Colorado State University
Extension

Cytospora Canker in Tree Fruit Crops

Fact Sheet No. **2.953** Crop Series | **Diseases**

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Cytospora canker may kill the whole tree, limb, or shoots resulting in partial or total loss. Even if not killed, the infected trees start blooming later than healthier trees which results in delay in fruit maturity and production of undersized fruits. Such fruits won't reach the packing shed or will increase culling percentages during the packing processing. Cankered areas often are covered by gum, produced by the tree in response to infection (Fig. 1). The disease name is attached with the fungus name and the fungal names change with new taxonomic research, thus there are different names for the same disease such as *Leucostoma* canker, *Cytospora* canker, *Valsa* canker or Perennial canker.

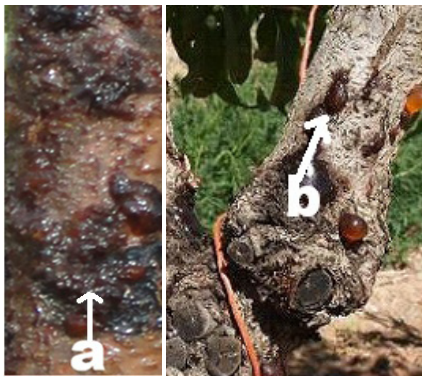

Figure 1. Dark colored gummosis and canker beneath on a peach tree trunk (pointed by arrow a) and on tree trunk and the branch (pointed by arrow b) indicates *Cytospora* infection.

Distribution

The disease is widely distributed in North and South America, Asia and Europe and is more important in peach, nectarines and sweet cherries in cooler climates such as in Canada and the northern fruit growing region of the United States (Biggs, 1995). In Germany, the *Cytospora* cankers on sweet cherry, are caused by *L. persoonii*. In Ontario and western New York, *C. cincta* is more common whereas *L. persoonii* is the major pathogen in Eastern New York, New Jersey, Michigan, and Illinois. Information on prevalent species in other states including Colorado is not available. The symptoms, disease cycles, and control methods are similar for both species. In Colorado it is believed that both species are present based on the infection type and existing weather conditions; however, it is most likely that species predominance varies with the location. In the U.S., the species involved and severity of disease depend on the location. The disease is severe in Colorado, Washington, Pennsylvania, New Hampshire, North Carolina (peach tree short life), Oregon and Florida. In Colorado, the disease is found in all fruit growing areas with variability in its incidence.

Host

Different species of *Cytospora* infect more than 60 genera of hardwood and conifer trees including aspen, green ash, Siberian elm, alder, cottonwood, and multi- and single stemmed willow as well as stone and pome fruits. Most of the stone and pome fruit varieties are susceptible, but the disease is more important in peaches, nectarines, sweet cherries, apricots, and plums. Susceptibility differs with crops and varieties but, in general, all are more susceptible during dormancy.

Importance of Disease

Hard data on total losses due to this disease are not available, but losses in stone fruits in Colorado are estimated to be 15-20 percent depending upon area, management practices, varieties planted and many other factors. However, surveys of grower's fields found that incidence and loss were several-

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Quick Facts

- *Cytospora* Canker, a disease of conifer and hardwoods, is caused by various species of fungi, depending on the host tree infected.
- This disease is the most important among pests and diseases in stone fruits but is a minor problem in pome fruits in Western Colorado.
- The fungus infects the bark and causes cankers which eventually girdles and kills the tree.
- Peach growers in Colorado often call the disease 'gummosis' although this refers more to its symptom than the disease itself.
- *Cytospora* Canker is widely distributed in North and South America, Asia and Europe and is more important in peach, nectarines and sweet cherries in cooler climates such as in Canada and the northern fruit growing region of the United States.

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fold higher than estimated (Pokharel and Larsen, 2009a). Examples of common problems among many stone fruit producers in this area include the loss of 30% of cherry trees in third year of planting or infections increasing from 15% to 70% in an orchard of 700 peach trees (Fig. 2).

Tree mortality is related with the age of the tree when infected. Trees infected in early age have higher loss rates as compared to infection in older trees. There is limited direct impact of the disease on fruit quality. The disease may kill the whole tree, limb, or shoots resulting in partial or total loss. Even if not killed, the infected trees start blooming later than healthier trees which results in delay in fruit maturity and production of undersized fruits. Such fruits won't reach the packing shed or will increase culling percentages during the packing processing.

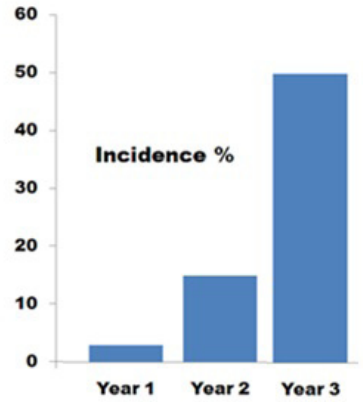

Figure 2. Increase in the incidences of *Cytospora* canker in a grower's orchard where 700 peach trees were planted in a year.

Pathogen Life Cycle

The fungi are ascomycetes in the order *Diaporthales*, family *Valsaceae*. There are approximately 500 species in the genus *Cytospora* that cause the disease in plants. Generally imperfect (anamorphic) stages of two species, *Cytospora cincta* (*Leucocytospora cinctum*) and *C. leucostoma* (*L. persoonii*), are commonly associated with tree fruits. The species are closely related and can be separated only by microscopic examination of the sexual fruiting structures and/or molecular characterization. Both species have three subgroups. Two sub-groups of *Leucocytospora cinta*, a primary pathogen of stone fruits, infect stone fruit and one infects pome fruits. In contrast, two out of three groups of *L. persoonii* infect apple and one infects stone fruits.

Reproduction

Both species and all their subgroups can reproduce asexually and sexually, but the sexual reproductive stage is hard to find in the orchard.

Asexual Reproduction

The infected tree/branch or twigs are killed by girdling the infected part. Asexual fruiting bodies called *pycnidia* are produced 2-3 weeks (up to 6 months) after the death of the bark. Under moist conditions and favorable temperatures, mature *pycnidia* extrude flesh- to orange-colored tendrils, or *cirrhi*, containing thousands of *conidia* stuck together by sticky mucilage. This mucilage dissolves when wet and huge numbers of *conidia* are liberated and dispersed. These spores are produced throughout the year and are carried—primarily by splashing rain, pruning tools, or insect—up to a distance of 40 feet from the site of production. The distance the spore travel, however, depends on wind speed, especially with high moisture. High moisture favors spore production. There are significant correlations between spore counts for *L. persoonii* and *L. cinctum* and the number of hours that temperatures are between 50 and 60°F (10 and 15°C), the duration of wetness, and the length of time that relative humidity is above 90%. *Conidia* are resistant to desiccation when contained within the cirrhus; however, upon release by water and subsequent drying, most of them die within six hours (Biggs, 2005). Short-range dispersal of *conidia* indicates rain or wind-driven rain as dispersal agents. Localized splash dispersal due to sprinkler irrigation in absence of rain is the major contributor of spore dispersal in arid fruit production areas like Colorado. Spread of *L. persoonii* may also occur via infested pruning tools, birds, and possibly by the shot-hole borer (*Scolytus rugulosus*), but these are minor compared to air, wind-blown rain, and local splash and washing.

Sexual Reproduction

The sexual reproductive structures (perithecia containing *ascospores*) are formed 2 to 3 years after the original formation of *pycnidia*. *Ascospores* are discharged forcibly into the air following rain showers at any time of the year when rainfall occurs, but they are most abundant in late spring and early autumn. The role of *ascospores* in the disease cycle is not known.

Infection

Viable *Cytospora* spores can be found on the surface of peach trees all year long, including during times of below-zero temperatures, with peak months being July through September. Infection takes place via wounds on bark and can occur from February to early April. Larger area colonization takes place around 36-46°F, but colonization can occur at temperatures of 50-59°F. The fungus grows in the bark during the winter whenever the temperature rises above freezing and stops again in the spring when the tree's defense and growth resume. The fungus can't infect actively growing trees so new infections usually start in the late fall or early spring when the tree is dormant. One should delay pruning until late winter or early spring greatly reduces risk of infection. The period of lowest spore availability usually is between March and May and corresponds to the period of low relative humidity and temperatures below 85°F. Increased duration of wetness and length of time with high humidity, especially humidity above 90%, increases disease incidence. Continuous wetting the canker with rain water or irrigation promotes spore formation and liberation. Injured cells at wounds provide the necessary food for the fungus spore to germinate and grow.

Canker development can take place throughout the year, but the greatest growth occurs in the spring and the minimum during the summer. Active tree growth can create a barrier that temporarily halts the fungus (Biggs et al., 1994). Infection of the tree occurs mostly through unhealed wounds and *conidia* are the primary source of inoculum for new infections. Such *conidia* are most abundant under the cool and moist conditions of late fall and early spring (maxima from November through March), but they are present throughout the year depending upon rainfall. In irrigated orchards, *conidia* are potentially present whenever water is available. The fungus can't infect without a wound or dead tissue including buds scars, mechanical injury, winter injury, sunburn, borer damage. In the summer and early fall the

fungus is present in phloem and xylem. In winter and early spring it is present in tree bark. Repeated infection occurs causing multiple cankers in a branch or a tree.

Disease Symptoms

The disease causes cankers at the infected site. The trees start oozing gum at or above the infection site. The canker generally grows later and often is covered by the gum. Growers consider the gummosis as the only identifying symptom of the disease, but stone fruits start oozing gum whenever trees are stressed by abiotic and/or biotitic causes. The following tips will help to identify the disease.

- Light brown colored gum early or late in the season but no canker associated with the cause: either stress other than *Cytospora* canker or early infection of the fungus
- Dark brown colored gum with associated canker -- confirms the infection by the fungus
- Excessive gum production followed by canker inside the gum - commonly observed in sweet cherry (Fig. 3A) and in peach (Fig. 3B). Light gum production is seen which dries quickly but canker symptoms on infected bark is visible which is often damaged by woodpecker - commonly seen in plum and apricot. (Fig. 4A)
- No gum and canker visible from outside, but the canker is visible with the removal of outer bark - generally seen in apple (Fig. 4B)

Sunken discolored areas with light and dark concentric circles of dead tissue often appear as a result of small twig infections. Nodal infections are easily observed 2 to 4 weeks after bud break. Infected tissues appear dark brown with oozing from the infected tissue unless the twig is killed entirely. One-year-old shoots that develop in the center of the tree are especially susceptible to nodal infections and, if left untreated, rapid invasion of scaffold limbs and large branches to which these shoots are attached may follow. Cankers that are formed on the main trunk, branch crotches, scaffold limbs, and older branches are the most conspicuous later. The infection on branches or trunks enlarges, girdles the

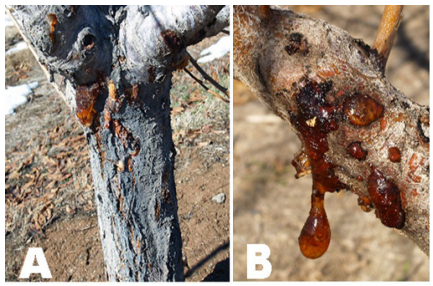

Figure 3. Early infection with a mild gummosis in cherry (A) and excessive gummosis in peach (B) and associated canker due to *Cytospora* canker infection.

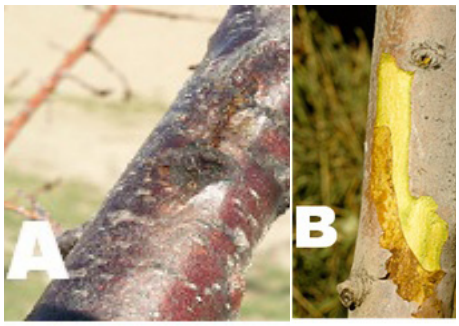

Figure 4. No gummosis but distinct canker growth in apricot (A) but lack of gummosis and the canker is distinctly visible only by removing the upper bark apple (B; photo by H. Larsen).


Figure 5. *Cytospora* canker infection, and a view of "flagging" symptoms due to *Cytospora* canker infection in a peach orchard.

infected part which will ultimately kill the scaffold or limbs called 'flagging' which are recognizable at a great distance in an infected orchard (Fig. 5). The leaves may exhibit symptoms when the branch or twig infection is severe; leaves often turn yellow, droop, and may wilt and die.

High Incidence in Colorado

The problem of *Cytospora* canker is more severe in Colorado, despite semiarid climatic growing condition with minimum rainfall (8") and clay and high pH soil, and may be because:

- Management practices such as irrigation, pruning, and nutrient management practices favoring disease incidence and spread;
- Use of minimum amount of fungicides for control of other diseases as compared to many other high rainfall states;
- The importance of the disease is not well recognized and the lack of effective management of chemicals. Abandoned or small acreage growers are not paying attention to the disease;
- Despite high importance, knowledge, research, and education efforts are not sufficient;
- Probable presence of multiple or mixed species of the fungus in stone fruit growing area.

Fertilization

Imbalance (low or high) in plant nutrients in soil and/or plants is one of the causes of tree stress that increases tree susceptibility to this disease. Peach orchards sampled and tested for nutrient availability in soil and leaf tissue exhibited deficiencies of many different micronutrients, especially iron (Fe), manganese (Mn) and zinc (Zn), in leaf tissues despite availability in soil. Availability of these nutrients is restricted by high soil pH which is common in the fruit production region. Because of this, dormant trunk sprays or foliar applications may provide better tree access to micronutrients like copper (Cu), iron (Fe), Zn, Mn and boron (Bo). In addition, some other important issues regarding fertilizer application should be considered to manage this disease efficiently. Need for the nutrients should be determined by foliage tissue analysis rather than soil available nutrients analysis. Check foliage growth in late summer; the foliage should have a healthy green color and terminal growth should be about 12 inches (30 cm) on bearing trees and 18-24 inches (46-61 cm) for non-bearing trees. Trees

with pale, nitrogen deficient leaves are more susceptible to infection by *Cytospora* canker. Balanced use of nutrients through fertilizer application supplying an adequate amount of all required nutrients will help to keep trees healthy, keeping the following points in mind:

- Check your plant nutrients in soil and leaves each year in late June or early to mid-July;
- Provide balanced nutrients regularly after checking the additional needed nutrients;
- Provide balanced N in the soil as its deficiency or excess causes problems. Avoid N application in late summer / early fall; that may delay tree dormancy and thereby induce cold susceptibility and increase plant stress;
- Apply adequate K (provides resistance);
- Correct yellow peach tree syndrome by applications of Fe, Mn and Zn as needed.

Pruning

Pruning is important and essential for tree productivity, but use of proper pruning technique and timing is critical for *Cytospora* canker management. Plants lack an active defense system during dormancy. Cuts made by pruning serve as an avenue for the entry of the fungus and spore production continues during winter also. So the timing and cut made during pruning are critical for the disease management practices.

Time of Pruning

Generally pruning is done in winter when the trees are dormant. Trees are more susceptible during winter when they are dormant and are more vulnerable in March to June. The cells injured by pruning provide the necessary food for the fungus spore to germinate and grow at the injury point. The common practice of pruning during winter or late fall increases vulnerability to *Cytospora*. Pruning promotes de-hardening of dormant wood; making the tree less resistant to cold injury and more susceptible to infection. Pruning should be delayed as late as practical for *Cytospora* Canker management.

Method of Pruning

A high incidence of disease starting from pruning cuts has been observed in grower fields. We found a reduction in disease incidence by more than 50% with the change to using proper pruning methods in grower orchards. A horizontal cut (Fig. 6) will retain moisture and fungal spores more readily than a vertical or slant cut (Fig. 6 inset). Often such horizontal pruning cuts are made almost flush and when infection takes place the infection immediately girdles the trunk, branch or limb and kills it (as in lower right hand picture). Avoid horizontal cuts, especially while making big cuts, and leave some short stubs so that infection will not immediately girdle the limb. Do not prune trees when there is high humidity (such as snowy or rainy days) or other conditions that might provide increased opportunity for the fungus to establish. Despite the problem of winterized sprays, a fungicide spray applied soon after the pruning helps to reduce the fungal infection in a freshly opened wound.

Figure 6. Severe infection started from pruning cut which was made horizontal close to trunk that girdled the tree, and it will kill the tree whereas in the left hand top corner (insertion) is right way of cut, a slant cut leaving stub (6-8") will reduce the chances of fungal spore to retain, start infection and kill the tree.

The other reason for infection spreading from pruning cuts may be due to the spread of fungal spores by the pruning implements. It can be time consuming and expensive for growers to sterilize the implements after each cut. However, by flagging infected trees so that they will be visible from a distance, and pruning them last, then treating the pruning equipment with alcohol will save time and resources.

Pruning Refuse Management

Brush piles or dead cut trees often are piled up near the orchards or properties for a long period of time. Since this fungus lives and grows in dead tissues, this refuse serves as an inoculum source especially when the rain occurs in a windy day. Rain aids both sporulation and liberation of fungal spores and wind spreads these to the nearby areas.

Irrigation

Irrigation done to fulfill the water requirement of the plants may trigger disease incidences by creating higher humidity. Thus, special precautionary measures are needed to reduce the disease outbreak by irrigation.

Irrigation Practices and *Cytospora* Canker

Sprinkler irrigation is considered effective and economical as compared to furrow irrigation, but it was found that emitters (especially the hanging type (Fig. 7A) which are the general trend in orchards) can promote disease incidence. Microjet sprinklers can create high humidity when the water they emit hits the foliage. In addition, Grove and Biggs, (2006) found that overhead and under tree sprinkler irrigations promote sporulation and dispersal of this fungus. As the irrigation water hits the infected trunk (Fig.7A) continually for a long period of time which is the general practice of the growers, it soaks the dry fungal mass that initiates spore production in the infected tissue. The water jet exerts pressure and helps to liberate and carry spores some distance. Those spores will be picked up by prevailing wind currents. Irrigation for a long duration, especially during a windy day, will encourage spore production and liberation, and carry the spores greater distances.

Inappropriate irrigation scheduling and duration can increase tree susceptibility by stressing the trees. Irrigation should be given to meet the water requirements of

the tree which is determined by prevailing temperatures. Drip irrigation may is better choice over sprinkles to manage this disease (Fig.7 B).

Duration of Irrigation

Frequent and short duration irrigations are better than long duration and long interval irrigations. The latter combination leads to over irrigation which can cause yellow peach tree syndrome that is associated with deficiencies of micronutrients such as Fe, Mn, and Zn; growers often assume the syndrome is cause by Fe deficiency alone and apply a source of Fe alone without testing the plant tissues for nutrient content. These micronutrient deficiencies and waterlogging create tree stress and make the tree vulnerable to disease. Long duration and long interval scheduled irrigations also increase tree stress by over-saturating the soil (reducing oxygen access for the root systems) and by creating a period of drought stress to the tree before irrigation. Proper irrigation timing and duration will lessen tree stress. In those cases where irrigation scheduling is at the mercy of water availability (some growers can only get the water at certain times /intervals), the grower needs to do the best they can to minimize the impact.

Despite grower perceptions to the contrary, in a recent study we found reduced irrigation had no impact on fruit quality in peaches. The following irrigation practices are recommended to reduce the disease incidence and spread:

- Use soil moisture sensors (gypsum block, irrometers, etc.) to assess irrigation timing if possible. An alternative is to take a handful of soil from 12" depth beneath the tree drip line, squeeze it in your hand and re-open your hand. If the soil does not stay as a 'balled unit' when poked with your finger, it is time to water;
- Check accumulated evapo-transpiration losses since the last irrigation and apply only as much water as needed to replace that lost water. Frequent irrigations with small amounts of water are better than long duration irrigations;

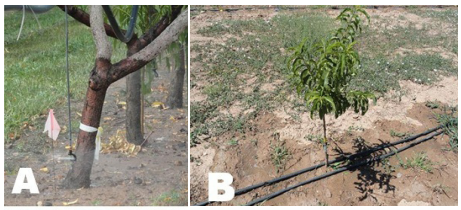

Figure 7. Use of hanging micro-jet sprinklers with long duration sets (A) promotes *Cytospora* spore production and liberation. Drip irrigation (B) does not wet the tree branches and trunk above the ground and does not promote spore liberation and dispersal.

- Just before the irrigation water access is shut off, do one last heavy irrigation to provide enough water for winter and leach the salt accumulated in root zone during growing season;
- Drip irrigation (Fig. 7B) may be better to avoid wetting tree trunks or limbs; that will reduce the spore production in the orchard;
- Avoid watering *Cytospora* canker-infected stone fruit blocks on windy days or nights.

Chemical Management Options with Regular Fungicide Sprays

According to Biggs et al., (1994) chemicals tested to study the efficacy of some chemicals were effective when tested in a laboratory condition on excised twigs. However, there are no fungicides registered specifically for control of *Leucostoma* spp., and efficacy trials have produced conflicting results (Biggs & Grove, 2005). Similar trials in Colorado with these chemicals, including the combination of some with alcohol to evaluate anecdotal grower reports of efficacy, also produced inconsistent results (Pokharel, 2011). However, the chemical Inspire provided effective control of the disease in the field for up to one year after treatment and, at the same time, limited re-infection was observed in repeated experiments. In addition, several experiments were conducted to increase fungicide efficacy in the field. If the chemicals are applied after removing the gum from the surface and disturbing bark and adding Pentabark, the chemicals effectively killed the fungus and controlled the disease, however, due to high inoculum pressure there were repeated infections.

Chemical penetration inside the tree bark was increased by applying chemicals with carrier materials such as adjuvant, especially the Pentabark. These are applied after removal of the gum and exposing the infected wood a little bit rather than to the intact surface. In a previous study chemicals were effective in excised twigs, but not in the field. That may be because the chemicals were not able to reach where the fungus is in a tree and no chemical can penetrate and translocate within the tree bark. The combination of Captan and thiophanate-methyl, when used for brown rot blossom blight control, may provide recent pruning cuts some degree of protection against infection by *L. persoonii*. Use of Demethylation-inhibiting (DMI) fungicides had very little activity against *L. persoonii* (Biggs & Grove, 2005).

Use 5-6 sprays of chemicals starting immediately after prunning, early summer, mid-summer, late summer, fall and early-winter. Alternate the following chemicals to avoid developing resistance: Captan 50wp, 2lbs/100 gal water; Rovral 50wp, 2lb/100 gal water; Topsin M 85WDG, 6oz/100 gal water; Calcium propionate, 1.5 -2.3 lbs anhydrous salt/100 gal. Rotation of these, especially after removing gum, may help to manage the disease.

Non-chemical disease management control

With increasing demand for and production of organic fruits, there also is a lack of effective management options for organic producers. Identification of effective non-chemical options to manage this disease could benefit both organic and conventional producers. Thus, non-chemical disease management strategies were also studied. Brown mustard was grown in the greenhouse until flowering; at flowering the whole plant was blended in a commercial blender with equal weight: volume of water to make slurry by mixing with soaked (25 hours in water) mustard and/or canola meal cake and poultices were made. Poultices were applied on top of the *Cytospora* canker, which killed the fungus

and protected the tree for at least a year; secondary infections from other infected trees were observed during the second year (Pokharel, 2011). However, its practicability was a big issue for commercial producers. Thus mustard oil (which also contains some level of *isothiocyanate*) was tested along with several plant-derived oils. Mustard oils applied in higher concentration >50% in water produced more consistent results than other chemicals (Pokharel and Larsen, 2009b). However, the tree was re-infected by secondary inocula after 5 months.

Cleaning

Most growers pay attention to a problem when it starts killing trees or limbs or when fruit production is affected. By that time it may be too late to manage the problem easily, or the problem has become unmanageable, with *Cytospora* spreading from a single infected tree to others in an orchard. Thus, treating the first sign of infection makes it easier to manage the disease as well as requiring less resources. When a new infection is seen in a tree or orchard, removing the gum from the infected spot and applying treatments (chemicals or non-chemicals) will make disease management easier. Often non-chemical means may be as effective as chemical, especially when the disease is low in incidence.

Consider the following approaches to manage the disease efficiently:

- Treat the first symptoms and the first tree in your orchard;
- Remove the gum from the bark before applying any treatments;
- When you see the disease in your orchard or your neighbor's field, take all necessary steps to minimize the disease incidences and spread.

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