obtained in present investigation are dissimilar to results of [Attalla et al. \(1998\)](#) who observed non-significant

differences in Dhaki fruit weight against the application of different pollination methods. This inconsistency of results could be attributed to the response different variety and climatic conditions.

3.6. Stone Weight

Data presented in Table 2, revealed that different pollination techniques have significantly influenced the stone weight. Maximum stone weight (1.7 g) was obtained in T₁ (control) in both studied years (2015-16). The control showed non-significant differences from rest of techniques except in T₄ (dusting with pollinator) in 2015 and from T₃ and T₄ in year 2016 for stone weight. Minimum stone weight was achieved when pollen dusting was done with pollinator in year 2015 (1.17) and 2016 (1.23).

3.7. Yield per Tree

In date palm strain 'Hillawi', yield per tree was significantly influenced when different pollination methods were applied (Table 4). However, when pollination was done with the help of placement

method (T₂) maximum yield per tree (87.70kg) was achieved followed by dusting with pollinator method (87.57 kg) in year 2015. While the yield was highest (83.17 kg), when pollens were dusted with the help of pollinator (T₄) followed by placement methods (78.93 kg). Both the treatments showed non-significant differences for the trait in studied years. These results are matched with the finding of Haffar et al. (1997) who noted maximum yield and minimum fruit drop with the application of different pollination technique (Concentrations of pollens used were 1:10 and 1:5 on a volume basis, with three mechanical pollinations frequency and different pomological traits of date variety Khalas were noted)

3.8. Total Soluble Salts

The value of total soluble salts (TSS) varied significantly with the application of different pollination techniques (Table 2). Highest TSS values (38.43 and 38.23 °Brix) were recorded for T₄ (dusting with pollinator) in both the investigated years (2015 and 2016, respectively).

Table 5. Correlation matrix of various fruit yield and yield related traits in date palm (*Phoenix dactylifera* L.)

Traits	Years	BW	FL	FR	FW	FWt.	SWt.	TSS
FL	2015	0.341 (0.21)						
	2016	0.483 (0.07)						
FR	2015	0.827 (0.004)	0.3701 (0.92)					
	2016	0.838 (0.001)	0.3315 (0.002)					
FW	2015	0.669 (0.03)	0.442 (0.001)	0.102 (0.74)				
	2016	0.603 (0.017)	0.440 (0.100)	0.504 (0.055)				
FWt.	2015	0.730 (0.002)	0.608 (0.95)	0.930 (0.00)	0.705 (0.49)			
	2016	0.834 (0.001)	0.777 (0.007)	0.932 (0.000)	0.6431 (0.009)			
SWt.	2015	0.703 (0.004)	0.891 (0.06)	0.690 (0.009)	0.719 (0.003)	0.680 (0.005)		
	2016	0.750 (0.002)	0.943 (0.009)	0.748 (0.001)	0.676 (0.078)	0.7008 (0.003)		
TSS	2015	0.493 (0.07)	0.373 (0.89)	0.870 (0.00)	0.039 (0.89)	0.807 (0.00)	0.504 (0.038)	
	2016	0.007 (0.978)	0.304 (0.102)	0.512 (0.613)	0.248 (0.372)	0.6833 (0.778)	0.5041 (0.43)	
Y	2015	0.919 (0.05)	0.377 (0.165)	0.889 (0.00)	0.805 (0.46)	0.862 (0.00)	0.789 (0.14)	0.072 (0.002)
	2016	0.910 (0.00)	0.5252 (0.44)	0.882 (0.00)	0.809 (0.018)	0.8651 (0.00)	0.746 (0.009)	0.029 (0.913)

Where FS(%)= Fruit setting(%age), BW=Bunch Weight (kg), FL=Fruit Length (cm), FW= Fruit Width (cm), FWt.=Fruit Weight (g), SWt.=Stone Weight (g), Y=Yield per plant(kg), TSS=Total Soluble Salts,

When pollen placement method (T_2) showed non-significant difference from the treatment T_4 (Year 2015). While it significantly differed from rest of the treatments in both investigated years. Results revealed that dusting with pollinator is an effective technique for improving the sweetness of fruits. These research findings are similar to that of Iqbal et al. (2010) who indicated that different pollination techniques improved the fruit setting and quality parameter in date plants.

3.9. Correlation Studies

Character association study showed that fruit retention percentage had a weak and negative link with fruit width and TSS. Dates sucker selection from mother plant based on any one of these traits may decrease the expression of other trait. A strong positive relationship among fruit weight, stone weight and fruit retention percentage indicates that fruits retention on the plant ultimately increases the fruit and stone weight in date palm. These results are strengthened by finding of El-Salhy, et al., (2010), who indicated that there was a positive correlation between fruit set percentage and the obtained bunch weight at harvest.

Bunch weight had a positive relationship with fruit length in both studied years (Table 5). Total soluble salts had a weak and negative correlation with bunch weight. Plants with higher bunch weight could produce suckers with low total soluble salts. These results are strengthened by finding of El-Salhy et al. (2010), they reported a positive correlation between fruit set percentage and the obtained bunch weight.

Fruit length had a positive and highly significant correlation with fruit weight and stone weight. This depicts that genes governing the expression of said traits may exist on the same chromosome. Fruit length had a weak association with fruit retention percentage and fruit width. Sucker selection based on fruit length may not help significantly in improving the fruit retention and its width.

Table 5 revealed that the width of the fruit had a strong positive impact on fruit and stone weight. Merely working on one trait could improve the other traits. Based on two years of studies (2015-2016), results showed that fruit weight had a strongly positive influence on stone weight. Correlation matrix (Table 5), indicated that fruit yield per plant had a strong positive relationship with fruit retention percentage, bunch, fruit and stone weight. Hillwi plants with higher fruit retention percentage,

appropriate bunch, fruit and stone weight could be selected for extraction of suckers and development of date orchard. A weak association of fruit length with yield per plant indicates that length of fruit plays a minor role towards improving the fruit yield. These findings are in accordance with some earlier researchers (Shaheen et al., 1989; El-Kassas et al., 1996), they found a positive association between fruit set percentage and bunch weight obtained at the time of harvest in date palm.

4. Conclusion

In date palm candidate strain "Hillawi" different pollination methods have significantly affect the fruit set percentage, yield per plant and quality parameters. Dusting with pollinator was found most effective technique compared to the other pollination methods. Mechanization of date production is becoming more important due to the rise of production cost and shortage of skilled manpower, as mechanical pollination is comparatively easier and cost effective then manual pollination techniques. However further studies could be conducted to investigate the efficiency of pollinator (a pollination device used in this study) and for further improvement.

List of Abbreviations: FS(%), fruit setting(%); BW, bunch weight (kg); FL, fruit length (cm); FW, fruit width (cm); FWt, fruit weight (g); SWt, stone weight (g); Y, yield per plant(kg); TSS, total soluble salts.

Acknowledgements: The authors gratefully acknowledge facilities provided by Ayub Agricultural Research Institute (AARI) Faisalabad, Pakistan to conduct this study. This research did not receive any funding and specific grant from funding agencies in the public, commercial, or not for profit sector. This work was done at Date Palm Research Sub-station, Jhang, Punjab, Pakistan.

Conflict of Interest: None of the authors have any competing of interest.

Authors Contribution: MU and JI conceived and designed of the study. MU and FA conducted the experiment and MI, MKR and JI performed the data analysis. MU, FA, JI, MI, MKR wrote the manuscript. MU and JI revised and prepared responses to reviewer's comments. All the authors read and approved the final manuscript.

References

Abdolvand, B., R. Zarghami and A. Salari. 2018. The effects of $AgNO_3$ and 2ip (N6-(2-Isopentenyl) adenine) on different stages of somatic

- embryogenesis in date palm (*Phoenix dactylifera* L.)(Cv. Medjool). Pakistan J. Bot. 50(2): 495-502.
- Al-Farsi, M.A. and C.Y. Lee. 2008. Nutritional and functional properties of dates: a review. Crit. Rev. Food Sci. Nutr. 48(10): 877-887.
- Alhamdan, A., B. Hassan, H. Alkahtani, M. Younis and D. Abdelkarim. 2016. Quality changes in fresh date fruits (Barhi) during individual quick freezing and conventional slow freezing Pakistan J. Agric. Sci. 53(4): 917-924.
- Al-Shahib, W. and R.J. Marshall. 2003. The fruit of the date palm: its possible use as the best food for the future? Int. J. Food Sci. Nutr. 54(4): 247-259.
- Amin, M., M.S. Zafar and A.Y. Anjum. 2007. Potential of date export. Hortmag, Newsletter.
- Assirey, E.A.R. 2015. Nutritional composition of fruit of 10 date palm (*Phoenix dactylifera* L.) cultivars grown in Saudi Arabia. Journal of Taibah University for Science. 9(1): 75-79.
- Association of Official Agricultural Chemists. 1995. Official methods of Analysis. A.O.A.C. 15th Ed. Published by A.O.A.C. Washington, D.C. (U.S.D)
- Attalla, A.M, M. O., Warring, and F.A. Sharaan.1998. Suitable time of two Saudi date palm cultivars. Alexandria. J. Agric. Res.43 (3): 203-208.
- Awad, M.A. 2010. Pollination of date palm (*Phoenix dactylifera* L.) cv. Lulu with pollen grains-water suspension. In: the abstract book of oral presentations of the 4th International Date Palm Conference, United Arab Emirates Univ., Abu Dhabi, p. 102.
- Baliga, M. S., B. R.V. Baliga, S. M. Kandathil, H. P. Bhat, P. K. Vayalil. 2011. A review of the chemistry and pharmacology of the date fruits (*Phoenix dactylifera* L.). Food Res. Int. 44:1812–1822.
- Bashir, M.A., A.M. Alvi, K.A. Khan, M.I.A. Rehmani, M.J. Ansari, S. Atta, H.A. Ghramh, T. Batool and M. Tariq. 2018. Role of pollination in yield and physicochemical properties of tomatoes (*Lycopersicon esculentum*). Saudi J. Biol. Sci. 25(7): 1291-1297.
- Bashir, M.A., S. Saeed, A. Sajjad, K.A. Khan, H.A. Ghramh, M.A. Shehzad, H. Mubarak, N. Mirza, S. Mahpara, M.I.A. Rehmani and M.J. Ansari. 2019. Insect pollinator diversity in four forested ecosystems of southern Punjab, Pakistan. Saudi J. Biol. Sci. doi: [10.1016/j.sjbs.2018.02.007](https://doi.org/10.1016/j.sjbs.2018.02.007).
- Bechar, A., I. Shmulevich, D. Eisikowitch, Y. Vaknin, B. Ronen, and S. Ganmor. 1999. Modeling and experiment analysis of electrostatic date pollination. Trans. ASAE. 42 (6): 1511-1516.
- Chandrasekaran, M. and A.H. Bahkali. 2013. Valorization of date palm (*Phoenix dactylifera*) fruit processing by-products and wastes using bioprocess technology – Review. Saudi J. Biol. Sci. 20(2): 105-120.
- El-Kassas, S.E., A.M. El-Salhy and A.Y. Abdalla. 1996. Efficiency of pollination of Zaghloul and Samany date palms with male strands at certain degrees of drying. Assiut J. Agric. Sci. 27: 37-45.
- El-Refaey F. A. El-Dengawy. 2017. Improvement of the Pollination Technique in Date Palm, J. Plant Production, Mansoura Univ. 8 (2): 307-314.
- El-Salhy, A.M., A.A. El-Bana, H.A. Abdel-Galil and E.F. Ahmed. 2010. Effect of pollen grains suspensions spraying on yield and fruit quality of Saidu date palm. Acta Hort. 882: 329-336.
- FAO. 2012. FAOSTAT. Statistics Division, Food and Agriculture Organization of the United Nations. Available online at <http://http://faostat3.fao.org/browse/Q/QC/E>.
- Government of Pakistan. 2016. Area, production and export of fruit, vegetables and condiments. Fruit, Veg. and Condim. Stat. Pak.19th ed. Ministry of Food and Agriculture, Economic Wing, Islamabad, Pakistan, p. 1-2, 25.
- Gros-Balthazard, M., K.M. Hazzouri and J.M. Flowers. 2018. Genomic insights into date palm origins. Genes. 9(10): 502.
- Haffar, I.H., Al-Juburi and M.H. Ahmed. 1997. Effect of pollination frequency and pollen concentration on yield and fruit characteristics of mechanically pollinated date palm tree (*Phoenix dactylifera* L.) var khalas. J. Agric. Engg. Res. 68(1): 11-14.
- Haider, M.S., I.A. Khan, M.J. Jaskani, S.A. Naqvi, S. Mateen, U. Shahzad, H. Abbas. 2018. Pomological and biochemical profiling of date fruits (*Phoenix dactylifera* L.) during different fruit maturation phases. Pakistan J. Bot. 50(3): 1069-1076.
- Hamad, I., H. AbdElgawad, S. Al Jaouni, G. Zinta, H. Asard, S. Hassan, M. Hegab, N. Hagagy and S. Selim. 2015. Metabolic analysis of various date palm fruit (*Phoenix dactylifera* L.) cultivars from Saudi Arabia to assess their nutritional quality. Molecules. 20(8): 13620.
- Huertas, A.J., M.P. López-Sáez and J. Carnés. 2011. Clinical profile of a Mediterranean population sensitised to date palm pollen (*Phoenix dactylifera*). A retrospective study. Allergologia et Immunopathologia. 39(3): 145-149
- Iqbal, M. M., Khan, M. Q, Munir, M. Ur Rehman, S. H. Ur Rehman, and M. Niamatullah. 2010. Effect of different pollination techniques on fruit set,

- pomological characters and yield of Dhakki date palm (*Phoenix dactylifera*L) in Dera Ismail Khan, KP. Sarhad J. Agric. 26(4): 515-518.
- Iqbal, M., K. Usman, M. Munir and M.S. Khan. 2018. Quantitative and qualitative characteristics of date palm cv. Gulistan in response to pollination times. Sarhad J. Agric. 34(1): 40-46.
- Johnson, D.V., J.M. Al-Khayri and S.M. Jain. 2015. Introduction: Date Production Status and Prospects in Asia and Europe. In: Al-Khayri, J.M., Jain, S.M., Johnson, D.V. (Eds.), Date Palm Genetic Resources and Utilization: Volume 2: Asia and Europe. Springer Netherlands, Dordrecht, p. 1-16.
- Kharb, P. and C. Mitra. 2017. Early Sex Identification in Date Palm by Male-Specific Sequence-Characterized Amplified Region (SCAR) Markers. In: Al-Khayri, J.M., Jain, S.M., Johnson, D.V. (Eds.), Date Palm Biotechnology Protocols Volume II: Germplasm Conservation and Molecular Breeding. Springer New York, p. 199-207.
- Khierallah, H.S.M., S.M. Bader, A. Hamwiah and M. Baum. 2017. Date Palm Genetic Diversity Analysis Using Microsatellite Polymorphism. In: Al-Khayri, J.M., Jain, S.M., Johnson, D.V. (Eds.), Date Palm Biotechnology Protocols Volume II: Germplasm Conservation and Molecular Breeding. Springer New York, p. 113-124.
- Lemlem, A., M. Alemayehu and M. Endris. 2018. Date palm production practices and constraints in the value chain in Afar Regional State, Ethiopia. Adv. Agric. 2018: 10.
- Mlih, R., R. Bol, W. Amelung and N. Brahim. 2016. Soil organic matter amendments in date palm groves of the Middle Eastern and North African region: a mini-review. J. Arid Land. 8(1): 77-92.
- Mohamed, R.M.A., A.S.M. Fageer, M.M. Eltayeb and I.A. M. Amed. 2014. Chemical composition, antioxidant capacity, and mineral extractability of Sudanese date palm (*Phoenix dactylifera* L.) fruits. Food Sci. Nutr. 2(5): 478-489.
- Mustafa, E.A.M., S.A.A. Heiba, M.M.S. Saleh, N.E. Ashour, A.M. Dorria and M.M.M. Abd El-Migeed. 2014. Effect of different pollinizer sources on yield, fruit characteristics and phylogenetic relationships with Amhat cv. date palm (*Phoenix dactylifera* L.) in Egypt using RAPD Markers. Int. J. Agric. Res. 9: 331-343.
- Nazri, M.M. 1995. Dates production and exports. September 11. Dawn.
- Salomon-Torres, R., N. Ortiz-Uribe, R. Villa-Angulo, C. Villa-Angulo, S. Norzagaray-Plasencia, C. Garcia-Verdugo. 2017. Effect of pollenizers on production and fruit characteristics of date palm (*Phoenix dactylifera* L.) cultivar Medjool in Mexico. Turkish J. Agric. Forest. 41(5): 338-347.
- Samouni., T. M. Mona, A.M. El-Salhy, F.M. Ibtisam, Badawy and E.F. Ahmed. 2016. Effect of pollination and thinning methods on yield and fruit quality of saidydate palms. Assiut J. Agric. Sci. 47 (3): 92-103.
- Sarrwy, S., E. Gadalla and E. Mostafa. 2012. Effect of calcium nitrate and boric acid sprays on fruit set, yield and fruit quality of cv. Amhat date palm. World J. Agric. Sci. 8(5): 506-515.
- Shafique, M., A.S. Khan, A.U. Malik, M. Shahid, I.A. Rajwana, B.A. Saleem, M. Amin and 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 J. Bot. 43(2): 831-839.
- Shaheen, M.A., M.A. Bacha and T.A. Nasr. 1989. Effect of male type on fruit chemical properties in some date palm. Ann. Agric. Sci. Fac. 34: 265-281.
- Shahid, M.A., M. Iqbal, M. Niamatullah. 2017. Response of male pollinizers in fruit set, yield and quality of date palm (*Phoenix dactylifera* L.). Cv. Dhakki. Sarhad J. Agric. 33(1): 108-116.
- Steel, R. G. D., J. H. Torrie and D. A. Dickey. 1997. Principles and procedures of statistics: A biometrical approach. 3rd ed. McGraw Hill Book Co. Inc. New York, p. 400-428.
- Vayalil, P.K. 2012. Date fruits (*Phoenix dactylifera* Linn): An emerging medicinal food. Crit. Rev. Food Sci. Nutr. 52(3): 249-271.
- Weber, R.W. 2010. On the Cover - Date Palm. Ann. Allergy Asthma Immunol. 105(4): A4.

INVITATION TO SUBMIT ARTICLES:

Journal of Environmental and Agricultural Sciences (JEAS) ISSN: 2313-8629) is an Open Access, Peer Reviewed online Journal, which publishes Research articles, Short Communications, Review articles, Methodology articles, Technical Reports in all areas of **Biology, Plant, Animal, Environmental and Agricultural** Sciences. For manuscript submission and information contact editor JEAS at edito.jeas@outlook.com.

Online Submission System <http://www.jeas.agropublishers.com>

Follow JEAS at Facebook: <https://www.facebook.com/journal.environmental.agricultural.sciences>

Join LinkedIn Group: <https://www.linkedin.com/groups/8388694>