Journal of the American Pomological Society 61(2):61-70 2007

# Canopy Separation and Defoliation do not Improve the Dry-on-Vine (DOV) Raisin-Making Method for 'Thompson Seedless' Grapevines on Traditional Trellises

Matthew W. Fidelibus[1], Stephen J. Vasquez[2] and Kimberley A. Cathline[1]


## Abstract

'Thompson Seedless' (syn. 'Sultana') grapevines (*Vitis vinifera* L.) were subjected to canopy separation and defoliation treatments to determine whether either or both of those factors could increase pruning efficiency, the number of clusters per vine, canopy evaporative potential, yield, or quality of dry-on-vine (DOV) raisins. Canopy separation methods included: 1) within-row alternate bearing (WRAB), where fruiting canes and renewal shoots were trained to opposite sides of the trunk such that each were adjacent to similar structures of neighboring vines, 2) Wave, where fruiting and renewal canes were trained to opposite sides of the trunk such that the fruiting canes of one vine were adjacent to the renewal shoots of the next vine, or 3) non-separated. Defoliation treatments, applied near cane severance, included burning or blowing the leaves, application of concentrated solutions of calcium ammonium nitrate (CAN-17), urea ammonium nitrate (UAN-28), or ethephon (750 ppm) to leaves, or no defoliation. None of the canopy separation or defoliation treatments provided any consistent benefit with respect to the variables measured. On the contrary, vines with separated canopies sometimes had more congested fruiting zones, as evidenced by their greater number of cluster layers, than vines with non-separated canopies, and their raisins were often moister at harvest. In one trial, defoliation by blowing or burning enhanced drying of raisins on vines whose canopies were subjected to the WRAB method, but in another trial the use of those defoliation methods resulted in raisins that were too moldy to process. Thus these canopy management methods did not improve the DOV raisin-making method for 'Thompson Seedless'.


California produces 35 to 40% of the world's raisins each year (3). For nearly 8 decades, the vast majority of California's raisins have been made from the fruits of 'Thompson Seedless' grapevines (*Vitis vinifera* L.) subjected to a traditional drying process where field workers manually harvest clusters of mature berries and lay them on paper trays, between the vine rows, to dry. Drying grapes with this method requires considerable labor; as many as 55,000 people have been needed annually to prepare California's raisin crop (3). In recent years the availability of farm labor has decreased so the cost has increased, prompting growers to consider adopting mechanical harvesting technologies. The most promising of these is known as dry-on-vine (DOV). Canes bearing mature fruits are severed and the grapes attached to the severed canes are left to DOV (10). When dry, raisins are collected from the trellis with a mechanical grape harvester.

Grapes generally require two to three weeks to dry on trays, but 1.5 months or more may be necessary for grapes to DOV because temperatures at the soil surface are much higher than those at trellis heights (4). Thus, 'Thompson Seedless' grapes, which mature between late August and early September, may not DOV adequately by mid-October, the end of the drying season (12). Raisin lots with moisture contents $\geq$16% must be finish-dried, either through a commercial dehydrator or on-farm drying setup. Both approaches add cost, which can negate any savings expected from the DOV process.

Recently, Peacock and Swanson (12) suggested that the DOV method could be im-

[1] Department of Viticulture and Enology, University of California, One Shields Ave., Davis, CA 95616-8749
[2] University of California, Cooperative Extension, 1720 S Maple Ave., Fresno, CA 93702

proved by separating grapevine canopies into fruiting and renewal sections within the vine rows. Possible benefits of within-row canopy separation might include ease of cane severance, improved raisin drying, and increased fruitfulness (12). The effects of within-row canopy separation *per se* on DOV performance has not been tested, but the need to reduce production cost is so great, and vine drying of 'Thompson Seedless' grapes using conventional training is so poor, that as many as 8,000 ha, about 10% of California's raisin grapes, have been trained to within-row separated canopies in recent years (M.W. Fidelibus, personal observation).

Within-row canopy separation is achieved by tying the canes to one side of a vine trunk while leaving spurs on the opposite side (Figure 1A, B). Fruiting canes and the sterile 'renewal' shoots arising from spurs may be further organized by coordinating the position of fruiting and renewal sections between the trunks. The sections may alternate between pairs of trunks, a system known as Within Row Alternate Bearing, or WRAB (12) (Fig. 1A), or they may be adjacent to each other (Fig. 1B), a system growers refer to as the 'Wave'. In a traditional non-separated canopy, canes and spurs are left on both sides of a vine (Fig. 1C).

Some growers, whether they separate their canopies or not, defoliate the fruiting zones of their vines with propane torches or blowers, to better expose the clusters which they hope will enhance berry drying. Although not registered for this purpose, applications of concentrated fertilizer salts (8, 13, 16) can also cause leaf desiccation and abscission, and thus may be an alternative to burning or blowing, both of which might eventually be prohibited in the San Joaquin Valley by increasingly strict air quality laws. The purpose of this research was to determine whether canopy separation, defoliation, or the interaction of these factors, affects pruning efficiency, drying performance, and raisin yield and quality of 'Thompson Seedless' grapevines on traditional trellises.

## Materials and Methods

*Trials 1 and 2, 2003*. Two experiments were conducted in 2003; one in a commercial vineyard near Easton, Fresno County, and the other at the Kearney Agricultural Center (KAC), Parlier, Calif. Each experiment used split plot designs where the main plot factors were defoliation treatments, replicated four times, and the subplot factors were canopy separation treatments. Main plots were established within vine rows to facilitate treatment applications, and sub plots were assigned at random within each main plot. Each treatment replicate consisted of three-vine plots,

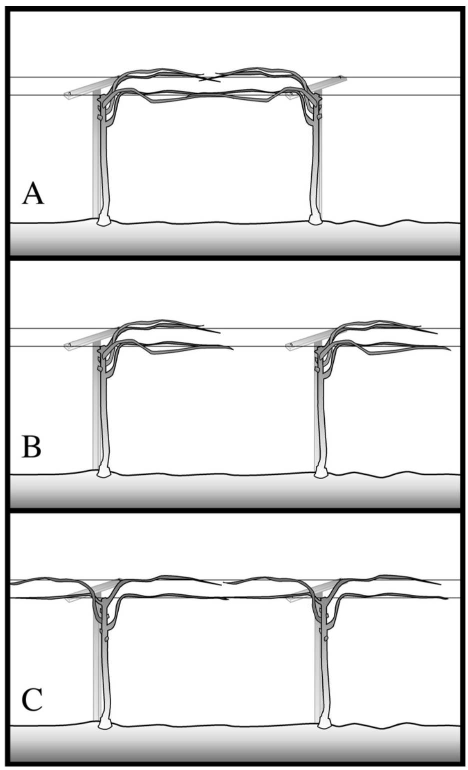


**Figure 1.** Three canopy separation treatments for production of dry-on-vine (DOV) raisins on a traditional trellis; A) horizontal canopy separation with canes tied to every other vine section (WRAB), B) horizontal canopy separation with canes always tied to one side of each vine trunk (wave), C) canopy not separated, with canes tied to each side of vine truck (control).

but data were only collected from the middle vine of each plot. All data were subjected to the ANOVA procedure (PROC ANOVA) of SAS statistical software (SAS Inst. Inc., Cary, NC). When defoliation and canopy separation factors interacted to affect a variable, the effect of one factor was determined at each level of the other factor by separating the means by Duncan's New Multiple Range Test (DNMRT), or by Least Significant Difference (LSD), as appropriate (6). In the absence of interaction effects, only main effects were summarized, and significant ($\alpha$ =0.05) main effects were separated by DNMRT.

Both vineyards were composed of mature, 25-year-old, own-rooted, 'Thompson Seedless' (*Vitis vinifera* L.) grapevines that were cane pruned and head trained to a traditional T-trellis with a 0.6 m cross arm. The canopy separation treatments were as follows; Within Row Alternate Bearing, or WRAB (12), where fruiting canes and renewal shoots were arranged between vines so that fruiting and renewal sections alternated between pairs of vine trunks (Fig. 1A), Wave, where the canopies were separated such that the fruiting canes of one vine were adjacent to the renewal shoots of the next vine (Fig. 1B), or non-separated, where canes and spurs were left on both sides of each vine (Fig. 1C). Regardless of the training method, six 15-node canes, and about eight two-node spurs, were left on each vine.

Beginning the first week of August, fruit maturity was assessed weekly. Once juice soluble solids reached about 20◦ Brix, berry samples were collected, and canes severed. Samples consisted of 3 berries collected from each of about 33 clusters (one berry from the top, middle, and bottom of each cluster) per vine. The samples were weighed, and average berry weight calculated. The berries were then homogenized in a blender, and soluble solids of the filtered juices were determined with a hand-held, temperature compensating, digital refractometer (Palette 101, Atago, Farmingdale, NY). Cane severance occurred on 22 August, at KAC, and on 27 August, at Easton. The time needed for a typical vineyard worker to sever fruiting canes of all vines in each treatment replicate was recorded with a stopwatch. Each replicate of a given treatment was pruned one at a time, with the order of treatments determined at random. The same worker was used to prune all the treatments within a block.

At Easton, defoliation treatments consisted of burning or blowing the leaves, or no defoliation (control). By necessity, some defoliation treatments were applied on different dates. Leaves were subjected to burning one week before cane severance because burning of dried leaves, as would occur after cane severance, is prohibited by local environmental laws. A propane torch was used to burn a 0.33 m tall swath of leaves in the fruiting zone. In contrast, leaves were subjected to blowing two weeks after cane severance because severance is needed to stimulate leaf abscission, and clusters shatter too easily in the first week after cane severance to allow blowing at that time (16). A gasoline-powered back-pack leaf blower (Solo Inc., Newport News, VA) was used to remove leaves. At the KAC, defoliation treatments consisted of foliar applications of either calcium ammonium nitrate (20% wt/wt; 1,870 L per ha; 8) or ethephon (750 ppm; 1,870 L per ha), one week before cane severance, or no treatment. Applications were applied to the fruiting zones just until runoff, using a back-pack sprayer (Solo Inc., Newport News, VA).

Atmometers (C&M Meteorological Supply, Riverside, CA), hemispherical (5 cm diam.) ceramic instruments, were used to determine evaporative potential (5). The instruments were filled with deionized water, weighed, hung in the canopy on 28 August, then collected one week later and reweighed. Average daily evaporative potential was calculated as the difference in the atmometer's weights, divided by seven.

The number of flower clusters per vine was determined in the spring, when inflorescences arising from shoots from the basal nodes of canes and spurs were removed. The number of leaf and cluster layers in the fruiting zone was determined a few days before cane severance by passing a steel rod 25 times through the canopy of each vine and dividing the number of contacts with leaves or clusters by the number of passes (14). Raisins were harvested on 20 October, KAC, and 24 October, Easton, from each single-vine replicate, and weighed. A subsample of each raisin lot was then ground to a paste and its moisture content determined with a USDA dried fruit moisture tester. Yield was adjusted to 14 percent moisture for treatment comparisons. Airstream raisin grades and percent mold were determined by dried-fruit inspectors at the USDA Processed Products Division, Fresno, Calif.

*Trial 3, 2004 and 2005*. A similar experiment was conducted in 2004, and repeated in 2005, at the KAC. Again the design was a split plot, with defoliation treatments (none, leaf burning, blowing, or application urea ammonium nitrate, UAN [22% urea wt/wt; 1,870 L per ha]) as main-plot factors, replicated 5 times, and canopy separation treatments (WRAB, wave, or non-separated) as the subplot factors, replicated 20 times. Main plots were established within vine rows to facilitate treatment applications. Subplot factors were assigned at random within each mainplot. Each treatment replicate consisted of three-vine plots, but data were only collected from the middle vine of each plot.

In 2005, the moisture content of raisins from some treatments was too high at harvest to measure directly with the dried-fruit moisture tester. Therefore, those raisins were weighed, placed in a forced-air oven (60 ˚C) to dry for several hours, and re-weighed before being ground to a paste and subjected to moisture measurements. The mass of water lost during oven-drying was added to the mass of water in the oven-dried raisins, which was estimated from the moisture content data collected with the dried fruit moisture tester. The sums of those values were divided by the raisin masses at harvest to estimate the water content of each original sample. Otherwise, data collection and analyses were as described for trials 1 and 2, in 2003, except that the split-plot treatment structure was nested within year, which was considered to be a random variable.

In 2004, leaves were burned and UAN applied, on 9 August; leaves were removed by blowing on 23 August. On 14 September, atmometers were filled with deionized water, weighed, and hung in the canopy. On 21 September, the atmometers were collected, reweighed, and evaporative potential was then calculated as the difference between the initial and final weights, divided by the number of days spent in the vineyard. Canes were severed on 10 August, and raisins were collected on 18 October. In 2005, leaves were burned and UAN applied, on 3 August; leaves were removed by blowing on 21 August. Atmometers were placed in the canopy on 24 August, and removed on 31 August. Cane severance occurred on 11 August, and raisins were collected on 7 October.

## Results and Discussion

*Trials 1 and 2*. At Easton, vines with separated canopies had about 30% fewer clusters than vines with non-separated canopies (Table 1). The reason for this is unclear, but could be due to mechanical interference or to the selection of poor quality canes. Because the trellises only had two wires, when the canopies were separated the number of canes wrapped on each wire was doubled. As more canes are wrapped on a wire, the likelihood of nodes being obstructed by neighboring canes may also increase. If so, bud burst can be suppressed and the number of clusters per vine thereby decreased (L. Peter Christensen, personal communication). However, canopy separation did not affect the number of clusters per vine at the KAC (Table 2) suggesting that another factor, such as poorer cane selection (1), might have reduced the number of clusters on vines with divided canopies at Easton. For example, at winter pruning, both cane quality and position had to be considered when selecting canes on vines with sep-

**Table 1.** Average number of clusters, leaf layers, and cluster layers, per vine, and cane severance time of 'Thompson Seedless' grapevines subjected to different defoliation and canopy separation treatments, Easton, Calif., 2003.

| Factor | Clusters (no./vine) | Leaf layers (no.) | Cluster layers (no.) | Evaporative potential (ml/d) | Cane severance time (s/vine) |
|---|---|---|---|---|---|
| **Defoliation Method** | | | | | |
| None | 33[z] | 5.8 | 1.7 | 26 | 34 |
| Blow | 25 | 5.7 | 1.4 | 28 | 30 |
| Burn | 31 | 5.7 | 1.6 | 28 | 31 |
| **Canopy Separation** | | | | | |
| None | 38 a[y] | 5.7 | 1.5 | 28 | 37 a |
| Wave | 28 b | 5.7 | 1.4 | 27 | 29 b |
| WRAB[x] | 23 b | 5.7 | 2.0 | 26 | 28 b |

[z] Values are treatment means; n = 4 (defoliation method), n = 12 (canopy separation method)
[y] Means followed by a different letter are significantly different according to Duncan's New Multiple Range Test, $p \leq 0.05$
[x] Within-row alternate bearing

**Table 2.** Average number of clusters, leaf layers, and cluster layers, per vine, and cane severance time of 'Thompson Seedless' grapevines subjected to different defoliation and canopy separation treatments, KAC, Parlier, Calif., 2003.

| Factor | Clusters (no./vine) | Leaf layers (no.) | Cluster layers (no.) | Evaporative potential (ml/d) | Cane severance time (s/vine) |
|---|---|---|---|---|---|
| **Defoliation Method** | | | | | |
| None | 38[z] | 4.6 | 1.9 | 34 | 29 |
| Ethrel | 43 | 4.8 | 1.2 | 33 | 33 |
| Desiccant | 36 | 4.6 | 1.5 | 34 | 31 |
| **Canopy Separation** | | | | | |
| None | 44 | 4.4 | 1.1 b[y] | 35 | 30 |
| Wave | 40 | 4.8 | 1.7 a | 34 | 32 |
| WRAB[x] | 33 | 4.9 | 1.8 a | 33 | 32 |

[z] Values are treatment means; n = 4 (defoliation method), n = 12 (canopy separation method)
[y] Means followed by a different letter are significantly different according to Duncan's New Multiple Range Test, $p \leq 0.05$
[x] Within-row alternate bearing

arated canopies, whereas cane quality was the main criteria for selecting canes on vines with non-separated canopies.

Grapevine canopies at both locations had similar numbers of leaf layers whether they were separated or not (Tables 1 and 2), but either method of canopy separation increased the number of cluster layers at the KAC (Table 2). More cluster layers would be expected in vines with divided canopies at the KAC because those vines had similar cluster counts as vines with non-divided canopies, but all of the clusters in a divided canopy are concentrated in half the trellis length. Others (12) hypothesized that a divided canopy would improve berry drying by reducing the shading of clusters by green leaves, but layered clusters are also shaded. At Easton, both canopy separation methods reduced the time needed for cane severance, compared to the non-separated canopies, but this effect was not observed at the KAC (Tables 1 and 2). The same workers severed canes at the KAC and then at Easton. Thus, canopy separation might reduce cane severance time for experienced workers.

At Easton, defoliation treatments were applied after clusters, and leaf and cluster layers, were counted, so the lack of defoliation effects on those variables was expected and confirms the uniformity of the plots (Table 1). In contrast, vines were subjected to defoliation by burning before cane severance times were measured, and to either burning or blowing before evaporative potentials were measured, but neither defoliation method affected cane severance times or canopy evaporative potentials (Table 1). Likewise, ethephon and CAN-17 were both applied to vines at the KAC before cane severance times or canopy evaporative potentials were measured but neither treatment affected either of those variables (Table 2). In fact, application of ethephon had no apparent effect on the leaves or fruits, and CAN-17 caused little defoliation even though it caused extensive injury to leaves (Fidelibus, personal observation). Weaver and Poole (16) also found that desiccated grapevine leaves often failed to abscise, but Jensen et al. (8) observed that concentrated solutions of ammonium nitrate were effective grapevine defoliants. Unfortunately, the registration of ammonium nitrate has been withdrawn.

At Easton, neither canopy separation nor defoliation affected berry soluble solids (data not shown), or raisin yield or moisture at harvest (Table 3). However, vines having a non separated canopy that were also subjected to blowing yielded a higher proportion of "B and better" raisins than vines of some other treatment combinations (interaction not shown). Perhaps blowing removed some lower quality berries in the vineyard, and if so, vines whose canopies were not separated may have lost more low quality berries in the vineyard because they had fewer cluster layers, the presence of which could reduce the force of the blowing air on interior clusters. However, raisins from vines whose canopies were defoliated by blowing were moldier than raisins from vines that were not defoliated (Table 3). Raisins lots having > 5% mold are not acceptable to the California

**Table 3.** Yield, quality, moisture, and percent mold, of raisins from 'Thompson Seedless' grapevines subjected to different defoliation and canopy separation methods, Easton, Calif., 2003. Canes were severed on 27 August, and raisins were harvested on 24 October 2003.

| Factor | Yield (kg/vine)[z] | Quality (% B and better) | Moisture (%) | Mold (%) |
|---|---|---|---|---|
| **Defoliation Method** | | | | |
| None | 4.1[y] | 58.9 | 18.6 | 2.7 b[x] |
| Blow | 3.4 | 77.5 | 17.9 | 6.7 a |
| Burn | 4.5 | 68.4 | 16.8 | 5.7 ab |
| **Canopy Separation** | | | | |
| None | 4.4 | 67.1 | 17.4 | 4.8 |
| Wave | 4.0 | 69.5 | 17.7 | 5.5 |
| WRAB[w] | 3.6 | 68.2 | 18.3 | 4.9 |

[z] Yield is based on raisin weights standardized to 14% moisture
[y] Values are treatment means; n = 4 (defoliation method), n = 12 (canopy separation method)
[x] Means followed by a different letter are significantly different according to Duncan's New Multiple Range Test, $p \leq 0.05$
[w] Within-row alternate bearing

**Table 4.** Yield, quality, moisture, and percent mold, of raisins from 'Thompson Seedless' grapevines subjected to different defoliation and canopy separation methods, KAC, Parlier, Calif., 2003. Canes were severed on 22 August, and raisins were harvested on 21 October 2003.

| Factor | Yield (kg/vine)[z] | Quality (% B and better) | Moisture (%) |
|---|---|---|---|
| **Defoliation Method** | | | |
| None | 5.3[y] | 61 | 14.0 |
| Ethrel | 5.2 | 60 | 14.0 |
| Desiccant | 4.5 | 75 | 14.2 |
| **Canopy Separation** | | | |
| None | 5.1 | 64 | 13.2 b[x] |
| Wave | 5.0 | 63 | 13.9 b |
| WRAB[w] | 4.9 | 69 | 15.0 a |

[z] Yield is based on raisin weights standardized to 14% moisture
[y] Values are treatment means; n = 4 (defoliation method), n = 12 (canopy separation method)
[x] Means followed by a different letter are significantly different according to Duncan's New Multiple Range Test, $p \leq 0.05$
[w] Within-row alternate bearing

raisin industry regardless of their air-stream sorter grades (9) so raisins from vines defoliated by blowing or burning would have been rejected by a packer.

The reason why blowing might have increased the moldiness of raisins is unknown, but the forced air might have had the following effects: berry injury which could increase their susceptibility to infection, increased inoculum deposition on the berries, a more favorable microclimate for mold growth, or several of these. A grower (J. Paboojian) observed that defoliation by burning greatly increased mold on his DOV raisins; the increased moldiness was attributed to cuticle damage and to increased fruit exposure to dew (L. Peter Christensen, personal communication). The defoliation or canopy separation treatments tested at the KAC did not affect berry soluble solids (data not shown) or raisin yield and quality except that raisins from vines subjected to the WRAB canopy separation system had greater moisture levels at harvest than the other vines (Table 4).

*Trial 3, 2004 and 2005*. Regardless of the canopy separation or defoliation treatments applied, the vines had similar numbers of leaf layers and they bore similar numbers of clusters, in 2004 and 2005 (Table 5). Grapevine shoots growing in full sun develop more fruitful nodes than shoots growing in shade (2), so others (12) speculated that canopy separation might improve fruitfulness if it allowed the renewal shoots to develop in a less shaded microclimate. Our results suggest that a horizontally divided canopy does not appreciably improve the microclimate for shoots.

Vines subjected to the WRAB canopy separation method had more cluster layers than other vines in 2004, as noted at Easton in 2003, but all vines had similar numbers of cluster layers in 2005, as observed previously at the KAC (data not shown). In 2004, the number of cluster layers increased for vines subjected to the following defoliation treatments; desiccants, none and burning, and blowing (data not shown). Defoliation treatments did not affect the number of cluster layers in 2005 (data not shown). Because vines were not subjected to the defoliation treatments until after cluster layers were counted, defoliation effects on these variables are spurious. Neither cane severance time nor canopy evaporative potential were affected by canopy separation or defoliation factors in either year, confirming the results of our 2003 trials (Table 5). Further, berry soluble solids (data not shown), and raisin yield and

**Table 5.** Effect of year, canopy separation, and defoliation on the number of clusters per vine, the number of leaf and cluster layers in the fruiting zone, cane severance time, and evaporative potential of the fruiting zone, of 'Thompson Seedless' grapevines, KAC, Parlier, Calif.

| Factor | Clusters (no./vine) | Leaf layers (no.) | Evaporative potential (ml/d) | Cane severance time (s/vine) |
|---|---|---|---|---|
| **Year** | | | | |
| 2004 | 30[z] | 4.8 | 62 b[y] | 59 a |
| 2005 | 32 | 4.6 | 67 a | 40 b |
| **Defoliation Method** | | | | |
| None | 31 | 5.0 | 62 | 50 |
| Blow | 26 | 4.6 | 67 | 47 |
| Burn | 33 | 4.3 | 66 | 51 |
| Desiccant | 33 | 5.1 | 62 | 49 |
| **Canopy Separation** | | | | |
| None | 32 | 5.0 | 65 | 48 |
| Wave | 30 | 4.6 | 64 | 49 |
| WRAB[x] | 31 | 4.6 | 64 | 51 |

[z] Values are treatment means; n = 60 (year), n = 5 (defoliation method), n = 20 (canopy separation method)
[y] Means followed by a different letter are significantly different according to Duncan's New Multiple Range Test, $p \leq 0.05$
[x] Within-row alternate bearing

**Table 6.** Yield and quality of raisins from 'Thompson Seedless' grapevines subjected to different defoliation and canopy separation treatments, KAC, Parlier, Calif., 2004 and 2005.

| Treatment | Yield (kg/vine)[z] | Quality (% B and better) |
|---|---|---|
| **Year** | | |
| 2004 | 4.54 a[y] | 87.4 a |
| 2005 | 3.19 b | 61.6 b |
| **Defoliation Method** | | |
| None | 3.95 | 80.6 |
| Blow | 3.81 | 73.9 |
| Burn | 3.82 | 73.2 |
| Desiccant | 4.00 | 70.9 |
| **Canopy Separation** | | |
| None | 4.06 | 77.5 |
| Wave | 4.11 | 76.0 |
| WRAB[x] | 3.51 | 70.2 |

[z] Yield is based on raisin weights standardized to 14% moisture
[y] Values are treatment means, n = 60 (year), 5 (defoliation method), or 20 (canopy separation method). Means followed by a different letter are significantly different according to Duncan's new multiple range test, $p \leq 0.05$
[x] Within-row alternate bearing

quality were also similar regardless of canopy management (Table 6).

Year, canopy separation, and defoliation factors interacted to affect raisin moisture at harvest (Table 7). In 2004, raisins from non-defoliated vines subjected to the Wave method of canopy separation were moister at harvest than vines whose canopies were not separated (Table 7). However, raisins from defoliated vines had similar moisture at harvest regardless of whether or not their canopies were separated. In 2005, defoliation by blowing or burning reduced the moisture of raisins on vines whose canopies were subjected to the WRAB canopy separation method but raisins from vines subjected to other canopy separation or defoliation methods were of similar moistness at harvest (Table 7). In no case did canopy separation improve raisin drying.

In conclusion, canopy separation or fruitzone defoliation may offer little or no benefit to growers making DOV raisins from 'Thompson Seedless' grapevines on traditional trellises. On only one of four harvests

**Table 7.** Field moisture of 'Thompson Seedless' raisins from vines subjected to different defoliation and canopy separation treatments, Parlier, CA, 2004 and 2005.

| | Raisin moisture (%)[z] | | | | | |
|---|---|---|---|---|---|---|
| | 2004 | | | 2005 | | |
| | Canopy separation method | | | Canopy separation method | | |
| Defoliation Method | Control | WRAB | Wave | Control | WRAB | Wave |
| Control | 20.7 b[y] | 21.0 ab | 22.0 a | 26.7 | 34.8 | 24.3 |
| Blow | 21.1 | 20.7 | 19.6 | 22.5 | 20.4 | 21.3 |
| Burn | 20.6 | 20.5 | 21.0 | 19.9 | 22.5 | 23.0 |
| Desiccant | 22.8 | 21.6 | 20.8 | 23.4 | 24.1 | 25.4 |
| LSD (0.05)[x] | 1.8 | 1.8 | 2.7 | 6.8 | 10.3 | 5.8 |

[z] Average of five replications
[y] Means followed by a different letter, within years and rows, are significantly different according to Duncan's new multiple range test, $p \leq 0.05$
[x] Mean separation within columns by LSD test

were workers able to sever the canes of separated canopies more quickly than those on non-separated canopies. However, at two of four harvests, raisins from vines having separated canopies were moister at harvest than raisins from vines whose canopies were not separated. Further, poor drying was only partially remedied by fruit zone defoliation in one of four harvests. In one of four trials, canopy separation reduced the number of clusters per vine, but it never increased it. These data confirm the view of others (15) that the late maturing 'Thompson Seedless' grapevine cultivar is poorly suited for DOV raisin-making without the use of drying aids, as is practiced in Australia (7).

## Acknowledgments

This research was supported by grants from the USDA Viticulture Consortium and the California Raisin Marketing Board. We gratefully acknowledge Jorge Osorio Aguilar, Nathan Cannell, Donald Katayama, and Karin Kawagoe, who provided technical assistance, and L. Peter Christensen, who provided helpful comments on an earlier manuscript draft. We also thank Gwen Conville, who prepared an illustration of the canopy separation methods, and George Tatoian, who allowed us to work in his vineyard.

## Literature Cited

1. Antcliff, A.J., W.J. Webster, and P. May. 1958. Studies on the Sultana vine. VI. The morphology of the cane and its fruitfulness. Aust. J. Agric. Res. 9:328-338.
2. Christensen, L.P. 1978. Pruning for "sun canes" in 'Thompson Seedless'. Blue Anchor 55:9-11.
3. Christensen, L.P. 2000. Background and resources. Pp. 3-8. In: Raisin production manual. L.P. Christensen (Ed.). University of California, Agricultural and Natural Resources, Oakland.
4. Clingeleffer, P.R. 1984. Effects of time of season, fruit depth, and covering at night when ground drying, on acceptable moisture content of sultana raisins. J. Sci. Food Agric. 35:173-181.
5. English, J. T., A. M. Bledsoe, and J. J. Marois. 1990. Influence of leaf removal from the fruit cluster zone on the components of evaporative potential within grapevine canopies. Agr. Ecosyst. Environ. 31:49-61.
6. Gomez, K.A., and A.A. Gomez. 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York.
7. Grncarevic, M. and W.J. Lewis. 1976. Drying of grapes in Australia. Food Technol. Aust. 28:66-67, 69-71, 76.
8. Jensen, F., L. P. Christensen, and L. Bettiga. 1984. Desiccants for grapevines. Calif. Agr.: 9.
9. Kagawa, Y. 2000. Quality standards and inspection. Pp. 236-241. In: Raisin production manual. L.P. Christensen (Ed.). University of California, Agricultural and Natural Resources, Oakland.
10. May, P., and G.H. Kerridge. 1967. Harvest pruning of Sultana vines. Vitis 6:390-393.

11. May, P., P.R. Clingeleffer, and C.J. Brien. 1978. Pruning Sultana vines by the arched cane system. Aust. J. Exp. Agric. Anim. Husb. 18:301-308.
12. Peacock, W.L., and F.H. Swanson. 2005. The future of California raisins is drying on the vine. Calif. Agr. 59:70-74.
13. Shigeura, G.T., R.M. Bullock, and J.A. Silva. 1975. Defoliation and fruit set in Guava. HortScience 10(6):590.
14. Smart, R. and M. Robinson. 2001. Sunlight into wine. Winetitles, Adelaide.
15. Studer, H. E., and H. P. Olmo. 1971. The severed cane technique and its application to mechanical harvesting of raisin grapes. Trans. ASAE 14:38-43.
16. Weaver, R.J., and R.M. Pool. 1971. Defoliation of *Vitis vinifera* grapevines by artificial means. Am. J. Enol. Vitic. 22:76-79