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FIRE BLIGHT OF APPLE

Fire blight, caused by the bacterium *Erwinia amylovora*, is a common and very serious bacterial disease. The disease is also referred to as blossom blight, spur blight, fruit blight, twig blight, or rootstock blight – depending on the plant part that is attacked. *Erwinia amylovora* infects approximately 75 different species of plants, all in the family Rosaceae. The hosts for this bacterium include apple, blackberry, cotoneaster, crabapple, firethorn (*Pyracantha*), hawthorn, Japanese or flowering quince, mountain-ash, pear, quince, raspberry, serviceberry, and spiraea. The cultivated apple, pear, and quince are the most seriously affected species, but many ornamentals serve as overwintering hosts for the bacterium and are important sources of new infections each year.

Figure 1. Infected blossoms wilt; turn light to dark brown on apple; black on pear.

Figure 2. Rough corky tissue forms at margin of canker.

Losses from fire blight in apples and pears include: (1) death or severe damage to trees in the nursery; (2) death of young trees in the orchard; (3) delay of bearing in young trees due to frequent blighting of shoots and limbs; (4) loss of limbs or entire trees in older plantings as the result of girdling by fire blight cankers; and (5) partial loss of the crop by the blighting of the blossoms and young fruits.

The seriousness of fire blight is demonstrated by its effect on the commercial pear industry. At one time, the pear was a popular and widely grown fruit in the Midwest, comparable in importance to the apple. Fire blight has eliminated the possibility of commercial pear production in most areas of the Midwest.

Symptoms

The fire blight bacterium can infect any portion of a susceptible plant. The common types of infection are blossom blight, shoot blight, and branch and trunk canker. Blossom blight is most com-

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mon on pear, apple, hawthorn, mountain-ash, and *Pyracantha*. Infected blossoms become water-soaked and darker green as bacteria invade new tissues. Within 4 or 5 days fruiting spurs may begin to collapse, turning dark brown to black (spur blight) (Figure 1). The leaves wilt, die, and turn dark brown to black, usually remaining attached to the tree throughout the summer. As the bacteria move through the pedicel, the tissue becomes water-soaked and dark green. Infected tissues may exude either small droplets of a milky-white ooze or fine, hairlike strands containing millions of fire blight bacteria that can initiate new infections. The ooze, which later turns an amber color, contains countless bacteria that also are capable of causing new infections.

Figure 3. Apple shoots affected by fire blight. Not "shepherd's crooks" at the tips. (Photo courtesy of A.L. Jones, Michigan State University).

Shoot blight is recognized by the rapid dieback of shoots. Infections begin in the shoot tips and move rapidly down from one to twelve inches a day. Newly infected tissue becomes water-soaked and dark green or reddish brown in color. As in spur blight, infected leaves die and turn either dark brown (apple, crabapple) or black (pear) and remain attached throughout the growing season. Frequently, the tip of the blighted shoot bends over and resembles a shepherd's crook (Figure 3). Hawthorn leaves turn yellow, then brown, shrivel, and fall prematurely.

The terminal shoots of Jonathan apple trees are often blighted back 12 to 36 inches (30 to 90 centimeters). The infection may continue down a shoot or flower spur into a larger branch or trunk, forming a canker. These cankers continue to enlarge during the growing season and may girdle the affected part, resulting in the death of the entire branch or tree. The surface of a canker is somewhat sunken, relative to the surrounding healthy tissue, and the bark is usually darker in color. A distinct zone of rough, corky tissue may form at the margin of the canker (Figures 2 and 6). In some cultivars, it is difficult to determine the margin of the canker without cutting into the wood to expose the discolored and infected tissue. The diseased inner bark of older branches becomes reddish brown and marbled, in contrast with the whitish color of normal wood. The surface of smooth-barked branches darkens; also, cracks usually develop at the margins of the diseased area.

Figure 4. Droplets of bacterial ooze on immature apple. (Photo courtesy of A.L. Jones, Michigan State University).

Fruits are susceptible to infection until just before maturity. The incidence of fruit infection is usually low; however, infections can follow mechanical injury such as hail or insect feeding. Diseased fruit is first water-soaked, turns brown, shrivels, and turns black. Droplets of milky and sticky bacterial ooze are commonly observed on the fruit surface during wet, humid weather (Figure 4).

A phenomena called "rootstock blight" usually occurs in high density orchards planted with susceptible rootstock such as M.9 and M.26. Rootstock blight is caused by formation of cankers on susceptible rootstocks which can completely girdle and kill the tree in one to a few months (Figures 5 and 6). The

Figure 5. A three-year old Fuji apple tree killed from infection of M.9 root stock by fire blight.

bacteria in the infected blossoms or shoots pass through healthy limbs and trunks and reach the rootstock and produce the cankers. Root suckers and sprouts from susceptible rootstocks also may become infected, much as do the shoots. These infections can also lead to the invasion of the entire root system and the rapid death of the tree. Fire blight is often followed by Black Rot and Wood Rot.

Disease Cycle

The fire blight bacteria overwinter in living tissue at the margins of trunk and branch cankers that were formed by infections initiated in previous years, and possibly in buds. The bacteria resume growth in the spring when temperatures are above 65°F (18°C) with survival favored by rain, heavy dews, and high humidity. By the time trees are blossoming, ooze containing bacteria are present on the surface of cankers. Relatively few cankers survive winter, become active, and produce bacteria in the spring. However, a single active canker will produce millions of bacteria, enough to infect an entire orchard. The cankers most likely to produce bacteria in the spring are those with smooth margins between healthy and infected tissue, and those formed in older wood. Cankers produce bacteria in droplets of ooze that are spread by splashing rain or insects (mostly bees, flies, and ants) to open blossoms. The bacteria multiply rapidly on the blossom and invade the tissue through the nectaries (non-cutinized or flower parts). The bacteria then spread from blossom to blossom by rain or pollinating insects. The optimum temperature range for blossom blight infection is 65° to 86°F (18° to 30°C).

Figure 6. Fire blight on the M.9 root stock of an apple tree.

Succulent shoot tips are frequently infected by bacteria that have been spread from cankers and infected blossoms. The invasion of shoot tips can occur through natural openings, such as lenticels and stomata, but more commonly through wounds created by sucking insects such as aphids, leafhoppers, and tarnished plant bugs, by wind whipping, or by hail. The fire blight bacteria reproduce rapidly within an infected shoot. Droplets of ooze form on the shoots within three days. This ooze serves as a source of inoculum for the further spread of the disease. Shoots remain highly susceptible to infection until vegetative growth ceases and the terminal bud forms.

Warm (optimum temperature 76°F or 24°C) and moist weather is favorable for infection, and rapid growth encourages disease development. Nitrogen fertilization, late fertilizer application, poor soil drainage, and other factors that promote succulent growth or delay the hardening of the tissues from midsummer into autumn tend to increase the severity of this disease.

Dried bacterial ooze remains infectious for more than a year if it is not subjected to alternate wetting and drying. Contaminated boxes or other containers that are taken into orchards for fruit picking may serve as a potential source of infection.

Control

No single method is adequate to effectively control fire blight. A combination of practices is needed to reduce the severity of the disease.

1. **Choose the proper cultivars**. Apple cultivars differ widely in their susceptibility to fire blight (Tables 1 and 2). During warm and rainy weather, cultivars rated moderately susceptible or moderately resistant will develop shoot infections; however, the extent to which shoot infections progress will be less in resistant cultivars than in susceptible cultivars. **Commercial growers should select rootstocks that are less susceptible to fire blight. Bartlett pears are extremely susceptible to fire blight and are not recommended for planting in Illinois.**

2. **Select planting sites with good soil drainage**. Trees are more susceptible to fire blight in poorly drained sites than in well-drained ones. Tree productivity will also be lower on such sites. Drainage can often be improved by tiling.

3. **Follow proper pruning and fertilization practices**. Using nitrogen containing fertilizer and/or doing heavy pruning promotes vigorous growth and increases susceptibility. Fertilization and pruning practices on susceptible cultivars should be adjusted to limit **excessive** growth. For bearing trees, moderate shoot growth is 6 to 12 inches (15 to 30 centimeters) per year. If the growth is more than 12 inches, do **not** apply fertilizer until shoot growth is reduced to less than 6 inches.

   Apply fertilizer in the early spring (6 weeks before bloom) or apply in late fall after growth has ceased. Applications in midseason prolong the time during which shoots are susceptible to infection and increase the likelihood of winter injury to tender wood.

4. **Prune out fire blight cankers during the dormant season**. Delay the removal of infected shoots until the dormant season in order to avoid spreading infection to healthy shoots. Make pruning cuts at least 6 inches (15 centimeters) below the last point of visible infection. After each pruning cut, sterilize the pruning shears by dipping them in a freshly made solution of 1 part liquid bleach (Clorox, Purex, Saniclor, Sunny Sol) added to 4 parts of water. Examine the larger branches and trunks carefully for cankers, since these are likely to overwinter and produce new infections in the spring.

   Root suckers and watersprouts should also be removed because infection of these parts can lead to infection and death of entire trees. Certain dwarfing rootstocks used for apples are prone to suckering. Commercial growers should select rootstocks that are resistant to fire blight or that show little tendency to produce root suckers.

   Examine wild, neglected, ornamental hosts of the fire blight bacterium growing in the vicinity of home or commercial orchards for cankers. In addition to seedling apples, crabapples, pears, and quince, check hawthorns (*Crataegus* spp), firethorns (*Pyracantha* spp), cotoneasters, mountain-ashes (*Sorbus* spp), and spiraea. Remove the cankers when found or destroy the entire plant where feasible.

5. **Follow a bactericide spray program**. Like most bacterial diseases of plants, fire blight is very difficult to control; however, it can be reduced by spraying. Commercial orchardists should follow the spray schedule outlined in the annual Commercial Tree Fruit Spray Guide (http://www.extension.iastate.edu/Publications/PM1282.pdf)

The antiobiotic streptomycin[1] is the most effective herbicide for controlling fire blight; timely sprays will reduce the incidence of fire blight **but must be applied before the appearance of symptoms.**

Temperatures at the prebloom and bloom stages are important in determining whether fire blight will occur in any given year. The bacteria reproduce **only** when the temperature is warmer than 65°F (18°C).

The following concept was developed for predicting outbreaks of blossom blight in Illinois. The first idea to understand is that of a "heating degree-day." A "degree-day" occurs when the maximum daily temperature reaches 66°F (19°C). Start counting degree days after each spring frost. A freeze greatly reduces the number of fire blight bacteria in holdover cankers and on tree surfaces. Bacteria reach dangerous population levels ONLY after 30 degree-days have elapsed since the last frost. Degree-days may be accumulated in a variety of ways; for example, 2 days with a maximum daily temperature of 80°F (27°C), 3 days of 75°F (24°C), or 6 days of 70°F (21°C) following a freeze will provide enough accumulated warmth to allow bacterial populations to increase greatly in number and present a serious fire blight threat to blossoms. When 30 degree-days have occurred and when blossoms are still present (including secondary bloom), apply the first streptomycin spray. Repeat the spray at 4-day intervals through the bloom period. At temperatures above 86°F (30°C), bacteria will not multiply. Therefore, it is not necessary to apply streptomycin when the temperatures average below 65°F or above 86°F.

Paul Steiner at the University of Maryland developed a computer software package which very accurately predicts the potential for fire blight occurrence. The prediction is based upon temperature and moisture during bloom. This computer software is called MARYBLYT and is available from the University of Maryland, Department of Botany, College Park, MD 20742.

Streptomycin can effectively protect the susceptible apple and pear flowers, but for maximum effect it must be applied the day of, or the day before infection event occurs. Missing the critical window of effectiveness by even 24 hours can result in plant infection and buildup of a significant amount of bacteria for later infections. If the blossom blight is well controlled, the subsequent increase of fire blight in summer is often prevented. To prevent development of streptomycin-resistant strains of the pathogen, no more than 4 applications of streptomycin per season is recommended. Streptomycin is more effective in preventing blossom infection and the management of the shoot blight phase of fire blight should not be attempted with streptomycin. However, application of streptomycin immediately following hail storms is highly recommended. Streptomycin is most effective when applied alone, as a dilute spray, under slow drying conditions (generally between 10 p.m. and 3 a.m.), and when daytime temperatures reach 65°F or above. Apply 100 parts per million (ppm) of streptomycin if the temperature is below 65°F, and 50 ppm if the temperature is above 65°F.

Bordeaux mixture (8-8-100), made by mixing 8 pounds of crystalline copper sulfate (bluestone or blue vitriol) and 8 pounds of fresh hydrated spray lime in 100 gallons of water, will help control fire blight but may cause russeting of the fruit. Bordeaux mixture is recommended for use by growers who had a severe epidemic the previous year. Bordeaux mixture should be applied at the silver tip

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Streptomycin for plant use is marketed as Agrimycin 17, and Agri-strep. These products are recommended only to commercial fruit growers. Use these products strictly according to the manufacturer's directions.

stage of flower bud growth. Do not mix bordeaux with other chemicals, and use it as soon as it is prepared. Do not follow bordeaux mixture with streptomycin, and do not concentrate bordeaux mixture greater than 2 times.

Copper sulfate (4 lb/100 gal or 2kg/400 liters), applied when trees are dormant in early spring also helps reduce the number of bacteria present in ooze on cankers and thus slows the buildup of bacteria in the orchard prior to bloom.

6. **Control sucking insects**. Good control of aphids, leafhoppers, plant bugs, and psylla on pears helps prevent shoot infection. Commercial orchardists should follow a spray program outlined in Tree Fruit Spray Guide* (http://www.extension.iastate.edu/Publications/PM1282.pdf)

**This publication is available at your nearest Extension Office or from Information Technology and Communication Services (ITCS), 1401 S. Maryland Dr., Urbana, IL 61801 (217/333-2007).*

For additional information on fireblight of apple, refer to the articles prepared by Paul W. Steiner.

! The Biology and Epidemiology of Fire Blight (http://veg-fruit.cropsci.uiuc.edu/Diseases/Fruit/Apple/Fire-Blight/Biology.pdf

! Managing Fire Blight in Apples (http://veg-fruit.cropsci.uiuc.edu/Diseases/Fruit/Apple/Fire-Blight/Management.pdf)

! Problems in Managing Fire Blight in High Density Orchards (http://veg-fruit.cropsci.uiuc.edu/Diseases/Fruit/Apple/Fire-Blight/Dense_Orchard.pdf)

! How Good Are our Options with Copper, Bio-controls and Alliette for Fire Blight Control (http://veg-fruit.cropsci.uiuc.edu/Diseases/Fruit/Apple/Fire-Blight/Copper.pdf)

! A Philosophy for Effective Fire Blight Management (http://veg-fruit.cropsci.uiuc.edu/Diseases/Fruit/Apple/Fire-Blight/Philosophy.pdf)

Table 1: Relative Susceptibility of Common Apple Cultivars and Rootstocks to Fire Blight

Highly susceptible	Moderately susceptible	Moderately resistant
APPLE		
Beacon	Baldwin	Arkansas Black
Braeburn	Ben Davis	Britemac
Burgundy	Empire	Carroll
Cortland	Golden Delicious	Delicious
Fuji	Granny Smith	Liberty
Gala	Gravenstein	Northwestern
Ginger Gold	Grimes Golden	Greening
Idared	Jerseymac	Liberty
Jonathan	Jonafree	Melba
Liberty	Jonagold	Priam
Lodi	Jonamac	Prima
Molly's Delicious	Julyred	Priscilla
Niagara	Macoun	Quinte
Nittany	Maiden Blush	Redfree
Paulared	McIntosh	Sir prize
Red Yorking	Milton	Stark Bunty
R.I. Greening	Monroe	Stark Splendor
Rome Beauty	Mutsu	Turley
Spigold	Northern Spy	Viking
Starr	Scotia	Wellington
Twenty Ounce	Spartan	Winesap
Tydeman Early	Spijon	
Wayne	Starkspur Earliblaze	
Wealthy	Stayman	
Winter Banana	Summer Rambo	
Yellow Newton	Summer Red	
Yellow Transparent		
York Imperial		

Highly susceptible	Moderately susceptible	Moderately resistant	Resistant
PEAR			
d'Anjou	Asian Pears	Kieffer	Bradford[a]
Aurora	Hosui	LeConte	
Bartlett	Shinseiki	Magness	
Bosc	Comice	Moonglow	
Clapp's Favorite	Douglas	Old Home	
Femish Beauty	Duchess	Starking Delicious	
Gorham	Ewart	Tyson	
Hardy	Garger	Waite	
Red Bartlett	Harrow Delight		
Reimer Red	Lincoln		
Sheldon	Maxine		
Starkrimson	Seckel		
Winter Nelis			

[a] Ornamental tree - no edible fruit

Highly susceptible	Moderately susceptible	Moderately resistant
ROOTSTOCKS		
Alnarp 2		
Bud.9	Bemali	Geneva 11
C.6 (interstem)	Bud.118	Geneva 30
M.9	Bud.140	Geneva 65
M.9 (interstem)	MM.106	M.7
M.26	MM.111	Novole
M.27	Ottawa 3	Robusta 5
Mark		
P.2		
P.16		
P.22		

Table 2. Modern Crabapples are highly resistant or immune to Rusts, Scab, Fire Blight, Powdery Mildew and Frogeye Leaf Spot

Ames White	Henningi	Mount Arbor Special
Baskatong	Henry Kohankie	Professor Sprenger
Burton	Honeywood #14 hybrid (scab immune clone GR 700-58)	R.M.F. 102
Case Seedling		Robinson
Golden Gem		Simpsin 4-28
Golden Gem (BD 115-58)	Minn. 1492	Simpson 11-57
	Morden 19-27	Simpson 11-58
Golden Gem (PLT 788-58)		