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Influence of liquid pollination technique on fruit yield and physico-chemical characteristics of date palm cultivars Khadrawy and Zahidi

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Abstract

Present study was designed to evaluate the response of date palm cultivars Khadrawy and Zahidi to varied concentrations of pollen grains liquid suspension (1, 2, 3 and 4g.L^{-1}). The experiment was arranged on two-factorial randomized complete block design. Results of the study revealed that the pollen application of 4g.L^{-1} significantly increased fruit set (86%), fruit weight (11.27g), fruit length (38.27mm), fruit width (23.70mm), fruit thickness (18.90mm), fruit geometric diameter (24.93mm), fruit arithmetic diameter (26.96mm), fruit surface area (1953.93mm^2), fruit volume (11.29cc), yield per palm (23.97kg), seed length (2.40cm), pulp weight (9.83g), pulp:seed ratio (6.88) and moisture content (22.72%). However, fruit drop parameter was minimal (37%) in that treatment as compared to others. All other parameters (fruit sphericity, seed weight, seed diameter, percent of pulp, percent of seed, total soluble solids, total sugars, reducing sugars and non-reducing sugars) were statistically non-significant. However, application of 3g.L^{-1} pollen grains liquid suspension treatment was closely followed by 4g.L^{-1} pollen grains application regarding all these attributes. Comparison between the date palm cultivars, Khadrawy was observed superior than Zahidi regarding aforesaid parameters. The interactional data of both factors showed positive impact of 4g.L^{-1} pollen suspension concentration when applied to cultivar Khadrawy, which was closely followed by 3g.L^{-1} application. It is therefore, concluded from the present research that although the application of 4g.L^{-1} pollen suspension treatment gave the best results in both cultivars, however, application of 3g.L^{-1} pollen suspension can also be practiced at a minimal compromise on date palm yield and quality for both cultivars.

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Introduction

Date palm (*Phoenix dactylifera* L.) is a unisexual (dioecious) species, which means male (staminate) and female (pistillate) flowers are borne on separate individual trees. Male flowers produce pollen grains, which are applied to fruit buds on the female palms, the process is known as pollination (Bekheet and Hanafy, 2011). Pollen tube formation initiates after pollen grain settles on the stigma. The two synergid cells attract pollen tube to grow down the length of the style towards the ovule (egg cell) for fertilization to form seed (Higashiyama *et al.,* 2001). In order to achieve a successful fertilization, the tip growth of the pollen tube, is precisely guided by female cues (Higashiyama and Takeuchi, 2015). Several female-secreted peptides have been identified as species-specific attractants that directly control the direction of pollen tube growth (Okuda *et al.,* 2009; Márton *et al.,* 2012; Takeuchi and Higashiyama, 2012). In *Arabidopsis*, the pollen tubes precisely respond to the guidance signal from its own species is the tip-localized pollen-specific receptor-like kinase 6 with an extracellular leucine-rich repeat domain, which is an essential receptor for sensing of the LURE1 attractant peptide, and is important for ovule targeting in the pistil (Takeuchi and Higashiyama, 2016). The molecular mechanism of pollination and fertilization indicated the importance of fruit setting and yield attributes, particularly for a dioecious species like date palm. Therefore, a numbers of date palm pollination methods have been adopted to achieve maximum benefits regarding fruit set and ultimately the yield such as male strands (spikes) placement method, pollen dusting method, pollen suspension method etc. (Haffar *et al.,* 1997; Hajian, 2005; El-Dengawy, 2017). These pollination methods have been approved by the date palm growers according to their own experience and pollen source availability. However, adopting an appropriate and improved pollination method could save pollen grains and enhance fruit yield (Awad, 2010).

Natural pollination by wind and bees is characterised in regions where date palm is extensively grown in wilds through 100% seeds with about 50% male population. However, that practice is not economical and leads to the development of parthenocarpic fruits without any commercial value (Zaid and de Wet, 1999; Johnson *et al.,* 2013). Therefore, progressive date palm growers adopted artificial pollination techniques. The most common method of date palm pollination is the placement of four to ten (depends on the size of female inflorescence) male flower strands between the strands of the female inflorescence (Zaid and de Wet, 1999). However, it is laborious, expensive and required large number of male strands, which sometime are not available particularly for early flowering date palm cultivars. Moreover, the female inflorescence emerged and opened at different times on same palm, which required lot of manpower if such method is practiced (Dowson, 1982). Another pollination technique is the dusting of dried pollen grains on female inflorescence. In that technique, pollens are either applied onto walnut sized cotton balls and around two cotton balls are placed between the female inflorescence or they are mixed with inert filler substances (pollen/filler ratio, 1:4) and brushed or dusted by hand or using mechanical sprayer to the female inflorescence. The cotton balls method is labour-intensive and expensive while the mechanical method is economically feasible and saves time. However, a high rate of parthenocarpic fruits could occur when this technique is used (Nixon and Carpenter, 1978; Hajian, 2005).

As an alternative method, pollen grains liquid suspension spray is recommended, which is more practical, worthwhile, and likely to lower labour-cost in the date palm production (Awad, 2010). Therefore, several studies have been conducted to determine the beneficial effects of liquid spray pollination methods for many fruits such as peach (Mizuno *et al.,* 2002), kiwifruit (Hopping and Simpson, 1982; Yano *et al.,* 2007; Barnett *et al.,* 2017), Japanese pear (Sakamoto *et al.,* 2009). Abdalla *et al.* (2011) observed reduction in fruit set percentage, fruit retention and bunch weight of date palm cv. Zaghloul when the pollen grains suspension concentration was reduced and concluded that the application of pollen grains

suspension containing 1.5g.L^{-1} of pollens plus either 2g.L^{-1} ascorbic acid or 0.2g.L^{-1} boric acid mixed with 10% Vinasse increased the yield and fruit quality. However, Al-Wasfy (2014) sprayed mixture of pollen suspension (4g.L^{-1} pollens + 2ml treacle + 2g.L^{-1} ascorbic acid + 1g.L^{-1} boric acid) after two days of female inflorescence cracking that promoted yield and fruit quality of Zaghloul date palms. For promoting production of Saidy date palms, Ahmed (2014) recommended pollen-water suspension application containing 1.25g.L^{-1} pollens plus 5g.L^{-1} starch. However, Soliman *et al.* (2017) recorded highest fruit yield and quality in Segae dates when the palms were sprayed with 2g.L^{-1} pollens mixed with 3g.L^{-1} sugar in a suspension culture. Keeping in view the practical importance of liquid pollen application method, present study was planned to evaluate the effect of different concentrations of pollen grains water suspension spray on fruit set, yield and fruit quality of two date palm cultivars Khadrawy and Zahidi under arid ecological conditions.

Materials and methods

Experimental Site, Layout and Treatments

During 2017 and 2018 year growing seasons, twelve year old date palm cultivars Khadrawy and Zahidi were selected in a private orchard (Latitude 26°6' 26.6472" N and Longitude 68°16' 28.6824" E), to study the effects of varied pollen grains levels diluted in water on yield and physico-chemical attributes. Twenty-four date palm trees of both cultivars (twelve palms for each cultivar) having uniform vigour and size were selected for the study. The soil of the orchard was sandy loam. Five spathes of similar size, emerged and opened on same date, were remained on each palm and the rest (early, late and small-sized spathes) were removed. Pollen grains were collected from the same named male cultivars in order to avoid pollen incompatibility problem. Pollen viability of hundred fresh pollen grains was determined by staining with acetocarmine (Moreira and Gurgel, 1941). Twelve date palm trees of each cultivar were divided into four treatments and each treatment had five replicates. Required pollen concentrations (1, 2, 3 and 4g) were diluted in one-liter water containing two grams of corn-starch, which is used as an adhesive. The experiment was arranged on two-way Factorial Randomized Complete Block Design as below:

	Factor-A: Pollen grain concentrations	Factor-B: Date palm cultivars
T_1	One gram pollen grains per liter water	Khadrawy and Zahidi
T_2	Two grams pollen grains per liter water	Khadrawy and Zahidi
T_3	Three grams pollen grains per liter water	Khadrawy and Zahidi
T_4	Four grams pollen grains per liter water	Khadrawy and Zahidi

The pollen grains suspension treatments were applied to uniform female spathes of each cultivar (100ml suspension per spathe) by manual handheld pressure pump sprayer (2L capacity, made of HomeDecision) at 11am morning when the ambient temperature was around 23°C. This practice was repeated after three days again to ensure maximum fruit set. After pollination, the spathes were covered with brown paper bags to avoid natural pollination by wind or insects, which were removed after fruit set. Standard doses of straight fertilizers (Urea, SSP, K_2SO_4) per palm were applied in one-meter band ring around the stem to both cultivars i.e. 920g N, 500g P_2O_5 and 500g K_2O (Munir *et al.*, 1992; Munir *et al.*, 1993). All other cultural practices were carried out accordingly.

Parameters Studies and Statistical Tool

The parameters studied were recorded according to the standard procedures for fruit set, fruit drop, fruit weight, fruit length, fruit width, fruit thickness, fruit geometric mean diameter, fruit arithmetic mean diameter, fruit sphericity, fruit surface area, fruit volume, yield per palm, seed weight, seed length, seed diameter, pulp weight, percent of pulp, percent of seed, pulp:seed ratio, moisture content, total soluble solids, total sugars, reducing sugars and non-reducing sugars. The recorded data were analysed statistically using GenStat version 18 (VSN International Ltd, Hemel Hempstead, UK) software and the significant means were separated by the Duncan Multiple Range Test using the same program.

Results

Pollen Grain Concentrations

Data in Table 1 revealed that there was a significant (P≤0.05) difference among means of different concentrations of pollen grains (1, 2, 3 and 4g.L^{-1}) regarding fruit set, fruit drop, fruit weight, fruit length, fruit width, fruit thickness, fruit geometric diameter, fruit arithmetic diameter, fruit surface area, fruit volume and yield per palm. Maximum fruit set (86%), fruit weight (11.27g), fruit length (38.28mm), fruit width (23.70mm), fruit thickness (18.90mm), fruit geometric diameter (24.93mm), fruit arithmetic diameter (26.96mm), fruit surface area (1953.93mm^2), fruit volume (11.29cc) and yield per palm (23.97kg) was recorded when pollen grains were applied @ 4g.L^{-1}, whereas these attributes were least when pollen grains were applied @ 1g.L^{-1}. Fruit sphericity parameter was non-significant statistically, whereas maximum fruit drop (53.50%) was recorded when pollen grains were applied @ 1g.L^{-1}.

Table 1. Effects of different concentrations of pollen grains liquid application on fruit set, fruit drop, fruit weight, fruit length, fruit width, fruit thickness, fruit geometric mean diameter, fruit arithmetic mean diameter, fruit sphericity, fruit surface area, fruit volume, and yield per palm of date palm cultivars Khadrawy and Zahidi.

Treatments	Fruit set (%)	Fruit drop (%)	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)	Fruit geometric diameter (mm)	Fruit arithmetic diameter (mm)	Fruit sphericity (mm^2)	Fruit surface area (mm^2)	Fruit volume (cc)	Yield per palm (kg)
A. Pollen Grains												
PG 1g	74.67^{c}	53.50^{a}	8.25^{b}	31.87^{c}	19.47^{b}	15.22^{b}	20.48^{b}	22.18^{b}	0.64^{a}	1321.65^{b}	9.14^{b}	18.34^{b}
PG 2g	79.67^{bc}	46.83^{b}	9.12^{b}	32.90^{bc}	20.13^{b}	15.90^{b}	21.19^{b}	22.98^{b}	0.65^{a}	1413.67^{b}	9.77^{b}	20.25^{ab}
PG 3g	84.50^{ab}	38.17^{c}	11.39^{a}	36.35^{ab}	23.40^{a}	18.33^{a}	24.15^{a}	26.03^{a}	0.67^{a}	1835.48^{a}	11.10^{a}	22.82^{a}
PG 4g	86.00^{a}	37.00^{c}	11.27^{a}	38.27^{a}	23.70^{a}	18.90^{a}	24.93^{a}	26.96^{a}	0.65^{a}	1953.93^{a}	11.29^{a}	23.97^{a}
LSD$_{(5\%)}$	5.45	6.65	0.91	4.04	1.72	1.63	1.18	1.36	0.068	169.20	1.10	4.28
B. Cultivars												
Khadrawy	82.92^{a}	42.25^{a}	10.56^{a}	36.49^{a}	21.73^{a}	17.40^{a}	23.19^{a}	25.21^{a}	0.64^{a}	1702.69^{a}	10.78^{a}	25.45^{a}
Zahidi	79.50^{a}	45.50^{a}	9.46^{b}	33.20^{b}	21.63^{a}	16.78^{a}	22.19^{b}	23.87^{b}	0.67^{a}	1559.68^{b}	9.86^{b}	17.24^{b}
LSD$_{(5\%)}$	3.85	4.70	0.64	2.86	1.22	1.15	0.84	0.96	0.048	119.70	0.78	3.02
C. Pollen Grains × Cultivars												
PG 1g × Khadrawy	76.33^{bc}	51.33^{ab}	8.53^{e}	32.87^{c}	19.43^{b}	15.73^{c}	20.92^{c}	22.68^{d}	0.64^{a}	1375.60^{c}	9.34^{cd}	21.95^{bd}
PG 2g × Khadrawy	81.67^{ab}	45.33^{bd}	9.20^{de}	34.07^{bc}	20.47^{b}	16.07^{bc}	21.59^{c}	23.53^{cd}	0.64^{a}	1463.78^{c}	10.26^{bd}	24.38^{ac}
PG 3g × Khadrawy	85.67^{a}	37.00^{de}	12.60^{a}	38.60^{ab}	23.23^{a}	18.57^{a}	24.67^{ab}	26.80^{ab}	0.65^{a}	1915.56^{ab}	11.60^{ab}	27.24^{ab}
PG 4g × Khadrawy	88.00^{a}	35.33^{e}	11.90^{ab}	40.43^{a}	23.77^{a}	19.23^{a}	25.58^{a}	27.81^{a}	0.63^{a}	2055.83^{a}	11.94^{a}	28.21^{a}
PG 1g × Zahidi	73.00^{c}	55.67^{a}	7.97^{e}	30.87^{c}	19.50^{b}	14.70^{c}	20.04^{c}	21.69^{d}	0.65^{a}	1267.70^{c}	8.93^{d}	14.73^{e}
PG 2g × Zahidi	77.67^{bc}	48.33^{ac}	9.04^{de}	31.73^{c}	19.80^{b}	15.73^{c}	20.80^{c}	22.42^{d}	0.66^{a}	1363.57^{c}	9.27^{cd}	16.13^{de}
PG 3g × Zahidi	83.33^{ab}	39.33^{ce}	10.17^{cd}	34.10^{bc}	23.57^{a}	18.10^{ab}	23.62^{b}	25.26^{bc}	0.69^{a}	1755.40^{b}	10.60^{ac}	18.39^{ce}
PG 4g × Zahidi	84.00^{ab}	38.67^{de}	10.64^{bc}	36.10^{ac}	23.63^{a}	18.57^{a}	24.28^{ab}	26.10^{ab}	0.67^{a}	1852.04^{ab}	10.64^{ac}	19.73^{ce}
LSD $_{(5\%)}$	7.71	9.40	1.29	5.72	2.44	2.31	1.67	1.92	0.097	239.30	1.55	6.05

Means showing a common letter in a column are non-significant statistically at 5% Probability using Duncan Multiple Range Test.

Similarly, Table 2 showed a statistically significant (P≤0.05) difference among means of different concentrations of pollen grains (1, 2, 3 and 4g.L^{-1}) regarding seed length, pulp weight, percent pulp and seed, pulp:seed ratio and moisture content. Maximum seed length (2.40cm), pulp weight (9.83g, statistically at par with PG 3g.L^{-1} treatment i.e. 9.95g), percent pulp (87.17%), pulp:seed ratio (6.88, statistically at par with PG 3g.L^{-1} treatment i.e. 7.03) and moisture content (22.72%) was recorded when pollen grains were applied @ 4g.L^{-1}, whereas these attributes were least when pollen grains were applied @ 1g.L^{-1}, however, maximum percent seed (15.78%) was recorded in the same treatment. Parameters such as seed weight and diameter, total soluble solids, total sugars, reducing and non-reducing sugars were non-significant statistically, however, these attributes were higher when pollen grains were applied @ 4g.L^{-1}.

Comparison of Cultivars

The comparative analysis between two date palm cultivars indicated that cultivar Khadrawy had significantly (P≤0.05) maximum fruit weight (10.56g), fruit length (36.49mm), fruit geometric

diameter (23.19mm), fruit arithmetic diameter (25.21mm), fruit surface area (1702.69mm²), fruit volume (10.78cc) and yield per palm (25.45kg) as compared to cultivar Zahidi (Table 1). Other parameter such as fruit set, fruit drop, fruit width, fruit thickness and fruit sphericity were statistically non-significant. Table 2 indicated that pulp weight (9.24g), percent pulp (87.27%), pulp:seed ratio (7.09) and total soluble solids (61.58%) were higher in cultivar Khadrawy compared to cultivar Zahidi. Other fruit quality characteristics such as seed weight, seed length, seed diameter, moisture content and sugar contents were non-significant statistically, however, apart from seed attributes, moisture content and sugar contents were higher in cultivar Khadrawy than cultivar Zahidi.

Table 2. Effects of different concentrations of pollen grains liquid application on seed weight, seed length, seed diameter, pulp weight, percent of pulp, percent of seed, pulp:seed ratio, moisture content, total soluble solids, total sugars, reducing sugars and non-reducing sugars of date palm cultivars Khadrawy and Zahidi..

Treatments	Seed weight (g)	Seed length (cm)	Seed diameter (cm)	Pulp weight (g)	Percent pulp (%)	Percent seed (%)	Pulp:Seed Ratio	Moisture content (%)	Total soluble solids (%)	Total sugars (%)	Reducing sugars (%)	Non-Reducing sugars (%)
A. Pollen Grains												
PG 1g	1.30^{a}	2.15^{b}	0.91^{a}	6.95^{b}	84.22^{b}	15.78^{a}	5.55^{b}	19.77^{b}	58.10^{a}	64.58^{a}	55.48^{a}	9.10^{a}
PG 2g	1.33^{a}	2.20^{ab}	0.94^{a}	7.79^{b}	85.39^{ab}	14.61^{ab}	5.93^{ab}	21.05^{ab}	58.78^{a}	64.85^{a}	56.65^{a}	8.20^{a}
PG 3g	1.44^{a}	2.34^{ab}	0.95^{a}	9.95^{a}	87.11^{a}	12.89^{b}	7.03^{a}	22.12^{a}	60.50^{a}	66.55^{a}	57.72^{a}	8.83^{a}
PG 4g	1.44^{a}	2.40^{a}	0.97^{a}	9.83^{a}	87.17^{a}	12.83^{b}	6.88^{a}	22.72^{a}	61.68^{a}	67.38^{a}	58.38^{a}	9.00^{a}
LSD$_{(5\%)}$	0.196	0.234	0.061	0.886	1.996	1.996	1.154	1.70	4.37	4.97	2.97	5.45
B. Cultivars												
Khadrawy	1.32^{a}	2.31^{a}	0.93^{a}	9.24^{a}	87.27^{a}	12.73^{b}	7.09^{a}	21.93^{a}	61.58^{a}	66.30^{a}	57.44^{a}	8.86^{a}
Zahidi	1.44^{a}	2.23^{a}	0.96^{a}	8.02^{b}	84.68^{b}	15.32^{a}	5.61^{b}	20.90^{a}	57.96^{b}	65.38^{a}	56.68^{a}	8.71^{a}
LSD $_{(5\%)}$	0.139	0.166	0.043	0.627	1.411	1.411	0.816	1.20	3.09	3.51	2.10	3.86
C. Pollen Grains × Cultivars												
PG 1g × Khadrawy	1.21^{b}	2.15^{a}	0.91^{a}	7.32^{de}	85.79^{bc}	14.21^{bc}	6.23^{bc}	20.10^{cd}	60.03^{ac}	65.27^{a}	56.00^{a}	9.27^{a}
PG 2g × Khadrawy	1.29^{ab}	2.27^{a}	0.92^{a}	7.91^{bd}	85.95^{bc}	14.05^{bc}	6.23^{bc}	21.37^{ad}	61.20^{ac}	65.37^{a}	57.47^{a}	7.90^{a}
PG 3g × Khadrawy	1.39^{ab}	2.37^{a}	0.94^{a}	11.21^{a}	88.91^{a}	11.09^{d}	8.23^{a}	22.67^{ab}	62.57^{a}	67.07^{a}	57.60^{a}	9.47^{a}
PG 4g × Khadrawy	1.38^{ab}	2.43^{a}	0.95^{a}	10.52^{a}	88.42^{ab}	11.58^{cd}	7.66^{ab}	23.57^{a}	62.50^{ab}	67.50^{a}	58.70^{a}	8.80^{a}
PG 1g × Zahidi	1.38^{ab}	2.15^{a}	0.92^{a}	6.59^{e}	82.65^{d}	17.35^{a}	4.86^{c}	19.43^{d}	56.17^{c}	63.90^{a}	54.97^{a}	8.93^{a}
PG 2g × Zahidi	1.36^{ab}	2.13^{a}	0.95^{a}	7.68^{ce}	84.83^{cd}	15.17^{ab}	5.63^{c}	20.73^{bd}	56.37^{bc}	64.33^{a}	55.83^{a}	8.50^{a}
PG 3g × Zahidi	1.49^{a}	2.30^{a}	0.96^{a}	8.68^{bc}	85.31^{cd}	14.69^{ab}	5.82^{c}	21.57^{ad}	58.43^{ac}	66.03^{a}	57.83^{a}	8.20^{a}
PG 4g × Zahidi	1.50^{a}	2.36^{a}	0.99^{a}	9.14^{b}	85.92^{bc}	14.08^{bc}	6.11^{bc}	21.87^{ac}	60.87^{ac}	67.27^{a}	58.07^{a}	9.20^{a}
LSD $_{(5\%)}$	0.278	0.332	0.086	1.254	2.823	2.823	1.632	2.40	6.18	7.03	4.20	7.71

Means showing a common letter in a column are non-significant statistically at 5% Probability using Duncan Multiple Range Test.

Interaction of Pollen Grains and Cultivars

The interaction data of pollen grains and cultivars showed that apart from fruit sphericity variable all other variable were significantly different at 5% level of probability (Table 1). Maximum fruit set (88%), fruit length (40.43mm), fruit width (23.77mm), fruit thickness (19.23mm), fruit geometric diameter (25.58mm), fruit arithmetic diameter (27.81mm), fruit surface area (2055.83mm²), fruit volume (11.94cc) and yield per palm (28.21kg) were recorded when 4g.L^{-1} pollen grains applied on cultivar Khadrawy, whereas fruit weight (12.60g) was recorded when 3g.L^{-1} pollen grains applied on cultivar Khadrawy. On the other hand, highest fruit drop was recorded when 1g.L^{-1} pollen grains applied on cultivar Zahidi. The overall expression of the interactional data depicted that 4g.L^{-1} pollen grains application to Khadrawy and Zahidi cultivars produce better results than the other treatments.

The interactional data in Table 2 indicated that pulp weight (11.21g, statistically at par with PG 4g.L^{-1} treatment and Khadrawy i.e. 10.52g), percent pulp (88.91%), pulp:seed ratio (8.23) and total soluble solids (62.57%) were significantly higher when 3g.L^{-1} pollen grains applied on cultivar Khadrawy, followed by 4g.L^{-1} pollen grains applied on cultivar Khadrawy regarding moisture content (23.57%). Similarly, data regarding seed weight (1.49 and 1.50g) and percent seed (17.35%) were higher in cultivar Zahidi when pollen grains were applied @ 3, 4 and 1g.L^{-1}, respectively. Other parameters such as seed length,

seed diameter, and sugar contents were non-significant statistically, however, seed length (2.43g), total sugars (67.50%) and reducing sugars (58.70%) were higher when 4g.L^{-1} pollen grains applied on cultivar Khadrawy. The overall expression of the interactional data depicted that 4g.L^{-1} pollen grains application to Khadrawy and Zahidi cultivars produce better results than the other treatments.

Discussion

Pollination is one of important cultural practices in the production chain of plants that influence fruit set, yield and quality (Mangena and Mokwala, 2018). Adopting a viable and sustainable pollination method that not only delivers satisfactory results of fruit development, yield and quality attributes but also minimise the amount of pollen grains application is essentially needed for date palm production (Awad, 2006; Awad, 2010.). The results of present study indicated that the pollen liquid spray of 4g.L^{-1} or 3g.L^{-1} significantly increased fruit set, fruit weight, fruit length, fruit width, fruit thickness, fruit geometric diameter, fruit arithmetic diameter, fruit surface area, fruit volume, yield per palm, seed length, pulp weight, pulp:seed ratio and moisture content. However, fruit drop parameter was minimal in these two treatments as compared to others. All other parameters such as fruit sphericity, seed weight, seed diameter, percent of pulp, percent of seed, total soluble solids, total sugars, reducing sugars and non-reducing sugars were statistically non-significant (Table 1, 2). However, in another study wherein different pollen application methods were applied on date palm cv. Khalas it was observed that liquid pollination showed valuable results followed by dusting method which displayed more or less similar results at the expense of pollen quantity, however, male strands placement method showed poor results (Munir, unpublished).

Our findings indicated that the enhancement of fruit setting was associated with increasing pollen concentrations, which negatively marked total fruit drop. These results are in agreement with that of Abu-Zahra and Shatnawi (2019) who reported that highest fruit set was observed when 4g.L^{-1} pollen suspension was sprayed to date palm cvs. Barhee and Madjol. Similarly, Ahmed (2014) observed highest fruit set percentage in date palm cv. Saidy when it was sprayed with 5g.L^{-1} pollen plus 5g.L^{-1} starch suspension. In cultivar Segae, maximum number of retained fruit were counted when pollen suspension was applied at 3g.L^{-1} compared to 2g.L^{-1} (Soliman *et al.,* 2017). Al-Wasfy (2014) observed highest fruit setting and retention percentage in cv. Zaghloul when 4-6g.L^{-1} pollen suspension was applied. Similar results were reported in date palm cvs. Lulu (Awad, 2006) and Khenazy (Awad, 2010).

Present study showed that the fruit characteristics (fruit length, width, weight, and volume) were improved at higher concentration of pollens in both date palm cultivars, which coincide with the results of Abdalla *et al.* (2011) in date palm cv. Zaghloul. Similarly, liquid application of pollen grains increased fresh fruit weight of date palm cvs. Barhee and Madjol (Abu-Zahra and Shatnawi, 2019) and cv. Segae (Soliman *et al.,* 2017). Likewise, Ahmed (2014) reported that fruit length, diameter and weight of date palm cv. Saidy were significantly improved by the liquid application of pollen grains. Al-Wasfy (2014) stated that application of pollen suspension at 6g.L^{-1} significantly enhanced fruit length, width, weight and flesh weight.

Enhancement of date palm fruit yield is one of the most important benchmarks of a research study. The outcome of our study indicated that with the increase in pollen grains concentration in suspension the fruit yield was increased linearly in both cultivars. Present results are in line with that of Abu-Zahra and Shatnawi (2019) who obtained highest yield in cv. Barhee when 4g.L^{-1} pollen suspension was applied, whereas in cv. Madjol it was 3-4g.L^{-1} treatment that gave highest fruit yield per palm. Similarly, highest yield per palm was recorded in date palm cv. Zaghloul when 4-6g.L^{-1} pollen grains suspension was sprayed (Al-Wasfy, 2014). Ahmed (2014) obtained highest yield per bunch in date palm cv. Saidy when it was sprayed with 5g.L^{-1} pollen plus 5g.L^{-1} starch suspension.

Similar results were reported by Soliman *et al.* (2017) in cv. Segae at 3g.L^{-1} compared to 2g.L^{-1} pollen grains liquid application. The quality of date palm fruits establishes a dynamic composite of their physico-chemical attributes and consumer preference. These properties are also important to be considered while fruit shipment such as the moisture content of the fruit. Findings of present research study revealed that both date palm cultivars had significantly higher pulp:seed ratio, moisture content and TSS when female inflorescences were sprayed with 3-4g.L^{-1} pollen suspension. However, there was non-significant effect of any treatment on sugar content, which might be influenced by the varied plant nutrition rather than pollen concentration. Ahmed (2014) reported highest moisture content in date palm cv. Saidy when sprayed with 5g.L^{-1} pollen plus 5g.L^{-1} starch suspension, however, highest percentage of TSS and sugar content was estimated at lower concentrations of pollen grains suspension and starch content. Al-Wasfy (2014) reported non-significant effects of pollen grains suspension concentrations on TSS and sugar contents of date palm cv. Zaghloul, which are in line with our study. Soliman *et al.* (2017) reported similar results regarding moisture content in cv. Segae, however, TSS and sugar contents were significantly increased when sprayed with 2-3g.L^{-1} pollen grains suspension, which was contradictory to the present study. However, Mostafa (1998) suggested that the fruit thinning of date palm can be achieved by reducing concentration of pollens in suspension to promote fruit quality.

Conclusion

Date palm is pollinated through artificial application techniques to obtain high yield and best quality fruits. Present research contribution evaluated the yield and fruit quality response of date palm cultivars Khadrawy and Zahidi when subjected to different concentrations of pollen grains liquid suspension (1, 2, 3 and 4g.L^{-1}). Higher application of pollen grains concentration (4g.L^{-1}) significantly improved all yield and fruit quality characteristics, which was closely followed by 3g.L^{-1} pollen grains liquid application. Similarly, date palm cultivar Khadrawy was Fig.d out superior than Zahidi, when both cultivars were statistically analysed. However, the interaction analyses of both factors (pollen grains concentration and date palm cultivars) showed positive impact of 4g.L^{-1} pollen suspension concentration when applied to cultivar Khadrawy, which was also followed closely by 3g.L^{-1} application. It can be concluded that although the application of 4g.L^{-1} pollen suspension treatment gave the best results in both cultivars, however, application of 3g.L^{-1} pollen suspension can also be performed at a minimal compromise on date palm yield and quality for both cultivars.

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