Leaf Removal for Nonchemical Control of the Summer Bunch Rot Complex of Wine Grapes in the San Joaquin Valley

JAMES J. STAPLETON, Statewide Integrated Pest Management Project, University of California Kearney Agricultural Center, 9240 S. Riverbend Ave., Parlier, CA 93648, and R. STANLEY GRANT, E. & J. Gallo Winery Ranches, Livingston, CA 95334

ABSTRACT

Stapleton, J. J., and Grant, R. S. 1992. Leaf removal for nonchemical control of the summer bunch rot complex of wine grapes in the San Joaquin Valley. Plant Dis. 76:205-208.

Field experiments were conducted with several wine grape cultivars during 1988–1990 near Livingston, California, to determine the effects of leaf removal on summer bunch rot. This cultural practice was found to consistently reduce experimental disease parameters, compared with the nontreated control. Damage due to the summer bunch rot complex (primarily sour rot) was reduced by as much as 69%. A trend toward higher harvestable yields was observed, but differences were rarely significant. Rot reduction after leaf removal was greatest when leaves were pulled from the fruit zone on both sides of cordon-trained vines, but more sunburn also occurred after such treatment. Retaining foliage on the side of the vines facing the afternoon sun reduced the incidence of sunburn but also sometimes reduced the effectiveness of leaf removal in controlling bunch rot. The cost of leaf removal in the San Joaquin Valley may be justified by the benefits of reduced bunch rot, possible enhanced wine characteristics, decreased need for insecticide sprays, and improved pesticide coverage.

Leaf removal is a viticultural practice involving partial defoliation of basal portions of shoots near the clusters, performed shortly after bloom. This method of canopy management has been studied intensively as a technique to control Botrytis bunch rot, caused by *Botrytis cinerea* Pers.:Fr., in the coastal areas of California where wine grapes (*Vitis vinifera* L.) are grown (1–4). Wind speed through grapevine canopies was shown to increase markedly after leaf removal (3), and development of *B. cinerea* decreased inversely with wind speed (9). In some instances, leaf removal also resulted in improved fruit quality for wine making (2).

Botrytis bunch rot is the principal fruit disease of grapes grown in coastal areas of California, whereas a summer bunch rot complex prevails in the warmer and drier San Joaquin Valley (5). Botrytis bunch rot is present, particularly in the northern portion of the valley subject to the marine climatic influence of San Francisco Bay, but its prevalence decreases to the south. Sour rot, the principal component of the summer bunch rot complex, can be caused by several microorganisms, including species of *Acetobacter, Aspergillus, Diplodia, Penicillium*, and *Rhizopus* (6). These organisms usually act as secondary wound invaders, but some may also infect sound berries as primary pathogens (6). The pathogens are often vectored by vinegar flies (*Drosophila* spp.). Historically, fungicide applications have been ineffective against summer rot (5,6).

Because of the success of leaf removal in controlling Botrytis bunch in coastal growing areas, it was postulated that the practice might also be effective for management of the summer rot complex. Therefore, several leaf removal experiments were conducted near Livingston, California, in the central San Joaquin Valley during 1988–1990 to test the effects. Leaf removal as practiced in coastal areas where wine grapes are grown involves removing leaves from the entire fruit zone on both sides of cordon-trained vines, which allows maximum air movement through the canopy. However, sunburn is a concern with exposed fruit in the warm San Joaquin Valley. Consequently, leaf removal has been practiced more cautiously, with leaves sometimes being left on the side of the vines exposed to the afternoon sun (8). Both one-sided and two-sided leaf removal treatments were included in some of these experiments to compare their effects on rot control and sunburn.

Accepted for publication 3 September 1991 (submitted for electronic processing).

MATERIALS AND METHODS

Four leaf removal trials were conducted in 1988 using the cultivars Chenin blanc, Sauvignon blanc, and Barbera, trained on either a bilateral or a quadrilateral cordon system. Vineyard cultural details for all experiments are given in Table 1. Each field trial included two treatments, leaf removal and nontreated control, in 30-vine plots replicated five times and arranged in a completely randomized design. Leaves were removed from the single nodal positions above, below, and adjacent to clusters about 3 or 4 wk after bloom. Approximately four to six leaves were removed from each shoot; numerous leaves remained. Leaves were pulled from both sides of vines, but a single layer of leaves was left on the exterior of the side facing the afternoon sun (i.e., west or south) to help prevent berry sunburn (one-sided leaf removal). Five vines from each replicate were selected at random for evaluation of incidence and severity of sour rot and Botrytis rot before harvest (Table 2).

The six experiments conducted in 1989 had the same treatments as in 1988 but were arranged as randomized complete blocks. Each replicate consisted of nine vines, with one vine at each end serving as a buffer. Harvest data collected for

Table 1. Cultural details of leaf removal experiments, Livingston, California, 1988–1990

Vineyard (year planted)	Cultivar (relative vigor)	Cordon training system	Trellis type	Leafing dates (bloom dates) 1988	1989	1990
A (1970)	Chenin blanc (vigorous)	Bilateral	T	10 June ND[z]	24 May (27 April)	24 May (4 May)
B (1971)	Chenin blanc (vigorous)	Bilateral	One wire vertical	ND	18 May ND	ND
C (1972)	Chenin blanc (moderately vigorous)	Bilateral	T	11 June ND	18 May (27 April)	ND
D (1983)	Chenin blanc (vigorous)	Bilateral	T	ND	18 May (27 April)	22 May (6 May)
E (1982)	Sauvignon blanc (very vigorous)	Quadrilateral	One wire above each cordon	12 June ND	19 May (4 May)	31 May (26 May)
F (1968)	Barbera (moderately vigorous)	Bilateral	T	13 June ND	18 May (2 May)	25 May (5 May)

[z]No data.

Table 2. Effect of leaf removal on bunch rots of wine grapes, Livingston, California, 1988

Vineyard	Cultivar Treatment	Days before harvest	Botrytis rot I[x]	Botrytis rot S	Sour rot I	Sour rot S	Total rot I	Total rot S
C	Chenin blanc							
	Leafed	17	ND[y]	ND	ND	ND	3.7*[z]	ND
	Control		ND	ND	ND	ND	7.7	ND
	Leafed	1	10.0	1.5*	19.0*	4.6*	27.0*	5.6*
	Control		10.0	2.8	42.0	12.4	48.0	14.4
F	Barbera							
	Leafed	35	ND	ND	ND	ND	1.9*	ND
	Control		ND	ND	ND	ND	5.2	ND
	Leafed	1	2.7*	0.5	13.0	3.0	17.0	3.4
	Control		8.7	2.2	26.3	6.2	33.4	7.9

[x]I = Incidence (% of clusters affected), S = severity (% damage per cluster).
[y]No data.
[z]* = Value differs from that of corresponding control treatment according to Student's *t* test ($P < 0.05$).

Table 3. Influence of leaf removal on yield and rotten cluster weight per vine for six leaf removal trials, Livingston, California, 1989

Vineyard	Cultivar	Treatment	Total yield (kg/vine)	Rotten cluster weight (kg/vine)	Usable yield (kg/vine)
A	Chenin blanc	Leafed	27.4	1.0	26.4
		Control	26.4	1.3	25.1
B	Chenin blanc	Leafed	24.7	0.7	24.0
		Control	25.2	1.7	23.5
C	Chenin blanc	Leafed	12.0	0.6	11.3
		Control	13.4	1.0	12.4
D	Chenin blanc	Leafed	28.0*[z]	0.7*	27.3*
		Control	24.7	1.2	23.5
E	Sauvignon blanc	Leafed	30.8	0.7	30.0
		Control	29.0	1.2	27.7
F	Barbera	Leafed	22.4	0.2*	22.1
		Control	22.2	0.7	21.5

[z]* = Value differs from that of corresponding control treatment according to Student's *t* test ($P < 0.05$).

analysis included total yield, weight of rotten clusters (cull clusters containing 25% or more berries with rot, which are unacceptable to wineries), and usable yield.

The four trials conducted in 1990 were similar but included a treatment in which no layer of leaves was left to shade clusters from the afternoon sun (two-sided leaf removal). Data on bunch rot, yield, and poor fruit attributes (sunburn, raisining, ambering) were collected at harvest.

RESULTS AND DISCUSSION

Vines with leaves removed had significantly lower incidence of bunch rot at the Chenin blanc C and Barbera F vineyards than nontreated control vines in 1988 (Table 2). Although levels of Botrytis bunch rot were low, sour rot was far more prevalent. Relatively little rot was found for both control and leafed vines at the Chenin blanc A and Sauvignon blanc E locations. Cool weather prevailed during the bloom period for Sauvignon blanc in 1988. Consequently, fruit set was poor and clusters were looser than normal, perhaps accounting for the uniformly lower rot ratings in that cultivar.

The weight of rotten clusters tended to be lower for vines with leaves removed than for control vines in all trials during 1989 (Table 3). The differences were statistically significant only at the Chenin blanc D and Barbera F vineyards. Greater differences between treatments may not have developed because 1989 was a particularly light year for bunch rot in most vineyards at the Livingston ranch. Total and usable yield parameters were significantly increased after leaf removal at the Chenin blanc D vineyard only.

Sun-damaged fruit was evident in all of the leaf removal experiments in 1990, although very few clusters were affected in the Chenin blanc D vineyard. In Chenin blanc vineyards A and D, the number of clusters with sun-damaged fruit was higher with two-sided removal than with one-sided or no leaf removal (Table 4). In addition, the number of sun-damaged berries per cluster was greater with two-sided leaf removal than with no leaf removal. Two-sided leaf removal also resulted in the greatest number of clusters with sun-damaged fruit on Sauvignon blanc vines (Table 4). Unlike Chenin blanc vines, however, Sauvignon blanc vines with one-sided leaf removal had significantly more clusters with sun-damaged fruit than did control vines. The reason for this most likely lies in differences in training systems and canopy management practices. The Chenin blanc vines were bilateral cordon-trained onto a trellis with a crossarm for foliage support. This system provides protection for the fruit even after hedging, a routine practice done with a vertical, rotary, tractor-mounted implement after each irrigation to facilitate cultivation for weed control. The Sauvignon blanc vines were quadrilateral cordon-trained onto a trellis system, with a foliage support wire positioned above each cordon. Shoots are held upright, and much of the fruit on both sides of the vines is exposed when these vines are hedged,

Table 4. Influence of leaf removal on one or both sides of vines on poor fruit quality parameters, Livingston, California, 1990

Vineyard	Cultivar	Treatment	Fruit raisined, ambered, or sunburned: Incidence (% of clusters)	Fruit raisined, ambered, or sunburned: Severity (% of berries)
A	Chenin blanc	Leafed, one side	5.5 b[z]	20.5 ab
		Leafed, two sides	10.6 a	28.0 a
		Control	4.7 b	17.5 b
D	Chenin blanc	Leafed, one side	0.4 b	3.3 ab
		Leafed, two sides	1.3 a	5.6 a
		Control	0.0 b	0.3 b
E	Sauvignon blanc	Leafed, one side	1.8 b	14.2 a
		Leafed, two sides	3.5 a	15.4 a
		Control	0.5 c	7.7 b

[z]Values in a column for a given trial followed by different letters differ significantly ($P < 0.05$) according to Fisher's protected LSD test.

particularly if leaves have been removed. As a consequence of this training system, the occurrence of sunburn is fairly common with Sauvignon blanc vines that have had leaves removed.

Bunch rot was widespread in many vineyards in the Livingston area in 1990. As in previous years, Botrytis bunch rot represented a small portion, compared with sour rot, of the total rot present in the leaf removal field experiments. Although leaf removal did not appear to affect bunch rot incidence or severity at the Chenin blanc A vineyard, the weight of rotten clusters from vines with two-sided leaf removal was considerably less than that of rotten clusters from vines with one-sided or no leaf removal (Table 5). At the Chenin blanc D vineyard, bunch rot was significantly reduced by two-sided, but not by one-sided, leaf removal. For vines in the Sauvignon blanc E vineyard, both one- and two-sided leaf removal resulted in reduced incidence and severity of sour rot. Weight of rotten clusters was very low in the Barbera F trial, and leaf removal had little effect. Although a trend toward slightly increased usable yield was observed in each experimental vineyard after leaf removal, no significant differences were found.

The removal of leaves resulted in a consistent trend toward reduced bunch rot during each year of testing. However, the disease reductions were not always statistically significant and did not always result in increased usable yield.

Removing leaves from both sides of cordon-trained vines resulted in greater reductions of bunch rot than did removing them from the afternoon shade side of vines only. The incidence and severity of sun-damaged fruit were also greater after this treatment. However, the amount of sunburn was less than the amount of rot in most instances, and sun-damaged fruit did not represent lost production, which fruit infected with bunch rots frequently did.

Leaves were removed about 3 or 4 wk after bloom in 1988. In 1989 and 1990, leaves were removed about 1.5–2 wk after bloom. This difference in timing did not appear to affect the influence of leaf removal on bunch rot, confirming previous data (2,7).

Removing leaves by hand is a labor-intensive and expensive practice. Where the value of wine grapes is low, as it is in most of the San Joaquin Valley as compared with the coastal growing areas, reduced crop losses to bunch rot or increased color in red grape cultivars may not be sufficient to recover the cost of treatment (8). However, leaf removal can be a valuable prophylactic treatment, especially when conditions for disease development are optimal, since chemical treatments are historically ineffective against the summer bunch rot complex. Certain wineries and growers justify the annual expense of leaf removal by business-related or personal aversion to pesticide use. Moreover, the practice offers benefits not reported here. Leaf removal allows for greater penetration of pesticide sprays into the fruit zone, thus increasing their coverage and effectiveness (1,4). Also, leaf removal in proper timing with the first brood of leafhoppers may eliminate the need for one or more insecticide sprays for this key pest (7,8). When considered together, these factors provide additional justification for the expense of manual leaf removal. The widespread use of several types of leaf removal machines, either commercially available or under development, may reduce or eliminate the need for expensive hand labor and thereby make leaf removal a more cost-effective practice.

ACKNOWLEDGMENTS

We thank the UC Statewide IPM Project for financial support of these studies, E. & J. Gallo Winery Ranches for cooperation, and D. Aguilar, R. Duncan, D. Hubert, M. V. Norton, and J. Sandoval for technical assistance.

LITERATURE CITED

1. Bettiga, L. J., Gubler, W. D., Marois, J. J., and Bledsoe, A. M. 1989. Integrated control of Botrytis bunch rot of grape. Calif. Agric. 43:9-11.
2. Bledsoe, A. M., Kliewer, W. M., and Marois, J. J. 1988. Effects of timing and severity of leaf removal on yield and fruit composition of Sauvignon blanc grapevines. Am. J. Enol. Vitic. 39:49-54.
3. English, J. T., Thomas, C. S., Marois, J. J., and Gubler, W. D. 1989. Microclimates of grapevine canopies associated with leaf removal and control of Botrytis bunch rot. Phytopathology 79:395-401.
4. Gubler, W. D., Marois, J. J., Bledsoe, A. M.,

Table 5. Influence of leaf removal on one or both sides of vines on incidence and severity of bunch rot and on yield, Livingston, California, 1990

Vineyard	Cultivar	Treatment	Rot incidence (% of clusters): Botrytis rot	Sour rot	Total rot	Total rot severity (% of berries)	Total yield (kg/vine)	Rotten cluster weight (kg/vine)	Usable yield (kg/vine)
A	Chenin blanc	Leafed, one side	0.0 a	11.8 a	11.8 a	38.7 a	19.1 a	1.2 a	17.9 a
		Leafed, two sides	0.0 a	9.5 a	9.5 a	33.5 a	17.7 a	0.6 b	17.0 a
		Control	0.1 a[y]	10.3 a	10.4 a	35.2 a	18.5 a	1.6 a	14.9 a
D	Chenin blanc	Leafed, one side	0.5 a	5.0 ab	5.4 ab	32.0 a	25.2 a	1.5 a	23.7 a
		Leafed, two sides	0.2 a	3.0 b	3.2 b	18.1 b	24.3 a	0.5 b	23.8 a
		Control	0.6 a	7.8 a	8.4 a	40.0 a	26.0 a	2.4 a	23.6 a
E	Sauvignon blanc	Leafed, one side	0.0 a	2.1 b	2.1 b	17.2 b	21.6 a	0.5 a	21.1 a
		Leafed, two sides	0.0 a	2.1 b	2.1 b	12.0 b	24.5 a	0.6 a	24.0 a
		Control	0.0 a	4.5 a	4.5 a	25.5 a	23.0 a	1.0 a	22.0 a
F	Barbera	Leafed, one side	ND[z]	ND	ND	ND	17.2 a	0.1 a	17.1 a
		Leafed, two sides	ND	ND	ND	ND	16.2 a	0.0 a	16.2 a
		Control	ND	ND	ND	ND	16.7 a	0.2 a	16.5 a

[y]Values in a column for a given trial followed by different letters differ significantly ($P < 0.05$) according to Fisher's protected LSD test.
[z]No data.

and Bettiga, L. J. 1987. Control of Botrytis bunch rot of grape with canopy management. Plant Dis. 71:599-601.

5. Hewitt, W. B. 1962. Summer bunch rot of grapes. Wines Vines 43:17.
6. Hewitt, W. B. 1974. Rots and bunch rots of grapes. Calif. Agric. Exp. Stn. Bull. 868. 52 pp.
7. Stapleton, J. J., Barnett, W. W., Kelley, K. M., Leavitt, G. M., Norton, M. V., and Verdegaal, P. S. 1989. Leaf removal for management of diseases and pests of wine grapes in the San Joaquin Valley. (Abstr.) Phytopathology 79:1137.
8. Stapleton, J. J., Barnett, W. W., Marois, J. J., and Gubler, W. D. 1990. Leaf removal for pest management in winegrapes. Calif. Agric. 44:15-17.
9. Thomas, C. S., Marois, J. J., and English, J. T. 1988. The effects of wind speed, temperature, and relative humidity on development of aerial mycelium and conidia of *Botrytis cinerea* on grape. Phytopathology 78:260-265.