Basal Cankers and Coppice Failure of *Eucalyptus grandis* in Florida

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ABSTRACT

Barnard, E. L., Geary, T., English, J. T., and Gilly, S. P. 1987. Basal cankers and coppice failure of *Eucalyptus grandis* in Florida. Plant Disease 71: 358-361.

The relationship of basal cankers to coppice failure in a *Eucalyptus grandis* plantation in southern Florida was investigated. Canker incidence increased from about 15 to 57% over 4 yr. *Cryphonectria cubensis* and *Botryosphaeria dothidea* were isolated frequently from bark samples removed from cankered trees and stumps. After a February harvest at age 13, 44% of residual stumps failed to generate coppice shoots, or they initiated new shoots that soon died. Incidence of coppice failure was not significantly correlated to the presence or severity of basal cankers, but stumps of cankered trees had significantly fewer coppice-bursting centers. Dead coppice shoots on 99 of 100 randomly selected stumps supported pycnidia and/or perithecia of *C. cubensis* at their bases 18 mo after harvest. Dead coppice shoots on 50 of the same 100 stumps supported pycnidial stromata characteristic of those described for *C. gyrosa*, a species not previously reported in Florida.

Eucalyptus plantations managed on short rotations are regenerated by coppicing. In southern Florida, the percentage of stumps of *Eucalyptus grandis* Hill ex Maid. that coppice is often insufficient to produce a well-stocked stand. On some stumps, no coppice shoots develop; on others, shoots grow for a few months and then die. Coppice failure is worst after summer harvest (9,20).

The fungus *Cryphonectria cubensis* (Bruner) Hodges (= *Diaporthe cubensis* Bruner) causes basal cankers on *E. grandis* in Florida (12). The effects of the cankers on stand productivity in Florida are unknown, but cankers rarely, if ever, kill trees. However, basal cankers have killed 30 and 50% of stems in plantations of *Eucalyptus* spp. in Brazil and Surinam, respectively, and have reduced coppicing substantially (4,13,14).

We have suspected that *C. cubensis* was a cause of some, if not all, coppice failure of *E. grandis* in Florida (Fig. 1). Therefore, we surveyed for basal cankers in an 11-yr-old *E. grandis* plantation that had been studied earlier by Hodges et al (12), isolated from cankered tissues to identify associated fungi, and evaluated coppice regeneration in the plantation after it was harvested at age 13. Preliminary observations from the canker survey have been reported (1).

MATERIALS AND METHODS

Survey. The study plantation was located in Glades County in south central Florida and was about 4 ha (10 acres). Every third tree in every sixth row of the plantation was evaluated in 1980 for the presence and severity of basal cankers. Severity classes were based on the percentage of stem circumference cankered: <25% = class I, 25–50% = class II, and >50% = class III sensu Hodges and Reis (13). The resulting 166 sample trees (about 6% of the trees) were marked with aluminum tags nailed to prominent lateral roots. Tissue samples were collected for culturing from cankers on

Contribution 591, Bureau of Plant Pathology.

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Accepted for publication 17 October 1986.

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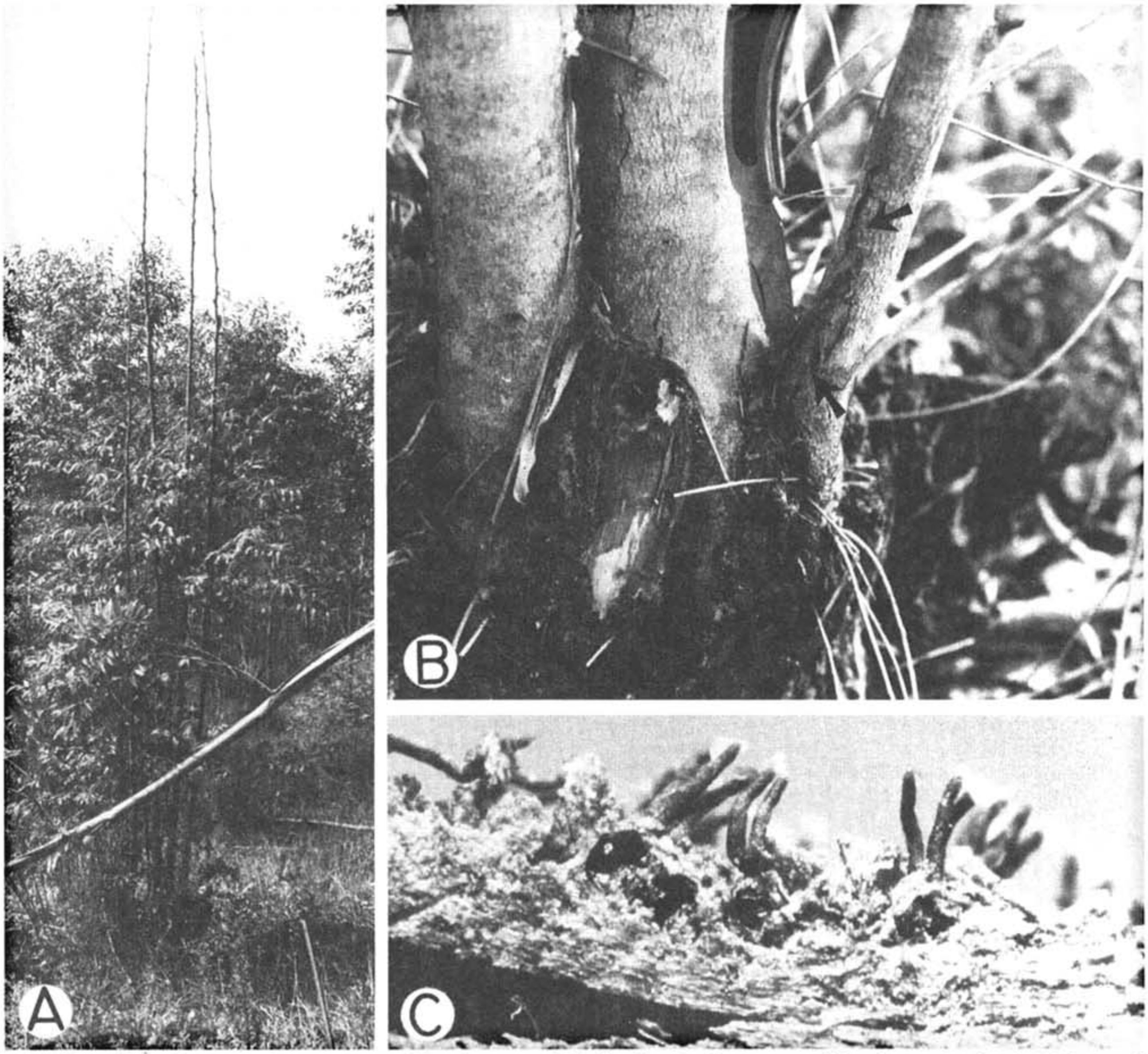

Fig. 1. Failure of 2-yr-old coppice shoots on stump of *Eucalyptus grandis* in Florida related to presence of *Cryphonectria cubensis*. **(A)** Stump with dying coppice shoots. **(B)** Bark fissuring (arrows) and cankers at bases of dying shoots. **(C)** Perithecia of *C. cubensis* embedded in and protruding from bark removed from cankered tissues.

21 sample trees and six stumps of trees that had been felled several months earlier.

Harvesting and coppice evaluation. The plantation was harvested in early February 1982. Half of the trees were felled with a hydraulically operated chainsaw mounted on a buncher-feller, and half were felled with conventional hydraulic shears. The harvesting machines were used alternately as rows of trees were progressively felled. In late July, each tagged stump was evaluated for the presence and condition of coppice shoots, the number of coppice-bursting centers present (i.e., the number of points or loci producing coppice shoots), and the degree of mechanical bark damage resulting from the harvesting operation(s). One year later, 100 randomly selected stumps with dead coppice shoots were examined for signs of associated fungi. Relationships among factors evaluated on the 166 sample stumps were examined by chi-square tests, analyses of variance and covariance, and correlation matrices.

Table 1. Effect of basal cankers on coppice regeneration of *Eucalyptus grandis* in a south central Florida plantation 5.5 mo after harvest

	Treatments					
	Canker class[w,x]				Canker presence[y]	
Variable	0	I	II	III	(−)	(+)
Number of stumps	71	52	21	22	71	95
Number of bursting centers per stump	4.1	2.3	3.4	3.4	4.1 a[z]	2.8 b
Percent stumps with live coppice	56	42	57	45	56 a	46 a

[w] Class I = <25%, class II = 25–50%, and class III = >50% of stem circumference cankered, respectively (13).

[x] ANOVA failed to yield significant F values for treatment differences at $P \leqslant 0.05$.

[y] Canker classes I, II, and III pooled for analysis.

[z] Numbers within a row followed by different letters are significantly different at $P \leqslant 0.05$ (ANOVA).

RESULTS

Fifty-seven percent of the stems surveyed in 1980 had basal cankers typical of those resulting from infection by *C. cubensis* (12–14). Fifty-five percent of the cankers were class I, 22% were class II, and 23% were class III (Table 1). *C. cubensis* was isolated from 71% of the cankers sampled on living trees and from

50% of the cankers on stumps. *Botryosphaeria dothidea* (Moug. ex Fr.) Ces. & de Not. (= *B. ribis* Grossenb. & Dugg.) was isolated from 52% of the tree cankers and from 33% of the stump cankers. Both fungi were commonly isolated from the same canker. A *Diplodia* sp. was isolated from one stump.

By late July 1982, 5.5 mo after the February harvest, 75% of the stumps had coppiced, but on 33% of those stumps, the coppice was dead or dying. Survival or death of shoots on a stump was absolute—either all shoots were living or all were dead or dying. The mean height of the tallest living shoot per stump was 135 cm, and that of the tallest dead or dying shoot was 35 cm. Sheared stumps had 23% of the bark circumference damaged (usually a tearing of bark away from the wood), whereas sawn stumps had 28% bark damage. The difference in bark damage between harvesting tools was not statistically significant, nor was the difference in coppicing success between tools: 46% of sheared stumps and 54% of sawn stumps bore living coppice. All stumps were pooled for subsequent analyses. Neither the presence of cankers nor the severity of cankering was correlated to coppicing success (i.e., successful establishment of at least one coppice shoot on a stump). However, stumps with cankers had significantly fewer bursting centers (Table 1).

Pycnidia and/or perithecia of *C. cubensis* were detected at the basis of dead coppice shoots on 99 of the 100 stumps examined 18 mo after harvest. In addition, pycnidial stromata of an *Endothia*-like fungus that we have identified as *C. gyrosa* (Berk. & Br.) Sacc. were detected at the bases of dead coppice shoots on 50 of the 100 stumps.

DISCUSSION

Canker incidence in the study plantation increased from about 15% in 1976 (12) to 57% in 1980. This level of incidence may be exceptional in southern Florida. Recent surveys in five other plantations of *E. grandis* revealed fewer than 1% of the trees with basal cankers (7,16).

Considerable disagreement exists in the literature regarding the taxonomy of *C. gyrosa*, *Endothia havanensis* Bruner (5), and *E. tropicalis* Shear & Stevens. Kobayashi (15) considered *E. havanensis* and *E. tropicalis* synonymous. Barr (2) and Roane (18) both recognize the synonymy of *C. gyrosa* and *E. tropicalis* but maintain *E. havanensis* as a separate species. However, the descriptions of *C. gyrosa* (*E. tropicalis*) provided by these workers differ widely. Barr (2) lists the dimensions of asci, ascospores, and conidia for this organism as 21–26 × 5–6, 3.5–7 × 2–2.5, and 2.5–3.5 × 1.5–2.5 μm, respectively, whereas Roane (18) lists 40–55 × 5.5–8.5, 7.5–12.5 × 3.5–5, and 3.5–7 × 1.5–2.5 μm, respectively, as representative of the species. According to Barr (2), the ascospores and conidia of *E. havanensis* are larger than those of *C. gyrosa* (*E. tropicalis*), whereas according to Roane (18), the reverse is true. Hodges (10) suggests that the dimensions listed for ascospores of *C. gyrosa* (*E. tropicalis*) by Barr (2) may have been in error and points out that the original description of *Diatrype gyrosa* Berk. & Br. (3) (*C. gyrosa*) includes ascospore measurements (7.5–10 × 3.75–5 μm) "almost identical to dimensions given for *Endothia tropicalis* Shear & Stevens (7.5–10 × 3.5–5 μm) by Shear *et al.*" (19). Hodges (10) agrees with Barr (2) and Roane (18) regarding the conspecificity of *E. tropicalis* and *C. gyrosa*; however, he goes on to state (10) that "ascospore dimensions for *E. havanensis* given in the original description were 7.47–9.54 × 2.92–4.15 μm, only slightly smaller than those for *C. gyrosa*" and that comparisons he had made of *E. tropicalis* specimens from Sri Lanka with the type of *E. havanensis* "showed them to be almost identical" and "therefore, *E. havanensis* must be considered a synonym of *C. gyrosa*," thus agreeing with Kobayashi's (15) earlier suggestion of synonymy.

In light of the above and the apparent logic of arguments presented by Hodges (10), we have opted to call the *Endothia*-like fungus we found at the bases of dead coppice shoots *C. gyrosa*. Our identification of *C. gyrosa* is based on 1) the subsequent finding of associated perithecia in the field on both *E. grandis* and *E. robusta*, 2) morphological comparisons of the teleomorph and anamorph with those of *C. cubensis*, 3) microscopic comparisons of conidia produced in culture from ascospore isolates of both fungi, and 4) agreement of our observations with descriptions provided by Hodges (10) (Table 2). This paper represents the first published report of this organism in Florida. However, a similar fungus has been observed previously in association with bark fissuring and/or localized branch and stem cankers on *E. camaldulensis* Dehorh., *E. grandis*, and *E. robusta* Sm. in the Tampa Bay area on Florida's Gulf Coast (E. L. Barnard, *unpublished*). The origin of *C. gyrosa* (= *E. tropicalis*, = *E. havanensis*?) and the extent of its distribution in Florida are unknown.

The cause(s) of coppice failure is (are) undoubtedly complex and may involve pathological, environmental, physiological, and genetic factors. The specific roles

Table 2. Key comparative features of *Cryphonectria cubensis* and *C. gyrosa*[a] used to identify *C. gyrosa* in southern Florida

Study Fungus	Conidiomata	Conidia	Perithecia	Asci	Ascospores
Hodges					
C. cubensis	Superficial pycnidia, stroma lacking	2.5–4.0 × 1.8–2.2 μm ("Clavate to broadly oval")	Stroma lacking	25–33 × 5.0–6.5 μm	5.8–8.2 × 2.2–3.0 μm (two-celled)
C. gyrosa	Loculate pycnidial stromata, similar to perithecial stromata	3.2–4.5 × 1.0–1.5 μm ("Allantoid to rod shaped")	Distinct orange stroma similar to conidiomata	33–41 × 5–7 μm	7.5–9.5 × 3.0–5.0 μm (two-celled)
Barnard et al					
C. cubensis	Superficial pycnidia, stroma lacking	3.6 × 1.6 μm[b] (Distinctly not rod-shaped; tear-drop-shaped or broadly oval)	Stroma lacking	27.7 × 5.8 μm[b]	6.7 × 2.3 μm[b] (two-celled)
C. gyrosa[c]	Loculate pycnidial stromata, similar to perithecial stromata	2.8 × 1.0 μm[b] (Bacillar, allantoid, or rod-shaped)	Distinct orange stroma similar to conidiomata	31.2 × 6.3 μm[b]	8.5 × 3.0 μm[b] (two-celled)

[a] As reported by Hodges (8) and used in our study to identify the fungus.
[b] Means of 20 measurements.
[c] Voucher material deposited in the University of Florida Mycological Herbarium, Gainesville (FLAS F54263). Culture deposited with American Type Culture Collection (ATCC 60862).

and/or interactions of *C. cubensis*, *C. gyrosa*, and *B. dothidea* in the pathology of eucalyptus in southern Florida require further study, including controlled inoculations. *C. cubensis* is a known pathogen of *E. grandis* (8,11,12,14) and was a common organism in cankers and dead coppice shoots. This is complicated, however, by the presence of *B. dothidea* and *C. gyrosa*. Davison and Tay (6) reported *B. ribis* (=*B. dothidea*) and *E. havanensis* (=*C. gyrosa*?) to be pathogens of *Eucalyptus marginata* Donn. ex Sm. in Western Australia. Our data and observations indicate the possibility that canker fungi play a role in coppice failure on *E. grandis* in southern Florida. A killing role for canker fungi (especially *C. cubensis* and *B. dothidea*) is consistent with their reported pathogenicities and the fact that coppice failure in Florida is typically greatest after summer harvest (9,20), when hot and rainy weather is ideal for infection by *C. cubensis* (10,14). Killing of coppice by fungi, either before or after the bursting of shoots from the bark, may not necessarily depend upon the presence of cankers on trees before harvest. Direct infection of new shoots might occur after coppice emergence. Variation between genotypes in susceptibility to coppice failure is known in *E. grandis* plantations in southern Florida and might be exploited to reduce failure incidence (17).

ACKNOWLEDGMENTS

We wish to thank Georgia Pacific Corporation for assistance with harvesting operations. We also thank Helen Battacharya for statistical analyses and C. S. Hodges, M. Barr Bigelow, K. M. Old, and R. J. Stipes for mycological counsel.

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