Book 2

Chapter 3

Diseases

Authors: B.A. Faber, A. Eskalen, & G. S. Bender

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Please refer to this website for current information as this website is updated quite often.

ANTHRACNOSE

Pathogen: *Colletotrichum gloeosporioides*
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

Anthracnose symptoms can develop on flowers, fruit, leaves, or twigs. Infected fruit is the most serious concern, but most fruit damage does not develop until after harvest. External symptoms are difficult to see on ripe 'Haas' fruit because of its dark skin color. Unhealthy or dead leaves are the most obvious symptom in groves. Spots form on leaves, beginning as yellow, then brown discolorations that coalesce into large dead areas. Necrosis occurs across or between leaf veins, on leaf margins, and most often at leaf tips. If disease is severe, trees drop many leaves prematurely. New shoots can develop brown or purplish lesions, and shoots may dieback. Infected flower heads can turn dark and die without producing fruit, or young fruit may form and then drop.

Before harvest, brown to black lesions less than 0.2 inch (5 mm) in diameter develop around lenticels on infected fruit. These small discolorations can be overlooked while fruit are still on the tree, and lesions usually do not enlarge until fruit ripens after harvest. Large lesions sometimes occur on avocados on the tree, usually after infected fruit is injured by insects or mechanical wind rubbing.

After harvest, lesions become blacker, larger, and increasingly sunken. Lesions eventually spread over the entire fruit surface and throughout pulp. When the fruit is cut in half through one of the lesions, rot extending into the flesh often exhibits a hemispherical pattern. Decayed pulp initially is firm, but becomes soft and putrid as decay advances. Pink spore masses may form on the fruit surface and, under wet conditions, a slimy mass of pink spores erupts through the fruit skin.

COMMENTS ON THE DISEASE

Colletotrichum gloeosporioides is widespread in avocado and citrus groves. It normally is of little importance because unusually large numbers of spores are required to produce damaging infections. Low humidity and no rain during much of the growing season limit disease development in California. With extended foggy or rainy conditions and mild winter temperatures, and where many dead leaves and twigs and mummified fruit accumulate in trees, the fungus can produce enough spores to cause a disease problem. Spores spread in splashing

water and can cause infection anytime from fruit set to harvest. Once infected fruit starts to ripen, temperatures of 75°F and above will accelerate anthracnose development, while temperatures below 59°F retard disease development.

Fuerte, Rincon, and Wurtz scion cultivars are more susceptible to anthracnose than Hass. Healthy trees often recover from foliar infections and defoliation once conditions become dry. Anthracnose becomes a postharvest problem after the grove has been excessively wet for extended periods. Poor growing practices and mishandling of fruit during or after harvest greatly increase the potential for significant fruit loss.

MANAGEMENT

Control anthracnose primarily with good cultural practices in the grove and proper preharvest and postharvest fruit handling. Prune out dead limbs and twigs where fungi sporulate. If many dead leaves are entwined in the canopy, knock them out of the tree. Prune low limbs to at least 2 feet (60 cm) off the ground to reduce humidity within canopies by improving air circulation. Dispose of dead wood and old fruit away from avocado trees before bloom. Prune and harvest only during dry conditions and minimize fruit contamination and injury.

Postharvest treatments should not be needed if fruit is properly handled. Keep fruit dry and cool until sold. Postharvest temperature is especially critical to anthracnose development. Cool fruit to 41°F as soon as possible after harvest. Delays of longer than 6 hours before cooling and higher pulp (air) temperatures during these delays will result in increased postharvest fruit decay. Cooling fruit promptly is of increasing importance as the season progresses because fruit ripens faster as it increases in maturity. Avoid storage temperatures below 41°F because chilling injury may occur. Market fruit rapidly.

Chemical Control: Anthracnose is rarely significant enough in California avocado groves to warrant fungicide application. Copper compounds thoroughly sprayed on healthy tissue can prevent infection.

Common name (trade name)	**Amount/Acre**	**R.E.I.+ (hours)**	**P.H.I.+ (days)**

When choosing a pesticide, consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

A. COPPER HYDROXIDE
(BlueShield, Champ, Kocide, etc.) Label rates 24 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M1)
COMMENTS: Apply as a trunk spray. Make the first application at the start of the growing season and repeat every 60 days. Repeat applications at 60 days are important; a single trunk spray is not sufficient to arrest the disease. Do not exceed 20 lb/acre/year.

\+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment until harvest. In some cases the REI exceeds the PHI. The longer of these two intervals is the minimum time that must elapse before harvest.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a

resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

PRECAUTIONS (see last page of this chapter)

ARMILLARIA ROOT ROT (Oak Root Fungus)

Pathogen*: Armillaria mellea*
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

Armillaria is a soil-borne fungus that causes a root and trunk rot of avocado. The fungus can become well established in roots and the root crown before any symptoms become visible above ground. Infected trees usually die prematurely, and young trees often die quickly after infection. Mature trees may die quickly or slowly, or may recover at least temporarily if conditions become good for tree growth and poor for disease development.

Wilted, downward-hanging foliage is often the first obvious symptom of Armillaria root rot. Other symptoms include foliage yellowing, leaf drop, and dieback of upper limbs. During the rainy fall and winter, groups of short-lived mushrooms often grow around the base of *Armillaria*-infected trees.

The most reliable sign of Armillaria root rot is fungal growth in cambial tissue. If trees exhibit aboveground symptoms of infection, cut off bark at the base of the tree and crown to diagnose the presence of *Armillaria* mycelium. Fungal mycelia are whitish and have a strong mushroom odor. Growth typically occurs in patches in the cambium and inner bark. Large roots can be infected throughout their diameter.

COMMENTS ON THE DISEASE

Armillaria root rot infects many crops and native and ornamental plants. Common hosts include avocado, cherimoya, citrus, and oaks. The fungus persists in infested roots and wood in soil, infecting new plantings and spreading to infect nearby plants.

Armillaria mycelium persist for years under the bark of diseased roots or the root crown. The fungus spreads from tree to tree mainly by rhizomorphs growing along or out from diseased roots and eventually contacting and infecting the healthy roots of adjacent trees. *Armillaria* also spreads by any activity that moves soil containing infested wood fragments, such as during cultivation.

Long after the aerial parts of a tree are gone, *Armillaria* can remain alive in roots and stumps. When avocado trees are planted, new roots grow into contact with *Armillaria*-infected roots or infested wood pieces, and the new tree becomes infected. *Armillaria* can also be introduced on infected nursery stock.

Armillaria can spread by root-to-root grafts and by cordlike rhizomorphs, which resemble small dark roots. In contrast, healthy avocado roots are lighter-colored, usually light brown to whitish. When pulled apart, rhizomorphs have a cottony interior, while the center of a healthy root is solid and woody. Rhizomorphs grow on buried wood, the surface of diseased roots and root crowns, and short distances on or through soil. Infection occurs when rhizomorphs contact and directly penetrate the root bark.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove (see MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS). Provide a good growing environment and proper cultural practices and use good sanitation to manage Armillaria root rot. Providing good drainage and avoiding excess irrigation are important. *Armillaria* fungus is very susceptible to drying. Excavating soil around the trunk to temporarily air-dry the root crown can prolong the life of citrus trees and may also be effective on avocado, but apparently has not been tested on avocado. Shade any exposed root crowns from sunburn. Once trees die, remove them and any immediately adjacent trees that may also be infected. Remove the stumps and as many root pieces from the soil as possible. Thoroughly clean all soil from equipment and leave soil on-site before removing equipment. Consider replanting only with crops not susceptible to *Armillaria*.

AVOCADO BLACK STREAK

Pathogen: unknown

(Reviewed 1/07, updated 1/07)

SYMPTOMS AND SIGNS

Black streak appears as an elongated dark discoloration on bark. Small cankers can develop in a direction that parallels the direction of limb or trunk growth but sometimes cankers encircle limbs or the trunk. On green shoots and young trees, lesions look like black blotches with distinct margins. Cankered bark develops shallow cracks that ooze sap, which dries as a brownish or white powder on the bark surface. This exudate is readily washed off by rain or sprinklers, and in the absence of the powder the canker can be difficult to see externally on bark. Black streak lesions can be very small or encompass the greater part of the trunk. Cankers often first appear on the lower trunk and the underside of lower limbs and then later appear higher in the tree. Scraping off bark over the canker reveals shallow reddish brown to black areas. This discoloring forms mottled areas of dead and live tissue or merges into one large necrotic area. It rarely extends into the wood and can be removed easily by inserting a knife blade under the canker and prying upwards. Because trees can die with very few lesions, the lesions appear to be a symptom of the disease and not the cause of tree death.

COMMENTS ON THE DISEASE

Black streak develops under adverse growing conditions and is a serious disease that can kill avocado trees. The specific cause of the disease is unknown and apparently is not a viroid as was previously believed.

Many symptoms of avocado black streak are similar to those from other causes; the appearance of the cankers is the most diagnostic characteristic of this disease. Avocado black streak appears after prolonged periods of environmental or cultural stress, especially conditions of high salinity and insufficient water. An affected tree can decline gradually and may eventually die, or it may collapse and die rapidly. Conversely, with improved cultural practices trees can recover and symptoms can virtually disappear.

Avocado black streak may occur wherever Guatemalan cultivars are grown in California. All ages of trees are affected, and symptoms have been observed on trees ranging from 1 year to over 35 years old. Many groves are apparently free of the disease, and disease incidence varies considerably within affected groves. Avocado black streak symptoms typically are most severe on trees that appear to be the most stressed.

MANAGEMENT

Current management of avocado black streak consists of maintaining plant health with good fertilizer and irrigation practices, and preventing stress. Adequate irrigation with high quality water is believed to be especially important.

AVOCADO ROOT ROT (Phytophthroa Root Rot)

Pathogen: *Phytophthora cinnamomi*
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

Foliar symptoms of avocado root rot include small, pale green or yellowish leaves. Leaves often wilt and have brown, necrotic tips. Foliage is sparse and new growth is rare. There may be little leaf litter under infected trees. Small branches die back in the tree top, exposing other branches and fruit to sunburn because of the lack of shading foliage. Fruit production declines, but diseased trees frequently set a heavy crop of small fruit.

Small, fibrous feeder roots are scarce at advanced stages of this disease. Where present, small roots are black, brittle, and dead from infection. Foliage is wilted even when soil under diseased trees is wet. Affected trees will decline and often die either rapidly or slowly.

COMMENTS ON THE DISEASE

Phytophthora root rot is the most serious and important disease of avocado worldwide. The causal agent, *Phytophthora cinnamomi,* has over 1,000 hosts, including many species of annual flower crops, berries, deciduous fruit trees, ornamentals, and vegetables.

Root rot thrives in areas of excess soil moisture and poor drainage. Trees of any size and age may be affected. The pathogen is easily spread through movement of contaminated nursery stock of avocado and other plants, on equipment and shoes, in seed from fruit lying on infested soil, or by any activity by people or animals that moves moist soil from one place to another. *Phytophthora* produces four different spore stages that are involved in disease development and survival: sporangia, zoospores, chlamydospores, and oospores. They spread easily and rapidly in water moving over or through the soil. Entire areas can readily become infested. *Phytophthora* species are not true fungi but have many fungal-like attributes.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove by MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS. Use an integrated approach that emphasizes prevention. Purchase certified disease-free nursery stock (if available) and root rot-resistant cultivars. Inspect roots before planting and if their health appears questionable seek advice from a farm advisor or private consultant before planting trees. Employ stringent sanitation measures, good cultural practices, and appropriate chemical controls. The most important control of this disease is good irrigation management. For example, where new trees are interplanted among older trees, separate irrigation lines are needed to insure appropriate irrigation timing and amounts for the different aged trees.

Cultural Controls Use cultural practices that promote growth of the tree while discouraging growth of the pathogen.

Provide favorable soil conditions. In new plantings, avoid soils favorable to root rot development, including poorly drained, saline, or pathogen-infested soils. Plant on well-drained

soil, or improve drainage by planting on a soil berm, deep-ripping impervious subsoils, or installing subsurface drains. In established plantings, manage soils carefully so that excess moisture does not accumulate.

Use certified disease-free nursery stock. Request certified, disease-free plants, especially when planting new areas, because disease is especially damaging to young trees. Nurseries should disinfest propagation material, such as by immersing seed in water at 120 to 122°F for 30 minutes and then quickly cooling it. Nurseries should also use pasteurized soil mix, clean irrigation water from deep wells or disinfested surface water, and stringent sanitation to prevent pathogen introduction and spread. Nurseries that rely only on fungicides for disease prevention can promote fungicide resistance and produce symptomless plants with infections that develop after planting.

Plant resistant rootstocks. Certain rootstock cultivars are more tolerant of root rot, including Dusa, Latas, and others. Newer recommended cultivars such as Uzi and Zentmyer may also be available. Barr Duke, Duke 7, and Duke 9 can also be good rootstocks but have less *Phytophthora*-resistance than some newer cultivars. To obtain rootstocks with maximum resistance to avocado root rot, choose rootstocks produced by a nursery using the clonal method because clones of recommended cultivars are more resistant than seedlings. Be aware that resistant rootstocks are not immune to root rot; if they are planted or maintained under adverse conditions, they may be killed by the combination of adverse conditions and the pathogen.

Prevent soil or water movement from infested areas. Excluding *P. cinnamomi* from an uninfested grove is the most economical control method. Install water-tight drains to divert surface runoff if a diseased area lies above a healthy grove. Control gophers, as their burrows can provide means of moving the fungus in water. Do not work in infested groves when the soil surface is wet; *Phytophthora* is readily spread by activities such as walking or driving on infested wet soil. Bring only clean bins and equipment into groves. Begin harvesting and other activities in healthy areas of the grove; work in diseased areas last to minimize pathogen movement.

Soil solarization. Soil solarization can be effective for treating infested soil following tree removal in warm inland areas of California through a process in which radiant heat from the sun is trapped under clear polythene sheets laid on the surface of the soil. Solarization is effective when soil temperatures in the top 2 inches of soil reach between 108° to 131°F.

Establish a barrier. If the fungus occurs in only one area of the grove and cannot spread downhill in surface runoff or drainage water, erect a physical barrier and post warning signs to prevent people and activities from spreading the fungus into protected areas. Establish the barrier around healthy sections of the grove, at least two tree rows beyond where tests indicate the fungus is present.

Irrigate carefully. Appropriate irrigation is the single most critical practice for improving tree health and managing root rot. Schedule irrigation frequency and amount using sophisticated methods, such as based on local evapotranspiration or by installing soil moisture monitoring devices, such as tensiometers. Good irrigation management is especially important where trees are diseased, near the margins of diseased areas of groves, and beneath thick mulch. It may be

necessary to replace irrigation emitters around unhealthy trees by installing lower output sprinklers to avoid saturating the soil. Do not water soil that is already wet because it will become waterlogged and accelerate disease.

Use high-quality irrigation water. Irrigation water with high overall salinity or an excess of boron, chloride, or sodium promotes infection of roots by *Phytophthora. Phytophthora* can contaminate irrigation water, such as surface water that is runoff from infested soil. The extra cost of purchasing high quality water can often be justified by reduced disease and increased crop quality and yield.

Apply gypsum and mulch. Create soil conditions that suppress development of Phytophthora root rot. Apply gypsum under the canopy of each tree, perhaps 25 lb beneath a medium-size tree. Apply at least 4 to 6 inches of coarse organic mulch onto soil beneath canopies, but keep mulch several inches away from the trunk. Use coarse organic mulch such as avocado trimmings, composted greenwaste (yard trimmings), or hardwood chips. Mulching promotes development of beneficial microorganisms antagonistic to *Phytophthora cinnamomi* and reduces the adverse effects of saline soil and water. Gypsum supplies calcium, which suppresses the formation of *Phytophthora* spores. Apply mulch and gypsum when the orchard is being established. Consider periodically applying additional mulch containing mostly ground wood, which provides better *Phytophthora* control than naturally dropped leaves. Reapply gypsum as the old material dissolves from view.

Provide appropriate nutrition. Moderate amounts of nitrogen promote good growth that helps avocado better tolerate root rot. Avoid excess amounts of fertilizer, especially avoid large amounts of animal manures or other products high in ammonia or salts. Avocado roots are sensitive to ammonia and salts.

Rotate crops. Replanting infested soil to resistant crops for at least several years reduces avocado root rot propagules in soil. The fungus has a wide host range, but plants such as cherimoya, citrus, and persimmon are highly resistant to the *Phytophthora* sp. causing *Phytophthora* root rot in avocado.

Chemical control. Certain phosphonate fungicides (phosphorous acid and phosphonate compounds) can markedly improve trees' ability to tolerate, resist, or recover from infection by *Phytophthora cinnamomi.* Good control requires using fungicides in combination with other recommended practices, such as careful irrigation practices and applying wood chip mulch. Phosphonates cannot eradicate *Phytophthora* from the grove and avocado root rot requires ongoing management throughout the life of the trees.

If only a few trees are affected, and the disease is detected early, trees can be cut off at ground level and the soil fumigated with the maximum rate of fumigant. However, eradication of *P. cinnamomi* from infested field soil is extremely difficult and fumigation is not recommended. Often *P. cinnamomi* re-invades fumigated soil and the avocado root rot becomes worse than before because the soil microbial community and competing microorganisms have been reduced by the fumigation.

Application methods. Varying with the product label, phosphite fungicides may be sprayed onto bark or foliage, injected into soil with irrigation water (chemigation), or injected into trunk vascular tissue. If permitted on the product label, proper trunk injection is generally the most effective application method when treating severely diseased trees. Proper application timing is critical. Phosphites can move both up and down within plants. To induce phosphites to move to roots, apply phosphites prior to initiation of new root growth. This effective application time is when about three-fourths of leaf flush is complete or just as new leaves harden, usually in late spring (May) and summer (August). Optimal application dates vary according to local conditions. If applied during early flush or when many new leaves are flushing, most of the phosphite will move to leaves and provide little *Phytophthora* control. If injected when new leaves are hardening, phosphites will move upward in the xylem stream, then move downward in the phloem where they can encourage healthy new root growth.

Inject trunks using proper equipment, such as spring powered or gas powered (CO_2) injectors. Drill relatively small diameter holes to the depth of the drill bit, at a slightly downward and sidewise angle so that more of the phosphonate material is deposited in the outer wood. Larger holes do not heal properly and continuous weeping and bacterial infection in the holes often occurs. Drill holes into smooth sections of the trunk or main limbs, avoiding knots and side branches. Where feasible, locate holes above any trunk area that is wetted by mini-sprinklers to facilitate injection wound closure.

Application (spraying) directly onto bark is usually not effective for managing avocado root rot. Bark application may be more effective in managing the trunk canker fungus *Phytophthora citricola.* Application through the irrigation system is more effective in slowing down the spread of avocado root rot disease than it is in controlling disease in already infected trees.

Common name (trade name)	**Amount/Acre**	**R.E.I.+ (hours)**	**P.H.I.+ (days)**

When choosing a pesticide, consider information relating to environmental impact.

NONBEARING TREES

A. ALUMINUM TRIS PHOSPHONATE

(Aliette) WDG	Drench: 5 oz/10 gal	12	365
(Aliette) WDG	Foliar: 5 lb/100 gal	12	365

COMMENTS: For drench application: apply 1 qt per pot or sleeve of each tree 2-3 days before transplanting. For foliar application: begin application at transplanting or the start of the growing season and continue for up to 4 applications/year at 60-day intervals.

BEARING TREES

A. PHOSPHOROUS ACID

(Agri-fos, Fosphite)	1–2 qt	4	0

MODE OF ACTION GROUP NAME (NUMBER[1]): Phosphonate (33)

COMMENTS: Do not apply with copper-based fungicides or fertilizers; allow 10 days before applying copper-based compound after phosphorous acid treatment or 20 days before applying phosphorous acid after copper treatment. Do not apply to dormant or heat- or moisture-stressed trees.

B. ALUMINUM TRIS PHOSPHONATE

(Aliette) WDG	5 lb	12	12 hours

COMMENTS: Begin application at the start of the growing season and repeat every 60 days. Do not exceed 20 lb/acre/year.

C. MEFENOXAM

(Ridomil Gold) EC	Label rates	48	0 - drench;
		48	28 - chemigation

MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)

COMMENTS: Apply as a drench or by chemigation. Trials indicate this material is less effective on older trees, but is effective for a few years on young trees that have been replanted into *Phytophthora*-infested soil.

\+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

PRECAUTIONS (see last page of this chapter)

BACTERIAL CANKER

Pathogen: *Xanthomonas*
(Reviewed 1/07, updated 1/07)

SYMPTOMS AND SIGNS

Bacterial cankers appear as slightly sunken, dark areas on the bark and vary in size from about 1 to 4 inches in diameter. Bark around cankers may crack. Fluid often oozes and dries, leaving a white powder around or over the lesion. Usually cankers appear and spread upward in a line on one side of the trunk or branch. Cutting under the bark surface reveals a decayed, reddish brown necrotic pocket, which may contain liquid. Dark streaks in the wood radiate out both above and below from the lesions. These necrotic streaks are usually in the bark cortex or xylem, but sometimes extend deeper into the center of branches or trunks. Often the disease will become inactive and canker wounds will close, except that a bark flap over the wound will remain.

Severely affected trees may have pale, sparse foliage and low yields on one branch or on the entire tree, but this is rare. Sometimes newly planted trees become stunted with many lesions; new branches may grow from buds below the affected part.

COMMENTS ON THE DISEASE

Bacterial canker is widespread but is a relatively unimportant disease. In some groves the bacterium infects over 60% of the trees, but most of these trees will perform well if otherwise cared for appropriately. The pathogen can also be introduced through nursery practices.

Xanthomonas campestris is a common bacterium on avocado leaves and green twigs, where it apparently is harmless. Its reproduction and spread is favored by wet plants and humid conditions. It can infect through wounds and branch stubs and spread within the plant's vascular system. Drought stress and boron deficiency may promote development of disease symptoms. The disease most typically shows up in drought years, at the end of irrigation lines, or at points where irrigation system water pressure is lowest.

MANAGEMENT

Normally the disease is a minor problem. Usually no control is necessary on established trees. If the disease is severe and yield is affected, remove the tree. Keep trees healthy and provide good cultural care. Provide appropriate amounts and frequency of irrigation and good uniformity of water distribution among trees. Use certified, disease-free nursery stock if available. Regularly inspect young trees and remove and dispose of young trees if they are infected. Nurseries should use stringent sanitation, regularly screen stock for disease, and dispose of affected trees so they are not planted.

DEMATOPHORA OR ROSELLINIA ROOT ROT

Pathogen: *Dematophora necatrix*
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

Yellow foliage, shriveled fruit, and little or no new growth are symptoms of Dematophora root rot. Cottony, white mycelia cover small feeder roots, and roots decay. Mycelia grow into soil and upward in the tree, forming small, pale patches under or in bark of major roots, the root crown, and lower trunk, which eventually decay. Older mycelium become gray or black. The fungus can also cause a purple canker in wood at the root crown of young trees. Diseased trees will defoliate and always die prematurely, usually within 1 to 3 years of initial infection.

COMMENTS ON THE DISEASE

Dematophora root rot is not common in avocado in the United States. Although uncommon, when present, it is a very serious disease and requires prompt action to prevent its spread to other trees.

Dematophora root rot is also called white root rot in reference to its pale mycelium, or Rosellinia root rot because the fungus is named *Rosellinia necatrix* during another stage of development. The fungus persists for years in buried wood and organic matter in soil. It spreads to nearby trees through root grafts and can also be moved longer distances in infected soil or wood. Spores apparently are not important in causing disease.

The whitish mycelial patches of *Rosellinia* resemble those of *Armillaria,* but *Rosellinia* mycelia lack the characteristic mushroomlike odor produced by *Armillaria.* One method to diagnose *Rosellinia* is to seal infected wood, roots, or soil in a moist container. Extensive white mycelium will grow within a few days. However, because of its severity and persistence, seek expert assistance if Dematophora root rot is suspected.

MANAGEMENT

The biology and management are much the same as described for *Armillaria.* Uproot and dispose of infected trees. Remove immediately adjacent trees that may also be infected. Remove as many root pieces from soil as possible and trench around the infected site to break root grafts. Establish a dry zone and prevent soil movement or water runoff from that site. Fumigate or solarize the ground well before replanting.

DOTHIORELLA CANKER

Pathogen: *Botryosphaeria* and *Fusicoccum* spp.
(Reviewed 1/07, updated 6/10)

SYMPTOMS AND SIGNS

Dothiorella cankers exude reddish sap that dries to a brown and white powder. Bark may be cracked, darkly discolored, or slightly sunken. With older cankers, bark may shed or can be easily removed from the damaged area. Under the canker, inner bark and wood is brown, orangish, or red, instead of the normal pale color. Brown dead leaves remain attached if much of the xylem becomes infected and rapidly kills the entire limb.

Dothiorella canker can be a serious problem in new plantings; stock sometimes arrives from the nursery with latent infections in the graft union. Where infection kills the graft union, the dead scion retains a dry brown canopy, while shoots and green leaves sprout up from the rootstock. The graft union may be unusually swollen and rough before the young tree dies. Cutting inside at the graft union reveals dark, discolored wood that can extend through the entire width of the small trunk.

Dothiorella canker is usually of minor importance in established, older trees. Scattered small branches and sometimes large limbs can die back. Usually the entire tree is not affected and the tree remains productive. In severe cases, the main trunk may be girdled, killing the tree.

COMMENTS ON THE DISEASE

Several pathogens cause Dothiorella canker on trunks and large limbs. This disease was formerly attributed to a *Botryosphaeria* anamorph, *Dothiorella gregaria* (teleomorph *B. ribis),* and the disease was known as Dothiorella canker. *Neofusicoccum luteum* is now known to be the most common cause of Dothiorella canker disease on avocados in California. *Botryosphaeria dothidea* also causes Dothiorella canker in California. Several other *Botryosphaeria, Diplodia,* or *Fusicoccum* spp. cause DOTHIORELLA FRUIT ROT, DOTHIORELLA LEAF AND STEM BLIGHT, and cankers and these fungi can not be reliably distinguished during certain stages of their growth, except with molecular tests such as PCR (polymerase chain reaction).

Dothiorella cankers closely resemble Phytophthora canker. Dothiorella cankers usually occur higher above the ground, beginning around the first main branch crotch or higher. *Dothiorella* can infect much smaller limbs, such as twigs and small branches, as well as the upper trunk and large limbs. When cut into with a knife, Dothiorella cankers sometimes extend deep into wood, while Phytophthora canker discolors only a shallow layer of outer wood. Except when trees are young, Dothiorella canker is usually not as serious as diseases caused by *Phytophthora* spp.

Botryosphaeria spp. can infect only through wounds. Heavy rainfall causes increased spore production and infection. Spores spread in air and water. Trees that are stressed are much more susceptible to this disease. Common stresses include poor irrigation, low quality irrigation water, nutritional deficiencies, or severe insect and mite feeding. Drought stress especially promotes symptom development and triggers latent infections to develop into disease. Mexican rootstocks are generally much more resistant to this disease than are Guatemalan cultivars.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove using recommended monitoring methods. Consider planting rootstock cultivars that have some resistance to this disease. Where Dothiorella canker is a problem, rely primarily on sanitation and good cultural practices to control it. Prune out dead limbs and twigs, where the pathogen pycnidia (spore-forming structures) and spores persist. Dispose of dead wood and old fruit well away from avocado trees. Prune and harvest only during dry conditions. Correct environmental and nutritional stresses, and minimize other pest problems. Appropriate amount and frequency of irrigation is especially important. Leach soil periodically and use low salinity water if salt toxicity is a problem. Nurseries should use stringent sanitation measures, disinfest propagation material, and consider treating graft unions with fungicide.

DOTHIORELLA FRUIT ROT

Pathogens: *Botryosphaeria* and *Fusicoccum* spp.
(Reviewed 1/07, updated 6/10)

SYMPTOMS AND SIGNS

Dothiorella fruit rot is usually not obvious while fruit is on the tree. Small, superficial lesions can develop on fruit in the grove, but the disease usually is apparent only on fruit that is very overmature, hanging on dead limbs, or dropped on the ground.

Infections usually become active after the fruit is picked and starts to soften. Initially lesions are small, irregular brown to reddish discolorations on the peel. Under the peel, brown streaks running lengthwise in flesh may be observed because decay initially spreads along vascular bundles in the fruit. Small, purplish brown spots may appear on any part of the fruit, most often at the stem end. As fruit ages, the surface lesions gradually enlarge and become sunken and black. Fruit shrivels, and the black surface can become covered with grayish brown fungal mycelium and spores. Decay then spreads throughout the entire fruit, causing the flesh to turn brown and watery with an offensive odor.

COMMENTS ON THE DISEASE

Postharvest rots are a relatively minor problem of avocados in California. Dothiorella fruit rot is caused by several *Botryosphaeria* and *Fusicoccum* species. *Neofusicoccum luteum* and *Botryosphaeria dothidea* are common causes.Disease was formerly attributed to *Dothiorella gregaria,* hence the name Dothiorella fruit rot. Several *Botryosphaeria, Diplodia,* and *Fusicoccum* spp. fungi can cause Dothiorella fruit rot, canker, or leaf and stem blight.

These pathogens spread by wind blown or water splashed spores produced in or on cankers, dead twigs, and dying fruit and leaves. Spores infect through wounds and lenticels (tiny natural openings) on fruit. Infection occurs in the grove, but disease usually is not obvious until after fruit is picked and starts to ripen.

Damage from Dothiorella fruit rot closely resembles that from anthracnose and stem end rot, and fruit damaged by these pathogens are usually culled and lumped together in the packing house. During its early stages, Dothiorella fruit rot lesions can occur anywhere on the avocado skin, while stem end rot initially occurs only near the narrow end of fruit, where decay begins under the button. Anthracnose produces pink sporulation on the fruit surface, in contrast with the grayish mycelium from Dothiorella fruit rot.

MANAGEMENT

Use good sanitation and optimal cultural practices to minimize fruit rots. Prune out dead limbs and twigs. Dispose of dead wood and old fruit away from avocado trees. Prune and harvest only during dry conditions. Correct environmental and nutritional stresses, and minimize other diseases and disorders that injure bark, fruit, or leaves. For example, anything that causes a large number of leaves to develop necrosis will cause fruit decay spores to become abundant on those leaves and spread to infect nearby fruit. Provide sufficient irrigation with appropriate placement

of high quality water to minimize this and many other avocado problems. Follow the same postharvest handling instructions for fruit as discussed in the ANTHRACNOSE section.

DOTHIORELLA LEAF AND STEM BLIGHT

Pathogens: *Botryosphaeria* and *Fusicoccum* spp.
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

Small branches and leaves can be killed, leaving entirely brown dry leaves that usually remain on dead limbs for months. Dead branches may retain fruit, which blackens and shrivels. When leaves are infected but are attached to healthy stems, leaves often are mostly green with necrosis only in brown patches along leaf margins and at tips. When stems are healthy, typically only some of the leaves on that stem have necrotic patches. Within a tree, usually only one or a few scattered stems have necrotic leaves, and all leaves on most branches will show no symptoms of infection.

COMMENTS ON THE DISEASE

Dothiorella leaf and stem blight is caused by several similar fungal species named in DOTHIORELLA CANKER. Dothiorella leaf and stem blight is a common disease of minor importance to the health of established trees. Stem and leaf blight commonly develops during hot weather and where irrigation is not adequately managed. Otherwise healthy trees tolerate scattered necrotic leaves and a few branches killed by Dothiorella disease. The primary concern is fruit and nursery stock health. Copious spores are produced on dead limbs and leaves. Spores inoculate fruit on the tree, sometimes causing significant fruit rot and stem end rot after harvest. Contamination of plant parts used for propagation can kill young trees because of infection of the graft between rootstock and scion.

MANAGEMENT

Prune off dead limbs and twigs during dry conditions and dispose of dead wood and old fruit away from avocado trees. Knock down groups of dead leaves stuck in trees. Maintain a thick layer of mulch to hasten decomposition of fungi on the ground. Use good sanitation and optimal cultural practices to minimize disease as discussed in DOTHIORELLA CANKER and DOTHIORELLA FRUIT ROT. When weather changes from cool to warm, appropriately modify the irrigation program, and pay special attention to irrigation needs during periods of hot weather.

PHYTOPHTHORA CANKER AND CROWN ROT (Citricola Canker)

Pathogen: *Phytophthora citricola*
(Reviewed 1/07, updated 8/08)

Phytophthora cankers usually originate at or below ground level but can occur higher above ground, especially where trunks or lower limbs have been wounded. The canker appears as a region of dark bark that often exudes red resin, which becomes brownish to white and powdery as it dries. Cutting away the superficial canker reveals an orange-tan to brown lesion, instead of the normal white or cream-colored tissues. The lesion may have a fruity odor when exposed. The lesion infects the inner bark and outer layer of wood, killing cambium and phloem. Discoloring rarely extends deeper into wood than the outer woody layer. Depending on the local conditions and rootstock, the tree may ward off the disease and the lesions may heal.

Affected trees show a gradual loss of vigor and decline of the top. With advanced disease, foliar symptoms of Phytophthora canker differ some from symptoms caused by avocado root rot *(Phytophthora cinnamomi)*. With Phytophthora canker, leaves retain their normal size, there is a gradual loss of canopy, and branch dieback (staghorning) is less typical. Unlike root rot, canker and collar rot affects the major tree roots and the smaller feeder roots are usually still present. Occasionally, in advanced stages, trees will die suddenly, with leaves turning brown within a short period of time. Confirmation of *P. citricola* is achieved by laboratory tissue isolations onto selective media for *Phytophthora.*

COMMENTS ON THE DISEASE

Phytophthora canker is the most important of several canker diseases infecting avocado and is second only to root rot in severity among diseases of avocado. *Phytophthora citricola* infects the root crown and lower trunk and limbs of older trees, causing diseases called Phytophthora canker, Citricola, Citricola canker, Phytophthora canker and collar rot, or Phytophthora canker and crown rot. *Phytophthora citricola* also causes PHYTOPHTHORA FRUIT ROT. It has a wide host range, including cherimoya, cherry, fir, and walnut.

Phytophthora citricola damages trunks and limbs and only the larger roots, while *P. cinnamomi,* which cause avocado (Phytophthora) root rot damages small roots. *P. citricola* occurs innocuously on the feeder roots of many or most avocados, but disease occurs on only some of these trees. Disease develops after crowns, limbs, or trunks become infected through wounds, such as injuries from equipment, pruning, vertebrate chewing, and wind damage. Spore spread and disease development are favored by excess soil moisture and wet conditions. Cankers often occur on the side of trunks wetted by irrigation sprinklers. *Phytophthora citricola* produces oospores, which ooze from wounds and spread in splashing water or anything that contacts ooze. Contaminated equipment and tools that wound healthy trees can cause a new infection.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove by MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS. In California, the diseases caused by *Phytophthora* spp. (root rot and canker) are increasingly found together. Hence, integrated approaches to the control of both need to be followed including sanitation,

selection of tolerant rootstocks, good water management, and wound prevention.

Phytophthora citricola can easily be spread in contaminated nursery stock and on irrigation equipment, vehicles, and people. Follow the same sanitation procedures as described in the section AVOCADO ROOT ROT.

Certain rootstock cultivars are more resistant to or tolerant of Phytophthora canker or Phytophthora root rot. Consider planting more than one rootstock in a grove with a history of *Phytophthora.* Seedling rootstocks are much more sensitive than most of the clonal cultivars to trunk cankers. In University of California field trials, Toro Canyon, Duke 7, Duke 9, and Barr Duke have shown moderate tolerance, as compared to other, more susceptible rootstocks such G1033, G6, and G755B. Thomas rootstock has tolerance to root rot, but is quite susceptible to canker and collar rot and other problems such as excess salinity.

Do not keep the lower trunks wet for long periods, as this increases the chances of infection. Place drippers away from trunks, aim sprinklers to avoid wetting trunks, or switch from sprinkler to drip irrigation where feasible. Avoid wounding major roots and trunks, especially avoid pulling suckers so the bark below ground is injured. Do not stack cut wood against trunks. Rake mulch several inches back from the trunk.

Chemical Control: Consider promptly treating fresh wounds with fungicide, such as wounds from pruning. Remove suckers only by cutting them above ground, then treat the wound. Periodically disinfect pruning tools, such as after finishing work on each tree. If cankers are detected in an early stage before much of the trunk is invaded, they can sometimes be controlled by cutting out the infected tissue and spraying the wound with an effective fungicide. Where cankers extend below ground, a combination of aboveground application and soil drench with fungicide may be warranted. There is little documentation of fungicide efficacy for managing Phytophthora canker and crown rot in avocado. See AVOCADO ROOT ROT for discussion of *Phytophthora* fungicide application.

Common name (trade name)	**Amount/Acre**	**R.E.I.+ (hours)**	**P.H.I.+ (days)**

When choosing a pesticide, consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

A. ALUMINUM TRIS PHOSPHONATE
(Aliette) WDG — 2.5–5 lb — 12 — 0.5
COMMENTS: Apply as a trunk spray. Make the first application at the start of the growing season and repeat every 60 days. Repeat applications at 60 days are important (up to 4 applications/year); a single trunk spray is not sufficient to arrest the disease. Do not exceed 20 lb/acre/year.

B. PHOSPHOROUS ACID
(Agri-fos, Fosphite) — 1–2 qt — 4 — 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Phosphonate (33)
COMMENTS: Do not apply with copper-based fungicides or fertilizers; allow 10 days before applying copper-based compound after phosphorous acid treatment or 20 days before applying phosphorous acid after copper treatment. Do not apply to dormant or heat- or moisture-stressed trees.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

PRECAUTIONS (see last page of this chapter)

PHYTOPHTHORA FRUIT ROT

Pathogen: *Phytophthora citricola*
(Reviewed 1/07, updated 1/07)

SYMPTOMS AND SIGNS

Diseased fruit have a distinct circular black area that usually occurs near the bottom or lowest spot on the fruit. Internally, the rot extends into the flesh, darkening it in the same pattern as on the affected surface. Affected fruit are often touching the soil or are hanging on low branches. Most damage occurs within 3 feet of the ground.

COMMENTS ON THE DISEASE

Phytophthora fruit rot is caused by *Phytophthora* spp., usually *P. citricola,* the same fungus that causes Phytophthora canker and collar rot. Phytophthora fruit rot is usually of minor importance in California. Most damage occurs after prolonged wet conditions, the same situation that favors anthracnose. In contrast to anthracnose, which is primarily a postharvest problem, Phytophthora fruit rot infections often become obvious while fruit is still hanging on the tree, as well as causing decay after harvest.

MANAGEMENT

The most common cause of infection is believed to be the splashing of *Phytophthora* propagules from the soil surface to the fruit during heavy rain or sprinkler irrigation. Prune lower limbs so they are 2 to 3 feet from the ground. Maintain a thick layer of mulch to hasten decomposition of fungi on soil. Consider removing and disposing of fruit lying on the ground because the fungus sporulates on dropped fruit. Prune out dead limbs and twigs and dispose of dead wood and old fruit away from avocado trees.

SOOTY MOLD

Pathogen: *Capnodium* spp. and related fungi.
(Reviewed 1/07, updated 1/07)

SYMPTOMS AND SIGNS

Sooty mold consists of hyphae and spores of *Capnodium* spp. and related fungi. Sooty mold is black, somewhat felty fungal growth on the surface of fruit, leaves, or stems. Sooty molds grow on honeydew excreted by juice-sucking insects, including soft scales and whiteflies.

COMMENTS ON THE DISEASE

Sooty molds do not infect avocado and generally cause no damage. Exceptions are if leaves become so heavily covered that photosynthesis is significantly reduced, causing chlorosis and possible premature leaf drop. If fruit is noticeably fouled, it may be downgraded at the packing house.

MANAGEMENT

Manage sooty mold by controlling the insects that produce honeydew. Honeydew-producing insects in avocado are usually well-controlled by natural enemies. Control ants, minimize dust, and avoid broad-spectrum insecticides to conserve these beneficial parasites and predators. If direct insect control is required, use selective insecticides whenever possible.

STEM END ROT

Pathogen: *Lasiodiplodia theobromae (Botryodiplodia theobromae* and others)
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

Decay from stem end rot begins as slight shriveling around the stem button. Fungal mycelium are often visible on fruit if the button is removed. Conspicuous dark decay with a well-defined margin develops at the stem end. As fruit ripens, decay spreads and rots the entire fruit, which becomes dark and shriveled. Depending on the causal organisms, flesh may be watery and soft, or initially dry and corky, becoming watery later as secondary organisms colonize tissue.

COMMENTS ON THE DISEASE

Decay at the stem end of fruit is caused by the several species of bacteria and fungi. Causes include the fungus *Lasiodiplodia theobromae* and other fungi discussed in ANTHRACNOSE and DOTHIORELLA FRUIT ROT, as well as *Alternaria* and *Phomopsis* spp. These stem end rotting species are saprophytes (decay organisms) or weak pathogens, which are present in soil and most any dead or dying avocado tissue, including senescing flowers and injured bark, fruit, and leaves. Spores spread in wind and splashing water.

Stem end rot infection typically occurs in the grove during harvest, but does not develop into disease until after fruit is shipped to the packinghouse. Harvesting injures fruit around the button, and bacteria and fungi can enter the freshly cut stem, causing decay as fruit ripens.

MANAGEMENT

Use good sanitation and optimal cultural practices to minimize fruit rots. Prune out dead limbs and twigs. Dispose of dead wood and old fruit away from trees. Prune and harvest only during dry conditions. Correct environmental and nutritional stresses. Minimize other diseases and disorders that injure bark, fruit, or leaves. Provide sufficient irrigation with appropriate placement of high quality water. Maintain a thick layer of mulch under canopies to hasten decomposition of pathogen propagules. Do not harvest during or soon after rain; allow trees and fruit to dry before harvesting. Minimize the interval from harvest until fruit is placed into cold storage at the packing house; prompt cold storage reduces disease incidence. Follow the same postharvest handling instructions discussed in ANTHRACNOSE.

SUNBLOTCH

Pathogen: Avocado Sunblotch Viroid (ASBVD)
(Reviewed 1/07, updated 8/08)

SYPTOMS AND SIGNS

Sunblotch causes a wide variety of symptoms or may exhibit no symptoms in some hosts. Symptoms of sunblotch include necrotic, red, yellow, or white discolorations on fruit, often in depressions or scars in the fruit surface. Twigs can develop narrow, necrotic, red or yellow streaks on their surface or in shallow lengthwise indentations along the twig. Leaves may have white or yellowish variegated areas and be deformed, but leaf symptoms are uncommon. Rectangular cracking and checking of the bark, called "alligator bark," often occurs on the trunk and larger branches. Infected trees may be stunted and have a disproportionate amount of horizontal growth or sprawling lateral low limbs. Trees with visible sunblotch symptoms often have reduced yields. Infected trees can also be symptomless, although large reductions in yield of previously vigorous trees may indicate the presence of the viroid in otherwise symptomless carriers.

COMMENTS ON THE DISEASE

Sunblotch is caused by dozens of variants of submicroscopic particles of genetic material (viroids) that alter development and growth of infected plants. Sunblotch viroid can move systemically within avocado, and it persists in host tissues. Trees that do not show symptoms even though the viroid is present are known as "symptomless carriers." Nearly all cuttings and seed from symptomless carriers will be infected with viroid. However, seedlings from symptomless carriers do not show symptoms of sunblotch when they are used as rootstocks, but the disease often appears on scions grafted to them. Conversely, most seed from trees with symptoms are not infected, and budwood and shoot cuttings from symptomatic trees often do not contain viroid. The viroid transmits in pollen, but pollen only infects the fruit and seed produced from it. Unless a tree is infected by grafting or some way other than through pollen, there will be no viroid in budwood, root grafts, and shoot cuttings from that tree.

Transmission of the viroid most often occurs during grafting by using infected budwood or rootstock seedlings from infected trees with or without symptoms. Natural root-to-root grafts are important in transmitting sunblotch in groves. Mechanical transmission through wounds caused by contaminated harvest clippers, pruning tools, and injection equipment can also be important if infected trees are in the grove. Spread via pollen from an infected tree to the flower ovule of a noninfected avocado, resulting in infected seed, can cause fruit to be culled, but does not further spread the disease unless seed is propagated. There is no evidence of insect transmission.

MANAGEMENT

Careful propagation of nursery stock to eliminate viroid has greatly reduced sunblotch to a relatively minor disease. However, ongoing monitoring and management is required in nurseries and established groves. Sunblotch can be easily overlooked, and there are many ways that trees can become infected. Look for diseases and disease-promoting conditions regularly throughout the grove by MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS.

In the nursery, carefully select disease-free scions and seed sources. Use stringent sanitation and frequent disinfection to avoid spreading pathogens. Periodically confirm that propagation sources are disease-free (indexing) by grafting propagative source material to young Mexican seedlings and observing leaves and twigs for sunblotch symptoms, or by performing a genetic test.

Plant only indexed nursery stock that is registered as disease-free. Promptly remove symptomatic trees from the grove and chemically kill the stumps. Do not retain infected, symptomless trees just because yield does not seem to be affected; symptomless carriers are a highly infective source that can dramatically reduce yield on other trees. If only fruit and seed are infected (from infected pollen), it may not be necessary to remove that tree if indexing indicates the rest of the tree is not infected. However, trees with only fruit and seed infection indicate that other infected (possibly symptomless) trees nearby need to be indexed or removed.

The danger of spreading viroid increases in established orchards where mature trees are pruned to reduce tree size and restimulate or maintain fruit production. Severe pruning of symptomless carriers, and perhaps other severe causes of tree stress, are suspected of causing viroid to become active in the new growth, inducing previously symptomless trees to exhibit symptoms. Disinfect pruning tools, harvest clippers, and injection equipment before beginning work on a new tree. Scrubbing tools clean and then soaking them in a 1.5% sodium hypochlorite solution is effective. Growers must use a registered disinfectant and follow label directions.

SUNBURN

(Reviewed 1/07, updated 1/07)

SYMPTOMS AND SIGNS

Bark, fruit, and leaves exposed to direct sunlight can be injured by heating and drying of tissue. Damage typically is most severe on the south and southwest sides of trees. Sunburn initially causes a pale yellowish area on the exposed side of fruit. The center of discoloration may turn black, brown, or red, then necrotic or withered. Sunburned leaves develop chlorotic then necrotic blotches, which initially form between veins. Sunburned twigs become cracked, discolored, purplish, or roughened on their exposed (usually upper) side. When severe, sunburned trunk and limb bark and the cambium underneath can discolor and die, causing cankers that can girdle and possibly kill limbs.

COMMENTS ON THE DISEASE

Sunburn, sometimes called sunscald, typically occurs when trees defoliate, exposing fruit or previously shaded bark. Newly planted trees that grew with bark shaded in the nursery, and trees that are unable to take up enough water because of unhealthy roots or inappropriate irrigation, are highly susceptible to sunburn.

Prevent sunburn by providing trees with good growing conditions and proper cultural care, especially appropriate amount and frequency of irrigation. Where feasible, prevent conditions that cause foliage to drop prematurely, including Phytophthora root rot and high persea mite populations. If trees defoliate, do not irrigate until soil in the root zone approaches dryness. Defoliation reduces tree use of water, so soil will remain wet longer than with unaffected trees. Examine soil carefully and frequently and modify irrigation to prevent excess moisture in the root zone.

MANAGEMENT

Whitewash young trees routinely at planting. Whitewash the trunk and major limbs of older trees if they develop sparse canopies or are severely pruned, such as when cut back to trunks and grafted with new scion (stumped). Special whitewash products are available, or white interior latex paint diluted 50% with water can be applied. An inexpensive whitewash formula is 50 lbs hydrated lime and 4 lbs zinc sulfate to each 100 gallons of water. Certain white film kaolin clay particle products can be sprayed onto foliage to reduce sunburn and tree heat stress, apparently without interfering with leaf photosynthesis.

VERTICILLIUM WILT

Pathogen: *Verticillium dahlia*
(Reviewed 1/07, updated 8/08)

SYMPTOMS AND SIGNS

The entire tree or only one or several branches wilt suddenly when infected with *Verticillium.* Leaves turn brown and die, but the dead leaves usually remain on the tree for several months. Brown to gray-brown streaks are visible in the xylem of the branches or roots when the bark is removed. Trees with Verticillium wilt often send out new, vigorous shoots within a few months after the initial wilting. If well cared for, affected trees often recover completely with no reoccurrence of the disease. However, not all trees survive an infection and disease symptoms sometimes reoccur after an apparent recovery.

COMMENTS ON THE DISEASE

Verticillium dahliae fungus infects many hosts, including various berry and flower crops, cotton, eggplant, olive, pepper, stone fruit trees, strawberry, and tomato. Verticillium wilt is present throughout the state but is less common in avocado than root rot and canker diseases. *Verticillium dahliae* persists for years as microsclerotia in soil. Microsclerotia spread in infested organic matter and soil that is moved. The fungus infects through feeder roots, and then moves up in the water-conducting xylem system, retarding or preventing water movement to foliage from the roots.

MANAGEMENT

No known methods are effective in curing infected trees. Trees often recover completely and display no further symptoms, even though they are still infected. After dieback ceases and new growth begins, prune off dead branches. Provide optimal irrigation and modest fertilization to promote new growth. If a tree dies from *Verticillium,* remove it.

In areas where *V. dahliae* is known to occur, plant Mexican rootstocks instead of the more *Verticillium*- susceptible Guatemalan rootstocks. Do not plant avocado on land where crops susceptible to Verticillium wilt have previously grown. Do not interplant avocado with other hosts of *Verticillium,* which are listed in publications such as *Plants Resistant or Susceptible to Verticillium Wilt* (UC ANR Publication 2703). Even if they have recovered, do not use trees that have been affected with Verticillium wilt as a source of budwood or seed.

PRECAUTIONS FOR USING PESTICIDES

Pesticides are poisonous and must be used with caution. **READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER**. Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest's name.

Legal Responsibility. The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation. Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage. Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container Disposal. Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of Nonpest Animals and Plants. Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting Treated Fields. For some materials, restricted entry intervals are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest Intervals. Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit Requirements. Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Processed Crops. Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop Injury. Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal Safety. Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.

Diseases I

Fig. 1 Avocado fruit with black specks or lesions of anthracnose, caused by *Colletotrichum gloeosporioides*

Fig. 2 Clusters of *Armillaria* mushrooms

Fig. 3 Trunk canker and discoloration, symptoms of avocado black streak disease.

Fig. 4 Avocado with dead twigs, leafless branches, and sparse foliage from Phytophthora root rot, caused by *Phytophthora cinnamomi.*

Fig. 5 A close-up of a bacterial canker

Fig. 6 White patches of Dematophora root rot

Fig. 7 White exudate and dark bark on an avocado trunk with Dothiorella canker, caused by *Dothiorella gregaria.*

Fig. 8 Avocado decayed by Dothiorella fruit rot, caused by *Dothiorella gregaria*. Note fungal spores visible as a brown discoloration on the fruit.

Diseases II

Fig. 9 Browning of leaf margins and tips on an avocado branch with Dothiorella canker, caused by *Dothiorella gregaria.*

Fig. 12 Citricola scale-infested leaves showing sooty mold growth.

Fig. 15 Avocado fruit with a black and yellow lesion from wildland fire (left) and fruit with black, red, and yellow discoloration from sunburn (right)

Fig. 10 Tree trunk with symptoms of *Phytophthora citricola*

Fig. 14 Avocado fruit deformed and streaked from avocado sunblotch viroid

Fig. 11 Phytophthora fruit rot: black circular area on an avocado fruit caused by *Phytophthora cinnamomi,* identical to symptoms commonly caused by *P. citricola*

Fig. 13 Avocado fruit showing dark decay with a well-defined margin, damage from stem end rot, caused by *Dothiorella gregaria* and *Alternaria* spp.

Fig. 16 Verticillium wilt symptoms.