Late-season Plastic Canopy Covers Affect Canopy Microclimate and Fruit Quality of 'Autumn King' and 'Redglobe' Table Grapes

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Summary. California table grape (*Vitis vinifera*) growers cover the canopies of late-season varieties with plastic (polyethylene) covers to shield the fruit from rain. Green- or white-colored covers are commonly used, but there is lack of information whether either cover might be preferable based on canopy microclimate or fruit quality. In late September, 'Redglobe' (in 2011) and 'Autumn King' (in 2012) table grapevines were covered with green or white plastic, or left uncovered, and canopy microclimate, fungal and bacterial rot incidence, and fruit yield and quality at harvest, and after postharvest storage, were evaluated. Green covers were more transparent and less reflective than white covers, and daily maximum temperature difference in the top center of the canopies of grapevine with green covers was consistently >5 °C than that of grapevine subjected to other treatments, but covers had little effect on temperatures in the fruit zones, which were not enveloped by covers. Effects on relative humidity (RH) depended on location within the canopy and time of day; RH peaked in early morning and was at a minimum in late afternoon. All cover treatments had relatively similar peak RH in south-facing fruit zones and the top center of the canopy. However, in the north-facing fruit zone, vines with green covers had higher RH at night than vines subjected to other treatments. Both covers consistently reduced evaporative potential in the top center of the canopy, but not in fruit zones. Treatment effects on condensation beneath the covers were inconsistent, possibly due to differences in canopy size, variety, or season, but south-facing cover surfaces generally had less condensation than the top or north-facing surfaces. About 0.5 inch of rain fell on 5 Oct. 2011, but no rain occurred during the 2012 experiment. In 2011, green covers delayed fruit maturation slightly, but not in 2012. Covers did not affect vineyard rot incidence, the number of boxes of fruit harvested, or postharvest fruit quality in 2011, but fruit from covered grapevine had less postharvest rot in 2012 than fruit from noncovered grapevines, even though a measurable rain event occurred in 2011 but not in 2012. In conclusion, our results suggest that white covers may be preferable to green since green covers were associated with higher temperatures in both seasons and higher RH in the 'Autumn King' trial of 2012, but otherwise performed similarly.

Table grapes are a labor and material intensive crop; annual operating expenses in California may exceed $9000 per acre (Peacock et al., 2007). This considerable investment is put at risk by exposure to precipitation within 6 weeks of harvest, which may stimulate the development of rots and molds that render grapes unmarketable (Gerawan and Zweigle, 2004). The most common bunch rot of grape in the San Joaquin Valley is summer bunch rot, a disease complex associated with numerous species of fungi and bacteria, including *Aspergillus* sp., *Botrytis cinerea*, *Cladosporium* sp., and *Acetobacter* sp. (Bettiga and Gubler, 2013). Botrytis bunch rot may also occur in the San Joaquin Valley, particularly in autumn, when temperatures moderate and clusters become wetted by condensation or precipitation. Canopy management practices that reduce humidity and promote cluster dryness help minimize the incidence of both types of rots (Bettiga and Gubler, 2013). Exposure to precipitation may be avoided by harvesting fruit before 1 Oct., after which time the chance of rain increases considerably, especially in the north-central San Joaquin Valley (Christensen, 2000). However, the grapes of some late maturing varieties may not have achieved optimal market quality by then and prices paid for grapes often increase toward the end of the harvest season, thus providing an incentive to harvest fruit as late as possible.

Some growers cover their grapevines with a sheet of polyethylene film to help prevent precipitation from wetting the clusters of grapes and thereby potentially extend the harvest season (Novello and de Palma, 2008). The films, which are generally ≈1-mil thick and 100 inches wide, are typically deployed in late August or early September and installed in such a way that they form an uninterrupted cover along the entire row length (Gerawan and Zweigle, 2004). In California, the covers are generally supported by the trellis and grapevine canopy and are thus in direct contact with the grapevines' leaves. The vast majority of growers use one of two different covers, which are green or white colored (Fig. 1). The radiometric properties of plastic covers can affect canopy microclimate (Novello et al., 2000), but there is a lack of knowledge on the effects that covers used in California may have on canopy microclimate, yield, and fruit quality.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
4.5839	fl oz/inch^2	mL·cm^{-2}	0.2182
0.3048	ft	m	3.2808
2.54	inch(es)	cm	0.3937
6.4516	inch^2	cm^2	0.1550
0.4536	lb	kg	2.2046
1.1209	lb/acre	kg·ha^{-1}	0.8922
28.3495	oz	g	0.0353
(°F − 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

Fig. 1. One block of the ‘Autumn King’ grape study site on 17 Sept. 2012. There were three blocks in both study sites, each including three entire vine rows assigned to one of the three cover treatments in a randomized complete block design. In this block a white-covered row is visible on the left, an uncovered row is in the center, and a green covered row is to the right. Portions of additional blocks can be seen on the far left and right portions of the photo.

Other grape-growing countries, particularly Italy, also use plastic covers, but the timing and method of deployment, and materials used are quite different (Novello and de Palma, 2008). In Italy and some other countries, plastic sheets may be used as a form of protected cultivation, in which the plastic forms a roof and walls around the vineyard (Novello and de Palma, 2008; Novello et al., 2000). Such systems may be installed in winter and kept in place until bloom to promote early ripening (Novello et al., 1999, 2000). Alternately, plastic may be installed later in the season, around veraison, to delay ripening and/or to protect fruit of late-ripening varieties from precipitation (Novello and de Palma, 2008). In such cases, lateral sheets may be retracted, leaving colorless transparent polyethylene sheets attached to frames above the trellising system, with areas between each vine row left uncovered (Novello and de Palma, 2008).

In California, growers use thinner, colored plastics that are installed late in the season, for a relatively short period of time, and in direct contact with the grapevine canopy. Such covers may have different effects on canopy microclimate and fruit quality than the Italian systems. Furthermore, growers may use covers of different colors, primarily green or white, which may differentially affect canopy microclimate, and thus fruit integrity and quality (Novello et al., 2000). Therefore, experiments were conducted to determine the effect of green- and white-colored plastic grapevine covers on several microclimate variables in the fruit zone and on yield, quality, and postharvest spoilage of grapes.

Materials and methods

Experiments were conducted in 2011 and 2012 in commercial table grape vineyards in the north central San Joaquin Valley. In 2011, the variety tested was ‘Redglobe’ (red, seeded) and in 2012, ‘Autumn King’ (green, seedless). The grapevines were grafted on ‘Freedom’ [*Vitis champinii* × (*Vitis solonis* × *Vitis othello*)] rootstock spaced 7 × 12 ft in rows oriented east-west, trained to quadrilateral cordons, spur-pruned, and supported by open-gable trellis systems. Plastic (polyethylene) covers (Rain Film; Jim’s Supply Co., Bakersfield, CA) were installed and secured by the grower on 30 Sept. 2011 and 10 Sept. 2012. An entire vine row was assigned to one of three cover treatments in a randomized complete block design, replicated three times: 1) no cover, 2) green cover, and 3) white cover. After installation, the film generally covered the entire upper surface of the trellis and the uppermost portion of the canopy on the north and south sides of the trellis (Fig. 1). The edges of the plastic covers ended above the fruiting zone.

In 2012, incident and reflected radiation were measured with a pyranometer (PY 5018; LI-COR, Lincoln, NE) interfaced with a recorder (LI-185B, LI-COR) immediately after the vine covers were installed. Canopy reflectance was calculated as the fraction of incident radiation reflected by the top of the canopy. Dataloggers (Hobo Pro in 2011 and Hobo Pro V2 in 2012; Onset Computer Corp., Bourne, MA) were placed in three locations in each plot: 1) within the fruit zone on the south side of the trellis, 2) ≈6 inches below the surface of the top center of the vine canopy, and 3) within the fruit zone on the north side of the trellis. Dataloggers were programmed to continuously collect temperature and RH data. In addition, fruit-zone evaporative potential, an environmental variable that is inversely correlated with botrytis bunch rot in table grapes (English et al., 1990), was measured with atmometers (C&M Meteorological Supply, Riverside, CA). On 6 Oct. 2011 and 28 Sept. 2012, three atmometers were weighed and hung in three similar locations as the dataloggers. Atmometers were left in the field for 1 week, reweighed, and evaporative potential was calculated (English et al., 1990). Condensation formed on the undersurface of the covers was determined on 14 Oct. 2011 and on 19 and 28 Sept. 2012. Paper towels of known area (677 cm^2) were placed in plastic zipper-top bags, weighed, and taken to the field. Towels were then removed from their bags, pressed against the undersurface of the covers until the moisture beneath the towels was absorbed, and returned to their bags and reweighed. Condensation in terms of milliliters per square centimeter was calculated from the mass of water absorbed by the towels divided by the area of the paper towel, assuming 1 g water = 1 mL water. Two measurements were made at each of three locations in each plot, i.e., north facing, top center, and south facing, at ≈0700 (morning) and 1400 HR (afternoon).

Summer and botrytis bunch rot incidence in the field were estimated on 4 and 19 Oct. 2011, by counting the total number of clusters on three typical vines in each row and the proportion of those clusters having four or more adjacent rotted berries. In 2012, four representative vines in each row were randomly selected and all of the rotted berries in each plot were trimmed out of the clusters and weighed; when heavily rotted clusters were noted, the entire cluster was included in the rot weight.

On 4 and 20 Oct. 2011, paired samples of berries were collected from each replicate, near locations where environmental data were collected. One sample consisted of 100 berries collected at random from the shoulders of potentially marketable clusters. Berries of this sample were counted, weighed, homogenized, the juice filtered, and total soluble solids (TSS) were measured with a refractometer (Palette 32; Atago, Tokyo, Japan) and titratable acidity (TA) determined at an end of point of pH 8.2 with a titrator (DL-15; Mettler-Toledo, Columbus, OH). An additional sample of 50 berries was collected from each plot, by carefully clipping berries from shoulders of potentially marketable clusters with shears. The color of berries in the 50-berry sample was then measured with a reflectance colorimeter (CR-10; Minolta, Osaka, Japan) that reports color in terms of lightness (L*), chroma (C*), and hue (h°), where L* refers to the lightness of a color, from black = 0 to white = 100; C* refers to the intensity of a color; and h° is the position on the color wheel, where 0° = red, 90° = yellow, 180° = green, and 270° = blue (McGuire, 1992). On 20 and 28 Sept. 2012, one 100-berry sample was collected from each plot, and berry weight, TSS, and TA were determined.

Clusters of grapes in each row were harvested by professional crews on 11 and 27 Oct. 2011, 11 Nov. 2011, and 13 Oct. 2012. In California, table grapes are shipped in boxes containing 19 lb of fruit, so the number of 19-lb boxes packed in each plot (row) was recorded at each harvest. Three boxes of fruit from each replicate were collected on the 27 Oct. 2011 harvest and on 13 Oct. 2012. One box from each replicate was selected at random at three different times during the day to ensure fruit were sampled from different parts of each row to improve representation of the samples. Boxes were promptly delivered to the Kearney Agricultural Research and Extension Center in Parlier, CA, for cold storage. The fruit were stored at ≈32 °F and 80% RH for 33 d in 2011 and for 30 d in 2012. Sulfur dioxide generator pads were included in each box, but the boxes were not otherwise fumigated so that any treatment effects on rot in postharvest storage would not be masked by fumigation. Fruit were inspected after 33 or 30 d of storage in 2011 and 2012, respectively. On inspection, the overall visual appearance of boxed grapes was rated according to the following scale: 1 = excellent, 2 = acceptable, or 3 = commercially unacceptable (Crisosto et al., 2002).

The data were subjected to a one-way analysis of variance using general linear model procedure of SAS (version 9.3; SAS Institute, Cary, NC) appropriate for randomized complete block arrangement of treatments. The time periods for the occurrence of minima and maxima of canopy temperature and RH variables

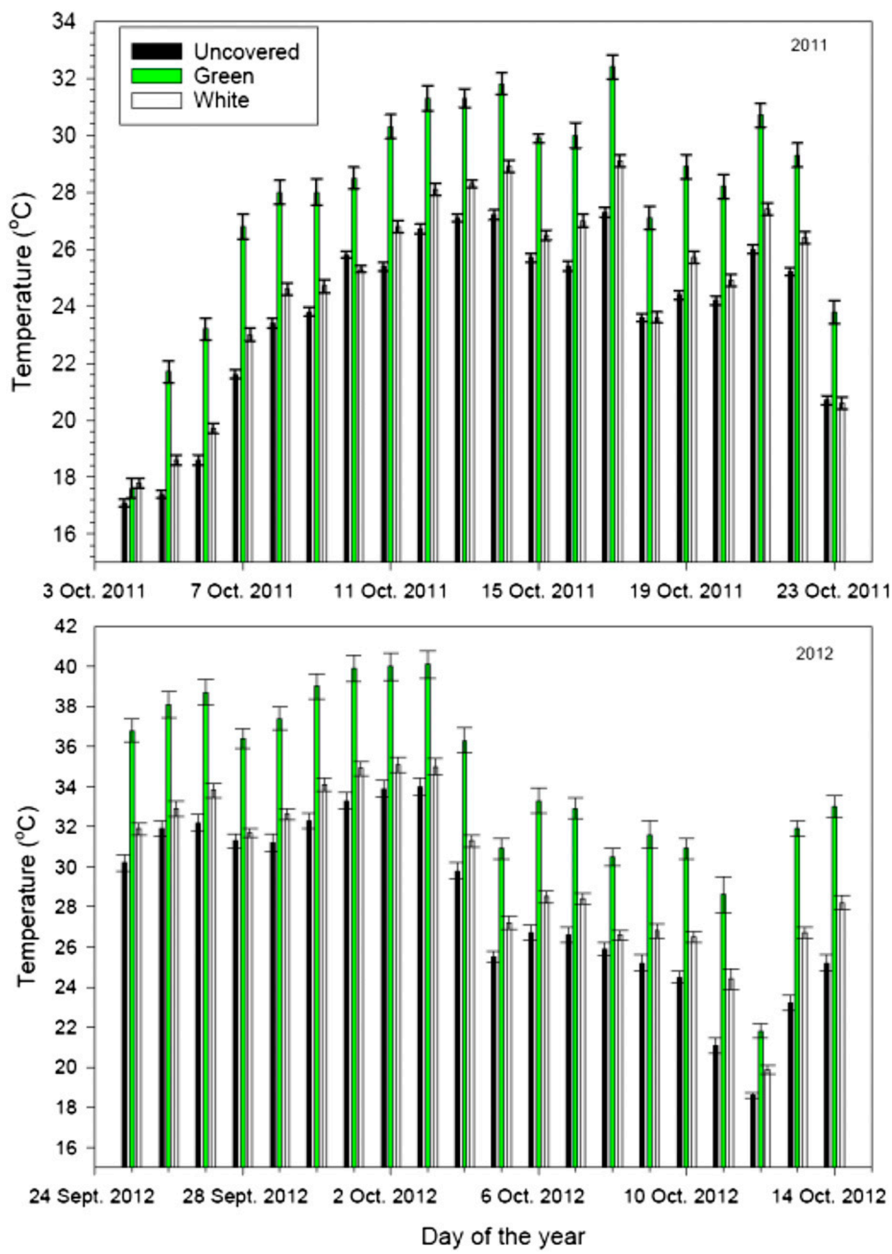

Fig. 2. Average peak daily temperature in the top center of the canopy of 'Redglobe' (3 to 23 Oct. 2011) or 'Autumn King' (24 Sept. to 14 Oct. 2012) grape uncovered or covered with green or white plastic film; (1.8 × °C) + 32 = °F.

were calculated with the frequency procedure of SAS. The canopy temperature and relativity humidity variables were then subjected to repeated measures analysis using the mixed procedure of SAS. Treatment means were considered significantly different by Duncan's new multiple range test at $P < 0.05$.

Results and discussion

Environmental effects of covers. The covers did not enclose the fruiting zone of the vines or affect fruit zone temperatures (data not shown). However, vines with green covers had much greater (≈5 °C) average daily peak temperature difference in the middle of their canopy than vines with white covers or uncovered vines (Fig. 2). The white covered vines reflected ≈50% of solar radiation, whereas green covered and uncovered vines reflected significantly less radiation, ≈30%. Thus, differences in temperature between the cover treatments were likely due to the different radiometric properties of the films and their capacity to trap infrared and longwave radiation within the covered vines (Novello et al., 2000).

In 2011, the RH sensors in the majority of the plots malfunctioned, most likely due to damage from exposure to excessive RH (100%), so there were insufficient data to report. In 2012, new sensors with a better design were installed and RH data were successfully collected. The results show that the type of cover, location within the canopy, and time of day affected RH (Fig. 3). In all treatments and locations, maximum RH occurred in early morning, and minimum RH was observed in late afternoon (data not shown). All cover treatments had relatively similar peak RH in south-facing fruit zones and in the top center of the canopy (Fig. 3). However, in the north-facing fruit zone, vines with green covers had higher RH at night than vines subjected to other treatments. High RH is one environmental variable that favors the development of botrytis bunch rots (English et al., 1989).

In 2011, more condensation accumulated under green covers than under white covers in morning, but not in afternoon (Table 1). In morning, the south-facing portion of the covers accumulated less condensation than the top (center) or north-facing portions of the covers (Table 1). In afternoon, there was less condensation under covers regardless of cover material, but there were greater positional effects on the amount of condensation, with the south side again having the least condensation,

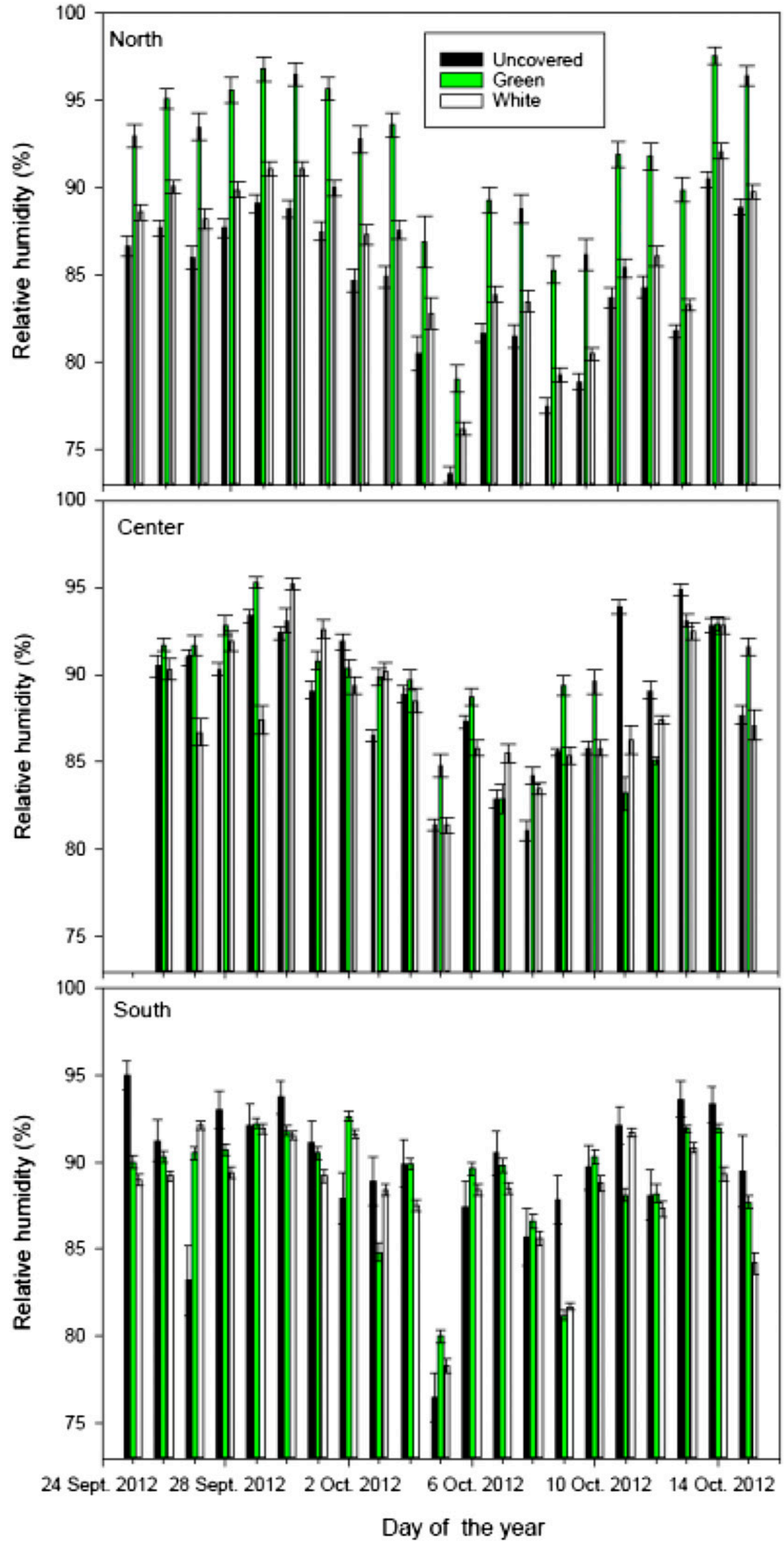

Fig. 3. Average peak daily relative humidity in the north fruit zone, top center of the canopy, or south fruit zone of 'Autumn King' grape 24 Sept. to 14 Oct. 2012.

followed by the north side and then the top (Table 1). Condensation was observed to precipitate onto vines and clusters when the covers were physically disturbed by workers or wind, but the frequency and amount of condensation that may precipitate onto clusters, and its potential contribution to bunch rots, was not measured.

There was much less condensation in 2012 than in 2011 (0.0002 to 0.008 mL·cm^{-2} vs. 0.008 to 0.032 mL·cm^{-2}), and treatment effects were only observed on one measurement date, 19 Sept. 2012. On that date, plastic and canopy position interacted to affect condensation, with the south side of white-colored plastic having much less condensation in afternoon than the center or north sides (data not shown). The vines used in 2012 were smaller than those used in 2011, so there was more space between the plastic and canopy surfaces in 2012 than in 2011 (M. Fidelibus, personal observation), which might account for the relative lack of condensation, and treatment effects on condensation, observed in 2012.

In 2011, evaporative potential was similar throughout the canopy of uncovered vines, but vines covered with green or white plastic had lower evaporative potentials in the center of their canopies than in the north or south fruit zones (Table 2). Similar treatment and position effects were observed in 2012 (data not shown). Italian systems minimize condensation on covers by elevating them above the canopy surface and by using antidroplet formulations of plastic (Novello and de Palma, 2008).

More than 1/2 inch of rain was recorded near the 'Redglobe' vineyard on 5 Oct. 2011, day of the year 278 (University of California, Davis, 2015). The rain thoroughly wetted most, if not all, clusters on uncovered vines, but few clusters on covered vines were wetted. Windy and warmer weather (Fig. 4) followed the storm and by the next day, most of the clusters on uncovered vines appeared to have dried. No substantial rain occurred during the 'Autumn King' trial in 2012.

Table 1. The effect of plastic covers and position in the canopy on condensation on the undersurface of the covers in the morning (0700 HR) and afternoon (1400 HR) on 'Redglobe' grape on 14 Oct. 2011.

Factor	Morning	Afternoon
	Condensation (mL·cm^{-2})[z]	
Cover		
Green	0.026 a[y]	0.020
White	0.017 b	0.016
Position		
North	0.025 a	0.019 b
Central	0.032 a	0.028 a
South	0.009 b	0.008 c

[z]1 mL·cm^{-2} = 0.2182 fl oz/inch^2.
[y]Values are treatment means (n = 3). Means followed by different letters, within columns and factors, are significantly different according to Duncan's new multiple range test (P < 0.05).

Table 2. The effect of vine cover treatments and position in the canopy of 'Redglobe' grape on evaporative potential on 13 Oct. 2011.

Cover	South	Top	North
	Evaporative potential (mL·d^{-1})[z]		
Uncovered	6.47	6.18 A[y]	6.85
Green	6.99 a[y]	4.24 B b	6.92 a
White	7.12 a	3.27 B b	6.35 a

[z]1 mL = 0.0338 fl oz.
[y]Values are treatment means (n = 3). Means followed by different capital letters are significantly different within columns according to Duncan's new multiple range test (P< 0.05). Means followed by different lower case letters are significantly different within rows, according to Duncan's new multiple range test.

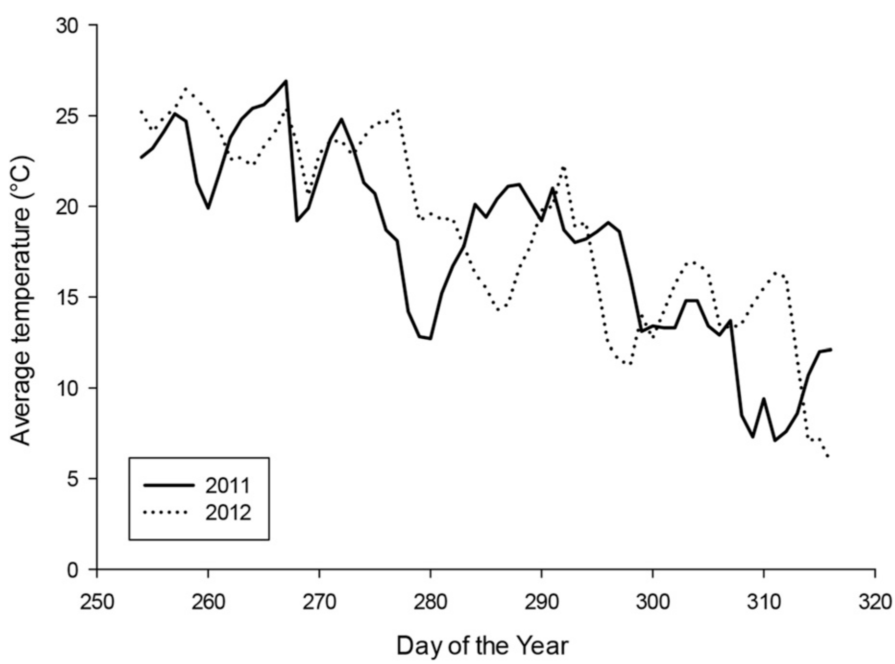

Fig. 4. Average daily temperatures from the Del Rey/Fowler, CA, weather station on day of the year 255–315 in 2011 and 2012; (1.8 × °C) + 32 = °F.

EFFECTS OF COVERS ON BERRY COMPOSITION, PREHARVEST ROT, YIELD, AND POSTHARVEST QUALITY. 'Redglobe' berries matured in October, as evidenced by the fact that they became heavier, darker, and redder in color (lower L*, C*, and h°), their TSS increased, and TA decreased between early and late October (Table 3). Green covers appeared to inhibit ripening slightly, as berries from vines with green covers had slightly greater h° and TA compared with berries from uncovered vines or from vines with white covers (Table 3). Novello and de Palma (2008) noted that covers, which induce excessive heating can delay ripening, so the delayed ripening of 'Redglobe' under green covers is likely related to the increased canopy temperatures we observed.

'Autumn King' berries were comparatively more mature at the time of covering than the 'Redglobe' berries, as evidenced by their higher TSS at an earlier date [October for 'Redglobe', vs. September for 'Autumn King' (Tables 3 and 4, respectively)]. Even so, the 'Autumn King' berries also continued to mature during the study period, with TSS increasing and TA decreasing (Table 4). However, no treatment effects on fruit quality were detected in 2012 (Table 4), possibly due to the more advanced maturation of the berries, the shorter observation period, or the fact that the smaller 'Autumn King' vines allowed more space between the covers and the vine canopy, as discussed earlier.

In 2011, 'Redglobe' grapes under white covers had greater preharvest rot incidence on 4 Oct. than grapes under green covers or not covered (Table 5). However, by 19 Oct., rot levels had increased and become similar for all vines, regardless of cover treatment (Table 5). 'Autumn King' vines also had a similar amount of rotten fruit at harvest, ≈3.7 kg/vine, regardless of treatment (Table 5). A similar amount of 'Redglobe' grapes were harvested from vines in every cover treatment on 11 and 26 Oct., but more fruit were harvested from vines with green covers on 2 Nov. (Table 6). Treatments did not affect the total amount of fruit harvested in 2012 (Table 6). 'Autumn King' grapes were only harvested once, on 10 Oct. 2012 and, as with 'Redglobe' in 2011, a similar amount of fruit was harvested from all vines, regardless of cover treatment (Table 6). It is unclear why covers did not affect preharvest rot levels, especially in 2011. It may be that preharvest fungicide applications provided sufficient rot protection for uncovered vines exposed to relatively modest precipitation as observed in the trial.

After 33 d in cold storage, 'Redglobe' grapes remained in relatively good condition (Table 7). Visual appearance on box opening was excellent regardless of treatment, though careful inspection revealed a few rotten berries in 15% to 28% of clusters, regardless of preharvest cover treatment (Table 7). In 2012, after 30 d of postharvest storage, ≈44% of 'Autumn King' grape clusters from uncovered vines had signs of rot, which was significantly greater than the 18% rot observed on fruit from vines with either cover; visual scores averaged ≈1.78 and

Table 3. Main effects of sampling date and vine covers on 'Redglobe' grape berry weight, color characteristics, total soluble solids (TSS), and titratable acidity (TA) in 2011.

		Berry color characteristics				
Factor	Berry wt (g)[z]	Lightness	Chroma	Hue	TSS (%)	TA (%)
Date						
4 Oct.	14.5 b[y]	35.91 a	11.82 a	24.60 a	14.9 b	0.41 a
20 Oct.	15.5 a	32.51 b	10.63 b	16.79 b	15.5 a	0.37 b
Cover						
Uncovered	15.2	33.86	11.41	19.3	15.3	0.38 b
Green	14.9	34.36	11.31	22.0	15.1	0.40 a
White	14.8	34.40	10.97	20.8	15.2	0.38 b
Significance						
Date	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cover	0.17	0.34	0.52	0.06	0.55	<0.01
Date × cover	0.15	0.11	0.65	0.29	0.35	0.06

[z]1 g = 0.0353 oz.
[y]Values are treatment means (n = 9, date; n = 3, cover). Means followed by a different letter, within columns and factors, are significantly different according to Duncan's new multiple range test (P < 0.05).

Table 4. Main effects of sampling dates and cover treatments on berry weight, total soluble solids (TSS), and titratable acidity (TA) of 'Autumn King' grape in 2012.

Factor	Berry wt (g)[z]	TSS (%)	TA (%)
Date			
20 Sept.	10.6	18.4 b[y]	0.35 a
28 Sept.	10.6	19.0 a	0.33 b
Cover			
Uncovered	10.6	18.6	0.34
Green	10.5	18.8	0.34
White	10.6	18.5	0.34
Significance			
Date	0.88	0.02	<0.01
Cover	0.78	0.41	0.87
Date × cover	0.71	0.71	0.57

[z]1 g = 0.0353 oz.
[y]Values are treatment means (n = 9, date; n = 3, cover). Means followed by a different letter, within columns and factors, are significantly different according to Duncan's new multiple range test (P < 0.05).

Table 5. Preharvest rot of 'Redglobe', 2011, and 'Autumn King', 2012, grape with different vine covers. Rot was expressed as percent clusters with rot in 2011, and as kilograms per vine in 2012.

	Rot[z]		
	(% clusters with rot, by count)		(kg/vine)[y]
	2011		2012
Cover	4 Oct.	19 Oct.	13 Oct.
Uncovered	7 b[x]	21	4.38
Green	8 b	21	2.98
White	14 a	19	3.67

[z]In 2011, rot was estimated by dividing the total number of clusters on three typical vines (subsamples) in each of three rows (plots) of the same treatment.
[y]1 kg = 2.2046 lb.
[x]Values are treatment means (n = 3). Means followed by different letters are significantly different within columns according to Duncan's new multiple range test (P < 0.05).

Table 6. Boxes of marketable 'Redglobe' (2011) and 'Autumn King' (2012) grapes harvested from vines with different cover treatments on each date, and total number of boxes harvested in 2011 and 2012. In 2012, fruit were only harvested once, on 10 Oct.

	Marketable grapes (boxes/acre)[z]				
	2011				2012
Cover	11 Oct.	26 Oct.	2 Nov.	Total	10 Oct.
Uncovered	614[y]	726	838 b	2,178	656
Green	641	717	1,143 a	2,501	504
White	651	744	772 b	2,117	448

[z]1 19-lb (8.6 kg) box/acre = 21.2962 $kg \cdot ha^{-1}$.
[y]Values are treatment means ($n = 3$). None of the means, within columns, were significantly different according to Duncan's new multiple range test ($P < 0.05$).

Table 7. Effect of vine covers on preharvest and postharvest rot and visual appearance of 'Redglobe' (2011) or 'Autumn King' (2012) table grapes after 33 or 30 d of storage, respectively.

	Yr			
	2011		2012	
Cover	Clusters with rot (%)	Visual appearance score (1–3 scale)[z]	Clusters with rot (%)	Visual appearance score (1–3 scale)
Uncovered	28[y]	1	18.5 b	2.0
Green	19	1	18.5 b	1.7
White	15	1	44.4 a	1.7

[z]1 = excellent, 2 = acceptable, 3 = commercially unacceptable.
[y]Values are treatment means ($n = 3$). Means followed by a different letter, within columns, were significantly different according to Duncan's new multiple range test ($P < 0.05$).

were unaffected by covers (Table 7). Additional data are needed to confirm that covers have a repeatable benefit in reducing postharvest rot and, if so, what the possible mechanism may be.

Green covers were associated with higher peak temperatures and RH at night than white covers (data not shown). Neither cover had horticulturally significant effects on fruit quality or rot in the vineyard, but both provided some protection from postharvest rots in the 'Autumn King' trial of 2012. Thus, our results suggest that white covers may be preferable to green covers as they have less undesirable microclimate effects than green covers.

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