Effect of Leaf Removal and Tie-Up on Date Palms Transplanted in Extremely Hot, Arid Conditions

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Leaf removal and tie up are standard industry practices when transplanting palms (Nixon & Carpenter 1978, Broschat 1991, Costonis 1995, Zaid 1999, Broschat & Meerow 2000). Recent research findings are somewhat mixed, though, on whether these practices are beneficial. For example, when transplanting juvenile, trunkless specimens of Canary Island date palm (*Phoenix canariensis*) and queen palm (*Syagrus romanzoffiana*) and large, trunked specimens of Mexican fan palm (*Washingtonia robusta*), leaf removal and tie-up did not affect establishment and survival (Downer et al. 2013; Hodel et al. 2003, 2006). Broschat (1994) found a similar response for leaf tie-up when transplanting pygmy date palms (*Phoenix roebelenii*) if they were provided with daily irrigation. However, Broschat (1991) found that complete leaf removal was necessary when transplanting palms like the palmetto palm (*Sabal palmetto*), where all roots cut during transplanting die and the palm must rely solely on stored water in the trunk for survival until a new root system can be produced.

The impetus for this study arose when a large supplier of date palms (*Phoenix dactylifera*) for landscape use and a major producer of date fruits for the fresh market stated that he did not feel confident that our earlier work (Hodel et al. 2003, 2006), which showed that leaf removal and tie-up were likely of little value in transplanting palms, was applicable to transplanting mature date palms in extremely hot, arid conditions like those frequently encountered during the summer in the U.S. Desert Southwest. The purpose of this study was to determine the effect of leaf removal and tie-up on survival and quality of mature date palms transplanted in extremely hot, arid conditions.

Materials and Methods

We conducted this study from June 2009 to July 2011 at a date orchard near Desert Center, California (33°42′31.99″N, 115°14′20.25″W), about half way between Indio and Blyth. This location is in the Colorado or low desert, which is characterized by low dew points (10°C), low annual rainfall (75 mm), and high daily maximum summer temperatures (38–42°C) (NWS 2009). Soil at the site is an unclassified desert sand with pH of 6.5 and an EC of 2.0. Twenty-four mature plants of date palm (*Phoenix dactylifera* 'Halawy'), each with about four meters of trunk and a canopy containing 50–60 leaves, were used in the study.

1. The palms were planted and backfilled with the naturally sandy soil at the site (D.R. Hodel).

The palms were dug on June 30, 2009 (Front Cover) and laid on the ground, where four leaf removal and tie-up treatments were performed. The four treatments were: no leaves removed,

2. The backfill was thoroughly watered in to minimize settling (D.R. Hodel).

3. The transplanted palms were spaced about six meters apart in rows six meters (D.R. Hodel).

no leaves tied up (control); about 60% of the leaves removed, the remainder tied up (standard industry practice); about 60% of the leaves removed, the remainder not tied up; and no leaves removed, all leaves tied up. Leaf removal was accomplished by removing older leaves and shortening the remaining leaves by about half their length before tying them up. We marked the newest, fully emerged leaf with red tape to track leaf production. After digging and performing the treatments the palms remained on the ground for 24 hours with leaves and root balls uncovered, unprotected, and unirrigated to simulate how the palms are typically handled when dug, transported, and replanted into the landscape in this area.

The palms were planted (Figs. 1 & 2) into a nearby vacant plot on July 1, 2009, spaced about six meters apart in rows six meters apart (Fig. 3). Treatments were replicated six times and the palms were arranged in a randomized complete block design (4 treatments × 6 replications × 1 species = 24 palms total). Each row was a block in which the four treatments were completely randomized. Palms were irrigated thoroughly at planting and then every other day through the summer with about 1,000 l of water applied to each palm at each irrigation event. During the fall and winter irrigation was reduced to about 1,000 l once every two weeks.

For each palm we counted the quantity of new leaves one year after transplanting and estimated the percent of the canopy that was green (alive) and assigned an overall quality rating one and two years after transplanting. Weather data, including maximum temperatures, dew point, and wind speed, were obtained from the National Weather Service weather station in Thermal and reference evapotranspiration data was obtained from the California Irrigation Management Information System station in Indio (Station #200), California, the closest stations that best approximate conditions in Desert Center.

We conducted analysis of variance using the Mixed Procedure (v. 9.3, SAS Systems, Cary, NC) with the overall error rate for multiple comparisons controlled by Tukey-Kramer adjustment. For new leaf growth measured in July 2010, we included the initial number of leaves at transplanting as a covariate. Linear contrasts were conducted to understand the difference between pairs of means (e.g., leaf removal vs. no leaf removal and leaf tie-up vs. no leaf tie-up).

To address potential autocorrelation of percent green canopy and quality estimates, which were measured on the same plants for multiple sampling dates, we conducted repeated measures analysis of variance using the Mixed Procedure with the overall error rate for multiple comparisons controlled by Tukey-Kramer adjustment. We selected the following covariance models from four possible ones based on measures of relative fit: Unstructured (UN) for quality and Compound Symmetry (CS) for brown canopy. Linear contrasts were also conducted for each of these parameters.

Table 1. Average maximum temperatures (°C), dew point (°C), and wind speed (m·sec^{-1}) in July, August, and September, 2009, Thermal, California. (Source: National Weather Service Data, NWS 2009).

July	Maximum	Average	Minimum
Maximum Temperatures	46.7	43.3	37.2
Dew Point	23.9	11.1	-10.5
Wind Speed	11.6	3.1	0.0
August			
Maximum Temperatures	47.8	41.7	37.2
Dew Point	23.3	10.0	-10.5
Wind Speed	14.8	3.6	0.0
September			
Maximum Temperatures	43.3	39.4	33.9
Dew Point	25.0	9.4	-14.4
Wind Speed	13.9	2.7	0.0

Results and Discussion

On June 30, 2009, the day the palms were dug, the maximum temperature was 45.5 °C at the study site. Throughout the next three months of the study (July through September), which are critical for transplant success, maximum daily temperatures averaged well above 39°C, dew points averaged about 10°C, and wind speeds averaged about 3 m·sec^{-1} at the National Weather Service weather station in Thermal, California (NSW 2009) (Table 1). Monthly reference evapotranspiration was 248.6 mm in July, 203.6 mm in August and 169.2 mm in September, 2009 in Indio, California (CIMIS 2009).

After one year, the standard industry practice produced significantly more new leaves than any other treatment and after one and two years had a significantly greater percentage of the canopy that was green than any other treatment (Figs. 4–8) (Table 2). Palms subjected to leaf removal, regardless of tie-up, performed significantly better in all three growth categories than palms with no leaves removed. Palms subjected to no leaf removal, regardless of leaf tie-up, performed the worst, with none

Table 2. Effect of leaf removal and tie up treatments on mean leaf production after one year and percent green canopy and overall quality after two years on transplanted date palms (*Phoenix dactylifera* 'Halawy'), 2009–2011, Desert Center, California.

Treatment	New leaves (no.)[w]	Percent green canopy[x]	Quality[x]
60% of leaves removed, the remainder tied up[y]	10a[z]	83a	4a
60% of leaves removed, the remainder not tied up	4b	54b	3a
No leaves removed, all leaves tied up	0c	15c	2b
No leaves removed, no leaves tied up	0c	12c	1c
P value	<0.0001	<0.0001	<0.0001

[w] Measured one year after transplanting with the initial quantity of leaves at transplanting included as a covariate in the analysis.

[x] 1=dead, 5=optimal. Measured one and two years after transplanting.

[y] Standard industry practice.

[z] Means within a column followed by different letter denote a significant comparison.

4. The experimental plot one year after transplanting (D.R. Hodel).

producing any new leaves and two-thirds (8 out of 12) dying by the end of the first year (no additional palms died after one year).

While both leaf removal and leaf tie-up evaluated separately significantly improved growth compared to no leaves removed and no leaves tied up, leaf removal is more critical than tie-up for successfully transplanting mature date palms in a harsh, hot, arid climate. Linear contrasts indicate that leaf removal had a greater impact on growth than did leaf tie-up, producing more new leaves, a greater percent of the canopy that was green, and a higher quality rating. Estimated least square means differences between leaf removal and tie-up were 7 vs. 3 for leaf production, 55 vs. 16 for percent green canopy, and 2.3 vs. 0.6 for quality. Broschat (1994) showed that pygmy date palms under severe water stress also responded more strongly to leaf removal than to tie-up.

We conclude that leaf removal and tie-up enhance establishment of mature date palms transplanted in extremely hot, arid conditions. Coupled with other work showing that leaf tie-up had little, if any, effect on transplant success (Broschat 1994; Downer et al. 2013; Hodel et al. 2003, 2006), though, we conclude that, in some situations, especially in more moderate climates and where immediate esthetic concerns demand an untied canopy, leaves may be untied after transplanting with little effect on transplant success. For ease of handling and to protect the apical meristem leaves should always remain tied up during the digging, transport, and planting processes but can be untied, where appropriate, after planting.

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5 (top left). After one year palms subjected to the standard industry practice, some leaves removed and the remainder tied up, performed best. 6 (top right). Palms with some leaves removed and the remainder not tied up did not perform as well as those with the standard industry practice although at the end of two years the palms were considered acceptable. 7 (bottom left). Palms with no leaves removed but all leaves tied up performed poorly and either died or were unacceptable. 8 (bottom right). The control, palms with no leaves removed and no leaves tied up, died. (all photos by D.R. Hodel).

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