Organic Management of Fireblight in the Upper Midwest

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Fruit farmers are increasingly trying to meet the demand for organic, locally grown apples and pears in the Upper Midwest. Fire blight and other diseases are a major barrier to organic fruit production in our region, and growers in the Organic Fruit Growers Association have repeatedly expressed concern over the impact of fire blight on their orchards as well as uncertainty about the best methods for organic control. Recent research has shown new possibilities for managing this devastating disease.

To help organic farmers control this disease and to lay the groundwork for future research, in this publication we have summarized recent scientific research alongside information from in-depth interviews with practicing organic farmers. Although we hope that this publication will be useful to pear growers, we've primarily focused on apples, because apples are more commonly grown in this region and because much of the research with organic control methods has been with apples.

What are the impacts of fire blight on organic orchards in our region? What are the best methods for controlling the disease? How do growers currently manage the disease, and what factors influence their management decisions? Read on.

About the Organic Fruit Growers Association

We are a community of fruit growers, industry professionals and customers, working together to share information and encourage research to improve the organic production and marketing of fruit and to represent the interests of fruit growers. Our activities center around education and knowledge sharing between fruit growers, including field days and farm tours, a winter growers' retreat, an annual grafting workshop, quarterly newsletter, and on-farm research. Visit us online.

Attendees discuss fire blight at an OFGA field day, July 2023

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This document offers specific pest management suggestions, including pesticide uses, based on research and experience, but it does not guarantee their efficacy. Management decisions at your farm should be tailored to your specific circumstances. References to products in this publication are for your convenience and are not an endorsement of one product over similar products. You are required by law to use pesticides according to the product label. Consult your organic certifier before applying pesticides to ensure compliance with organic standards.

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Contributing Growers

This publication draws heavily on information collected from organic fruit growers in our region. In the winter of 2022-2023, twenty-five growers completed an anonymous internet survey where they told us about the impacts of fire blight on their orchard and about their management practices.

Later that winter, we conducted in-depth follow-up phone interviews with nine experienced organic fruit farmers from Minnesota, Wisconsin, and Michigan. These growers shared copious details about their farm and their experience with fire blight, including their past successes, frustrations, and failures. We deeply appreciate their generosity and willingness to contribute to this project. In alphabetical order, they are:

Rami Aburomia
Atoms to Apples
Mount Horeb, WI

After managing a non-organic orchard for many years, Rami has farmed at Atoms to Apples since 2013. He raises over 4 acres of certified organic, high-density apples and pears, marketed as fresh fruit and value-added products in the Madison, WI area.

Deirdre Birmingham
The Cider Farm
Mineral Point, WI

Nearly twenty years into her farming career, Deirdre raises 18 acres of certified organic, high-density cider apples, for fermenting into small batch cider and brandy.

Peggy Callahan
Dream Apple Farm and
DreamPort Harvest Market
Grafton, WI

Peggy and Ed Callahan raise two acres of high-density organic apples, north of Milwaukee and near the shores of Lake Michigan. Peggy and Ed also operate a local food market, where they sell their fruit, value-added products, and broad selection of products from other farms.

Rachel Henderson
Mary Dirty Face Farm
Menomonie, WI

Rachel and Anton Ptak have farmed since 2009, and now raise 10.5 acres of organic apples and pears together with an array of other fruit crops and livestock. They market fresh fruit and processed products in the Chippewa Valley and Twin Cities.

Harry Hoch
Hoch Orchards and Gardens
LaCrescent, MN

Harry and Jackie Hoch have raised organic apples and a variety of other fruit near La Crosse, WI for over 25 years. Their fruit and value-added products are for sale in the Twin Cities, La Crosse, and grocery stores throughout our region.

John Knisley
Alternative Roots Farm and Tallgrass Cider
Madelia, MN

John and Brooke Knisley have farmed organically since 2011 near Madelia MN, two hours southwest of the Twin Cities, and they raise apples for fresh eating and cider for sale in local markets.

Chris McGuire
Two Onion Farm
Belmont, WI

Chris and Juli McGuire raise three acres of organic apples and produce value-added products for sale in southwest Wisconsin and the Madison, WI area.

Tom Rosenfeld
Earth First Farms
Berrien Center, MI

Tom and his family raise 55 acres of semi-dwarf apples, 35 acres of blueberries and 15 acres of other fruits and vegetables, all organic, in southwest Michigan, 100 miles from Chicago. They market their fruit and a variety of value-added processed products to a community-supported agriculture (CSA) program and to wholesale accounts.

Paul Wymar
Kalliroe Orchard
Montevideo, MN

Paul and Amy Bacigalupo have grown apples since 2002 in far western Minnesota. They now raise 2 acres of apples marketed through community-supported agriculture and wholesale channels.

Fire Blight

A basic understanding of the fire blight pathogen and disease symptoms is important for managing this disease. Fire blight is the most important bacterial disease of apples, and it can be especially devastating when warm and wet conditions occur during bloom or when high winds or hail damage actively growing shoots. Many apple varieties and rootstocks are susceptible to this disease, and young, vigorously growing trees are particularly susceptible to infections.

Symptoms

Characteristic symptoms of fire blight shoot infections include browning or blackening of dead tissue, giving the appearance of being burned by fire. Infected shoots often show orange color and wilt or flag at their tips. Ooze (bacterial cells of the pathogen) may also exude from infected shoots before necrosis is observed, especially in periods of warm weather. 'Shepherd's crook', when the tip of a dead shoot bends over into an upside-down U-shape, is a classic and common symptom of the final stage of shoot infections.

Flowers and flower clusters infected with fire blight will droop and shrivel, turning brown or black. These shriveled, dark flowers remain attached through the growing season. In humid conditions, ooze may be observed on flowers.

Infected apple fruits appear small and shriveled, sometimes with patches of necrotic tissue. In warm, humid weather fruits may also ooze.

Cankers in wood appear as darkened areas. These cankers form when the pathogen moves from shoot infections to older wood at branch junctions. Infections can girdle and kill branches. Infections can spread to the central leader and eventually kill the tree.

Fire blight can also infect fire blight susceptible rootstocks. Early signs of rootstock infection are oozing below the graft union, followed by death of roots and the entire tree.

Pathogen Biology and Life Cycle

Fire blight is caused by the bacterial pathogen *Erwinia amylovora*. The pathogen overwinters in cankers (often referred to as "holdover cankers"). As temperatures begin to warm in the spring, *E. amylovora* becomes active in canker margins and bacterial ooze may be visible on the bark surface. Ooze can spread from cankers to flowers via insects, such as flies, or by rain splash. Once on the flowers, *E. amylovora* colonizes the surface of the stigmas and multiplies there (known as epiphytic growth). During this epiphytic growth phase, *E. amylovora* does not actually infect plant tissue or cause disease. Bacterial cell growth depends on temperature: optimal growth of *E. amylovora* occurs between 70°F and the low 80's °F, but slower growth occurs over a wide range of temperatures. Pollinators, such as honeybees, can pick up bacteria from the stigmatic surface and play an important role in spreading the pathogen between blossoms.

Blossom blight develops when bacteria move down from the stigmatic surface and enter the floral cup at the base of the flower. Rainfall or heavy dew is required for the pathogen to infect the floral cup.

After bloom, secondary phases of the disease include infections of shoots, fruit, and rootstocks. Following bloom there are two sources of inoculum that can cause additional shoot blight infections: blossom blight infections and active limb cankers. Wind and rain movement of the pathogen results in new infections. Shoot and fruit blight stages often require wounds for *E. amylovora* to infect. Wounds can result from insect feeding, strong winds, and hail. When infections occur following severe weather such as hail, this is often referred to as "trauma blight". During the summer, bacteria continue to multiply and spread within infected tissues. Cankers expand more slowly towards the end of the summer as temperatures get cooler.

Infections of the rootstock can result from movement (translocation) of *E. amylovora* from higher up on the tree or more directly from shoot blight infections of suckers (shoots) growing from the rootstock. In young trees movement of the bacteria through the central leader from shoots to the rootstock can be rapid.

Overall, infection severity is dependent on many factors such as environmental conditions, age, cultivar, and nutrition status. For instance, trees with young, succulent tissues and those receiving excessive nitrogen fertilizers often have more severe fire blight infections. In high density orchards with short branches, bacteria can spread quickly from branches into the central leader, and thus kill the entire tree. It is also important to note that the bacterium can also exist as an endophyte inside of symptomless, apparently healthy tissue such as branches, limbs, and budwood.

The fire blight pathogen has a very broad host range (over 200 plant species), but primary economic host plants include pome fruits such as apple, pear, and quince. Other wild and ornamental hosts include many members of the Rosaceae family. Of particular concern in the

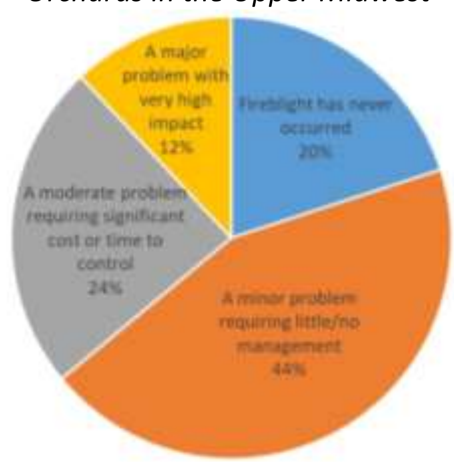
Upper Midwest may be the native hawthorns (*Craetaegus* spp.), crab-apples (*Malus*) and serviceberries and juneberries (*Amelanchier* spp.) These small trees and shrubs can be common in fencerows and forest edges near orchards and may serve as sources of fire blight inoculum.

Fireblight Impact on Organic Fruit Growers in the Upper Midwest

The impact of fire blight varies widely between orchards. Twenty percent of the farms we surveyed for this project have never experienced fire blight, and an additional forty-four percent consider it only a minor problem which requires little or no management.   Most growers did not consider fire blight a dominant threat to their orchard's production or the viability of their business. Many reported that other diseases, such as apple scab, cedar apple rust and summer fruit rots, are more destructive and have more influence on their management decisions. At the same time, however, we interviewed several orchardists who suffer significant losses to fire blight. Deirdre Birmingham at The Cider Farm, for example, considers fire blight a significant threat to her production, in part because the heritage cider varieties which are the core of her orchard are often highly susceptible to fire blight.

All growers interviewed noted considerable year to year variation in the severity of fire blight. Much of this variability appears due to variations in weather during bloom or to occasional severe summer storms which damage leaves, spread inoculum, and result in trauma blight.

Impact of Fire Blight on Organic Apple and Pear Orchards in the Upper Midwest

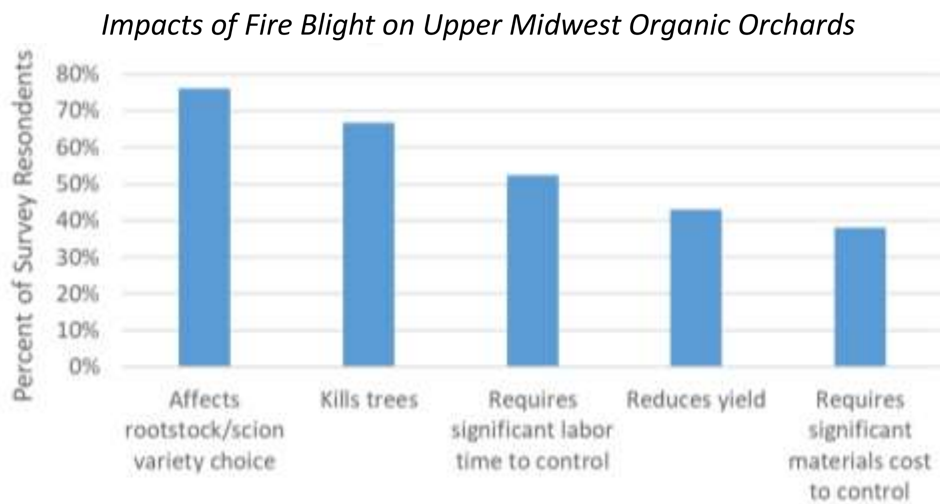


Data from OFGA internet survey, winter 2022-2023

Newly planted orchards often escape fire blight for some time during an initial "honeymoon" period. Several newer orchards reported that the disease only appeared 5-10 years after planting. Many growers wondered about the initial source of infections in orchards without other apple or pear trees nearby and also questioned how infections can be delayed or prevented altogether in newly established orchards.

Several newer orchards which escaped fire blight for some time after planting said that disease has steadily increased since its first appearance and recently become worrisome. However, there are cases where fire blight damage has decreased over time. Harry Hoch at Hoch Orchards and Gardens has suffered less fire blight in recent years, saying "I find fireblight to be an issue with young plantings or topworked blocks. The higher the percentage of young trees in the orchard, the worse the fireblight pressure is in the entire orchard. In the late nineties and early 2000's, when we had a lot of younger blocks, we had more fire blight. Now, the majority of my trees are mature. I have fewer outbreaks, and when I do have fire blight it is not a big problem." In another example, Tom Rosenfeld at Earth First Farms suffered repeated fire blight outbreaks in one block of Rome apples from 2006-2012. The affected trees died from a severe winter freeze event in 2012, and since then he has seen virtually no fire blight in their 55-acre orchard.

When asked to describe the impacts of fireblight, 76% of growers said that it affected their choice of rootstock or scion varieties, and 67% said that it killed trees. Fewer growers reported yield loss, or significant labor or materials costs incurred to control fire blight.



Data from OFGA internet survey, winter 2022-2023

Notably, most growers recognize that fire blight is a potentially devastating disease. Fire blight influences management decisions even in orchards which do not suffer the disease currently. Most orchardists, even those who have suffered little or no fire blight, report that fire blight resistance affects their choice of rootstock and scion varieties. Tom Rosenfeld, who has not suffered fire blight in ten years, has nevertheless avoided planting high density dwarf apples largely because he fears that fire blight will infect and spread quickly in a block of young, rapidly growing high-density trees. Peggy Callahan at Dream Apple Farm, who has never experienced fire blight in her orchard, is concerned about investing in a hedging machine for summer pruning because it could spread fire blight. Fire blight's impact thus spreads beyond the orchards which currently suffer serious outbreaks.

Management of Fire Blight

National organic standards (section 205.206) require that producers rely primarily for disease control on practices such as crop rotation, soil and crop nutrient management, resistant varieties, suppressing the spread of disease organisms, or the application of non-synthetic biological, botanical, or mineral inputs. If those management practices are insufficient for control, then a substance included on the National List of synthetic substances allowed for use in organic crop production may be used for disease control.

Fire Blight Resistant Varieties

Eighty-eight percent of organic fruit growers surveyed said they had planted fire blight-resistant rootstocks. Growers generally spurn highly susceptible apple rootstocks such as M.9 and M.26 in favor of resistant or tolerant rootstocks such as the Geneva series or Bud 9. With a wide selection of rootstock varieties now commercially available, most growers, even those who have not suffered fire blight, consider planting resistant rootstocks a sensible, low-cost precaution. In addition to fire blight resistance, most growers identified size-control and commercial availability as the main factors which they consider in rootstock selection; other factors sometimes considered are replant tolerance, susceptibility to graft union breakage, winter-hardiness, and tolerance to local soil conditions.

Is that a blight-resistant rootstock?

For more information:

Geneva Apple Rootstocks Comparison Chart. Rates Geneva rootstocks for fire blight resistance and other traits.
Apple Rootstocks: Capabilities and Limitations. Ratings and reviews from Penn State Extension.

In contrast, fireblight resistance is generally a much less important factor in scion variety selection. There is general consensus among growers surveyed that fruit marketability is the most important factor in variety selection. For example, Deirdre Birmingham at The Cider Farm grows apples exclusively for hard cider and brandy, and she has therefore primarily planted heirloom cider varieties with the traits needed for high quality cider. Fresh market growers mainly select varieties to ensure a consistent, season-long supply of apples with desirable flavor and texture. Several growers also mentioned that resistance to other diseases (primarily apple scab, but also in some cases cedar-apple rust and summer fruit rots) is much more important than resistance to fire blight, and that is difficult to identify "perfect varieties" with broad disease resistance and desirable fruit characteristics. Tom Rosenfeld at Earth First Farms and Chris McGuire at Two Onion Farm both pointed out that varieties like Liberty, Priscilla, and Enterprise have excellent resistance to fire blight, scab, and other diseases, but are not always popular with customers.

Priscilla resists fire blight. Consumers may resist Priscilla.

Several growers also commented that it was difficult to choose resistant varieties because there is a lack of reliable information. Deirdre Birmingham planted little-known cider varieties and had to learn their fireblight resistance through her own experience, which she has generously shared in the sidebar shown here.

Another grower humorously remarked on the inconsistent published ratings of varietal susceptibility to fire blight. For example, Cornell University recently summarized ratings of varietal susceptibility to fire blight from nine sources. There is some consensus:

Fire blight susceptibility of cider apple varieties grown at The Cider Farm, Mineral Point, WI.

Variety	Fireblight Susceptibility (1=Most Resistant, 10=Most Susceptible)
Brown Snout	10
Medaille d'Or	9
Sommerset Redstreak	8
Dabinett	6
Chisel Jersey	6
Ellis Bitter	5
Major	4
Kingston Black	4
Brown's Apple	3
Bramley's Seedling	3
Geneva Tremlett's Bitter	2
Kronebusch	2
Calville Blanc d'Hiver	2
Harrison	2
Redfield	1
Geneva Crab	1
Priscilla	1
Liberty	1

Source: Deirdre Birmingham, The Cider Farm

Priscilla and Liberty are widely considered resistant, while Mutsu, Gala, and Jonathan are susceptible. Other varieties, however, have been rated in very inconsistent ways. The scab-resistant varieties Jonafree, Redfree, and Sir Prize, for example, have each received varying rankings ranging from highly susceptible to highly resistant.

Although there was general consensus that it is not practical to plant only highly resistant scions in a commercial organic orchard, many growers also believe that the highly susceptible varieties should be avoided, because once infected they will continually develop strikes and cankers year after year and serve as an inoculum source for other varieties in the orchard. Harry Hoch at Hoch Orchards and Gardens says: "We will not plant varieties that are highly susceptible to fire blight. Period." Chris McGuire at Two Onion Farm removed or topworked all their Scarlet O'Hara trees once their extreme susceptibility to fireblight became apparent. Other varieties which some growers ranked as highly susceptible to fire blight include Cortland, Crimson Topaz, Gala, Ginger Gold, Jonathan, Paula Red, Regent, Rome, and Sansa.

Although the growers interviewed for this publication generally stated that fire blight resistance was not a major factor in selection of scion varieties, we heard an alternative view from Sam Kedem, now retired from operating Kedem Nursery and Garden in Hastings, MN. Prior to starting his own orchard, Sam had worked in Michigan, where he saw severe devastation from a fire blight outbreak in 1980, especially on susceptible varieties such as Red Delicious, Golden Delicious, Rome, Macintosh, and Wealthy, as well as susceptible rootstocks M.26 & M.9. This made him very wary of fire blight, and in his own orchard he avoided varieties known to be highly susceptible to fire blight, planting Honeygold, Regent, Honeycrisp, Haralred, Sweet 16, Zestar, SweeTango, Chestnut Crab, and Prairie Spy. In his orchard of freestanding trees, primarily on M.7 rootstocks, with minimal nitrogen applications, he did not see fire blight in twenty years of commercial orcharding.

For more information:
Fire blight Susceptibility of Common Apple Varieties. Cornell University researchers summarize ratings of fire blight resistance in apple scion varieties from nine sources.

Orchard Layout and Landscape Management

In our internet survey, 56% of respondents reported that they had tried to reduce the impact of fire blight through windbreaks, management of the surrounding landscape, and/or row orientation for better air movement. Most who had tried these practices were unsure whether they had any effect on fire blight. There have been few scientific studies on how windbreaks, tree spacing, and row orientation specifically affect the incidence of fire blight.

Strong winds can spread fire blight bacteria through an orchard. For example, heavy rainfall combined with winds from 7 mph to 14 mph can propel droplets carrying the fire blight pathogen up to 40 inches, but higher wind speeds can spread the pathogen over 100 yards. Windbreaks at orchard edges therefore can presumably reduce the spread of fire blight during high wind events. Regional extension and USDA-NRCS offices can provide guidelines for species selection and planting density in windbreaks, such as this information from the University of Minnesota. Many of the growers interviewed for this project have installed windbreaks, in general not to reduce the spread of fire blight, but to reduce damage from severe winds, such as trees tipping over or snapping at the graft union and physical damage to foliage and fruit.

Some wind, however, is desirable, because low air circulation and high humidity will tend to promote fire blight infection. For example, research shows that close tree spacing within the orchard and proximity to nearby forest both are correlated with higher fire blight infection. At Mary Dirty Face Farm, Rachel Henderson has deliberately avoided planting a windbreak around their orchard to promote rapid drying of the canopy after rains.

Widely spaced trees at Earth First Farms

Several of the growers we interviewed deliberately manage tree spacing to allow open space between trees and promote drying of the canopy. For example, Tom Rosenfeld's orchard at Earth First Farms consists of semi-dwarf trees (grafted on M106, M7 and other rootstocks) planted at approximately 150-200 trees/acre. Combined with rigorous pruning, this spacing leaves a generous amount of open ground between trees and allows him to drive a tractor and mower through the orchard perpendicular to the tree rows. Several growers also mentioned orienting rows to maximize air flow through the orchard from prevailing winds, but topography and a desire to plant tree rows on the contour often dictates row orientation regardless of prevailing wind direction.

Another example of landscape management is removing alternate hosts of fire blight, such as wild hawthorns, crab apples, and juneberries. Chris McGuire at Two Onion Farm removed hawthorns from his fenceline after observing fire blight symptoms on them.

For more information:
A re-examination of fire blight epidemiology in England. Billing & Berrie, 2002. Acta Horticulturae 590:61-67.
Examining Spatial Distribution and Spread of Fire Blight in Apple Orchards: Two Case Studies. Wallis & Cox, 2021. Plant Health Progress 22(4):445-449.
Wind dissemination of waterborne Erwinia amylovora from Pyrus to Pyracantha and Cotoneaster. Bauske, 1971. Phytopathology 61:741-742.
Selecting Trees and Shrubs For Windbreaks. Information from University of Minnesota Extension.

Nitrogen Management

Nitrogen (N) is an essential nutrient for plant growth and development, as it is a key component of chlorophyll, amino acids, and proteins. However, high levels of nitrogen within trees increases the susceptibility to fire blight, probably because nitrogen promotes abundant vegetative growth, and new and growing tissue is highly susceptible to fire blight infection. (Similarly, excessive pruning also stimulates lush growth which is susceptible to fire blight.)

Organic mulches of bark or wood chips slowly add nitrogen to the soil as they decompose.

The organic fruit growers surveyed for this report apply little or no nitrogen in their orchards. In most orchards, nitrogen is only added to the orchard through decomposition of organic mulches such as wood chips or bark, nitrogen fixation by legumes in the orchard floor, and/or foliar sprays of compost teas or liquid fish fertilizers which contain low amounts of nitrogen.

Harry Hoch at Hoch Orchards and Gardens used to apply nitrogen by broadcasting Sustane® fertilizer on the orchard floor, but he has since moved away from that practice. Now, he says, “our system is biological, not chemical. We create our organic matter within the orchard, by mowing the understory, chopping prunings with a flail mower, and spraying compost teas to enhance soil biology and promote epiphytic microbes.”

Deirdre Birmingham at The Cider Farm is one of the few growers surveyed who broadcasts a high nitrogen fertilizer (typically feathermeal), but she only applies it on specific varieties when indicated by foliar nutrient analysis and she is careful to restrict the amount of nitrogen applied, both to reduce the trees' susceptibility to fire blight and because high levels of nitrogen in fruit are not desirable for cider fermentation.

Notably, most growers consider their nitrogen management practices to be part of an organic philosophy of promoting plant health and overall measured, balanced growth: they have not restricted nitrogen solely to control fire blight.

Vigorous vegetative growth allows newly planted trees to quickly fill their alloted space

A drawback of low soil nitrogen levels can be reduced vegetative growth, which is particularly significant in young high-density orchards where rapid growth in the first two years after planting allows trees to fill their allotted space quickly and then produce early heavy yields. Both Rami Aburomia and Deirdre Birmingham believe that higher nitrogen application in their newly planted organic orchards would have led to more rapid growth and earlier yields. Other growers, however, reported that they are glad to restrict nitrogen in their orchards because they are constantly fighting to contain overly vigorous trees!

For more information:
Influence of nitrogen and rootstock on tree growth, precocity, fruit quality, leaf mineral nutrients, and fire blight in 'Scarlet Gala' apple. Fallahi & Mohan, 2000. Hortechnology 10:589–592.

Blossom Thinning

A fire blight control technique which is important in specific cases is to pinch off blossoms from young, non-bearing trees. Young trees, especially when grown on dwarfing rootstocks, can bloom in the year of planting or subsequent years when fruit are not desired. Open blossoms serve as an entry point for the fire blight pathogen, and young trees are extremely vulnerable to fire blight. If there is fire blight inoculum in your orchard, it's good practice to remove flower buds or newly opened flowers from non-bearing trees before they have the chance to become infected. This is particularly true for newly-planted trees, which often bloom later than established trees, at a time of year when higher temperatures and humidity are very favorable for fire blight infection.

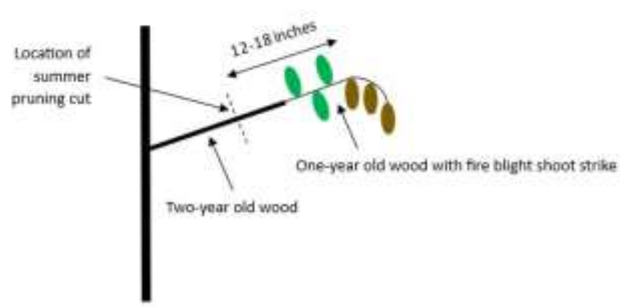
Summer Pruning

All the growers surveyed for this publication who have suffered fireblight infections have attempted to manage the disease by pruning shoot strikes in summer. A few common themes emerged during interviews. Most orchardists believe that summer pruning is an important part of fire blight management, but practical constraints, particularly available time, often limit pruning. There is also a great deal of uncertainty and confusion about the specific techniques which should be used to prune and sanitize tools, and growers expressed frustration over conflicting advice from researchers and consultants on these topics.

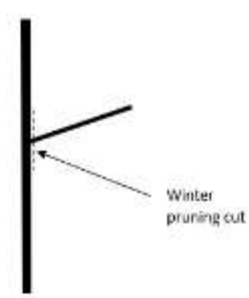
Summer Pruning Techniques

To demystify summer pruning, a multi-state experiment has recently been conducted in major apple production regions including Washington State, New York, Oregon, and Pennsylvania. These pruning trials took place in orchards differing in age of trees, scion varieties, rootstocks, tree vigor, training system and disease pressure. The research provided answers to several key questions about fire blight prevention and management. Here are important conclusions:

- Timely summer pruning of fire blight strikes dramatically reduces the number of trees that subsequently die from fire blight. <u>Pruning out fire blight in summer is an important task that should be prioritized.</u>
- The most effective pruning technique is in the fact the commonly recommended "best management practice." Cut off fire blight strikes 12 to 18 inches below the edge of symptoms, being sure to cut into at least two-year-old wood. More aggressive pruning 30 inches below symptoms did not improve fire blight control compared to pruning 12 to 18 inches below the symptoms.
- It is effective to leave a long stub in summer while pruning out fire blight strikes, rather than cutting off infected branches flush with the central leader of the tree. The long stub reduces the likelihood that a canker will subsequently form in the leader of the tree. The long stub can be subsequently removed during winter pruning.



Ideal location of summer pruning cut



Subsequent dormant pruning cut

This trial also showed that the practice of snapping off fire blight strikes by hand at the junction between one- and two-year old wood, although fast, was not effective and resulted in more subsequent fire blight cankers than the standard best management practice. This practice is not recommended.

Summer pruning techniques vary among the orchards represented in our survey. Two orchardists reported during phone interviews that they do not use the stub technique, but instead summer prune back to a branch junction in two-year-old or older wood. But most growers use a similar technique to the best management practice described above, pruning at least 6-12 inches or more below visible symptoms and leaving a stub to be pruned off during subsequent dormant pruning. Some orchardists do not mark the stubs left during summer pruning, reporting that stubs are easy to see during dormant pruning and/or that flagging would take too long; others do tie flagging tape around the ugly stub cuts to make them more visible in winter. One grower in fact scoffed at the notion that it would be possible to notice all or even most unmarked ugly stubs during winter pruning in a commercial sized orchard. Opinions vary…

Flagging tape marks pruning stubs left after summer pruning at The Cider Farm.

One area of uncertainty for many growers is when, and whether, to remove fire blight infected trees. Several growers commented from experience that when fire blight infects a tree of a very susceptible variety, it can be best to remove the tree and not have it serve a continual source of inoculum for other trees in the orchard. However, it's obviously difficult to remove a mature tree given that substantial past investment and future yield that each tree represents, especially for an established larger semi-dwarf tree. And growers reported from experience that with careful intense pruning (including cutting far back into the leader in some cases), it is possible to salvage a tree, even one that has numerous fire blight strikes, and fire blight may never reappear on that tree. This is particularly true for varieties that are at least moderately resistant to the disease. When faced with a severely infected tree where infection has entered the leader, Deirdre Birmingham at The Cider Farm sometimes cuts the tree close to the ground, below the graft union, and hopes for healthy regrowth from the rootstock which can later be topworked to a desirable scion variety.

For more information:
Evaluation of Pruning Therapies in Apple Trees with Fire Blight. DuPont & others, 2023. Journal of Plant Pathology 105:1695–1709
Managing Fire Blight Infections: Pruning, Sanitation. Video recording of 2023 webinar summarizing recent research.

Sanitation

To avoid spreading the fire blight pathogen, it is often recommended to sanitize pruning tools in between cuts (or in between trees) when pruning out fire blight strikes in summer. However, the recent multi-state experiment mentioned above, as well as previous trials, showed that sanitation does not reduce the chance that fire blight symptoms will re-develop after summer pruning. Researchers emphasize that in orchards with significant fire blight infections, the priority should be to prune and remove blight as quickly as possible to minimize the number of trees that die. Sanitizing pruners and loppers slows down pruning and is therefore not recommended.

Pruning sanitation procedures vary among growers surveyed for this project. A few orchardists do not sanitize tools at all while summer pruning, in line with the recommendations above. Most growers do disinfect tools using various materials, including rubbing alcohol, Oxidate, copper fungicide mixed with water, or bleach. Some disinfect between each cut; others disinfect only between trees to save time while pruning. Several growers commented that it is much quicker and less cumbersome to disinfect by spraying blades from a spray bottle rather than by dipping tools into a disinfectant solution.

Disposal of prunings can also be a concern. The fire blight pathogen will persist and survive only in living tissue. Therefore, prunings that are completely dry and dead should not harbor the bacteria and serve as a source of future infections. However, there is a possibility that bacteria in recent, fresh prunings could be spread by wind and splashing rain and thus infect nearby trees. Therefore, experts often recommend that fire blight prunings should be removed from the orchard promptly and destroyed by burning. If time is a constraint, however, prunings can be left in the row middles to dry out and then chopped with a mower. Most of the growers surveyed here remove fire blight prunings from the orchard to burn them, although a few do leave prunings to dry out in row middles and/or mow them.

If fire blight is present in an orchard, it is generally recommended to avoid cutting or damaging plant tissue (e.g., by summer pruning or hand thinning) during damp or wet weather when the fire blight bacteria can easily be spread between plants and infect wounds.

Management of Summer Pruning

In a busy commercial orchard, it can be challenging to locate fire blight infections that need to be pruned, especially during summer when shoot blight can appear over an extended time. Many growers look for shoot strikes while spraying, mowing, or doing other tractor work in the orchard and return later to prune those strikes out. Several growers emphasized the importance of training employees to recognize fire blight strikes and record their location for subsequent follow-up pruning. At Mary Dirty Face Farm, Rachel Henderson reports that when they had low levels of fire blight, they would rely on noticing outbreaks while doing other work, but now that fire blight has become more common in their orchard, they schedule a scouting walk in early summer to identify outbreaks and prioritize them for summer pruning. At Kalliroe Farm, where fire blight is a major concern, the farmers and their crew walk the entire orchard during summer, starting with the most valuable and/or susceptible varieties, pruning out strikes as they go. At The Cider Farm, another orchard where fire blight is a serious concern, Deirdre Birmingham used to walk the entire orchard every 3-5 days during early summer, pruning strikes, but since the orchard has expanded in acreage, she now restricts summer pruning to areas where strikes have been identified while doing other work.

Summer shoot strikes appear over an extended time, and repeated pruning sessions are required to prune them out promptly. In a bad fire blight year at Two Onion Farm, Chris McGuire visited fire blight hotspots fourteen times in a single season (once or twice per week for most of June through August) to promptly identify and cut out new strikes. In practice, however, labor availability often dictates how often summer pruning is performed: growers need to fit in pruning fire blight strikes between myriad other orchard tasks. Mary Dirty Face Farm is a diverse farm growing berry crops as well as 10.5 acres of apples and pears, and Rachel Henderson rates the labor required for summer pruning fire blight strikes as a major management concern, especially because the pruning overlaps with a busy early summer berry harvest season. Weather can also be a serious constraint: Deirdre Birmingham at The Cider Farm avoids summer pruning of fire blight strikes when rain is forecast within the next several days, which can greatly reduce the times when pruning is possible. In particularly bad years, when fire blight is prevalent and labor limited, several growers have (unwillingly) “walked away” and left fire blight strikes unpruned until winter.

Time required for summer pruning varies widely, based on the severity of infection and how often growers revisit infected trees. At Mary Dirty Face Farm, with 10.5 acres of apples and pears, summer pruning can consume 8-10 hours per week at the busiest time of year, with the workload tapering off to 2-3 hours per week later in summer. In a one-acre block of apples at Two Onion Farm, weekly summer pruning usually took 20 minutes to an hour, but up to 3 hours at the peak of the season.

Two of the orchardists interviewed commented on the importance of keeping detailed written records of the rows and/or individual trees which show infection each year. These records help to focus future scouting and pruning attention on previously infected trees and also serve to identify trees which show symptoms in consecutive years and may merit removal. Most growers, however, do not keep such detailed records given the intense demands on their time and attention during the summer pruning season.

Winter Pruning

In general, experts recommend dormant pruning to cut out any fire blight cankers on the trunk or branches and to cut back long stubs left during the previous summer’s pruning. In dormant pruning it is recommended to cut at least 4-6 inches below cankered or infected tissue to ensure that all infected tissue is removed.

All the growers interviewed for this study who have suffered fire blight do use dormant, winter pruning to manage the disease. This dormant pruning for fire blight is done at the same time as standard dormant pruning (i.e., growers are not making separate passes through their orchard to cut out fire blight and then subsequently to do general pruning). Most growers say that their goal is to search for and prune out all fire blight cankers, focusing their search on areas where fire blight occurred in the previous season.

Growers vary in their confidence in identifying fire blight cankers – several said that fire blight cankers are obvious and easy to distinguish; while others (anonymously!) confessed themselves unable to identify fire blight cankers and said that they merely try to prune out all cankers, whether caused by fire blight or fungal rots.

At The Cider Farm, Deirdre Birmingham and her crew scrape out fire blight cankers in winter. During the dormant season, but at a separate time from pruning, they walk through known fire blight hotspots within their orchard and use a grafting knife to scrape away cankered tissue until they reach healthy green tissue. The goal is to remove cankers from the leader and branches while avoiding drastic pruning cuts to the tree. Scraping requires about 8-16 hours of labor per year in their 18 acres of organic apples.

These photographs show a fire blight canker before and after scraping at The Cider Farm

Sprays to Control Fire Blight in Organic Orchards

Organic standards require that growers implement cultural practices for disease control before turning to disease controlling sprays which include substances from the National List of synthetic substances allowed for use in organic crop production. In practice, cultural techniques such as pruning, nitrogen management, and resistant varieties are strongly recommended, but have not proven effective in and of themselves for fire blight control in many situations. Many organic growers have thus used, or at least considered, sprays for fire blight control. Numerous "restricted" spray products are available for fire blight control (i.e., these products may be used only if the requirements of 205.206(e) are met, which require the use of preventive, mechanical, physical, and other disease management practices).

Organic Growers' Sprays

Our internet survey of 25 growers showed that the most popular spray products for control of fire blight were various copper formulations, Regalia, Serenade Opti, and Double Nickel or Stargus. In general, growers were uncertain that their sprays were effective, particularly in the case of non-copper products. Eight of thirteen growers who had sprayed copper products to control fire blight thought that the copper application had been effective; for all other sprays products most growers who had applied the product were unsure whether it had been effective. This uncertainty likely reflects that (1) fire blight incidence varies greatly year to year, making it hard to determine whether particular sprays were effective, (2) most growers do not have the time, resources, or inclination to conduct replicated trials of spray products, and (3) many of the organic spray products are only moderately effective and only provide partial control. It is notable that Blossom Protect, a product which has provided very effective control of fire blight in scientific trials, has only been used by two of the twenty-five growers surveyed.

Organic Growers' Use of Organic Spray Products to Control Fire Blight

		Number of Growers Responding:		
Active Ingredient	Brand Name(s)	Tried this; it seemed effective	Tried this, unsure if it had any effect	Never tried this
Copper, various forms	Cueva, Magna-Bon, Champ, Kocide, Previsto, etc.	8	5	12
Extract of *Reynoutria sachalinensis*	Regalia	1	10	14
QST 713 strain of *Bacillus subtilis*	Serenade	2	8	15
Liquid Lime Sulfur		2	6	17
Bacillus amyloliquefaciens strain D747	Double Nickel or Stargus	0	5	20
Hydrogen Peroxide and Peroxyacetic Acid	Jet-Ag or Oxidate	1	3	21
Bacillus mycoides isolate J	Lifegard	1	3	21
Pantoea agglomerans strain E325	Bloomtime Biological	0	2	23
Aureobasidium pullulans strain DSM 14940/14941	Blossom Protect	1	1	23
Bacillus pumilus strain QST 2808	Sonata	0	1	24
Bacteriophage	Agriphage	0	0	25
Pseudomonas fluorescens A506	BlightBan	0	0	25
Pseudomonas chlororaphis strain AFS009	Howler	0	0	25
Banda de Lupinus albus doce (BLAD)	ProBlad Verde	0	0	25

Data from OFGA internet survey, winter 2022-2023

In our focused phone interviews with fruit farmers, we delved more deeply into their spray programs and their motivations and considerations in selecting spray products.

Airblast sprayer used for spraying at The Cider Farm

Eight of the nine growers who participated in the phone survey use a tractor-powered airblast sprayer to spray their orchards; the ninth uses a tractor powered sprayer with a hand wand. Most growers typically applied spray volumes of 50-100 gallons per acre.

Spraying is time-consuming, typically requiring about 30 minutes to an hour per acre, and spraying the entire orchard requires 8-14 hours in their larger orchards surveyed. Orchards with larger, semi-dwarf trees generally required less time per acre for spraying, presumably because of their wider row spacing. Most of the orchards surveyed rely on a single sprayer implement, and in most cases the owner-operators of the orchard do all spraying themselves.

The time required for spraying strongly motivates growers to avoid, when possible, spray products which require frequent re-application or which cannot be tank-mixed with other products which must be applied in the same season, and to prefer products that control multiple pests or diseases. During bloom, the most critical time for sprays to control fire blight, growers rarely spray insecticides or foliar nutrients, but it is common to spray for other diseases (particularly apple scab) or for blossom thinning.

Time Required to Spray Orchards

Orchard Size (Acres)	Hours Required to Spray Entire Orchard*
2	0.67
2	3
2.5	2.5
4	2
10.5	4
14	12
18	8
25	12
75	14

*Includes time to fill and rinse sprayer tank.

Data from OFGA internet survey, winter 2022-2023

A number of the growers surveyed mentioned interest in some of the newer biological products as alternatives to copper for fire blight control, but reported difficulty in sourcing these products or in knowing which of the newer products are effective and when specifically they should be sprayed. Other growers mentioned that Seven Springs Farm, Nutrien (particularly the Galesville, WI branch), and Wilbur-

Ellis (particularly the Almond, WI branch) are good sources for many of the spray products allowed in organic production.

Several growers mentioned product toxicity as a factor in selecting spray products. For example, several growers shy away from copper, liquid lime sulfur, and/or sulfur because of concerns about their toxicity to the humans handling and spraying the product or their impacts on the environment and non-target organisms.

The federal Worker Protection Standard mandates that commercial farms (including organic farms) observe the Restricted Entry Intervals (REI) indicated on pesticide labels. Many organic orchards rely on considerable hand labor for weeding, summer pruning, thinning, and other tasks, and lengthy REI's or frequent spraying of products with shorter REI's can complicate scheduling and managing labor. REI's vary from 4-48 hours on most organically-allowed spray products for control of fire blight or other diseases.

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Broadly speaking, over the course of a growing season there are three types of sprays possible to control fire blight: (1) an early-season dormant or delayed-dormant spray of copper to kill fire blight bacteria as they are secreted from existing cankers, (2) bloomtime sprays to prevent infection of flowers, and (3) post-bloom sprays to prevent shoot blight during summer. We will consider these three types separately.

Early Season Copper Sprays

Copper can be sprayed in early spring, while trees are dormant or just breaking bud, to kill fire blight bacteria as they are secreted from overwintering cankers, and thus reduce the inoculum in the orchard which can cause further infections.

Multiple copper-containing products are available for managing fire blight at bud-break, including formulations containing copper hydroxide, copper sulfate, copper oxychloride, and more. These products operate similarly, providing copper ions, which inhibit bacterial or fungal growth. The specific copper compound's hydroxyl or sulfate portion doesn't contribute to this inhibitory effect. It's crucial to compare the copper ion content in different products, typically expressed as a percentage of dry product weight (e.g., 50% indicates one pound of copper within two pounds of the formulated product), or as pounds per liquid volume, e.g., 2 lbs/gallon.

When applying copper to apple trees during bud-break, the target is typically 1-2 lbs. of actual copper per acre, as recommended by Dr. Patty McManus, retired fruit crop pathologist at UW-Madison. The efficacy of copper applications depends on factors like the particle size of copper salts in formulated products. Smaller particle sizes are less likely to be dislodged by rain, potentially leading to better copper distribution on fire blight cankers. Obtaining information on particle size may be challenging, but distributors can sometimes assist with this. Copper distribution on cankers can be improved by applying copper with higher water volumes, such as 75-125 gallons per acre, depending on tree size, and adding a spray oil such as Organic JMS Stylet Oil at 1 gallon of oil per 100 gallons of water.

Early season copper applications are made early in the year not because fire blight bacteria are rapidly growing at that time, but because copper is phytotoxic to green leaf tissue. Once copper products dry, they are no longer phytotoxic. The goal of the early season spray is to apply copper when there is little or no green tissue present, and then to leave a dry copper residue that is sufficient to kill bacterial cells through the following weeks, whenever warm weather prompts rapid bacterial growth.

Fruit russeting is another concern associated with copper sprays on apples. If sufficient copper residue remains at petal-fall, rainfall can redistribute it onto developing fruitlets, leading to russeting. It is generally believed that approximately 3-4 inches of rain between application and fruit-set can mitigate this risk.

To mitigate the risks of phytotoxicity, consider the following suggestions: (1) apply copper under conditions of low humidity when drying is rapid, (2) avoid application of copper within 24 hours of a freeze event, (3) omit oil from the application (although oil does improve the distribution of the copper), and (4) reduce the rate of copper applied per acre.

Some growers in our study expressed concern with spraying copper in their orchards because of toxicity to handlers and applicators, negative environmental impacts, and long restricted entry-intervals. There are many disease controlling sprays allowed in organic production which do not contain copper. Unfortunately, however, we are not aware of any trials of non-copper products sprayed around budbreak. Most of the non-copper products are thought to be effective only in warmer weather later in the year, when rapid bacterial growth and infections occur. In addition, so-called "low dose" copper products, such as Cueva, are thought to be ineffective at budbreak because they leave insufficient copper residue to provide control during the following weeks.

Bloomtime Sprays

The most critical period to apply fire blight sprays is generally during bloom. As described in the description of the fire blight life cycle at the beginning of this publication, fire blight bacteria can rapidly multiply on the stigmas of flowers and be spread then by rain or dew into the floral cup where they will infect the flower and cause blossom blight, which will then serve as a source of subsequent infections during the growing season.

At bloom, many commercial spray products are available for use in organic orchards, including many non-copper products. Many of these products have been developed recently and have not been extensively tested by researchers or growers. Most of the growers surveyed for this project expressed curiosity and interest in these sprays but were unsure which products were most effective and useful. Therefore, we have attempted to summarize results from research trials of the efficacy of these spray products.

It is important to understand how fire blight spray product trials are typically conducted. Researchers either intentionally inoculate trees (i.e., blossoms) or rely on natural infections in higher disease pressure environments and then subsequently measure the efficacy of sprays in reducing the disease's impact. Impact of the disease is often measured as the number of symptomatic blossoms and/or blighted strikes in the tree canopy. Efficacy is often expressed as the percent reduction in disease when compared to infected but unsprayed control trees.

It is difficult to interpret spray trials because the results vary enormously between trials. Many factors contribute to this variation: (1) Trials have been conducted in various climates and regions, including in the arid Northwest, where bloomtime weather is significantly drier than in the humid Midwest. Environmental conditions during bloom hugely impact fire blight infection rates. (2) The amount of fire blight bacteria varies between trials because of differences in how the trees were artificially inoculated and/or the level of natural infection pressure. (3) Trials have been conducted on different apple varieties, which differ in their susceptibility to fire blight. (4) Trials vary in how sprays are timed in relation to the stage of bloom, tree inoculation, and rainfall events.

Because of this variation, a product which is effective in one research trial may not be effective in another trial, or in your orchard. Confidence in specific spray regimens only emerges after repeated research trials and extensive grower experience. For many of the newer spray products, we do not have enough data to be very confident in their efficacy. Our goal here is to help growers understand the broad picture which has emerged from research trials. Continued research and grower experience will refine what we know. Currently, the most proven products for control of fire blight during bloom in organic orchards are various copper products and Blossom Protect.

Copper Fungicides During Bloom

A variety of copper-based products, including Cueva, Mastercop, Previsto, and Instill-O have provided excellent control (typically a 50-80% reduction in fire blight incidence compared to untreated controls) when sprayed 2-3 times during bloom. Research indicates that the best fire blight control is achieved during bloom with spray rates between 0.16 and 0.25 pounds of metallic copper per acre. In addition to fire blight, copper fungicides likely provide some control of apple scab and possibly also some control of cedar apple rust.

There are several disadvantages of copper fungicides. First, copper applied to actively growing trees may cause phytotoxic reactions, especially fruit russeting but also possibly leaf injury. Low-dose products, such as Cueva or Previsto, are less likely to cause phytotoxicity, presumably because less copper per acre is applied to trees. Second, most copper products have lengthy REI periods. Cueva has a 4-hour REI, but Previsto, Magnon, Kocide, Badge X2 and most other copper fungicides have 48-hour REI periods. Growers who rely heavily on these products for disease control during bloom may struggle to find a time available for conducting any hand labor in their orchards! Deirdre Birmingham at The Cider Farm found that it was extremely frustrating to spray Previsto for fire blight control during bloom because of its 48-hour REI.

Third, many of the growers surveyed for this project were concerned about the long-term environmental impacts of repeated copper sprays as well as the toxicity of copper to non-target organisms and orchard workers. Some copper pesticides (e.g., Champ, Previsto, Mastercop, and MagnaBon) have the Danger signal word, indicating that the product is highly toxic to applicators or handlers, whereas other have the Warning or Caution signal words, indicating moderate or low toxicity, respectively. The Xerces society generally rates copper products as having low-moderate toxicity to bees.

Blossom Protect

The active ingredient in Blossom Protect is a naturally occurring live yeast fungus, *Aureobasidium pullulans*. When Blossom Protect is sprayed on open flowers, the fungus colonizes both the stigmatic surfaces and floral cups of the flowers, where it reproduces and grows in number. It has been thought that Blossom Protect sprays prevent fire blight because the yeast fungus competes for space and resources with the fire blight bacteria and/or the yeast fungus physically blocks the fire blight bacteria from invading plant tissue. However, recent evidence suggests that yeast fungus may actually act by stimulating natural disease resistance responses in the plant, which then ward off infection by fire blight. Spraying Blossom Protect does not appear to reduce populations of fire blight bacteria on the flower but does reduce subsequent infection of the flower.

The manufacturer recommends that Blossom Protect is tank-mixed with a second product, Buffer Protect NT (active ingredients citric acid and disodium phosphate), which acts as a buffering agent and maintains the spray tank pH of 3-4 which the *Aureobasidium pullulans* fungus requires. Label instructions are to spray 1.25 pounds of Blossom Protect plus 8.75 pounds of Buffer Protect NT in 50-200 gallons of water per acre, with up to 4 applications during bloom, preferably the day before predicted infection conditions.

Bloomtime sprays of Blossom Protect have repeatedly provided excellent control of fire blight in trials, both in the arid Northwest as well as in humid eastern regions. Relative to untreated control treatments, Blossom Protect has provided average reduction in fire blight of 70%-90% over multiple years in several regions, including humid climates. Other advantages of Blossom Protect are that it has a short, 4-hour REI, it is non-toxic and safe to handle (although the Buffer Protect NT buffering agent is highly acidic and is labeled with a Warning signal word), and it probably has little or no effect on bees and other beneficial arthropods nor other negative environmental impact.

There have been cases where Blossom Protect did not provide excellent control in trials. Factors that may reduce the effectiveness of fire blight include cold weather during bloom and poorly timed applications. It is probably important to allow 12-24 hours between a Blossom

Protect spray and subsequent rain event to allow time for the yeast fungus populations to increase and/or for an induced plant resistance to develop before rain washes fire blight bacteria into the floral cup of flowers. However, if Blossom Protect is applied too far in advance of rain, many flowers may have opened after the spray and thus not be colonized by the yeast fungus and protected from fire blight.

Only 2 of the 25 growers surveyed for this project reported that they had tried Blossom Protect in their orchard. One disadvantage of Blossom Protect is that it does not provide any control of diseases other than fire blight, such as scab or cedar-apple rust, which may infect trees during bloom. There are also limits of which products can be mixed with Blossom Protect in the spray tank. The *Aureobasidium pullulans* fungus is a living organism, which is sensitive to some fungicides and other materials. The manufacturer has published a list of other spray products which are and are not compatible with Blossom Protect. Of interest to organic growers, the following active ingredients or products are considered incompatible with Blossom Protect: *Bacillus amyloliquefaciens* strain D747 (Double Nickel, Stargus), potassium bicarbonate (Carb-o-nator), lime sulfur, copper fungicides, *Bacillus subtilis* (Serenade Opti), *Bacillus pumilus* QST2808 (Sonata), some formulations of Granulosis virus, and some cinnamon Oil and orange Oil products. By contrast, Elemental sulfur, *Reynoutria sacchalinensis* (Regalia), *Bacillus thuringiensis* spp. Kurstaki (e.g., Dipel), Nu-Film P (pinolenes, nonionic surfactants), and paraffinic oil (JMS Stylet Oil) are all considered compatible with Blossom protect. Incompatible products should not be tank-mixed with Blossom Protect, and the manufacturer has issued conflicting recommendations (from 1-3 days) on how much time should elapse before or after a Blossom Protect application and application of an incompatible product. Ken Johnson at Oregon State University has conducted numerous trials of Blossom Protect and generally believes that it is okay to spray an incompatible product immediately *before* spraying Blossom Protect, but that an incompatible product should not be sprayed within 48 hours *after* a spray of Blossom Protect.

Another practical limitation to tank-mixing with Blossom Protect is that the Buffer Protect NT product lowers the pH of the spray tank to 3-4, which is below the recommended range for some other spray products. For example, the manufacturer of Blossom Protect lists Dipel and Regalia as compatible with Blossom Protect (i.e., Blossom Protect should remain effective when tank-mixed with those products), but the manufacturer of Dipel recommends a tank pH >4.5, and the manufacturer of Regalia has implied that a tank pH of 6-8 is best, so Dipel and Regalia may not function well when mixed with Blossom Protect.

Research and grower experience in the Northwest have shown that it is not critical to spray Blossom Protect early in bloom, presumably because fire blight bacteria populations have not built up at that point and the risk of infection is less. In that region a standard spray regimen which controls fire blight and allows for thinning fruitlets with liquid lime sulfur (considered incompatible with Blossom Protect) is: Liquid Lime Sulfur at 20% and 70% bloom for blossom thinning, followed by Blossom Protect at 80% bloom, and then Blossom Protect, a low-dose copper fungicide, or Serenade Opti at 100% bloom. (Blossom Protect is omitted from the final spray at 100% bloom, primarily because it may cause slight fruit russeting at this stage, not because it is ineffective against fire blight.)   This regime was also moderately to highly effective over several years of multi-state trials in the eastern U.S.

Blossom Protect contains a live organism which must be preserved during storage. The manufacturer states that it can be stored for 24 months at cold temperature (not to exceed 46°F), or 10 months at room temperature (not to exceed 68°F). Bags of Blossom Protect are labeled with an expiration date, and one grower surveyed for this project cautioned that a retailer once sold them bags that were past expiration.

Alum

Alum, potassium aluminum sulfate, is a chemical compound used as a pickling salt to maintain crispness in pickled produce. To our knowledge there are no alum products currently available as registered pesticides for fruit production in the United States, and alum is not listed by OMRI (the Organic Materials Review Institute) as allowed in organic production. However, several trials of alum have shown that it is very effective at suppressing fire blight when sprayed at 8-10 pounds/acre during bloom, with performance comparable to copper products and Blossom Protect. Alum is known in general to inhibit the growth of bacteria and fungi. According to rumor, a manufacturer is interested in commercializing an alum pesticide and seeking approval for its use in organic production. We are not aware of information on the environmental impact of alum sprays.

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Many other spray products are labeled for control of fire blight. In the very broadest terms, most of these other products have either not been tested or have provided low-moderate control of fire blight in research trials (typically 20%-50% disease suppression relative to untreated controls), and the effects often vary greatly between years and trials, from “pretty decent control” to “basically no effect.” Virtually all the products listed below have short, 4-hour REI’s, and most have low toxicity to humans and presumably little long-term environmental impact. Some are also effective against diseases other than fire blight.

Plant Essential Oils: Thymeguard and Cinnerate

Thymeguard (active ingredient Thyme) and Cinnerate (active ingredient Cinnamon Oil) have both been evaluated for control of fire blight. Laboratory assays have shown that these plant oils have antibacterial activity against fire blight bacteria. Trials in many U.S. states have demonstrated moderate disease suppression (often 40-50% a reduction in fire blight compared to untreated controls) from bloomtime sprays of 1 quart/acre Cinnerate or 2 quarts/acre Thymeguard.   These products may also provide some control of fungal diseases and some insect pests. Both products are oil-based, and it may be important to observe typical precautions for spray oils: the Cinnerate label specifically prohibits spraying in temperatures above 90 degrees F, and the Thymeguard label cautions against tank-mixes with Sulfur and peroxides. Oil products may also impact non-target insects and mites in the orchard.

Resistance Inducers: Regalia and Lifegard

The active ingredients in these products are very different: an extract from giant knotweed, *Reynoutria sachalinensis* (Regalia) and the bacteria *Bacillus mycoides* isolate J (Lifegard). However, both products induce a natural disease resistance response in plants. In Michigan and New York trials, both products have provided variable control of fire blight – in some years excellent control but in other years little or no effect. In addition to fire blight, both products are labeled to control many fungal diseases including scab and cedar-apple rust. It is generally recommended to spray these products 1-2 days ahead of an infection event to permit time for the induced plant resistance to develop.

Other bacterial biopesticides

Bacterial-based products which have been trialed include Howler (*Pseudomonas chlororaphis* strain AFS009), Theia (*Bacillus subtilis* strain AFS032321), Stargus (*Bacillus amyloliquefaciens* strain F727), Serenade Opti (*Bacillus subtilis* strain QST 713), and Double Nickel 55 (*Bacillus amyloliquefaciens* strain D747). These products all presumably act as anti-microbial agents, and each is labeled for control of numerous plant diseases. In general, trials show that they provide an inconsistent, low-moderate level of fire blight control.

Oxidizing agents: Jet-Ag and Oxidate

These products are based on the same active ingredients, a combination of Hydrogen Peroxide and Peroxyacetic Acid. These are essentially sterilizing agents, which will kill fire blight bacteria (and other microbes) which are present at the time of spraying. These products are generally considered to have no residual activity, i.e., if they are sprayed on a flower, they will not affect bacteria which arrive on the flower after spraying. Trials have shown variable low-moderate suppression of fire blight from bloomtime sprays of these products, and control probably depends greatly on timing and frequency of sprays. Populations of fire blight bacteria will rebound in the days after spraying, and for best control it may be necessary to reapply every 2-3 days. These products can cause fruit russeting. The Xerces society considers these products highly toxic to bees. In concentrated form, both products are highly toxic to handlers and applicators and the labels are marked with the Danger signal word. Once sprayed, they are relatively non-toxic, and the REI is merely "until sprays have dried." According to the labels, these products should not be tank-mixed with biopesticides containing live organisms.

Agri-phage

The active ingredient in Agri-phage is a live bacteriophage (virus) which infects and kills the fire blight bacteria, although it will not affect most other bacteria. Agri-phage has a short 4-hour REI, is non-toxic to humans, and presumably has no negative environmental impact. However, it has provided very inconsistent results in trials. One important factor may be sunlight. The bacteriophage is very sensitive to UV-radiation and may be rapidly rendered ineffective in sunny weather. The product label cautions against tank-mixing with copper and recommends a spray pH of 6-8.5.

Pro-Blad Verde

This product has been only recently offered for sale in the U.S. The active ingredient is Banda de Lupinus albus doce (BLAD), a naturally occurring protein in lupine plants. The manufacturer has aggressively touted Pro-Blad Verde's efficacy against fire blight, and some research trials are underway.

For more information on bloomtime sprays:
Blossom Protect. Information from the manufacturer.
Evaluation of biopesticides for the control of Erwinia amylovora in apple and pear. DuPont & others, 2023. Journal of Plant Pathology.
History, efficacy, orchard ecology, and mode of action of Aureobasidium pullulans, the microbial agent in Blossom Protect, for suppression of fire blight of pome fruit. Kunz & others, 2023. Journal of Plant Pathology.
Organic Pesticides: Minimizing Risks to Pollinators and Beneficial Insects. Guidelines from the Xerces Society.
Refinement of Nonantibiotic Spray Programs for Fire Blight Control in Organic Pome Fruit. Johnson & others, 2022. Plant Disease 106(2):623-633.
Using biopesticides to help control fire blight. Video recording of 2023 webinar summarizing recent research.

Information on certain pesticides used for control of fire blight in organic orchards. This information is largely compiled from pesticide labels.

Product	Active Ingredients	Labeled for use on apples?	Labeled for use on pears?	Labeled to control fire blight?	Other Labeled Uses on Apples or Pears:	OMRI-Listed*	EPA certified For Organic Production	Label Signal Word**	Restricted-Entry Interval
Agri-phage	Bacteriophage active against *Erwinia amylovora*	X	X	Yes			X	None	4 hours
Badge x2	Copper Oxychloride and Copper Hydroxide (28.2% Metallic Cu equivalent by weight)	X	X	Yes	Control scab, sooty blotch and/or flyspeck, powdery mildew, summer fruit rots, other diseases.	X		Warning	48 hours
BlightBan	*Pseudomonas fluorescens* A506	X	X	Yes		X		Caution	4 hours
Blossom Protect	*Aureobasidium pullulans* strain DSM 14940/14941	X	X	Yes	Control other diseases.		X	Caution	4 hours
Buffer Protect NT	Citric acid, Calcium carbonate	X	X	Yes				Warning	n/a
Champ	Copper hydroxide (50% metallic Cu equivalent)	X	X	Yes	Control other diseases.	X		Danger	48 hours
Cinnerate	Cinnamon oil	X	X	No	Control cedar apple rust or other rusts, powdery mildew. Control certain insect pests.	X		Caution	4 hours
Cueva	Copper Octanoate (Copper Soap) (1.8% metallic Cu equivalent)	X	X	Yes	Control scab, cedar apple rust or other rusts, sooty blotch and/or flyspeck, other diseases.	X		Caution	4 hours
Double Nickel 55	*Bacillus amyloliquefaciens* strain D747	X	X	Yes	Control scab, cedar apple rust or other rusts, sooty blotch and/or flyspeck, powdery mildew, other diseases.	X		Caution	4 hours
Howler	*Pseudomonas chlororaphis* strain AFS009	X	X	Yes	Control scab, powdery mildew, alternaria blotch, summer fruit rots.	X		Caution	4 hours
Instill-O	Copper Sulfate Pentahydrate (3.1% metallic Cu equivalent)	X		Yes	Control scab, other diseases.	X		Caution	48 hours
Jet-Ag	Hydrogen Peroxide and Peroxyacetic Acid	X	X	Yes	Control scab, cedar apple rust or other rusts, powdery mildew, alternaria blotch, other diseases.	X		Danger	Until sprays have dried
Kocide 3000	Copper Hydroxide (30% metallic Cu equivalent)	X	X	Yes	Control scab.	X	X	Caution	48 hours
Lifegard	*Bacillus mycoides* isolate J	X	X	Yes	Control sooty blotch and/or flyspeck, summer fruit rots.	X	X	Caution	4 hours
Lime Sulfur Solution	Calcium Polysulfide	X	X	No	Control scab, powdery mildew, other diseases. Control certain insect pests. Thin blossoms or fruitlets.	X		Danger	48 hours
MagnaBon	Copper Sulfate Pentahydrate (5% metallic Cu equivalent)	X	X	Yes	Control scab, powdery mildew, alternaria blotch, other diseases.	X		Danger	48 hours

Product	Active Ingredients	Labeled for use on apples?	Labeled for use on pears?	Labeled to control fire blight?	Other Labeled Uses on Apples or Pears:	OMRI-Listed*	EPA certified For Organic Production	Label Signal Word**	Restricted-Entry Interval
Mastercop	Copper sulfate pentahydrate (5.4% metallic Cu content)	X		Yes	Control scab.	X		Danger	48 hours
Oxidate 5.0	Hydrogen Peroxide and Peroxyacetic Acid	X	X	Yes	Control scab, cedar apple rust or other rusts, sooty blotch and/or flyspeck, powdery mildew.	X		Danger	Until sprays have dried
Previsto	5% Copper Hydroxide (3.3% metallic Cu equivalent)	X		Yes	Control scab, sooty blotch and/or flyspeck.	X	X	Danger	48 hours
ProBlad Verde	Banda de Lupinus albus doce (BLAD)	X	X	Yes	Control scab, sooty blotch and/or flyspeck, powdery mildew, summer fruit rots, other diseases.	X	X	Caution	4 hours
Regalia	*Reynoutria sachalinensis* extract	X	X	Yes	Control cedar apple rust or other rusts, sooty blotch and/or flyspeck, powdery mildew, alternaria blotch, summer fruit rots.	X	X	Caution	4 hours
Serenade Opti	*Bacillus subtilis strain* QST 713	X	X	Yes	Control cedar apple rust or other rusts, sooty blotch and/or flyspeck, powdery mildew, summer fruit rots, other diseases.	X	X	Caution	4 hours
Sonata	Bacillus pumilus strain QST 2808 (spores, solids, solubles, and water)	X	X	No	Control scab, powdery mildew.	X		Caution	4 hours
Stargus	*Bacillus amyloliquefaciens* strain F727* cells and spent fermentation media	X	X	Yes	Control scab, sooty blotch and/or flyspeck, powdery mildew, alternaria blotch, summer fruit rots, other diseases.	X	X	Caution	4 hours
Theia	*Bacillus subtilis* strain AFS032321	X	X	Yes	Control scab, cedar apple rust or other rusts, sooty blotch and/or flyspeck, powdery mildew, alternaria blotch, summer fruit rots, other diseases.	X		Caution	4 hours
Thymeguard	Thyme	X	X	Yes	Control other diseases. Control certain insect pests.	X		Caution	None

*OMRI-listed means that the product label bears the OMRI Organic Materials Review Institute) seal of approval. See OMRI for more information, including restrictions on use.

**Signal words are found on pesticide product labels, and they describe the acute (short-term) toxicity of the formulated pesticide product. The signal word can be either: DANGER, WARNING or CAUTION. The only pesticide products that are not required to display a signal word are those that fall into the lowest toxicity category by all routes of exposure (oral, dermal, inhalation, and other effects like eye and skin irritation). CAUTION means the pesticide product is slightly toxic if eaten, absorbed through the skin, or inhaled, or it causes slight eye or skin irritation. WARNING indicates the pesticide product is moderately toxic if eaten, absorbed through the skin, or inhaled, or it causes moderate eye or skin irritation. DANGER means that the pesticide product is highly toxic by at least one route of exposure. It may be corrosive, causing irreversible damage to the skin or eyes, or it may be highly toxic if eaten, absorbed through the skin, or inhaled.

Fire Blight Predictive Models

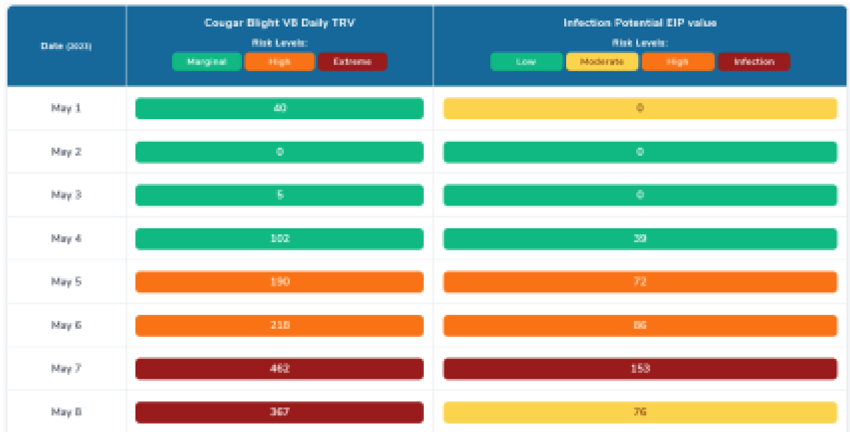
Growers can time bloomtime sprays based on computer-based models which predict the likelihood of fire blight infection in their orchard based on recent weather together with forecasted upcoming weather. It's best to use these models in conjunction with a weather station in your orchard which collects weather data specific to your site. In our region, most growers who implement these models have a weather station which is linked to NEWA (The Network for Environment and Weather Applications). The NEWA platform offers a wide range of models which predict insect and disease activity in apples (and other crops) as well as irrigation needs and response to fruit thinning sprays. If you have a weather station linked to the NEWA network, NEWA will run the fire blight predictive models for your location. If you don't have a weather station in your orchard, you can view and use model output based on weather data from a nearby weather station.

The fire blight models are based on the biology of the bacteria. Recall that during bloom, the *Erwinia amylovora* bacteria colonize flowers and that the bacteria reproduce and increase in number on the surface of the flowers. The rate of growth for the bacterial population in flowers depends on temperature. When bacterial populations on the surface of the flower have reached sufficient size, a wetting event (rain or heavy dew) is needed to wash bacteria down to the floral cup where they can infect the flower. The models do not predict shoot blight infections and should only be used for the blossom blight phase of fire blight.

Cougar Blight was developed at Washington State University. This model calculates a total risk value (TRV), which reflects how much bacterial population growth could have occurred in recent days based on recorded temperatures at your location. The user must rate the history of fire blight in their orchard as "Fire blight occurred in your neighborhood last year", "Fire blight is now active in your neighborhood", or "No fire blight in your neighborhood last year." The model uses this neighborhood fire blight history as a measure of fire blight inoculum which will be present in your orchard. The TRV and the local fire blight history are then combined to produce a "risk level," either marginal, high, or extreme, which indicates the likelihood of fire blight infections occurring on a given day if a wetting event occurs.

The MaryBlyt model calculates an epiphytic infection potential (EIP), which, like the TRV, is based on the temperatures in recent days and is a measure of how much bacterial populations on flowers have grown. When the EIP reaches 100 or above, the model predicts that fire blight bacterial populations have reached sufficient number that a wetting event will result in fire blight infection. In addition to an EIP>100, the MaryBlyt model has three other conditions which must be met for infection to occur: a wetting event, an average daily temperature >60 degrees F, and open flowers. If flowers are open but none of the other three conditions is met, MaryBlyt calculates a "Low" risk level; if flowers are open and one of the other three conditions is met, the risk level is "Moderate", and if flowers are open and two of the other tree conditions are met, the risk level is "High", and if all four of these conditions are met, then MaryBlyt produces a Risk level of "Infection," meaning that according to the model, an infection has occurred.

A third fire blight predictive model is available on the Rimpro network. Rimpro is an online network, similar to NEWA, which is commonly used in Europe, but rarely in the U.S. Upper Midwest growers can access the Rimpro network by first linking their weather station to NEWA and then purchasing a Rimpro membership together with a NEWA data license which **will export their weather** data from NEWA to Rimpro. Srdjan Acimovic at Virginia Tech has published a description of the process for accessing Rimpro. The Rimpro fire blight model adds additional complexity in its modelling of bacterial growth and infection and may be more reliable than the two models more widely used in the U.S.



Date (2023)	Cougar Blight V5 Daily TRV Risk Levels: Marginal, High, Extreme	Infection Potential EIP value Risk Levels: Low, Moderate, High, Infection
May 1	40	0
May 2	0	0
May 3	5	0
May 4	102	39
May 5	190	72
May 6	218	86
May 7	462	153
May 8	367	76

Cougar Blight and MaryBlyt model output from NEWA for a Wisconsin orchard, 2023 bloom.

In practice, the Rimpro model appears to be rarely used in the Upper Midwest. Of the two U.S. models, MaryBlyt is often considered more reliable in the eastern and midwestern U.S. Neither model is infallible, and both can produce false positive and false negative results, i.e., they can predict an infection where none occurs, or they can predict no infection where one does occur. However, they do provide valuable guidance for decision making.

Both the TRV calculated in Cougar Blight and the EIP in MaryBlyt are similar in that they are strictly based on recent temperatures. If fire blight bacteria are in your orchard, both metrics provide an indication of how many fire blight bacteria are present on the surface of your flowers and whether rain or heavy dew is likely to result in infection. If you have ever had fire blight in or very near your orchard, it is probably wise to assume that there are at least some fire blight bacteria on flowers and act accordingly. However, the interpretation of the model metrics will depend on how much inoculum is present. An MaryBlyt EIP of 150, for example, in an orchard with a history of heavy fire blight could indicate the potential for a catastrophic level of infection, whereas in an orchard with very little fire blight inoculum the same EIP might only indicate potential for a light or moderate outbreak.

Another factor to consider in interpreting model results is the number of open blooms in your orchard. Insects or rain must physically carry bacteria to blooms for the bacteria to colonize those flowers. Not all flowers will have fire blight bacteria present in them. At peak bloom, the number of flowers open in your orchard is vast, and even if only a small percentage of them have actually been colonized by fire blight bacteria, that still represents many possible infections. Early or late in bloom the number of open flowers may be much lower. A given EIP, therefore, warrants more action at peak bloom than at times when fewer flowers are open.

Another nuance is that an individual flower needs to be open for several days before bacteria populations in that specific flower can reach sufficient size to infect that flower. Consider a warm afternoon at early-mid bloom, when 40-50% of spur blossoms may be open: most of those flowers may have just opened that day, and only a handful of very early opening flowers may have been open long enough for bacterial populations to have reached sufficient size to infect those flowers in a wetting event. Therefore the risk of numerous fire blight infections on the day is low, even though a significant number of flowers are open.

An unavoidable difficulty with using the fire blight models is that interpretation depends on the weather forecast. High bacterial populations on the surface of flowers will only cause infection if there is rain or heavy dew, and weather forecasts of precipitation are notoriously unreliable. None of the organic sprays for fire blight appear to have “kickback” activity which will allow them to control fire blight after an infection occurs.

How can these models be used in conjunction with sprays in an organic orchard? Unfortunately, most of the published recommendations for sprays based on these models assume the use of antibiotic sprays which are not allowed in organic orchards. Some organic sprays, including Blossom Protect, Regalia, and Lifegard, need some time, probably 1-2 days, between application and the infection event to be effective. (Keep in mind that if you spray 1 or 2 days before an infection event you probably do not need to worry about flowers which open between the time of spraying and the infection event because bacteria generally only colonize flowers after opening, and bacterial populations on recently opened flowers will not have grown to the size needed to infect those flowers). The oxidizing agents (Jet-Ag or Oxidate) kill bacteria but probably do not have any residual activity, so they are best applied shortly before an infection event. The copper products do have some residual activity (although the residue can be washed away by heavy rains), so they could generally be sprayed anytime between flower opening and infection event to protect a given flower. The mode of action and residual activity for some of the other products is less clear and it is difficult to determine the best time for spraying relative to flower opening and an infection event.

For more information:
MaryBlyt 7.1.1 manual.
Cougar Blight Model.
Description and Preliminary Validation of RIMpro-Erwinia: A New Model for Fire Blight Forecast.

Bloomtime Spray Schedules

Early blooming Williams Pride (right) is in full bloom, while an adjacent row of CrimsonCrisp (left) has not yet begun to flower.

All the orchards surveyed in this study grow multiple varieties, and a complication with bloomtime sprays is that varieties vary widely in bloom phenology. On May 8, 2023, for example, Pristine was at 95% spur bloom in southwest Wisconsin while Prima in the same orchard was at less than 1% spur bloom, with other varieties ranged in between those two.

Additionally, some varieties may bloom over long drawn-out, periods, especially when late-opening blooms are produced on one-year-old wood. And, of course, unfavorable spraying conditions such as high winds and rain will also complicate any precise bloomtime spray schedule. An Upper Midwest orchardist managing a diverse orchard will likely find it very difficult or impossible to spray all their varieties at the precise times dictated by theory or fire blight model output. Some compromise will be inevitable, guided by an understanding of the fire blight pathogen and of the mode of action and efficacy of specific pesticides.

Summer Sprays

During summer, after bloom, additional fire blight infections (shoot strikes) can occur when wind and rain spread fire blight bacteria from infected blossoms or limb cankers. Infections are especially likely to develop after occasional severe storms in which wind and rain spreads the bacteria and hail damages plant tissue and creates entry points for the pathogen. When fire blight is known to be present, and especially with young vigorously growing apple or pear trees, it is prudent to consider regular summer sprays against fire blight. In research trials, copper products (e.g. Cueva, Magna-Bon CS), Regalia, Lifegard, and Serenade have all demonstrated at least some efficacy in reducing shoot blight when sprayed at regular intervals in early summer. We have not seen enough data to make specific recommendations about the best products, spray schedules, and application rates. New fire blight infections can occur for approximately two months after bloom, and if sprays should be re-applied, probably on 1-2 week intervals, as residue is washed off and new plant tissue develops on growing shoots.

After a severe hailstorm, it may be possible to quickly spray a copper product to kill fire blight bacteria which were spread during the storm, before the bacteria have had a chance to infect through open wounds. By contrast, it is unlikely that the biopesticide products, especially Regalia and Lifegard, will have any effect if sprayed after a severe storm event, because they require time to induce a resistance reaction in the trees.

Fruit Russeting

Fruit russeting on these Akane apples may not be a problem in local markets.

Apple fruits can develop russeting of the skin from many spray products, including copper fungicides, Blossom Protect, and oxidizing agents. In general, susceptibility to russeting increases over time during the growing season, and russeting is more likely to occur from sprays made at petal fall than from sprays earlier in bloom. Fruit russeting is often a major consideration in fire blight spray programs recommended by researchers. Midwest organic growers should keep in mind, however, that some amount of russeting may be acceptable in their markets. The warnings of russeting on many pesticide labels may be aimed primarily at large scale organic apple producers who sell their fruit into distribution and marketing channels with exacting standards for fruit finish. In the Upper Midwest, customers at farmers markets and local grocery stores often hold local organic fruit to more accepting standards. Harry Hoch from Hoch Orchards and Gardens notes that a small amount of russeting is acceptable in regional organic markets. When he is concerned about a possible fire blight outbreak in a young block of trees after a damaging summer storm, he will not hesitate to spray copper fungicides immediately after the storm – the chance of having to downgrade a few fruits because of excessive russeting is far preferable to the risk of a severe fire blight outbreak. Furthermore, russeting is irrelevant when apples are grown for cider, allowing Deirdre Birmingham at The Cider Farm to rely on copper (Cueva) for fire blight control for most of the growing season, although she does stop sprays close to harvest to prevent small amounts of copper residue in the juice from interfering with the fermentation process.

Conclusion and Research Needs

Fire blight is a potentially devastating disease of apples. It is a major production issue for some organic orchards in the Upper Midwest, and even in orchards where it is not currently a significant problem, it influences management decisions. Cultural control methods, including resistant rootstocks and scions and restricted nitrogen application, are important, but they are not always feasible and will not prevent all fire blight.

Organic fruit growers expressed confusion over conflicting recommendations for summer pruning of fire blight strikes. Trials show that summer pruning is effective at controlling fire blight and is important to prioritize. The best technique is to cut off fire blight strikes 12 to 18 inches below the edge of symptoms, being sure to cut into at least two-year-old wood and leaving a long stub to be removed during subsequent winter pruning. Sanitizing tools between pruning cuts does not reduce the spread of the disease.

Many growers are reluctant to rely on copper products for control of fire blight because of its toxicity and environmental impact, but they are uncertain about the efficacy of alternative products. Copper products are the only tried and true option for early spring sprays to reduce bacteria on overwintering cankers. During bloom, there are many pesticide options to reduce blossom blight. Lower dose copper products are effective. Blossom Protect (active ingredient *Aureobasidium pullulans*) provides excellent control of fire blight but has important limitations on tank-mixing. We would welcome continued regional trials of Blossom Protect and more clarity on when it can be applied together with, or in close conjunction with, other pesticides and thinning materials. Many other organic pesticide products provide at least moderate control of fire blight and may have a role on organic orchards where fire blight is a minor problem and/or where these products are also used to control other diseases during bloom. We support continued research on these alternatives. What factors such as spray timing or weather influence their efficacy? Can they be combined for increased effectiveness?

Computer models of fire blight, such as those on the NEWA platform, give insight into bacterial populations on flowers and help time sprays. More information about the ideal spray timing for pesticides relative to infection events would help organic growers to utilize the information from the computer models.

During summer, several products (including low-dose copper products, Regalia, Lifegard, and Serenade) are at least moderately effective at controlling shoot blight. We support more research into the efficacy and best use of these products in summer.