The Role of Tree Genetics in Controlling Fire Blight in Apples and Pears

Fire blight is a bacterial disease caused by *Erwinia amylovora* that affects apple and pear trees, as well as a number of related ornamental and wild plants. The bacterium is native to eastern North America, but has now spread to Europe, the Near East, and New Zealand. *E. amylovora* enters the plant through flower blossoms and wounds, and can be spread by insects, rain, hail, wind, birds, and through cultural practices that damage the bark such as pruning or tractor equipment. Once inside the tree, the bacteria multiply and spread through the plant's vascular system. If the bacteria move into the rootstock, fire blight can kill the entire tree. Once an infection is observed, growers typically prune out diseased wood, which is labor intensive and thus expensive (>$1,000/acre). Control is most successful when materials such as antibiotics and copper are used to prevent infection. Once infected, no materials will kill the bacteria in the tree. This is in contrast with the use of antibiotics to control established infections in humans and livestock.

Fire blight resistance

All apples and pears are susceptible to infection by the fire blight bacteria to varying degrees. Once a tree is infected, greater genetic resistance (or tolerance) leads to less spread of the disease in the tree and less damage. As a rule, the older the tree, the more tolerant it is to fire blight damage, and older wood on a tree is more tolerant than young wood on the same tree. Different plant parts show varying susceptibility. For example, flowers of 'Red Delicious' are very susceptible, but the young wood is not; thus, bacteria entering through the flower do not spread very far down the branch and damage is limited. 'Red Delicious' has the greatest level of resistance of all apple cultivars in wide commercial use, but can still suffer 45-65% infection of blossoms if untreated. Unfortunately, market demand over the past 15 years has shown that organic consumers have a relatively low preference for fruit from this cultivar.

Apples and pears are grown as grafted trees, so the resistance of both the scion (fruiting top-part of the tree) and rootstock must be considered. Over the past several decades, commercial apple growers have transitioned to dwarfing rootstocks that increase productivity and fruit quality, as well as general pest and disease control efficacy (critical for organic) and legally mandated worker safety. However, dwarfing rootstocks flower at an earlier age (when the tree is more susceptible) and tend to have more secondary and tertiary bloom (which occur later in the spring when there is increased infection risk). The most widely planted dwarfing rootstock is the Malling series 'M.9', which is highly susceptible to fire blight. The new 'Geneva' rootstock series has a greater level of fire blight resistance than the Malling or Malling-Merton series, and desirable horticultural qualities, but trees are not yet widely available from nurseries, who estimate a 4-5 year time frame to be able to fulfill the demand. Additionally, the resistant rootstock does not confer resistance to infection or damage in the scion part of the tree. The practical benefit of rootstock resistance is that an infected scion is less likely to kill the entire tree.

Pears show less variation in resistance and are generally more susceptible than apples. Many pear orchards are decades old and these large trees may become infected but are less likely to die than young trees. 'Bosc' pear is particularly susceptible to fire blight, and even older trees can be killed. But since 'Bosc' produces less late bloom than 'Bartlett' pear (the primary California cultivar), it generally escapes infection because bloom occurs during cooler periods that are not high risk for infection. The "blight resistant" cultivars that have been developed by various pear breeding programs around the world have not been popular with growers or consumers, and have only shown some tolerance to fire blight, not resistance or immunity.

Several online resources present lists of apple and pear cultivars that are fire blight resistant. These are generally compilations from different sources that did not necessarily use the same methodology for assessing resistance and tend to show considerable variability in their recommendations. For example, Purdue University lists Winesap apple as highly resistant, while West Virginia University lists it as susceptible, and Colorado State University lists it as moderately resistant. However, these lists do typically state that **none** of the listed cultivars is immune and **all** will become infected under high-risk conditions.

Plant breeding for resistance

Planting cultivars with either a high level of multi-gene resistance or full immunity would be one potential long-term solution for fire blight control. However, apple (and pear) breeding programs tend to focus on the visual and eating quality of the fruit first, as this determines the economic viability of the cultivar. North American apple scion breeders have seldom actively bred for fire blight resistance, while some European breeders are working towards this goal. With the advent of genome mapping and marker-assisted breeding, it is becoming easier to screen for specific traits such as fire blight resistance; however this work is in its infancy and it frequently takes more than 20 years to breed and release a new variety.

Breeders have also successfully transferred fire blight resistance genes into commercial cultivars (e.g., 'Gala'). Genetic manipulation (GM) using genes from only *Malus* species (i.e. *cis-genic*, rather than transgenic) is being pursued to increase resistance to fire blight in standard varieties with an established consumer base. However, these GM plants are not yet commercially available and would not be permissible to organic growers under the current National Organic Program.

Some traditional breeding programs have developed cultivars with fire blight resistance by crossing dessert apple trees with closely related crab apple trees that have inherent fire blight resistance. The apple breeding program at Dresden-Pilnitz has produced several selections in the 'Re' series with enhanced resistance to fire blight and putative commercially acceptable fruit quality. According to apple biotechnologist Henryk Flachowsky (Dresden, Germany), "Only a few varieties have a certain degree of resistance to [fire blight], but these are not grown commercially. Resistance genes are normally found only in wild species, but these tend to have very small fruit." Other apple breeding programs have used 'Red Delicious' or 'Golden Delicious' as a parent for increasing fire blight resistance, while some others have conducted their breeding and then simply screened progeny for their resistance. None of these programs has developed a cultivar that has had both favorable horticultural characteristics and consumer acceptability and thus these varieties have not been adopted by commercial fruit growers.

Planting more resistant trees

The life of a modern apple planting is generally 15-20 years, compared with a 30-80+ year life for pear orchards. Replanting an orchard is a very expensive process. It costs between $12-22,000 or more per acre to remove the old trees, remediate the soil, plant new trees and install the support systems. In this scenario, a grower could replace both the scion and rootstock with more fire blight resistant choices if: 1) there is a market for the fruit, 2) the scion is available, and 3) the rootstock is available. A grower needs to order the specific scion/rootstock combination from a nursery several years in advance. Thus, despite the existence of the 'Geneva' rootstock series, a grower wanting to replant an orchard could probably not do so with resistant rootstock until 2-6 years from now. Another less expensive alternative is to cut off the scion and re-graft a new scion. This would allow use of a more resistant scion, but rootstock resistance would not be increased.

Introducing a fire blight resistant apple or pear variety would need to occur over a period of many years and therefore is not a short-term solution to the antibiotic phase-out planned for U.S. organic producers. Apples, and to some extent pears, are one of the few food items sold by cultivar name in the U.S. Until a consumer market is developed for a new variety, it is not possible to sell significant volume through commercial channels. Developing consumer recognition and acceptance of a new variety is a multi-year and multi-million dollar process. At present it is not economically sustainable for organic growers to assume the market risk of planting acreage of a fire blight resistant variety with no consumer acceptance or recognition.

- *Drafted by David Granatstein, Tim Smith, and Greg Peck on behalf of the Organic Tree Fruit Industry Work Group; October 2011.*