Apple Disease Control

Cooperative Extension Service
College of Agriculture and Home Economics

Guide H-317

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This publication is scheduled to be updated and reissued 4/05.

Several infectious disease agents (biotic pathogens such as fungi, bacteria, viruses, nematodes, and mycoplasmas) and non-infectious factors (abiotic factors such as temperature, moisture, nutrients, soil conditions, and chemicals) can cause diseases on apple trees. The climate in New Mexico tends to limit the common types of diseases; however, the diseases that do occur can be serious.

Disease severity is dependent on the susceptibility of the host, the aggressiveness of the pathogen, and the environment. Cultural management of the host also plays an important role in the severity of disease. Factors influencing the susceptibility of the apple trees include genetic tolerance, tree maturity, vigor (degree of stress), and planting density. Most infectious microorganisms go through a life cycle that includes a period of dormancy. During this period, the organism cannot cause disease. When the pathogen is not dormant, other factors such as its natural state of virulence (aggressiveness) and population density will influence disease severity. Environmental conditions play a key role in disease outbreaks. Disease is most severe when the environment is ideal for infection and disease development.

Diseased trees will produce a variety of symptoms, depending on which part of the tree is attacked (table 1).

Table 1. Symptom expression in diseased apple trees.

Part of plant affected	Physiological function impaired	Symptom development
Roots, crowns	Uptake and transport of water and nutrients	Poor plant vigor (poor or weak growth, chlorosis, stunting, tip or branch dieback, loss of leaves or flowers, poor fruit set, poor fruit quality, etc.), loss of roots (rot)
Trunk, branches	Damage to cambium, impaired transport of water and nutrients	Cankers, dead limbs, girdling
Twigs, foliage, blossoms, fruit	Impaired ability to manufacture food	Chlorotic or necrotic spots, flower loss, poor fruit set, poor fruit quality

Growers should monitor trees frequently for symptoms of disease. Watch for indications of stress such as poor growth, branch or twig dieback, yellowing, and discolored or sunken areas on roots, trunk, branches, leaves, or fruit. This type of monitoring may require scraping bark, digging feeder roots, or removing soil around the crown or lateral roots. Keep good records on all phases of orchard management, including routine monitoring for diseases. Record the date of inspection; disease symptoms and signs; environmental conditions; information on recent irrigation, fertilization and chemical applications; and the presence of pests. Sometimes positive diagnosis of diseased trees is not possible at first inspection. Draw a map of the orchard to keep track of suspect trees, which will allow for easy follow-up inspection of suspect trees.

Seasonal and environmental influences on apple tree diseases is great. Some pathogens are only active at certain times of the year. Diseases caused by these organisms are highly dependent on the environment and somewhat less dependent on the degree of host stress. For example, most diseases that affect the flowers, fruit, and leaves are triggered by excess moisture, so the diseases cause problems in the spring during periods of rain, fog, and heavy dew. Some pathogens attack tree roots in the fall; however, symptoms are not visible until the spring when the actively growing tree is unable to take up sufficient water and nutrients. Some pathogens weaken plants year round. These diseases are less dependent on the environment and more dependent on degree of host stress.

The primary goals of a disease management program are to prevent disease outbreaks and to reduce the impact of plant diseases. Often the best approach is to attack the problem by manipulating the plant and its environment. Many pathogens establish themselves slowly over years. Once disease symptoms appear, management options become limited; therefore, the key to effective disease management is prevention. Disease management strategies also must be cost effective.

Disease management begins before the trees are planted. Selecting proper rootstock and cultivars is important in the overall success of the orchard. In selecting trees, make decisions based on market and cultural considerations, but also take into account soil conditions, climate, and the most likely disease problems.

Soil preparation prior to planting will impact tree health and vigor. Apples require deep, level soil with good drainage. Cultivation and amendment of the soil may be necessary to reduce the impact of compacted soil, hardpans, and poor drainage.

Tree establishment and cultural management of the orchard will also affect the overall health and performance of the trees. Careful water and fertilization management are critical in maintaining healthy, vigorous trees. Other important management considerations include sanitation practices, pruning, thinning, harvesting, and pest control. For more information on orchard management, see New Mexico State University Cooperative Extension Guide H–321.

Controlling diseases in apple orchards is difficult once trees are infected. There are no chemical controls available for many diseases, particularly root and crown rots and cankers. Control of these diseases can only be obtained by careful water management and good sanitation practices. Chemical controls are directed at fungal and bacterial diseases of fruit and foliage. The current climate for pesticide registration makes it difficult to maintain a current listing of available materials. Check current chemical references for registration of available fungicides.

Avoid injuring trees, fruit, and beneficial organisms when using pesticides. Copper compounds used to control fungal diseases may cause russeting on developing fruit. Likewise, sulfur compounds used incorrectly may disrupt the natural control of mite pests by destroying predaceous mites. Always read and follow the product label carefully.

COMMON APPLE DISEASES IN NEW MEXICO ORCHARDS

Powdery Mildew

One of the most common diseases in New Mexico apple orchards is powdery mildew, which is caused by the fungus, *Podosphaera leucotricha*. The disease occurs during periods of high humidity (above 70%) and warm temperatures. Infected trees develop a white, powdery appearance on the underside of the leaves. This powdery growth is mycelium and spores (conidia) of the fungus. As the infection develops, the disease spreads to twigs, flowers, and fruit. Infected leaves curl upward, and infected fruit develops a net-like russeting on the surface. Late in the season tiny black fruiting bodies (cleistothecia) of the fungus may appear on infected leaves and twigs. Severe infection causes stunted trees with reduced vigor, yield, and fruit quality.

Powdery mildew overwinters as fungal strands (mycelium) in buds infected the previous year. The infected terminals may be silvery-gray in color, stunted, and misshapen. When the buds break dormancy, the new leaves and flowers are infected by the fungus. The powdery fungal growth produced on infected tissue consists of thousands of tiny spores, called *conidia,* which are responsible for secondary spread and infection. Conidia are disseminated throughout the orchard in wind currents and water splashes. High humidity (greater than 70%) and relatively warm temperatures are required for the conidia to germinate. Although spore germination depends on high humidity, they will not germinate in free water. Thus, while the leaf surface is wet, the fungus is not active. When the water evaporates from the plant surface, the humidity in the plant canopy increases and the fungus becomes active. A new batch of conidia are produced 5 days after infection. In favorable conditions, the disease spreads rapidly.

Conidia are the fungus's short-term survival spore. However, they can withstand hot, dry periods for many weeks. Once the disease begins, it is a potential threat throughout the season. This fungus may also produce fruiting bodies, called *cleistothecia,* which contain ascospores. These spores are protected from the winter climate. Thus, if produced, the fungus has two mechanisms for overwintering, as dormant mycelium in buds and as ascospores. The disease cycle of apple powdery mildew is illustrated in fig. 1.

Management of powdery mildew on apple begins before the orchard is planted by selecting cultivars with some degree of tolerance to the disease. Highly susceptible cultivars include 'Jonathan', 'Rome Beauty', 'Gravenstein', and 'Mutsu' (Crispin). 'Golden Delicious' and 'Granny Smith' are moderately susceptible. Avoid these cultivars in areas with a history of severe powdery mildew problems. No cultivars are completely resistant to infection. Check with tree producers for information regarding the tolerance of individual cultivars.

Additional management practices include good sanitation practices and protective fungicide spray programs. Sanitation programs should include removing fallen leaves and pruning shoots suspected of infection during dormancy or in early spring. This will help to reduce the primary infection and limit the amount of fungus present in the environment. Routine

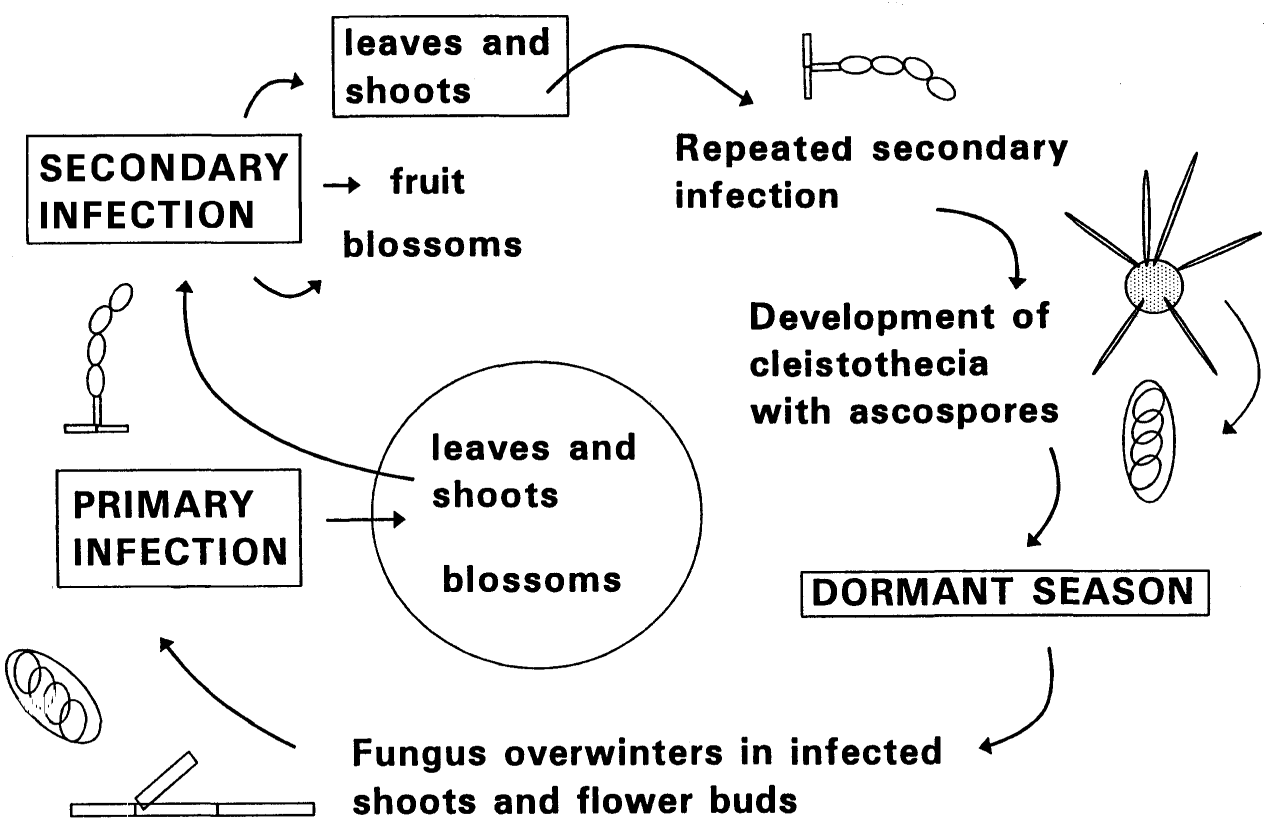

Fig. 1. Disease cycle of powdery mildew.

pruning and thinning are also helpful in allowing good air circulation around the trees, reducing humidity and chances for severe disease development.

In orchards where powdery mildew is known to be a problem, a preventative fungicide spray program can be helpful in controlling the disease. Fungicides are most effective when applied at 7- to 10-day intervals from prepink stage through petal fall. In some areas continued sprays may be necessary until terminal growth stops. A number of registered fungicides control powdery mildew on apple. However, pesticide registrations are constantly changing, making it difficult to compile pesticide lists that will stand up over time. Check with your local county extension service or chemical representative for product availability. Always be sure to read the current label before using any pesticide.

Phytophthora Crown, Collar, and Root Rot

One of the most serious diseases that infects apples is Phytophthora crown, collar, or root rot. This disease is caused by several species of *Phytophthora.* Crown rot is a disease of the rootstock, affecting bark at the crown (the point where the roots join the stem). When the scion portion of the trunk is affected, the disease is called collar rot. Root rot occurs when the fungus attacks roots away from the crown area. These diseases may occur simultaneously, in any combination, or singly depending on the portion of the tree that is attacked.

General foliar symptoms result from infection by *Phytophthora* spp. Infected trees exhibit varying degrees of decline:

- Trees will have poor terminal growth.
- Trees become stunted in comparison to non-infected trees.
- The foliage will generally be sparse and yellow.
- Early fall color may occur on infected trees.
- The fruit will be small and color prematurely.

Trees infected with *Phytophthora* typically decline slowly over many years; however, if infected during an excessively wet spring or fall, the tree may die in the first year.

To see symptoms produced at the collar or crown, the bark must be removed. The underlying tissue is discolored orange-red to brown. Older infections are dark brown to almost black. A distinct margin separates healthy and diseased tissue. Initial infection sites on roots are difficult to see; however, as the disease progresses, the roots decay and become discolored, firm, and brittle. When secondary organisms invade decaying roots, they may become soft.

The speed with which infected trees decline is dependent on several factors, such as the particular *Phytophthora* species, the tree's age, the type of rootstock and scion, water management, and climatic conditions. In general, younger trees, trees under stress, and trees attacked at the crown are more likely to collapse and die more quickly than older, stronger trees.

Phytophthora spp. are soil-borne fungi that are favored by heavy, wet, poorly drained soils. In the absence of a host plant, the fungus persists in soil for long periods. Severe disease problems occur with heavy rains in late fall through spring, when the soil remains flooded or saturated for a long time. The fungus is most active during relatively cool temperatures. Because disease development is dependent on cool temperatures and high soil moisture, the activity of the fungus is limited during unfavorable conditions. Trees suffering from root rot alone may be able to regenerate roots and recover from infection when the environment is unfavorable for the fungus. In contrast, trees infected with crown or collar rot will not recover once infected, and the tree will eventually die.

Water management is the key to controlling diseases caused by *Phytophthora* spp. Do not allow water to accumulate around trees crowns! Provide adequate drainage, and avoid planting in heavy soils, low spots, and areas that flood frequently. Once *Phytophthora* is established in an orchard, it is impossible to eradicate. Therefore, replanting where trees have died from this disease is risky. If trees are replanted in diseased areas, plant them on raised mounds or on broad ridges so that the upper roots are near the soil surface. Always plant with the graft union well above the soil line.

Another important aspect of control is the use of disease-resistant rootstock and scion. This is particularly important in choosing cultivars to replant orchards where *Phytophthora* has been a problem. Rootstock and scion cultivars will vary in their sensitivity to different *Phytophthora* spp., therefore every effort should be made to identify the species present in the orchard before replanting.

Fire Blight

Fire blight is a bacterial disease caused by *Erwinia amylovora*, a bacterium that causes a distinct fire-like appearance on infected plant parts. New shoots are highly susceptible to infection; however, all aboveground plant parts are susceptible to disease.

The bacterium overwinters in cankers and invisible infections on twigs and in buds. In the spring, the bacteria multiplies in infected tissue and begins to ooze from natural openings in the plant. The bacterial cells spread to healthy tissue by water, insects, and pruning tools. Rain, sprinkle irrigation, or high humidity and temperatures between 75 and 85° F provide ideal conditions for infection and disease development. Symptoms develop in spring and summer; hot, dry summer weather generally stops spread and development of the disease.

Apple cultivars vary in their susceptibility to fire blight. Highly susceptible cultivars such as 'Jonathan', 'Gala', 'Fuji', 'Mutsu' (Crispin), and 'Granny Smith' should be avoided in areas known to have a history of the disease.

Cultural practices are important in managing this disease. Removing and destroying infected tissue from trees can go a long way in reducing the severity of the disease. When pruning, cut the branches several inches below visible symptoms, as the bacterium advance through the tissue ahead of symptom development. Clean pruning tools between pruning cuts to avoid inadvertent spread of the bacterium throughout the tree or orchard. Clean tools by dipping them in 70–95% alcohol solution or a 10–50% bleach solution between each pruning cut.

Rapidly growing, young, succulent twigs resulting from excessive tree vigor are particularly susceptible to fire blight. Avoid practices that promote excessive vigor, such as excessive nitrogen fertilization, to reduce the incidence of disease. Proper orchard management practices, including irrigation, fertilization, pruning, thinning, and pest control, will help to maintain moderately vigorous, strong trees that will be less susceptible to bacterium attack.

Antibiotics and copper compounds can be used to control fire blight in orchards with a history of disease. Timing of sprays is critical. Make applications from first bloom to petal fall, but beware of overuse, as copper can damage fruit and bacteria readily develop resistance to antibiotics.

Crown Gall

Crown gall, caused by the soil-borne bacterium *Agrobacterium tumefaciens*, is an important disease of many plant species and is found in all types of soils

worldwide. The bacterium is somewhat unique in its behavior. It stimulates plant tissue to grow and divide abnormally, causing tumor-like galls at infection sites. Gall development impedes the flow of water and nutrients in the plant, resulting in above-ground symptoms of decline and reduced growth.

The bacterium enters the roots, crowns, and branches through wounds created by cultivation, pruning, insects, frost injury, and growth cracks. Once inside the tree, a tumor-inducing plasmid in the bacterium stimulates plant cells to grow abnormally. The resulting tumors, made of plant tissue, are rough in texture and appearance. This disease is sometimes confused with galls produced by woolly apple aphid. However, the woolly apple aphid generally produces more numerous, smaller galls. Additionally, the red-purple insects hidden in a white cottony wax will appear on the trunk of infected trees from spring through fall.

Once a tree is diseased by crown gall, it will eventually die, though the progress of disease development may be slow, causing the tree to linger in a weak state. Decline of infected trees may be slowed by painting above-ground galls with paint containing antibiotics. When treating trees in this manner, it is important not to paint more than 50% of the tree circumference at one time. When trees die, remove and burn the stumps and roots. Wait 2–3 years before replanting.

The best control for crown gall is preventing infection. Plant certified disease-free rootstock, and when planting, take care to avoid injuring the roots and crown. When cultivating around trees be careful to avoid injuring the crown and surface roots. In some cases, the crown and roots may be protected by dipping them in a biological control agent, *Agrobacterium radiobacter*, prior to planting. *A. radiobacter* is the same bacterium as *A. tumefaciens*, but it lacks the tumor-inducing plasmid, thus it is unable to cause disease. *A. radiobacter* protects the roots and crown by occupying infection sites and thereby excluding the disease-causing bacterium. Unfortunately, *A. radiobacter* is not effective against all strains of crown gall. Thus, this control practice is not 100% effective.

Alternaria Rot

Alternaria alternata is a common saprophyte (an organism capable of growth and survival without the aid of another living organism) which can become somewhat infectious to apple fruit that is predisposed to infection because of an injury. Common injuries that can lead to Alternaria rot include mechanical or chemical injury, sunscald, or chilling injury. Infection can occur before or after harvest, although it is more commonly a post-harvest problem.

Alternaria rot is managed by avoiding injury during harvest and packing. Additionally, post-harvest fruit dips in chlorine can help to prevent post-harvest disease problems. Cold storage is another good practice that will reduce disease problems.

Moldy Core

Moldy core is caused by many different species of fungi. This disease is characterized by infection within the locules (the cavity of the ovary or seed cavity), without penetration into the fruit flesh. External symptoms on the fruit are quite subtle, and typically the disease goes unnoticed until the fruit is cut open. External symptoms may include premature ripening, and infected fruit may drop from the tree.

The fungi responsible for this disease colonize the flower parts as soon as the blossoms open. The fungi then enter the developing fruit through an opening in the calyx. Moldy core is primarily a problem during years with light fruit set or in years when dry weather in early summer is followed by heavy rains in late summer. In addition, wet weather during bloom may cause conditions favorable for the fungi to produce spores.

Apple cultivars vary in their susceptibility to moldy core. This difference is primarily related to the presence of the sinus opening at the calyx end of the fruit. ‘Delicious’, ‘Gravenstein’, and ‘Idared’ are susceptible cultivars and should be avoided in areas prone to moldy core problems. In some studies, fungicides used during bloom have been successful in controlling moldy core, but the results are erratic and fungicides are rarely recommended. Cultural practices, such as tree training and pruning (which open up the tree canopy and allow good airflow and light penetration), will help to promote fast drying of plant surfaces, reducing the potential for spore development. These practices should help to reduce the incidence of moldy core.

Nutrient Deficiencies

Nutrient deficiencies result either from a lack of available nutrients (low fertility) or from soil pH that inhibits the uptake of nutrients from the soil. Additionally, an imbalance of nutrients may impair a tree’s ability to absorb certain nutrients. Symptoms of nutrient deficiencies vary depending on the deficient element. However, general symptoms include abnormal or reduced growth, discoloration of the foliage and fruit, loss of flowers, reduced yields, and poor fruit quality.

In New Mexico the nutrients most commonly deficient are iron, manganese, and zinc. These elements are relatively unavailable in soils that have a high pH, which is typical of our high-alkaline, low-organic-matter soils.

Iron deficiency, also called iron chlorosis, is identifiable by interveinal chlorosis, where the veins of the leaves remain green while the interveinal areas turn yellow. Severe deficiency may cause white spots or leaf scorch on affected foliage. The symptoms first appear on new growth, but the whole tree may be affected in severe situations. Leaf size is not affected by lack of iron, as happens with zinc deficiency. When iron chlorosis is the result of alkaline soil conditions, as in New Mexican orchards, it is best corrected by acidifying the soil with soil sulfur. As soil pH decreases, the iron in the soil will become available for plant use.

Manganese deficiency symptoms may be similar to those of iron deficiency. The intervienal areas of the leaves become yellow or golden (but will not turn white). As with iron deficiency, a lack of manganese will not affect leaf size. Using acid-forming nitrogen fertilizers usually helps to reduce problems associated with manganese deficiency. Additionally, a foliar spray of manganese sulfate in April can help to alleviate the problem.

Zinc deficiency symptoms develop on the tips of new growth. Leaves are small, stiff, and more narrow than normal—a symptom often called "little leaf." Other symptoms include yellow mottling of the foliage, reduced fruit size and quality, and slow development of lateral branches. In orchards with a history of zinc deficiency, yearly applications of zinc are necessary to control the situation. Zinc is best applied in the spring as the trees are leafing out. Foliar applications are usually more efficient than soil treatments.

Bitter Pit

Bitter pit is a common disorder in apples grown in New Mexico. This physiological disorder is associated with an insufficient amount of calcium in the developing fruit. Bitter pit is not an infectious disease and does not spread from fruit to fruit.

The disorder first appears as small, water-soaked lesions on the surface of the fruit. Gradually, the spots will turn brown and look like bruises. Spots vary in size from 2 to 10 mm, depending on the variety. With time, the spot will become sunken and the underlying tissue spongy. Spots most frequently occur at the calyx end of the fruit, though the entire fruit is susceptible. Fruit is predisposed to bitter pit while on the tree, but while symptoms can develop before harvest, the disorder often does not appear until after harvest. Maximum symptom development usually occurs within 1–2 months in storage. Affected fruit tastes bitter.

Any condition that causes calcium to concentrate in the leaves at the expense of the fruit can cause bitter pit. The disorder is more likely to occur on vigorous upright branches with lots of leafy growth because calcium is diverted away from developing fruit to the rapidly growing leaves. Other factors contributing to bitter pit include variety susceptibility, poor fruit set, excessive nitrogen or potassium fertilization, and a hot, dry growing season. In New Mexico, climate plays an important role in the development of bitter pit. The hot, dry climate typical in many locations causes high rates of evapotranspiration (movement of water through the plant). High evapotranspiration rates cause a diversion of calcium to the leaves at the expense of the fruit. Once calcium gets into the leaves, it is not easily redistributed to the fruit. Additionally, trees that have lost their crop the previous year to frost are more likely to develop bitter pit the following year.

Cultivars vary in their susceptibility to bitter pit. Selection of cultivars may be an important consideration in areas likely to have serious problems associated with the disorder. Apple varieties that are highly susceptible to bitter pit include 'Golden Delicious', 'Jonathan', and 'Granny Smith'. 'Red Delicious' is moderately susceptible. 'McIntosh' and 'Rome Beauty' are fairly resistant to bitter pit.

There is no control for bitter pit once fruit develop symptoms. The best management for this disorder is to use cultural practices that reduce excessive vegetative growth and increase the fruit-to-foliage ratio. Take soil and leaf tissue samples for analysis of nutrient levels and develop a fertilization program according to the orchard's needs. Avoid excessive applications of nitrogen and potassium fertilizer. Avoid heavy dormant pruning, as it results in excessive growth and light fruit set. Summer pruning of vigorous young trees may help lower the incidence of bitter pit. In hot, dry climates, growers should evaluate the potential damage from bitter pit and sunscald and prune accordingly. For example, if sunscald will cause greater losses than bitter pit, prune the trees to encourage moderately vigorous growth.

Other recommended management practices for avoiding heavy losses include avoiding early thinning and overthinning; avoiding early harvest; and storing apples in a cool, climate-controlled environment. In some areas, summer calcium sprays using calcium nitrate or calcium chloride may be effective in managing bitter pit. Apply at least three sprays at one-month intervals beginning mid-June. Take care when applying these materials, as they may cause fruit russeting or leaf burn. Additionally, post-harvest dips in

calcium chloride may reduce the amount of bitter pit that develops after harvest.

Watercore

Watercore is similar to bitter pit in that it is an abiotic disorder that does not spread between fruit. This disorder, which causes water-soaked, translucent, glassy cores, is caused by rapid translocation of sugar into the fruit. The disorder is not usually noticeable from the outside of the fruit.

Watercore is most likely to develop on fruit exposed to high levels of heat and sunlight. Additionally, the conditions that favor bitter pit, such as excessive vigor and poor fruit set, also increase the incidence of watercore. Cultural practices that reduce the incidence and severity of bitter pit are also recommended for managing watercore.

The high sugar content of the fruit makes mildly affected fruit good eating quality. Mild watercore symptoms usually disappear after a few weeks in storage. Thus, timely storage of affected fruit can help avoid losses associated with the disorder. Affected fruit should not be stored over six months, as the fruit may begin to develop internal browning.

Salt Injury

Too much soluble salt, such as sodium and chlorine, in the soil or water can adversely affect apple trees by causing burning or scorching on the leaf tips or margins (edges). Water deeply so that accumulated salts leach down to the root zone.

Frost Injury

At maximum dormancy, apple trees can tolerate temperatures well below freezing. However, in early spring as temperatures increase, the plant begins to grow and the young succulent growth is susceptible to frost injury. Mild frost during early development may injure fruit (causing corky ring), twigs, and branches (causing dieback and cankers). Frost later in fruit development can cause internal necrosis. Hard freezes can cause canker damage to larger branches and the trunk. Sap may ooze from cracks caused by low temperatures, a condition called “gummosis.”

In areas were freezing temperatures are a serious threat, the likelihood of frost injury may be reduced by conserving heat in the orchard. Keep cover crops or weeds mowed or tilled under. This will help keep the soil surface firm and moist. Experience shows that recently disked orchards or orchards with knee-high ground cover can be considerably colder than an orchard with a clean-cultivated, firm, moist floor. In some locations in New Mexico, it may be more important to try to prolong dormancy, thus avoiding injury due to premature bud break. In these areas, ground cover may help by keeping the temperatures a little cooler. Sprinklers or wind machines also may be beneficial in areas with high frost danger.

Sunburn Injury

Sunburn, also referred to as sunscald, affects fruit that are exposed to direct sunlight. The first symptom of sunburn is the development of yellow or flushed areas on the skin. The discolored areas eventually turn dark while the fruit is still on the tree. This symptom is easy to see, so damaged fruit can be avoided at harvest. Another symptom, small yellow spots, are less easy to see and may be overlooked at harvest. The injury is noticed in storage when the spots turn brown.

Sunburn is managed by proper tree training and pruning. In some areas, overhead sprinklers may help to reduce the heat load on developing fruit. However, overhead irrigation can cause other disease problems, so its value in preventing sunburn is probably limited.

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Reprinted April 2000 **Las Cruces, NM**
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