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Effect of Strand Thinning on Yield and Fruit Quality of Egyptian Dry Date Palm (*Phoenix dactylifera* L.) cv. Sultani

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Abstract

Strand thinning is one of the common cultural practices used by Egyptian date palm farmers to reduce the incidence of alternate bearing, increase flowering, reduce the compactness of bunches, and improve yield and fruit quality. Five treatments of strand thinning were carried out; 15% strand thinning on the day of pollination, 30% strand thinning on the day of pollination, 15% strand thinning 15 days after pollination, 30% strand thinning 15 days after pollination, and the control. Compared to the control, all thinning treatments improved fruit weight, flesh weight, and tannin, vitamin C, and total and reducing sugars concentrations. Thinning 30% of strands 15 days after pollination resulted in the best physical and chemical characteristics compared to other thinning treatments.

Egypt is a subtropical country which lies between 22° and 31° North latitudes and between 25° and 35° East longitudes. Its climate (comprising a mild and wet winter from November to April and a hot and dry summer from May to October) is suitable for the production of many field and horticultural crops (Directorate of Intelligence, 2011). Date palm is an important fruit crop in Egypt where the total annual production of date fruits is about 1,430,000 tonnes (FAO Statistics, 2013).

In terms of moisture content, date fruits can be classified into three groups: soft, semi-dry and dry. The Nile delta and the Mediterranean coast are the main production regions for typical soft date cultivars which have a high moisture content (>50%) and low sugar concentration (25-30%). Typical cultivars are 'Hayani', 'Zagloul', and 'Samani' that require about 2100 heat units during the growing season (May-October) with an average daily temperature of less than 77°F (25°C). The west delta and the New Valley are the main production regions of semi-dry date cultivars which have moderate moisture content (30-45%) and medium sugar concentrations (45-50%). Typical semi-dry cultivars are 'Siwi', 'Amri', 'Agalni', and 'Saidy' that require about 2700-2900 heat units during the growing season (May-October) with an average daily temperature higher than 80-84°F (27-29°C). Upper Egypt and the southern parts of the New Valley are the main production regions of dry date cultivars which have low moisture content (15-20%) and high sugar concentrations (65-70%). Dry date cultivars include 'Sultani', 'Barakawi', 'Abrimi', 'Sakouti', 'Barmatoda', 'Melkabi', 'Gondeila', 'Gargoda', 'Digna', and 'Shamia' that require about 3600-4300 heat units during the growing season (May-October) with an average daily temperature higher than 104-113°F (40-45°C) (Riad, 1993).

The Arabic names for the various stages of development of dates are the terms used universally. After pollination, date fruits initially have a slow growth period essentially due to

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cell division up to the end of the six weeks from pollination. Thereafter fruits enter into the rapid phase of growth which is termed the "Kimiri" stage when fruits are young and green in color (16 weeks from pollination). Fruits then begin to change color and reach maximum weight and size at the "Khalal" (also called "Bisr") stage (20 weeks from pollination); this is considered as the maturity stage. Fruits enter the ripening or "Rutab" stage (22 weeks from pollination) when the fruit begins to soften, lose moisture content and astringency, and starts acquiring a dark and less attractive color. Finally, fruits continue to lose their fresh weight and reach the lowest value at the "Tamr" stage (23 weeks from pollination) which may be considered as the senescence stage (Hobani et al., 2003; Taain, 2013). Soft cultivars are harvested and used at the "Khalal" and "Rutab" stages, but semi-dry and dry cultivars are harvested and used at the "Tamr" stage (Riad, 1993).

Strand thinning is one of the main cultural practices of date palm farming that often helps to reduce the compactness of fruit bunches, enhance fruit quality, and increase flower numbers in the following year. Such results can be obtained either by reducing the number of fruits per bunch or by reducing the number of bunches per palm (Hussein, 1970; Moustafa, 1993, 1998; Nixon, 1940, 1956). Removing whole or parts of the strands or individual fruits rather than whole bunches was more successful in small-fruit date palm cultivars (Nixon, 1956). Farmers' preference for a specific thinning method and time of thinning depends on the date palm cultivar. Thinning begins early during the "Kimiri" stage. Bunch thinning generally increases fruit size and soluble solids concentration (SSC) with no effect on fresh weight or acid concentration (Godara et al., 1990). Severe thinning (50% bunch removal) in 'Zagloul' dates reduced bunch weight and increased SSC and total sugars (Hussein et al., 1992). Thinning generally reduces the incidence of alternate bearing and ensures adequate flowering in the following year (Ibrahim and Khalif, 1998; Nixon, 1940). Al-Obeed et al. (2005) found that 15% strand thinning at pollination improved yield and fruit quality of 'Succary' dates. Amen et al. (2007) reported that removing 15% of the total number of strands per bunch or shortening the strands to 85% of their length improved fruit maturity and development, and increased total yield and fruit quality of 'Hayany' and 'Halawy' dates. Behseresht et al. (2007) reported that thinning 'Kabakab' cultivar at the "Kimiri" stage had no significant effects on fruit quantity and quality when compared with thinning at pollination. They found that cutting one-third of the strands from the tip-end reduced total yield but increased fruit quality. Fruit thinning also reduced fruit shriveling and improved fruit physico-chemical characteristics of 'Khalas' and 'Succary' dates (Al-Darwish, 2010; Soliman and Al-Obeed, 2012; Soliman et al., 2011).

The present study was carried out to provide more knowledge regarding strand thinning effects, in terms of time and amount of thinning, on the yield and physico-chemical characteristics of 'Sultani' dates, which are considered to be one of the most important dry date cultivars in Egypt.

Materials and Methods

This work was carried out during two successive seasons; 2012 and 2013, on 10-year-old female date palms (*Phoenix dactylifera* L.) cv. 'Sultani' grown in loamy sand soil on a private orchard in the New Valley Governorate, Egypt.

Fifteen uniform palms in size and growth vigour were chosen. They were in the on-year during the 2012 season, and they all received the normal schedule of cultural practices. Ten bunches were selected on each palm, and leaf:bunch ratio was maintained at 9:1. Hand pollination was carried out during the third week of April in both seasons using pollen grains from a 'Majhal' male palm. Palms were divided into five groups: each treatment was imposed on three palms and each palm represented one replicate per treatment. Thin-

ning treatments were carried out by center cut strand thinning; i.e., by counting the total number of strands per spathe, then removing 15% or 30% of the center stalked strands (to reduce fruit compactness and improve ventilation), as follows: 15% strand thinning at pollination, 30% strand thinning at pollination, 15% strand thinning 15 days after pollination, 30% strand thinning 15 days after pollination, and the control (no thinning).

Bunches were harvested at the "Tamr" stage and average bunch weight (kg) was calculated for each treatment. Total yield per treatment was calculated as average bunch weight multiplied by 30 (the total number of bunches per treatment). A sample of 60 fruits was randomly picked from each bunch to determine fruit and flesh weight, fruit dimensions (length and diameter), firmness, soluble solids concentration (SSC), total and reducing sugar, tannin, and vitamin C concentrations. Chemical characteristics were measured according to A.O.A.C. (1995).

Data were analyzed using the SPSS 17.0 program (Statistical Packages for the Social Sciences, released 23 August 2008) in a complete randomized design according to Little and Hills, 1972. Means were compared using Duncan's new multiple-range test at P value $\leq 0{\cdot}05$ (Duncan, 1965).

Results

Bunch weight (kg) increased significantly with all thinning treatments compared to the control (Table 1). Removing 15% of strands 15 days after pollination had a pronounced effect over all the treatments and the control in both seasons; 11.5 kg in 2012 and 13.1 kg in 2013. In contrast, removing 30% of strands 15 days after pollination generally reduced bunch weight compared to the other treatments in both seasons.

Total yield (kg) per treatment had the same trend as bunch weight (Table 1). The highest yield was recorded following a removal of 15% of the strands 15 days after pollination in both seasons; 345 kg in 2012 and 393 kg in 2013.

Fruit weight (g) increased significantly with all thinning treatments in both seasons, except when 15% of strands were removed 15 days after pollination in the 2013 season when average fruit weight was as low as the control (Table 1). Removing 30% of strands 15 days after pollination resulted in the maximum fruit weight in both the 2012 and 2013 seasons; 12.6 and 16.4 g, respectively.

Flesh weight (g) had the same trend as fruit weight. The highest value occurred when 30% of the strands were removed 15 days after pollination in both the 2012 and 2013 seasons; 11.2 and 14.2 g, respectively (Table 1).

Fruit dimensions (length: diameter ratio) showed insignificant differences among all treatments and the control (Table 2).

Fruit firmness (N) for all thinning treatments was lower than that of the control, but the differences were only significant for 30% at 15 days after pollination in 2012, and all treatments except for 15% at pollination in 2013 (Table 2). When 30% of the strands

Table 1. Effect of strand thinning on bunch weight, total yield and some physical characteristics of 'Sultani' dates during 2012 and 2013.

Amount and time of strand thinning	Bunch weight (kg)		Total yield (kg)		Fruit weight (g)		Flesh weight (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
15% at pollination	9.4 bc	10.6 b	282 bc	318 b	11.9 ab	12.5 b	9.9 b	10.6 b
30% at pollination	10.0 b	10.3 bc	300 b	309 bc	12.1 a	14.1 ab	10.2 b	11.9 b
15% at 15 days after pollination	11.5 a	13.1 a	345 a	393 a	11.7 b	11.6 c	9.2 b	9.7 c
30% at 15 days after pollination	9.3 c	10.1 c	279 c	303 c	12.6 a	16.4 a	11.2 a	14.2 a
Control	8.4 d	9.0 d	252 d	270 d	11.0 c	11.6 c	7.7 b	7.9 c

Means followed by a common letter in the same column are not significantly different by DMRT ($P \leq 5\%$)

Table 2. Effect of strands thinning on some physical characteristics of 'Sultani' dates during 2012 and 2013.

Amount and time of strand thinning	Length: Diameter ratio		Firmness (N)		SSC (%)		Total sugars (%)	
	2012	2013	2012	2013	2012	2013	2012	2013
15% at pollinations	1.8 a	1.9 a	4088.1 ab	4398.0 a	54.2 b	56.5 b	59.8 bc	68.2 b
30% at pollination	1.9 a	1.7 a	3904.9 a	3931.8 b	59.8 a	64.0 ab	65.9 ab	70.1 b
15% at 15 days after pollination	1.9 a	1.8 a	3888.0 ab	3802.4 b	60.0 a	58.9 ab	70.2 a	73.3 ab
30% at 15 days after pollination	2.1 a	1.8 a	3781.1 b	3722.9 b	63.1 a	65.7 a	73.2 a	76.2 a
Control	1.9 a	1.8 a	4166.0 a	4494.4 a	46.8 c	48.7 c	55.0 c	54.8 c

Means followed by a common letter in the same column are not significantly different by DMRT ($P \leq 5\%$)

were removed 15 days after pollination, fruit firmness was the lowest; 3781 and 3722 N, respectively in 2012 and 2013.

Soluble solids concentration (SSC) increased significantly with all thinning treatments compared to the control in both seasons (Table 2). The highest SSC was recorded when 30% of the strands were removed 15 days after pollination; 63.1% and 65.7% in the 2012 and 2013 seasons, respectively.

Total and reducing sugars (%) also increased significantly with all thinning treatments compared to the control in both seasons (Table 2 and 3, respectively), but the difference in total sugars was insignificant for 15% at pollination in 2012. Removing 30% of strands 15 days after pollination showed the highest total sugars (73.2 and 76.2%; Table 2) and reducing sugars (52.0 and 60.6%; Table 3) in the 2012 and 2013 seasons, respectively.

Tannins (%) were reduced with all thinning treatments compared to the control in both seasons, but the differences were insignificant for 15% at pollination in 2012 and 15% at 15 days after pollination in 2013 (Table 3). Thinning 30% of the strands 15 days after pollination had the greatest effect; 0.37% and 0.36% in 2012 and 2013 seasons, respectively.

Vitamin C concentration (mg·100 g^{-1} fresh weight) increased with all thinning treatments compared to the control, but the differences were only significant at 15% and 30% at 15 days after pollination in both seasons (Table 3). Thinning treatments imposed 15 days after pollination had more pronounced effect; on vitamin C content compared to the control in both seasons. Removing 30% of strands 15 days after pollination enhanced vitamin C concentration most (to 2.2 mg·100 g^{-1} fresh weight) in both seasons.

Discussion

The trend of these results is in general agreement with the previous findings of the thinning effects on date palm, reported by Nixon (1940), Hussien (1970), Moustafa et al. (1984), Moustafa (1993 and 1998), Ibrahim and Khalif (1998), Al-Obeed et al. (2005), Amen et al. (2007), Behseresht et al. (2007), Iizadi et al. (2010), Soliman et al. (2011), and

Table 3. Effects of strands thinning on some chemical characteristics of 'Sultani' dates during 2012 and 2013.

Amount and time of strand thinning	Reducing sugars (%)		Tannins (%)		Vitamin C (mg·100 g^{-1} f.w.)	
	2012	2013	2012	2013	2012	2013
15% at pollination	46.0 a	46.4 b	0.44 a	0.39 bc	1.5 bc	1.5 b
30% at pollination	48.0 a	55.4 ab	0.39 b	0.37 bc	1.6 bc	1.7 b
15% at 15 days after pollination	48.8 a	52.5 ab	0.39 b	0.41 ab	1.9 ab	2.1 a
30% at 15 days after pollination	52.0 a	60.6 a	0.37 b	0.36 c	2.2 a	2.2 a
Control	40.2 b	36.7 c	0.45 a	0.44 a	1.4 c	1.4 b

Means followed by a common letter in the same column are not significantly different by DMRT ($P \leq 5\%$)

Soliman and Al-Obeed (2012). This work reports new findings on strand thinning effects on yield and fruit quality of 'Sultani' dates growing under the conditions of the New Valley. All thinning treatments generally improved bunch weight, total yield, fruit weight and flesh weight. The treatment that led to the greatest fruit and flesh weight was thinning 30% of strands 15 days after pollination, which reduced the number of fruits per bunch, resulting in big fruits, but less bunch weight and yield compared to the other thinning treatments. Severe thinning led to a reduction in bunch weight and fruit number per bunch, but increased average fruit weight due to the reduction in fruit compactness within the bunch that gives more room for the fruit to grow (Al-Saikhan, 2008; Moustafa, 1993). However, fruit length:diameter ratio was not significantly different among treatments, as previously reported by Godara et al. (1990). Fruit firmness and chemical composition were also improved with thinning treatments compared to the control, and removing 30% of strands 15 days after pollination had the most pronounced effect in that regard. The increases in sugar and vitamin C are attributed to an internal adjustment that makes the remaining fruits capable of using assimilates efficiently (Ali-Dinar et al., 2002; Hammam et al., 2002; Nixon, 1940, 1956; Soliman and Al-Obeed, 2012; Soliman et al., 2011) due to change in source (leaf) to sink (fruits) ratio (Pallas et al., 2013; Taiz and Zeiger, 2010). In contrast, there were no significant differences between 15% and 30% thinning at pollination (except for reducing sugars in 2013) showing the importance of postponing thinning for a period after pollination to make sure that only intact fertilized fruit are retained (Ali-Dinar et al., 2002; El-Gassas, 1986; El-Hamady et al., 1983; Moustafa et al., 1984; Nixon, 1940, 1956; Soliman and Al-Obeed, 2012; Soliman et al. 2011; Tavakkoli et al., 2006), taking into account that the response to strand thinning may differ based on variety and geographical location.

Conclusion

Strand thinning is a common practice in date palm farms to improve fruit yield and quality. This practice can be effective only if date palms are healthy, properly managed and have an optimal leaf: bunch ratio. Removing 30% of central strands 15 days after pollination improved yield and fruit quality of 'Sultani' dates grown under Egyptian conditions. This thinning effect may need to be adjusted based on the cultivar and geographical location of the production site. Further research on other date cultivars in other areas is recommended.

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