# Black Rot Lesions on Overwintered Canes of *Euvitis* Supply Conidia of *Guignardia bidwellii* for Primary Inoculum in Spring

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## ABSTRACT

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Black rot lesions, caused by *Guignardia bidwellii*, on overwintered canes of *Euvitis* grapevines released >8,000 conidia per lesion at budbreak in laboratory assays during 1990 and 1991; numbers declined during the growing season. Approximately 1,000 conidia per lesion were detected near harvest. During 1992, 250 and 900 conidia per lesion were detected from Aurore and Delaware canes, respectively, and no conidia were detected after 14 June, just before bloom. Significantly higher levels of black rot occurred on the foliage beneath individual, tagged lesions on overwintered canes than occurred on foliage growing beneath canes with no lesions. Significantly higher levels of black rot also occurred on vines suspended beneath bundles of 1-year-old canes with lesions, compared with vines without bundles. The level of black rot that developed beneath bundles of dead, 2-year-old canes with lesions was not significantly different from that beneath 1-year-old canes during a season with above average rainfall. Since lesions on dead, 2-year-old canes can be a source of inoculum, mechanically pruned grapevines, which are nonselectively pruned and retain debris in the trellis, may be at increased risk of black rot from this source of inoculum. Lesions on overwintered canes may be a more important inoculum source than mummies in hand-pruned vineyards, because conidia were released earlier, compared with mummies in the canopy, and the selective process of hand pruning usually removes mummies from the canopy. Lesions on 1-year-old canes are likely to be sources of inoculum in vineyards regardless of whether grapevines are pruned selectively by hand or nonselectively by machine.

Additional keywords: epidemiology, *Vitis*

Black rot, caused by *Guignardia bidwellii* (Ellis) Viala & Ravaz, causes significant yield losses to *Vitis* in the Eastern United States. In the subgenus *Euvitis* (*Vitis vinifera* L., *V. labruscana* L. H. Bailey, and *Vitis* interspecific hybrids), ascospores of *G. bidwellii* from overwintered mummies are the major source of primary inoculum (4,18). Ascospores have been detected within 1-year-old black rot mummies that overwintered on the ground, from just after budbreak until 1 to 2 month after bloom (4,18). In addition, conidia (*Phyllosticta ampelicida* (Englem.) van der Aa) have been detected within overwintered mummies (5,18,19), and within lesions on overwintered petioles, tendrils, and canes (7,11,15,17,18,19,21) but their significance as primary inoculum has not been documented. Conidia from black rot lesions on overwintered canes, and ascospores, from leaves that were infected with *G. bidwellii* the previous season, are considered important sources of primary inoculum for grape cultivars of the subgenus *Muscadinia* (*V. rotundifolia* Michx.) (2,10, 14). Vineyards in the northeastern United States consist exclusively of cultivars of *Euvitis*, so ascospores of *G. bidwellii* from overwintered mummies have been assumed to be the main source of primary inoculum (4).

Some eastern vineyardists are shifting from pruning vines by hand to hedging vines using tractor mounted cutting bars (9,13). Mechanical hedging is a nonselective pruning practice that retains debris, which may serve as inoculum for initiating diseases of grapevine, such as Phomopsis cane and leaf spot (16). Following mechanical hedging, canes with black rot lesions may also be retained within the canopy. Canes with black rot lesions can also remain within the canopy following hand pruning; however, fewer canes remain following hand pruning, compared with vines pruned mechanically. The objectives of this study were to quantify conidia within black rot lesions on overwintered canes and to determine if they can serve as a primary inoculum source. A preliminary report has been published (1).

## MATERIALS AND METHODS

**Inoculum from lesions on canes.** Grapevine canes with black rot lesions from the previous growing seasons were collected in February or March 1990, 1991, and 1992, from canes of the *Vitis* interspecific hybrid Aurore from Dresden, N.Y., and during 1992 from canes of *V. labruscana* Delaware from Naples, N.Y. Canes with lesions were suspended within a grapevine trellis system at Dresden, N.Y., during 1990, 1991, and 1992. Each year, 15 canes with black rot lesions were selected arbitrarily on five to seven dates from budbreak until harvest. Individual lesions plus 1 to 2 mm of the surrounding healthy-appearing tissue were excised from each cane and placed into a 1.5-ml microfuge tube with 1 ml of distilled water. Each lesion was removed after 2 h, and the tubes were spun on a microfuge for 7 min. The solution was discarded, and the pellet was suspended in the remaining ~100 μl of water by shaking the tube vigorously on an orbital shaker for 10 to 20 s. The resuspended pellet was then placed on a microscope slide, covered with a coverslip, and the total number of conidia of *G. bidwellii* was counted. Mean conidia per lesion per date and standard error of the mean were determined using Minitab 7.1 (Minitab, Inc., State College, Pa.).

For comparison with the availability of inoculum from mummies, 60 mummies were collected from the ground at weekly intervals from the Aurore vineyard at Dresden, NY, during 1990, 1991, and 1992, beginning at budbreak. Three subsamples of 20 mummies from each collection were soaked in water for 2 h, and the number of ascospores and conidia released per mummy was determined.

**Development of black rot in association with lesions on canes.** Prior to budbreak in 1990, 1991, and 1992, bundles of 20 to 25 1-year-old, 3- to 5-node Aurore canes with black rot lesions were collected from Dresden, NY. In 1992, similar-sized bundles of 1-year-old Delaware canes were collected from Naples, N.Y. Each year four bundles were suspended above *V. labruscana* Concord vines at Fredonia, N.Y. No black rot symptoms had been observed on the Concord vines for at least 5 years. In 1991 and 1992, the bundles from the previous season treatments (referred to as 2-year-old canes) were relocated over different Concord vines, which had been free of black rot. Between veraison and harvest during the growing season, incidence and severity (percent cluster area with black rot) of black rot on 50 clusters was recorded and the number of black rot lesions per leaf was recorded by node position on 10 shoots growing beneath each bundle of canes. Vines without bundles of canes served as controls. No fungicides were

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applied during the growing season. Incidence and severity data were subjected to analysis of variance, and mean separation was determined using the Waller-Duncan *k*-ratio *t* test in SAS (SAS Institute Inc., Cary, N.C.).

Prior to budbreak in 1990 and 1991, individual black rot lesions on 1-year-old Aurore canes were tagged on 20 vines at Dresden, N.Y. No fungicides were applied during the growing season. The incidence and severity of black rot on the basal 15 leaves of a single shoot growing beneath each tagged lesion was recorded. Similar data were collected from the same vine, from leaves on different shoots beneath 1-year-old canes without visible black rot lesions, as well as from the foliage of shoots growing above the top trellis wire. For statistical analysis of data, individual vines were considered as blocks, with the three treatments randomized on individual canes. Incidence and severity data per year were subjected to analysis of variance, and mean separation was determined using the Waller-Duncan *k*-ratio *t* test in SAS (SAS Institute Inc., Cary, N.C.).

**Environmental monitoring.** For comparison of symptom development with environmental conditions, black rot infection periods (20) were determined and amount of rainfall was recorded during each growing season at Fredonia and Dresden, N.Y.

Temperature, hours of leaf wetness, and rainfall amount and duration were recorded within the vineyard at Dresden, N.Y., using a CR 21 datalogger equipped with 107 temperature probe, 237 wetness sensing grid, and TE525 tipping bucket rain gauge (Campbell Scientific, Inc., Logan, Utah). At Fredonia, environmental data were recorded using an Pestcaster Weather Station (Neogen Inc., Lansing, Mich.) that was 90 m from the experimental site.

## RESULTS

**Inoculum from lesions on canes.** Prior to budbreak in 1990 and 1991, lesions that were soaked in water for 2 h released over 8,000 conidia per lesion (Fig. 1). Fewer conidia were detected from each successive sample as the season progressed, but approximately 1,700 conidia per lesion were still detected near harvest. During 1992, 250 and 900 conidia per lesion were detected at budbreak from Delaware and Aurore canes, respectively, and no conidia were detected from lesions after mid-June. Budbreak was on 27 April, 2 May, and 6 May, in 1990, 1991, and 1992, respectively, and the first black rot lesions were observed on foliage on 29 May, 30 May, and 8 June, respectively.

From mummies collected from the ground, 0 to 5,500 ascospores of *G. bidwellii* per mummy were detected from 23 April until 14 May during 1990, whereas 875,000 ascospores were detected on 18 May. During 1991, <1,100 ascospores per mummy were detected from 24 April until 13 May, whereas 21,500 ascospores were detected on 20 May. Less than 4,500 conidia per mummy were detected in assays through 20 May 1991. During 1992, <200 ascospores per mummy were detected only on 11 May from weekly collections that began on 30 April, with >500,000 ascospores detected on 27 May. Between 30 April and 19 May 1992, 2,500 to 4,700 conidia per mummy were detected.

**Development of black rot in association with lesions on canes.** During each season, black rot lesions on clusters and foliage were significantly higher beneath bundles of 1-year-old canes with lesions, compared with the control vines (Table 1). The incidence and severity of black rot on the foliage and clusters beneath 2-year-old canes with lesions were not significantly different ($P = 0.01$), from control vines in 1991. In 1992, disease incidence and severity beneath bundles of 2-year-old canes with lesions was significantly greater ($P = 0.05$) on clusters, but not on foliage when compared with control vines.

The incidence and severity of black rot on foliage was significantly greater beneath 1-year-old canes that had been tagged with black rot lesions, compared with foliage beneath canes without lesions or on foliage that was above the top trellis wire (Table 2). Increased levels of black rot were especially evident on the basal leaves beneath individual, tagged lesions. The number of black rot infection periods and total rainfall per month was higher in 1990 than in 1991 and appeared to correlate with higher levels of black rot (Table 2).

## DISCUSSION

In New York, black rot lesions of canes of *Euvitis* consistently supplied conidia

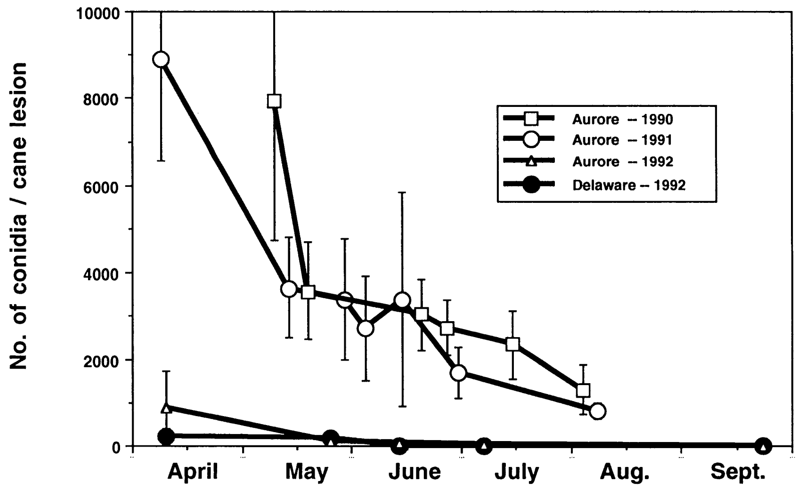


**Fig 1.** Laboratory assays of conidia released from lesions overwintered on canes. Data are mean number of conidia per lesion following a 2-h soaking in water for 15 lesions on each sample date. Bars indicate standard errors of the mean. Budbreak occurred on 27 April, 2 May, and 6 May, bloom occurred on 25 June, 3 June, and 16 June, and veraison occurred on 10 August, 18 July, and 12 August during 1990, 1991, and 1992, respectively.

**Table 1.** Development of black rot on Concord clusters growing beneath bundles of canes bearing black rot lesions, at Fredonia, NY

| Cultivar of canes | Year bundles collected | 1990[t] | | 1991[u] | | 1992[v] | |
|---|---|---|---|---|---|---|---|
| | | Incidence[w] | Severity[x] | Incidence | Severity | Incidence | Severity |
| Aurore | 1990 | 55.6 a[y] | 6.5 a | 1.0 b | 0.02 b | 12.0 c | 1.3 c |
| Aurore | 1991 | ...[z] | ... | 72.0 a | 7.1 a | 48.0 b | 10.5 b |
| Aurore | 1992 | ... | ... | ... | ... | 50.7 b | 7.7 b |
| Delaware | 1992 | ... | ... | ... | ... | 89.3 a | 33.3 a |
| Control | | 2.5 b | 0.1 b | 0.0 b | 0.0 b | 8.0 c | 1.1 c |

[t] Cluster data are means from observations on 2 August, 14 September, and 1 October, 1990. Foliar observations conducted on 2 August 1990. During May, June and July, there were 1, 3, and 5 black rot infection periods (20) and 125, 87, and 120 cm of rain, respectively.
[u] Cluster data were collected on 24 July 1991. During May, June and July, there were 2, 1, and 4 black rot infection periods and 52, 33, and 85 cm of rain, respectively.
[v] Cluster data were collected on 5 August, 1992. During May, June and July, there were 4, 3, and 9 black rot infection periods and 61, 77, and 164 cm of rain, respectively.
[w] Percentage of clusters with black rot.
[x] Percentage of cluster area with black rot.
[y] Numbers followed by the same letters do not differ significantly at $P = 0.05$ according to the Waller-Duncan *k*-ratio *t* test.
[z] Not applicable.

prior to or at budbreak, whereas, ascospores in overwintered mummies were generally not detected until 2 or 3 weeks after budbreak. Individual lesions on canes released a maximum of 9,000 conidia per lesion, yet mummies soaked in water released 25,000 to >100,000 ascospores and/or conidia per mummy (C. M. Becker, *unpublished data*). However, conidia from cane lesions were available as susceptible tissues unfolded from buds, and can be rain-splashed to nearby tissue. *Guignardia bidwellii*-infected tissues can form pycnidia quickly and produce conidia that serve as secondary inoculum during the season (5,21). Therefore, lesions on canes should not be overlooked as sources of inoculum because conidia produced in them probably initiate infections earlier in the season than inoculum from mummies.

That conidia of *G. bidwellii* were detected within overwintered lesions of *Euvitis* verified early speculations about the importance of black rot lesions on canes of the subgenus *Euvitis* (7,11,17,18), and parallelled observations of the subgenus *Muscadinia*, in which cane lesions are considered an important source of initial inoculum (2,10,12,15). Black rot lesions appear to develop similarly on shoots of *Euvitis* and *Muscadinia,* with pycnidia liberating conidia during the rains during the season in which they were infected.

Our strongest evidence of the importance of conidial release from lesions on canes was during 1991; that year conidia were detected at budbreak from lesions on canes on 2 May 1991, whereas high numbers of ascospores from mummies were first detected on 20 May. An infection period for black rot was recorded on 17 May, with the first foliar lesions observed on 30 May. Since the average temperature from 20 to 30 May was too low for lesion formation if ascospores from mummies were the source of inoculum (21), then the conidia released on 17 May were the probable source of inoculum.

Our observations indicate that the severity of black rot that develops beneath cane lesions is more dependent on the number of infection periods than on the amount of primary inoculum produced in each lesion. Nine times fewer conidia per lesion were detected at the beginning of the 1992 growing season than at the beginning of the 1990 or 1991 growing seasons. However, despite the fewer conidia detected per lesion in 1992, substantial crop loss occurred beneath bundles of canes with lesions following the more numerous black rot infection periods, which accompanied above-average rainfall. Contrasting conditions occurred in 1991; a higher number of conidia were detected per lesion at budbreak, yet an insignificant amount of black rot developed during the drier-than-normal season. Even though few conidia per cane lesion were detected in 1992, black rot infections that developed on basal leaves early in the season probably had substantial influence in the buildup of disease. Number of conidia trapped in rain water below early infected leaves were many magnitudes higher than the number of ascospores trapped from air (4).

The potential for numerous infection periods to allow buildup of black rot from a relatively low amount of inoculum was also demonstrated by the development of black rot beneath 2-year-old black rot lesions on canes. The level of black rot that developed beneath 2-year-old canes with lesions during the wet season of 1992 was not significantly different from that of canes with 1-year-old lesions, whereas in the dry season (1991) the level of black rot was not significantly different from that on control vines.

Pruning vines by hand, pulling brush, and tying canes to the trellis wire are labor-intensive practices and their combination is the most expensive portion of the variable costs of operating a vineyard (8). Some vineyardists have adopted mechanical hedging practices to reduce the time required to prune the vines, but the resultant canopy retains several years of cane growth, including black rot lesions and mummies, and may be more difficult to penetrate with pesticides. Results from our studies show that significant crop loss can occur when canes are the primary source of inoculum. Therefore, removal of canes should reduce the primary inoculum and ultimately the severity of black rot. Removal of canes during normal hand pruning or during a follow-up to machine pruning can be very time consuming since cane lesions may be difficult to identify. In addition, removal of canes with lesions may be undesirable when lesions occur at the base of canes that are needed for optimal cropping levels.

Our study identifies conidia as an important source of primary inoculum for black rot. These data indicate that tissues should be protected with fungicides beginning at budbreak. Tissues infected at or shortly after budbreak include basal internodes that are likely to be retained the following season and basal leaves that will provide secondary inoculum throughout the season for infection of nearby clusters. Removal of canes with lesions may reduce the source of inoculum; however, this practice alone will probably not result in satisfactory control. The application of fungicides with efficacy against *G. bidwellii* on a protective or postinfection schedule (3,6,21) is likely to provide the best control of black rot.

**Table 2.** Incidence and severity of black rot on Aurore foliage in relation to black rot lesions on canes from the previous season at Dresden, NY[u]

| | 9 July 1990[v] | | 16 July 1991[w] | |
|---|---|---|---|---|
| **Location of observations** | **Incidence[x]** | **Severity[y]** | **Incidence[x]** | **Severity[y]** |
| Under canes w/ lesions | 41.8 a[z] | 1.73 a | 21.5 a | 0.87 a |
| Under canes w/ no lesions | 31.3 b | 0.96 b | 11.7 b | 0.27 b |
| Above uppermost canes | 21.0 c | 0.61 c | 13.7 b | 0.33 b |

[u] Numbers represent means of 15 basal leaves from one shoot on each of 20 vines.
[v] During May, June and July there were 1, 6, and 7 black rot infection period (20) and 148, 22, and 112 cm of rain, respectively.
[w] During May, June and July there were 2, 0, and 6 black rot infection periods and 36, 27 and 82 cm of rain, respectively.
[x] Percentage of leaves with black rot.
[y] Number of black rot lesions per leaf.
[z] Numbers within each column followed by the same letter do not differ significantly at $P = 0.05$, according to the Waller-Duncan $k$-ratio $t$ test.


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