Branch, Stem and Collar Rot of Apple caused by *Phytophthora* Species of the '*cactorum* Group'

BARK rot of apple trees, caused by *Phytophthora cactorum* (Leb. and Cohn) Schroeter, has been reported from most of the world's major apple-growing areas. Outbreaks of this soil-borne disease are often epidemic in character and may result in the complete bark-girdling and death of many trees.

Both *P. cactorum* and the closely related *P. syringae* Kleb. have been shown to be pathogenic to apple bark[1-3]; but a recent report from Holland[4] is the only published record of crown or collar rot of apple caused by *P. syringae*. This fungus has been isolated from naturally infected trees in Essex, Kent and Suffolk, and it now appears possible that *P. syringae* bark rot may be more widespread in England than that caused by *P. cactorum*, which in Europe and New Zealand primarily affects the variety Cox's Orange Pippin. *P. syringae* has been isolated from mature trees of Cox's Orange Pippin, Worcester Pearmain, Laxton's Fortune and Superb, and Miller's Seedling, and from one-year-old trees of Cox, Worcester and Tydeman's Early Worcester. *P. syringae* thus appears to be capable of attacking a wider range of varieties under orchard conditions than *P. cactorum*.

Disease outbreaks in 20–30-year old trees tend, like those caused by *P. cactorum*, to be widespread in the first instance. Trees are rarely completely girdled before external symptoms are visible; bark lesions frequently extend up the trunk in narrow tongues seldom spreading more than one-third around it.

Inoculation investigations indicate that susceptibility to both species varies markedly with the stage of host development, and that *P. syringae* can cause extensive damage at low temperatures in February and March when inoculations with *P. cactorum* have frequently failed. Resistance to both pathogens is lowest during and for some weeks following budburst. Extension of established *P. cactorum* lesions may continue in the subsequent summer and winter, whereas *P. syringae* lesions are often arrested in the summer; subsequent bark splitting and callus formation around the lesion may stop further extension and trees then recover without treatment.

Both species are difficult to isolate from rotted bark, especially *P. syringae* which grows and produces sporing structures very slowly. In the most successful isolation method, 5-mm cubes of bark from the margins of active lesions were irrigated in running tap water for 24–48 h and then incubated at laboratory temperature in a shallow layer of still water for a further 12 h. Under a wide-field binocular microscope *P. cactorum* was detected by the presence of the characteristic, coarse, irregular hyphæ, frequently bearing sporangia. The hyphæ of *P. syringae* were less readily seen for they protruded only a short distance from the bark blocks and rarely formed sporangia. Suspect hyphæ were inserted into apple fruits on which firm, brown, somewhat irregular lesions developed after 5–10 days and isolations from the margins of these on to cornmeal agar generally yielded pure cultures of the pathogen. Incubation temperatures should not exceed 20° C. Most isolates of *P. cactorum* readily produce sporangia and oospores, but *P. syringae* does so very sparsely and may fail to form oospores except in old cultures. Many *P. syringae* isolates form characteristic complex chains of hyphal swellings. All isolates of *P. syringae* have failed to grow at 25° C, the optimum temperature for *P. cactorum*.

Investigations of *Phytophthora* spp. in orchard soils have revealed marked differences in their seasonal activity, and also that the third member of the '*cactorum* group', *P. citricola* Sawada (syn. *P. cactorum* var. *applanata* Chester), is widespread and abundant. This species causes black root rot of hops[5], and as certain isolates have been shown by the authors and Smith[6] to be very mildly pathogenic to apple bark, all species of the '*cactorum* group' may be implicated to varying degrees in collar and crown rot diseases of apple. The Malling and Malling–Merton apple rootstocks have been tested[2] for resistance to *P. cactorum*; tests with *P. syringae* are in progress together with comparative studies of the resistance of apple scion varieties to both pathogens.

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Apple Scald Induction by Anaerobiosis

SCALD is a physiological disorder which seriously affects the appearance and utility of the apple fruit. It initially appears during, or following, cold storage as a brown discoloration of the epidermis of the green-coloured portion of the fruit. With advancement, it affects the anthocyanin-bearing epidermis, the hypodermis and the adjacent cortex. Extensive investigations over the past 60 years have provided several theories[1-7]; but relatively little knowledge pertaining to the cause of scald. Several means of control have been devised[2,8,9]. As early as 1903[1], it was observed that scald formation was influenced by the availability of oxygen to the fruit. Our results now provide a basis for defining the ætiology of apple scald in terms of basic cause and effect components, anaerobiosis and aerobiosis.

Fruits of the McIntosh and Red Rome varieties of apple (*Malus sylvestris*, Miller) stored for 3 months at 0°–2° C were used for this investigation. Scald-free apples were placed in chambers at 20° C through which either air or nitrogen gas was supplied for various durations at a rate to provide two atmosphere changes per hour. The fruits were examined for scald at the termination of nitrogen

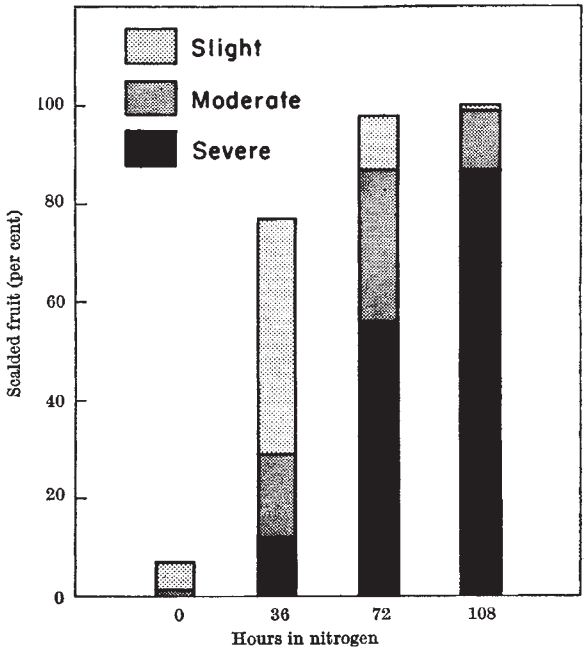

Fig. 1. Percentage and severity of scald on McIntosh apples following anaerobiosis treatments after 7 days in air at 20° C