Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@po.state.ct.us

FIRE BLIGHT

Fire blight is probably the most devastating bacterial disease of apples, pears, and many other rosaceous plants grown in North America. While outbreaks are sporadic in occurrence, they often result in significant losses when they occur, whether measured by loss of trees or loss of dollars. In 2000 and 2001, several Connecticut orchards were affected by fire blight and disease outbreaks were also reported throughout New England and New York. The severity of Connecticut outbreaks in 2001 could be partly attributed to the unusual weather conditions in spring which included a heat wave during bloom followed immediately by frost. Michigan also experienced severe fire blight problems during 2000 and reported a $42 million total economic loss for the region that resulted in the removal of 350,000-450,000 apple trees covering approximately 1,550-2,300 acres. The 2000 outbreak followed a previous Michigan outbreak in 1991 which resulted in losses of over $3.8 million. In 1998, fire blight outbreaks were reported in Washington and northern Oregon in which apple and pear growers reported losses of over $68 million.

Although fire blight is erratic in occurrence, there is a trend for more frequent and more devastating outbreaks that can be attributed to several factors associated with current orchard management practices and market demand. Four key changes over the last decade have increased our vulnerability to fire blight. These are briefly summarized as follows:

- **Orchard density:** instead of planting 100-200 apple trees/acre, we now plant up to 10 times that density with 250-1,500 trees/acre;
- **Tree size:** in order to accomplish high tree densities, it is necessary to use size-controlling rootstocks; M.9 and M.26 are two of the most commonly used rootstocks; they are also highly susceptible to fire blight;
- **Varieties:** many of the new varieties that meet the demands of the fresh fruit market (e.g., Gala, Fuji, Gingergold, Jonagold, Braeburn) are also highly susceptible to fire blight; the combination of susceptible varieties on susceptible rootstocks further complicates the susceptibility problem;
- **Training systems:** new training systems used to make high density plantings more productive push trees immediately into strong vegetative growth and force early production.

HISTORY

Fire blight is considered to be a disease of American origin and was known in this country for many years before it was reported in the Hudson Valley of New York in 1794. By the 1900s, fire blight had spread to most areas where pears and apples were grown in the U.S. and was associated with many outbreaks and epidemics. Fire blight now occurs worldwide and is found in many of the important countries for pome fruit production.

CAUSAL AGENT

Fire blight is caused by the bacterium *Erwinia amylovora*. This organism is readily spread by wind, splashing rain, insects, and human activities. Although this bacterium is considered a plant pathogen, it is also a competent epiphyte which can grow and multiply on plant surfaces, regardless of whether the plant is resistant or susceptible to fire blight. At moderately warm temperatures (65-75°F), it has been estimated that the bacterium can double every 20-30 minutes. Strains of the fire blight bacterium with resistance to streptomycin have been reported in the eastern U.S. but are widespread in most apple and pear regions of the western U.S.

HOSTS

- **Primary Economic Hosts:** pome fruits, including apple, pear, and quince; varieties and rootstocks differ in susceptibility to fire blight (Tables 1 and 2)
- **Ornamental Hosts:** many members of the Rosaceae family including crabapple, hawthorn, mountain ash, pyracantha, and cotoneaster

INFECTION TYPES OR PHASES

There are five different types or phases of infections that can occur during a fire blight outbreak. However, not all infection types occur during every outbreak of the disease. The infection types are canker, blossom, shoot, trauma, and rootstock blight. These types differ in the sources of inoculum, types of tissues that are infected, and the weather conditions that influence the infection process. The symptoms associated with each infection type can be quite distinct but once an epidemic is underway, they become increasingly difficult to differentiate. Since the same control strategies don't work for all infection types, it is important to be able to recognize the infection type in order to select the appropriate control measure.

A. Canker Blight:

Symptoms: Overwintering cankers are often clearly defined and appear as slightly to deeply depressed areas of discolored bark on trunks and large limbs. These cankers are usually easy to recognize and occasionally develop cracks at the margins. Many much smaller cankers are also often present on the trees but are not very easy to recognize. These small cankers are believed to provide a *major source of inoculum* in spring and are found on small twigs or limbs where infections had occurred the previous year. Since the cankers are relatively young, they can be less than one inch in diameter and are usually not particularly sunken and are rarely cracked. Cankers are often focused on a branch stub or fruit spur and when outer bark is cut away, inner tissues are water-soaked with reddish streaks. Overwintering cankers can also produce wilted shoots which are often confused with the shoot blight phase of disease. This symptom develops as bacteria move from overwintering cankers into nearby shoots. Infected shoots have a yellow-orange discoloration of the tip bud and stem which helps to distinguish them from shoot blight phase symptoms. In spring, bacterial ooze can appear on canker surfaces or margins during wet weather. This ooze is attractive to many insects (flies, in particular) which feed on the ooze and then move to the nectaries of flowers in nearby trees and transfer the bacteria to the surfaces of flower parts. It has been estimated that one active, overwintering canker can produce enough bacteria to severely contaminate flower blossoms on trees in an area consisting of ¼-½ acre.

Importance: This infection type is the primary source of inoculum and renewed infectious activity of the bacteria in the spring. Overwintering cankers are responsible for spread of disease into adjacent flowers, shoots, and growing tips. This phase of disease is always present if fire blight was a problem the previous season.

B. Blossom Blight:

Symptoms: Symptoms of this phase of fire blight usually appear within one to two weeks after bloom although they can develop as late as one month after infection if temperatures are cool. Blossoms first appear water-soaked and the sepals and whole blossoms blacken. Infected blossoms often adhere to the cluster base. Infection of a single flower in a cluster of five usually kills the entire spur. Bacterial ooze can develop under wet conditions and the bacteria are readily spread by pollinating insects. Symptoms can develop on infected fruit and can differ in appearance depending upon when the fruit were infected. Bacterial ooze can develop on fruit surfaces during wet weather.

Conditions for Blossom Infection: Blossom blight may or may not occur in any given season and varies in its incidence and severity with the number of open flowers colonized by the bacteria, temperature, and wetting events. Flowers must be open (full bloom) and colonized by the bacteria. They are subject to infection within minutes after any wetting event (e.g., heavy dew, rain) when the average daily temperatures are equal to or greater than 60°F. Wetting events also include high volume sprays or overhead irrigation applied during bloom. Relative risk levels can be predicted using predictive models such as Maryblyt® developed by Dr. Paul Steiner, University of Maryland, and Cougarblight developed by Dr. Timothy Smith, Washington State University.

Importance: This phase of disease is critical for the development of fire blight epidemics. Once the bacteria have successfully infected the blossoms, they are readily spread throughout the orchard by pollinating insects.

C. Shoot Blight:

Symptoms: Shoot blight symptoms are also called “blight strikes” and develop on actively growing vegetative shoots. They can be associated with, but not limited to, insect feeding or damage. Disease occurrence has also been associated with modest wind damage to tender young shoots. Infected shoots first appear slightly wilted and develop the diagnostic “shepherd's crook” typical of fire blight. Leaves on these shoots first show dark streaks along the midveins and then wilt and brown. Entire shoots blacken and develop the diagnostic “burned” appearance as the bacteria move progressively down the shoot.

Importance: This phase is especially destructive to young, vigorous trees. On highly susceptible varieties, infections move rapidly and can invade large supporting limbs. Depending upon the cultivar and stage of development, a single shoot infection can result in the death of an entire limb, or if the central leader of a main trunk is involved, a tree can be lost in a single season. In general, shoot infections that occur between petal fall and terminal bud set usually lead to the greatest limb and tree losses.

D. Trauma Blight:

Symptoms: Symptoms are similar to shoot blight but are usually more random and widespread throughout the orchard. This phase of fire blight is associated with a traumatic event such as hail, frost, or severe wind. Although mature shoots and limbs are generally resistant to infection, these traumatic events cause wounds which allow the bacteria to directly penetrate the tissues and bypass normal defenses. Since the bacteria are usually already present on the tissues as epiphytes, all they need are wounds and moisture in order to infect.

Importance: Infection is not limited to susceptible varieties since the physical damage of the trauma destroys natural defense mechanisms in the tree. The amount of trauma blight is usually associated with the amount of epiphytic colonization in the orchard since this phase of disease requires bacteria to already be present in the orchard.

E. Rootstock Blight:

Symptoms: The primary way rootstocks are infected is now known to be through internal means, often through apparently healthy limbs and trunks of trees that had only a few blossom infections or shoot strikes. Rootstock blight can develop in four phases: 1) oozing of bacterial masses from the rootstock within 2-4 weeks after symptoms appear in the canopy; 2) rapid collapse and death of a tree in late June to late July; 3) development of early fall red color in the canopy of a tree in late August and early September; and 4) early decline and death of a tree the spring following infection; during this phase infected rootstocks often have active cankers that extend towards the scion. Rootstock blight is common on highly susceptible M.9 and M.26 rootstocks. Research has demonstrated that on very young trees, low numbers of bacteria can move from infections in the upper tree, down through the trunk, and into the rootstock in approximately 21 days.

Importance: Once the bacteria enter a susceptible rootstock, they form new cankers that can completely girdle and kill the tree in one to several months. Although not all trees with fire blight symptoms in the scion develop rootstock blight, the susceptibility of the rootstock is a key factor. Although many trees with rootstock infections may have "reasonable looking" canopies, most will not survive into the next season. Rootstock infections on trees during their first 3 years are most devastating.

STRATEGIES FOR MANAGEMENT OF FIRE BLIGHT

Because of the inoculum potential and the ability of new inoculum to be repeatedly dispersed throughout an orchard by wind, splashing rain, and insects, it has been said that ***There is no such thing as a "little bit" of fire blight*** when dealing with this disease. Therefore, it is important to follow an aggressive program that addresses ALL infections, regardless of their apparent significance, location on the tree, or time of year.

1. Removing Primary Sources of Inoculum:

- **Dormant pruning-** Since the bacteria overwinter in living tissues at the margins of cankers, pruning during the dormant season will remove a significant amount of primary inoculum. A thorough pruning is necessary in order to remove as many of the infections as possible. It is especially critical to recognize and remove the small, young cankers. Whole trees or large branches should be removed from the orchard during dormant pruning. Small branches can be raked into row centers and mulched with a flail mower.

- **Early season inspection and pruning-** It is helpful to inspect the orchard for any overwintering cankers that may have been overlooked during dormant pruning. Many of the small cankers that went unnoticed during previous pruning efforts become more visible once they start to ooze bacteria. These inspections usually begin around green tip.

2. Monitoring Weather Factors in the Orchard:

- Because of the importance of weather to fire blight, it is helpful to monitor the orchard for temperature and rainfall. A weather station that records the daily minimum and maximum temperatures and rainfall amounts is necessary. Information from leaf wetness meters is also helpful for the predictive models.
- **Predictive Models-** Weather information is critical for predictive models such as Maryblyt® or Cougarblight. It is used to identify potential infection periods and to improve the timing of antibiotic sprays.

3. Bactericide Control:

- **Copper sprays-** Copper sprays *do not* kill bacteria within overwintering cankers but are used to reduce the ability of the fire blight bacteria to colonize bark and bud surfaces during the early pre-bloom period. Because of this mode of action, critical timing and thorough spray coverage are important. The first applications are made at green tip since that coincides with the period when the bacteria are growing and becoming available for infection. It is very important to spray ALL trees within the block, regardless of their susceptibility to fire blight since the bacteria are spread at random within the block and can colonize all tissues as epiphytes. These serve as important additional sources of inoculum. The benefits of copper sprays during the season are questionable and have yielded inconsistent results. Additionally, these sprays can be highly phytotoxic to fruit.
- **Streptomycin sprays-** Prevention of blossom infections is a critical aspect of a disease management program. Streptomycin is bactericidal so it kills the bacteria. At bloom, antibiotic sprays are highly effective against the blossom blight phase of disease. Predictive models such as Maryblyt® and Cougarblight help to identify potential infection events so antibiotic sprays can be applied to protect the tissues from infection. Timing of these sprays is critical to control since this antibiotic is only active for 3 days after application. Streptomycin sprays have been found to be ineffective for prevention and control of shoot blight infections. However, they can be helpful to control trauma blight associated with wind damage and hailstorms *if* applied immediately (within 12-18 hours) after the weather event. Since resistance to streptomycin has been documented in many populations of *E. amylovora,* there are significant concerns about over or incorrect use of this compound.
- **Biochemical sprays-** Messenger®, a biochemical pesticide containing the harpin protein, has been found to help in control of the blossom blight phase of fire blight, especially when used in combination with streptomycin sprays. This compound has no direct action on the bacterium but activates the <u>S</u>ystemic <u>A</u>cquired <u>R</u>esistance (SAR) genes in the host plant. About 5-7 days are needed to activate the SAR system of the host plant and the effects last approximately 14 days. Therefore, Messenger® needs to be applied several days prior to fire blight infection periods.

- **Biological sprays-** Limited and inconsistent information is available on the efficacy of compounds such as BlightBan®. Check local registration for the availability of this compound.
- **New England Apple Pest Management Guide (current edition)-** This guide is a good reference for detailed information on compounds currently registered for use in Connecticut.

4. Removing Secondary Sources of Inoculum:

- **Cutting of blight strikes-** This is critical for control of secondary spread of fire blight. Over the years the philosophy regarding removal of this shoot blight phase has undergone significant changes-- to prune or not to prune. It is now clear that new infections should be cut as soon as they appear and before significant necrosis is evident. This is especially important for young trees. If the strikes are not cut, the risks of continued spread and rootstock infections are highly increased. When strikes are numerous and distributed throughout a block, first priority should be given to strikes that threaten the main trunk, strikes that appear in the tops of young trees, and strikes on dwarfing rootstocks. Since bacteria in and on freshly cut shoots and limbs can remain viable for some time and serve as a source of inoculum, prunings should be immediately removed and destroyed. However, in blocks with tight spacing, special care must be taken to avoid spreading the bacteria during the process of removal. Where this isn't possible, it is probably best to place prunings in row middles where they can dry. When *thoroughly dry*, they can be mulched with a mower.
- **Methods for making the cuts-** The suggested method of cutting 8-10 inches below visible symptoms has certain limitations since the bacteria can be found as far as 9 feet back on the symptomatic branch. Cuts on symptomatic shoots should be made back to 2-year or older wood at least 8-12 inches below the visible symptoms. Since these cuts often leave a 4-5 inch naked stub above the next leaf, spur, or branch, this method has been called "ugly stub" cutting. Many growers use this method so overwintering cankers can be easily recognized during dormant pruning. Some growers actually spray the ugly stubs with bright colored paint for easy dormant season detection. The idea of disinfesting pruning tools between cuts has also been under scrutiny. Studies have demonstrated that if the ugly stub method is used, the need to disinfest is not necessary if time is a limiting factor. However, it should probably be done as a precaution if time allows. If possible, pruning should be done in dry weather. When pruning is done in wet weather, tools should be disinfested as a precaution. Removal of blight strikes should NOT be combined with routine summer pruning practices.

5. Cultural Practices:

- Use management systems that promote early cessation of tree growth without affecting tree vigor.
- Apply appropriate amounts of fertilizer to maintain vigor. Excessive vigor due to overfertilization increases the risk for fire blight.

- Use of plant growth regulators (e.g., Apogee) to control shoot growth is an area that is still somewhat experimental. Preliminary evidence suggests that applications at late bloom or at petal fall can help slow fire blight infections by reducing shoot elongation on certain varieties.

6. Resistant Varieties:

- Consider the susceptibilities of scion and rootstock to fire blight. Some scion/rootstock combinations are highly susceptible to disease and represent extremely high economic risks. Refer to Tables 1 and 2.

INFORMATIVE WEB SITES

- **Antibiotics and Resistance**
  http:/www.apsnet.org/online/feature/Antibiotics/Top.html

- **General Fire Blight- Michigan**
  http://www.msue.msu.edu/vanburen/fb2000.htm

- **General Fire Blight- West Virginia**
  http://www.caf.wvu.edu/kearneysville/disease_descriptions/omblight.html

- **General Fire Blight- Washington**
  http://www.ncw.wsu.edu/fireblt6.htm

- **Maryblyt®**
  http://www.intrepid.net/afrs/fb8.htm (Maryblyt® home page)
  http://www.caf.wvu.edu/kearneysville/maryblytfaq.html

- **Cougarblight**
  http://www.ncw.wsu.edu/fbsmith.htm

Table 1. Varietal Reactions of Apple to Fire Blight.

Very Susceptible	***Susceptible***	***Moderately Resistant***
Braeburn	Cortland	Delicious
Fuji	Golden Delicious	Early McIntosh
Gingergold	Jerseymac	Empire
Gala	Northern Spy	Liberty
Granny Smith	McIntosh	Priscilla
Idared	Macoun	
Jonagold	Red Free	
Jonathan	Spartan	
Lodi		
Mutsu		
Paulared		
Rhode Island Greening		
Rome Beauty		
Spigold		
Yellow Transparent		
Highly Susceptible Rootstocks: M.26, M.9, Mark		

Table 2. Varietal Reactions of Pear to Fire Blight.

Very Susceptible	***Moderately Susceptible***	***Resistant***
Bartlett	Comice	Old Home
Bosc	Winter Nelis	Keiffer
Hardy	BPM	
Starkrimson		
Sensation Red Bartlett		
Max Red Bartlett		
Rootstocks: Bartlett most susceptible on: *Pyrus betulaefolia, P. communis, P. calleryana*		

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