increased noticeably over that required to secure germination in conidia tested shortly after maturation. Conidia produced in the 16-, 24-, and 32-hr production-storage treatments required incubation periods of 4–6 hr to initiate germination. Schmitt and Freytag reported that freshly matured conidia incubated at 21 C began to germinate after less than 1 hr of incubation (11). The delayed germination of conidial inoculum does not present a problem. The inoculated plants are incubated for 24 hr after inoculation, which allows ample time for conidial germination.

The major advantages of this method of producing conidial inoculum are that it secures maximum production of conidia from the donor leaves and provides flexibility in timing the plant inoculations. I have used the system for several months to produce inoculum to test sorghum genotypes for resistance to *P. sorghi*. In this operation, the donor leaves are incubated at 4:00 P.M. the day before the planned inoculation, and the conidia are collected at any time between 8:00 A.M. and 4:00 P.M. on the day of the inoculation. The reactions of resistant and susceptible genotypes of sorghum and corn to conidial inoculum produced with the tiered temperature system were the same as those induced by inoculum obtained with previously reported methods (2,11; *unpublished*).

LITERATURE CITED

1. Bonde, M. R., Schmitt, C. G., and Dapper, R. W. 1978. Effects of dew-period temperature on germination of conidia and systemic infection of maize by *Sclerospora sorghi*. Phytopathology 68:219-222.
2. Craig, J. 1976. An inoculation technique for identifying resistance to sorghum downy mildew. Plant Dis. Rep. 60:350-352.
3. Craig, J., and Frederiksen, R. A. 1980. Pathotypes of *Peronosclerospora sorghi*. Plant Dis. 64:778-779.
4. Craig, J., and Frederiksen, R. A. 1983. Differential sporulation of pathotypes of *Peronosclerospora sorghi* on inoculated sorghum. Plant Dis. 67:278-279.
5. Frederiksen, R. A. 1980. Sorgum downy mildew in the United States: Overview and outlook. Plant Dis. 64:903-908.
6. Jones, B. L. 1970. A simple technique of inoculating sorghum with *Sclerospora sorghi* using conidia as inoculum. Plant Dis. Rep. 54:603-604.
7. Kenneth, R., and Shahor, G. 1983. Systemic infection of sorghum and corn by conidia of *Sclerospora sorghi*. Phytoparasitica 1:13-21.
8. Kimigafukuro, T., and Leu, L. S. 1976. Method for collecting ungerminated conidia of *Sclerospora sacchari* and TARC's downy mildew program. Kasetsart J. 10:143-147.
9. Lal, S. 1981. Developmental stages in *Peronosclerospora sorghi*, the sorghum downy mildew of maize. Acta Bot. Indica 9:171-174.
10. Safeeulla, K. M. 1976. Biology and Control of the Downy Mildews of Pearl Millet, Sorghum and Finger Millet. Wesley Press, Mysore, India. 304 pp.
11. Schmitt, C. G., and Freytag, R. E. 1974. A quantitative technique for inoculating corn and sorghum with conidia of *Sclerospora sorghi*. Plant Dis. Rep. 58:825-829.
12. Traylor, E. A., and Dunkle, L. D. 1981. Effects of antibiotics and metabolic inhibitors on germination of *Peronosclerospora sorghi* conidia. (Abstr.) Phytopathology 71:909.

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

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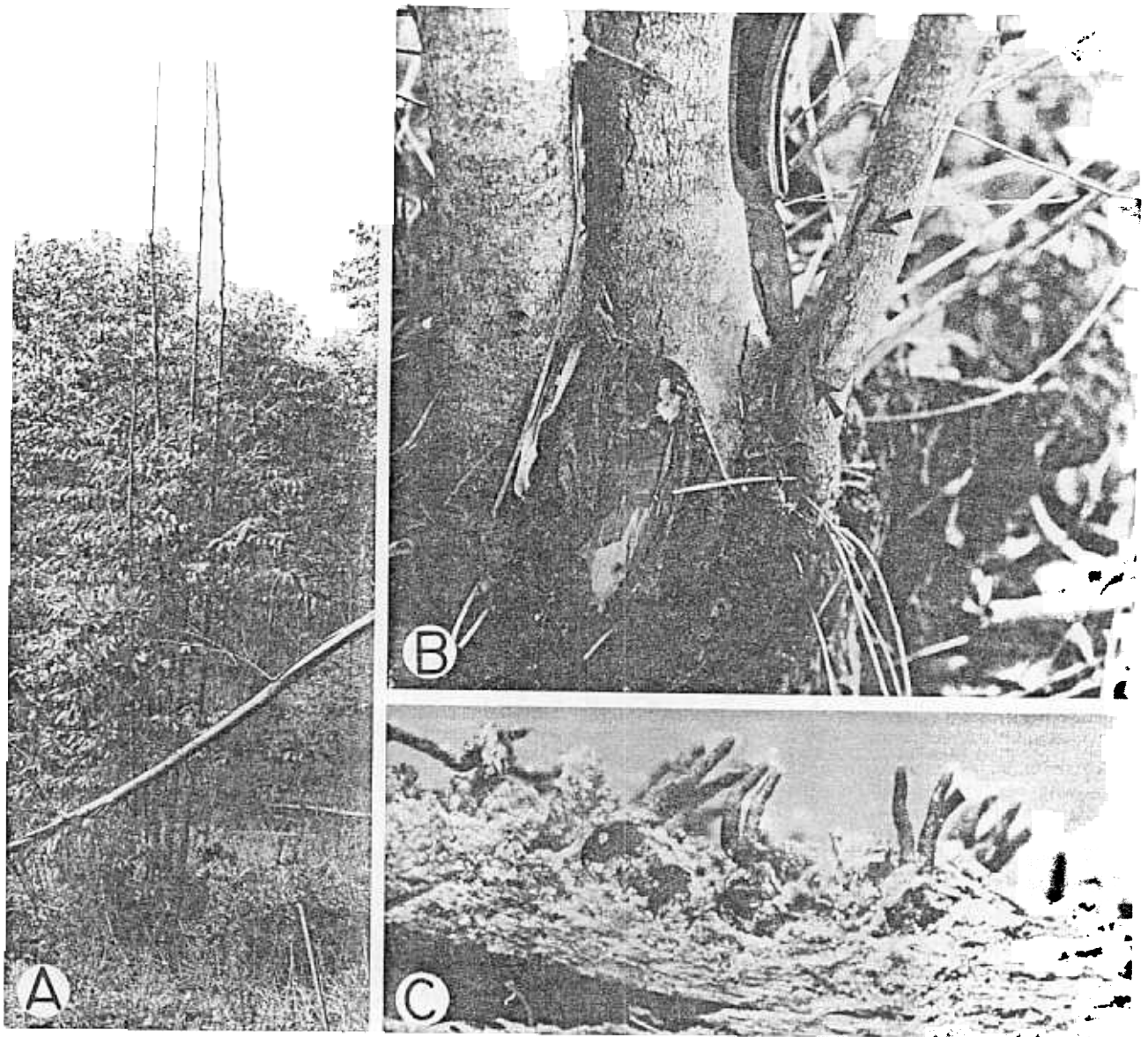

Fig. 1. Failure of 2-yr-old coppice shoots on stump of *Eucalyptus grandis* in Florida related to presence of *Cryphonectria cubensis*. **(A)** Stump with dying coppice shoots. **(B)** Bark fissuring (arrows) and cankers at bases of dying shoots. **(C)** Perithecia of *C. cubensis* embedded in and protruding 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	
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 $P \leq 0.05$.
[y] Canker classes I, II, and III pooled for analysis.
[z] Numbers within a row followed by different letters are significantly different at $P \leq 0.05$ (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).

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LITERATURE CITED

1. Barnard, E. L., and English, J. T. 1980. Basal cankers of *Eucalyptus* spp. Fla. Dep. Agric. Consumer Serv. Div. Plant Ind. Plant Pathol. Circ. 219. 2 pp.
2. Barr, M. E. 1978. The Diaporthales in North America with emphasis on Gnomonia and its segregates. Mycol. Mem. 7:1-232.
3. Berkeley, M. J., and Broome, C. E. 1875. Enumeration of the fungi of Ceylon. J. Linn. Soc. Lond. 14:29-140.
4. Boerboom, J. H. A., and Maas, P. W. T. 1970. Canker of *Eucalyptus grandis* and *E. saligna* in Surinam caused by *Endothia havanensis*. Turrialba 20:94-99.
5. Bruner, S. C. 1916. A new species of *Endothia*. Mycologia 8:239-242.
6. Davison, E. M., and Tay, F. C. S. 1983. Twig, branch, and upper trunk cankers of *Eucalyptus marginata*. Plant Dis. 67:1285-1287.
7. Dixon, W. N., and Barnard, E. L. 1984. Eucalypt pest survey: Southern Florida—1982. U.S.Dep. Agric. For. Serv. Southeast. Area State Priv. For. For. Pest Manage. Asheville Field Office Rep. 84-1-11. 8 pp.
8. Ferreira, F. A., Reis, M. S., Alfenas, A. C., and Hodges, C. S. 1977. Avaliação da resistencia de *Eucalyptus* spp. as cancro causado por *Diaporthe cubensis* Bruner. Fitopatol. Bras. 2:225-241.
9. Geary, T. F., Meskimen, G. F., and Franklin, E. C. 1983. Growing eucalypts in Florida for industrial wood production. Gen. Tech. Rep. SE-23. U.S. Dep. Agric. For. Serv. Southeast. For. Exp. Stn., Asheville, NC. 43 pp.
10. Hodges, C. S. 1980. The taxonomy of *Diaporthe cubensis*. Mycologia 72:542-548.
11. Hodges, C. S. 1983. Canker of eucalyptus caused by *Cryphonectria cubensis*. (Abstr.) Abstracts of papers. Int. Congr. Plant Pathol., 4th. Melbourne, Aust. 273 pp.
12. Hodges, C. S., Geary, T. F., and Cordell, C. E. 1979. The occurrence of *Diaporthe cubensis* on ecualyptus in Florida, Hawaii, and Puerto Rico. Plant Dis. Rep. 63:216-220.
13. Hodges, C. S., and Reis, M. S. 1974. A influência do cancro basal causado por *Diaporthe cubensis* Bruner na brotação de *Eucalyptus saligna* Sm. Bras. Flor. 5:25-28.
14. Hodges, C. S., Reis, M. S., Ferreira, F. A., and Henfling, J. D. M. 1976. O cancro do ecucalipto causado por *Diaporthe cubensis* Fitopatol. Bras. 1:129-170.
15. Kobayashi, T. 1970. Taxonomic studies of Japanese Diaporthaceae with special reference to their life histories. Bull. Gov. For. Exp. Stn. Meguro 226:1-242.
16. Martin, M. B., and Anderson, R. L. 1981. Incidence of diseases and insect damage in selected eucalypt plantations, southern Florida. U.S. Dep. Agric. For. Serv. Asheville Field Office. Rep. 81-1-20. 11 pp.
17. Meskimen, G., and Franklin, E. C. 1984. Hybridity in the *Eucalyptus grandis* breeding population in Florida. U.S. Dep. Agric. For. Serv. Pap. SE-242. 15 pp.
18. Roane, M. K. 1986. Taxonomy of the genus *Endothia*. Pages 28-39 in: Chestnut Blight, Other Endothia Diseases, and the Genus *Endothia*. M. K. Roane, G. J. Griffin, and J. R. Elkins, eds. American Phytopathological Society, St. Paul, MN. 53 pp.
19. Shear, C. L., Stevens, N. E., and Tiller, R. J. 1917. *Endothia parasitica* and related species. U.S. Dep. Agric. Bull. 380:1-82.
20. Webley, O. J., Geary, T. F., Rockwood, D. L., Comer, C. W., and Meskimen, G. F. 1986. Seasonal coppicing variation in three eucalypts in southern Florida. Aust. For. Res. 16:In press.

Scanning Electron Microscopy of Flyspeck of Apple, Pear, Japanese Persimmon, Plum, Chinese Quince, and Pawpaw

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ABSTRACT

Nasu, H., and Kunoh, H. 1987. Scanning electron microscopy of flyspeck of apple, pear, Japanese persimmon, plum, Chinese quince, and pawpaw. Plant Disease 71: 361-364.

Flyspeck of apple, pear, Japanese persimmon, plum, Chinese quince, and pawpaw was observed by scanning electron microscopy. Fungal structures formed and behaved similarly on all plant surfaces examined. Hyphae from germinated conidia grew on waxy bloom of the respective plants, degenerated bloom crystals around them, and aggregated to form sclerotiumlike structures on plant surfaces. Waxy bloom crystals disappeared along the hyphae. Hyphae and sclerotiumlike structures were covered with a thin film.

In Japan, flyspeck disease occurs on grape, Japanese persimmon, and pear. The causal fungus had been identified as *Leptothyrum pomi* (Montague et Fries) Saccardo. However, our recent investigation (7) revealed that the causal fungus of flyspeck in Japan as well as that of leaf speckle of banana (6), greasy blotch of carnation (2), and flyspeck of apple (4,5) is *Zygophiala jamaicensis* Mason.

Although the pathogen has been reported to occur on at least 78 species in 36 families of flowering plants over much of the temperate and tropical world (2), the only reports on detailed observation of the pathogen on host plant surfaces are of carnation greasy blotch (2) and flyspeck of apple (2) and grape (8,9). Our recent investigation of grape flyspeck with light (8) and a scanning electron microscope (9) revealed that the causal fungus was an ectoparasite growing on berry surfaces and probably using waxy bloom crystals as its sole source of external nutrition without penetration into epicarp tissues. Hyphae growing on berry surfaces were covered with a thin film probably composed of degenerating product(s) of bloom crystals. The sclerotiumlike structures with a raised, thick center and accompanying thin margin also were entirely covered with a similar thin film. In this paper, flyspeck of apple, pear, Japanese persimmon, plum, Chinese quince, and pawpaw was studied by scanning electron microscopy.

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MATERIALS AND METHODS

Fresh, infected fruits of apple (*Malus pumila* Mill. var. *domestica* Schneid. 'Fuji'), pear (*Pyrus serotina* L. 'Taiheiyou'), Japanese persimmon (*Diospyros kaki* L. 'Fuyu'), Chinese