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PREVENTION OF PHYTOPHTHORA ROOT ROT DEVELOPMENT IN NEW PLANTINGS, AND OTHER PHASES OF ROOT ROT RESEARCH

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Our research on the avocado root rot problem can be divided into three phases, which essentially are interrelated but present different aspects of the situation:

1) Prevention of disease development in new plantings. This phase will be emphasized in this paper.
2) Control of the disease in groves where it is now present.
3) Control in future plantings in diseased or healthy sites by use of resistant rootstocks.

A brief summary of results applying to these three phases and of projected research in these aspects follows.

1. Prevention of disease development in new plantings.

There are several aspects of this phase of control of Phytophthora root rot; one of the most important is the avoidance of disease in new plantings by planting in well-drained soil. This is a means of disease prevention that cannot be too strongly emphasized. There is a very close connection between disease development and excess soil moisture. In the presence of **Phytophthora cinnamomi**, root rot invariably develops on poorly drained soil.

Several means of spread of the fungus have been determined in recent years; knowledge of these is important in preventing development of disease in new plantings as well as in healthy established plantings, particularly those on poorly draining soil. These means of spread include: nursery stock, movement of moist infested soil, movement of water over soil infested with **P. cinnamomi**, and avocado seed infested with **P. cinnamomi**.

To prevent introduction of the avocado root rot fungus into an avocado planting therefore, the following precautions should be taken:

A. Insist on healthy, vigorous nursery stock grown in fumigated or steamed soil, or in the case of field-grown trees, from a nursery site that does not favor disease development. Nurseries should not be planted on old avocado soil, on areas that tend to

stay wet or are poorly drained, or on areas adjacent to groves with root rot.

Equal care should be used in selecting ornamental plants for planting on an avocado property. **Phytophthora cinnamomi** attacks many woody plants in addition to the avocado, and could be carried onto an avocado property in poor stock. For trees or other plants grown in containers, soil fumigation, steaming, or drying will insure soil free of Phytophthora. Methyl bromide is an effective fumigant, when used under a plastic cover at the dosage of 3 pounds per 100 cubic feet of soil for 24 hours. Steaming soil to 180°F. for from ½ to 1 hour is effective. Drying soil to a very low moisture content will also kill the fungus.

B. All possible and practical steps should be taken to prevent movement of soil or water from diseased areas into your grove. The fungus can be moved by any means by which moist soil is moved, as on cultivation equipment, shovels, soil augers, shoes. In laboratory cultures made this past winter **P. cinnamomi** has been recovered from mud scraped from shoes following walking over an area of soil infested with the fungus. Small pieces of equipment, as shovels, augers, trowels, should be washed well after using around diseased trees and wiped or dipped in alcohol or formaldehyde solution. A 70 per cent solution of methanol, ethanol or rubbing alcohol can be used. Commercial formalin or formaldehyde should be diluted to make a 5 per cent solution. Cultivation equipment should be used first in the healthy portion of the grove, then washed and allowed to dry thoroughly after using in the diseased section.

The fungus also can be spread downhill from an area of infection by means of surface drainage water, as it forms swimming spores which are readily moved in water. Precautions include installation of drains to take care of surface run-off if a diseased area lies above a healthy grove, and prevention of soil movement from diseased to healthy areas particularly when soil is wet.

C. The root rot fungus can also be spread in avocado seed, if the fruit from which the seed was taken were allowed to remain for several days on ground which is infested by the fungus. Ideally all seed used for planting should be taken from fruit picked from the trees. Where this is not possible, seed should be carefully inspected for light-brown discolored areas in the cotyledons, and suspicious-looking seed discarded.

To be certain of freedom from fungus infection in seed taken from the ground, as noted in another paper in this Yearbook by Durbin, Frolich, and Zentmyer, the seed should be heat treated by immersing in a hot water bath at from 120° to 125°F. for 30 minutes. This treatment will kill **Phytophthora cinnamomi** in the seed but will not damage the seed.

2. Control of the disease in groves where it is now present.

Fungicides and Fumigants—several chemicals appear promising as possible eradicants for use in small areas of infection, as when one or several trees are diseased as the result of bringing in the fungus on nursery stock. Materials under investigation are: Vapam as a drench in basins or in the sprinkling system; chloropicrin, D-D, and Telone (1, 3-dichloropropene) injections; and methyl bromide injection under a polyethylene tarpaulin. More information is available for Vapam than for the others; based on a large

number of field plots this material is giving good results in apparently eliminating the fungus based on plots up to 2 years old. A dosage of 1 qt. per 100 sq. ft., followed by or in 4 gallons of water per sq. ft. has been used. D-D has shown promise in early plot work in light soils in San Diego county, but this material as well as the others noted are being investigated further in several soil types.

Vapam has not appeared as promising from the standpoint of treating living trees, due to the toxicity of this chemical to avocado roots as well as to Phytophthora. Other fungicides are being tested against the root rot fungus in a screening program in the laboratory and greenhouses at Riverside. Other cooperative work headed by Dr. Wm. Moje of the Department of Soils and Plant Nutrition is aimed at finding a chemical that will stimulate the soil fungus **Trichoderma** as an antagonist of **P. cinnamomi**. Further investigation is planned of the possibility of a systemic fungicide that could be applied to the foliage and would be translocated to the roots to prevent infection; preliminary results were promising.

Soil amendments—alfalfa meal continues to give encouraging results when applied at the rate of 100 to 150 lbs. per tree around trees in early stages of disease or healthy trees bordering infected areas. Further large-scale plots were established in the spring of 1957. Research is aimed at discovering the basis for this effect.

The effect of lowering the pH and of other nutritional factors is being studied further in cooperation with Dr. Frank Bingham, of the Dept. of Soils and Plant Nutrition. Field plots have been established investigating the effect of lowering pH of the soil with sulfur.

Irrigation—further investigations are planned with Dr. Sterling Richards of the Dept. of Irrigation and Soils, to study the effect of varying moisture levels on spore formation and mycelial growth of the fungus, in relation to intensification and spread of the disease.

Alternate Crops—it is now known that macadamia nut, citrus, cherimoya, and persimmon are resistant to this disease. Cultures show however that **Phytophthora cinnamomi** remains alive for at least 6 years under macadamia culture, while the fungus died out in a current experiment after two years of citrus culture. Further studies are planned of suitable alternate crops.

Barrier Zones—studies are under way of several different types of barriers which might prevent the spread of the fungus from diseased to healthy sections of a planting. Types of barriers established this past year have been: ditch barriers, dug into the impervious layer beneath the surface soil; chemical barriers, in which a strip 8 to 10 feet wide around the diseased area has been treated with 200 ppm. of Vapam, using 4 gallons of solution per sq. foot (1 qt. Vapam per 100 sq. ft. of surface); and dry barriers, in which an area on the margin of the diseased zone is removed from irrigation. To have any possibility of success with barriers it is first necessary to map the area and have cultures made to determine the extent of invasion of the fungus, as it may be present on trees which are apparently healthy.

3. Control by use of resistant rootstocks.

The main emphasis in this project continues to be in this phase which offers the most promise of success, both for replanting infested as well as healthy areas and possibly

for use in inarching present diseased trees.

Approximately 130 collections have been made in Latin America over the past several years, and material collected by other investigators has also been tested. It is still evident that **Persea Skutchii**, and **P. borbonia** are highly resistant but not compatible with avocado. Of some 66 collections made in 1956 in a trip to Latin America, three have high resistance (**P. caerulea** from Venezuela, **P. chrysophylla** from Colombia, and **P. alba** from Brazil). Two others appear to have moderate resistance (**P. durifolia** from Peru, and a **P. americana** collection from Colombia). No data are yet available on compatibility of these above species with avocado. Additional collections are being received and tested.

The Duke variety continues to show appreciable resistance, and further tests are being made of selections from this variety in experimental beds and in the field. In a number of field plots established in 1955, Duke cuttings and a good percentage of trees budded on Duke seedlings are still making good growth in infested soil. Additional field plots were established this spring (1957).

Further tests are being made in experimental beds and in the field of cuttings made from trees selected by several investigators in the field for possible resistance, in old groves where root rot has been present for many years.