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Investigation of Bunch Cut at Different Times After Pollination and Flower Position in the Spikelet in Date Palm 'Sukkary' Variety

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Abstract

As many studies on other crops showed an acropetal decline of fruit-set and fruit size in the inflorescence, this paper investigates the effect of flower position in spikelets in the 'Sukkary' variety of date palm on fruit-set and final fruit weight. Also studied was the best time to apply strand-cut (bunch cut) as an alternative to hand thinning, to increase final fruit weight. Hand thinning is a labor cost operation and worker productivity operation is one adult tree per day maximum. To study fruit-set in relation to fruit position, three types of pollen were used to pollinate female trees: new pollen harvested in March 2018, pollen stored for one year at room temperature (25-35° C), and pollen stored for two years at room temperature. Four weeks after pollination, fruits aborted and those non-aborted in every bunch were counted. Recording was done in every spikelet from proximal to distal. To study the effect of fruit position in spikelet on fruit weight, fresh pollen was used to pollinate 'Sukkary' females. Every two days, fruit weight was measured from pollination to harvest, and fruit growth pattern was drawn. An analysis of variance (ANOVA) was carried out for the final fruit weight in every spikelet part. This investigation showed no pattern in fruit-set or in final fruit weight when using new pollen. When pollinated with old pollen that was one and two years old, the proximal 'Sukkary' flowers of the spikelets showed less fruit-set compared to those of the middle and distal part. This basipetal decline is explained by low viability of old pollen, combined with the basipetal opening of the spathes in date palm. For strand-cut timing, the highest fruit weight was obtained when the strands were cut earlier at time of pollination (Cut0: 15.82 g), 15 days after pollination (15 DAP or Cut1: 15.36 g) or 30 DAP (Cut2: 14.89 g). Cutting strands later generated lower fruit weight respectively equal to 13.86 g for Cut3 (45 DAP), 13.61 g for Cut4 (60 DAP), and 13.75 g for Cut5 (75 DAP); all not significantly different from the 13.20 g obtained in the control where the strands were kept without cut (Non-cut).

Keywords: Bunch cut, Acropetal, Date Palm, Fruit, Thinning.

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Introduction

Date palm (*Phoenix dactylifera* L.) has been cultivated in the Middle East and North Africa (MENA region) for millennia; however, the exact origin of the date palm has not been verified. The date palm can be cultivated in all five continents of the world, largely between 39 degrees northernmost and 20 degrees southernmost latitudes. The main region of production is the Middle East and North Africa, where 89% of dates are produced (Manickavasagan et al., 2012).

Current world date production is 8.68 million tons. The Kingdom of Saudi Arabia (KSA) is the fourth largest producer of dates. With about 25 million date palm trees, covering approximately 72% of the total area under permanent crops, KSA produces 1.3 million tons of dates annually, which represents 15% of the world date production (FAOSTAT, 2018).

The date palm is one of the major crops that need to be improved from the technical side to optimize production expenses and decrease dependence on manpower.

The 'Sukkary' date is one of the most popular varieties consumed in Saudi Arabia due to its appealing taste. Therefore, the authors' objective for this study is to investigate the best time to apply bunch cutting and keeping 12 fruits on each spikelet as an alternative method to hand thinning, which is a high-cost labor operation. Whatever method of thinning used in the crops they studied, many authors agreed on the fact that the time of thinning had a great influence on fruit size, and that early thinning generated good cell division and, therefore, larger fruit size (Goffine et al., 1995; Sutton et al., 2020; Szot, 2010).

In their investigation of the 'Sukkary' date palm variety, Eljiati et al. (2020) concluded that cutting the bunch at the time of pollination, and keeping 12 fruits on each spikelet, was a better alternative to hand thinning in increasing fruit size without affecting the yield per bunch and yield per tree. When two other methods of thinning were applied by Moustafa et al. (2019), two months after pollination on 'Khadrawi' date palms, and Soliman and Harhash (2012), applied thinning three months after pollination on the 'Sukkary,' date palm they both obtained an increase in fruit size that negatively affected the yield per bunch and yield per tree compared to un-thinned trees (control). The two methods consisted of removing 15% or 30% of the total number of strands from the bunch center.

Another objective of this study is to examine the effect of flower position in spikelets on fruit-set and on fruit weight in the 'Sukkary' date palm variety, as many studies on other crops showed an acropetal decline of fruit-set and fruit size in the inflorescence (Bawa and Webb, 1984; Berry and Calvo, 1991; Diggle, 1995; Obeso, 1993).

Fruit-set is considered to be higher in the base of the inflorescence than in the top. This is because basal flowers open and pollinate first and as a fruit exert a competition on water and nutrients to apical delayed ones (Diggle, 1995; Lee, 1989; Stephenson, 1981).

Materials and Methods

This study was carried out on the Nafeesa farm of Yousef Bin Abdul Latif and Sons Agriculture Co. Ltd. (YALA) in Shihiyah, Saudi Arabia. The first part of the experiment was undertaken during the year 2018, and the second part during the year 2019.

Effect of Bunch Cut at Different Times After Pollination on Fruit Weight

Nine date palm trees aged nine years old of the variety 'Sukkary' were used to study the effect on final fruit size of cutting the strands (spikelets) at different intervals of time after pollination.

To evaluate the best time to apply bunch cut as an alternative method to hand thinning, the authors selected nine trees of the 'Sukkary' variety, aged nine years old, and in each tree, one bunch per treatment was chosen in such a way that they all opened at the same time. They were then pollinated with fresh pollen and tagged.

The bunch cut was applied by cutting the strands in such a way that it kept 12 fruits per strand and removed the rest of the strand. The times of bunch cut evaluated (treatments) were: at the time of pollination (Cut0), and 15 days after pollination (15 DAP or Cut1), 30 DAP (Cut2), 45 DAP (Cut3), 60 DAP (Cut4), and 75 DAP (Cut5), compared to the control where no bunch cut was applied (non-cut).

Every three days, one strand per treatment, per tree, was collected periodically and repeatedly, and their fruits were weighted from pollination until fruit maturation and harvest. In every measurement the authors had nine strands per treatment to measure their fruits and calculate their average fruit weight that would be used to draw their fruit pattern curve. Fruit fresh weight was measured using a top load balance.

Effect of Flower Position in the Spikelet on Fruit-Set and Fruit Weight

To study fruit-set in relation to fruit position, three types of pollen was used to pollinate female trees used in this investigation: new pollen harvested in March 2018, pollen stored for one year at room temperature (25-35 °C), and pollen stored for two years at room temperature (25-35 °C). The three types of pollen were all extracted from the same male genotype. Their viability was assessed before pollination. To do so, pollen staining was done by preparing agar medium, where 10% sucrose was added to 1% agar and the medium was poured into a petri dish. After cooled, the authors placed pollen on the agar medium and added a droplet of 1.0% MTT (2,5-diphenyl mono tetrazolium bromide) solution to pollen. After incubation at 28° C for one hour, the pollen activity was examined under an optical microscope. The pollen activity percentage was calculated after counting approximately 1,000 pollen (Khatum and Flowers, 1995; Rodriguez-Riano and Dafni, 2000). Non-viable pollen grains, which remain light colored, were distinguished from viable ones, which turned to a dark color (violet-purple), indicating the presence of dehydrogenases (Sheffield et al., 2005).

To study the effect of fruit position in the spikelet on fruit weight, one type of fresh pollen extracted from a male genotype was used. The pollen grain was prepared by cutting male flower strands and spreading them onto a paper sheet for two days to dry at room temperature. The pollen grain was extracted manually from the flowers by shaking the male strands and sieving them to remove impurities.

Each of the three types of pollen was used to pollinate one bunch in each of the three nine-year-old trees of the ‘Sukkary’ variety used in this experiment. All bunches pollinated were chosen so that they were homogenous in size and would open at the same time. To avoid pollen contamination, bunches were covered before and after their pollination with paper craft bags (Figure 1).

The pollination was made with pure fresh pollen (100% pollen) without diluting it in any carrier, and by using a bulb duster (Figure 2). Every bunch was dusted with 10 grams of pollen powder. Three powder squirts were applied from the top to the bottom of the female bunch.

Effect of Flower Position in the Spikelet on Fruit-Set

Three weeks after pollination, the paper bags were removed and replaced by mesh bags (Figure 3). Four weeks after pollination, after making sure that fruit-set occurred; the authors recorded whether every fruit was aborted or non-aborted. During the recording, the authors respected the order of the fruits in their spikelet from proximal to distal in every bunch of the three trees. Aborted fruits, called “shiss” by farmers, have three carpels (Figure 4.a). The fruit-set was counted in every third of the spikelet and abortion percentage was calculated.

Effect of Flower Position in the Spikelet on Fruit Weight

To study the effect of fruit position in the spikelet on its weight, three nine-year-old female trees of the ‘Sukkary’ variety were used. One bunch from each tree was pollinated and tagged using fresh pollen extracted from a male genotype employing the same above mentioned methods for both extraction and pollination.

From the day of pollination until maturation and harvest, a destructive method was carried out using a top load balance to measure fruit fresh weight periodically and repeatedly. Wherefore, every three days, three strands were collected from three of the nine bunches to measure their weight. The data were recorded in such a way that the order of the fruits in their spikelets from proximal to distal was respected in every measure. The data were collected and the fruit growth pattern of every part of the spikelet was drawn. An analysis of variance (ANOVA) was also carried out to assess the final fruit weight in every spikelet part.

Results and Discussion

Effect of Bunch Cut at Different Times After Pollination on Fruit Weight

Hierarchical Cluster Analysis: Hierarchical clustering using the average linkage clustering method with the Euclidean distance measurement method was performed to the 49 measurements of fruit weight taken from pollination to harvest for all bunch cut methods (Figure 5). The dendrogram obtained grouped the bunch cut methods into two clusters with additional subgroups in each group. Group I was composed of the methods of cutting the bunch respectively, at the time of pollination (Cut0), 15 days after pollination (Cut1), and 30 days after pollination (Cut2). Group II included the control where the bunch was kept without cut (non cut) plus the methods of cutting the bunch respectively 45 DAP (Cut3), 60 DAP (Cut4), and 75 DAP (Cut5).

Both groups were further divided into two subgroups each: in Group I, the subgroup 1 contained the two methods of bunch cut: at time of pollination (Cut0) and 15 DAP (Cut1). Subgroup 2 is composed of solely the method of bunch cut at 30 DAP (Cut2).

In Group II, the subgroup 1 is composed of only the method of bunch cut at 45 DAP(Cut3), and in subgroup 2, the methods of bunch cut were at 60 DAP (Cut4), at 75 DAP (Cut5), in addition to the control where no bunch cut was applied (non-cut)

Additionally, the heat map compared the value of the weight taken during every measurement time period. Each data cell was colored based on the highest and lowest value, where the yellow color was the highest, the white was the medium and the blue was the lowest. The bunch cut methods respectively, at the time of pollination (Cut0), at 15 DAP (Cut1), and at 30 DAP (Cut2), kept the highest weight value during all the periods of fruit growth. They all belonged to Group I, in comparison to the rest of bunch cut methods belonging to Group II, where only bunch cut method 45 DAP (Cut3) that had a high fruit weight in the beginning of the fruit growth and finished with a lowest weight value.

An ANOVA was also run to analyze whether any of the final fruit weight mean differences between the treatments were significant. Accordingly, the results showed significant ($p<0.01$) differences between all bunch-cut methods (Table 1).

This confirmed the results obtained by the heat map analysis applied to data of fruit weight from pollination to harvest. The four subgroups of treatments are clearly shown in Figure 5. The first subgroup with the highest fruit weight composed of cutting strands at time of pollination (Cut0) and 15 DAP (Cut1), is followed by subgroup 2 where strands were cut at 30

Figure 1. Sukkary bunches covered before and after pollination with paper craft bags.

Figure 2. A bulb duster is used to pollinate female bunches.

DAP (Cut2). Both subgroups were placed into the same group (a) by the heat map analysis (Figure 5). While Cut3 (45 DAP), Cut4 (60 DAP), and Cut5 (75 DAP) were placed into the same subgroup (b). Non-cut, however, was in an isolated subgroup with the lowest fruit weight.

Fruit weight, despite following the same growth pattern in all treatments (Figure 6), reached "tamr," or mature stage, maintaining the same ranking as the one the authors obtained using the ANOVA and heat map. Fruit growth of the 'Sukkary' date palm variety followed a sigmoidal pattern in accordance with the findings of Rouhani and Bassiri (1976), Torahi and Arzani (2010), and Awad et al. (2011) for other date palm varieties, and Eljiati et al. (2020) for 'Sukkary' and 'Khlass.' Three main growth phases were identified accordingly (Figure 6).

Lag Phase: Starting from pollination until 35 DAP and where there is a very slight increase in fruit weight.

Exponential Phase: Starts from 35 DAP and ends at 130 DAP. This phase is characterized by maximum fruit growth.

Stationary and Diminishing Growth Phase: Increase in fruit size became stationary from 129 DAP, and fruit developed into mature stage, or "tamr," where the fruit started losing humidity gradually until reaching around 20% of moisture at harvest.

The operation of bunch cut as an alternative to hand thinning, when done in the lag phase (Cut0, Cut1, and Cut2), generates an increase in final fruit weight (Figures 5 and 6, and Table 1). In most crops, the lag phase, known as phase S1, plays a relevant role in defining the final fruit size. Farinati et al. (2017) reported that in Rosaceae fruits, the length of the early stage of development (S1), known as the cell division stage, plays a relevant role in determining the final fruit size at harvest, and that this stage is very short or absent in small fruits (i.e., in raspberry), while it lasts for 7–25 and 21–35 days in peach and apple fruits, depending on the variety.

In peach fruit, cell division is restricted to the early part of the growth cycle. Four weeks after full bloom, the final cell number in the mesocarp and endocarp appears to be fixed (Masia et al. 1992). When they studied different varieties of peach, Yamaguchi et al. (2002) concluded that the cultivar that ceased cell division early had a small final number of mesocarp cells, resulting in small fruit, and that the smallest size of wild peach is attributable to slow cell division and poor cell growth. In same species, Wu et al. (2005) reported that early fruit size had a positive influence on subsequent fruit growth, while Souza et al. (2019) and Scorza et al. (1991) both stated that the number of cells had greater influence on the final peach fruit size than the cell area. Sutton et al. (2020) considered that the majority of cell division during peach fruit growth occurs during the S1 stage at early fruit development.

Figure 3. The bunches are covered with a mesh bag to make fruit-set counting easier.

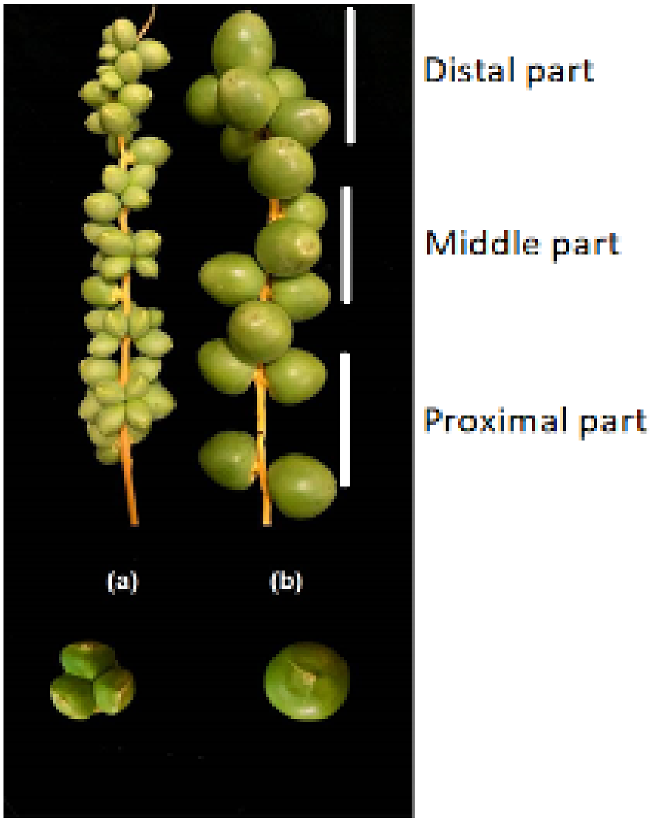

Figure 4. (a) Aborted flowers giving three carpels called "shiss," and (b) flowers where the fruit-set was successful.

The same finding was reported in melons. According to Higashi et al. (1999), the size of melon fruit is defined by the cell number in the pericarp. In olives, a strong linear correlation, was found between the final cell number and the fruit size, indicating that fruit size increased linearly with cell number, but not with cell area, and that the rate of increase of cell number in Period I was 5–11 times greater than in Period II (Hammami et al., 2011).

Cell number has also been shown to be the major determining factor for fruit size differences among cultivars of Japanese apricots (Yamaguchi et al., 2004), Japanese plums (Nagashima et al., 2019), and sweet cherries (Olmstead et al., 2007), as well as other fruits, such as apple (Harada et al., 2005), blueberries (Johnson et al., 2011), and Japanese pears (Zhang et al., 2006).

In an attempt to increase date fruit size, most date farmers are used to applying hand thinning starting from the "hababook" stage, when date fruit size reaches at least a chickpea grain, so that they can catch fruits between their fingers. This stage is equivalent to the end of lag phase and the beginning of the exponential phase (after 35 DAP).

This present investigation showed that this practice would have little impact on final fruit size. When the authors cut strands after the end of lag phase (35 DAP) or later, it generated fruit weight respectively equal to 13.86 g for Cut3 (45 DAP), 13.61 g for Cut4 (60 DAP), and 13.75 g for Cut5 (75 DAP); all not different statistically from the 13.20 g, obtained in the control, where the strands were kept without cut (Non-cut).

The authors only obtained high fruit weight when they cut the strands earlier during time of pollination (Cut0: 15.82 g), 15 DAP (Cut1: 15.36 g), or at the latest, 30 DAP (Cut2: 14.89 g).

In apples, Szot (2010) reported that thinning done at different times has shown significant effects on the final fruit size closely associated with the differences in cell numbers in the cortex, and that smaller fruit size produced by heavily cropping trees can be attributed to low cell number. Cell number is an important component in determining final fruit size. The time of thinning has a great influence on the mean fruit mass. He showed that there was a reduction in mean fruit mass when the time of hand thinning was delayed, and that flower thinning at the pink bud stages and towards the end of the flowering stage had significant effects in obtaining high fruit weight exactly similar to what the authors noted when strand-cut was applied at time of pollination (Cut0).

DeMason et al. (1982) stated that in the endosperm of Mejdool date fruit, at nine weeks after pollination (63 DAP),

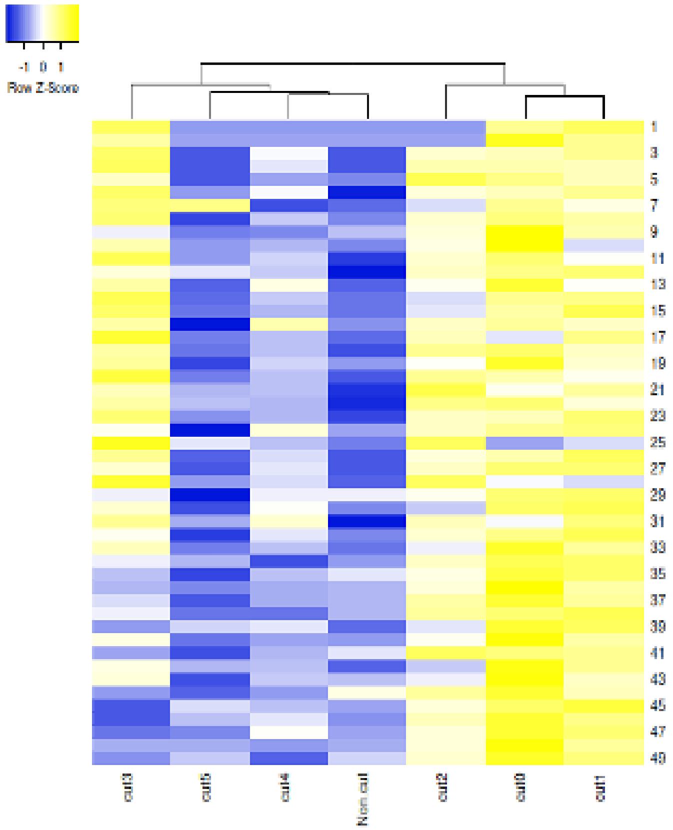

Figure 5. Dendrogram of 6 bunch cut methods and the control based on 45 fruit weight measurements from pollination to harvest of the 'Sukkary' date palm variety.

cell division was already completed and there was the beginning of cell wall thickening. Few mitotic cells remained at 11 weeks (99 DAP). Depending on the layer, cells expand together with a thickening of cell walls, which lasts from 9-17 weeks (63 to 119 DAP). At 17 weeks (119 DAP), all cells had completed their elongation phase, resulting in the maximum fresh weight of fruits.

In apples, fruits thinned at earlier stages were able to increase in weight and cell number, but fruit from trees thinned beyond 10 DAP and fruit from un-thinned trees were not able to develop beyond a weight of 190 g or 50 million cortex cells. This is presumably because early thinning allows fruit to continue cell division in the later stages of fruit development (Goffine et al., 1995).

When the 'Sukkary' fruits are at the end of stage 1 (lag phase), and the beginning of stage 2 (exponential phase), cell number is supposed to already be determined. Early bunch cut (at pollination time) is, therefore, important to allow for a better fruit increase.

The practical consequence of this study is that bunch cut as an alternative to hand thinning in the 'Sukkary' date palm variety should be applied at time of pollination, or in the worst case, 15 days after pollination. The authors do not advise the last practice as it needs more time because, the workers will be asked to visit the tree two times (at time of pollination and at time of cut), the cut operation becomes difficult when the fruits are big, as the cut of the bunch needs two or three shots to be given, compared to one shot at time of pollination.

If, for any reason, a farmer missed the strand cut after 30 days from pollination, it would be useless to do it later. This is because it will not generate any increase in the fruit size, as it will only decrease the number of fruits per bunch, and the yield.

Effect of Flower Position in the Spikelet on Fruit-Set and Fruit Weight

The spikelets were divided into three parts: the proximal third (down part), middle third (middle part), and distal third (upper part). At the level of each spikelet, the authors calculated the percentage of abortion in each of the three parts. Table 2 shows the average abortion percentage per spikelet

Table 1. Average final 'Sukkary' fruit weight when strand-cut was applied at different times after pollination (12 fruits per strand were kept).

Treatment	Time of Application of Strand-Cut	Average Final Fruit Weight (g)(*)
Cut0	Cut is applied at time of pollination	15.82 ± 0.75 ^{a}
Cut1	Cut is applied 15 days after pollination (15 DAP)	15.36 ± 0.84 ^{a}
Cut2	Cut is applied 30 days after pollination (30 DAP)	14.89 ± 0.71 ^{a}
Cut3	Cut is applied 45 days after pollination (45 DAP)	13.86 ± 0.74 ^{b}
Cut4	Cut is applied 60 days after pollination (60 DAP)	13.61 ± 0.54 ^{b}
Cut5	Cut is applied 75 days after pollination (75 DAP)	13.75 ± 0.66 ^{b}
Non-cut	No strand cut is applied	13.20 ± 0.44 ^{b}

(*) Averages final fruit weights that do not share the same letter are significantly different according to T-test anals.

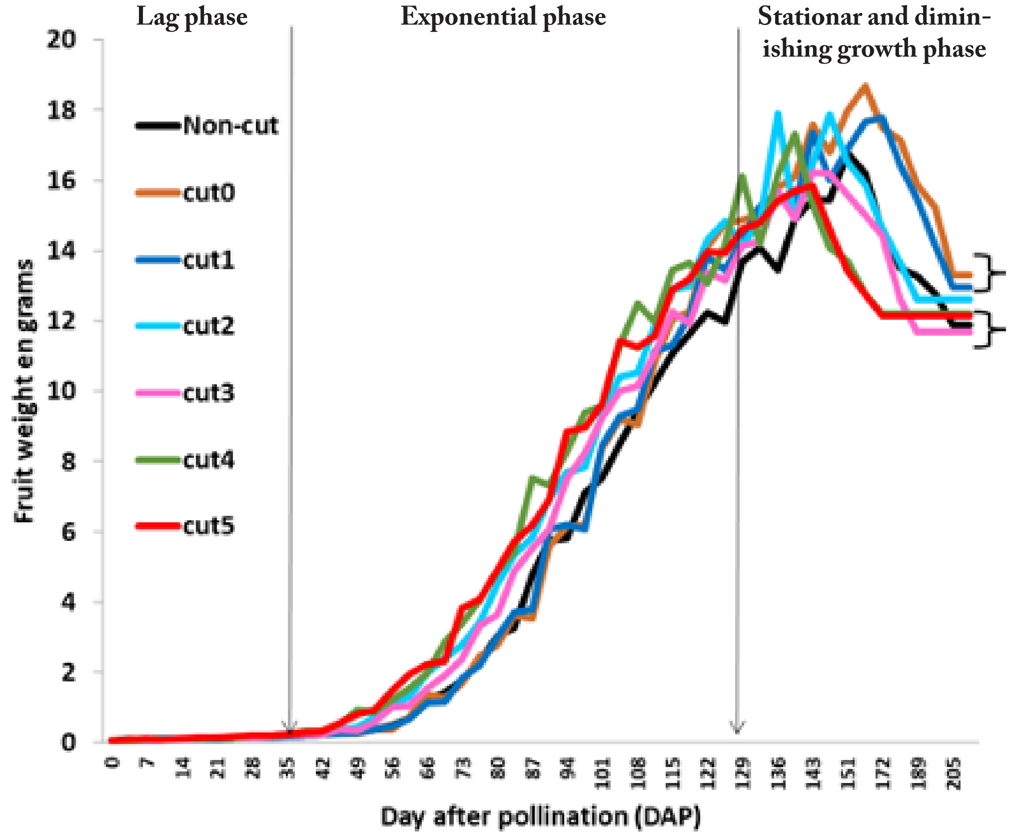

Figure 6. Fruit growth pattern (g) of 'Sukkary' fruit where bunch was cut at different interval times.

part and per pollen age.

When pollen is new (harvested in the same season), the position in the strand does not affect the fruit-set, as the authors noted no significant differences in abortion percentage between the three spikelet positions. Whereas with old pollen (one-year-old and two-year–old), with very low viability (Table 3), the proximal flowers of the spikelets are exposed to abortion more than those of the middle and distal parts (Table 2).

The spathe of date palm inflorescence always starts to open from the top of inflorescence to the bottom. Only flowers exposed to sunlight open. DeMason et al. (1982) reported that flower primordia and their subtending bracts are formed first at the base of the rachillae, and are initiated in an acropetal sequence as the rachillae elongate. In later development, all flowers within an inflorescence are at approximately the same stage of development, although they may not be of the same size. However, the authors considered that maturation of date palm sexual organs seem to occur in a basipetal direction before anthesis. This is true as proximal flowers are always the last to open and, therefore, their receptivity to pollen is delayed compared to distal flowers. When the authors performed pollination, they covered the bunches with paper craft bags so as to not only avoid pollen contamination, but also keep pollen available as long as possible and minimize the negative effects of any of weather conditions on pollination (wind, rain, etc.).

The basipetal decline pattern in the fruit-set obtained in the old pollen and the non-pattern, which was obtained with fresh pollen, differed completely from the acropetal decline trend found in many species where the fruit-set is higher at the base of the inflorescence than at the apex (Bawa and Webb, 1984; Berry and Calvo, 1991; Diggle, 1995; Obeso, 1993).

Many researchers explain the acropetal decline trend in fruit distribution by both, the earlier opening of the basal flowers whose transformation into fruit would limit later younger distal fruit-set, and by the position of proximal flowers/fruits with respect to resources compared to distal flowers and fruits located farther from the supply of resources (Diggle, 1995; Lee, 1989; Stephenson, 1981). For date palms, the first assumption is not true, as flower anthesis starts from distal to proximal.

The same finding has been reported by Arista et al. (1999) in carob (*Ceratonia cilica*) populations, a dioecious leguminosae tree. The authors found that racemes-setting fruit arrangement follows a definite basipetal decline pattern that remains constant between years and populations of carob trees: fruit production was significantly higher in the apical zone of the raceme and lower in the basal zone. They attributed this to pollinators' activity (flies and wasps) that showed a clear preference for beginning their visits at the apex of a raceme. Therefore, the pollen load deposited on the stigmas decreased from the apex to base of the raceme. They found out that in most of the flowers situated in the central and basal zones of the raceme, the number of pollen grains deposited on their stigmas was lower than the number of their ovules.

To prove this, the authors applied hand pollination to the flowers of the carob, and obtained a contrasting acropetal decline pattern in both the number of fruits initiated and those ripening within the raceme (those closest to the resource origin).

Effect of Flower Position in the Spikelet on Fruit Weight

The fruit weight measured every three days from pollination to harvest in each of the three parts of the spikelets of the 'Sukkary,' generated the information shown in Figure 7. During all life cycles of fruits in every of the three parts of the strand, the three curves were almost similar, and no part of the spikelet showed a superiority compared to the other parts. To confirm this, an ANOVA was used to analyze the average final fruit weight measured in the three spikelets to follow the fruit growth pattern. The analysis revealed no significant difference between fruit weight of the parts of the strand (Table 4).

This investigation showed no pattern of fruit growth related to fruit position in the spikelet. However, many studies on other crops demonstrated an acropetal decline in fruit size within inflorescences.

Diggle (1995) considered that declining fruit length may have been due to a decline in the number of ovules fertilized or to an increase in ovule or seed abortion, but the decline could also be caused by a decrease in ovary size and number of ovules per ovary with position.

Means that do not share the same letter are significantly different, according to T-test analysis. On other crops, distal flowers typically reach anthesis after proximal flowers and, thus, initiate fruit development at a later time. If sink strength of fruits increases with size and age, distal fruits will have lower competitive ability (with respect to resources) compared to early fruits within an inflorescence. In addition, distal flowers and fruits located farther from the supply of resources may, therefore, have less access to resources (Diggle, 1995). However, the authors consider that competition for resources between distal and basal flowers and fruits, would not be the sole explanation for declining fruit-set acropetally.

In date palms, the anthesis starts from distal to proximal flowers. When using fresh pollen, the authors did not obtain any pattern of fruit-set related to the position of the flowers in the spikelet. At the same time, no pattern was obtained in fruit weight (Figure 7 and Table 4).

In tomatoes, Bangerth and Ho (1984) demonstrated that the final size of the tomatoes is determined by both the potential sink strength, which is determined to a great extent before fruit-set, and the competition for assimilate supply, determined by the sequence of fruit-set. The latter effect on fruit growth is also modified by the potential sink strength of the fruit and the time lapse between fruit-set.

Other studies, however, have identified opposite patterns in which the proximal positions are not associated with high fruit-set and maturation. That is the case of McKone (1985), who studied patterns of fruit-set in five *Bromus* species (Poaceae). He concluded that, except in *Bromus inermis*, fruit production was not randomly distributed among florets with respect to spikelet position, and that in three of the five Bromus species there was a peak in seed-set in the middle third florets, and then a decline in seed-set occurring in the upper (distal) florets; seed-set fell consistently with floret position acropetally in *B. tectorum*.

Stocklin and Favre (1994) discovered that proximal and distal positions within the inflorescence of ovules within fruits showed higher abortion rates than intermediate positions in the two *epilobium* species they studied. They, however, concluded that proximity to resources and the absence of competing older fruits were not necessarily an advantage.

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Table 2. Effect of the position in the spikelet in the 'Sukkary' date palm on abortion percentage pollinated, with pollen having different storage times.

	Abortion Percentage (%)			
	Proximal Third of Spikelet	**Middle Third of Spikelet**	**Distal Third of Spikelet**	**Total**
New Pollen	5.4 ± 1.3 %^{a}	4.0 ± 1.2 %^{a}	4.5 ± 1.9 %^{a}	13.9%
One-Year-Old Pollen	25.0 ± 1.4 %^{a}	19 ± 2.1 %^{b}	11.6 ± 0.7 %^{c}	56.0%
Two-Year-Old Pollen	27.0 ± 2.7 %^{a}	20.0 ± 2.5 %^{b}	16.3 ± 1.0 %^{b}	68.3%

Means that do not share the same letter are significantly different according to T-test analysis.

Table 3. Viability of pollen with different storage times used to assess fruit-set, in relation to flower position in the 'Sukkary' date palm variety.

	Pollen Viability %
New Pollen	89%
One-Year-Old Pollen	50%
Two-Year-Old Pollen	19%

Table 4. Fruit weight per spikelet part for 'Sukkary' pollinated with fresh pollen.

Fruit Position in Spikelet	**Average Fruit Weight (g)**
Proximal Fruits	10.7 ± 0.44 ^{a}
Middle Fruits	10.1 ± 0.25 ^{a}
Distal Fruits	10.0 ± 0.30 ^{a}

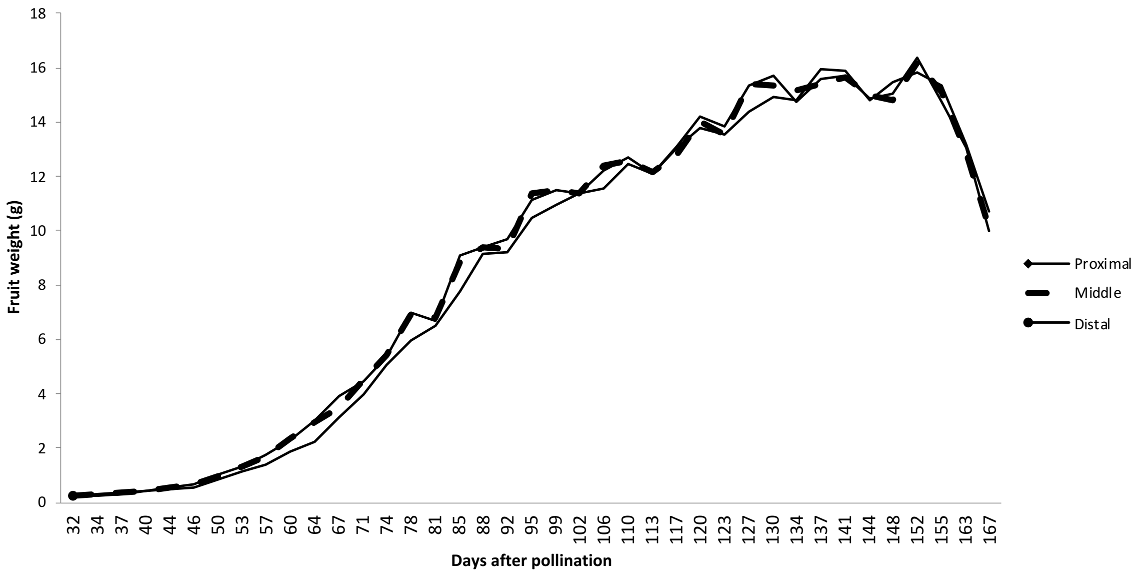

Figure 7. Fruit growth pattern (g) of the three parts of the spikelet of 'Sukkary'.

Berry and Calvo (1991) studied the pollination method and flower position in *Myrosmodes cochleare* (Orchidaceae). They found that when plants are self-pollinated, fruit-set decreased from 100% in proximal positions to 0% in distal positions, while fruit-set in open-pollinated plants was maximal in the middle third of the inflorescence and declined both basipetally and acropetally. This led the authors to conclude that the pattern observed in the open-pollination treatment reflected the activity of pollinators.

A survey of the literature made by Thomson (1989) revealed that the number of ovules per flower decline from proximal to distal position flowers in 13 of 15 species. He concluded that this decline was associated with a lower probability of fruit-set in later flowers.

In *Aquilegia buergeriana* var. oxysepala, Itagaki and Sakai (2006) expected that if they applied bud removal, this would reduce interflora competition, and then the number of seeds produced by the remaining flowers within inflorescences would increase. After conducting trials, they concluded that such removal had little impact on the number of seeds produced by the remaining flowers. This means that resource competition hypothesis does not always explain acropetal decline in fruit and/or seed-set within inflorescences.

All above, research shows that the acropetal decline over flowers is not a universal biological model.

Conclusion

At the opposite of many other crops, the 'Sukkary' date palm variety did not show any pattern in fruit-set and final fruit weight regardless of the position of the fruit/flower in the strand.

Bunch cut as an alternative to hand thinning in the 'Sukkary' date palm variety should be applied at time of pollination, as it is this generates the highest fruit weight, it is easy to apply due to the small size of the bunch.

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