

PHYTOPHTHORA CANKER OF MACADAMIA TREES

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In cultivation in California as well as in Florida, Hawaii, and Australia, the macadamia trees (*Macadamia integrifolia* and *M. tetraphylla*) has been singularly free of diseases. No major fungus or virus diseases have been encountered with this nut-bearing tree; a flower blight caused by the fungus *Gloeosporium* has occasionally been a minor problem in Hawaii. Early investigations with this plant have indicated that the roots are resistant to the avocado root rot fungus, *Phytophthora cinnamomi* (2, 4).

This resistance was evident on planting macadamia seedlings in soil infested with the root rot fungus, and waterlogging the soil. Observations of macadamia trees replanted in soils from which avocado trees had been removed because of root rot also revealed that macadamias made good growth in these infested soils.

In October 1959, however, trunk cankers were observed on two macadamia trees in a commercial planting in Vista (3). The trees had been replanted in an area where avocado trees had been removed because of *Phytophthora* root rot, caused by *Phytophthora cinnamomi*. One of these was a *Macadamia integrifolia* seedling, the other was clone 508 of *M. integrifolia* grafted on a *M. Tetraphylla* seedling. In the latter case the canker occurred on both rootstock and scion.

One canker had progressed to the extent of girdling the base of a branch approximately $\frac{3}{4}$ inch in diameter. Excision of the bark revealed brown discoloration in bark and outer wood, extending in a narrow streak from ground level to the girdled lateral branch 18 inches above the ground. No external symptoms of the canker were visible on the bark except for a slight gum exudation. The second tree had two slightly sunken and rough areas on the lower trunk; discoloration in bark and outer wood was also found here.

Culturing pieces of bark and wood tissue from the active-appearing margins of the lesions on corn meal agar resulted in isolation of *Phytophthora cinnamomi* from both trees.

Sixteen macadamia seedlings (8 *M. tetraphylla* and 8 *M. integrifolia* seedlings) were inoculated in October 1959 with the isolate of *P. cinnamomi* obtained from the *M. integrifolia* seedling (isolate SD 808), and with an isolate from avocado roots (isolate SB 216). The seedlings were vigorous and ranged from 10 to 14 inches in height. Slits were made in the bark of the lower stem of the seedlings, 5 mm disks from a potato-dextrose agar culture of the fungus were placed in the wound, and the wound was wrapped with adhesive tape. Four other trees were not wounded but inoculum was placed on the stems, covered with moist cotton, and wrapped with adhesive tape. Four

trees were wounded but not inoculated.

The first visible symptoms from the inoculations appeared in 3 weeks, and by 4 weeks after inoculation, 9 of the 12 seedlings which were wound-inoculated had developed cankers of varying extent. *P. cinnamomi* was readily re-isolated from lesions on these stems. Two of the *M. integrifolia* and one of the *M. tetraphylla* seedlings died within 4 months after inoculation. Some gum exudations and sunken, cracked areas on the stems were apparent on other seedlings. No lesions developed from inoculations made without wounding. Both isolates of *P. cinnamomi* were pathogenic to macadamia. No additional seedlings developed cankers up to 10 months after inoculation. There was indication from these first inoculation tests that *M. integrifolia* was more susceptible to the canker disease than was *M. tetraphylla*.

To provide further information on susceptibility of the two species of *Macadamia* and to further study the progress of the disease, 50 additional seedlings were inoculated in March 1960. Twenty-five of these were *M. integrifolia* seedlings, and 25 were *M. tetraphylla* seedlings.

The same inoculation method was used as described above, with mycelial disks of *Phytophthora cinnamomi* being placed in small cuts made in the lower stem of each seedling. All cuts were wrapped with tape following inoculation with the fungus. Results of these inoculations are presented in Table 1.

Table 1. Susceptibility of MACADAMIA species to PHYTOPHTHORA CINNAMOMI.

Species	Number of trees	Number with canker	Average length of cankers
<i>M. integrifolia</i>	25	20	22.5 mm
<i>M. tetraphylla</i>	25	4	10.0 mm

The above data, taken 11 months after inoculation, indicate that *M. integrifolia* seedlings are much more susceptible to *Phytophthora* canker than are *M. tetraphylla* seedlings. Two of the four *M. tetraphylla* seedlings affected, however were killed rapidly by the disease, so that there is evidently considerable individual variation within the species. Two of the *M. integrifolia* seedlings were also killed by the disease; in four others the top was killed and many leaves were killed or shed.

Symptoms were quite variable in the various seedlings, ranging from death of the seedling within two months after inoculation to merely light streaking in the wood. Many of the young trees showed extensive gum exudations above the point of inoculation; in some cases the bark was cracked and growth of the stem was restricted below the inoculation point. A number of the infected seedlings made little growth.

In California and in Florida the senior author of this paper had observed another somewhat similar bark disorder of macadamia trees which is not caused by *Phytophthora cinnamomi*. In the case of this other disease, gum exudations occur but they are usually discrete and not connected with a definite canker traceable to the ground as in the case of *Phytophthora* canker. Bark is also roughened and cracked in

some cases. No pathogen has yet been isolated from this bark disorder; the problem is still under investigation.

In Hawaii, Hamilton and Holtzmann described a bark disorder of macadamia trees in 1958 (1). No pathogen has been isolated in the case of this disease, and the problem is restricted to one clone of the variety "Wailua."

Following discovery of the *Phytophthora* canker problem in California and proof of the pathogenicity of *Phytophthora cinnamomi* to macadamia trunks, a survey was made of macadamia trees replanted in areas in southern California where avocado trees had been removed because of *Phytophthora* root rot. Several hundred trees were examined in these old root rot sites; of these, only one additional case of *Phytophthora* canker was found. This was on a *M. integrifolia* seedling.

The results of these inoculations and of the examination of trees in the field show that trunks or branches of macadamia trees, particularly of *M. integrifolia* types, are susceptible to the avocado root rot fungus when it is introduced through a wound. The fact that few trees were found in the field with this disease, even though replanted directly in sites where avocado trees were removed because of root rot, indicates that the canker may not be a serious problem under California conditions. If it should become more of a problem, there is a good possibility of preventing the disease, as in the case of citrus gummosis, by spraying the lower trunk of trees with Bordeaux mixture and avoiding wounding. Control of this type of disease by tree surgery is also possible if cankers are detected in a sufficiently early stage.

It is evident that macadamia trees are still quite resistant to the root rot phase of *Phytophthora cinnamomi*, as indicated by the consistent lack of root rot development when seedlings have been planted experimentally in soil heavily infested with this fungus, and in the case of trees replanted in old avocado root rot areas in a number of locations in southern California (2).

LITERATURE

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