Summer Outbreaks of Fire Blight in Tree Nurseries in South Alberta, Canada

M. Lanthier
CropHealth Advising & Research
Kelowna, British Columbia
Canada

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Abstract

Fire blight is the #1 cause of plant mortality in commercial tree nurseries in South Alberta, Canada. Hundreds of trees are destroyed every year after disease infection is confirmed by visual symptoms or laboratory culturing. The region is prone to violent storms almost annually between late June and mid July. Winds gusting over 50 km/h combined with rain and hail cause extensive leaf damage such as holes and ripping. The storms are followed by outbreaks of fire blight on susceptible hosts, especially Malus, visible within 10 to 14 days as “shooit blight” and ooze on affected twigs and leaf petioles. The inoculum is found inside the nursery on trees previously infected, on native plants growing around the nurseries or possibly as epiphytic population on purchased liners. From 2007 to 2010, almost 5500 trees were destroyed at a cost of Cdn$ 1.4 million in lost sales. In spring, the disease is successfully managed with strict sanitation of hold-over cankers, avoidance of overhead irrigation during bloom, and repeated spray applications during early bloom with biological fungicides in rotation with an antibiotic. During summer, management is done by prompt removal and burning of infected trees, yet new strikes are found repeatedly until late summer. The label of the antibiotic product does not allow for sprays during summer months following trauma blight caused by hail or wind. New management tools are needed for management of summer strikes, including technology for earlier detection of infection after a storm, effective pesticide products to reduce disease incidence after hail and on-site confirmation of disease infection on native hosts.

INTRODUCTION

Infection of host plants by fire blight (Erwinia amylovora (Burrill) Winslow et al.) is mostly by entry of the bacteria through flowers. During the summer, severe infection may occur on shoots, leaves and fruits following a climatic event which produces wounds on the plant surface, such as a hail associated with rain (Crop Protection Compendium, 2005).

Fire blight was first described in North America (Beer, 1997) and is well established in Canada (Solymer and MacDonald, 2006). In the Prairie provinces, the central region of Canada that includes Alberta, fire blight is reported to be “the most important disease of ornamental rosaceous trees and shrubs” (Hiratsuka, 1987). In commercial tree nurseries of Southern Alberta, it is the #1 cause of plant mortality, ahead of plant mortality caused by cold weather injury, high salt soils, decline after planting or tree boring insects (Lanthier, 2007).

This report is a documentation of fire blight occurrence in tree nurseries and a review of summer weather events that could explain occasional severe outbreaks.

SITUATION IN ALBERTA NURSERIES

Commercial nurseries are found in all regions of Canada that offer suitable climate and land. In 2009, sales totalled Can$ 658 millions with field and container production covering 20,593 ha of land, of which 16% was found in Alberta (Statistics Canada, 2009). The bulk of Alberta’s production is done by the 32 nurseries with membership in the province’s trade organisation (Canadian Nursery Landscape Association, 2010).
The nursery industry is servicing a population growth triggered by gas and oil exploration. Alberta’s population growth rate has been double the Canadian rate from 2006 to 2010. The two largest cities, Calgary and Edmonton, saw a population growth of 12.4 and 9.6% between 2001 and 2006 (Government of Alberta, 2010a). The average annual Gross Domestic Product growth rate between 1989 and 2009 was estimated at 3.1% per year, compared with the national average of 2.3% per year (Government of Alberta, 2010b).

A number of important diseases are reported on broadleaf trees growing in this region including leaf and twig blight caused by Venturia spp., black knot caused by Apiosporina morbosa and cankers associated with Nectria cinnabarinia and Cytospora chrysosperma (Hiratsuka, 1987). Fire blight caused by Erwinia amylovora most severely affects Sorbus aucuparia and Malus coronaria, but also Malus baccata ‘Columnaris’, Malus pumilla, Crataegus spp., Cotoneaster spp., Amelanchier alnifolia and Rubus spp. (Evans, 1996).

Host plants showing symptoms typical of fire blight have been sampled repeatedly since 1997. The pathogen Erwinia amylovora has been confirmed by culture on selective media or immunostrip tests (Anonymous, 2004). Other pathogens recovered on these samples were Alternaria sp. and Pseudomonas syringae. To our knowledge, fire blight isolates from this region have not been characterized for molecular content or resemblance to isolates from other regions of North America.

During the 7-year period 1998 to 2004, counts were made of crabapple trees (Malus cvs.) showing fire blight symptoms. Cultivars most affected were ‘Norland’, ‘Parkland’, ‘Fall Red’, ‘Rudolph’, ‘Battleford’, ‘Royalty’, ‘September Ruby’, ‘Rosthern’ and ‘Strathmore’, whereas cultivars seldom diagnosed with fire blight were ‘Thunderchild’, ‘Big River’, ‘Kelsey’ and ‘Kerr’. Over the years, only the cultivar ‘Thunderchild’ has been mostly exempt of this disease (pers. observ.).

In August 2010, tree nurseries in South Alberta were surveyed for number of trees destroyed because of fire blight infection from 2007 to 2010 (Table 1). Results account for 626 ha, or 78% of the total nursery production in the region. For the period covered, nearly 5500 trees were destroyed because of fire blight. Most affected were Malus cultivars, especially ‘Rudolph’, ‘Dolgo’, ‘Big River’, ‘Spring Snow’, ‘Fuchsia Girl’ and ‘Rosthern’. Other hosts affected were Crataegus, Sorbus and Pyrus.

The lost sales for these trees was about Can$ 1.4 millions, assuming a wholesale price of $ 225 to 275 per tree, depending on caliper size. Other costs to the nurseries would include removal and disposal of infected trees, then purchase and planting of new trees to maintain the inventory.

SUMMER HAILSTORMS

The region is characterized by a dry continental climate. Summers are warm and dry, with temperatures 20 to 30°C for extended periods and up to 40°C in southern regions. Winters are cold, with temperatures -20 to -30°C for extended periods that can go to -45°C when Arctic air masses move over the province (Government of Alberta, 2010c).

The region is also prone to severe thunderstorms during summer months, with an average of 61 hailfall days each summer, with July being the most active month (Wojtiw, 1975). The storms develop over the foothills of the Rocky Mountains from the effects of differential heating and surface winds, before migrating north-east over the plains (Knott and Taylor, 2000). There were 3 to 7 thunderstorm events per 10,000 km² per year over the south part of the province from 1982 to 1991 (Paruk and Blackwell, 1994).

An intense thunderstorm infested with large hail can inflict severe damage to residential properties and agricultural crops (Khandekar, 2002). Recent examples are the hailstorm of 17 June 2007 which occurred on a Sunday (Fig. 1), the hailstorm of 16 July 2008, which occurred during the evening and was associated with winds up to 120 km/h (Calgary Herald, 2008), the hailstorm of 5 August 2009 which hit at night (Strathmore Standard, 2009) (Fig. 2), and the hailstorm of 3 August 2010 with golf ball size hail, which triggered over 500 claims for crop damage (Farm Credit Canada, 2010) (Fig. 3).
A tree nursery can suffer extensive damage from a hailstorm associated with violent winds. Damage symptoms include torn leaves, broken twigs and scars on trunks. The pathogen *Erwinia amylovora* affects younger plant tissue more severely than older tissue; it also develops most rapidly between 24 and 29°C and can enter a host plant through wounds created by hail or wind whipping (van der Zwet, 1999). Thus, a hailstorm during July can trigger a severe outbreak on young nursery plants growing vigorously.

There are multiple sources for the fire blight pathogen in South Alberta nurseries. The disease is known to occur on trees purchased as liners from suppliers in British Columbia and on cotoneaster hedges located near nurseries (pers. observ.). The pathogen is also reported on mature apple fruit trees growing in City residential areas (City of Calgary, 2004).

In June 2008, a thunderstorm associated with strong winds and hail traveled a large distance. Three nurseries located 30 to 40 km apart showed new fire blight strikes 10 to 14 days later. The storm tracked from the North-West and strikes first appeared in that portion of each nursery. At one nursery, the July strikes were the first confirmed report of fire blight, indicating the pathogen arrived with the storm or was present as epiphytic population on purchased liner trees. A fourth nursery located in the same area was not affected in June 2008 but severely damaged by a thunderstorm in August 2009. There was no indication of fire blight following the storm, up until fall 2010 (pers. observ.).

**SEASONAL MANAGEMENT OF DISEASE**

Management of fire blight in South Alberta nurseries follows standard protocols. In spring, the disease is successfully managed with strict sanitation of hold-over cankers, avoidance of overhead irrigation during bloom, and repeated spray applications during early bloom with commercial formulations of bacterial antagonists (*Pantoea agglomerans*, *Pseudomonas fluorescens* or *Bacillus subtilis*) in rotation with an antibiotic (streptomycin).

Hold-over cankers may be the most important source of inoculum for new infections and strict sanitation of these tree parts has long been advocated for fire blight control (Aldwinckle, 1979). Nursery production areas are walked for visual symptoms of fire blight cankers. The inspection must be regular, ideally weekly, as trees in appearance healthy one week will develop characteristic cankers and oozing the following week (pers. observ.).

Inspection for new cankers continues throughout the growing season. Current recommendation is for removal of the whole tree rather than pruning infected parts, as nursery trees may only be 3 to 5 year old. In many cases, the pruning cut would be in the main trunk if the cut is made 15 to 30 cm below the canker margins, as often recommended (van der Zwet, 1999).

Some growers attempt to save the tree by removing only affected branches. They are occasionally successful. However, often new strikes develop in the pruned tree which requires a return pruning visit (pers. observ.). Delaying removal of the affected tree allows an important source of inoculum to remain on-site for longer than necessary.

Spray programs based on streptomycin were difficult from 1998 to 2008 as the product was available on a year-to-year temporary registration. Commercial products were found in limited supply and often only on pre-order basis. Nursery growers without fire blight one year, and not ordering product during winter, could not spray streptomycin the following spring or summer if disease symptoms appeared.

Prior to 2008, control programs in late dormancy and during bloom were based on copper-based pesticides, such as tri-basic copper sulphate or copper oxychloride (Health Canada, 2010a). Efficacy was usually passable. Since 2008, the recommended spray program for the spring period has a strong emphasis on bloom protection (Table 2).

In 2008, the Canadian government granted “continued registration of products containing streptomycin for sale and use in Canada”. The agency evaluated available scientific information and concluded the products “do not present unacceptable risks to
human health or the environment when used according to label directions” (Health Canada, 2008a). The commercial product Streptomycin 17WP (streptomycin sulphate 25.2%) is labeled for a maximum of three applications per year.

Biological control is possible since 2008 using commercial formulations of bacterial antagonists. Health Canada proposed full registration of Pantoaea agglomerans strain E325 in 2008 (Health Canada, 2008b), with the commercial products “BlightBan C9-1” and “Bloomtime Biological” becoming available in late 2007; Pseudomonas fluorescens strain A506 in 2010 (Health Canada, 2010b), with the commercial product BlightBan available since 2009; and Bacillus subtilis strain QST 713 in 2009 (Health Canada, 2009) with the commercial product Serenade MAX available since 2007.

Management after a hail storm is most difficult. The Canadian label of streptomycin specifies to “apply spray up to 14 days after petal fall” (Health Canada, 2010a). Application during summer after damage from hail or wind has been removed from the Canadian label. Nevertheless, the window for application after hail damage is short, likely 12 to 18 h (Steiner, 2000) as the product effectiveness may be lost 24 h after the storm (Ockey, 2006). Many hail storms occur during the evening, creating a 12- to 18-h delay between damage and application the following day.

The shoot growth regulator prohexadione-calcium was granted temporary registration in Canada in 2007 (Health Canada, 2007). It is sold commercially as Apogee and labeled for suppression of fire blight by reducing disease incidence and severity on shoots and leaves (Health Canada, 2010a). Mechanism of action may be linked to structural changes inside the plant and not a reduction in pathogen population (McGrath, 2009). The product is recommended during summer months at nurseries with a history of fire blight. However, nursery managers often neglect these pre-emptive applications and are not concerned with fire blight measures until a hail storm touches their own operation.

CONCLUSION

Nurseries in the Canadian Prairie provinces tend to be large size, especially in Alberta, accounting for 16% of total land in nursery production in the country. The region is prone to violent wind and hail storms between late June and late July from weather patterns that develop in the foothills of the Rocky Mountains. When a hail storm lands on a tree nursery during July or early August, it is followed by an outbreak of fire blight, visible within 10 to 14 days as “shoot blight” and ooze on affected twigs and leaf petioles.

The inoculum is found in native plantings growing around the nurseries, especially cotoneaster hedges, or on native hosts such as Crataegus and Amelanchier that show plant dieback but not complete mortality. Inside the nursery, hot summer temperatures favor the rapid development of the disease, oozing from infected tissues and spread to near-by plants. Between 2007 and 2010, lost sales was over Can$ 1.4 millions for trees destroyed because of fire blight infection, with the majority being Maltus cultivars.

Following a hail storm, fire blight may appear at a nursery where no disease had been found before. In a study in an apple nursery in the eastern United States, wind-driven rain was reported to be the most important factor involved in spreading the pathogen in the nursery (McManus, 1994). Bacterial strands may be wafted into wind currents and transported over long distances, including in raindrops to a distant location (van der Zwet, 1979). In a study in a commercial apple orchard in eastern Canada, the bacterial population recovered on tree leaves was highest from mid-July to late August (Ducek, 1975).

The pattern of disease infection may follow descriptions made earlier in England, where primary blossom blight is rare, alternative hosts such as hawthorns and cotoneasters can be important reservoirs, and damaging night storms may play an important role (Billing, 2006). In those situations, the outbreaks of “shoot blight” have followed damaging storms and heavy rain with winds gusting at 54 km/h or more (Berrie, 1996).

Management in South Alberta nurseries is done by prompt removal and burning of infected trees, yet new strikes are found repeatedly until late summer. New management
tools are needed for management of summer strikes, including earlier detection of inoculum following a hail storm, effective pesticide products to reduce disease incidence after hail, and on-site confirmation of disease infection on native hosts.

ACKNOWLEDGEMENTS
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**Tables**

Table 1. Number of nursery trees destroyed after fire blight infection in south Alberta nurseries, 2007 to 2010. Survey results for 78% of nursery land production.

<table>
<thead>
<tr>
<th>Host</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Total for host</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Malus</em> ‘Rudolph’</td>
<td>1144</td>
<td>18</td>
<td>259</td>
<td>0</td>
<td>1421</td>
</tr>
<tr>
<td><em>Malus</em> ‘Dolgo’</td>
<td>315</td>
<td>90</td>
<td>84</td>
<td>0</td>
<td>489</td>
</tr>
<tr>
<td><em>Malus</em> ‘Strathmore’</td>
<td>354</td>
<td>84</td>
<td>14</td>
<td>8</td>
<td>460</td>
</tr>
<tr>
<td><em>Malus</em> ‘Big River’</td>
<td>128</td>
<td>67</td>
<td>230</td>
<td>0</td>
<td>425</td>
</tr>
<tr>
<td><em>Malus</em> ‘Spring Snow’</td>
<td>19</td>
<td>2</td>
<td>269</td>
<td>81</td>
<td>371</td>
</tr>
<tr>
<td><em>Malus</em> ‘Fuschia Girl’</td>
<td>5</td>
<td>99</td>
<td>213</td>
<td>0</td>
<td>317</td>
</tr>
<tr>
<td><em>Malus</em> ‘Rosthern’</td>
<td>36</td>
<td>43</td>
<td>120</td>
<td>0</td>
<td>199</td>
</tr>
<tr>
<td><em>Malus</em> others a</td>
<td>416</td>
<td>48</td>
<td>334</td>
<td>223</td>
<td>1021</td>
</tr>
<tr>
<td><em>Crataegus</em></td>
<td>61</td>
<td>291</td>
<td>43</td>
<td>0</td>
<td>395</td>
</tr>
<tr>
<td><em>Pyrus</em></td>
<td>2</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td><em>Sorbus</em></td>
<td>288</td>
<td>83</td>
<td>5</td>
<td>0</td>
<td>376</td>
</tr>
<tr>
<td><strong>Total for year</strong></td>
<td>2768</td>
<td>847</td>
<td>1571</td>
<td>312</td>
<td>5498</td>
</tr>
</tbody>
</table>

a These include Prairie-hardy apple cultivars such as *Malus* ‘Battleford’, ‘Haralson’, ‘Nokent’, ‘Norland’, ‘Parkland’, ‘September Ruby’ and ‘Westland’.
Table 2. Recommended fire blight spray programs in commercial tree nurseries of south Alberta. Commercial formulations of bacterial antagonists became available starting in 2007. Streptomycin received full registration in 2008.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Tree development stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bud break</td>
</tr>
<tr>
<td>Prior to 2008</td>
<td>Fixed copper</td>
</tr>
<tr>
<td>Since 2008</td>
<td>---</td>
</tr>
</tbody>
</table>

Figures

Fig. 1. Hourly wind speed in km/h at Calgary Airport, Alberta during June 2007. On 17 June, winds were recorded over 32 km/h, gusting to 50 km/h. Fire blight symptoms became obvious at many nurseries after 1 July.
Fig. 2. Hourly wind speed in km/h at Calgary Airport, Alberta during August 2009. On 3 August, winds over 65 km/h and hail was recorded at 01:00 hour. Damage was extensive in the path of the hail storm, including to plants, houses and buildings.

Fig. 3. Hourly wind speed in km/h at Strathmore, Alberta during July 2010. On 14 July 2010, winds over 50 km/h were recorded between 13:00 and 15:00 hours. Damage was extensive and new fire blight strikes became obvious by 24 July.
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