Crown Gall

O & T Guide OD-1

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Cooperative Extension Service • College of Agriculture and Home Economics • October 2006

Hosts: Crown gall, caused by the soil-borne bacterium *Agrobacterium tumefaciens*, has a wide host range among woody and herbaceous plants. More than 600 plant species in over 90 plant families are susceptible. Some of the most common species affected in New Mexico include: apple, cottonwood, elm, grapes, juniper, pear, poplar, purple-leaf plum, pyracantha, roses, stone fruits, and willows.

Symptoms: The bacterium stimulates host cells to divide and enlarge, causing tumor-like galls to develop. Galls on woody plants usually occur on roots and/or trunks at or just below ground level (the root crown) and at graft unions. The bacterium may become systemic in some host plants and cause galls on trunks, stems, branches and leaves above the root crown. Galls may also develop above the crown by pruning with infested cutting shears. On herbaceous plants, galls form on the roots and stems and, occasionally on leaves. Initially, galls are whitish, soft, and spongy. Later, the gall develops an irregular, rough, corky surface and a hard or woody interior. It eventually turns brown or black and may slough off the plant. Galls increase in size as the plant grows and may be less than an inch in diameter to several feet in diameter. The galls impede water and nutrient movement in the plant. Reduced transport of water and nutrients causes chlorosis, stunting, slow growth, and a general decline in plant health. Severity of the disease is related to number and size of the galls, the age of the plant at the time of infection, and the overall health of the plant. Some plants infected with crown gall will continue to grow seemingly unaffected, while others decline over time until they have to be removed. Severely infected plants and plants stressed by the environment or other pests may go into a rapid decline. Young plants and seedlings may die from the infection.

Crown gall on a poplar tree. Photo: E. Shannon, New Mexico State University.

Crown gall on juniper. Photo: E. Shannon, New Mexico State University.

Crown gall on roots. Photo: APS.

Crown gall on rose. Photo: North Carolina State University.

Conditions for Disease: The bacterium survives in galls, on root surfaces, and in soil. It can survive years in soil in the absence of a true host by colonizing roots of non-host plants. It is spread by soil, water and in or on plants.

The bacterium enters roots or stems near the ground through fresh wounds created by cultural practices environmental stresses, insects and nematodes. Any fresh wound or injury is a potential site for infection. This disease rarely kills a mature plant on its own; however, the galls weaken plants, making them susceptible to other diseases, insects and environmental stresses.

Management: Once infected, there is little that can be done to help the plant other than providing adequate water and nutrients. Well-managed trees are less likely to go into a rapid decline. Other management practices which help to reduce the occurrence and severity of the disease include:

- Plant disease-free nursery stock.
- Avoid injury to roots and crown at planting.
- Prune properly to reduce risk of entry through improper pruning cuts.
- Avoid injury to ornamentals when mowing lawns or using weed-whackers.
- Clean pruning and other tools with 10% liquid household bleach or 70% alcohol between cuts.
- Dig up and get rid of (burn or place in trash) all severely infected plants.
- Avoid propagating from infected plants.
- Do not replant the same type of plant or other susceptible plant species in the infested spot for at least five years.
- Replant infested locations with resistant species or non-hosts.

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Cytospora Canker

O & T Guide OD-6

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Hosts: Cytospora canker is caused by several species of the opportunistic fungus *Cytospora*. This fungus is a relatively weak pathogen which typically attacks weak, stressed trees. In New Mexico, this disease commonly affects cottonwood, poplars and willows, and has been associated with the decline or death of many tree species, including stone fruits, apple, elm, spruce, and pecan.

Symptoms: Circular, elongated or irregular-shaped cankers first appear on infected trees as brown, slightly sunken areas in the bark of branches and trunks. As the canker enlarges, the outer bark may become black, brown, gray, reddish brown, or yellow. The inner bark turns reddish-brown to black in color and may have a foul, salty odor. The discolored inner bark often exhibits a zonate pattern caused by the yearly growth of the fungus. As the cankers grow, they begin to girdle the branches resulting in wilting, poor growth and, eventually, dieback. Cankers quickly girdle small branches and twigs resulting in rapid dieback. It may take several years to completely girdle large limbs and trunks. Cankers frequently start at wound openings. Pinhead-sized black or orange fruiting bodies (pycnidia) are produced on the outer bark of the cankers. These fruiting bodies help to distinguish Cytospora canker from other canker diseases. Under moist conditions, these fruiting bodies produce spores on long, coiled, thread-like tendrils. Watery ooze is commonly associated with the disease on aspen trees and infected stone fruit trees often exude gummy ooze. The cankers on spruce trees are sunken and surrounded by swollen callus tissue. Black fruiting bodies may appear in the cankers and the canker may ooze copious amounts of resin. As the cankers enlarge, they girdle the branches and the needles turn yellow then reddish-brown as they die. Eventually, the affected branches die. The disease typically starts on the lower branches and slowly kills the tree from the bottom up.

Dieback caused by Cytospora canker. Photo: J. K. Clark, University of California.

Canker with fruiting bodies caused by *Cytospora*. Photo: Food and Agriculture Organization of the United Nations.

Thread-like tendrils produced from pycnidia of Cytospora. Photo: B. Cain, U.S. Forest Service.

Oozing associated with Cytospora canker. Photo: C. E. Swift, Colorado State University, Extension.

Cytospora canker on spruce. Photo: University of Minnesota, Plant Disease Clinic.

Conditions for Disease: Cytospora canker only attacks trees that have been weakened by other stresses. It will not infect healthy, undamaged trees. The most common predisposing condition is winter injury; however plants stressed by other factors such as drought, low fertility, sunscald, insects, other diseases, root damage, and mechanical injuries are also susceptible. The fungus overwinters in established cankers. Spores are spread by rain, wind, insects, birds, humans, and pruning tools. The fungus is most active in warm (above 85 ºF), moist conditions.

Management: Since this is a disease of weak, stressed trees, the best management is to prevent infection by keeping trees from becoming stressed. Maintain good water and fertilizer practices and prune out injured branches as they occur. On infected trees, remove all dead and dying branches. Do not prune trees when bark is wet. Clean pruning tools between cuts with a solution of 10% household bleach or 70% alcohol. Destroy prunings. Promote vigorous, strong growth on affected trees with proper water and fertilizer management. Avoid physically or chemically injuring the bark. No fungicides are available to treat this disease.

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Fire Blight

O & T Guide OD-3

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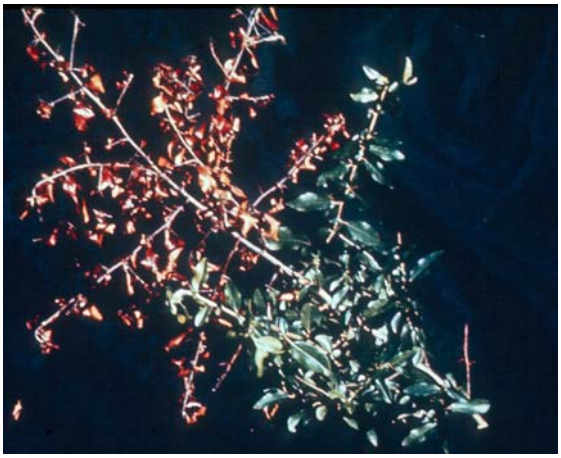
Hosts: Fire blight is a bacterial disease caused by *Erwinia amylovora*. It affects only plants in the rose family (Rosaceae). In New Mexico, the disease is most common on apple, pear, crabapple, pyracantha, photinia, and cotoneaster. Other hosts include rose, quince, hawthorn, loquat, almond, apricot, plum, cherry, chokecherry, mountain ash, raspberry, blackberry, and strawberry.

Symptoms: Fire blight can infect blossoms, fruit, stems, leaves, and woody branches. The characteristic symptom of fire blight is that affected plant parts (most notably the branch terminals) suddenly wilt, turn black and appear to have been scorched by fire. The afflicted plant parts die but usually cling to the plant. Young, vegetative shoots are shrunken and brown to black, and the tips often curl downward at approximately 180º angles to resemble shepherd's crooks. Dead, slightly sunken, discolored cankers with sharp often cracked margins form on the twigs, branches, and trunk. When the bacterium is active, the inner tissue (under infected bark areas) is water-soaked with reddish streaks. This reddening can help to distinguish fire blight cankers from cankers caused by environmental stress such as freeze injury or sunburn. Severe fire blight infections can girdle and kill branches, major limbs, or entire plants. During periods of high humidity, infected tissue may produce characteristic ooze.

Fire blight on pear (note shepard's crook). Photo: Iowa State University.



Fire blight on cotoneaster. Photo: E. Shannon, New Mexico State University.

Fire blight canker. Photo: Government of British Columbia, Ministry of Agriculture and Lands.

Fire blight canker and twig dieback on crabapple. Photo: Missouri Botanical Garden.

Conditions for Disease: The bacterium overwinters at the living margins of cankers, mostly on the branches and trunk or as symptomless infections in leaf and flower buds. In the spring, the bacterium oozes from infected cankers and is spread by splashing water, wind, contaminated pruning tools and insects (primarily bees) to nearby blossoms. The bacterium enters the plant though wounds or natural openings (such as stomata, hydathodes, lenticels, and nectaries). Infection commonly follows hail or other injuries. Environmental conditions favorable for fire blight are rainy or humid weather with daytime temperatures in the range of 75° to 85°F, especially when night temperatures stay above 55°F. Hot, dry weather (over 90°F) slows or stops disease development, but does not cure the disease. Fast-growing succulent tissue, produced as a result of excessive nitrogen applications, is more susceptible to disease.

Management: Cultural practices which help to reduce the occurrence and severity of the disease include:

- Prune out overwintering cankers during the dormant season.
- Prune active infections as they appear. Prune at least 6-12 inches below the disease margin (margin between healthy and diseased tissue).
- Sterilize pruning tools between cuts using a 10% bleach solution, 70% isopropyl alcohol, or a propane torch.
- Burn or otherwise dispose of all prunings.
- Maintain appropriate fertilizer levels.
- Avoid excessive nitrogen applications.
- Provide adequate water.
- In areas with a history of disease, replant with resistant cultivars.
- Reduce damaging insect populations.
- Copper fungicides and antibiotics can be effective sprays, however, timing is critical and improper use can lead to phytotoxicity (from the copper chemicals) or development of resistance in the bacterial population.

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True Mistletoe

O & T Guide OD-10

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Cooperative Extension Service • College of Agriculture and Home Economics • October 2006

Hosts: Mistletoes are parasitic higher plants which affect many ornamental trees and shrubs. True mistletoes, also known as leafy mistletoes, are caused by *Phoradendron* species. These plants parasitize hardwood trees, such as cottonwoods, elms, ash, willows, oaks, and locusts.

Symptoms: This parasite is most noticeable in the winter when their deciduous host trees have dropped their foliage. It appears as green, bushy growths hanging from infected branches. Heavily infected trees may almost appear to be evergreens in winter due to excessive mistletoe growth. Mistletoes do not have true roots, but are attached to their host by modified roots called haustoria or "sinkers." Haustoria grow into the branches and extend internally in the tree up to one foot past the site of infection. Haustoria not only anchor the parasite to the branch, but function in the removal of water and nutrients from the tree. Branches may become swollen at the sight of infection. Mistletoes continue to grow and enlarge in size from year to year. True mistletoes cause a slow decline in their host plant. Heavily infected trees are more susceptible to other diseases, insects, and environmental stresses. When trees are infected for many years, they may eventually be completely overtaken by mistletoes and chlorosis, branch dieback or complete tree death may occur.

Biology of True Mistletoes: True mistletoes have chlorophyll but no true roots, thus, they are capable of producing some of their own food (carbohydrates produced through photosynthesis), but rely on host plants for water and nutrients. This parasite is disseminated by birds, which feed on the seed-bearing mistletoe berries and deposit the seeds on host plants in their droppings. If the seed is deposited anywhere on a susceptible host, it can germinate and start a new infection.

True mistletoe, *Phoradendron* sp., with berries. Photo: Hilton Pond Centers.

Mature plant of true mistletoe, *Phoradendron* sp. Photo: J. K. Clark, University of California.

Swollen branches on an ash tree caused by mistletoe infection. Photo: J. K. Clark, University of California.

Ash tree heavily infested with true mistletoe. Photo: N. P. Goldberg, New Mexico State University.

Management: The most effective means of managing true mistletoe is removal of the parasite as soon as it is discovered. Infected branches should be pruned to a main lateral branch or at least a minimum of one foot below the infection. When whole branches can't be removed or the infection is in the main branch, aerial shoots should be removed by cutting or chemically by the use of ethefon (ethylene) products. Although the parasite will grow back, periodic removal helps to alleviate some of the stress placed on the host plant. Aerial shoots should be removed before they set seed. This will help to reduce inoculum in the immediate area. Heavily infested trees in severe decline should be removed. Replant with non-hosts or more resistant species.

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Powdery Mildew

O & T Guide OD-4

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Hosts: Powdery mildew is caused by many different species of fungi which all belong to the same fungal group. Powdery mildews are some of the most common diseases worldwide. Almost all plants can be affected by powdery mildew; however different powdery mildew fungi cause disease on different plants. Powdery mildew fungi may be restricted by plant family or may be restricted to a single host. In New Mexico, powdery mildew is common on rose, euonymus, crape myrtle, lilac, verbena, sunflower, photinia, zinnia, mesquite, Mexican bird of paradise, Mexican elder, turfgrass and many other ornamentals, fruits, and vegetables.

Symptoms: All powdery mildew fungi produce a common appearance on affected plants: a white, powdery growth on the surface of affected plant parts. Individual spots may enlarge and coalesce until the entire leaf, stem or flower is covered with white powder. Any above ground plant part, including fruit are susceptible to infection. Affected parts may be dwarfed, distorted, and curled. If the disease is severe, the leaves often turn yellow, wither, and drop prematurely. Infected flower buds may fail to open. Toward the end of the growing season, tiny black fruiting bodies (cleistothecia) may be produced within the white mycelium. Powdery mildew fungi are obligate parasites (they survive only on a living host plant) and typically do not kill their hosts, but infected plants become unsightly and are weakened to attack by other pathogens, insects and environmental stresses.

Powdery mildew on rose. Photo: J. K. Clark, The University of California.

Powdery mildew on euonymus. Photo: J. K. Clark, The University of California.

Powdery mildew on verbena. Photo: N. P. Goldberg, New Mexico State University.

Powdery mildew fruiting bodies (cleistothecia) on a lilac leaf. Photo: E. Shannon, New Mexico State University.

Conditions for Disease: Powdery mildew fungi overwinter as cleistothecia on fallen leaves or as mycelium and spores in or on infected plants. In spring, new shoots become infected from old mycelium, from conidia (asexual spores) or ascospores (sexual spores). These spores are spread to other susceptible hosts by air currents and splashing water.

In general, powdery mildew fungi are favored by high humidity in the plant canopy and warm temperatures (60-80ºF). The fungal spores cannot germinate in free water. But they germinate readily when the relative humidity in the plant canopy is high (97-99% at night and 40-70% during the day). The severity of the disease depends on several factors including the cultivar, age of the plant at the time of infection, overall condition of the plant prior to infection, and weather conditions. Young succulent growth is most vulnerable to the disease. The disease is common in crowded plantings, in heavily shaded areas, and in locations with limited air circulation.

Management: Cultural practices which help to reduce the occurrence and severity of the disease include:

- Prune out infected plant parts if possible.
- Remove fallen leaves (reduce overwintering inoculum).
- Destroy all infected plant material.
- Increase air flow around plants and prune or thin plants in overcrowded areas; thereby reducing humidity in the plant canopy.
- Selectively prune other trees and shrubs to reduce shade.
- Maintain appropriate fertilizer levels.
- Avoid excessive nitrogen applications.
- Provide adequate water.
- Where mildew has been a persistent problem, replant using tolerant cultivars.
- Contact and systemic fungicides are available for most plants. However proper timing of applications and thorough coverage of all above ground plant parts is critical for control.

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Phymatotrichum root rot

O & T Guide OD-8

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Cooperative Extension Service • College of Agriculture and Home Economics • October 2006

Hosts: Phymatotrichum root rot (also known as Texas root rot or cotton root rot) is caused by the soil-borne fungus *Phymatotrichopsis omnivora*. The fungus has an extremely wide host range that affects more than 2,300 species of dicotyledonous (broad-leafed plants). Monocots are not affected, although the fungus has been found to grow and reproduce on some monocots without causing any disease. Observations in New Mexico indicate that many native plants such as mesquite, creosote and desert willow, do not succumb to the disease, however they are likely to harbor the pathogen.

Distribution: The fungus is limited geographically to parts of the United States (parts of Arizona, New Mexico, and Texas) and Mexico. Even within its geographical boundaries, the fungus is spotty in occurrence. The pathogen may be so isolated that it is only found in small areas; areas small enough that only one or a few plants are affected. It may also be found in larger areas where many plants may be affected. It is found only at elevations below 5,000 feet. In New Mexico, the disease has been found only in the southern part of the state.

Symptoms: Symptoms first appear during the summer when air and soil temperatures are high. The first evidence of the disease is a slight yellowing of the leaves. The leaves quickly turn to a bronze color and begin to wilt. Permanent wilting can occur very rapidly - as little as two weeks from the first expression of disease. Plants infected with *Phymatotrichopsis* die rapidly with the leaves remaining firmly attached. In some cases, the tree wilts so quickly that there is little color change, though the leaves become dry and brittle. The disease may progress more slowly in plants grown at higher elevations. The roots are brown and rotted. A reddish lesion develops around the trunk near the soil-line of trees killed by this fungus.

Pecan tree killed by *Phymatotrichopsis*. Photo: N. P. Goldberg, New Mexico State University.

Signs: The fungus also produces signs on or near infected plants. Strands of fungal hyphae are produced on the surface of infected roots. These strands usually are visible with a good hand lens. When strands are viewed under a light microscope, cruciform (cross-shaped) hyphae unique to this fungus can be seen. Another sign is the formation of a white to tan colored spore mat on the soil surface around infected plants. Spore mats may develop during periods of high moisture. Spores produced in spore mats have never been germinated and are considered to have no function in survival or infection by this pathogen. Therefore, spore mats do not spread disease but are merely evidence of the fungus' presence.

Fungal strand on a root. Photo: R. B. Hine, University of Arizona.

Cruciform hyphae. Photo: N. P. Goldberg, New Mexico State University.

Spore mat. Photo: R. B. Hine, University of Arizona.

Conditions for Disease: The disease is associated with soils low in organic matter and high in alkalinity (pH). The fungus survives indefinitely deep (12 feet or more) in the soil as sclerotia (masses of hardened hyphae). Plants become infected when roots come in contact with sclerotia. It may take many years for plants to develop a root system deep enough to encounter the fungus. This explains why many plants will live for years before succumbing to the disease. Spread of the fungus is limited as it does not produce any viable spores. The only known spread is through root grafts between nearby plants.

Management: This disease is very difficult, if not impossible, to control. If caught very early in the development of the disease, affected plants should be cut back immediately, leaving sufficient supporting branches for normal growth. Applying soil sulfur, ammonium sulfate, and steer manure out to the drip line of infected trees may help to delay the development of the disease. This treatment must be done on an annual basis and is no guarantee of control. Avoiding areas known to be infested with the pathogen or planting immune or resistant plants in these areas is the best control measure.

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Rose Mosaic Virus

O & T Guide OD-9

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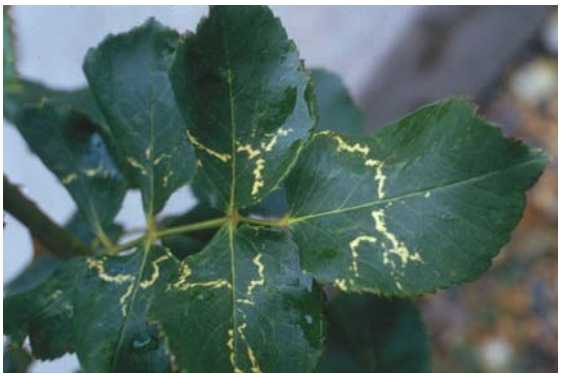
Hosts: Rose mosaic is a disease of roses caused by Prunus Necrotic Ringspot Virus (PNRSV) and Apple Mosaic Virus (ApMV). These two common viruses are found worldwide and are known to cause serious diseases in stone fruits and apples. These viruses, separately and together, have been found in rose bushes. The disease in roses is referred to as Rose Mosaic Virus.

Symptoms: The symptoms are highly variable, depending on the variety, the virus and the environment. Some of the more common symptoms include; chlorotic bands or ringspots, wavy lines, yellow vein banding, oak-leaf pattern, and general mosaic (splotches of yellow and green on leaves). Color-breaking (mottled flower color) has also been reported in some cultivars. Symptom development on only a portion of a plant is common. Some infected plants never express symptoms. Symptoms usually appear in the spring and remain throughout the growing season.

Conditions for Disease: In stone fruits and apples, the viruses are pollen transmitted. In roses, the only proven means of transmission is through vegetative propagation of infected buds, scion or root stocks. There has been much speculation and research conducted on other means of transmission in roses. However, to date, the disease has not been proven to be transmitted by any other means and there is no evidence that rose mosaic spreads from plant to plant in a garden setting. Because the disease often occurs on only one cane or a few leaves, it is mistakenly thought to be relatively harmless. However infected plants have decreased vigor, produce fewer flowers on shorter stems, have poorer transplant survival rates, and are more susceptible to winter-kill.

Chlorotic bands in an oak-leaf pattern caused by rose mosaic. Photo: George Philley, Texas Agricultural Experiment Station.

Chlorotic ringspots caused by rose mosaic. Photo: Oregon State University.



Wavy lines caused by rose mosaic. Photo: E. Shannon, New Mexico State University.

Yellow vein banding caused by rose mosaic. Photo: N. Tisserat, Kansas State Unviersity.

Symptoms caused by rose mosaic. Photo: Mississippi State University Extension Service.

Mosaic symptoms caused by rose mosaic. Photo: University of Georgia.

Mosaic symptoms caused by rose mosaic. Photo: E. Shannon, New Mexico State University.

Management: Once the plant is infected, there is no cure. Infected portions of the plant can be pruned, however this simply removes the symptoms; the plant is systemically infected and will eventually develop symptoms on other leaves and canes. Infected plants should be removed and destroyed if they are not performing up to desired levels, but they are not a risk for spreading the disease to healthy plants. When purchasing new roses, by only certified virus free plants.

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Rust on Ornamentals

O & T Guide OD-7

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Hosts: Rust on ornamentals is caused by a number of different, but closely related, species of the rust fungi. A wide range of plants can be infected by rust fungi, but individual rust fungi have a very limited host range. In New Mexico, some of the more commonly affected ornamentals species include cottonwood, crabapple, desert broom, geranium, hollyhock, juniper, New Mexico privet, oak, pennstemon, periwinkle, pine, rose, snapdragon, and willow. Daylily rust, a newly emerging rust disease problem in the United States, has also been found in New Mexico.

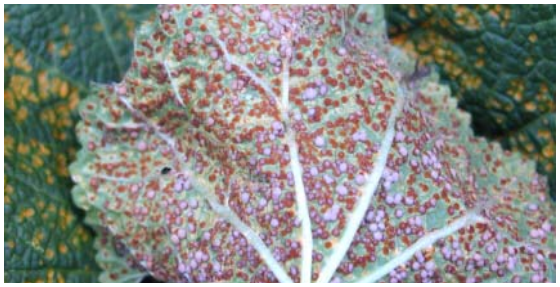
Life Cycles: Some rust species have complex life cycles and others have simple life cycles. Rust fungi may have up to five different spore stages in their life cycle. Rusts may be autoecious (having only one host) or heteroecious (having two hosts). Heteroecious rusts need both hosts to complete its sexual life cycle, although the infection can build on one host through asexual reproduction. When two hosts are required to complete the life cycle, spores from one host infect the other host and vice versa. With this type of rust disease, one host is often considered the "economic host" (the desirable plant) and one is called the "alternate host." In some cases, such as apple-cedar rust, both hosts are desirable hosts. Weeds often serve as the alternate host, especially for pine and oak.

Symptoms: The most common symptom of rust infection is the production of powdery pustules on the leaves, stems, twigs, flowers and fruit of susceptible plants. Pustules are most common on the lower leaf surface and stem. Pustules may be bright yellow, orange, orange-red, reddish brown, chocolate brown, or black in color. Pale yellow to orange spots may appear on the upper surface of infected leaves. These spots enlarge and may coalesce as the infection builds. Rusted leaves often turn yellow, die, and drop prematurely. If the infection is severe the plant may become stunted and exhibit an overall unthrifty appearance. The presence of spore pustules is a diagnostic sign of rust infection. Rust on junipers, especially red cedars, has a completely different look. It appears as green, then reddish brown, round to kidney-shaped, corky galls on the twigs. Yellow to orange, gelatinous tendrils protrude from the galls during spring rains.

Rose rust (note yellow lesions on upper leaf surface and pustules on the lower leaf surface). Photo: J. K. Clark, University of California.

Cedar-apple rust on juniper (top) and apple (bottom). Photos: The Ohio State University (top) and Kansas State University (bottom).

Geranium rust. Photo: D. S. Mueller, Iowa State University.



Hollyhock rust. Photo: University of Minnesota.

Daylily rust. Photo: D. S. Mueller, Iowa State University.

Conditions for Disease: Rust fungi infect only the plant's aboveground parts, and while rust fungi generally do not directly kill their host plants, severe infections ultimately may lead to death by other factors (winter-kill or other diseases). Rust fungi overwinter as spores or mycelia in infected plants and plant debris. Some spores produced by rust fungi can be carried several hundred miles in wind currents. Spores are also moved short distances by wind, insects, rain, and animals. Water on the plant surface is required for spore germination and infection. After the plant is infected, water is not needed for continued disease development. Rust diseases are favored by moderate temperatures.

Management: Rust fungi may be managed by the integrated use of several different management practices:

- Depending on the host, tolerant varieties may be available.
- Plant disease-free plant material.
- Space plants appropriately to allow for good air circulation and rapid drying of the foliage.
- Avoid wetting foliage
- Remove infected bedding plants and other annuals.
- Avoid planting the same species in locations where rust has been a problem.
- Prune out infected portions on perennial hosts.
- Remove and destroy infected plant debris.
- Destruction of the alternate weed host for some heteroecious rusts may help to reduce the disease.
- Contact and systemic fungicides may help to reduce or prevent disease.

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Slime Flux

O & T Guide OD-2

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Hosts: Slime flux, also known as bacterial wetwood, is a disease that can be caused by several different species of bacteria. These bacteria can infect many different species of woody trees. Some of the most commonly affected species in New Mexico include: elm, willow, cottonwood, and mulberry.

Symptoms: The most noticeable symptom of slime flux is ooze flowing down the trunks or branches of infected trees. It first causes the bark to appear moist (thus the name wetwood) and eventually dries to a whitish color. The ooze may be white, slimy and frothy and possess a foul odor. This bacterial exudate is attractive to insects and large numbers may be found in the ooze of actively sliming trees. Branches on affected trees may wilt and dieback. The slime is toxic to the bark and to plants growing under the tree. Bark killed by the ooze, especially around the exit wound, may become loose and may eventually slough from the tree.

Conditions for Disease: The bacteria that cause slime flux are ubiquitous in the environment and are commonly found in soil. They are spread by wind, soil and insects.

The bacterium enters the plant through wounds or natural growth cracks. Once inside the tree, the bacteria raise the internal gas pressure in the tree. As a result, the bacteria are forced back out of the tree in the form of ooze. The most common entry wounds are made by improper pruning cuts, other mechanical injuries, and insects. Fast growing trees produce growth cracks which may become entry points for the bacteria. Trees damaged by environmental stresses such as freezing temperatures, wind and sunburn are especially susceptible to the disease.

Cherry tree with slime flux. Photo: N. P. Goldberg, New Mexico State University.

White, frothy, slime produced by a bacterial infection. Photo: Utah State University.

Dried ooze on Chinese elm. Photo: N. P. Goldberg, New Mexico State University.

Management: If the infection is restricted to a lateral branch, the limb should be removed using proper pruning techniques. When infection is present in the trunk, there is little that can be done to help the plant other than providing adequate water and nutrients. Well-managed trees will produce less slime and are less likely to go into decline. Washing the slime off the tree with a hard spray of water will help to reduce the toxic effects. However, care must be taken to avoid washing the slime onto other plants. To help prevent infection in healthy trees, avoid injuries to the trunk and roots and follow good pruning practices which promote rapid healing of wounds. With proper care (appropriate water and fertilizer), infected trees can live for many years, however weak limbs should be removed if they become hazardous. Trees in severe decline should be removed.

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Verticillium wilt

O & T Guide OD-5

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Hosts: Verticillium wilt is caused by two species of soil-borne fungi, *Verticillium dahliae* and *Verticillium albo-atrum*. *V. dahliae* is the most common species found in New Mexico. These fungi are found worldwide in all soil types and can affect more than 300 species of woody and herbaceous plants. Some of the more susceptible tree hosts include ash, catalpa, elm, maple, pistachio, redbud, Russian olive and fruit trees.

Symptoms: The external symptoms of Verticillium wilt vary, but usually the leaves on an entire plant, or on one or more limbs on one side of a plant, suddenly wilt. An overall yellowing of the foliage sometimes precedes this wilting. The wilted leaves may either drop prematurely or remain attached to the branches. Some trees, such as ash, may defoliate while they are still green, before noticeable yellowing or wilting occurs. Other external symptoms include: decline in twig growth and dieback of individual twigs and branches, leaf curling, leaf scorch, abnormal reddening, and sparse crowns with small leaves. *Verticillium* species exist in many different genetic strains (called races) that vary in their aggressiveness and host range. Thus, a plant can be infected with a mild strain and exhibit chronic mild to moderate symptoms over a long period. Or, a plant can be infected with a severe strain and be killed within one growing season. Either way, the disease is ultimately fatal. The rate at which infected trees decline is also related to the age of the plant at the time of infection. Young trees typically die within one year, where mature trees may decline more slowly over several years. The internal symptom of Verticillium wilt is discoloration of the vascular tissue (sapwood). This symptom is typically most visible after the plant has shown advanced stages of wilt. The discoloration in most woody species is medium to dark brown, but in some plants the streaks may be olive green, greenish black, bluish, or purplish. Vascular discoloration can be used to help distinguish plants affected by abiotic stresses which cause similar symptoms from those affected by *Verticillium*. However, it should not be relied on for diagnosis as other pathogens can also cause this symptom and vascular discoloration does not always occur. Diagnosis of the disease should be confirmed with laboratory analysis.

Close-up of wilted limb on a catalpa infected with *Verticillium*. Photo: J Nickel, Albuquerque Master Gardener.

Catalpa infected with *Verticillium*. Photo: J. Nickel, Albuquerque Master Gardener.

Vascular discoloration caused by *Verticillium*. Photo: University of Kentucky.

Conditions for Disease: *Verticillium* is a soil-borne fungus that invades trees through the root system. The fungus usually enters through wounds, although a weakened tree is often invaded directly. The fungus grows in the roots, and can spread up the tree by spores transported in the xylem. *Verticillium* produces enzymes and toxins that can affect host cells distant from the infection site. Therefore, it is not always possible to isolate the pathogen from symptomatic tissue. When a plant dies, the fungus can survive in the roots and trunk for many years and can survive in soil by producing resting structures called microsclerotia. The most common means of spread is through the movement of infested soil or infected plant material.

Trees stressed by adverse conditions that affect root health such as drought, freeze damage and wounding, are most susceptible to the disease. *Verticillium* is active when soil temperatures are between 65-85°F. The optimum temperature range for fungal growth is 65-72°F.

Management: Prevention is the best method for managing Verticillium wilt in trees and shrubs. Never plant susceptible trees in soils where other plants are known to have died from the disease. Infested areas should be replanted with immune or tolerant species. Gymnosperms, such as pine and spruce, are immune to the disease. Some of the more tolerant woody plant species include, apples, crabapples, mountain ash, boxwood, pyracantha, sweet gum, honey locust, oaks, pears, poplars, sycamores, flowering quince, and willows. Trees suffering from a chronic infection may benefit from good cultural practices. For example, a balanced fertilizer (10-10-10) may help alleviate symptoms in infected trees. Avoid the use of high-nitrogen fertilizers. Infected trees should be watered appropriately to prevent drought stress, and dead branches should be removed and burned. Avoid wounding the roots or the trunk when planting, cultivating, or mowing. Fungicides are not effective for control of this disease.

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