# Control of Botrytis Bunch Rot of Grape with Canopy Management

W. D. GUBLER, Extension Plant Pathologist, J. J. MAROIS, Assistant Professor, and A. M. BLEDSOE, Staff Research Associate, Department of Plant Pathology, University of California, Davis 95616, and L. J. BETTIGA, Farm Advisor, Cooperative Extension, University of California, Salinas 93901

**ABSTRACT**

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Botrytis bunch rot of grape (cultivar Chenin blanc) was significantly reduced in canopy management field trials established in 1984 and 1985 in Monterey County, California. Treatments consisted of hedging, shoot removal, leaf removal, a movable wire system, and a nonmanaged control. Treatments in 1985 were similar, but the movable wire system was omitted. An additional trial in 1985 in Napa County, California, compared the leaf removal treatment with the nonmanaged control. All plots were established in a split-plot design with or without fungicides. Control of Botrytis bunch rot was greatest in the leaf removal treatments. In Monterey, the leaf removal treatments in 1984 and 1985 reduced disease incidence from 11.9 to 1.8 and from 55.0 to 23.9, respectively. Leaf removal also reduced disease severity in the Monterey trials. Percent rot by weight was reduced from 1.78% in the nonmanaged, nonsprayed control to 0.30% in the vines manipulated by leaf removal in 1984. In 1985, severity was reduced from 15.30% rot per cluster to 2.85% in the leaf removal treatment. Application of fungicide in 1984 significantly reduced disease in all treatments except leaf removal, whereas the reduction in incidence attributable to fungicide was not significant in 1985. In the Napa trial in 1985, leaf removal also reduced disease incidence from 30.52 to 6.17% in the nonsprayed controls. Disease severity was reduced from 3.36% rot per cluster in the intact, nonsprayed control to 0.30% in the nonsprayed leaf removal treatment. Fungicides did not significantly reduce incidence or severity.

Additional key words: cultural control

Bunch rot of wine grapes (*Vitis vinifera* L.) caused by *Botrytis cinerea* Pers. is a serious disease on grapes grown in the cooler coastal production areas in California. Severity of disease increases in years when late-season rains occur, but serious yield losses may occur without rain moisture. In these instances, Botrytis infection of grape berries commonly occurs in cultivars with dense canopies or tight berry clusters. In California, first symptoms of disease on susceptible cultivars are generally evident by mid- to late August, when sugar levels begin to increase (veraison).

Savage and Sall (4,5) reported that canopy management by hedging or by means of wire systems resulted in a moderate reduction of bunch rot incidence and severity. Research into other potential means of canopy management has shown positive effects of increased yields and higher quality fruit resulting from changes in canopy microclimate (6).

The purpose of this study was to further investigate the use of grapevine canopy management alone or combined with fungicide applications for potential control of Botrytis bunch rot. A portion of this research has been reported previously (1).

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## MATERIALS AND METHODS

A field trial was conducted in 1984 in a 14-yr-old Chenin blanc commercial vineyard in Monterey County, California. Vines on this site were moderately vigorous, cordon-trained, spur-pruned, and planted on a spacing of 3.6 × 2.4 m. A 2 × 5 split-plot design with four replicates was used to study subplot effects of hedging, a movable wire system, shoot removal, leaf removal, and a control treatment in which no canopy management was practiced. Within each of the canopy management treatments, vines were either not sprayed or sprayed with iprodione at 2.3 kg/ha at bloom, preclose, and veraison. Applications were made with a commercial over-the-vine boom sprayer delivering 1,900 L/ha.

**Canopy management treatments.** *Hedging.* Hedging was done at late bloom with hedge trimmers. Shoots about 100 cm long were hedged back 30–45 cm. This reduced the curtain effect that results when shoots "fall" with increased growth.

*Movable wire.* The movable wire system was established at late bloom by attaching wire to the end posts and stringing on either side of the canopy to a height of 1.3 m to keep the shoots oriented upward.

*Shoot removal.* Shoots were removed at late bloom. All interspur and crown shoots were removed, and spurs were thinned to two shoots.

*Leaf removal.* Leaves and laterals located opposite, one node above, and one node below each flower cluster were removed by hand at late bloom, resulting in a "window" of exposed clusters.

At maturity, four vines from each treatment in each replicate were hand-harvested and evaluated for incidence of bunch rot and yield. Severity ratings were obtained by determining the diseased berry weights per cluster per vine.

In 1985, two canopy management spray trials were established. One trial was established using the same vines used the previous year in Monterey County. Treatments in the 1985 trial were similar to but varied slightly from those in 1984. This trial was established using a 2 × 4 split-plot design with four replicates. Canopy management (subplot) treatments included hedging, prebloom shoot removal, leaf removal, and a control. Main plot treatments included fungicide spray or no spray.

Hedging in 1985 was done with a commercial sickle-bar hedger at preclose (pea-sized berries), resulting in removal of 15–30 cm of terminal shoot growth. Shoot removal was done about 4 wk before bloom. All interspur shoots were removed, and spur shoots were thinned to three. Leaf removal was done at cluster set as described previously. Canopy management and control treatments were conducted on each of two vine rows in each replicate. One of these vine rows served as the nonsprayed control. The other row was treated with iprodione at 2.3 kg/ha at bloom, preclose, and veraison with a commercial over-the-vine boom sprayer delivering 1,900 L/ha.

A second trial in 1985 was established in a vigorous 11-yr-old Chenin blanc vineyard in Napa County, California. Vines in this vineyard were cordon-trained, spur-pruned, and planted on AXR at a 2.4-m spacing within rows with 3.6 m between rows. The plot design was a 2 × 4 split plot with four replicates.

Canopy management in this trial was divided into two categories: 1) normal cultural practice, in which the grower conducted crown suckering on the entire vineyard (this practice involves removing all shoots arising from noncount buds and is done annually in this vineyard when shoot lengths reach 30–45 cm); and

2) leaf removal, which was conducted at cluster set by removing leaves and laterals from above, opposite, and below each grape cluster.

Fungicide applications (subplot) also were investigated in this trial. Spray timings were established according to growth stages of the grapevine. Treatments included single applications of benomyl 50W at 1.7 kg/ha + captan 50W at 4.5 kg/ha at bloom and preclose. A third treatment included two sprays at the timings described, and a fourth treatment was a nonsprayed control. The spray treatments were applied to the two inside rows of a four-row block with a commercial air-blast sprayer at 1,900 L/ha. In each treatment, one of these paired rows had the leaf removal treatment and the other was the intact control.

Bunch rot and yield evaluations were conducted at harvest. Four randomly selected vines from each treatment and replicate were harvested. Yields were obtained by taking cluster weights. Bunch rot incidence was evaluated by counting diseased clusters per vine. Severity ratings were determined by counting rotted berries per cluster and converting these figures to a percent rot per cluster based on the average number of berries per cluster.

## RESULTS

**Monterey County, 1984.** In 1984, Botrytis bunch rot was relatively low in both incidence and severity. Orthogonal contrasts identified significant differences resulting from canopy management in the 1984 trial (Table 1). The mean subplot effects of canopy management showed that bunch rot incidence was significantly reduced from 8.7 to 1.7% in the control and leaf removal treatments, respectively ($P < 0.05$). Shoot removal reduced disease incidence by only 3.1%. Disease was slightly increased in the hedging and movable wire treatments to 10.7 and 9.6%, respectively. Fungicide application resulted in no further significant disease reduction in the leaf removal treatment but was effective in reducing disease incidence in all other treatments.

Disease severity, determined as percent rot by weight (Table 1), also was influenced by leaf removal in the subplot and by fungicides in the main plot. Grape bunches on the nonmanaged, nonsprayed control vines had an average of 1.22% rot by weight, whereas bunches on vines with leaves removed averaged 0.20% rot by weight. Other canopy management treatments did not significantly reduce rot severity. Fungicide applications further reduced bunch rot severity. The greatest reduction occurred in the shoot removal treatment, where severity was reduced from 1.58 to 0.22%. Two treatments significantly ($P < 0.05$) reduced yields, shoot removal by 2.24 tons/acre and leaf removal by 1.40 tons/acre.

**Table 1.** Effects of canopy management practices and fungicide applications on incidence and severity of Botrytis bunch rot and yield on Chenin blanc in Monterey County in 1984

| | Incidence (percent disased clusters)[a] | | | | | |
|---|---|---|---|---|---|---|
| | Hedged | Leaf removal | Shoot removal | Movable wire | Control | Mean |
| Sprayed[b] | 7.3 | 1.6 | 2.0 | 4.6 | 5.6 | 4.22** |
| Nonsprayed | 14.2 | 1.8 | 9.2 | 14.6 | 11.9 | 10.34 |
| Mean | 10.7 | 1.7* | 5.6 | 9.6 | 8.7 | |
| | Severity (percent rot by weight)[a] | | | | | |
| Sprayed[b] | 0.63 | 0.10 | 0.22 | 0.41 | 0.66 | 0.41* |
| Nonsprayed | 2.31 | 0.30 | 1.58 | 1.31 | 1.78 | 1.46 |
| Mean | 1.48 | 0.20* | 0.90 | 0.86 | 1.22 | |
| | Yield (tons per acre)[a] | | | | | |
| Sprayed[b] | 8.55 | 5.96 | 5.30 | 6.65 | 6.87 | 6.66 NS |
| Nonsprayed | 7.13 | 6.10 | 5.07 | 6.96 | 8.00 | 6.65 |
| Mean | 7.84 | 6.03* | 5.19* | 6.80 | 7.43 | |

[a] Results are expressed as an average of four replicates. Mean differences were determined with orthogonal contrasts. Figures followed by an asterisk denote a significant ($P<0.05$) effect from that treatment.

[b] Sprayed with iprodione at 2.3 kg/ha at bloom, preclose, and veraison.

**Monterey County, 1985.** Disease conditions in 1985 were more conducive for bunch rot development than in 1984. Planned orthogonal contrasts of data of canopy management treatments showed that leaf removal again resulted in a significant reduction in disease incidence (Table 2). Incidence of bunch rot in 1985 reached 50.9% in the nonmanaged control treatment. Disease was significantly reduced by 30.5% ($P<0.05$) in the leaf removal treatment and by only 6.0 and 5.2% in the shoot removal and hedging treatments, respectively.

Severity of bunch rot also was influenced by canopy management treatments (Table 2). Leaf removal and hedging were the only management treatments to significantly reduce rot severity. Bunches produced on control vines had an average of 12.30% rot per cluster, whereas bunches produced on leaf removal vines averaged only 2.27% rot per cluster ($P<0.01$). Shoot removal resulted in no significant reduction in severity, and hedging reduced bunch rot severity from 12.30 to 8.56% ($P<0.05$). Fungicide applications had no significant effect on reduction of bunch rot incidence in 1985. Yields in 1985 were significantly affected by shoot removal only, which reduced yields by 1.79 tons/acre ($P< 0.05$).

**Table 2.** Effects of canopy management practices and fungicide applications on incidence and severity of Botrytis bunch rot and yield on Chenin blanc in Monterey County in 1985

| | Incidence (percent diseased clusters)[a] | | | | |
|---|---|---|---|---|---|
| | Hedged | Leaf removal | Shoot removal | Control | Mean |
| Sprayed[b] | 44.1 | 16.9 | 47.0 | 46.8 | 38.7 NS |
| Nonsprayed | 47.4 | 23.9 | 42.9 | 55.0 | 42.3 |
| Mean | 45.7 | 20.4* | 44.9 | 50.9 | |
| | Severity (percent rot per cluster)[a] | | | | |
| Sprayed[b] | 8.05 | 1.69 | 11.30 | 9.30 | 7.58 NS |
| Nonsprayed | 9.08 | 2.85 | 10.20 | 15.30 | 9.35 |
| Mean | 8.56* | 2.27** | 10.70 | 12.30 | |
| | Yield (tons per acre)[a] | | | | |
| Sprayed[b] | 6.54 | 7.59 | 4.84 | 8.19 | 6.76 NS |
| Nonsprayed | 6.32 | 7.31 | 5.17 | 5.39 | 6.05 |
| Mean | 6.43 | 7.45 | 5.00* | 6.79 | |

[a] Results are expressed as an average of four replictes. Mean differences were determined with orthogonal contrasts. Figures followed by an asterisk denote a significant effect from that treatment at * = $P<0.05$ and ** = $P=<0.01$.

[b] Sprayed with iprodione at 2.3 kg/ha at bloom, preclose, and veraison.

**Napa County, 1985.** Leaf removal significantly reduced incidence and severity of bunch rot (Table 3). Orthogonal contrast analysis of the data indicated that disease incidence was significantly reduced from 30.52% in the control treatment to 6.17% when leaves were removed ($P<0.01$).

Leaf removal also significantly decreased disease severity. Data showed a reduction in severity from 3.80% rot per cluster in the control treatment to 0.31% rot per cluster in the leaf removal treatment ($P<0.01$).

Single fungicide applications at bloom and preclose resulted in no further significant reduction in disease incidence in the vines managed by leaf removal (Table 3). Similarly, fungicide applications at both bloom and preclose did not significantly reduce bunch rot incidence on leaf removal vines. Fungicide application on intact vines resulted in slightly better disease control only when applications were made at both bloom and preclose, resulting in a 5.46% reduction in bunch rot. Yields were not significantly reduced by any treatment.

**Table 3.** Effects of canopy management practices and fungicide applications on incidence and severity of Botrytis bunch rot and yield on Chenin blanc in Napa County in 1985

| | Timing of fungicide application[a] | | | | |
|---|---|---|---|---|---|
| | Control | Bloom | Preclose | Bloom + preclose | Mean |
| | | | Incidence (percent diseased clusters)[b] | | |
| Leaf removal | 6.17 | 7.08 | 4.00 | 5.07 | 5.58* |
| Leaves intact | 30.52 | 29.19 | 29.18 | 20.70 | 27.40 |
| Mean | 18.35 | 18.14 | 16.61 | 12.89 | NS |
| | | | Severity (percent rot per cluster)[b] | | |
| Leaf removal | 0.30 | 0.43 | 0.14 | 0.27 | 0.31* |
| Leaves intact | 3.36 | 5.14 | 3.65 | 3.06 | 3.80 |
| Mean | 1.87 | 2.78 | 1.89 | 1.66 | NS |
| | | | Yield (tons per acre)[b] | | |
| Leaf removal | 4.65 | 5.05 | 4.71 | 3.83 | 4.56 NS |
| Leaves intact | 5.80 | 5.20 | 5.40 | 5.36 | 5.44 |
| Mean | 5.23 | 5.13 | 5.06 | 4.60 | NS |

[a] Sprayed with benomyl 50W + captan 50W at 1.7 and 4.5 kg/ha, respectively.
[b] Results are expressed as an average of four replicates. Mean differences were determined with orthogonal contrasts. Figures followed by an asterisk denote a significant ($P<0.01$) effect from that treatment.

## DISCUSSION

In California, controlling Botrytis bunch rot of grape through the use of canopy management is a viable alternative to repeated fungicide applications. Data from field trials conducted in 1984 and 1985 on Chenin blanc showed that leaf removal resulted in excellent disease control even under conditions otherwise causing severe rot. Other treatments used in this study did not appear as promising as leaf removal. Late-season hedging currently is used in some areas of California to remove the lower canopy curtain to allow for increased airflow under and presumably through the canopy. The discrepancy in data obtained from both shoot removal and hedging between 1984 and 1985 can be explained partially on the basis of the stage of plant growth when these treatments were performed. In 1984, shoot removal was conducted near cluster set and resulted in less lateral shoot growth than in 1985, when shoots were removed prebloom. Hedging in 1984 was done at late bloom and resulted in an increase in lateral shoot development compared with 1985, when hedging was done at veraison. Based on 1984 results, shoot removal has potential for use in bunch rot control strategies. Although disease control was minimal when fungicides were not used, excellent control was achieved when fungicides were applied to vines in which shoots were removed at cluster set. The movable wire system was omitted from the 1985 trials because of its poor performance in disease control in 1984.

Savage and Sall (5) reported that midseason hedging was associated with slightly lower disease levels. Our results also showed that hedging offers only minimal disease control when done in midseason and offers no control when done in early season. This study further confirmed results of Savage and Sall (5) that hedging resulted in delayed maturity, thus making this type of canopy management questionable from a viticultural standpoint.

Yield loss from Botrytis bunch rot in California varies from year to year, influenced primarily by late summer and fall weather conditions. Wineries generally will accept up to 2% rot; however, bunch rot incidences greater than 2% may result in significant cullage, thus incurring increased harvesting costs and reduced quality or yield. Data obtained from these studies show that, even under conditions conducive for high rot incidence, rot severity was reduced to less than 3%, enabling growers to harvest all fruit produced.

Fungicides currently are used widely in California to control *B. cinerea* on grapes but generally become less effective as the grapevine matures because of heavy canopy growth and bunch closing. Usually, by the third fungicide application at or near veraison, it becomes virtually impossible to penetrate the canopy with enough volume to adequately protect the cluster targets. Preliminary spray efficiency data have shown that leaf removal does result in increased spray coverage within the canopy (W. D. Gubler and L. J. Bettiga, *unpublished*).

Results of fungicide timing trials also lead us to question the need for a fungicide application at bloom. Our data show no significant difference in disease control between single fungicide applications made at bloom or preclose, although McClellan and Hewitt (2) reported that applications at bloom were most effective. They based this on the ability of *B. cinerea* to infect immature grape berries via senescing flower parts resulting in latent infections. Savage and Sall (3), however, were unable to detect the presence of the fungus in the immature berries.

Fungicides alone do not provide adequate protection against *B. cinerea* during severe disease pressure. By integrating the cultural control practice of leaf removal with chemical control, we have shown that growers might eliminate at least two fungicide applications. One fungicide application at either bloom or preclose appears to afford adequate protection when used in conjunction with leaf removal.


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