Review paper

The Genera *Cylindrocladium* and *Cylindrocladiella* in South Africa, with Special Reference to Forest Nurseries

P.W. Crous[1], A.J.L. Phillips[1] and M.J. Wingfield[2]

[1]*Plant Protection Research Institute, Private Bag X134, Pretoria 0001 and* [2]*Department of Microbiology and Biochemistry, University of the Orange Free State, P.O. Box 339, Bloemfontein 9300*

SYNOPSIS

Species of *Cylindrocladium* and *Cylindrocladiella* are widely distributed throughout the world and are known to be important pathogens of numerous angiosperm and gymnosperm hosts. Several species are notorious pathogens in nurseries, and have frequently been found on tree genera such as *Eucalyptus*, *Pinus* and *Acacia*. This paper provides a review of current knowledge, identifies areas of future research, and outlines the importance of *Cylindrocladium* and *Cylindrocladiella* in South African forestry.

INTRODUCTION

The genus *Cylindrocladium* was erected in 1892 by Morgan, with *C. scoparium* Morgan as the type. This species was found on a dead pod of honey locust (*Gleditschia triacanthos* L.) in Ohio (Morgan, 1892). Subsequently, Graves (1915) isolated the same fungus from roots of *Pinus strobus* L., *P. resinosa* Ait. and *Tsuga canadensis* L. but failed to induce symptoms through artificial inoculations. He, therefore, assumed it to be saprophytic. Massey (1917) and Anderson (1919) were the first to show that *C. scoparium* could cause disease. Jackson (1938) associated this fungus with damping-off, root rot and crown canker of several conifer species. The fungus has subsequently been found to be a devastating pathogen of numerous hosts (Cox, 1953; Bugbee and Anderson, 1963a, 1963b; Bertus, 1976a, 1976b). Gibson (1975) concluded that *C. scoparium* is probably one of the most serious nursery pathogens of eucalypts at all growth stages. At that time it had however not been noticed on African *Eucalyptus* stock.

Boesewinkel (1982a) selected several small-spored species in the genus *Cylindrocladium* (*C.*), and placed them in a new genus, *Cylindrocladiella* Boesewinkel (*Ca.*) . This genus currently comprises five species (Boesewinkel, 1982a, 1982b), three of which have been reported as pathogens of *Eucalyptus* (Batista *et al.*, 1965; Sharma and Mohanan, 1982; Mohanan and Sharma, 1985a).

At present, approximately 33 *Cylindrocladium* spp. have been described (Boedijn and Reitsma, 1950; Alfieri *et al.*, 1970; Gill *et al.*, 1971; Panwar and Bohra, 1974; Hunter and Barnett, 1978; Schoulties *et al.*, 1982; El-Gholl *et al.*, 1986, 1989), 12 of which are pathogenic to *Eucalyptus* (Peerally, 1974a, 1974b; Almeida and Bolkan, 1981a; Sharma and Mohanan, 1982; Mohanan and Sharma, 1985a; El-Gholl, *et al.*, 1986). Only one *Cylindrocladium* sp., *C. scoparium*, has been reported from *Eucalyptus* in South Africa (Lundquist and Baxter, 1985). Additional local hosts for *C. scoparium* include *Acacia* spp. (Doidge, 1950; Hagemann and Rose, 1988), *Persea americana* Mill. (Darvas, 1978), *Medicago truncatula* Gaertn. (Lamprecht, 1986) and *Syncarpia glomulifera* (Smith) Niedz. (PREM 45419). Darvas *et al.* (1978) found *C. scoparium* and *Ca. parva* (Anderson) Boesewinkel to be pathogenic on pines. The latter fungus was subsequently found on roots of avocado (Darvas, 1978), *Protea aurea* (N.L. Burm.) Rourke (PREM 45440) and has recently been isolated by us from roots of *Acacia mearnsii* de Wild, *Pinus radiata* D. Don. and forest litter. Although Sharma and Mohanan (1982) reported *Ca. parva* as pathogenic to *Eucalyptus*, we have found it growing saprophytically on *Eucalyptus* leaf litter. These observations support similar findings that, under certain conditions, *Cylindrocladium* spp. can occur as saprophytes (Boedijn and Reitsma, 1950; French and Menge, 1978).

The genera *Cylindrocladium* and *Cylindrocladiella* are hardly known in South Africa. Preliminary surveys have, however, indicated that a number of species occur in this country, and that they are potentially important pathogens of various plants, especially *Eucalyptus* spp. No previous review of information pertaining to the two genera has been published. Therefore, this paper reviews current knowledge of *Cylindrocladium* and *Cylindrocladiella* and considers their importance in forest nurseries in South Africa. Future areas of research on the pathogenic species are also outlined.

TAXONOMY AND MORPHOLOGICAL CHARACTERISTICS

Cylindrocladium, together with other closely related genera such as *Cylindrocladiella*, *Gliocladium* Corda, *Cylindrocarpon* Wollemw. and *Fusarium* Link: Fr. are grouped in the order *Hypocreales*. *Cylindrocladium* has a *Calonectria* de Not. teleomorph, while the latter genera have *Nectria* Fr. states (Booth, 1966; Rossman, 1979a, 1979b, 1983).

Apart from cultural characteristics, the main criteria on which identifications of *Cylindrocladium* and *Cylindrocladiella* species are based include conidial dimensions and septation, shape and size of the vesicle, characteristics of the stipe, phialides, branching habit and individual branch dimensions. Species differentiation is complicated because of plasticity of the fungus on different media and under various environmental conditions (Zumpetta, 1976; Hunter and Barnett, 1978).

Cylindrocladium is characterised by having species with hyaline, cylindrical conidia, 1–7 (or more) septate, with obtuse ends (Hunter and Barnett, 1978), mostly encased in an irregular mucilaginous matrix. Conidia form on monophialides, which occur singly or in groups of up to five on penicillate branches of the conidiophore. These branches arise laterally from central or lateral specialised hyphae, referred to as the stipe, being septate, branched or unbranched, giving rise to a fertile, terminal, thin-walled structure of characteristic shape, called the vesicle. Chlamydospores occur in clusters and form microclerotia in soil, debris, host tissue and culture media.

Cylindrocladiella is, at present recognised by having small, cylindrical 0–1 septate spores, borne on monophialides. Conidiophores can either be subverticillate or penicillate. In the latter case the branches are usually arranged around a central stipe, which is non-septate, but separated from a basal cell by a septum. A thin-walled vesicle is formed at its apex, and this can develop a septum with age. Chlamydospores are more frequently arranged in chains than in clusters (Boesewinkel, 1982a).

COMMONLY ACCEPTED SPECIES

Both *C. scoparium* and *Ca. parva* occur in forestry regions of the Cape, Transvaal and Natal. Although various other species have been found in South Africa, they will be dealt with in a subsequent study. Species described in *Cylindrocladium* and *Cylindrocladiella* have been found to have a wide geographic distribution and host range (*Tables 1* and *2*).

TABLE 1. Host range, geographic distribution, symptoms and literature pertaining to Cylindrocladium *spp.*

Fungus	Geographic distribution	Hosts	*Eucalyptus* spp.	Symptoms	References on control	General references
Cylindrocladium avesiculatum Gill, Alfieri & Sobers Teleomorph: *Calonectria avesiculata* Schubert, El-Gholl, Alfieri & Schoulties	Georgia, Florida, USA	*Ilex* spp., *Rhododendron obtusum* *Pyranchanta coccinea*		Leaf spot, twig die-back, defoliation		Gill, Alfieri & Sobers, 1971; Schubert, El-Gholl, Alfieri & Schoulties, 1989; Sobers & Alfieri, 1972
Cylindrocladium brassicae Panwar & Bohra	India	*Brassica camprestis*		Not given		Panwar & Bohra, 1974
Cylindrocladium braziliensis (Batista & Ciferri) Peerally Synonym: *C. scoparium* Morgan var. *braziliensis* Batiste & Ciferri	Brazil	*Eucalyptus* spp.	*E. alba,* *E. citriodora,* *E. grandis,* *E. saligna*	Damping-off, die-back of adult trees		Batista, 1951; Peerally, 1974g
Cylindrocladium candelabrum Viegas	Brazil	*Annona* sp., *Luma* sp.		Leaf spot		Viegas, 1946
Cylindrocladium citri (Fawcett & Klotz) Boedijn & Reitsma Synonym: *Candelspora citri* Fawcett & Klotz	Florida, USA	*Citrus sinensis*		Fruit decay		Boedijn & Reitsma, 1950; Fawcett & Klotz, 1937; Schoulties, El-Gholl & Alfieri, 1982