



Fig. 1. (a) *Ceratobasidium theobromae* (Ct) on water agar showing *Rhizoctonia*-like hyphae with right-angled branching pattern and septa (black arrows); (b) the dolipore septum in Ct hyphae; (c) hyphae stained with Calcofluor White; (d) green spots on yellowing leaves several leaves behind the flush; (e) discolouration of vascular traces and; (f) Ct sporulation on VSD-infected cocoa in Sulawesi, Indonesia. Scale bar in (b) represents 5 µm. Figure (f) was taken by Prof. Philip Keane.

Common Name: *Ceratobasidium theobromae*

Disease: Vascular Streak Dieback (VSD)

Classification: K: Fungi P: Basidiomycota C: Agaricomycetes O: Ceratobasidiales F: Ceratobasidiaceae
Vascular Streak Dieback (VSD) caused by the tulasnelloid basidiomycete *Ceratobasidium theobromae* (*syn. Oncobasidium theobromae, Thanatephorus theobromae*) infects cocoa (*Theobroma cacao*) which is an economically important crop. This pathogen is an obligate biotroph that colonizes the xylem of cocoa plants.

Biology and Ecology:

Hyphae are *Rhizoctonia*-like ranging between 5 - 10 µm in width with dolipore septa at junctions. Vegetative cells colonising xylem vessels are binucleate. The ellipsoid basidiospores (the suspected agents of infection) are about 17.5 - 7.5 µm in size, and are produced from sporophores bearing conically shaped sterigmata. Basidia are holobasidiate and swollen at the apex. As a near-obligate parasite, Ct cannot be maintained in subculture after isolation from infected plant materials.

VSD symptoms include: (1) green spotted leaf chlorosis; (2) necrotic leaf blotches with yellow chlorotic edges; (3) blackening of xylem tissue, visible at leaf scars from abscised leaves (three dots) or as dark streaks when stems are split; (4) rough bark as a result of swollen lenticels due to stress and (5) 'broomstick' symptoms as a result of proliferation and subsequent death of axillary buds following leaf abscission. Basidia form after several days of wet weather, releasing basidiospores before dawn. Basidiospores lose viability after exposure to sunlight, indicating that spores spread the disease only a short distance.

Distribution:

VSD was first described in the 1960s in Papua New Guinea from a still unknown indigenous host species. VSD is found in cocoa-growing areas in Burma, China (Hainan Island), southern India, Indonesia, Malaysia, Papua New Guinea (main island, New Britain and New Ireland), the Philippines and Thailand.

Impact:

Indonesia is the third largest cocoa producer (10% of global production) while PNG contributes about 1%. In 2012, VSD caused an estimated loss of 76,000 tons.

Host Range:

The main host is cocoa. The only known reported case in another plant host was on avocado seedlings in 1989 on Kar Kar Island (Papua New Guinea) which displayed similar symptoms except for the green spotting of leaves.

Management options:

Monitoring the presence of Ct before distributing cacao germplasm and planting materials is essential to prevent the spread of the disease. The development of reliable specific molecular markers to identify Ct would facilitate detection of the pathogen in infected plants. The international movement of cocoa germplasm requires a pre-export quarantine period of 6 months and clearance through the International Cocoa Quarantine Centre in the UK.

Effective management of the disease in the field involves strict nursery hygiene, the use of genotypes with partial resistance and good cultural practices e.g. new planting locations distant from older diseased cocoa plants or the covering of plants in nurseries to exclude inoculum. Pruning of cocoa trees for the removal of infected branches by trained farmers or as a means to increase aeration and sunlight on the foliage would decrease sporulation and infection by the pathogen. Under experimental conditions, systemic DMI fungicides have been shown to control VSD however they proved uneconomic.

Further Reading: Anderson RD (1989) Australasian Plant Pathology 18 (4): 96–97; Guest D, Keane P (2007) Phytopathology 97:1654-1657; Keane PJ, Prior C (1991) Phytopathological Papers, 33: 1-39; McMahon P, Purwantara A (2016) In: Bailey BA, Meinhardt LW (eds) Cacao diseases: a history of old enemies and new encounters. Springer, Cham, pp 307–335; Samuels GJ et al. (2012) Fungal Biol. 116 (1):11-23; Roberts P (1999) Rhizoctonia-forming Fungi. A Taxonomic Guide. Royal Botanic Gardens, Kew.; Talbot PHB, Keane PJ (1971) Aust. J. Bot. 19:203-206

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