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Factsheet

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An Annual Fire Blight Management Program for Apples

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Fire blight hit the 2007 growing season very hard. During bloom in southern New England, seven consecutive days rated as having high potential for fire blight were recorded from May 10 to 16. After a week of cool weather, a second period of high blight risk began in late May. By the end of May and into early June, reports of fire blight in apples were observed in New Jersey, Hudson Valley New York and throughout New England.

Fire blight frustrates growers and management consultants more than most apple diseases. Blight appears suddenly and moves quickly, and can cause significant damage in a matter of days. Orchards that have never had fire blight may suddenly be hit by an outbreak for no apparent reason. There are no foolproof ways to stop an epidemic in an orchard once it starts, and the chances that the disease may start up again the next year, and the next, are relatively high. Fire blight is both destructive and difficult to stop.

At the same time, there has been a shift away from varieties such as McIntosh, Cortland and Delicious that are more tolerant of fire blight, to varieties like Fuji, Honeycrisp, Gingergold, and Gala that are much more sensitive. Trees are also planted at higher densities, requiring dwarfing rootstocks such as M-26 and M-9 that are very blight susceptible. High-density trees are small trees, where blight can quickly move from branches to the main trunk, killing the tree. In short, an outbreak of fire blight is potentially much more destructive today than it was to the typical Northeastern orchards just 20 years ago. Fire blight risk is enhanced when growing a susceptible cultivar on top of a susceptible rootstock.

Our observation is that over the past 20 years, fire blight incidence in the Northeast has increased. Once in an orchard, fire blight not only damages trees but also creates much more work over the following years. As with many apple diseases, an ounce of prevention is worth several pounds of cure. The problem is, unlike apple scab or the summer diseases, blight does not hit every year. It may strike only one or two times every decade and it is easy to forget about it in the year that counts, until it is too late.

But managing fire blight is not impossible, and a well-designed and executed management program can greatly reduce fire blight risk. To control fire blight, it is critical that growers use multiple tactics in a year-round integrated program.

There is an unfortunate tendency for people who have

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Early stage of shoot blight and leaf vein infection by fireblight, June 14, 2007

not experienced fire blight to assume that their orchard is immune. But to keep an orchard free of serious fire blight outbreaks, it is critical that growers recognize that the potential for the disease is there every year, and use an appropriate management strategy.

An Understanding of the Microbe

While insects and weeds present plenty of problems in an orchard, at least you can see them. Fire blight and other orchard diseases, however, are caused by microscopic organisms. So, we do not discover that these pathogens are in the orchard until they are well established, usually causing disease. By then, getting the epidemic under control is far more difficult than it would have been earlier.

Interestingly, *Erwinia amylovora*, the fire blight pathogen, is usually present at some level in all apple orchards, on the surface of most apple trees and on other plants. There just are not many of them. As with mites, low numbers of *E. amylovora* do not cause a problem. But when mites flare, or bacterial populations explode, they do cause damage. The key to managing fire blight is knowing where the bacteria are most likely to be at different times and what can be done to reduce their numbers.

Fire blight bacteria overwinter around the edges of cankers, some of which may be very small and difficult to see. With warm weather, they move out and colonize the surfaces of bark and buds. The bacteria are blown around from plant to plant, or occasionally carried by insects. At around bloom the number of bacteria will increase rapidly if temperatures exceed 65ºF., and the warmer it is, the more rapid the increase. Bloom provides the most important natural entry point for the bacteria, and moisture that is sufficient to wash them to the base of flowers, where they can enter nectaries, will lead to infections. Pollinating insects will also carry bacteria from flower to flower at this time. Once inside the plant, if there are enough bacteria, they will start to produce a toxin that kills apple tissue, releasing the contents of cells, which the bacteria use as food. The bacteria travel inside the plant, and are often a few feet ahead of any visible symptoms. Most infections start at the flowers, though physical damage, called trauma, may also allow bacteria to enter and establish. Wind whipping and hail associated with summer storms are the most common cause of trauma. A few infections may directly start in shoots well after bloom, and it is not clear whether bacteria gain entry to the apple via insect feeding or some other mechanism. Most shoot blight is associated with earlier blossom blight.

As growth slows, and the apple responds to infection, the bacterial progress is stopped. In some trees, damage may be minimal, while in others the tree may be severely damaged or killed. The bacteria collect in areas where

Fruitlet infection, most likely a result of blossom 'blight' infection, June 22, 2007

visible damage has stopped. The margin between dead and healthy areas may be an obvious canker, discolored and sunken, or it may be along a shoot or branch. The bacteria will stay in this tissue until trees come out of dormancy and temperatures rise the next spring.

Management Strategy and Tactics

The overall strategy in fire blight management is to keep the population of fire bight bacteria in an orchard low. Tactics for doing that vary, depending on where the bacteria are and the risk of new infections.

Winter

Step 1 - Winter pruning. Dormant pruning of infected wood is critical to fire blight management. Even in "clean" orchards, it is important to look for possible cankers and remove them. This pruning gets fire blight primary inoculum out of the orchard, so that it will not be there to launch an epidemic in the spring. Applying copper or other chemicals will not kill bacteria in cankers. The wood that contains the bacteria has to be removed.

Early-Season Through Petal Fall

Step 2 – Early season copper. Regardless of whether fire blight was a problem, growers should apply copper in early spring at silver tip to green tip. Copper is applied because it is toxic to the fire blight bacteria, *Erwinia amylovora*. It is applied this early because it can also be toxic to new apple leaves and fruit. Copper should not be applied later than half-inch green, as it can russet fruit. To be effective, copper residues need to cover tree bark, and redistribute over the weeks from application. The purpose of the copper is not to kill bacteria in the overwintering cankers, but rather to reduce build-up of bacteria on apple buds and bark, particularly in the days just before and during bloom.

Up to bloom, the bacteria are continually growing and spreading back and forth between trees in the orchard. For copper to be effective, all trees in the orchard should be sprayed. It is not enough to spray only the sensitive trees, or the small trees. While the bacteria may not damage McIntosh as readily as Honeycrisp, they can and will live on McIntosh and then spread to Honeycrisp when flowers open. The Mac may not develop blight, but the more sensitive Honeycrisp probably will. Spraying copper on the whole orchard eliminates sites where bacteria may build up, and so that tolerant varieties do not server as inoculum reservoirs that infect sensitive varieties.

Step 3 – Monitor for fire blight risk at bloom. Protecting trees at bloom when environmental conditions warrant is critical. The overwhelming majority of fire blight epidemics start at bloom. The shock waves from these primary infections will continue through the summer and beyond, so it is essential that growers make a focused effort to stop blossom blight.

Fire blight forecasts give growers a recommendation as to whether or not to spray streptomycin, and if so, when to do it. They may save a spray, or they may save a block, depending on the year. They are a way of "watching" the bacteria without actually seeing them.

Forecasts are based on the fact that the fire blight bacteria grow very rapidly when temperatures are warm, and not so quickly when it is cool. When temperatures are optimal for the bacteria just before and during bloom, populations can explode. It is this rapid growth that makes fire blight epidemics "appear out of nowhere." Fire blight bacteria also need rain or heavy dew, something that will wash bacteria into the base of the blossom. During bloom, rain and 80º temperatures is fire blight weather. On the other hand, with rain and temperatures under 60º, there is very little risk of fire blight.

If risk is high at bloom, orchards should be treated with streptomycin. If risk is low, then they should not be treated. This not only saves the expense and effort involved in a spray, it preserves the effectiveness of streptomycin. The only time streptomycin should be used is when there is a predicted risk of fire blight during bloom. (There is one exception to this, and that is when there is a damaging "trauma" event such as a hail, or wind-driven rain that causes damage to the foliage, then streptomycin can be applied within 12 to 18 hours to reduce the risk of fire blight infection.) Streptomycin is not effective against cankers or shoot blight, and should not be used in protective sprays targeting either problem. Streptomycin has little ability to penetrate closed flowers – bloom must be open for the best effect.

There are several options that may be used to forecast fire blight risk. Growers may keep their own weather stations, and enter data into a computer program such as MaryBlyt, or use the data with Cougarblight charts. MaryBlyt requires that information be entered daily from green tip, while Cougarblight requires data only for the four days prior to the prediction. Some electronic weather stations provide one or both of these forecasting tools built into their software. (Spectrum Technologies, www.specmeters.com.) Alternatively, forecasts can be obtained through contract services that provide weather data and pest management information over the web or by e-mail (SkyBit, Inc., www.skybit.com.) Independent crop consultants or university outreach may also give either on-line or individual forecasts of fire blight risk. Growers may either do it themselves, or arrange to get the forecasts done for them. Regardless of how it is done, it is critical that growers know what the fire blight risk is during bloom and take action appropriately.

Step 4 – Spray streptomycin at bloom if needed. Streptomycin is the most effective fire blight chemical available. It needs to be used wisely, as fire blight bacteria can and have become resistant to it in some parts of the U.S. While there are other antibiotics, only oxytetracycline has been used under emergency registration in some states (Michigan), but it is not as effective as streptomycin. It is unlikely that other antibiotics will be registered for use against fire blight in the U.S.

When streptomycin is applied to open flowers, those flowers generally will be well protected through petal fall. New-formed fruit do not have an opening to allow bacteria to enter, and are much more resistant to infection. It is critical that streptomycin applications cover flowers well, so avoid poor spray conditions (wind, etc.) and alternate row applications. Adding the nonionic spreader-activator Regulaid will improve coverage and uptake of streptomycin.

Streptomycin generally works best if applied alone, though it can be mixed with other pesticides. For maximum uptake, apply streptomycin when drying is slow.

Nectaries at the bases of flowers are where bacteria enter apple trees, so it is critical that streptomycin reach flower interiors. If the streptomycin is not applied to an open flower, the residue inside that flower is greatly reduced or non-existent. It may be necessary to reapply streptomycin within two or three days of an initial application, not because the antibiotic loses efficacy, but because significant numbers of new flowers open.

One alternative, if multiple bloom sprays are needed, is Serenade. Serenade is a biocontrol that has worked well if used in rotation with streptomycin. Serenade's performance is erratic when it is the only material applied. Use streptomycin first, but if there are continued infection periods, Serenade may be applied as the second spray. It should be applied 24 hours after a forecast infection.

Step 5 – Deal with late blossoms. Another often overlooked problem with bloom sprays is that bloom is not synchronized across all trees, and it does not stop all at once. In any given variety, bloom may stretch over a week or two. As long as forecast models indicate a high risk of blight, and flowers are opening, streptomycin will need to be reapplied to them for protection.

Late blooming varieties, young trees, or varieties that have a few blossoms well after 99.9% petal fall present a particular problem. As long as there are high numbers of bacteria and open flowers, blight can get started.

'Late' bloom was a significant source of infection in 2007. Remember that many of our newer cultivars have a significant amount of bloom occurring on one-year-old wood. This bloom is undesirable both because it produces small fruit (we try to thin it off) and it also blooms 7-10 days later than regular bloom.

For non-bearing trees, getting rid of the blossoms by pinching them off will remove the opportunity for infection. Remove buds before blight risk is high. This is particularly important in new plantings where: trees are typically behind in bud growth stage compared to the rest of the orchard; bloom may be present into late May or early June depending on planting date, when weather conditions that promote fire blight epidemic are more likely; and infection of these first-leaf trees can either easily kill the tree outright or significant portion(s) of the young tree. De-flowering first-leaf trees and/or spraying them with copper when the buds break is highly recommended.

Step 6 - Control Potato Leafhoppers- Transmission of fire blight from one inoculum source to a new site or tree has long been associated with various insect populations. While the exact role of which insect species are responsible for the bulk of fire blight transmission is still being investigated, new research has shed some light on the problem.

The influence of insects can be divided into two parts: 1) Those that may physiologically vector the disease by carrying the bacteria from site to site, and 2) Those that may cause injury sites through normal feeding, thus creating small wounds that may allow bacteria to enter. Various species of sucking insects are usually associated with the first group.

Classic 'shepherds' crook shoot blight, June 26, 2007; these infected shoots were on cider varieties that typically bloom later, therefore they have an increased risk of fireblight infection

The two main groups of sucking insects present at this time of year are the aphids and leafhoppers. The green apple/spirea aphid complex is no longer thought to be a key problem in fire blight transmission. The leafhopper story is a little more complex. There are 3 species present in most orchards at this time of year: 1) white apple leafhopper, 2) rose leafhopper, and 3) potato leafhopper. Of the 3 species, potato leafhopper has been most often implicated in the transmission of fire blight. Potato leafhoppers are yellowish to pale green, and nymphs move sideways when disturbed. They overwinter in southern states and near the Gulf coast, move into our area in early June, and are present until the end of the season. Physical feeding injury will appear along leaf margins as a dried "burned" look, and may often be confused with nutrient deficiencies. If fire blight is present, no PLH should be tolerated. They should be controlled with an insecticide.

Step 7 – An Apogee decision. The growth regulator Apogee has the ability to control shoot blight. Under normal conditions, Apogee does not control blossom blight. Unfortunately Apogee has to be applied well before shoot blight symptoms are visible. Typically, 6 to 12 oz/ 100 gal are applied at late bloom or early petal fall, with a follow up application 3 to 4 weeks later. It takes 10 days for the first application to take effect against fire blight. This means the decision to use Apogee has to be an evaluation of risk at early petal fall.

There is no precise way to measure this risk, but a reasonable estimate can be made. The evaluation should be based on 1) the severity and number of bloom infection periods, 2) whether fire blight was active in the orchard during previous years, 3) the susceptibility of the cultivars and rootstocks in the orchard, and 4) the age of those trees. Obviously, the more infection periods, and the more severe they are, the greater fire blight risk. If an orchard had fire blight the previous year, risk is high in the present year. Sensitive varieties and rootstocks are at high risk. New trees are certainly at risk, but the greatest risk of significant fire blight damage appears to be to trees in their fourth to sixth leaf.

Apogee as a fire blight tool presents a dilemma. It stops new growth, and applications to young trees will slow desired development. It may also reduce fruit size and return bloom. Unfortunately, the timing and high rates that are most effective against fire blight also have the most effect on tree growth and bearing.

It is not clear whether later applications of Apogee, particularly after symptoms appear, can significantly slow an active shoot blight epidemic. Results of tests to date suggest that disease control from Apogee applied after symptoms show will be minor. At present, late treatments with Apogee would be either hopeful or experimental. The

Fire blight susceptibility ratings for apple rootstocks, listed in order of size reduction of the rootstock*.

Rootstock	Fire blight rating
Seedling	Tolerant
Novole	Resistant
Polish 18 (P.18)	Moderately resistant
Antonovka 313 (Ant.313)	Moderately susceptible
M.4	Tolerant
MM.111	Tolerant
MM.106	Moderately susceptible
M.7a, M.7 EMLA	Tolerant
CG. 6210	Resistant
Supporter 4 (S.4)	Highly susceptible
Geneva 30 (G.30)	Highly resistant
Geneva 935 (G.935)	Highly resistant
Geneva 202 (G.202)	Highly resistant
M.26, M.26 EMLA	Highly susceptible
Geneva 11 (G.11)	Moderately resistant
Ottawa 3 (O.3)	Susceptible
Geneva 16 (G.16)	Very resistant
M.9 strains	Very susceptible
Geneva 41 (G.41)	Highly resistant
Bud. 9 (B.9)	Susceptible
Polish 2 (P.2)	Susceptible
Mark	Susceptible
Bud. 146 (B.146)	Susceptible
Bud. 491 (B.491)	Susceptible
Polish 16 (P.16)	Susceptible
Geneva 65 (G.65)	Very resistant
M.27, M.27 EMLA	Susceptible
Polish 22 (P.22)	Moderately susceptible

*A chart detailing the characteristics and fire blight susceptibility of apple rootstocks is available at http://www.nc140.org/publications.html best results against shoot blight will be from bloom or petal fall treatments.

Step 8 - Rootstock sucker control. Many dwarfing rootstocks are highly susceptible to fire blight. Therefore, controlling root suckers is essential as root suckers may provide an entry point for fire blight bacteria. They should be removed. Ripping or pruning suckers can leave an open wound, and that may be an entry point in itself. So chemical treatment of suckers with NAA, sold as Monterey Sucker Stopper Concentrate, (Tree Hold Sprout Inhibitor) should be done in blocks where there are highly susceptible rootstocks.

In blocks with active blight, it may be more important to prune (not rip) suckers as soon as possible rather than waiting for NAA or other chemical treatment to kill them. When it comes to pruning, the highest priority is for root suckers on M.9 and M.26 rootstocks.

Summer Through Winter

After petal fall, fire blight bacteria have a much harder time infecting trees. Flowers are the most important entry point for the fire blight bacteria. Shoot blight is generally related to blossom blight, an extension of bloom infections. Dealing with shoot blight is stressful, because there are not any highly effective treatments, and new strikes may keep appearing all summer, even with treatment.

Step 9 - To cut or not to cut? When a surprised and anxious grower first sees the hooked and wilting tips of blighted shoots, the next question is almost always "Should I cut it out?"

There are a few opinions on this question. Growers who have tried to cut out active shoot blight often feel it is impossible or ineffective or both. However, cutting out active lesions and immediately getting the pruned wood out of the orchard effectively slows the spread of fire blight.

Dave Rosenberger of Cornell suggests a type of fire blight triage when it comes to making a pruning decision once blight has struck, going from highest to lowest priority:

- Young orchards 3-8 years old with just a few strikes.
- Young orchards 3-8 years old with severe strikes.
- Older orchards with a few strikes.
- Walk away group- orchards with so many strikes that most of the tree would need to be removed, severe pruning can stimulate new growth that can become infected.

When pruning fire blight, the best method to use is the "ugly stub" approach developed by Paul Steiner. To be most effective, strikes should be pruned out as soon as symptoms appear, and daily checks made to remove diseased shoots. Make cuts into wood that is at least two years old. Two-year-old wood is more resistant to fire blight, and is much better than younger wood at stopping infection movement in the tree. Fire blight bacteria travel well ahead of visible infection, up to several feet. Cutting back to a 4 to 6 inch naked stub in 2-year-old or older wood gives the tree a good chance of using its own resistance to isolate disease in the stub.

Inevitably the fire blight bacteria will form a canker an inch or two in from a cut surface. Sterilizing tools will not stop this, so it is not worth the effort. As a result, if a flush cut is made back to the branch collar, the resulting bacteria colonization and canker will form an inch or two into the next limb or in the trunk. By leaving a stub, the canker forms in it, and the stub can be cut off with the canker during the next winter. The stub can be spray painted with a bright color right after pruning, so that they are easy to find and remove during winter pruning.

Step 10 - Do not expect much from summer sprays. Most fruit growers are used to answering disease outbreaks with their sprayers. Unfortunately, this is not a very effective response to active shoot blight. Any of the suggestions given here come under the heading of experimental. They have not been widely tested, and may not have any effect, other than costing extra money and time. And remember, streptomycin sprays at this time are counterproductive and largely a waste of time and will hasten resistance

In "Step 6" above, we suggested that Apogee might have some value if applied one to three weeks after petal fall. This is based on the knowledge that Apogee works, at least in part, by stimulating the apple tree to produce an antimicrobial chemical. If this chemical is stimulated through mid- to late summer, then Apogee applications make sense. But we do not know that it is, and there are no studies that show significant shoot blight control using Apogee on active fire blight.

Similarly, while Serenade can be part of a multi-spray blossom blight program, whether it may be useful against shoot blight is still being tested.

Copper is another option. It works because it is toxic to bacteria, and it must contact bacteria to kill them. If the bacteria are already established and moving inside apple trees, those bacteria are not going to be bothered by copper. But any bacteria on the bark and other surfaces of the tree can be killed. In theory, this should reduce fire blight inoculum in the orchard. In tomatoes, a bacterial canker can be treated using a mix of copper and mancozeb. The mixture is more effective than copper alone, and there is limited evidence that this may be true for fire blight on apples. Again, this is experimental. While it almost certainly will not stop an epidemic, it may slow the spread. Of course, the down side of a copper applied at this time of year is that it will russet fruit. And mancozeb has a 77 day preharvest interval. If the copper/mancozeb option is tried, do not expect to market high quality fruit from the trees.

Since the introduction of Aliette, there have been suggestions, even recommendations, that phosphorus compounds known as phosphites and phosphonates (e.g. ProPhyte, AgriFos, Phostrol) can control fire blight. While some controlled tests indicate some reduction from treated controls when these materials are sprayed before and at bloom, disease reduction does not approach that of streptomycin at bloom. In addition, there is virtually no evidence that these compounds have a positive impact on shoot blight. Phostrol is labeled for fireblight control and is being evaluated in NJ by several growers.

Use an integrated approach. Keeping fire blight out of an orchard, or at least down to acceptable levels, takes year-round effort and involves several tools. Perhaps with fire blight more than other apple diseases, there is no silver bullet. Preserving the best single tool there is, streptomycin, requires that other practices for fire blight be used as well. But used together on an annual basis, an integrated program greatly reduce the chances that fire blight will become a serious epidemic in an orchard.

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