Prepared by CABI and EPPO for the EU
under Contract 90/399003

Data Sheets on Quarantine Pests

Phytophthora cinnamomi

IDENTITY

Name: *Phytophthora cinnamomi* Rands
Taxonomic position: Fungi: Oomycetes: Peronosporales
Common names: Root and fruit rot of avocado (English)
Pourriture des racines, pourriture du collet (French)
Phytophthora-Wurzel und Stammfäule (German)
Podredumbre de la raíz (Spanish)
Bayer computer code: PHYTCN
EU Annex designation: II/B

HOSTS

The host range is very wide; *P. cinnamomi* is the most widely distributed *Phytophthora* species, with nearly 1000 host species (Zentmyer, 1983). The principal food crop hosts are avocados (*Persea americana*), with which the EU is exclusively concerned), and pineapples (*Ananas comosus* on which it causes root and heart rot. *P. cinnamomi* also attacks *Castanea*, *Cinnamomum*, Coniferales, Ericaceae (including *Rhododendron* spp.), *Eucalyptus*, *Fagus*, *Juglans*, *Quercus* and many ornamental trees and shrubs. Its recorded host range includes most of the temperate fruit trees, but these are not important hosts in practice. In the EPPO region, avocados are a significant host, in the limited areas where they are grown.

GEOGRAPHICAL DISTRIBUTION

The geographical origin of *P. cinnamomi* is not clearly established. It was first described in Indonesia (Sumatra). Zentmyer (1988) suggests that the species is indigenous in Southeast Asia and in southern Africa, and spread across the Pacific to Latin America in the 18th Century. There is, however, no very clear evidence how such spread occurred. The appearance of the fungus in the EPPO region is much more recent. There is no useful purpose in giving a geographical distribution for countries where *P. cinnamomi* has been recorded on avocado, since the fungus is soil-borne, not host-specialized and can freely move from one crop to another. *P. cinnamomi* certainly already occurs on avocado in several Mediterranean countries.
EPPO region: Belgium, France (including Corsica), Germany, Greece (except Crete), Ireland, Israel, Italy, Morocco, Netherlands, Portugal (including Azores), Russia (European), Spain (including Canary Islands), Switzerland, Turkey, UK (England), Yugoslavia.
Asia: China (Jiangsu), India (Andhra Pradesh, Tamil Nadu, West Bengal), Indonesia (Java, Sumatra), Israel, Japan (Honshu, Ryukyu Archipelago), Malaysia (Peninsular, Sabah), Philippines, Taiwan, Turkey, Viet Nam.
Africa: Burundi, Cameroon, Congo, Côte d'Ivoire, Gabon, Guinea, Kenya, Madagascar, Morocco, Réunion, Rwanda, South Africa, Uganda, Zaire, Zambia, Zimbabwe.

North America: Canada (British Columbia), Mexico, USA (Alabama, Arizona, Arkansas, California, Delaware, Florida, Georgia, Hawaii, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia).
Central America and Caribbean: Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Panama, Puerto Rico, St. Lucia, St. Vincent and Grenadines, Trinidad and Tobago.
South America: Argentina, Bolivia, Brazil (Goias, São Paulo), Chile, Colombia, Ecuador, Guyana, Peru, Venezuela.
Oceania: Australia (New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria, Western Australia), Cook Islands, Fiji, Micronesia, New Zealand, Papua New Guinea.
EU: Present.
Distribution map: See IMI (1991, No. 302).

BIOLOGY

Sporangia release motile zoospores into soil water, and these swim to small roots (a chemotactic response to root exudates), encyst and germinate on the root surface. Penetration occurs within 24 h of germination (Zentmyer, 1961). The fungus then spreads in the young feeder roots causing a rot which may extend into the base of the stem. Propagules may also be splashed onto and infect aerial parts of the plant. Temperature, moisture and pH all influence growth and reproduction of the fungus. Effects of these factors have been reviewed by Weste (1983).

P. cinnamomi survives in dead plant material (survival influenced by soil matric potential) and can survive for long periods in this substrate (Shea *et al*., 1980). This saprophytic phase can allow an increase in the population of the pathogen. *P. cinnamomi* may also survive in the soil as mycelium, sporangia, zoospore cysts, chlamydospores and oospores and survival can be extended in the presence of an organic substrate (Weste & Vithanage, 1979). Mycelium of *P. cinnamomi* can survive for at least 6 years in moist soil (Zentmyer & Mircetich, 1966). Zoospore cysts can survive for at least 6 weeks at between -5 and -15 bar soil matric potential (MacDonald & Duniway, 1978). *P. cinnamomi* is heterothallic; oospores are very rare, and are slow to germinate. Varying germination periods may help to maintain a low but continuing population. Chlamydospore survival is also influenced by soil matric potential, and chlamydospores can survive for at least 6 years if soil moisture exceeds 3% (Zentmyer & Mircetich, 1966).

Chlamydospores form in soil, gravel or plant tissue during dry periods, germinate under favourable (moist) conditions and grow to form mycelia and sporangia or more chlamydospores. The latter may, in turn, remain dormant until conditions become suitable, then germinate to produce infective mycelia, sporangia and zoospores, or more chlamydospores. This cycle may continue for at least 5 years, provided there is a nutrient source (organic matter) and a non-competitive soil microflora.

Although *P. cinnamomi* was originally mainly reported in tropical and subtropical countries, it can apparently survive and develop in cooler countries, and does not seem to be obviously restricted by growing season or winter temperatures.

DETECTION AND IDENTIFICATION

Symptoms

P. cinnamomi causes a rot of fine feeder roots, leading to dieback and death of host plants. Larger roots are only occasionally attacked. Other symptoms include wilt, stem cankers (with sudden death of tree), decline in yield, decreased fruit size, gum exudation, collar rot (if infected through grafts near soil level).

Morphology

Hyphae with frequent nodules, up to 8 µm thick, hyphal swellings in clusters, typically spherical, average 42 µm diameter. Sporangiophores thin (3 µm), proliferating through the empty sporangium or occasionally branched. Sporangia broadly ellipsoid to ovoid, 57 x 33 µm (up to 100 x 40 µm), no papilla, slight apical thickening, not shed. Oogonia average 40 µm diameter, wall smooth, becoming yellowish with age. Antheridia amphigynous, 21-23 x 17 µm. A full description is given in Waterhouse & Waterston (1966).

MEANS OF MOVEMENT AND DISPERSAL

On a local scale, the pathogen can be moved naturally by soil-splash, by wind-blown soil or debris, or by water movement and run-off in drainage/irrigation ditches. The most likely means of more distant movement is in contaminated soil or plant debris. Propagules can also be carried on machinery used for cultivation or harvesting and on seed. Movement of contaminated road gravel has resulted in initiation of new epidemics in Australia (Weste, 1975). Movement of contaminated soil with container-grown ornamentals can spread the pathogen to disease-free areas, and this is the most probable pathway for international spread. Avocado planting material (scions, seeds) should not normally carry the disease, but rootstock plants could do so, if these are traded as such.

PEST SIGNIFICANCE

Economic impact

The most significant food crop losses due to *P. cinnamomi* root rot occur in avocado, particularly in California, USA (Coit, 1928), Australia (Allen *et al*., 1980) and South Africa (Toerien, 1979). The disease on avocado has recently been reviewed by Coffey (1992). Severe epidemics of *P. cinnamomi* have caused extensive damage to *Eucalyptus* forests in Australia (Weste & Taylor, 1971). In temperate areas, *P. cinnamomi* causes serious damage to high-value ornamental trees and shrubs produced by the nursery stock industry (Smith, 1988). It is also reported to infect trees in amenity plantings, forests or orchards, but there is little or no quantitative record of this, which suggests that losses are only minor.

Control

Cultural control measures include alleviation of high soil moisture levels and improving aeration by increasing drainage, and attention to mineral nutrition. Elements of the soil microflora suppress *P. cinnamomi* in some soils and may be potential biocontrol agents (Stirling *et al*., 1992). These factors were reviewed by Weste (1983). Soil solarization also controls *P. cinnamomi* on young avocado plants (Kotzé & Darvas, 1983). Smith *et al.* (1983) reviewed the combination of measures for controlling the disease in nurseries. An integrated approach is generally taken to control *P. cinnamomi* on avocado (Coffey, 1987).

Chemical control is possible with systemic fungicides, particularly fosetyl-aluminium (and phosphonic acid) and metalaxyl (e.g. Whiley *et al*., 1986), applied by soil drench, foliar spray or trunk injection. Addition of elemental sulfur reduced disease incidence in pineapple, apparently through effects on soil pH (Pegg, 1977).

Some rootstocks of avocado show tolerance (Kotzé & Darvas, 1983), and much work is reported on testing for resistance in avocado.

Phytosanitary risk

The pathogen is already present in much of the EPPO region, and it is not clear that there are any whole countries or large areas within countries where *P. cinnamomi* is known not to occur. As for other *Phytophthora* spp. on woody plants, low levels of infestation may be difficult to recognize (Tsao, 1990). *P. cinnamomi* has not been listed as a quarantine pest by EPPO or by any other regional plant protection organization. In a recent survey of possible new quarantine pests for the EPPO region, it was rated as doubtful. Avocado growers should certainly seek to exclude *P. cinnamomi* or keep populations down to low levels, by operating strict hygienic measures. However, it is not clear that imported material requires special measures, different from those taken domestically.

PHYTOSANITARY MEASURES

Hygienic precautions can be applied to exclude *P. cinnamomi* from a place of production (Smith, 1988). Unsterilized soil or growing medium, or farm machinery, should not be brought in. Introduced plants should be kept apart until their phytosanitary status has been checked. All propagation should be done from healthy plants or seed. Cultural measures should be taken to reduce the risk of spread in case of introduction. If land does become infested, incidence of *P. cinnamomi* can be reduced, if not necessarily eliminated, by leaving the land under non-susceptible crops for at least 4 years, and by applying various control measures (see Pest significance). Baum & Pinkas (1988) report on the first appearance of *P. cinnamomi* on avocado in Israel, and on the attempt to eradicate the disease, which was not successful.

BIBLIOGRAPHY

Allen, R.N.; Pegg, K.G.; Forsberg, L.I.; Firth, D.J. (1980) Fungicidal control in pineapple and avocado of diseases caused by *Phytophthora cinnamomi*. *Australian Journal of Experimental Agriculture and Animal Husbandry* **20**, 119-124.

Baum, D.; Pinkas, Y. (1988) [Phytophthora root rot six years after its first appearance in Israel]. *Hassadeh* **69**, 274-277.

Coffey, M.D. (1987) Phytophthora root rot of avocado: an integrated approach to control in California. *Plant Disease* **71**, 1046-1052.

Coffey, M.D. (1992) Phytophthora root rot of avocado. In: *Plant diseases of international importance. Volume III. Diseases of fruit crops* (Ed. by Kumar, J.; Chaube, H.S.; Singh, U.S.; Mukhopadhyay, A.N)., pp. 423-444. Prentice Hall, Englewood Cliffs, USA.

Coit, J.E. (1928) Pests and diseases of the avocado. *California Avocado Society Yearbook*, pp. 18-21.

IMI (1991) *Distribution Maps of Plant Diseases* No. 302 (edition 6). CAB International, Wallingford, UK.

Kotzé, J.M.; Darvas, J.M. (1983) Integrated control of avocado root rot. *California Agricultural Society Yearbook* **67**, 83-86.

MacDonald, J.D.; Duniway, J.M. (1978) Influence of the matric and osmotic components of water potential on zoospore discharge in *Phytophthora*. *Phytopathology* **68**, 751-757.

Pegg, K.G. (1977) Soil application of elemental sulphur as a control of *Phytophthora cinnamomi* root and heart rot of pineapple. *Australian Journal of Experimental Agriculture and Husbandry* **17**, 859-865.

Shea, S.R.; Gillen, K.J.; Leppard, W.I. (1980) Seasonal variation in population levels of *Phytophthora cinnamomi* Rands in soil in diseased, freely-drained *Eucalyptus marginata* Sm. sites in the northern jarrah forests of south-western Australia. *Protection Ecology* **2**, 135-156.

Smith, P.M. (1988) *Phytophthora cinnamomi*. In: *European handbook of plant diseases* (Ed. by Smith, I.M.; Dunez, J.; Lelliott, R.A.; Phillips, D.H.; Archer, S.A.), pp. 213-215. Blackwell Scientific Publications, Oxford, UK.

Smith, P.M.; Brooks, A.V.; Evans, E.J.; Halstead, A.J. (1983) Pests and diseases of hardy nursery stock, bedding plants and turf. In: *Pest and disease handbook*, 2nd edition (Ed. by Scopes, N.; Ledieu, M.), pp. 473-556. British Crop Protection Council, Croydon, UK.

Stirling, A.M.; Hayward, A.C.; Pegg, K.G. (1992) Evaluation of the biological control potential of bacteria isolated from a soil suppressive to *Phytophthora cinnamomi*. *Australasian Plant Pathology* **21**, 133-142.

Toerien, J.C. (1979) Seasonal incidence of ring-neck on avocados and possible causes. *South African Avocado Growers' Association Research Report* **3**, 49-51.

Tsao, P.H. (1990) Why many phytophthora root rots and crown rots of tree and horticultural crops remain undetected. *Bulletin OEPP/EPPO Bulletin* **20**, 11-18.

Waterhouse, G.M.; Waterston, J.M. (1966). *Phytophthora cinnamomi*. *CMI Descriptions of Pathogenic Fungi and Bacteria* No. 113. CAB International, Wallingford, UK.

Weste, G. (1975). The distribution of *Phytophthora cinnamomi* within the National Park, Wilsons Promontory, Victoria. *Australian Journal of Botany* **23**, 67-76.

Weste, G. (1983) Population dynamics and survival of *Phytophthora*. In: *Phytophthora, its biology, taxonomy, ecology and pathology* (Ed. by Erwin, D.C.; Bartnicki-Garcia, S.; Tsao, P.H.), pp. 237-258. American Phytopathological Society, St. Paul, USA.

Weste, G.; Taylor, P. (1971) The invasion of native forest by *Phytophthora cinnamomi* 1. Brisbane Ranges, Victoria. *Australian Journal of Botany* **19**, 281-294.

Weste, G.; Vithanage, K. (1979) Survival of chlamydospores of *Phytophthora cinnamomi* in several non-sterile, host-free forest soils and gravels at different soil water potentials. *Australian Journal of Botany* **27**, 1-9.

Whiley, A.W.; Pegg, K.G.; Saranah, J.B.; Forsberg, L.I. (1986) The control of phytophthora root rot of avocado with fungicides and the effect of this disease on water relations, yield and ring neck. *Australian Journal of Experimental Agriculture* **26**, 249-253.

Zentmyer, G.A. (1961) Avocado diseases in the Americas. *Ceiba* **9**, 61-79.

Zentmyer, G.A. (1983) The world of *Phytophthora*. In: *Phytophthora, its biology, taxonomy, ecology and pathology* (Ed. by Erwin, D.C.; Bartnicki-Garcia, S.; Tsao, P.H.), pp. 1-8. American Phytopathological Society, St. Paul, USA.

Zentmyer, G.A. (1988) Origin and distribution of four species of *Phytophthora*. *Transactions of the British Mycological Society* **91**, 367-378.

Zentmyer, G.A.; Mircetich, S.M. (1966) Saprophytism and persistence in soil by *Phytophthora cinnamomi*. *Phytopathology* **56**, 710-712.