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DISEASES OF THE AVOCADO

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(The part concerned with Phytophthora root-rot was given as an address at the annual meeting of the California Avocado Society, June 12, 1954)

Appreciation is expressed to the California Avocado Society /or *financial support of some of our research projects and for their continuing interest and encouragement. Also appreciation is expressed to the many growers on whose properties we have had experimental plots.*

Much of the work presented here is the result of cooperation with others in the Experiment Station and in the Agricultural Extension Service, including Drs. D. G. Aldrich, F. T. Bingham, F. F. Halma, S. J Richards, and C. A. Schroeder, Mr. *E. F. Frolich and J. J. Coony, George Goodall, C. D. Gustafson and K. M. Smoyer. Also I would like to acknowledge the fine assistance during the past several years of W. A. Thorn and recently of Dr. Jack Erspamer.*

Although the avocado industry is a relatively new one in California, a number of diseases of varying severity are already known to affect this tree in cultivation. From the first few importations of avocado material from the native home of this tree in Central America and Mexico in the latter part of the 19th century, acreage has increased to nearly 30,000 acres in California in 1955. The diseases now known to affect this tree or the avocado fruit will be considered in the order of their importance. in California.

PHYTOPHTHORA ROOT-ROT

A brief look at the history of the avocado root-rot disease in California presents some interesting facts. Thirty years ago the trouble was scarcely recognized. A California Experiment Station Circular by Professors Horne, Essig, and Herms in 1923 makes a brief reference to: "Soil or water injury of avocado: certain sickly conditions apparently caused by excess moisture due to hardpan or other soil defects. Trees apparently are sensitive to waterlogging of soil and have poor recuperative power after such injury." Dr. Knowles Ryerson in a bulletin on avocado culture, also in 1923, stated: "The avocado is extremely sensitive to poor drainage and will not endure a saturated soil for more than a few days."

Other than these notes there was little notice of this disease in California until the 1930's. The disease was not even mentioned in a talk on avocado diseases given by Dr. J. Eliot Coit in 1927. In 1934, Professor Horne named the trouble "melanorhiza or water injury," noted that it is fairly common in California and "is probably the most

serious menace to avocado trees, except on freely drained soils." By the 1940's the situation had developed considerably; in the 1943 Avocado Society Yearbook the statement appears that "The so-called decline of avocado trees is a matter of very grave concern to the industry."

Thus, from these first small notes in the 1920's this problem has increased in seriousness and scope until it is the number one headache of the industry, and has involved an estimated 2500 to 3000 trees.

Meanwhile reports of a root trouble or decline of avocado trees had appeared from other parts of the world: Cuba, Puerto Rico, Hawaii, South Africa, Central America, South America. The first record of an agent other than excess water being connected with this disease came in 1929 when the late Dr. C. M. Tucker, plant pathologist, reported isolation of a soil fungus named *Phytophthora cinnamomi* from diseased avocados in Puerto Rico *(Phytophthora—plant* destroyer). In 1940 Dr. Wagner, plant pathologist from South Africa working on a fellowship at Riverside, isolated this same fungus from rotting roots of declining avocado trees in southern California. Since these two reports of P., *cinnamomi* (cinnamon or avocado root rot fungus) on avocado, numerous reports have appeared of this fungus on avocado, and many other plants, from many parts of the world.

The work of these two men plus our work at Riverside during the past 8 or 9 years has demonstrated the role of this fungus as the causal agent in avocado root rot. We now know that we are dealing with a disease and that two factors are necessary for disease development: *Phytophthora cinnamomi* and excess soil moisture. Water is important because the fungus needs water to form its main spore stage, and to permit these spores to swim about, germinate on and infect avocado roots. Excess water is more important because of its effect on the fungus than because of any harmful effect on the host.

This is not to say that occasionally there may not occur some injury to avocado trees from excess water and reduction of the oxygen content of soil. We have seen such injury occasionally on young trees, and glasshouse experiments have shown that avocado seedlings are damaged by a 4-day exposure to solutions containing extremely low oxygen. *P. cinnamomi* is active at all levels of aeration except very low oxygen; there is indication in fact that low oxygen content of soil or water culture is harmful to the fungus.

The hypothesis is therefore submitted that without the fungus *Phytophthora cinnamomi* there would be little or no damage to avocado trees growing under conditions of impaired drainage. In other words, most of the early statements on sensitivity of avocado to poor drainage may really be reflections of the susceptibility of the avocado tree to attack by this fungus.

Realization that avocado root rot is a disease, with a fungus the primary causal agent, rather than simply a matter of drainage, makes possible different approaches to the problem. With avocado root-rot, environment is more important than with many diseases, soil moisture being the particularly critical phase of the environment.

Phytophthora cinnamomi was first described as causing a stripe; canker of cinnamon

trees in Sumatra in 1922. The first report of the fungus in the United States was on rhododendron plants in New Jersey in 193Q and the first record in California was in 1940 though it had undoubtedly been here for a number of years before that. Since these early reports publications have appeared from all over the world recording *P. cinnamomi* on a wide variety of plants—mostly woody, evergreen plants. A list of plants that this fungus attacks includes 116 different species of plants from many countries.

In any plant disease caused by a fungus the question of the origin of the fungus is often important in order to know-how to combat it. Fungi, just as higher plants, are not world-wide in their natural occurrence. Certain species of plants, such as our California sugar pine and the redwoods, grow as native plants only in certain parts of the world; the same thing holds true for fungi. For example we know that three serious fungus pathogens, the fungi causing white pine blister rust, chestnut blight, and the Dutch elm disease were all not native inhabitants of this country but were brought in by importation of nursery stock, or logs.

On the basis of present information it seems highly probable that *P. cinnamomi* was not a native inhabitant of southern California soils, but was brought in with soil when plants were imported from the tropics in the days before restrictions on such importation, or was brought from nurseries in the southern United States. Drs. Crandall, Gravatt, and Ryan, forest pathologists working on the chestnut root disease caused by this same fungus, speculate that *P. cinnamomi* may have been introduced into the southern United States in the early 19th century, possibly by means of importation of exotic tropical or semitropical plants from Asia and the East Indies. Dr. Tucker, pathologist who originally described the fungus on avocado and was a noted expert on the genus Phytophthora, in a letter several years ago stated that: "The dependence of species of Phytophthora on highly humid conditions makes it doubtful that *P. cinnamomi* is endemic in southern California."

Our sampling of native southern California soils to date has not resulted in finding any *P. cinnamomi. A* recent method that we have developed for isolation of the fungus from soil, placing avocado fruit on soil and keeping the soil -wet, is quite effective for recovering this fungus. The fungus has been found in several ornamental nurseries in southern California, affecting a variety of plants from camellia to pine, and in several avocado nurseries. The efficiency and danger of wide spread of such a soil fungus by means of nursery stock is evident. Other means by which such a soil fungus may be spread more locally include: in water, any means by which soil is moved, and on or in avocado seed. If a fruit lies on moist diseased soil the fungus will enter the fruit and grow into the seed. Planting such seed will then contaminate the nursery or orchard location where it is planted.

Obviously then, healthy nursery stock is a very important factor in preventing disease spread. Nurseries should be planted on well-drained, preferably virgin soil, not adjacent to any diseased *area.* Where trees are grown in containers, fumigation will insure freedom from the cinnamon fungus.

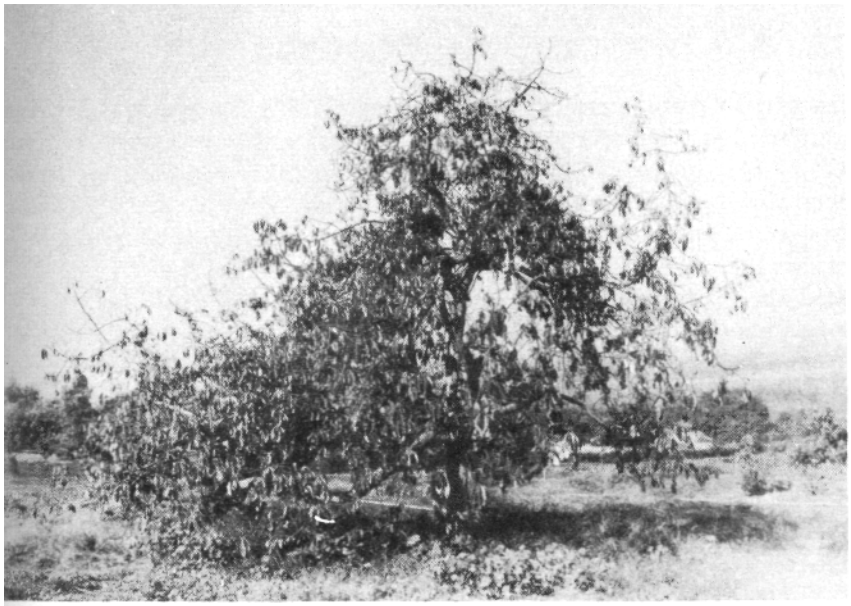

Fig. 1. Bearing avocado tree showing effect of root rot disease.

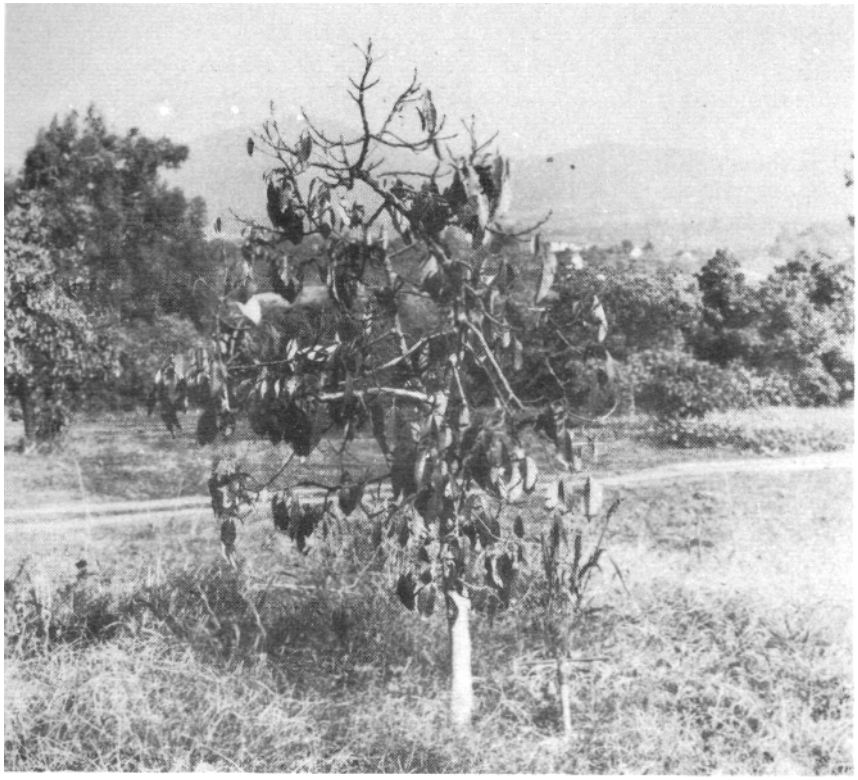

Fig. 2. Young avocado tree showing effect of root rot disease.

Next—some information on the fungus itself that is pertinent to our main concern — control of the disease. The fungus requires water for formation and liberation of its

spores, and for germination and infection. It has certain narrow temperature requirements. The spore-forming bodies are formed at relatively warm soil temperatures, mainly between 77° and 82 F. This indicates that the major infection takes place in the warmer months of the year. An experiment at Riverside, in which seedlings were exposed to natural infection for 2-month periods throughout the year showed that the main infection took place during the period from July to October when soil temperatures at a 6-inch depth reached 76°- 78° F. The fungus also has certain definite temperature requirements for growth. The mycelial or vegetative stage makes its best growth at 75°- 80° F., and does not grow above 90° F. or below 53° F.

Phytophthora cinnamomi produces a second type of spore—the oospore—a resistant spore stage. Just within the past few years we have devised a method for producing these spores in abundance; information is needed on the role that they play in the disease.

Fungi also have very particular food requirements. *P. cinnamomi* for instance grows well when certain sugars are present (as glucose, fructose, sucrose, maltose), but not on some other sugar sources, (lactose, arabinose). It uses either inorganic or organic nitrogen, and needs vitamin B_1 for its growth. It grows well over a fairly wide pH range, from pH 4.5 to 7, depending on other nutritional elements; growth is reduced at high pH and also low pH values.

Control of a soil fungus is in general much more difficult than control of a fungus affecting the aerial parts of a plant, as it is much more difficult to reach the fungus by any chemical or other treatment and the soil is a very complex medium. Several aspects of control have been investigated, and for convenience are grouped here into several broad groupings:

1. RESISTANT ROOTSTOCKS

Control of a disease by the discovery or development of a resistant variety is in many ways the ideal means of control. One of its limitations lies in the ability of some fungi to keep ahead of the plant breeders; some fungi mutate to form new varieties rapidly and not long after a resistant variety of cantaloupe, for example, was developed to powdery mildew a new strain of the fungus appeared that could attack the resistant variety. Be that as it may, resistance has been an increasingly important phase of plant disease control since the beginning of this century. Development of a rootstock resistant to the avocado root rot disease is therefore one of the most promising approaches to control of this disease and one to which a considerable portion of our time has been devoted during the past two years in particular. Basic to any attempt to find resistance is the development of a testing program which provides a severe, uniform, not too time consuming, and reproducible test. To determine the relative resistance of various plants they must be tested under uniform conditions. Several greenhouse tests have been devised that enable us to detect various degrees of resistance.

The resistance work has emphasized three approaches: the search for resistance in the native home of the avocado in Mexico and Central America, the search for resistance among miscellaneous seedlings and varieties now present in California, and the search

for resistance in groves in California where the disease has been present for a number of years. During the past two years many avocado varieties and relatives that I have collected in Central America or Mexico, or that have been collected by Dr. Schroeder from U.C.L.A., or others, have been tested by these methods. Of 12 different species of *Persea* (the avocado genus) tested, two have been found to have appreciable resistance to *P. cinnamomi: Persea borbonia* (sent to Dr. Schroeder from southern United States), and *P. Skutchii* which I collected in Honduras and Costa Rica. Unfortunately we know, as the result of work by Mr. Ted Frolich at U.C.L.A. that *P. borbonia* is not compatible with the avocado; we are not certain of the compatibility status of *P. Skutchii* yet, but budding attempts made recently do not look promising. The possibility still remains that these resistant types maybe hybridized with the avocado; Dr. P. A. Peterson is doing work along this line. In the phase of testing progeny from trees here in California, considerable variation in resistance is apparent, and several seedlings have withstood moderate infection in some of the test beds; these are being propagated further for field tests and for more severe glasshouse tests, Several trees have also been located in southern California that have apparent resistance in the field—that is, they are reasonably healthy in situations where most of the surrounding trees have succumbed to the disease. Mr. Frolich is propagating the rootstocks of some of these trees for more detailed testing.

2. FUMIGANTS AND FUNGICIDES

Passing from resistance to other phases of control, various types of chemical treatments have been evaluated, and considerable information obtained which is of use under special conditions. *P. cinnamomi* can be killed by any one of several fumigants: Shell D-D, chloropicrin, methyl bromide; any of these materials would be useful to eradicate a small isolated spot of infection. Methyl bromide is used extensively by ornamental) nurserymen for treating nursery potting soil, and is equally useful in avocado nurseries. Our fungicide testing program at Riverside has recently been expanded; in its preliminary phases the past few years several organic chemicals have been discovered which are effective against *P. cinnamomi* in soil. So far none has looked sufficiently promising to recommend for field treatment but further work on this phase is continuing.

3. NUTRITION

Another phase of the research on which considerable progress has been made in the past year, and in which much further work is planned, is that of nutrition in relation to root rot, in cooperation with Dr. Frank Bingham at Riverside. Already in this work significant information has been obtained on the pH at which this disease is most active, with no disease at very acid levels (pH 3 in nutrient solution), increasing to very severe disease development on the acid side of neutral (pH 6), with a slight decrease at pH 8. The research with Dr. Bingham has also given some interesting results in regard to nitrites, showing that the fungus is more sensitive to the presence of small amounts of nitrite than is the avocado plant. Other phases of nutrition including additions of N, P, and *Y* in varying amounts are being investigated in these nutrient solution tests.

Promising results obtained in this convenient test will be tried in soil in glasshouse and field.

An attempt will be made to analyze future possibilities for combating this disease on the basis of present knowledge.

The best possibilities for survival of the avocado industry in the face of this serious threat lie along four lines, which overlap somewhat depending on whether the establishment of new groves or maintenance of present groves is being considered.

1. Careful site selection for new groves. The history of this disease wherever it occurs has been one of a combination of Phytophthora and soils from which water drains slowly. There has been little disease on well-drained soils, with the possible exception of some tropical areas where rainfall is so heavy that what are normally considered as well-drained soils, hold sufficient water for a long enough time to permit the fungus to attack roots. Therefore rule No. 1—establish avocado groves on well-drained soil.

Two notes of caution should be interposed here. On some exceptionally well-drained soils where the trunks have been kept overly wet this versatile cinnamon fungus instead of attacking the roots will attack the trunks and cause a canker similar to citrus gummosis. This is a problem that can be more easily controlled however than can the root rot. Also, root rot has appeared in some soils in the San Gabriel Valley that would appear at first glance to be well drained, with light surface soil underlain by many feet of sand. The irrigation experts state that marked differences in soil structure often impede drainage, and this is evidently what is happening on this light soil. Here again the damage is occurring where *P. cinnamomi* is present; other trees in the same situation are healthy.

2. Exclusion of *Phytophthora cinnamomi—as* stated before I feel that without this fungus, avocado trees would grow to a happy old age even on what we call problem soils, or poorly-drained soils. On some of the poorest soils growth would not be normal, and in times of heavy rainfall or in case of improper irrigation some temporary damage might occur from excess water alone, but it would not approximate the damage where *P. cinnamomi* has been introduced. This emphasizes the importance of trying to prevent further movements of this fungus via nursery stock or other means. The fungus is already distributed over a wide acreage, but every effort should be made to keep *P. cinnamomi* out of new plantings. This means extreme care on the part of nurserymen to raise clean, non-infected trees, and also means vigilance on the part of the grower in not introducing the fungus to the property on other types of plants. This fungus can be moved in soil around plants, in water running over diseased soil, by any means by which soil is moved, and in avocado seed taken from fruit lying on diseased soil.

3. Cultural operations—one of the cardinal principles of plant disease control is to aim at some weak point in the life cycle of the fungus or other agent that causes the disease. One of the weak points in the life cycle of *P. cinnamomi is* its absolute requirement for water in order to produce its spores, and for water to permit germination of these spores and infection of avocado roots. Therefore any practice that tends to re duce the period that free water may remain in the soil will reduce severity of the disease even though it does not eliminate it. Examples of such practices include: selection of a

site with good drainage as noted above, careful irrigation to prevent watering soil that is already wet, and drain age to take care of runoff of winter rainfall.

Other cultural operations which give indication of perhaps affording at least some temporary relief from disease attack include the following: a. changing of the soil pH—recent experiments indicate that extremely acid conditions will reduce the activity of the root rot fungus; this phase has not been sufficiently explored in the field as yet. b. changing the soil microflora—making additions of organic matter such as alfalfa meal which increase certain beneficial organisms (fungi and bacteria) present in some soils and counteract the activity of *P. cinnamomi.* c. possibly other phases of nutrition will be of importance and can be made use of in the future. Work in Hawaii has indicated that high K reduces activity of this fungus on pineapples for instance; this is being investigated with respect to avocado.

The last of the four lines of possible future emphasis to permit Irving with this disease in California, but by no means the least important is that of:

4. Resistant rootstocks. Our best hope for the future of the avocado industry in many sections of southern California is the discovery of a rootstock resistant to *Phytophthora cinnamomi.* Without such a development many of the poorly-drained soils where this fungus now occurs or to which it will probably be introduced in the future, will go out of avocado production. It is apparently in many cases impossible to water these soils carefully enough to prevent accumulation of sufficient water for disease development.

Other than their restricted drainage characteristics and cinnamon fungus content these soils are generally ideally suited for avocado production, and such soils are continually being planted. It is for this reason that every effort is being made to find resistance to this disease. Incidentally a resistant rootstock could conceivably be used to inarch present diseased trees, as well as its obvious use as a rootstock for new trees. As indicated above there are promising developments in the resistance field but the surface has been merely scratched with respect to materials tested. Assuming discovery of a compatible, highly resistant root stock many other factors, such as effect of the rootstock on production and growth of the scion, response to other disease and soil and climatic factors, and the possibility of new strains of the fungus developing, would have to be considered and carefully studied before such a rootstock could be adopted commercially.

There are also exciting new developments in other phases of plant disease control which are not being overlooked. One of these is the development in systemic insecticides and fungicides. Phenomenal insect control has been attained by some of the new insecticides that are translocated to all parts of a plant when merely applied to the soil or to stems or leaves. Somewhat similar but less spectacular results have been obtained in control of plant diseases by chemotherapy or use of systemic fungicides. We are currently experimenting with some of the newer fungicides to see if any of them will be taken up by avocado leaves when seedlings are sprayed with them and transported to the root system in concentration sufficient to prevent root infection by *P. cinnamomi.* Also injections of the stems or branches of avocado seedlings with these chemicals are being tried with the same idea in mind. Some of the other fields, such as

soil fungicides and soil fumigants, also are worthy of further exploration.

With emphasis on these four phases—site selection, exclusion of *P*. *cinnamomi,* cultural operations and resistant rootstocks, the avocado root rot disease outlook is far from discouraging and with the interest and enthusiasm of the California Avocado Society to aid us, I am sure that a solution will be found to this difficult problem.

SUN-BLOTCH

Sun-blotch, the only known virus disease of avocado, was first described in California in 1928. Its virus nature was established by Prof. W. T. Horne and Dr. E. R. Parker in 1931. It is of common occurrence in California, but has been observed only a few times in Florida.

Typical symptoms are a yellow streaking of the green stems and branches and a yellow-to-red streak on the fruit. On fruit that remains green at maturity, the streak is yellow. On fruit that turns black or purple at maturity, the streak is usually red. A slight deformation and pronounced mosaic pattern may occur in the leaves, but the stem and fruit symptoms are the most common. Some affected trees tend to have a decumbent, willowy type of growth, and may be stunted. A checking of bark on mature branches and trunks is often associated with the disease, but it has not been definitely established that this is a symptom of the disease. In addition to the loss from decreased production that may be associated with sun-blotch, in many cases the fruit are severely damaged by the sunken streaks and are down-graded into cull grades.

Sun-blotch is readily transmitted through budwood or graftwood. Dr. J. M. Wallace at Riverside, has also demonstrated that the disease can be transmitted through the seed; in some cases a high percentage of seed from a given tree will transmit sun-blotch. Some trees are symptomless carriers of the disease, so a tree cannot be considered free of sun-blotch merely because it shows no symptoms. Seedlings from carrier trees may not show sun-blotch symptoms even though they are carrying the virus; when such seedlings are topworked to commercial varieties, however, the disease will appear in the scion.

The primary control measure for this disease involves careful selection of disease-free scion and seed sources.

DOTHIORELLA ROT

Dothiorella rot, the most important rot of avocado fruit in California, is caused by the fungus *Botryosphaeria ribis* (imperfect stage: *Dothiorella gregaria).* The disease is a serious problem on the Fuerte variety in plantings near the coast. In inland areas it is of relatively little importance. The fungus is commonly present on dead wood, dead leaf tips, and debris, It enters the fruit sometime before harvesting. After entering the fruit, it lies dormant, and rot does not develop until the fruit begins to soften, by which time it has reached the consumer. The fact that there is no method of detecting fruit that will develop this rot and culling it out in the packing house creates a difficult marketing problem.

This rot commonly appears first as small, brown, or purplish-brown spots on the green fruit surface. The spots gradually enlarge until much of the surface may be involved. In early stages there is little involvement of the flesh. As the disease progresses, however, the fungus invades the flesh and causes a brown discoloration and an offensive odor. Occasionally the fungus induces a stem-end rot. It may also invade fruit pedicels, causing the fruit to drop. In Florida the fungi *Diplodia* and *Phomopsis* are also involved in stem-end rot of fruit.

The following control measures are effective in reducing or eliminating this fruit rot: Removal of dead wood and dead leaf tissue from trees to reduce sources of fungus inoculum; use of all possible measures to reduce tipburn of leaves; use of low rather than overhead sprinklers; picking fruit before it reaches the peak of maturity, as it is not so severely affected in early season; and spraying trees.

Research in the 1930's indicated that 8-8-100 bordeaux mixture plus 6 pounds of wettable sulfur gave good control. It has been shown since then that Crag Fungicide 658 (1.5 pounds to 100 gallons), bordeaux 6-6-100, Cuprocide (2 pounds to 100 gallons), and zineb (2 pounds to 100 gallons) are effective in controlling the fruit rot. If rainfall is relatively light, as during the period from 1948 to 1951 in California, two sprays give good control, the first in mid-September and the second in early November.

VERTICILLIUM WILT

Verticillium wilt of avocado trees has been recognized as such since 1948 when isolation of the soil *fungus Verticillium albo-atrum* from affected trees and proof of its pathogenicity to avocado trees were reported by Zentmyer. Occasional reports during the previous 15 or 20 years in California and Florida had described sudden wilting and collapse of isolated trees in well-drained soils. In California the trouble was termed collapse, asphyxiation, or apoplexy and was thought to be the result of exclusion of oxygen from the soil, brought about by sudden saturation of the soil with water. Occasionally young trees may "collapse" when the soil in which they are growing has been waterlogged for a considerable period, but this is not common, does not occur on well-drained soils, and can be readily distinguished from Verticillium wilt

Avocado trees affected with Verticillium wilt show symptoms similar to those that develop on other woody hosts. The symptoms include a sudden wilting of all the leaves on a part of a tree, or on the entire tree, and the rapid death of the leaves. The leaves turn brown and remain attached to the branches for a long time. Typical brown streaks may be seen in the wood, when the bark is peeled from branches or roots of affected trees. Within a few months after the initial collapse of the tree, vigorous new shoots may appear, and within 1 to 2 years the trees may recover completely. Occasionally trees die from the disease, and occasionally the disease may recur in a given tree. Most of the affected trees observed in California have recovered completely and have shown no further symptoms. Similar observations have been reported in Florida.

This disease is not at present a serious problem in avocado production in California. Although cases of Verticillium wilt have been found in all the avocado-producing areas in southern California, the disease incidence has been low. The disease could become

a serious factor under coastal soil-temperature conditions and with a wider use of the more susceptible rootstocks.

Observations on avocado rootstock plots established by Dr. F. F. Halma in Santa Barbara county, plus inoculation tests, have shown that the Guatemalan varieties of avocado are much more susceptible to Verticillium wilt than are the Mexican varieties.

Several suggestions as to control of this disease can be made. Use of land that has been planted to a susceptible crop should be avoided, and susceptible crops should not be interplanted after the land has been planted to avocados. Other common plants affected by the fungus include tomato, pepper, eggplant, berries, apricot, potato, and a number of flower crops. Guatemalan varieties should be avoided as rootstocks because of their susceptibility to Verticillium wilt. Avocado trees that are, or have been affected with this disease should not be used as sources of bud-wood, as it is possible that the disease may be transmitted in budwood, as is the case with Verticillium wilt of rose.

CANKERS

Cankers of roots, trunks, or branches of avocado trees may be caused by several *fungi. Phytophthora cactorum* and *P. cinnamomi* are the two fungi most commonly involved in California in cankers of the lower trunk and rootstock. Artificial inoculations show that *Phytophthora citrophthora,* the fungus that causes brown rot of lemon fruits and brown rot gummosis of citrus trees, also is capable of invading avocado trunks. This fungus has not been found on avocado in the field, however.

The fungus *Botryosphaeria ribis* (imperfect stage: *Dothiorella gregaria)* also causes cankers of avocado trunks and branches. The cankers caused by this fungus are usually not as serious as those caused by the species of *Phytophthora.* Guatemalan varieties are particularly susceptible to this fungus.

Symptoms of the canker diseases in general vary from gradual loss of vigor and chlorosis of leaves to sudden death of the entire tree. Trees affected with Dothiorella cankers may show no symptoms in the top of the tree. Examination of the trunk usually reveals a darkening of the bark and an exudation of powdery white material from the affected bark. When the bark of the cankered area is cut into, it is found to be brown in color. Phytophthora cankers usually have a noticeably sour odor, and often extend into the wood. Dothiorella cankers are usually more superficial, often involving only the outer bark; margins of these cankers are very irregular. In many cases of Dothiorella canker, new bark forms beneath the affected tissue, and the cankered area is sloughed off.

If detected in a sufficiently early stage, Phytophthora cankers can be controlled by cutting out infected tissue and painting the treated area with a fungicidal paint such as bordeaux paste. Similar treatment may be given to Dothiorella cankers, though often if a tree *is* vigorous it will outgrow these infections. The Guatemalan varieties of avocado appear to be more susceptible to both Phytophthora and Dothiorella cankers. In an attempt to avoid Phytophthora cankers, therefore, it is desirable to bud Guatemalan varieties high and avoid covering the bud union with soil in low-budded trees.

ARMILLARIA ROOT ROT

The fungus *Armillaria mellea* (oak root fungus) has been found in recent years on avocado trees in Santa Barbara, Ventura, Riverside, and Los Angeles counties. The fungus is capable of causing a severe root rot of avocado, similar to its attack on citrus and many other hosts. Affected trees commonly wilt when much of the root system has been invaded, and may then die suddenly. The most characteristic symptom of this disease is the white mycelial fans of the fungus, which are seen on peeling the bark from roots of the diseased tree. These fans occur on roots of all sizes, from those 1/4 inch in diameter to the main roots of the tree, and the rootstock. Sometimes the black rhizomorphs ("shoestrings") of the fungus occur on the surface of diseased roots.

Little is known of the action of Armillaria on avocado, other than the fact that some trees are extremely susceptible. Tests to determine susceptibility of various rootstocks are being conducted at Riverside in cooperation with Dr. E. F. Darley.

Control measures similar to those used for citrus trees are suggested; these involve removal of diseased trees and the larger roots, and fumigation of the soil with carbon disulfide.

GIRDLING CANKER

A disease of relatively little importance at present has been given the name girdling canker. It *is* a disease of young transplants or young seedlings in the nursery. Symptoms are a yellowing of the top of the tree or in extreme cases a complete death of the top of young seedlings or young budded trees. The most characteristic symptom is a marked girdling and constriction of the rootstock near the ground level, with .an enlargement of the trunk immediately above this area.

The only organism found consistently associated with this disease is the soil fungus *Cylindrocarpon,* which is usually merely a saprophyte. It is not known whether this is the primary causal agent of this disease, or whether some other factor is involved. Species of Cylindrocarpon occasionally have been reported as attacking plants; the fungus is apparently capable of attacking only where wounds are present, or where the original seem tissue is buried beneath the soil when the young tree is planted in the field. Obvious control measures that can be suggested at present, therefore, are to plant trees at the same level that they were planted in the nursery, and to avoid wounding the rootstock.

OTHER DISEASES

Several diseases of the avocado occur in Florida and other areas where the tree is grown, but are not now found in California. A brief description of these diseases will be included here.*

Cercospora spot or blotch, caused by the fungus *Cercospora purpurea,* is the most important disease of avocado in Florida. Lesions on fruit appear as small, scattered, brown, slightly sunken spots that have a definite outline but irregular shape. Grayish spore-bearing structures of the fungus appear on the spots in humid weather. These

fruit spots, which are one-eighth to one-fourth inch in diameter, later develop cracks or fissures, which permit the entry of other fungi that cause fruit decay. The *Cercospora* fungus also causes small angular spots on leaves.

Research in Florida has demonstrated that the disease can be controlled by two or three copper sprays, the first between May 1 and May 15, the second not more than a month later, and the third a month after the second. The third is usually necessary only for varieties that mature in winter or early spring. Dr. G. D. Ruehle has shown that 6-6-100 bordeaux or 4-4-100 bordeaux (the latter where annual spraying is practiced), or wettable cuprous oxide (1.5 pounds to 100 gallons), or copper A (4 pounds to 100 gallons), or basic copper sulfate (3 pounds to 100 gallons) are equally satisfactory.

Scab, also an important disease of avocado in Florida, is caused by the *fungus Sphaceloma perseae,* which attacks both foliage and fruit. This fungus causes corky, raised, brownish, oval-shaped spots on the fruit. As the spots become older they may coalesce and give the fruit a russetted appearance. They may develop cracks that permit entry of other fruit-rotting organisms. Scabby, deforming lesions are also formed on leaves, leaf petioles, and twigs. There is considerable variation in susceptibility off the different varieties of avocado to this disease. Lula is listed as very susceptible; Hall, Taylor, Nabal, and Booth 7 and 8 moderately susceptible; and Fuchsia, Pollock, Booth 1, Waldin, Itzamna, Linda, and Collinson quite resistant.

On resistant varieties, and in solid block plantings of moderately susceptible varieties, scab can be controlled by spraying with 6-6-100 bordeaux or 1.5-100 wettable cuprous oxide, using the same schedule as the one for blotch. On the highly susceptible Lula variety, on susceptible seedlings and on moderately susceptible varieties interplanted to Lulas, it is necessary to apply the first copper spray as the bloom buds begin to open, to repeat in the last of the bloom and again 3-4 weeks later in addition to the sprays applied for control of cercospora blotch.

A third common disease of avocado fruit in Florida, but one causing less damage than blotch or scab, is anthracnose, or black spot, caused *by Colletotrichum gloeosporioides.* This disease is characterized by sunken black spots on the fruit, the spots being nearly circular in outline and one fourth to one-half inch in diameter. As the fruit ripens, the fungus invades the flesh to a greater degree until most of the fruit is rotted. The fungus is unable to enter unwounded fruit. It usually becomes established in lesions caused *by Cercospora* or *Sphaceloma.* Where spray applications are made to control cercospora blotch or scab, no additional sprays are necessary to control anthracnose.

Powdery mildew (Oidium species; perfect stage unknown) occasionally is found in Florida on foliage in nurseries or on young trees growing in shaded, damp locations. When young trees are affected, tender tips of shoots may be killed back. Dark-green discolorations may appear on the leaves, which show the characteristic white, powdery mildew growth on the lower side. Control may be obtained with copper fungicides if the problem becomes acute in non-bearing trees or in nurseries. The spray program for control of Cercospora blotch and scab is usually adequate for control of powdery mildew on bearing trees.

Phytophthora seedling blight—under tropical or subtropical conditions another species of *Phytophthora, P. palmivora,* can cause a severe blight of avocado seedlings. The

fungus invades the stems of young seedlings, causes cankers which girdle the stems, with subsequent wilting and death of the seedlings. This disease has been described from Florida by R. A. Conover, and from Honduras by G.A. Zentmyer and A. S. Muller. This type of disease would be expected to occur primarily in regions of high rainfall; it has not been found in California and probably would not I be a problem here.

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