Phytophthora Root Rot of Commercially Cultivated Proteas in South Africa

S. L. VON BROEMBSEN, Agricultural Researcher, Plant Protection Research Institute, Private Bag X5017, Stellenbosch 7600, and G. J. BRITS, Agricultural Researcher, Horticultural Research Institute, Tygerhoek Experimental Farm, P.O. Box 25, Riviersonderend 7250

ABSTRACT

Von Broembsen, S. L., and Brits, G. J. 1985. Phytophthora root rot of commercially cultivated proteas in South Africa. Plant Disease 69:211-213.

Phytophthora cinnamomi was isolated from the roots of 63 species of diseased proteas (Proteaceae) in commercial fields in the South Western Cape Province of South Africa. Disease was often associated with poor soil drainage. Aboveground symptoms ranged from wilting and rapid death to chlorosis, decline, and eventual death. *P. cinnamomi* was associated most frequently with *Leucospermum* and *Leucadendron* spp. Pathogenicity of *P. cinnamomi* to indigenous proteas in eight genera (*Leucadendron, Leucospermum, Protea, Aulax, Brabeium, Mimetes, Paranomus,* and *Serruria*) was demonstrated by artificial inoculation.

Additional key words: disease control

Proteas (Proteaceae) produce striking flowers that remain attractive for weeks in the vase. Protea cultivation in South Africa has grown from a few hectares in 1960 to more than 2,000 ha today, making South Africa the world's leading producer and exporter of proteaceous cut flowers (B. Gibson, *personal communication*). About 20 indigenous species and several Australasian species are cultivated on a large scale. The most important production species are from two major indigenous genera, *Leucospermum* and *Protea*.

In 1976, we investigated extensive patch deaths of the common pincushion (*Leucospermum cordifolium* (Salisb. ex Knight) Fourc.) in a commercial cut flower planting on a site with poor drainage. Affected plants showed chlorosis, rapid wilting, and death. *Phytophthora cinnamomi* Rands was recovered from the dark brown, decayed roots of affected plants. Although *P. cinnamomi* has been reported previously from proteaceous hosts in both South Africa (6) and Australia (11), no studies on commercial plantings in these regions have been reported. *P. cinnamomi* has, however, recently been shown to cause root rot of *Banksia* spp. in Hawaii, where the disease is commercially important to cut flower production by this genus (2).

This paper reports the general occurrence of Phytophthora root rot on commercially cultivated proteas in the South Western Cape Province of South Africa and demonstrates the pathogenicity of *P. cinnamomi* to representative species of indigenous proteas.

Accepted for publication 25 June 1984.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

MATERIALS AND METHODS

Field study. Deaths of proteas grown in the South Western Cape Province for cut flower production, seed production, and breeding were investigated during 1976–1983. Disease patterns and symptom expression on different kinds of proteas were recorded. Tissues from the roots and collars of diseased plants were surface-disinfested in 0.1% NaOCl, rinsed in sterile distilled water, and plated on P10VP (5) or P10VPH (4) medium (both selective for pythiaceous fungi) and on Difco cornmeal agar. Isolations from soil samples taken from the root zones of diseased plants were made using a lupin baiting technique (1). Isolates were identified using the criteria of Waterhouse (9,10).

Pathogenicity tests. The pathogenicity of *P. cinnamomi* to 31 indigenous species of South African proteas (Table 1) was tested. Species selected from the major indigenous genera, *Leucospermum, Leucadendron*, and *Protea*, represented most of the subgenera within these genera and included most commercially important species. Single species from five minor genera were included in the tests to obtain an overall indication of the reaction of the indigenous component of the family Proteaceae to *P. cinnamomi*.

Inoculum was prepared by growing an A1 isolate (C11) of the mating type of *P. cinnamomi* from *Leucadendron argenteum* R. Br. in V-8 juice broth (3) for 15 days, then comminuting and diluting with sterile water to about 1,000 colony-forming units per liter. Previous inoculation studies had shown that a dosage of about 100 propagules per plant was likely to cause consistent infection of the most susceptible species but would also allow differences in susceptibility to be shown. One-year-old plants grown for

Table 1. Infection and death of indigenous South African Proteaceae after artificial inoculation with *Phytophthora cinnamomi*

Plant	Infected[a]	Dead[a]
Aulax cancellata	4	4
Brabeium stellatifolium	3	0
Leucadendron		
argenteum	4	4
nervosum	0	0
orientale	2	2
saligum	5	5
uliginosum	0	0
Leucospermum		
conocarpodendron	2	0
cordifolium	4	4
cuneiforme	4	2
formosum	0	0
glabrum	2	0
patersonii	5	5
praemorsum	5	5
prostratum	2	2
reflexum	2	0
Mimetes hirtus	1	0
Paranomus reflexus	1	0
Protea		
caffra	0	0
compacta	0	0
cynaroides	0	0
exima	0	0
lanceolata	1	0
laurifolia	0	0
magnifica	1	0
minor	2	0
neriifolia	0	0
nitida	0	0
obtusifolia	0	0
repens	0	0
Serruria florida	4	4

[a] Number of infected or dead plants of five inoculated.

10–12 mo in 2-L pots were inoculated by irrigating 100 ml of the mycelial suspension into the potting mixture (1:10, compost:sand). Controls were treated similarly, except sterile water was applied instead of mycelial inoculum. Treatments were replicated five times with single plants as experimental units.

Plants were held in a sand-filled shadehouse bed heated from beneath to 25 C and watered as necessary but otherwise exposed to the ambient conditions prevailing between December 1978 and May 1979 at Stellenbosch (midsummer to autumn). Symptom development and plant deaths were recorded weekly. Dead plants were removed when noted, their root systems examined, and isolations made as described before. After 5 mo, the experiment was terminated and isolations were made from the root systems of all surviving plants.

RESULTS

Field observations. Dark lesions occurred on the roots of all diseased plants and on the collars and lower stems of some. Cortical tissues were decayed but the stele remained intact. Proteoid roots (densely clustered rootlets characteristic of the Proteaceae) and secondary roots were often missing. For the most severely affected species, the disease was characterized by rapid wilting and death with subsequent retention of leaves on branches. Chlorosis sometimes preceded wilting. For less severely affected species, gradual decline accompanied by chlorosis and stunting preceded death. Although diseased plants occurred more frequently in poorly draining areas of a field, they also occcurred on scattered plants at sites with good drainage. Deaths occurred most frequently in the hot, dry period from summer to early autumn.

P. cinnamomi was isolated from 63 species of proteas in nine genera: *Aulax cancellata* (L.) Druce (=*pinifolia* Berg.); *Banksia burdetti* E. G. Bak., *B. coccinea* R. Br., *B. hookerana* Meisn.; *Brabeium stellatifolium* L.; *Leucadendron argenteum*, *L. comosum* (Thunb.) R. Br., *L. daphnoides* (Thunb.) Meisn., *L. discolor* Phill. & Hutch., *L. galpinii* Phill. & Hutch., *L. laureolum* (Lam.) Fourc., *L. meridianum* I. Williams, *L. microcephalum* (Gand.) Gand. & Schinz, *L. nobile* I. Williams, *L. orientale* I. Williams, *L. pubescens* R. Br., *L. rubrum* Burm. f., *L. salignum* Berg., *L. spissifolium* (Salisb. ex Knight) I. Williams, *L. tinctum* I. Williams, *L. tradouwense* I. Williams, *L. uliginosum* R. Br.; *Leucospermum attenuatum* (Burm. f.) Rourke, *L. catherinae* Compton, *L. conocarpodendron* (L.) Beuk, *L. cordifolium* 'Gold Dust,' *L. cordifolium* × *tottum* (L.) R. Br. 'Firefly,' *L. cordifolium* × *lineare* R. Br. 'Red Sunset,' *L. cuneiforme* (Burm. f.) Rourke, *L. erubescens* Rourke, *L. formosum* (Andr.) Sweet, *L. fulgens* Rourke, *L. glabrum* Phill., *L. grandiflorum* (Salisb.) R. Br., *L. lineare* R. Br., *L. muirii* Phill., *L. mundii* Meisn., *L. patersonii* Phill., *L. pluridens* Rourke, *L. praecox* Rourke, *L. praemorsum* (Meisn.) Phill., *L. prostratum* (Thunb.) Stapf, *L. reflexum* Buek ex Meisn., *L. tomentosum* (Thunb.) R. Br., *L. tottum* (L.) R. Br., *L. truncatum* (Buek ex Meisn.) Rourke, *L. utriculosum* Rourke, *L. vestitum* (Lam.) Rourke; *Mimetes cucullatus* (L.) R. Br., *Orothamnus zeyheri* Pappe ex Hook; *Paranomus reflexus* (Phill. & Hutch.) N. E. Br.; *Protea aurea* (Burm. f.) Rourke (=*longiflora* Lam.), *P. cynaroides* (L.) L., *P. effusa* E. Mey ex Meisn. (=*marlothii* Phill.), *P. grandiceps* Tratt., *P. lepidocarpodendron* (L.) L., *P. longifolia* Andr., *P. magnifica* Link, *P. nitida* Mill. (=*arborea* Houttuyn), *P. punctata* Meisn.; *Serruria florida* Knight; and *Telopea speciosissima* R. Br.

The most severe symptoms (rapid wilting and death with leaf retention) occurred on infected *Leucospermum*, *Leucadendron*, *Banksia*, *Serruria*, and *Aulax* spp. These symptoms were considered diagnostic for Phytophthora root rot on these species and were subsequently observed at many other locations where no isolations were attempted. Severe symptoms were found most frequently on *Leucospermum* and *Leucadendron* spp. Symptoms were generally less severe and developed more slowly on *Protea, Paranomus, Mimetes*, and *Telopea* spp.

Pathogenicity tests. *P. cinnamomi* isolate C11 was pathogenic to 19 of the 31 species that were artificially inoculated (Table 1). All plants from which the fungus was isolated had root symptoms similar to those of diseased plants in the field. Some of the infected plants wilted rapidly or became chlorotic and died. Other plants became infected but did not die during the 5-mo trial. Many *Leucospermum* and *Leucadendron* plants became infected and died suddenly. Few *Protea* plants became infected and none died.

DISCUSSION

P. cinnamomi is shown in this report for the first time to cause root rot of species in eight genera of South African proteas. Previously, *P. cinnamomi* was reported to be the cause of root and crown rot of silver trees (*Leucadendron argenteum*) (6); however, only aboveground stems were inoculated and no symptoms or reisolations from belowground parts were reported.

The field study showed important differences in disease severity and disease patterns among *Leucospermum, Leucadendron*, and *Protea* spp. *Leucospermum* and *Leucadendron* spp. were severely affected by Phytophthora root rot and appeared to be very susceptible. Although there was a correlation between poor drainage and disease incidence within a field for both of these species, disease also occurred at sites with good drainage. *Protea* spp. were less severely affected. Disease of mature *Protea* spp. rarely occurs at sites with good drainage. In fact, growers are using *Protea* spp. to replant sites where pincushions (*Leucospermum* spp.) have died from Phytophthora root rot.

The importance of Phytophthora root rot to the development of the South African cut flower industry is indicated by its occurrence on a wide range of commercially cultivated proteas and by its severity in the family Proteaceae as a whole. Plant loss was 52% in the 2-yr period after discovery of the disease in the original field of *Leucospermum cordifolium*. High plant losses usually force premature abandonment of the planting.

Disease control primarily consists of planting disease-free nursery material in sites with good drainage and no history of disease. Controlling the disease is particularly difficult in the South Western Cape Province because of abundant natural inoculum from infected indigenous flora and infested river water (7,8). Most new protea plantings are established on land cleared of native vegetation. Recovery of *P. cinnamomi* from soil at several of these newly cleared fields demonstrates the importance of this inoculum source (*unpublished*). Suitable methods for decontaminating river water are available but are costly for field use. Currently available fungicides tested in this region are not suitable for field control of Phytophthora root rot on *Leucospermum* spp. Control with fosetyl-Al (Aliette) is inadequate, and metalaxyl is unacceptably phytotoxic to *Leucospermum* spp. under field conditions (*unpublished*).

The variation in susceptibility observed among and within genera in this study suggests that some measure of control might be possible through use of resistant or tolerant varieties. Particularly within the genus *Protea*, breeding and selection for resistance appear promising. Within the genera *Leucospermum* and *Leucadendron*, resistant varieties are considerably less likely, but tolerance could be useful in a rootstock development program.

ACKNOWLEDGMENTS

We thank J. A. van der Merwe and the late Maurice van Niekerk for technical assistance.

LITERATURE CITED

1. Chee, K. H., and Newhook, F. J. 1965. Improved methods for use in studies of *Phytophthora cinnamomi* Rands and other *Phytophthora* species. N.Z. J. Agric. Res. 8:88-95.
2. Cho, J. J. 1981. Phytophthora root rot of *Banksia*: Host range and chemical control. Plant Dis. 65:830-833.
3. Ribeiro, D. K. 1978. A Sourcebook on the Genus *Phytophthora*. J. Cramer, Lehr, Germany. 420 pp.
4. Tsao, P. H., and Guy, S. O. 1977. Inhibition of

Mortierella and *Pythium* in a *Phytophthora* isolation medium containing hymexazol. Phytopathology 67:796-801.
5. Tsao, P. H., and Ocana, G. 1967. Selective isolation of species of *Phytophthora* from natural soils on an improved antibiotic medium. Nature 223:636-638.
6. Van Wyk, P. S. 1973. Root and crown rot of silver trees. J. S. Afr. Bot. 39:255-260.
7. Von Broembsen, S. L. 1984. Occurrence of *Phytophthora cinnamomi* on indigenous and exotic hosts in South Africa, with special reference to the South Western Cape Province. Phytophylactica 16:221-225
8. Von Broembsen, S. L. 1984. Distribution of *Phytophthora cinnamomi* in rivers of the South Western Cape Province. Phytophylactica 16:227-229.
9. Waterhouse, G. M. 1963. Key to the genus *Phytophthora* de Bary. Commonw. Mycol. Inst., Mycol. Pap. 92. 22 pp.
10. Waterhouse, G. M. 1970. The genus *Phytophthora* de Bary. Commonw. Mycol. Inst., Mycol. Pap. 122. 59 pp.
11. Zentmyer, G. A. 1980. *Phytophthora cinnamomi* and the diseases it causes. Monogr. 10. American Phytopathological Society, St. Paul, MN. 96 pp.