SURVEY OF A STEM CANKER IN TEAK PLANTATIONS OF PUERTO RICO AND ST. CROIX, U.S. VIRGIN ISLANDS, 1983

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ABSTRACT

Teak plantations growing on Puerto Rico and St. Croix, U.S. Virgin Islands are severely damaged by a canker disease. Overall, 25 percent of the surveyed trees were cankered, and all surveyed stands had infected trees. Multiple cankering of the same tree was common. Cankers appear to result when the incitant enters the bark and kills the cambium in one growing season. Termite infestation of exposed sapwood and brown staining result in considerable internal defect. Decay was absent. A fungus, *Fusarium solani*, was recovered from a few cankers and may be the cause of cankers. Several research needs are identified.

INTRODUCTION

Plantations of teak (*Tectona grandis* Linn. F.) represent a valuable resource to the developing forestry programs of Puerto Rico and the U.S. Virgin Islands. Early thinnings yield high-quality and decay-resistant fenceposts that have high local demand. Seven-foot posts, 3 inches in diameter, sell for $2.25 each. Saw logs (12" d.b.h.) can be produced in 25 years; prices for finished lumber range from $8 to $11 per board foot (domestic retail). Because teak wood products are valuable, extensive damage of any kind would have potentially great impact.

A stem canker with wide distribution and high incidence was observed on three separate evaluations of tree pests of Puerto Rico and the U.S. Virgin Islands (Phelps and Landgraf, 1972; Cordell and Barry, 1976; Oak and Barry, 1982). This report presents the results of a more detailed survey to evaluate the cause, distribution, incidence, severity, and potential impact of stem cankers in teak plantations.

METHODS

The survey was conducted in late September 1983. Eight stands on Puerto Rico and four on St. Croix, U.S. Virgin Islands were sampled. Most had been thinned at least once. A single, 50-tree plot was established in each stand by entering the stand and randomly choosing the first plot tree, leaving a suitable buffer from the boundary (several rows). Consecutive trees in a row were then evaluated until 50 trees were completed. Where rows were difficult to define, plot trees were evaluated in a transect (width varying with stocking). Plot trees were noted as cankered or healthy. The height to cankers was estimated. Stand data included age, mean d.b.h. (10 trees), and basal area (obtained with a 10-factor prism). Suppressed and dead trees were not counted as plot trees. However, attempts were made to determine the cause of mortality when it was encountered. Notes were made of conditions associated with cankers (e.g., branches, stem wounds).

During the survey, five diseased trees were felled and sectioned through the cankers with a chainsaw to assess internal defects. Samples from these and other cankers were collected and used for isolating potential causal agents. Samples were kept on ice for 6 to 48 hours until cultured. Growth media included acidified 2 percent malt extract agar (broad spectrum medium) and ortho-phenylphenol agar (OPP; semi-selective for decay-causing basidiomycetes). Individual sample chips were split, one section being plated on each medium after surface sterilization (flaming with 95% ethanol).

RESULTS

Figures 1 through 4 show variation in canker appearance. Externally, typical cankers damaged a third to a half of the stem circumference and were 1 to 3 feet long. Canker margins were irregular, with healthy callus tissue. However, complete closing of cankers by callus formation was uncommon (Figure 4). Cankers are probably annual (active during part of one year) because of the presence of healthy callus at canker margins and the lack of killed callus in canker faces.

Developing cankers were inconspicuous, often just a fissure in the bark with dying inner bark beneath (Figures 5 and 6). The bark was frequently intact over the canker face in newly formed cankers. Older cankers had no adhering bark. Sometimes, only the surface of the inner bark was killed, leaving a smooth area overlain by a loose plate of dead, furrowed bark (Figure 7). Cankers apparently result when the incitant penetrates the bark and kills the inner bark down to the cambium. Large areas can be killed in a relatively short period. Most fungus-caused cankers of hardwood trees in temperate climate zones are active during the trees' dormant season or when trees are stressed by drought or freezing (Shoeneweiss, 1981). Though tropical conditions may have different influences, it is likely that teak cankers are probably most active during the dry (dormant) season and/or during periods of prolonged drought during the trees' normal growing season.

Stem cankers were present in all surveyed stands on both islands. Table 1 summarizes general stand data, canker incidence, and height to cankers for surveyed plantations. Average incidence of cankered trees within stands was 24 percent (range of 10 to 48 percent). Cankers were found on all sides of affected trees and occurred within 2 and 30 feet above ground (average height to cankers was 10 feet). One-third of all diseased trees had multiple cankers. A maximum of five discrete cankers were seen on some trees, but multiple cankers in close proximity often merged, which made enumeration imprecise in those instances.

Trends in canker occurrence, with regard to tree diameter or age, cannot be determined, because only small pole- to small sawtimber-sized stands in a relatively narrow age range were surveyed. However, local foresters have observed that small-diameter stump sprouts (1 to 3 inches) that develop after thinnings are often heavily cankered (Jose Figueroa, personal communication). We also noted this during our survey.

Canker-associated tree mortality and top-kill were rare. When this damage did occur, it resulted from the girdling of the stem after multiple cankers coalesced. Dead branch stubs were at the center of a few cankers (suggesting the infection originated on the stem and later spread into the stem; Figure 2).

Figure 1.--Callusing teak canker, once infested with termites.

Figure 2.--Teak canker with a dead branch stub as a possible indicator of the stem infection origin. Consistent canker-branch stub associations were lacking.

Figure 3.--Teak canker of recent origin (1 to 3 years). A loose plate of dead bark attached above and below the canker was removed to reveal this damage.

Figure 4.--Appearance of cankers was variable. These cankers show incomplete compartmentalization of the affected area by callus tissue formation. This symptom was uncommon, as most cankers had open faces.

Figure 5.--External evidence of an active, developing canker (left). Bark removed showing dead inner bark (right).

Figure 6.--External symptom of an active, developing canker on a basal sprout (left). Bark removed showing dead inner bark (right).

Figure 7.--Loose plates of dead bark with smooth bark beneath suggest that infections occur that do not kill the inner bark to the cambium.

Table 1.--Incidence and severity of cankers in 12 surveyed teak plantations, Puerto Rico and St. Croix, U.S. Virgin Islands, 1983.

Forest	Location	Age (years)	DBH (inches)	Basal Area (feet)	Canker Incidence (percent)	Cankered Trees With Multiple Cankers (percent)	Average Height to Cankers (feet)
Rio Abajo	Nieves 1	43	14	95	40	40	8
Cambalache	Los Ortices	42	12	110	14	43	18
St. Croix	Est. Thomas 1	28	8	70	48	50	12
St. Croix	Est. Thomas 2	28	9	80	26	23	10
St. Croix	Est. William	26	7	105	20	40	10
St. Croix	Plessen	26	7	50	16	25	8
Rio Abajo	Santa Rosa 1	23	7	80	22	27	12
Rio Abajo	Nieves 2	20	9	100	10	60	8
Rio Abajo	Santa Rosa 2	16	8	80	32	44	10
Rio Abajo	Las Vegas	13	5	85	26	23	6
Cambalache	Burnt	12	6	90	16	13	6
Cambalache	Camping Area	unk	4	90	22	9	9
	Average	25	8	86	24	33	10

Bird pecks (caused by the migrating yellow-bellied sapsucker, *Sphyrapicus varius*; Figure 8) seemed to be the origin of a few others. However, consistent association of cankers with these disturbances was lacking. Tree-nesting termites (*Kalotermes snyderi* Light; identified by D. A. Nickle, USDA-ARS, Beltsville, MD) frequently colonize canker faces, consuming the exposed sapwood beneath (Figures 1 and 9), but their activities do not seem to cause cankers.

Internal defects consisted of termite galleries (Figure 10) and brownish staining (Figure 11). The stain was present 1 to 2 feet above and below cankers, and a shorter distance beyond the lateral margins. The darkest stain was associated with termite galleries, with the extent of staining beyond the lateral margins related to the extent of termite infestation. Though extensive wood decay was absent, it is possible that decay does develop beneath cankers, but is quickly consumed by termites. Close examination of stained sapwood revealed darkly stained, individual elements that occasionally exuded an inky sap (Figure 12). These may serve to compartmentalize the damaged wood.

Fungus fruiting bodies were not observed on cankers or callus tissue, even after moist chambering for two weeks. Several fungi with the potential for causing disease were recovered from cankers. However, the most reliable results were obtained from developing cankers with actively advancing margins (Figure 6) on small stems originating from stumps or basal sprouts. These were from three widely separated plantations on the Cambalache and Rio Abajo State Forests (Puerto Rico).

When grown on fresh potato dextrose agar slants at room temperature with 16 hours of fluorescent light, the fungi produced abundant tan to brownish mycelium. Microscopically, the isolates produced long, simple phialides (spore-producing structures; Figure 13) and abundant micro- and macroconidia (Figure 14). Though variation in colony appearance and microscopic features exists between isolates, they are identified as *Fusarium solani* (Tousson and Nelson, 1976; Booth, 1977).

Older, seemingly inactive cankers yielded an isolate of *Fusarium roseum* (not a known tree-cankering organism) and one of *Lasiodiplodia theobromae* (a weakly pathogenic fungus of stressed trees). The preponderance of isolations were unsuccessful, yielding no fungi, nonsporulating fungi without distinctive features, or common contaminants. While the identity of the pathogen is uncertain, the best candidate of the identified fungi is *F. solani*, based on the condition of the host material from which it was obtained.

DISCUSSION

Cankers on teak trees growing on Puerto Rico and St. Croix, U.S. Virgin Islands occur wherever teak is grown and occur with high frequency. No surveyed stand was without canker damage. Trees are subject to multiple infections that sometimes coalesce into large areas of damaged stem wood. Decay is absent, but termite infestation can produce extensive internal defect. Brown staining commonly occurs. Mortality and top-kill are infrequent, but can result when multiple cankers coalesce.

Figure 8.--Bird peck caused by the migrating, yellow-bellied sapsucker, Sphyrapicus varius. Cankers were infrequently associated with bird peck.

Figure 9.--Close-up of termite galleries at the healthy callus tissue margin of an old canker.

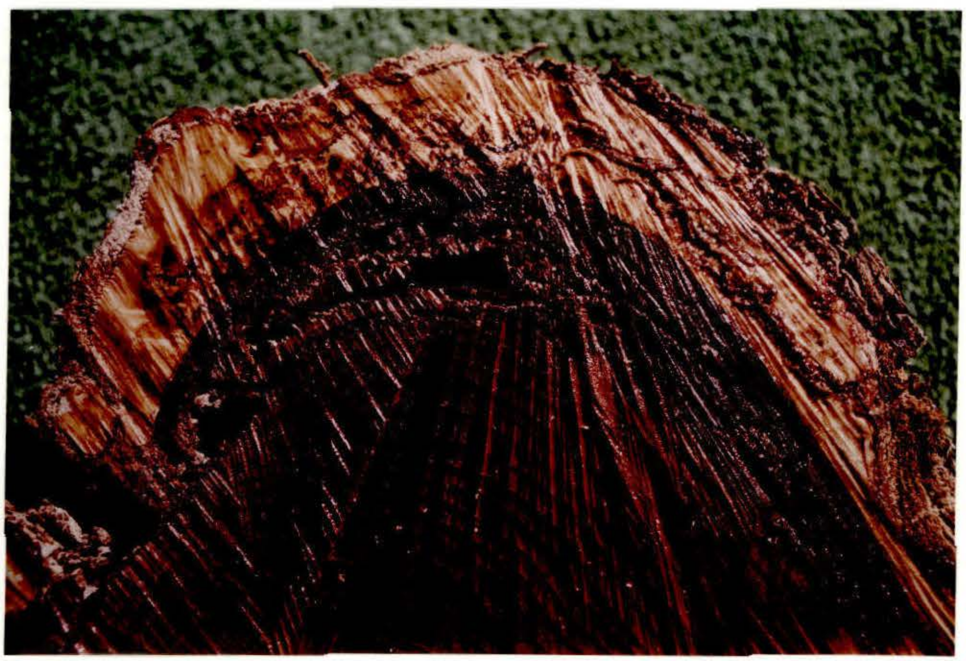

Figure 10.--Transverse stem sections through cankered areas, showing termite galleries, dark staining, and callus tissue formation (top). Close-up of termite damage beyond the margin of the canker, with dark staining (bottom).

Figure 11.--Transverse stem section 1 foot above the upper canker margin, showing brown staining.

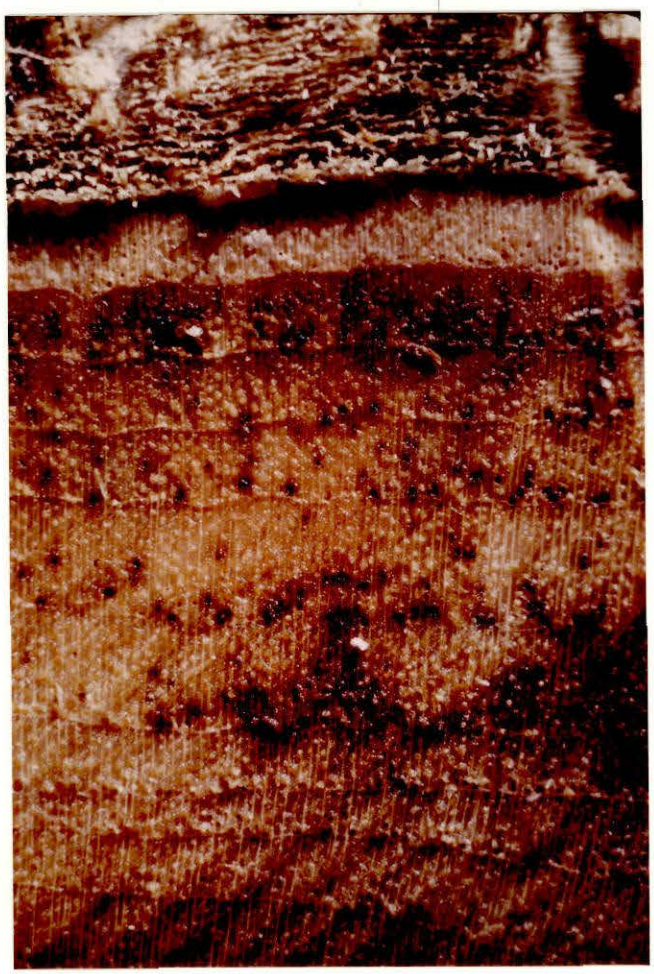

Figure 12.--Close-up of a portion of Figure 11, showing darkly stained vessel elements. One element at the upper left is exuding a small amount of inky sap. Staining can be a compartmentalizing response to injuries in many trees.

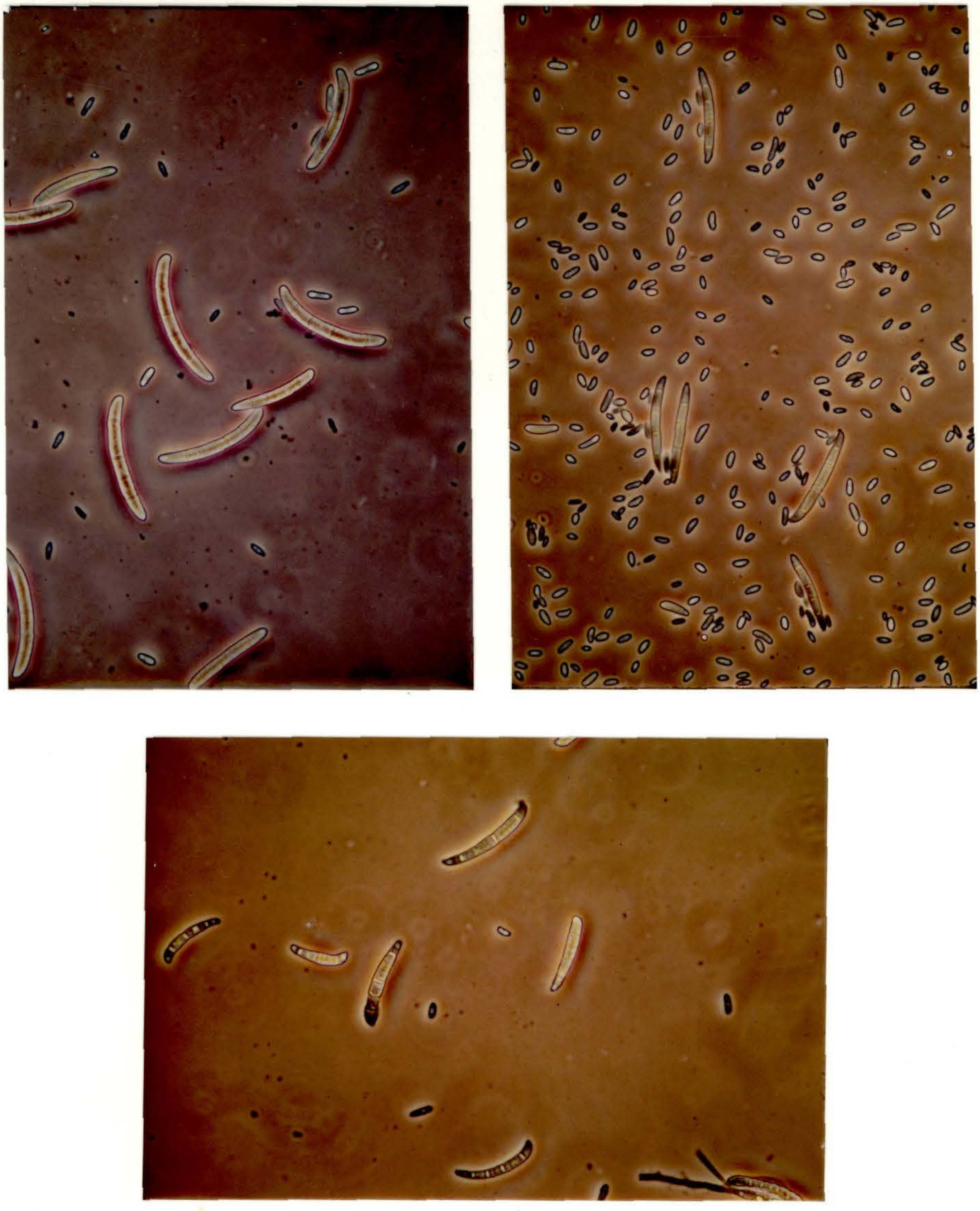

Figure 13.--Photomicrographs showing phialide (spore-producing structure) morphology that is characteristic of Fusarium solani isolates thought to cause teak cankers. (|—| = 10 microns)

NOTE: Photos for Figures 13 and 14 are interchanged.

Figure 14.--Photomicrographs showing variability in spore morphology of the different Fusarium solani isolates thought to cause teak cankers. (⊢⊣ = 10 microns)

Our survey showed that abundant cankers occur in trees between age 12 and 43 years. Indirect evidence (observations of small diameter stump sprouts) indicates they also occur on much younger, small-diameter stems. Because all diameter classes seem susceptible, the lack of external symptoms of completely callused cankers on older trees suggests the possibility that the disease developed recently. Early accounts of the performance of the first teak plantations established on the islands do not mention any such maladies. If cankers were not a problem early in the life of these stands, then the causal agent may have been introduced or is perhaps a native pathogen that has taken years to develop into the problem we observed.

The history of the problem is important in determining the expected losses when harvesting and processing lumber from older teak trees. If cankers were present early in the trees' development, substantial internal defect might be encountered. Records of cull from various causes are not available for the sawmilling that has been conducted thus far.

Losses cannot be quantified without further research. Most external defects would be eliminated in the scrap slabs. Careful sawmilling and marketing of small boards cut from trees with internal defects would limit losses. A market already exists for posts resulting from thinnings of young stands, and sanitation cuts (elimination of cankered stems) would provide more. However, removing most cankered trees in heavily diseased stands would result in poorly distributed stocking or understocking. This would interfere with long rotation management objectives.

Silvicultural methods aimed at minimizing losses also need further research. While sanitation thinnings may reduce incidence in the remaining stand, it is also conceivable that this activity may increase susceptibility of the crop trees.

The role of genetic variability in disease resistance could be potentially significant. Teak is an introduced species in the Caribbean, and the genetic diversity of the population is probably quite narrow. Since teak stands are established by planting "stumps" (top and root pruned seedlings) grown from locally collected seed, it is possible that large portions of the resource are closely related, genetically. Future stands resulting from stump sprouts would only perpetuate this situation. Screening of different geographic sources would be valuable, if teak is to be an important timber species for the future on these islands. Small plantings of different teak sources currently growing on the Caribbean National Forest; on the Rio Abajo State Forest, Puerto Rico; and on St. Croix are significant resources for investigations of genetic resistance.

The causal agent of teak cankers in Puerto Rico and St. Croix teak plantations remains unknown. However, *F. solani* is an excellent candidate as the pathogen. Reports of teak cankers in India plantations describe a very similar condition caused by *F. solani* or its sexual stage, *Nectria haematococcus* (Bagchee, 1947). Freezing stress is thought to be an aggrevating circumstance in some locations (Bagchee, 1952). Further, *F. solani* has been consistently isolated from teak stem cankers in Tanzania and has killed artificially inoculated teak seedlings (Hocking, 1968). Teak cankers also resemble those caused by *F. solani* on yellow poplar (*Liriodendron tulipifera*) and other hardwoods in the eastern U.S. More extensive monitoring of teak stands followed by pathogen isolation and inoculation trials are required before pathogenicity can be confirmed. Because these observations were made during a short period (10 days) and only during the growing season, we may have missed the primary infection period. This may explain the low frequency of actively growing cankers we observed and the limited success we had recovering *F. solani* or other potential pathogens from cankers. Close examination of teak trees during or shortly after the dormant season and other abnormal drought periods should offer the best chance for detecting new cankers and recovering the pathogen. Inoculations of seedlings and larger trees in the field must be made during the entire year to further illuminate important variables governing infection biology and disease development.

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