

Effect of pollen grain-water suspension spray on fruit set, yield and quality of 'Helali' date palm (*Phoenix dactylifera* L.)

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Abstract

During 2008 and 2009 seasons, the effect of pollen grain-water suspension spray at different concentration on fruit setting, yield and quality of 'Helali' date palm cultivar growing under Hada-Alsham conditions, KSA was examined. The results showed that fruit set, bunch weight and total yield per tree were significantly higher when spray pollinated at 0.5, 1.0 and 1.5 g L⁻¹ than the traditional pollination. In this respect, there were no significant differences among spray pollination at 0.5, 1.0 and 1.5 g L⁻¹. However, spray pollination at 2.0 g L⁻¹ gave fruit set percentage similar to traditional pollination. At harvest, the Rutab percentage in bunches was not affected by the method of pollination. At both the Bisir and Rutab stages, fruit, flesh and seed weight, diameter and length were not significantly affected by any of the pollination treatments. The biochemical characteristics of fruit such as TSS, acidity, vitamin C, total phenols and soluble tannins were not significantly affected by any of the pollination treatments at both stages. The concentrations of TSS and acidity were higher at the Rutab than at the Bisir stage. However, the concentrations of vitamin C, total phenols and soluble tannins were greatly lower at the Rutab than at the Bisir stage. This study showed the possibility to pollinate 'Helali' date trees by pollen grain-water suspension spray with optimum amount of pollen grains with no further need for thinning especially under hot arid conditions. However, more research work is required to standardize the optimum concentration of pollen grain-water suspension and the response of each date palm cultivar to this pollination technique.

Key words: Date palm, pollen grain suspension, pollination, yield, fruit quality

Introduction

Pollination and thinning are critical processes in the date palm production chain that affects fruit development, yield and quality and regulates tree yearly bearing (Nixon, 1955; Hussein *et al.*, 1993; Awad, 2006). Developing a pollination technique that results in an acceptable level of fruit set with a minimum amount of pollen grains with no further need for thinning is essentially required especially under harsh conditions (Awad, 2006). Being a dioecious species, commercial date palm production necessitates artificial pollination which ensures enough fertilization and overcomes disadvantages of dichogamy and also reduces the number of required male palms. Artificial pollination could be realized according to a traditional method or by using a mechanized device (Zaid and de Wet, 1999; Awad, 2006). The most common and primitive pollination technique is to cut the strands of male flowers from a freshly opened male spathe and place 5-10 of these strands, lengthwise and in an inverted position, between the strands of the female inflorescence and tie the pollinated female cluster 5 to 7 cm from the outer end with a strip torn from a palm leaflet or a string (Zaid and de Wet, 1999). However, the effective period for artificial pollination is limited, and the success of pollination is dependent on environmental factors such as wind and rainfall (Awad, 2006). Also, this pollination technique requires large number of male spathes that sometime are not available especially for early flowering season cultivars (Dowson, 1982). The male/female ratio in modern plantations is about 1/50 (2%). Under the Hada-Alsham region condition, fruit set in 'Halali' date trees ranges between 30-40% with the traditional pollination technique. With such low fruit set

percentage, fruit yield is greatly decreased. Therefore, improving pollination technique may increase fruit setting and tree yield. As an alternative technique, pollen grain-water suspension spray may increase fruit set and tree productivity. Several attempts have been made to establish spray pollination methods for many other fruit types. In a spray pollination of peach, a 10% sucrose solution and a wetting agent were used, but this yielded poor fruit set (Mizuno *et al.*, 2002). In kiwifruit, a practical technique was successfully established through the development of a pollen grain suspension medium (Hopping and Simpson, 1982). More recently, a liquid pollen grain suspension medium thickened with agar was also developed for kiwifruit (Yano *et al.*, 2007). Accordingly, the aim of this study was to evaluate pollen grain-water suspension spray pollination technique at different concentration on fruit set, yield and fruit quality of 'Helali' date palm cultivar.

Materials and methods

Plant materials and experimental procedure: During 2008 and 2009 growing seasons, four uniform 23-years-old 'Helali' date palm trees growing in sandy loamy soil, drip irrigated and receiving normal cultural practices at the experimental orchard of the Faculty of Meteorology, Environment and Arid land Agriculture, King Abdul-Aziz University at Hada Al-Sham region, Saudi Arabia were selected for this experiment. The experiment was designed as a randomized completely block design with four replicates (one tree for each replicate). At the middle of the flowering period (3-7 March in 2008 and 8-12 March in 2009 season), five normal bunches that were just cracked on the same day or the day before were randomly selected and

labeled on each tree. Pollens were collected from the spathes of one male tree, air dried at room temperature. Pollen grains were extracted and then suspended in water at the rate of 0.5, 1.0, 1.5 and 2.0 g L⁻¹ before the pollination process. Each of the five bunches on each tree were treated with one of the following treatments: traditional pollination (control) by placing 5 strands of male flowers, lengthwise and in an inverted position, between the strands of the female inflorescence and tying the pollinated female cluster 5 cm from the outer end with a strip torn from a palm leaflet; spraying with pollen grain-water suspension at 0.5; 1.0; 1.5 and 2.0 g L⁻¹. Spray pollination was applied to the bunches with a plastic hand sprayer (Matabi Style 1,5 Sprayer-1L, Goizper, Spain) by targeting the cone nozzle close to the bunch. The pressure during delivery of suspension was about 30-40 PSI. Each bunch received about 100 mL of suspension. The same male cultivar was used during both the seasons of the study. All of the other developed bunches on each tree were subsequently pollinated in a similar way as for the control bunch. Shortly after pollination, the number of bunches was adjusted to 7 bunches per tree.

Fruit set percentage: In both 2008 and 2009 seasons, at the middle of the Kimri stage (about 7-8 weeks from pollination), 20 strands per bunch were randomly selected and labeled. The number of attached fruitlets and the number of dropped fruitlets were counted and the percentage of fruit set was calculated.

Bunch weight and total yield per tree: In both 2008 and 2009 seasons, the total bunch weight at the middle of commercial harvest period (about 16 weeks from pollination), was recorded for each bunch. The total yield (kg/tree) was calculated by multiplying the mean bunch weight by the total bunches per tree.

Physical characteristics, TSS, acidity and vitamin C determinations: At commercial harvest time, four fruit samples of 20 fruits each, separately from the Bisir and Rutab stages, were collected in both seasons and kept at -20°C for physical and chemical parameter determinations. Fruit, flesh and seed weight, length and diameter were recorded independently in each of the 20 fruits per replicate. Homogeneous sample prepared from these 20 fruits per replicate for measuring total soluble solids (TSS), acidity, vitamin C, total phenols and soluble tannins. Total soluble solids (TSS) were measured as Brix % in fruit juice with a digital refractometer. Titratable acidity was determined in juice by titrating with 0.1N sodium hydroxide in the presence of phenolphthaleine as indicator (Ranganna, 1979), and the results were expressed as a percentage of malic acid. Ascorbic acid (vitamin C) was measured by the oxidation of ascorbic acid with 2,6-dichlorophenol endophenol dye and the results were expressed as mg/100 mL juice (Ranganna, 1979).

Total phenols determination: Total phenol content was measured according to Velioglu *et al.* (1998) using Folin-Ciocalteu reagent. Two hundred milligrams of fruit tissue (including skin and flesh) was extracted with 2 mL of 50% methanol for 2 h with shaking at ambient temperature. The mixture was centrifuged for 10 min, and the supernatant was decanted into 4 mL vials. Then, 200 µL of the extract was well mixed with 1.5 mL Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) and allowed to stand for 5 min at ambient temperature. A 1.5 mL of 20% sodium carbonate was added. After 90 min, absorbance was measured at 750 nm using a UV-Vis spectrophotometer. The blank contained

only water and the reagents. Total phenols were quantified from a calibration curve obtained by measuring the absorbance of known concentrations of gallic acid.

Soluble tannins determination: Soluble tannins were measured according to Taira (1996). Five grams of fruit tissue (including skin and flesh) was homogenised with 25 mL of 80% methanol in a blender and then centrifuged. The supernatant was collected and the precipitate was re-extracted with 80% methanol and centrifuged. The combined supernatant was brought to 100 mL with distilled water. Then 1 mL sample solution mixed with 6 mL distilled water and 0.5 mL Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) and was shaken well. After exactly 3 min, 1 mL of saturated sodium carbonate was added and mixed well. Then 1.5 mL distilled water was added and mixed well (total, 10 mL) and then left for 1 h at ambient temperature before measuring absorbance at 750 nm using a UV-Vis Spectrophotometer. The blank contained only water and the reagents. Soluble tannins were quantified from a calibration curve obtained by measuring the absorbance of known concentrations of gallic acid.

Statistical analysis of data: The obtained data were statistically analyzed using randomized completely block design with four replicates using the statistical package software SAS (2000). Comparisons between means were made by the least significant differences (LSD) at $P = 0.05$.

Results

Fruit set percentage, bunch weight, total yield per tree and Rutab percentage: Because of similarity between the results of the two seasons (no significant interactions between seasons), data were presented as the means of both seasons for fruit set, bunch weight and yield per tree. Fruit set percentage, bunch weight and total yield per tree were significantly higher in the spray pollination at 0.5, 1.0 and 1.5 g L⁻¹ than the traditional pollination. However, spray pollination at 2.0 g L⁻¹ gave fruit set percentage similar to traditional pollination (Table 1). In this respect, there was no significant difference between spray pollination at 0.5, 1.0 and 1.5 g L⁻¹ in fruit setting. The Rutab percentage was not affected by the method of pollination (Table 1).

Physical and biochemical characteristics of fruit at the Bisir and Rutab stages: At both Bisir and Rutab stages, fruit, flesh and seed weight, diameter and length were not significantly affected by any of the pollination treatments (Tables 2 and 4).

Table 1. Effect of pollination method on fruit set, bunch weight, total yield per tree and Rutab % at the commercial harvest time of 'Helali' date palm

Treatments	Fruit set (%)	Bunch weight (kg)	Yield (kg/tree)	Rutab (%)
Control (traditional pollination)	41.6b	5.49b	38.4b	22.6
Pollen grain-water suspension at:				
0.5 g L ⁻¹	56.6a	6.77a	47.4a	22.2
1.0 g L ⁻¹	58.5a	6.52a	45.6a	20.7
1.5 g L ⁻¹	58.4a	6.25a	43.7a	22.5
2.0 g L ⁻¹	42.0b	5.10b	35.7b	20.9
<i>F</i> -test	***	***	***	NS
LSD ($P=0.05$)	5.5	0.62	4.3	

NS and ***, not significant and significant ($P = 0.001$), respectively.

Table 2. Effect of pollination method on physical characteristics of 'Helali' dates at the Bisir stage

Treatments	Fruit weight (g)	Flesh weight (g)	Seed weight (g)	Diameter (cm)	Length (cm)
Control (traditional pollination)	20.19	19.51	0.68	3.02	3.63
Pollen grain-water suspension at:					
0.5 g L ⁻¹	19.31	18.64	0.67	2.93	3.57
1.0 g L ⁻¹	19.46	19.74	0.67	3.05	3.62
1.5 g L ⁻¹	18.89	18.20	0.69	2.86	3.51
2.0 g L ⁻¹	19.71	19.10	0.65	3.01	3.50
<i>F</i> -test	NS	NS	NS	NS	NS

NS, not significant.

Table 3. Effect of pollination method on chemical characteristics of 'Helali' dates at the Bisir stage

Treatments	TSS (Brix %)	Acidity (%)	Vitamin C (mg/100g fw)	Phenols (mg/g fw)	Soluble tannins (mg/g fw)
Control (traditional pollination)	25.3	0.226	7.98	0.91	8.32
Pollen grain-water suspension at:					
0.5 g L ⁻¹	26.7	0.226	7.98	0.95	8.38
1.0 g L ⁻¹	25.1	0.216	8.44	0.90	8.98
1.5 g L ⁻¹	25.6	0.226	7.55	0.94	8.67
2.0 g L ⁻¹	23.9	0.216	7.98	0.92	8.39
<i>F</i> -test	NS	NS	NS	NS	NS

NS, not significant.

Table 4. Effect of pollination method on physical characteristics of 'Helali' dates at the Rutab stage

Treatments	Fruit weight (g)	Flesh weight (g)	Seed weight (g)	Diameter (cm)	Length (cm)
Control (traditional pollination)	11.94	11.34	0.61	2.58	3.16
Pollen grain-water suspension at:					
0.5 g L ⁻¹	11.71	11.13	0.58	2.57	3.23
1.0 g L ⁻¹	11.95	11.36	0.59	2.66	3.14
1.5 g L ⁻¹	11.70	11.16	0.55	2.55	3.13
2.0 g L ⁻¹	11.69	11.17	0.52	2.57	3.14
<i>F</i> -test	NS	NS	NS	NS	NS

The biochemical characteristics such as TSS, acidity, vitamin C, total phenols and soluble tannins were also not significantly affected by any of the pollination treatments at the Bisir and Rutab stages (Tables 3 and 5). The concentrations of TSS and acidity were higher at the Rutab than at the Bisir stage. However, the concentration of vitamin C, total phenols and soluble tannins were greatly lower at the Rutab than at the Bisir stage.

Discussion

Pollination and thinning are critical processes in the date palm production chain that affects fruit development, quality and yield and regulates tree yearly bearing. Developing a pollination technique that results in an acceptable level of fruit set with a minimum amount of pollen grains and with no further need for thinning which is critically required for date palm production, especially under arid conditions (Awad, 2006).

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Table 5. Effect of pollination method on chemical characteristics of 'Helali' dates at the Rutab stage

Treatments	TSS (Brix%)	Acidity (%)	Vitamin C (mg/100g fw)	Phenols (mg/g fw)	Soluble tannins (mg/g fw)
Control (traditional pollination)	51.6	0.299	4.16	0.32	3.72
Pollen grain-water suspension at:					
0.5 g L ⁻¹	49.9	0.254	4.33	0.34	3.63
1.0 g L ⁻¹	49.8	0.310	4.33	0.35	3.64
1.5 g L ⁻¹	47.5	0.266	4.33	0.31	3.62
2.0 g L ⁻¹	47.5	0.267	4.49	0.35	3.67
<i>F</i> -test	NS	NS	NS	NS	NS

NS, not significant

The results of this study showed that spray of pollen grain-water suspension at different concentration significantly increased fruit set percentage, bunch weight and total yield per tree, in contrast to traditional pollination (Table 1). The highest fruit set percentage was obtained with spraying pollen at 0.5, 1.0 and 1.5 g L⁻¹ which was significantly higher than the traditional pollination. One of the major problems faced in the production of some date cultivars such as 'Helali' at the area of Hada Al-Shame in the southwest of the KSA is the relatively low fruit set and/or abnormal flowering accompanied with subsequently high fruit drop percentage (Awad, personal communication). This might be mainly due to environmental conditions (warm winter and lack of cold) and secondarily due to cultural practices. Shabana and Al Sunbol (2007) reported that the lack of fruit set and/or abnormal flowering observed in date palm cultivars growing at Tuhama region in Yemen was due to abnormal warm winter (about 16.5 °C) and insufficient cold. In this experiment, spray pollination especially at 0.5g L⁻¹ resulted in an acceptable level of fruit set (56.6%) with no further need for thinning (Table 1). Thus, under such conditions, spray pollination at certain concentration might be a practical technique to increase fruit set and regulate tree bearing without subsequent need for thinning process (flower and/or fruit thinning). On the other hand, in normally heavy bearing date cultivars such as 'Lulu', spray pollination at 0.5 g L⁻¹ decreased fruit set percentage and improved fruit quality without any subsequent thinning compared to traditional pollination (Awad, 2010). Moreover, in such technique, the pollen grains of excellent male can be stored and used for pollination of the early flowering cultivars (Dowson, 1982; Awad, 2010). One of the main objectives of fruit thinning is to obtain more uniform bunch sizes and increase in fruit size and weight depending on the level of fruit set. This might be due to more availability of assimilates to developing fruits by lowering fruit load (Nixon, 1955; Hussein *et al.*, 1993; Awad, 2006). However, in this experiment, the obtained levels of fruit set, especially with spray pollination at 0.5, 1.0 and 1.5 g L⁻¹ increased bunch weight and total yield per tree without significant negative impact on the physical and biochemical quality characteristics of fruit both at the Bisir and Rutab stages (Tables 2, 3, 4 and 5). It has been reported by few workers that low fruit load increased fruit size and weight of several date cultivars such as Deglet Noor (Nixon, 1955), 'Seewy' (Moustafa, 1998), 'Samany' (Hussein *et al.*, 1993) and 'Khalas' (Al-Khateeb *et al.*, 1993). Generally, cultivars which produce shorter and more round fruit such as 'Khenazy', 'Lulu' and 'Barhee' showed no or little response to thinning, in contrast to those that produce

a elongated fruit type (Awad, 2006). In the current study, TSS, acidity, vitamin C, total phenols and soluble tannins concentration were not affected by any of the pollination treatments (Tables 3 and 5). It was also reported that, for some date cultivars under certain climatic conditions, fruit load had no pronounced effect on the biochemical fruit quality (Al-Bekr and Al-Azzaoui, 1965; Awad, 2006). In conclusion, this study showed the possibility to pollinate 'Helali' date trees by spraying pollen grain-water suspension with optimum amount of pollen grains and with no further need for thinning especially under hot arid conditions. However, more research work is required to justify the optimum concentration of pollen grain-water suspension and the response of each date palm cultivar to this pollination technique.

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