A morphological study of *Dichapetalum cymosum* (Hook.) Engl. Part 1. The underground stem and root systems

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The underground structure of *D. cymosum* consists of a root system, as well as a complex system of lateral and adventitious stems. The stem system is mainly underground and only the apical parts of the branches appear above ground level. These erect aerial parts are 50 – 150 mm long and usually die back to below ground level each winter.

S. Afr. J. Bot. 1982, 1: 14 – 17

Die ondergrondse struktuur van *D. cymosum* bestaan uit 'n wortelsisteem, asook 'n ingewikkelde sisteem van sy- en adventiewe stingels. Die stingelsisteem is hoofsaaklik ondergronds en slegs die eindpunte van die takke steek bo die grondoppervlak uit. Hierdie regopstaande bogrondse dele is ongeveer 50 – 150 mm lank en sterf gewoonlik elke winter tot onder grondvlak terug.

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Introduction

Dichapetalum cymosum (Hook.) Engl. belongs to the family Dichapetalaceae and is the only representative of the genus in the Republic of South Africa. It has a limited distribution in the Transvaal and Natal where the plant is commonly known as 'gifblaar' owing to the fact that it is poisonous to stock. *D. cymosum* is a low-growing perennial shrub (Figure 1) with an extensive underground structure. From the literature (Leéman 1939; Mes & de Villiers 1944; West 1947 and Breteler 1973) it is obvious that the true nature of the underground structure of *D. cymosum* has not been settled satisfactorily. It is either referred to as a root system, or an underground stem system. The controversy led to the inclusion of this morphological study of the underground system of *D. cymosum* as part of a more extensive study of *D. cymosum* (Nel 1980).

Figure 1 A tuft of aerial flowering branches of *Dichapetalum cymosum* (Hook.) Engl.

Material and Methods

D. cymosum plants (3 years old) grown from seed at the University of Pretoria were used. The plants were grown in sandy soil in vertically maintained drainage pipes that were 1 m long and 0,1 m in diameter. The intact plants were carefully removed from the containers for photography and detailed organographic study. Parts of roots and stems were fixed in formic-acetic-alcohol for 48 h (Johansen 1940). The material was washed with water for 12 h, dehydrated and embedded in glycol methacrylate

(Feder & O'Brien 1968). The monomer mixture consisted of 94,5% (v/v) hydroxyethyl methacrylate, 5% (v/v) polyethelene glycol 200 and 0,5% (v/v) azobis-iso-butyronitrile (Feder & O'Brien 1968). Sections approximately 2 μm thick were cut with a Reichert OMU3 ultramicrotome, stained with periodic acid-Schiff's reagent (PAS) according to Feder & O'Brien (1968) using 0,5% 2,4-dinitrophenyl hydrazine (DNPH) in 15% acetic acid for 30 min, as a blocking agent. The sections were then stained for 1–5 min in 0,05% toluidine blue in a benzoate buffer at pH4,4 (Sidman *et al.* 1961).

Observations and Discussion

Morphology of the root and stem systems

Organography

Distinct primary roots with lateral roots were found in the unearthed plants (Figure 2). The diameters of the primary roots at their bases were approximately 25 mm and they reached a depth of 1 m. According to Mogg (1930) the primary root of older plants can reach a depth of 3 m and a diameter of 70 mm under natural conditions. The stem system described by Leéman (1939), which in fact might have been the root system, reached a depth of 30 m.

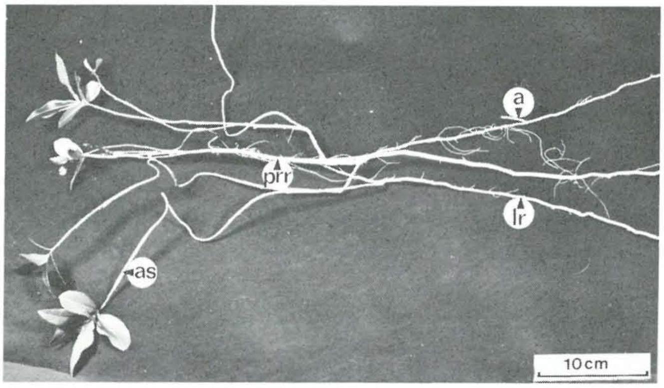

Figure 2 A young *D. cymosum* plant showing the primary root (prr), a lateral root (lr), a young (a) and older (as) adventitious stem.

Because the seed germination of *D. cymosum* was found to be hypogeal (see also Vahrmeijer 1970) and the seed remains of the plants studied were found close to the surface of the soil, only a small part of the primary stem of the plants was underground, while the primary root, forming lateral roots, deeply penetrated the soil (Figure 2). Adventitious buds developed spontaneously at various points on the taproot (and other major roots) down to 400 mm below ground level. These gave rise to vertically growing stems bearing scale leaves at the nodes of the underground portion and ordinary vegetative leaves on the aerial portion (Figure 2). The axillary buds on the primary stem as well as those on the adventitious stems may, at different stages, also develop into lateral, underground stems which may spread in a more or less horizontal direction for some distance before developing into aerial leafy branches. In this way a complex system of mainly underground adventitious and lateral stems is formed. The aerial parts of the plant which may also branch profusely, reach a height of 50–150 mm above ground level. Some aerial stems bear numerous flowers in early spring (Figure 1). The aerial stems which arise in early spring, usually die back to below ground level during the ensuing winter. *Dichapetalum cymosum* can therefore be regarded as a typical hemicryptophite (Raunkiaer 1934) or a geoxillic suffrutice (Theron, Morris & van Rooyen, in press). The underground system ramifies in all directions and may eventually cover a ground surface of approximately 30 m² (Brain 1939; Leéman 1939 and West 1947).

Anatomy of the root

Owing to the differentiation of the vascular cambium close to the root tip, all the sections used in this investigation contained secondary vascular tissue, although the tetrarch or pentarch primary xylem was still very clear (Figure 3). The xylem ray cells opposite the protoxylem poles are packed with starch grains (Figure 3), and constitute the greater part of the secondary xylem while the tracheal elements and fibres form narrow strips (Figure 3). The starch grains in the phloem ray cells are fewer and smaller than in the xylem ray cells. The primary phloem is soon obliterated as a result of secondary growth and no phloem fibres are present to demarcate the periphery of the stele (Figure 3). Part of the parenchymatous cortex can still be discerned in roots with a diameter of about 25 mm and the external surface of such older root segments is covered by a well-developed periderm (Figure 3).

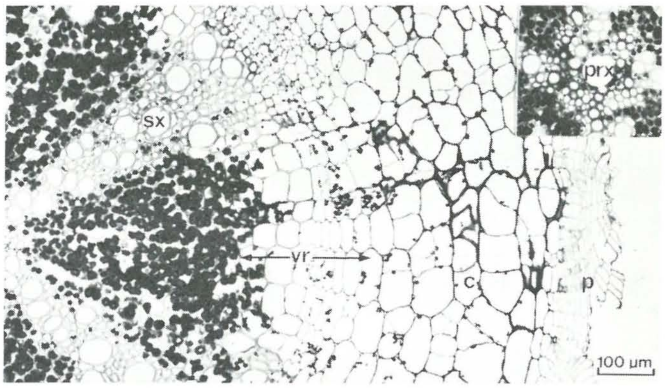

Figure 3 A transection of a primary root of *D. cymosum* showing an advanced state of secondary growth, the periderm (p), the cortex (c), vascular ray (vr) packed with starch grains and the tracheary elements of the secondary xylem (sx). Inset: the tetrarcheous arrangement of the primary xylem (prx) elements.

The origin of root buds

Although the ontogeny of root buds has not been studied, it is obvious from Figure 4 that the buds arise endogenously, opposite the protoxylem poles. Regarding this fact and Peterson's (1975) description of root bud development from the pericycle, it could be extrapolated that the root buds of *Dichapetalum cymosum* also develop from the pericycle.

Anatomy of the stem

In spite of the ephemeral nature of the aerial branches, they show relatively extensive secondary growth. Sections made 5 mm from the apex already show secondary xylem

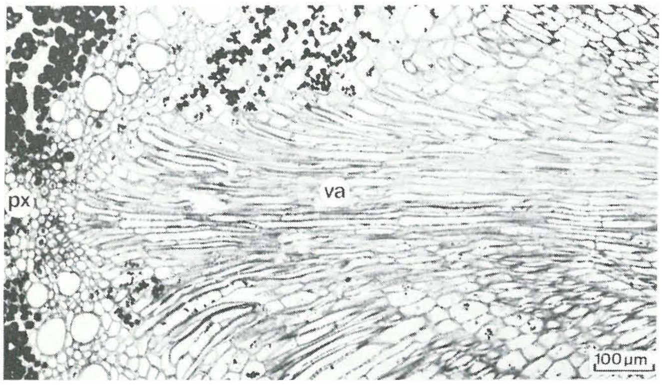

Figure 4 A transection of a primary root of *D. cymosum* to show the endogenous origin of the root bud (va, vascular elements of the root bud) opposite the protoxylem (px) poles.

and phloem as well as a hypodermal phellogen (Figures 5 & 6). The epidermis as well as most of the outer cortical and some of the inner cortex cells are tanniniferous (Figure 5). Primary phloem fibre caps are either continuous or alternate with interfascicular sclereids (Figures 5 & 6). The pith cells are thick-walled and some are tanniniferous (Figure 6).

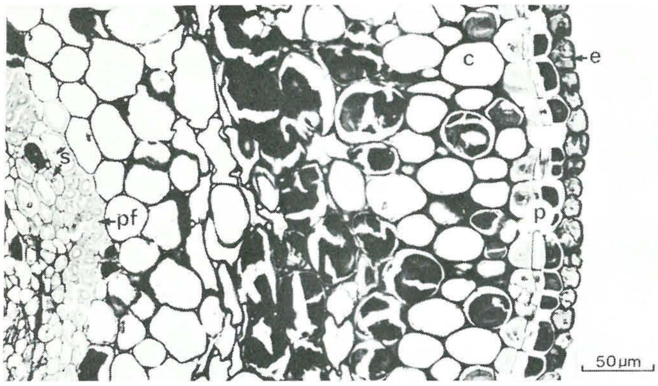

Figure 5 A transection of a young stem of *D. cymosum* showing the epidermis (e), the periderm (p), the cortex (c), the primary phloem fibre caps (pf) alternated by sclereids (s).

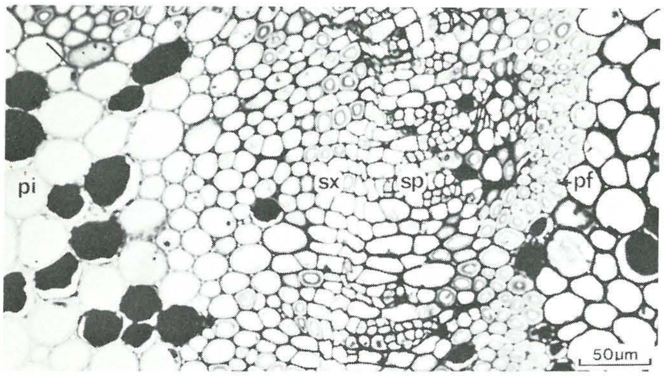

Figure 6 A transection of a young stem of *D. cymosum* showing the primary phloem fibre caps (pf), the secondary phloem (sp), the secondary xylem (sx) and the thick-walled pith cells (pi).

The young underground stems have basically the same structure as the aerial stems. Due to secondary thickening, older underground stems have very little primary tissue left. They are covered by a thick periderm (Figure 7) which, at this stage, has developed from the secondary phloem.

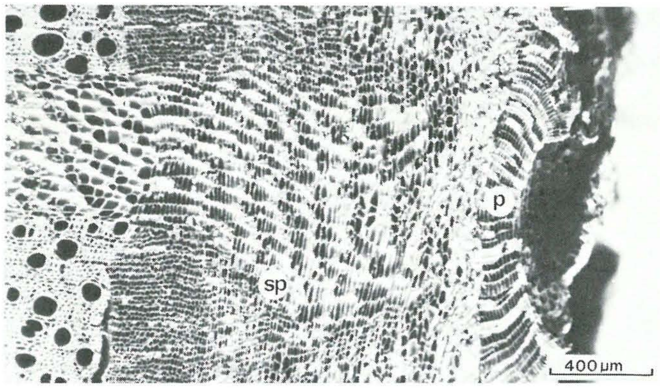

Figure 7 A scanning electron micrograph of a transection of an underground stem of *D. cymosum* with a thick periderm (p) which has developed from the secondary phloem (sp).

The wood is diffuse porous, with mostly solitary pores (Figure 8). Vessels are *ca.* 240 µm long with an average diameter of 80 µm, simple perforations and alternate bordered pits (Figures 9 & 10). Libriform fibres are absent and only fibre tracheids are present (Figure 11). The axial xylem parenchyma is paratracheal, vasicentric (Figure 12). The xylem rays are homogenous, both multi- and uniseriate. Multiseriate rays are up to 6 mm high. Ray cells are packed with starch grains (Figure 12).

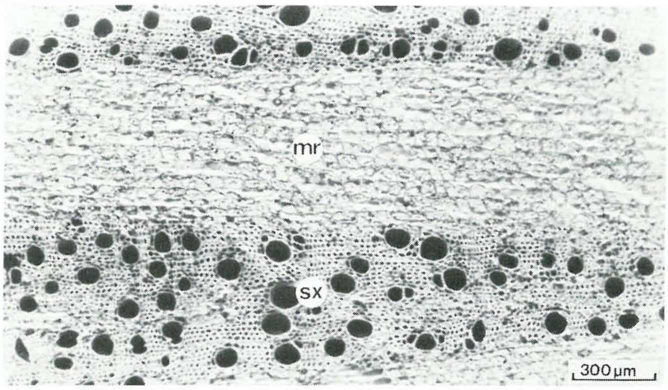

Figure 8 A scanning electron micrograph of a transection of the wood of an underground stem of *D. cymosum* showing the tracheary elements of the secondary xylem (sx) and multiseriate xylem ray (mr).

Conclusion

The complex underground structure of *Dichapetalum cymosum* consists of a definite primary root system with lateral roots. Adventitious stems originate from endogenously formed buds on the root system and lateral stems arise from axillary buds.

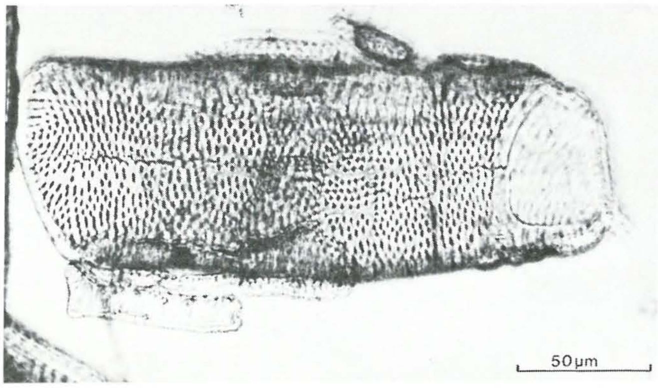

Figure 9 Vessel from a macerated *D. cymosum* stem.

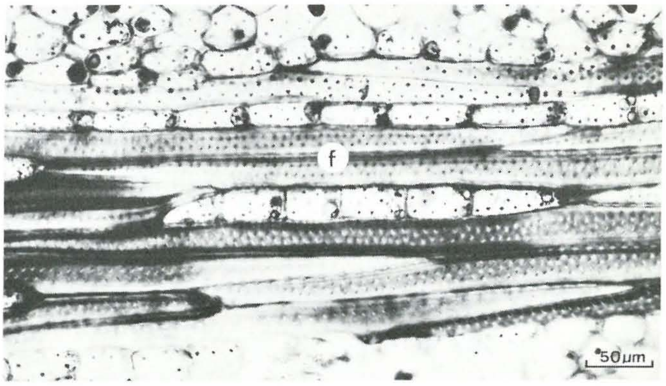

Figure 11 A tangential section of the wood of a *D. cymosum* stem showing the fibre tracheids (f).

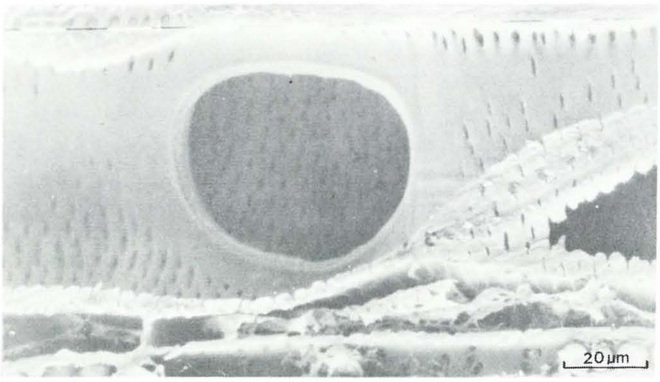

Figure 10 A scanning electron micrograph of a vessel showing a perforation.

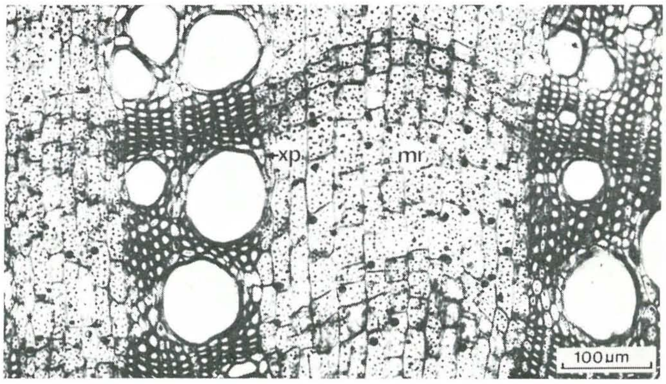

Figure 12 A transection of the wood of a *D. cymosum* stem, showing the paratracheal xylem parenchyma (xp) and a multiseriate xylem ray (mr).

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