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ANTHRACNOSE CANKER MANAGEMENT PLAN FOR COMMERCIAL APPLE ORCHARDS IN WESTERN WASHINGTON

By
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Anthracnose canker management plan for commercial apple orchards in western Washington

Figure 1. Anthracnose canker on apple tree.

Anthracnose canker (Figure 1), caused by the fungal pathogen *Neofabraea malicorticis* (synonym *Cryptosporiopsis curvispora)*, and potentially *Phlyctema vagabunda* (synonym *Neofabraea alba*), is a major disease, limiting apple production in western Washington, western British Columbia, and the Columbia Gorge (Spotts et al. 2009; Zang et al. 2011). The relatively mild temperatures combined with high humidity and frequent rains that occur during the autumn, winter, and spring in this region promote infection and disease development. Anthracnose canker is rare, or absent, on apple trees in the dry interior areas of the Pacific Northwest. Spores of the fungus infect healthy bark tissue, and the pathogen grows in the cambium beneath the bark for a period of time before killing the bark to form a visible canker.

In the absence of effective management, the disease can readily spread within an entire orchard in a short period of time, killing young trees, and structurally weakening established trees. Spores produced on the dead canker bark can cause additional cankers in infected trees, as well as surrounding trees, and also can cause a postharvest fruit rot (known as bull's-eye rot). The key to effectively managing anthracnose canker is to inspect apple trees regularly and apply treatments within the appropriate timeframe.

Pathogen and Disease Cycle

In the maritime Pacific Northwest, stem and trunk infections appear to occur primarily in the autumn, but infection can occur throughout the winter and early spring, especially during mild and moist weather. Initial disease symptoms include the appearance of a reddish-purple lesion on the tree bark, as shown in Figure 2A and 2B (Davidson and Byther 1992).

As the lesion enlarges, the necrotic tissue often begins to peel away, and a margin develops between the healthy and necrotic tissue, causing a separation of the bark tissue around the infected area (Figure 2C). The necrotic bark will eventually slough-off leaving bast fibers (strong, woody fibers from the phloem) behind, giving the appearance often referred to as "fiddle-string" (Dugan et al. 1993). Once the canker reaches the "fiddle-string" stage, it no longer increases in size.

Cankers can attain full size in one year, and can range from 1 to 10 inches long. By mid-summer to late autumn, acervuli (asexual fruiting bodies) are formed on mature cankers, producing conidia (asexual spores) that are held together in a water-soluble matrix. Rain dissolves the matrix, and the spores are disseminated by rain and wind to other parts of the tree, as well as to surrounding trees and fruit, causing new infections (Creemers 2014). The acervuli first appear as cream-colored pustules on the center of the canker surface and later on in the canker margin, and as acervuli age they become dark in color. Germination of conidia can occur under high humidity and temperatures between 30°F and 84°F (Cordley 1900; Spotts and Peters 1982). On cankers that are allowed to overwinter, the pathogen may produce apothecia (sexual fruiting bodies) in the old acervuli and release ascospores (sexual spores) into the air that can be carried over substantial distances.

Ascospore production begins by the end of March or early April, and can continue throughout the summer and into the autumn, under high humidity and temperatures between 40°F and 55°F (Jurkemikova and Rahe 1998). While the capacity of ascopores to incite infection is uncertain, it is presumed that airborne ascospores are the cause of initial infection (Rahe 1997). The pathogen can survive as mycelium in cankered limbs, or in fruit left lying on the orchard, and can produce spores that incite new infection during cool, moist weather.

Disease Management

Eradication of anthracnose canker is not guaranteed once the infection has become established. Managing the disease requires an integrated plan that includes removing cankers during dry weather year-round and applying an effective fungicide spray program to limit, or prevent, infection during the dormant and growing seasons.

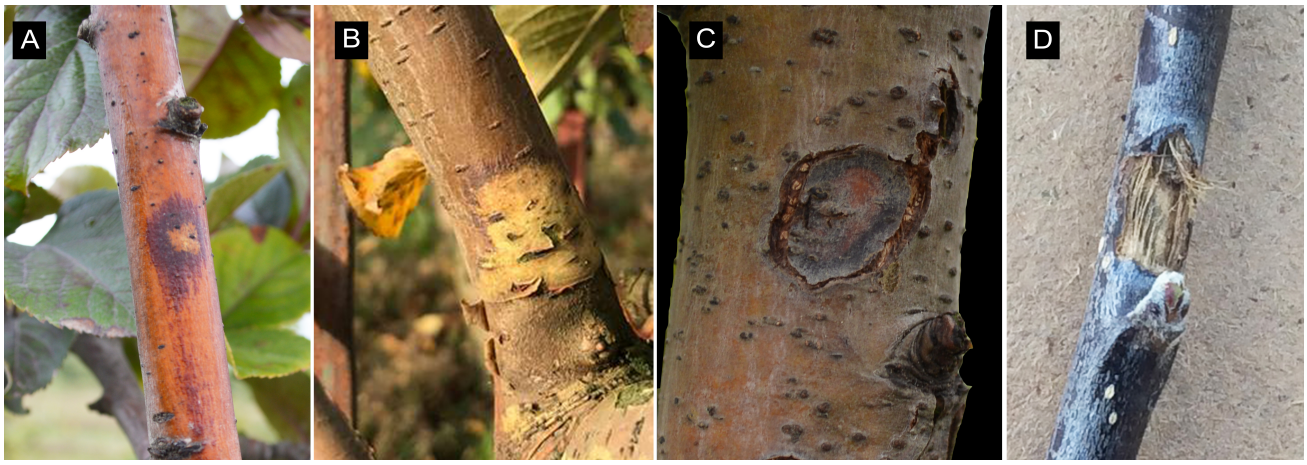

Figure 2. Anthracnose canker progression: a reddish-purple lesion is the first symptom of infection (A), necrotic tissue peels away from the infected area (B), a margin develops between the healthy and necrotic tissue (C), mature stage canker with "fiddle-string" appearance (D). Photos by Whitney Garton.

Cultural Controls

- Avoid planting trees adjacent to older and neglected apple or pear orchards that may have existing cankers, as these can serve as a constant source of inoculum.
- Fully inspect new trees for symptoms of canker initiation or development (Figure 2).
- Plant certified disease-free trees and return or destroy infected trees if symptoms are visible.
- Keep trees healthy and vigorous through proper planting, watering, soil management, and pruning. Refer to apple orchard management Extension publications (see Information Resources).
- Prune out and discard stems and branches that are infected with cankers. On trunks and larger limbs, remove cankers with a pruning knife (Figure 3).

Canker Removal

Scout the orchard once per month to look for first symptoms of infection such as bark discoloration (Figure 2A and 2B). During dry weather, excise infected tissue as well as any cankers (Figure 2C and 2D) found on larger limbs, branches, or the main trunk. To excise tissue, use a pruning knife to remove canker and approximately ¼-inch of healthy tissue beyond the canker margin (Figure 3A); remove any infected tissue including brown strands (Figure 3B and 3C) that may extend beyond the canker. Sterilize the knife after each canker removal with 10% bleach or 70% ethanol solution. Tie flagging tape next to the carved area and check monthly to determine whether the infection progresses. Prune out stems and branches that are heavily infected with four or more cankers (Figure 4A and 4B); make cuts at, but do not remove, the branch collar (Figure 4C). Avoid leaving stubs (Figure 4D).

Figure 3. Anthracnose canker removal: cut out the canker and healthy tissue ¼ inch beyond the canker margin (A); remove infected tissue (brown strands) that may extend beyond the canker (B,C). Photos by Whitney Garton

Trees that are heavily infected (having four or more cankers on the majority of branches and trunk) should be removed and burned to remove potential inoculum sources and prevent disease spread. Apply Bordeaux paste (see Bordeaux paste section) to all pruned and carved areas of the tree. In the autumn, remove all cankers and infected branches before the autumn rains begin. Discard or burn all canker pieces and prunings. Never leave diseased plant material underneath the tree because the pathogen survives as mycelium in cankered limbs or in fruit left lying on the ground, and produces spores during cool, moist weather at almost any time of the year. It is important to eliminate all sources of inoculum.

Chemical Control

The primary goal of a spray program is to prevent any viable spores from germinating and inciting infection. Apply a protectant fungicide such as Nordox 75 WG [active ingredient (a.i.), cuprous oxide], Ziram 76DF (a.i. zinc), Nu-cop 50 DF (a.i. copper hydroxide), Captan 80 WDG (a.i. captan), and Bordeaux mix (mixture of Basic Copper 53 and lime) every 3 weeks from late autumn through winter (November to February). To be in compliance with Washington State Department of Agriculture (WSDA) regulations, the Bordeaux mix must be mixed with a registered basic copper sulfate pesticide, and the company making the mixture may not sell it to someone else for application. For information on preparing and mixing Bordeaux mix, please refer to the publication provided in the Information Resources section. Add an adjuvant (e.g., surfactant or sticker) during rainy weather to prevent the product from washing off treated surfaces.

Rotate protectant chemical treatments with a systemic fungicide such as Luna Sensation (a.i. fluopyram and trifloxystrobin), Inspire Super (a.i. difenoconazole and cyprodinil), or Rally 40WSP (a.i. myclobutanil) to limit potential for development of fungicide resistance.

Protectant fungicides

are active on plant surfaces where they form a chemical barrier between the plant and fungus. There is no movement of the fungicide into the plant. Protectant fungicides must be applied before spores land on the tree surface and infect the tree. These products can prevent spore germination but have no effect once the infection is established.

Systemic fungicides

are absorbed into plant tissue and penetrate beyond the cuticle. There are different types of systemic fungicides, based on their ability to move when absorbed by the plant. *Locally systemic* fungicides remain in the area of initial plant contact and undergo very little movement within the plant. *Xylem-mobile* fungicides move upward from the point of entry through the xylem. *Amphimobile* fungicides move throughout the plant through the xylem and phloem.

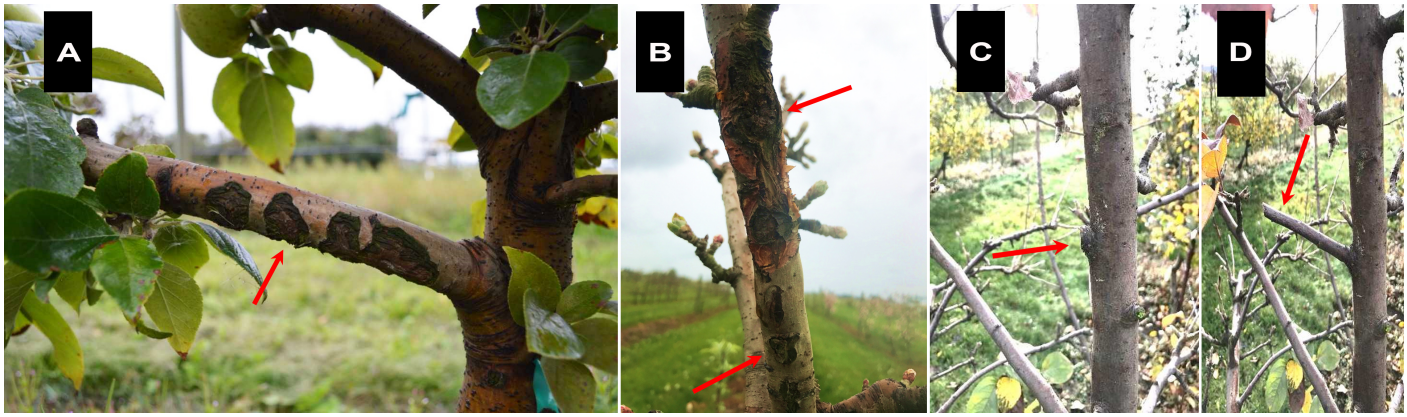

Figure 4. Prune out stems that are heavily infected with cankers (A,B). Makes cuts at the branch collar (C), avoid leaving stubs (D). Photos by Whitney Garton.

Table 1 provides a fungicide spray program for the dormant and growing seasons. Use of Ziram 76DF, or Luna Sensation should be limited to no more than four applications per year, and Inspire Super no more than five applications per year. Only one dormant application is allowed per season for Nu-cop 50 DF and Basic Copper 53. Starting shortly before bud break (March), spray trees with a protectant fungicide every 3 weeks until mid-July. Rotate sprays with a systemic fungicide. Use caution when applying copper-based fungicides during the growing season to avoid potential phytotoxicity (leaf burn) problems. A fungicide with a short pre-harvest interval (PHI, time between application and harvest) should be applied every 3 weeks from August through October (Table 1); fungicide application during this time may also control bull's-eye rot on fruit.

Excise any cankers found during this time and remove heavily infected stems or branches. Monitor trees monthly for new infections and remove diseased tissue and new cankers as they appear.

Diligence is key for successfully suppressing this disease once it has become established. Do not skip monitoring or management, as the disease can resurge and cause significant tree mortality if left unmanaged for even one season.

Table 1. Fungicides and timing of their application to control anthracnose canker on apple trees in western Washington; use this spray program to limit disease progression and spread for newly planted trees in areas where the disease is prevalent and also for established orchards where disease has been detected.

Growing season						
Rotate	**mid-Mar.**	**April**	**May**	**June**	**mid-July**	**Aug.–Oct.**
Protectant	Ziram 76DF	Captan 80WDG	Ziram 76DF	Captan 80WDG	Ziram 76DF	*Pre-harvest sprays
Systemic	Rally 40WSP	Inspire Super	Luna Sensation	Rally 40WSP	Inspire Super	

Dormant season				
Rotate	**Nov.**	**Dec.**	**Jan.**	**Feb.**
Protectant	Bordeaux mix	Captan 80W DG	Nordox 75W G	Nu-50DF
Systemic	Luna Sensation	Rally 40WSP	Inspire Super	Luna Sensation

*_**Pre-harvest fungicide**_ that has a short pre-harvest interval (PHI): Captan (PHI: 0 days)

Note: This fungicide spray program is targeted for apple orchards in western Washington. In central Washington, where environmental conditions are not favorable for disease development, the disease may be managed by lower fungicide inputs; refer to The Crop Protection Guide (EB0419) in the Information Resources section for management recommendations for that area.

Bordeaux Paste Preparation

Bordeaux paste is a combination of basic copper sulfate, lime, and water (Figure 5). A ratio of 10-10-100 works well for many disease-causing fungal pathogens (Broome and Donaldson 2010). The three hyphenated numbers represent the amount (by weight) of each material to add.

To be in compliance with WSDA regulations, the Bordeaux paste must be mixed with a registered copper sulfate pesticide, and the company making the mixture cannot sell it to someone else for application. Fixed copper fungicides should not be used in creating Bordeaux paste because they are less soluble and less effective.

You can use either dry hydrated lime or slaked lime to prepare Bordeaux paste. Most importantly, use fresh lime. Do not use lime from last season, and purchase only what you can use during the current season (Broome and Donaldson 2010).

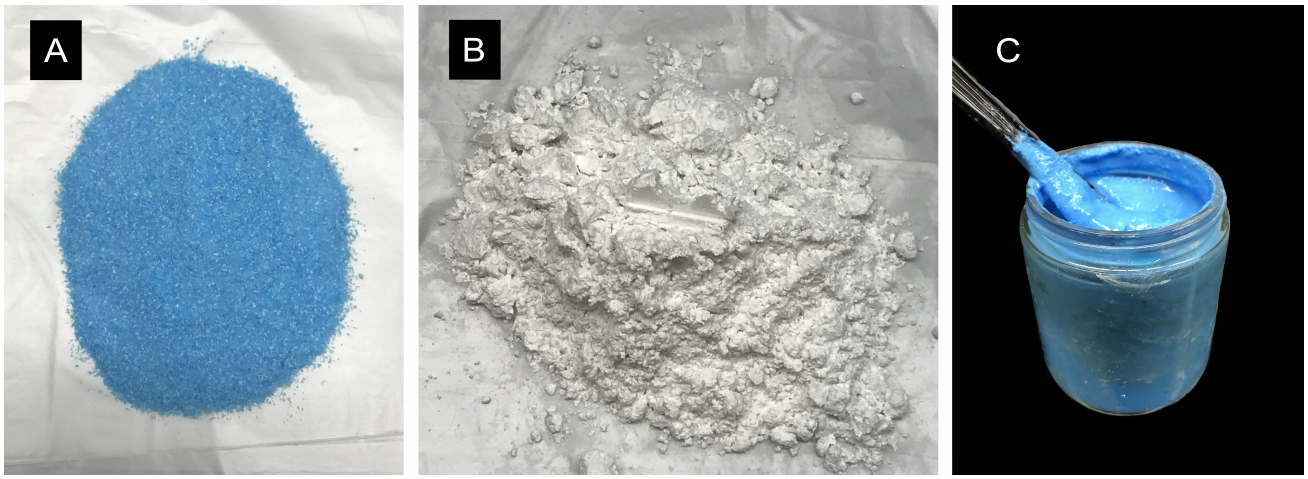

Figure 5. Preparation of Bordeaux paste: in separate containers, mix basic copper sulfate into water (A), and mix dry hydrated lime into water (B). When ready to use, mix the lime suspension into the basic copper sulfate suspension (C). Photos by Whitney Garton.

The effectiveness of Bordeaux paste depends on following the correct procedure for mixing the materials. Bordeaux paste uses the same materials and mixing process as that of Bordeaux mix, but it will form a paste as less water is used. Read the label directions carefully for basic copper sulfate regarding the proper protective equipment to wear when preparing and applying the mixture. When mixing hydrated lime, protect your eyes, nose, and mouth by using a dust and mist-filtering respirator. Apply the Bordeaux paste the same day you prepare it because the mixture will deteriorate upon standing. To make a small amount of a 10-10-100 Bordeaux paste (Figure 5C):

1. Obtain a corrosive-resistant container and add 100 mL of warm water to the container.
2. Slowly pour 40 grams (4 ½ tablespoons) of basic copper sulfate into the 100 mL of warm water and stir constantly to ensure the dissolution of basic copper sulfate.
3. In a separate corrosive-resistant container, mix 40 grams (7 ½ tablespoons) of dry hydrated lime into 100 mL of water.
4. When ready to use, slowly pour the lime suspension into the basic copper sulfate suspension and mix thoroughly.

Information Resources

Crop Protection Guide for Tree Fruits in Washington. 2017. *Washington State University Extension* EB0419.

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