

Cankers Caused by *Botryodiplodia gallae* Associated with Oak Sprout Mortality in Michigan

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ABSTRACT

Croghan, C. F., and Robbins, K. 1986. Cankers caused by *Botryodiplodia gallae* associated with oak sprout mortality in Michigan. *Plant Disease* 70: 76-77.

Botryodiplodia gallae was confirmed by wound inoculation as the cause of a canker disease that contributes to poor sprout survival after clear-cutting oak stands (*Quercus alba*, *Q. velutina*, *Q. ellipsoidalis*, and occasionally, *Q. rubra*) in the Huron-Manistee National Forest in Michigan. There was no significant difference in the number of cankers per stem between white and red oak groups.

Oak reestablishment after clear-cutting mature oak stands in the Huron-Manistee National Forest in the lower peninsula of Michigan usually results from naturally regenerated oak seedlings and stump sprouts. Between 1960 and 1981, 693 stands comprising about 10,400 ha were cut with this regeneration objective. Regeneration success was poor, however, especially for stands with site indexes lower than 56 (site index = average tree height in feet at age 50). We examined a number of these sites in 1981 and found a high incidence of perennial stem cankers on oak sprouts (Fig. 1). Indications of disease were dead and dying twigs and branches on the upper part of the sprout (Fig. 2). Main stems were often girdled by multiple cankers.

In August 1982, we conducted a survey of oak stands cut since 1960 to determine the distribution, incidence, and cause of these cankers.

MATERIALS AND METHODS

Fifty-four randomly selected oak stands (8% of total clear-cut since 1960) were surveyed. Sampling intensity was based on stand area, with each sample consisting of all oak sprouts growing from a single stump, i.e., a sprout clump: <20 ha, three sprout clumps; 20-40 ha, four clumps; 41-61 ha, five clumps; and >61 ha, six clumps. The first sample clump was located 60 m from the edge of the stand on a line diagonally crossing the stand. The remaining sample clumps were located at 40-m intervals along the same line.

Accepted for publication 5 September 1985.

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The species of oak, number of stem cankers, and condition of each sprout (living, dead, or top dead) were recorded for each sample clump. Stands with an average of at least one canker per sprout were classified as severely affected. Sprouts were classified as healthy if they had no cankers or top dieback. The presence of other pests was also recorded.

Representative cankers were selected for laboratory isolations. Cankers were surface-sterilized with flame, and isolations were made on potato-dextrose agar (PDA). Cultures were incubated in ambient room conditions.

The fungus isolated most frequently from cankers, identified as *Botryodiplodia gallae* (Schw.) Petrak & Sydow., was tested for pathogenicity using pure

cultures grown on PDA. Two sprouts 3.8-9 cm in diameter from each of four clumps of northern pin oak (*Quercus ellipsoidalis* E. J. Hill) in a 12-yr-old clear-cut stand on the Huron-Manistee National Forest were inoculated in May 1984. A sterile, 8-mm-diameter cork borer was used to make a hole in the bark of the main stem 1.5 m above ground level. The bark was removed and an 8-mm disk of agar and mycelium cut from an actively growing culture of *B. gallae* was placed in the wound with the hyphal side facing into the stem. The bark plug was replaced over the agar disk, and the stem was wrapped with Parafilm. One sprout in each of the four clumps was similarly wounded and wrapped, but a sterile agar disk was placed in the wound as a control.

RESULTS

Stem cankers were a major cause of oak sprout mortality, but dieback of noncankered sprouts was also present (Table 1). Cankers were found on oak sprouts in all seven districts of the Huron-Manistee National Forest and in all but five of the 54 surveyed stands. Eleven stands (20.4%) were severely affected



Fig. 1. *Botryodiplodia* canker on oak stump sprout.



Fig. 2. Dieback of oak stump sprouts infected with *Botryodiplodia gallae*.

(average at least one canker per sprout). One-third of all sprouts examined had one or more cankers. Eight percent of the sampled clumps (14 of 182) had no remaining healthy sprouts. Grouping the results by site index class (42–49, 50–56, or >56) indicated a trend toward a greater percentage of cankered sprouts in stands with low site indexes. This trend is also reflected in the high average number of cankers per sprout (0.96) in stands with low site indexes. Cankers were found on white oak (*Q. alba* L.), black oak (*Q. velutina* Lam.), northern pin oak, and occasionally, northern red oak (*Q. rubra* L.). There was no significant difference in the number of cankers per stem between the white and red oak groups (Student's *t* test, *P* = 0.01).

Cankers were typically elliptical, sunken areas of dead tissue often centered at a dead twig or branch. Bark frequently adhered to the face of the canker. The sapwood beneath the diseased bark was stained brown, and discoloration extended vertically beyond the margins of the canker. Cankers began as dark brown, slightly sunken areas in the bark. After the bark died, erumpent black pycnidia developed in it. Cankers became more pronounced and sunken as callus ridges developed during subsequent growing seasons.

The fungus most commonly associated with these cankers was *B. gallae*, which was recovered from 11 of 26 cankers (42%). Pycnidia located in clusters of black erumpent stromata measuring 300–700 μm were found on the faces of cankers. Pycnidia on cankers contained immature, single-celled, hyaline oval conidia or two-celled, dark conidia (12–17 × 18–25 μm). Similarly, pycnidial conidia that formed in culture were initially single-celled and hyaline but later became dark and developed a single septum.

Sprouts were examined for canker formation 1 yr after inoculation with *B. gallae*. Each inoculated sprout had a canker at the point of the wound. Wounds on control sprouts were completely closed. Cankers were 1.7–4 cm long × 0.8–2 cm wide with a mean of 2.8 × 1.3 cm. *B. gallae* was recovered from all inoculated sprouts and was not isolated from any control sprouts.

Several other fungi were associated with cankers and dieback. Fruiting bodies of *Coryneum kunzei* Corda and *Cytospora* Ehrenb. ex Fr. were frequently found on sprouts that had died back from cankers or other causes. In some sprout clumps, *Armillaria mellea* (Vahl ex Fr.) Kummer had grown from the stump into the bases of several sprouts, but whether this occurred before or after the sprout died was not known.

DISCUSSION

Other investigators have described oak

Table 1. Oak sprout canker incidence by site class, Huron-Manistee National Forest, Michigan, August 1982

Site index ^a class	No. of stands sampled	No. of stands with ≥ one canker per sprout	No. of sprouts sampled	No. of sprouts with dieback and no canker	No. of cankered sprouts	Cankers per sprout (± SD)
42–49	6	3	177	24 (14) ^b	89 (50)	0.96 ± 0.87
50–56	38	7	1,923	332 (17)	581 (30)	0.45 ± 0.52
>57	10	1	318	78 (24)	110 (35)	0.38 ± 0.42
Total	54	11	2,418	434 (18)	780 (32)	...

^aSite index is average tree height in feet at age 50.

^bFigures in parentheses are percentages.

cankers caused by similar fungi or possibly the same fungus (1–5, 7, 8, 10, 11, 13). All of these studies report cankers on twigs and branches of forest and shade trees, not on stump sprouts. Schmidt and Fergus (10) gave an excellent discussion of this literature but were unable to determine which if any of the earlier references describe the fungus with which they worked. They concluded that the fungus they isolated from dieback and cankers on chestnut oak (*Q. prinus* L.) was an unnamed species of *Botryodiplodia*. On the basis of synonyms for *B. gallae*, only Boyd (2) and Marshall (7), who cited *Sphaeropsis quercina* Cke. & Ell. as the cause of a twig canker on red oak, chestnut oak, and water oak (*Q. nigra* L.), reported the same organism that we found in Michigan. Their reports did not confirm the pathogenicity of this fungus.

Our results indicated that girdling by *B. gallae* is a major cause of death of oak sprouts on the Huron-Manistee National Forest. Marshall (7) reported *S. quercina* and other canker-causing species of *Sphaeropsis* to be mostly confined to stressed trees. Stress can be caused by many factors. Likely candidates in this case are repeated frost injury and poor sites, but these factors do not explain the entire problem. There was no evidence of frost injury in many stands, and 77% of the stands with site indexes < 57 were not severely affected by the cankers.

The goal of stump sprout management is to obtain one or two crop trees per stump by rotation age. The number of sprouts per stump decreases with increased time since cutting for all species. The loss of stump sprouts is expected and necessary if marketable crop trees are desired. However, the average number of remaining healthy sprouts per stump was lower than reported for oak in other areas. We found an average of 2.5 healthy sprouts on stumps cut 10 yr earlier, whereas Wendel (12) found four sprouts on white and seven sprouts on red oak stumps and Johnson (6) found five red oak sprouts per stump. These data suggest that sprout mortality was greater in the survey area than in healthy stands and may result in understocked stands.

Because most stands lack an adequate

number of established seedlings to ensure a fully stocked stand of oak in the future (9), the Huron-Manistee National Forest relies on oak stump sprouts as a major component of natural regeneration. Many of the clear-cut stands where cankers limit oak stump sprout survival have converted to dense sod, brush, and noncommercial species of cherry (*Prunus* spp.). To cope with this problem, the USDA Forest Service has begun a 20-yr study to determine effective methods of naturally and artificially regenerating oak on poor and medium sites in the Forest.

ACKNOWLEDGMENTS

We thank C. J. K. Wang, College of Environmental Science and Forestry, State University of New York, Syracuse, and B. C. Sutton, Commonwealth Mycological Institute, Kew, Surrey, UK, for identifying isolates of *Botryodiplodia gallae*.

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