

Effect of Pollination Method on Changes in Physical and Chemical Characteristics of Date Fruit During Development

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تأثير طريقة التلقيح على التغيرات في الصفات الطبيعية والكيميائية خلال تطور ثمرة التمر

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خلاصة: تم تلقيح أشجار النخيل بواسطة اليد وملقحتين يدوية وميكانيكية. وقد خلطت حبوب اللقاح للاستعمال في الملقحتين بدقيق القمح بالنسبة ١:٥ و ١:٧ و ١:٩ و ١:١٤. تم جمع عينات الثمار في مراحل الهابوك والكمري والبسر والرطب والتمر وأجريت عليها دراسة الصفات الكيميائية والطبيعية داخل المختبر. كانت نسبة عقد الثمار للملقحة الميكانيكية أقل عن النسبة التي أعطتها الملقحة اليدوية. لم تكن هناك فروقات معنوية من حيث تأثير طريقة التلقيح على الإنتاج. لم يثبت أن أي من الفروقات الكيميائية والطبيعية التي ظهرت أثناء المرحلة ذاتها يمكن أن تكون مؤشراً للنضج. ففي مرحلة الكمري احتوت الثمار على نسبة أعلى من البكتين (متاخرة النضج) باستخدام الملقحة الميكانيكية إذا ما قورنت بالتلقيح باليد والملقحة اليدوية. ولكن الملقحة الميكانيكية أعطت ثماراً أكبر حجماً في مرحلتَي البسر والرطب مقارنة بالملقحة اليدوية بينما اعتبر النقص في الحموضة في الثمار بين مرحلتَي البسر والرطب والنقص في حجم الثمار بين مرحلتَي الرطب والتمر مؤشراً للنضج المبكر للثمار المنتجة بواسطة التلقيح اليدوي. لكن النقص في الحموضة بين مرحلتَي الرطب والتمر يشير إلى أن الثمار المنتجة بواسطة التلقيح اليدوي تنضج بسرعة أقل عن تلك المنتجة بواسطة التلقيح الميكانيكي بغض النظر عن نسب خليط حبوب اللقاح مع الدقيق. ويمكن اعتبار الحالة الأخيرة ناتجة عن تحول الأحماض إلى الصيغة الداكنة في مرحلة التمر. وقد أعطت نسبة ١:١٤ (دقيق:حبوب لقاح) إنتاجاً أقل و كان عقد الثمار وسطاً وأعلى في المادة الجافة وكان الإنتاج مرتفعاً بينما أعطت النسبة ١:٥ نسبة أقل من سكر القصب والمادة الجافة مع زيادة في الأنتاج.

ABSTRACT: Date palms were pollinated by hand, hand duster and motorized duster. Pollen for the hand and motorized dusters was diluted with wheat flour each at 1:5, 1:7, 1:9 and 1:14 ratios. Fruit samples were collected during 'Hababook', 'Kimri', 'Bisir', 'Rutab', and 'Tammr' stages. Chemical and physical characteristics were determined in the laboratory. The motorized duster produced lower fruit set than the hand duster. No significant effect of pollination method on yield was observed. None of the physical or chemical differences that appeared during the same stage of fruit development proved to be an indicator of maturity. During 'Kimri', more fruits with higher pectin (late maturing) were produced by the motorized duster than those produced by hand pollination and hand duster. But the motorized duster produced fruits with larger volume (i.e. 'Rutab' and 'Tammr') than those of hand pollination. However, the reduction in acidity between 'Bisir' and 'Rutab' and in volume between 'Rutab' and 'Tammr' clearly indicated early maturity of the hand-pollinated fruits. The reduction in acidity between 'Rutab' and 'Tammr' indicated that hand-pollinated fruits ripen at a slower rate than the fruits of mechanized pollination at any of the pollen to flour ratios. The latter case could be attributed to the conversion of the acids to the dark pigmentation of 'Tammr'. The lowest pollen:flour ratio (1:14) produced the lowest yield, moderate fruit set and highest dry matter, whereas the highest ratio (1:5) produced a lower sucrose and dry matter and higher yield.

Keywords: date fruit, pollination method, Oman.

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The date palm is the most important fruit tree in the Arab world. Total world production in 1992 reached 3.4 million tons, of which 73.3% came from Arab countries (FAO, 1993). In the Sultanate of Oman dates are staple food and the palm has a special place in Omani traditions. It occupies 44.2% of the total cropped area (MAF, 1994). The dioecious nature of the date palm necessitates the transfer of pollen from the male spadix to the female spadix. Date palms are naturally wind pollinated. However, this method is inefficient and economically unfeasible (Clor *et al.*, 1974). Hand pollination has been practiced for centuries in Babylonia, it is well described in the Humorabi Laws and in the ancient Egyptian scripts (Al-Bakr, 1972). In this method the pollinator climbs the tree and places a certain number of male strands in each female spadix. As not all of these spadixes open at the same time, climbing the tree must be repeated. Besides being subjected to thorn stings, the pollinator will not be able to pollinate more than 3-5 palms per hour or approximately 1000 palms during the whole season.

The first attempt to mechanically pollinate the date palm was reported in India by Bonavia (1885) who applied pollen by pressing a rubber bulb to push pollen through a pipe. That was followed by Monceiro (1952) and Alexander (1952). Since then different methods have been developed. Ground-level dusters, including bloom and palm dusters were used in the USA by Brown and Perkins (1969), Brown *et al.* (1970), Perkins *et al.* (1972) and Perkins and Burkner (1973). Mechanical pollination was also intensively investigated in Iraq by Shabana *et al.* (1985, 1986); Mawlood *et al.* (1986); Ghalib *et al.* (1987) and Ibrahim (1988). This research concentrated on investigating the effect of different methods of pollination on physical characteristics of the date fruit. In general the above studies suggested that mechanical pollination increased labor efficiency, produced comparable yield and lower fruit set, required more pollen and offered greater returns compared to hand pollination. Results of several experiments showed consistent trends in the changes that occurred in the chemical composition of different date cultivars through the four major developmental stages of date fruit development (Basha *et al.*, 1988; Coggins and Knap, 1969; Hussein *et al.*, 1976; Sakri *et al.*, 1975; Buchaev *et al.*, 1987; Sawaya *et al.*, 1982; Ahmed and Ahmed, 1995; ElMardi *et al.*, 1998). These results showed that moisture, acidity, pectin and tannin continued to decrease as the fruit developed from 'Kimri' to 'Bisir' to 'Rutab', with a minimum content in 'Tamr'. On the other hand, total sugars and reducing sugars continued to increase from one stage to the next. However, sucrose increased in the case of dry dates and decreased in soft dates. The present experiment was intended to study the effect of pollination method and pollen concentration on chemical

and physical characteristics of the developing fruit of cultivar Fard.

Materials and Methods

Cultivar Fard, which is considered the main date cultivar in the packing industry of the Sultanate of Oman was selected for this experiment during the 1993 season. This was mainly because all the developmental stages are completed while the fruit is still intact on the tree. Medium height palms (7-8 m) in Nizwa Waliyat were randomly selected in a factorial experiment with 4 replicates. The pollination methods used were: 1) involving the insertion of 3 male strands of Khori cultivar in to the female spadix. The distil end of the pollinated spadixes were then tied by palm fronds; 2) A hand pollen duster, consisting of a small piston pump connected to a reservoir and mounted on an aluminum frame, was used to push pollen through tubing by compression. The pollen was released via a spring connected to a piston; and 3) A motorized pollen duster was also used. This consisted of a small air compressor, operated by a two-stroke gasoline engine, a 10l pressurized air storage tank, a spray gun, and plastic piping. A hand valve was used to release the pressurized air containing the pollen.

Pollen for the two mechanical methods was mixed with wheat flour (grade 1) in ratios of 1:5, 1:7, 1:9 and 1:14. The mixture of pollen and flour was released 4 times on each spadix. Early and late appearing spadixes were pollinated at weekly intervals, middle season spadixes were pollinated twice a week. This was necessary because they were bigger in size and they tended to open at a faster rate than early and late spadixes.

Fruit samples were collected to represent the five developmental stages: 1) 'Hababook' - small, rounded, light green fruits collected 4 weeks after pollination; 2) 'Kimri' - hard, elongated, dark green fruits collected 9 weeks after pollination; 3) 'Bisir' - hard, elongated, reddish-orange fruits collected 15 weeks after pollination; 4) 'Rutab' - partially soft, reddish-brown fruits collected 20 weeks after pollination; and 5) 'Tamr' - hard brown fruits collected 25 weeks after pollination.

Samples were immediately placed on ice until processing. Physical characteristics assessed were bunch weight and yield per bunch, number of fruits, fruit volume, and fresh and dry weight. Chemical characteristics determined were dry matter, total sugars, reducing sugar content, sucrose and pectin content and acidity level. Dry matter, total sugars, reducing sugars and sucrose percentages were determined using published procedures (AOAC, 1984). Pectin was analyzed according to Less (1977) and titrable acidity according to AOAC (1975 and 1984). Results for sugars, pectin, and

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TABLE 1

Effect of pollination method on physical and chemical changes during development stage of Fard dates.

Treatment	Kimri		Bisir		Rutab			Tamr			
	Number of fruits	Pectin (%)	Acid (%)	Moisture (%)	Acid (%)	Reduction in Acidity (%)	Volume (ml)	Volume (ml)	Reduction in Volume (%)	Yield (kg/tree)	Sucrose (%)
Hand pollen duster	26.63a	2.89b	2.51b	49.68b	1.84a	26.7	9.68bc	7.97ab	17.7	41.18b	2.59b
Hand pollination	16.75bc	1.75b	3.81a	48.63b	0.71c	81.4	9.75ab	7.37b	24.4	68.50a	6.60a
Motorized pollen duster	21.12b	3.54a	2.63b	55.58a	1.39b	47.1	10.86a	8.55a	21.3	43.75b	3.29b

Numbers in the same column followed by the same letter are not significantly different ($P < 0.05$).

acidity were expressed on a dry weight basis. Volume of fruit was determined by water displacement. Data were statistically analyzed using analysis of variance with LSD values being calculated for comparison of means.

Results and Discussion

The effects of pollination method on the physical and chemical characteristics of date fruits are shown in Table 1. It can be seen that the hand duster produced more fruits per strand (27 fruits) than the motorized duster (21 fruits) and the hand pollination method (17 fruits). The low percentage of fruit set obtained by the motorized duster was probably a result of a large amount of pollen being blown away from the target. Perkins and Burkner (1973) and Vis *et al.* (1971) obtained higher fruit set with hand pollination than mechanical pollination. They concluded that the closer the pollen outlet of the mechanical method to the target, the greater the fruit set. On the other hand, El-Kassas (1986) observed no significant differences in fruit set and yield obtained by a mechanical method and that obtained by hand pollination. Mawlood *et al.* (1986) reported greater fruit set at one experimental site by hand dusting than by hand pollination, but no difference was observed between tractor-trailed and hand carried pollen dusters. However, in the other two locations used, they did not observe a significant difference among the three methods of pollination. The above results reveal that other factors may influence the efficiency of mechanical pollination, including weather, physiological condition of the palms and their arrangement and spacing.

Pectin in 'Kimri' produced by the motorized duster (3.54%) was significantly higher than that produced by the hand duster (2.89%) and by hand pollination (1.75%). Acidity in 'Bisir' produced by the motorized duster (2.63%) and the hand duster (2.51%) was significantly lower than in that produced by hand pollination (3.81%). Therefore, when pectin is

considered as an indicator of maturity during 'Kimri' it appears that the motorized duster fruits were maturing at a slower rate than those produced by the hand duster. But when acidity during 'Bisir' is considered as the indicator of maturity, the motorized duster fruits were maturing at a faster rate than those of hand pollination. The lower the concentrations of pectin and acidity the more mature the fruits (Ahmed and Ahmed, 1995; Buchaev *et al.*, 1987; Sawaya *et al.* 1982). Consequently, the conflicting results of pectin and acidity in the fruits of the motorized duster during 'Kimri' and 'Bisir' indicate their unsuitability as maturity indicators. However, following the changes which may occur in the same compound or physical character while the fruit is developing from one stage to the other can provide a more accurate measure of fruit maturation. This situation can be demonstrated by the reduction in fruit acidity and volume that occurred between 'Bisir' and 'Rutab' and 'Rutab' and 'Tamr', respectively. The data in Table 1 shows that the percent reduction in acidity in 'Rutab' produced by hand pollination (81.4%) was greater than that produced by the motorized duster (47%) and by the hand duster (26.7%). A similar pattern was obtained for the reduction in the fruit volume: hand pollination (24.4%), motorized duster (21.3%), and hand duster (17.7%). These results indicate that fruits produced by hand pollination were maturing at a faster rate than those produced by the motorized and hand dusters.

The effect of pollen dilution on the physical and chemical characteristics of the fruit is shown in Table 2. This shows that the pollen to flour ratios of 1:7 and 1:9 produced a larger number of fruits per strand than hand pollination and the other pollen ratios. Despite the low number of fruits produced by hand pollination (Table 2) this method produced the highest yield (68.5 kg/tree). Furthermore, a comparison between the 1:14 and 1:5 ratios of pollen to flour, which produced the same number of fruits (21 fruits), revealed that the higher pollen to flour ratio produced the greater yield (29 and 43 kg, respectively). The general trend of the

TABLE 2

Effect of pollen to flour ratio on physical and chemical changes during development stages of Fard dates.

Pollen: flour	Kimri	Bisir			Tamr		Yield Kg/tree
	No. of fruits	Sucrose (%)	Reducing sugars (%)	Dry matter (%)	Acid (%)	Pectin (%)	
1:5	21.12b	1.88c	36.56ab	25.30bc	0.05a	0.94a	42.87b
1:7	27.75a	5.34a	34.37b	28.35ab	0.43ab	0.63bc	48.37b
1:9	25.75a	2.02b	38.71a	24.63bc	0.34bc	0.43c	49.75b
1:14	20.87b	2.40b	32.05b	29.87a	0.52a	0.77ab	28.87c
Hand pollination	16.75bc	1.45c	41.13a	23.60bc	0.54a	0.73ab	68.50a

Numbers followed by the same letter in each column are not significantly different ($P < 0.05$).

data indicates that a 1:14 pollen to flour ratio produced the lowest yield (29 kg/tree) and moderate quantities of fruit (21 fruits per strand), but these fruit had the strand, and 25% dry matter, respectively). Significant differences in chemical constituents of the fruits showed that during 'Bisir', hand pollination and a pollen to flour ratio of 1:5 produced fruits that were low in sucrose and dry matter and the highest in reducing sugars, indicating earlier maturation. The increase in reducing sugars that coincided with a reduction in sucrose is probably a result of the activity of invertase enzymes. These fruits however produced the highest acid and pectin concentration during 'Tamr', an indication of late ripening.

The interaction effects between pollen dilution and method of pollination on the physical characteristics of date fruits are shown in Table 3. There was no significant difference in the number of fruits during 'Hababook' and fruit volume during 'Tamr' produced by any of the four pollen concentrations applied by hand and motorized dusters compared with those produced by hand pollination. However, during 'Kimri' the hand duster with the four pollen concentrations developed significantly more fruits than hand pollination except at the 1:5 pollen concentration. During 'Kimri' the hand duster produced the greater number of fruits than the motorized duster when both applied 1:14 pollen to flour

highest dry matter (30%). The highest pollen concentration (1:5) produced moderate yield, quantity and dry matter percentage of fruits (43 kg, 21 fruits per ratio). But no significant difference in the number of fruits was observed when both dusters were operated at 1:5, 1:7 and 1:9 ratios. Such results suggest that higher pollen concentrations are not necessarily producing a higher percentage fruit set than the low pollen concentrations. This confirms the results of Vis *et al.* (1971) and Ghalib *et al.* (1987). Furthermore, the results of fruit set indicate that the hand duster is more efficient than the motorized duster if a low pollen concentration (1:14) is used. The lower fruit number produced by the motorized duster is probably a result of wind blowing the pollen off target. Variation in the pressure as a result of the long distance between the pollen source and the pollen exit and the difficulty in directing the pipe opening into the female spadix were probably contributory factors. There was a 41.6 and 8.30 % increase in fruit set during the period between 'Hababook' and 'Kimri' when the hand and motorized dusters, respectively, applied a 1:14 pollen to flour ratio. However, hand pollination caused a reduction of 21.1% in fruit set during the same period. This fruit drop was associated with a slightly larger number of fruits during 'Hababook' than that obtained by the hand and motorized dusters with a 1:14 pollen concentration. This

TABLE 3

Interaction effect between pollination method and pollen to flour ratio on physical characteristics of Fard dates during developmental stages.

Treatment (Pollen:flour)	Hababook	Kimri		Tamr			Average Bunch Wt (kg)
	Fruits/ Strand	Fruits/ Strand	Percent Change in Fruit Set	Volume (ml)	Fruit Fresh Weight (g)	Yield/ Tree (kg)	
Hand pollination	21.25abc	16.75cd	-21.1	9.75a	7.85b	68.50a	7.210
Hand duster (1:5)	24.00ab	25.52abc	5.2	9.87a	9.15b	45.00abc	3.750
Hand duster (1:7)	27.75a	28.25a	2.0	10.00a	8.70b	50.50abc	5.050
Hand duster (1:9)	26.50a	27.50a	4.0	10.00a	8.71b	41.25abc	3.750
Hand duster (1:14)	18.00bc	25.50ab	41.8	8.87a	7.60b	28.00c	3.500
Motorized duster (1:5)	17.50bc	17.00bcd	-2.8	10.75a	8.92b	40.75abc	4.178
Motorized duster (1:7)	22.25ab	27.25a	23.0	11.12a	8.82b	46.25abc	4.743
Motorized duster (1:9)	15.00c	24.00abcd	60.0	10.75a	8.60b	58.25ab	5.178
Motorized duster (1:14)	15.00c	16.25d	8.3	10.82a	10.95a	29.75bc	3.840

Numbers followed by the same letter in each column are not significantly different ($P < 0.05$).

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TABLE 4

Effect of interaction pollination method and pollen to flour ratio on chemical constituent of date fruit.

Treatment (Pollen:flour)	Hababook	Kimri		Tamr			
	Fruits/ Strand	Fruits/ Strand	Percent Change in Fruit Set	Volume (ml)	Fruit Fresh Weight (g)	Yield/ Tree (kg)	Average Bunch Wt (kg)
	21.25abc	16.75cd	-21.1	9.75a	7.85b	68.50a	7.210
Hand duster (1:5)	24.00ab	25.52abc	+5.2	9.87a	9.15b	45.00abc	3.750
Hand duster (1:7)	27.75a	28.25a	+2.0	10.00a	8.70b	50.50abc	5.050
Hand duster (1:9)	26.50a	27.50a	+4.0	10.00a	8.71b	41.25abc	3.750
Hand duster (1:14)	18.00bc	25.50ab	+41.8	8.87a	7.60b	28.00c	3.500
Motorized duster (1:5)	17.50bc	17.00bcd	-2.8	10.75a	8.92b	40.75abc	4.178
Motorized duster (1:7)	22.25ab	27.25a	+23.0	11.12a	8.82b	46.25abc	4.743
Motorized duster (1:9)	15.00c	24.00abcd	+60.0	10.75a	8.60b	58.25ab	5.178
Motorized duster (1:14)	15.00c	16.25d	+8.3	10.82a	10.95a	29.75bc	3.840

Numbers followed by the same letter in each column are not significantly different ($P < 0.05$).

could be attributed to the greater competition for food and nutrients (Nixon and Crawford, 1942; Furr and Hewitt, 1964) and to the tie of the spadix tip that may have exerted a stress on the emerging bunch.

Data on the yield per tree and average fruit weight followed a similar trend in the case of hand pollination and the two mechanical methods at 1:5, 1:7 and 1:9 pollen to flour ratios. However, at the 1:14 ratio the production by the hand duster (28.00 kg/tree) and the motorized duster (29.75 kg/tree) were both significantly lower than hand pollination, though the motorized duster fruits were heavier. Fruit fresh weights of 7.6 and 10.9 g were produced by the hand duster and motorized duster, respectively (Table 3). The larger yield per tree from hand pollination was associated with the heaviest bunch (7.2 kg). The lowest yields (28.0 and 29.7 kg/tree) were associated with the lowest bunch weights (3.5 and 3.8 kg) that were obtained by pollen concentrations of 1:14 using the hand duster and motorized duster, respectively. Furthermore, the hand and motorized dusters with 1:5, 1:7 and 1:9 pollen concentrations produced moderate yields (Table 3). These results indicate that the lower the pollen concentration, the greater the severity of fruit thinning, and consequently, the lower the yield. In such cases, whatsoever the higher fruit grades obtained will not compensate for the loss in yield that may result in low returns (Furr and Hewitt, 1964; Nixon and Crawford, 1942; El-Kassas, 1986). In balancing yield and fruit size the hand and motorized dusters were found to be the most satisfactory, working with 1:7 and 1:9 pollen to flour ratios, respectively.

The interaction between method of pollination and pollen to flour ratio on the chemical characteristics of the fruit are shown in Table 4. The data shows that dry matter percentage accumulated during 'Bisir' when using the hand duster at 1:14 pollen ratio and the motorized duster at 1:7 were 31 and 29%, respectively. Both were significantly greater than that obtained by

(23.6%). However, during 'Rutab' the motorized duster at the 1:7 pollen ratio produced lower dry matter (39.5%) than the hand duster at the 1:14 pollen ratio (53.4%) and hand pollination (53.4%). There was a considerable increase in dry matter content of dates obtained by hand pollination between 'Bisir' and 'Rutab' stages. This increase reached 126% and coincided with the highest fruit drop (21%) that occurred between 'Hababook' and 'Kimri' (Table 3). Furthermore, the increase in dry matter which occurred between 'Bisir' and 'Rutab', produced by the motorized duster at the 1:7 pollen concentration (37.5%) was much smaller than that produced by the hand duster at the 1:14 pollen concentration (72.0%). The former was associated with a smaller increase in the number of fruits between 'Hababook' and 'Kimri' (23.0%) than the latter (41.6%, Table 3). The dry matter accumulation rate in fruits produced by the motorized duster at the 1:7 pollen concentration was smaller than that in fruits produced by the same machine at the 1:5 pollen concentration (57%). The latter was associated with a drop (2.8%) in the number of fruits (Table 3). Evidently, the earlier the fruit development during the pollination season and the larger the fruit drop between 'Hababook' and 'Kimri', the greater the rate of dry matter accumulation.

Sucrose in 'Bisir' produced by the hand duster at 1:14 pollen was significantly greater than that produced by the motorized duster at 1:14 pollen, but it was similar to that in 'Bisir' produced by hand pollination. Such small variations in sucrose do not indicate a clear pattern of interaction between pollination method and pollen concentration.

Reducing sugars in the 'Rutab' of the two mechanical methods at 1:5, 1:7 and 1:9 ratios and that of the hand pollination were not significantly different. However, the hand duster at 1:14 produced fruits with higher reducing sugars than hand pollination and the motorized duster at 1:14 pollen.

Acidity 'Rutab' was greater in fruits of the hand duster at 1:14 pollen than in those of hand pollination and the motorized duster at 1:14 pollen, though at 1:5, 1:7 and 1:9 pollen ratios it was not significantly different. However, in fruit obtained by the hand duster using any of the tested pollen ratios, it was higher than in those obtained by hand pollination. Acidity in 'Tamr' obtained by the three methods when mechanical applications were at 1:5, 1:7 and 1:14 pollen ratio was not significantly different. But hand-pollinated fruits contained higher acidity than the hand and motorized dusters at 1:9 pollen ratios. Considering the reduction in acidity which occurred between 'Rutab' and 'Tamr' as an indicator of ripening, it can be seen that the motorized and hand dusters at any of pollen concentration resulted in a higher reduction than hand pollination (Table 4). In addition, fruits produced by the hand duster at any of the pollen to flour ratios resulted in faster reductions than those of the motorized duster at the corresponding pollen to flour ratio. Such a pattern of reduction in acidity indicates that hand-pollinated fruits ripened at a slower rate between 'Rutab' and 'Tamr' than any of the other treatments. However, it has been shown (Table 1) that hand-pollinated fruits produced a higher reduction in acidity between 'Bisir' and 'Rutab' than the hand and motorized dusters. These results indicate that acidity in hand-pollinated fruits was reduced at a faster rate in the period between 'Bisir' and 'Rutab' (81.4%) than between 'Rutab' and 'Tamr' (22.8%). This is probably a result of the transformation of these acids to the dark brown color of the fruit during late 'Rutab'. This also indicates earlier ripening than in the other treatments (Maier and Metzler, 1965). Pectin in 'Kimri' of the motorized duster was higher than that of hand pollination and hand duster when 1:9 and 1:14 ratios were applied. At the 1:5 and 1:7 pollen ratios, pectin content was similar in the two mechanical methods, whereas at the highest ratio (1:5) the hand duster fruits contained higher pectin than hand pollination, and at 1:7 ratio the motorized duster fruits had higher pectin than hand pollination.

The pattern of the results in the chemical analysis and physical characteristics of the date developmental stages indicates the existence of a balancing mechanism, perhaps of a genetic nature. There is accumulating evidence of variation in the quantity and quality of fruits from one year to the next. For dates (Walley *et al.*, 1979; ElMardi *et al.*, 1995), apple (Williams *et al.*, 1980), pistachio (Crane *et al.*, 1976), citrus (Goldschmidt and Monselise, 1977) and mango (Singh *et al.*, 1974) there is evidence for a relationship between the number, size and chemical constituents of fruits. These reports have shown an increase in yield associated with reductions in size of fruit and certain

chemical constituents, and vice-versa. A high yield in one year will be accompanied by poor quality, to be followed by lower yield and better quality fruits in the next year. From the data reported here, significant differences in the physical and chemical characteristics were observed during certain stages. These may disappear or reappear in subsequent stages. Such variations are possibly a result of preexisting conditions that need further investigation. The general trend of the results, however, indicated no significant difference in yield of hand-pollinated palms and that of the mechanical methods applied at pollen to flour ratios of 1:5, 1:7 and 1:9, and the quality of date fruits produced by the three methods. However, our observations have shown that the hand duster and motorized duster require less time to pollinate than hand pollination. This is also accomplished at lower labor costs. The hand duster was found more efficient than the motorized duster under the presently used system of open ditch irrigation, because it can easily be carried and operated and it does not need fuel. Therefore, the hand duster can be recommended for pollinating the 'Fard' cultivar under the conditions of this experiment.

Acknowledgments

The authors are greatly indebted to Sultan Qaboos University and the Ministry of Agriculture and Fisheries for their generous support of this research. Published with the approval of the College of Agricultural and Marine Sciences, Sultan Qaboos University, as paper 120996.

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Received January 2001.

Accepted May 2002.