Acres in Berry Production

<table>
<thead>
<tr>
<th>Area in Acres</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 20 acres</td>
<td>10.3%</td>
</tr>
<tr>
<td>11-20 acres</td>
<td>25.6%</td>
</tr>
<tr>
<td>7-10 acres</td>
<td>15%</td>
</tr>
<tr>
<td>&lt; 1 acre</td>
<td>20.5%</td>
</tr>
<tr>
<td>0-6 acres</td>
<td>30.9%</td>
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</tbody>
</table>

Figure 1. Acres in berry production.

Whole Sale (Processed)

<table>
<thead>
<tr>
<th>Area in Acres</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 20 acres</td>
<td>25%</td>
</tr>
<tr>
<td>11-20 acres</td>
<td>15%</td>
</tr>
</tbody>
</table>

Figure 2. Markets used by New York berry growers.

Production System

<table>
<thead>
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<th>System</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>High Spray</td>
<td>80%</td>
</tr>
<tr>
<td>Low Spray</td>
<td>20%</td>
</tr>
<tr>
<td>No Spray</td>
<td>20%</td>
</tr>
</tbody>
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Figure 3. Production systems used by New York berry growers. Note: Some growers indicated they are using more than one type of production system - hence the 139% total for this pie chart.

Streptomycin is the most effective antibiotic for control of fire blight on apple and is likely to remain as such; therefore it is imperative to identify cases of antibiotic resistance early before bacterial populations become established. Since 2001, we have screened fire blight samples for streptomycin resistance and have not found established resistant strains. However, the development of streptomycin-resistant fire blight in New York is more a question of WHEN, not IF. It is the responsibility of the agricultural community to make a concerted effort to prevent resistance by the judicious use of streptomycin in order to safeguard the valuable effectiveness of streptomycin for future use.

Fire blight resistance to streptomycin

Streptomycin-resistant strains of fire blight are not a new phenomenon. They were first identified in California pear orchards in the early 1970s and have since been found in Washington, Oregon, Missouri, and most recently Michigan in the early 1990s. In fact, streptomycin-resistant strains of fire blight have developed in nearly every country where streptomycin is applied. Currently the north-eastern growing region, including New York and Pennsylvania, remains the only major pome fruit-producing region in the United States that has not developed streptomycin-resistant fire blight. Once resistance to streptomycin develops, and becomes established in an area, it is extremely stable in the environment. In California pear orchards, fire blight bacteria, which are resistant to streptomycin could still be found ten years after application of the antibiotic had ceased. For this reason it is imperative to safeguard the New York growing region against the development of streptomycin-resistant fire blight for as long as possible.

Streptomycin acts by interfering with the activity of E. amylovora to synthesize certain vital proteins, killing the bacteria. There are two ways resistance to streptomycin can develop. The most common type of resistance occurs through spontaneous mutation in the bacterial DNA, rendering the antibiotic harmless. These mutations are natural variants that occur randomly within the bacterial population, regardless of streptomycin application. Although resistance arises spontaneously, it is the continued use of that antibiotic that will select for the resistant bacteria. The more numerous the resistant bacteria, the more likely they will become permanently established in the environment. The selection of resistant bacteria is described in Figure 1, where a red dot represents a randomly occurring resistant bacterial cell living on a newly opened apple blossom, along with several susceptible bacterial cells. When streptomycin is applied, the majority of susceptible bacterial cells are killed immediately. No longer having competition of resistant bacteria will be selected in that particular orchard. The second form of antibiotic resistance occurs when two different bacteria share genetic material, through a process known as bacterial conjugation or bacterial mating. Most bacteria contain small optional ‘packages’ of DNA known as plasmids, that are not necessary for the bacteria’s survival. When bacteria experience stressful environmental conditions, such as the application of an antibiotic, they undergo bacterial mating and exchange plasmids. Plasmid exchange occurs when one bacterium creates a bridge connecting it to another bacterium. Plasmids can be passed through this bridge leading to the transfer of resistance genes. Plasmid exchange was found to be the cause of fire blight resistance in Michigan, which is the only state with this form of resistance. Although rarely associated with fire blight, plasmids containing streptomycin resistance genes are very common in the environment. At the Geneva Experiment Station, Dr. Tom Burr found these plasmids responsible for streptomycin resistance in the Blister Spot bacterium, Pseudomonas syringae pv. papulans, in New York in the early 1990s.

Stated in their interview, “I only have two acres of berries, so I’m not sure how useful my information will be for you.” While this may be the case in some other production areas in the U.S., this is not the case in New York. The results of our survey found that more than 73% of NY berry growers had six acres or less in berry production. 56% of growers surveyed had three or less acres in berry production (Figure 1). Many of these farms grow multiple commodities including tree fruit, vegetables, flowers, herbs, cash crops, etc. Their area in berry production is small due in part to the diversity of their farm operation. For other operations, small-scale berry production provides supplemental income for those who have other farm regular or retirement income sources. Additionally a telling piece of information about the berry industry is the years of production experience current growers have. As illustrated in Figure 2, there is an even spread of experience ranging from less than five years to more than 20 years, an indication of an industry that is healthy and growing. This diversity in experience is a wonderful opportunity for exchange of new ideas and tested methods. Moreover, the interest in berry production in NYS is growing rapidly. Another part of the NYFVI project focuses on providing introductory workshops for first time berry growers interested in getting into the berry production business. Fourteen workshops, hosted by County CCE offices across the state in 2007-2008 had 500 people in attendance. The three-hour workshops discusses economics, marketing, labor, and production aspects of berry growing. Exit surveys of participants three months post workshop indicated many would be growers were not aware of the complex nature of berry crop production. A good portion of those decided not to pursue berry crop ventures. A smaller proportion of respondents indicated they are eagerly going forward with these new ventures; they felt better prepared to meet the challenges of berry crop production after attending the workshop.

What types of production systems are NYS berry growers using (Figure 3)? Although there is some variability, the majority of growers practice a no- or low-spray program (90.8%). Survey results indicate 33.6% of growers utilize either a ‘No Spray’ or a ‘Rigorous IPM Spray Program’. 39.8% are using a ‘Low Spray’ program and 17.5% of growers are growing berries organically (certified or non-certified). This desire to grow the crops with as few chemical inputs as possible was also clear in the interviews. Some growers expressed a concern about their own exposure, “I don’t want to have to expose myself to more chemicals than I need to.” This grower’s main concern was not marketing but their desire to limit personal exposure. Many growers expressed that a top concern of their customers, particularly U-pick customers, is the amount of chemicals that are used on their fruit. One grower commented “…it is often one of the first questions that I get asked by customers...do you use chemicals?”

The start of the New York apple season is just around the corner. With bloom rapidly approaching, now is the perfect time to start thinking about control of fire blight. Fire blight, caused by the bacterium Erwinia amylovora, can lead to significant monetary losses in the form of reduced yield and tree death when initial disease outbreaks are not prevented. Fire blight is conventionally controlled by orchard sanitation and the application of the antibiotics streptomycin during bloom. When applied effectively, streptomycin kills the fire blight bacteria colonizing apple and pear blossoms, preventing infection. Streptomycin has been used to control fire blight for over 50 years with great success, but there is serious concern about the future of streptomycin due to antibiotic resistance development by bacteria.

Figure 1. Acres in berry production.

Figure 2. Years of experience growing berries.

Figure 3. Production systems used by New York berry growers. Note: Some growers indicated they are using more than one type of production system - hence the 139% total for this pie chart.

Figure 4. Markets used by New York berry growers.

Figure 5. Advertising methods used by New York berry growers.

This work supported in part by the New York Apple Research and Development Program

Nicole L. Russo and Herb Aldwinckle
Department of Plant Pathology New York State Agricultural Experiment Station, Cornell University, Geneva, NY

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The New Face of New York Berry Growers: Insights From the 2007 NYS Berry Growers Survey

Rebecca Harbut, Cathy Heidenreich, Laura McDermott and Marvin Pritts
Department of Horticulture, College of Agriculture and Life Sciences, Cornell University Ithaca, NY

I f you ask Californians what a berry farm looks like you will probably get descriptions of endless acres of plasticculture continuously being harvested and replanted. Floridians might likely connect you to Plant City where their strawberry industry is concentrated. But what sort of image does a New Yorker conjur up when they think of a berry farm? It depends on who you ask. If you ask shoppers at a NYC Green Market you will probably be told about the committed farmer that comes from the Hudson Valley to bring them fruit, perhaps a bit uncertain of what the farm actually looks like. The family in central NY visiting their local pick-your-own probably thinks of a family run operation, while the rural neighbor to the strawberry being tested; however nothing has proven to be as effective or as durable as streptomycin. Several antibiotics have been proposed as alternatives for control of fire blight but resistance to human pathogens has impeded the registration of new antibiotics for agricultural use. Biological controls are a new class of products being tested for control of fire blight. These compounds are typically antagonistic with resistance. However the reality that New York is not overrun with streptomycin-resistant fire blight, despite 50 years of annual streptomycin use, suggests there is some factor impeding resistance development that remains unknown.

Figure 1. Fire blight bacteria colonizing a newly opened apple blossom. (A) A streptomycin-resistant bacterial cell (red dot) arises in a group of streptomycin-susceptible bacteria (green dots). (B) The majority of susceptible bacteria are killed after application of streptomycin. (C) The remaining resistant bacteria flourish and become the dominant bacteria within the blossom.

There is very little scientific evidence as to why resistant strains of fire blight have developed in some parts of the country but not in New York State. It is possible that the development of resistance is associated with a “cost to fitness” to the bacteria. The term “cost to fitness” refers to the idea that an organism will not gain resistance to an antibiotic or fungicide without losing some other attribute. A bacterium might gain resistance to streptomycin but will be disadvantaged in some other way, for example slower growth. Investigation of E. amylovora resistant to streptomycin has not identified a clear fitness cost associated with resistance. However the reality that New York is not overrun with streptomycin-resistant fire blight, despite 50 years of annual streptomycin use, suggests there is some factor impeding resistance development that remains unknown.

The consensus opinion on why resistance has not developed in New York is that orchards in the northeast historically used fewer antibiotic sprays during the growing season. Reduced application of streptomycin would lessen the selection pressure on resistant strains. In California, where streptomycin-resistant fire blight bacteria were first identified in 1971, streptomycin was applied 10 to 14 times a year, compared with current guidelines recommending one to three applications. In California, growers were also applying lower rates of streptomycin. Lower rates may have allowed bacteria to build a tolerance to streptomycin over the course of the growing season. In New York the most effective method to combat resistance development is to limit the number of unnecessary streptomycin sprays each season.

Control strategies to delay resistance of fire blight to streptomycin

To be effective, streptomycin must make direct contact with the fire blight bacteria. Bloom is the only period in which the fire blight bacteria are vulnerable to streptomycin. Aside from open blossoms, E. amylovora is unable to survive on the plant surface, therefore application of streptomycin other than at bloom is a misuse of time and money. There is some evidence that streptomycin applied after a severe hailstorm can reduce levels of temperature blight, but this is only recommended if a moderate level of fire blight is already present in the orchard. There is evidence that streptomycin is effective against the other phases of fire blight, shoot blight or rootstock blight. Excessive application of streptomycin increases the odds of selecting for a resistant bacterial population. This practice will also expose harmless orchard bacteria to unnecessary antibiotics increasing the likelihood of resistance gene transfer.

Alternative materials for control of fire blight are continually being tested; however nothing has proven to be as effective or as durable as streptomycin. Several antibiotics have been formulated for use on fruit trees with promising results. Oxysteracryn has been approved for use on pears, and is available on a limited basis for apples in California and Michigan, for use in areas where streptomycin-resistant fire blight has been identified. Oxysteracryn, however, is not as effective as streptomycin and only outperforms streptomycin in areas where streptomycin resistance occurs. In Israel, oxolinic acid is used to control fire blight but resistant bacteria were identified only one year after release. New antibiotics, such as gentamicin (Agy-Gent) and kasugamycin (Kasumin, Arysta LifeScience Corp.) have been evaluated for the control of fire blight. Unfortunately over concern about the spread of antibiotic resistance to human pathogens has impeded the registration of new antibiotics for agricultural use.

Biological controls are a new class of products being tested for control of fire blight. These compounds are typically antagonistic with resistance. However the reality that New York is not overrun with streptomycin-resistant fire blight, despite 50 years of annual streptomycin use, suggests there is some factor impeding resistance development that remains unknown. Unfortunately, biological controls are not consistent in their ability to control fire blight, and the additional cost is often too much for growers to afford. Another disadvantage lies in perfecting application timing for biological controls. Often these products need to be present before an infection event to be effective. Therefore these products need to be applied early in bloom regardless of the certainty of an infection event. One way these products could prove useful is by acting as an alternative mode of action. When combating fungicide resistance two products are alternated; the second chemical will kill any fungi resistant to the first class of chemicals. Due to restrictions on antibiotic use, alternating two different antibiotics is impossible. Biologics could, however, be used in combination with streptomycin to reduce the population of resistant bacteria before they become established. Presently further evidence is needed to support this strategy, but the potential is there. Recent evidence has shown that use of biologics in combination with streptomycin will reduce bloom blight and as well as the number of streptomycin applications required at bloom.
Fire blight resistance to streptomycin in NY State
Since 2001, Dr. Herb Aldwinckle’s lab at the New York State Agricultural Station in Geneva has screened fire blight samples for streptomycin resistance. With the help of Debbie Breth (CCE Lake Ontario Fruit Program), Dr. Dave Rosenberger (Cornell University, Hudson Valley Lab), and Kevin Jungerman (CCE Northeast NY Fruit Extension Program), fire blight samples from throughout NY have been screened for streptomycin resistance on a yearly basis. Yearly screening provides an early warning for the development of resistant strains. By identifying early outbreaks of streptomycin resistance eradication efforts may be able to prevent the spread of the resistant bacteria. Although streptomycin resistance has not become established in New York there have been isolated cases of streptomycin-resistant fire blight. In 2002, during a routine survey for streptomycin resistance, fire blight samples from two neighboring orchards in Wayne County, NY were found to be highly resistant to streptomycin. This constituted the first authenticated report of streptomycin-resistant fire blight in New York State. The growers in question contacted local extension personnel when fire blight broke out in newly established plantings. The trees, which had yet to bloom, had extensive fire blight cankers and were purchased from a nursery in southwest Michigan, which is known to have fire blight-resistant fire blight. These factors led investigators to believe the trees might have been infected with antibiotic-resistant fire blight prior to planting. Genetic evidence also supported the theory that resistant bacteria were imported from Michigan. Bacteria were found to have resistance plasmids similar to those found solely in Michigan. Fortunately this case was identified early enabling the grower and extension agents to quickly take action to prevent the spread of the resistant bacteria. In 2003 both orchards were removed. Beyond the two initial plantings, no streptomycin-resistant E. amylovora has been identified in New York since 2003.

This story is not meant to malign the nursery industry or to suggest it is dangerous to import nursery stock. The New York State apple industry relies heavily on imported nursery stock to establish new plantings and introduce new varieties, and is necessary to remain competitive in today’s market. Prohibiting the importation of plant material from states known to have streptomycin-resistant fire blight is both impractical and unnecessary. The majority of apple nurseries are located in areas free of streptomycin-resistant fire blight, and responsible nursery operations make a concerted effort to provide high quality disease free planting material. If not, each year there would undoubtedly be numerous instances of new diseases transported on infected plant material. It is important however for growers to be aware that plant material can act as a reservoir for antibiotic and fungicide resistant strains of pathogens, and to remain vigilant when establishing a new planting. Fortunately in this case immediate action by the growers and extension agents allowed for implementation of successful control and eradication measures.

Conclusions
Since the discovery of streptomycin-resistant E. amylovora in California in 1971 antibiotic usage in apple and pear regions has been reduced dramatically. Reduction in antibiotic sprays is largely possible due to the use of forecasting models such as MARYBLYT™ and CougarBlight™. These programs analyze the likelihood of infection using several factors including temperature, precipitation, and history of fire blight at that particular location. Although these programs have reduced antibiotic sprays, apple and pear growers still depend on antibiotics to control fire blight. Streptomycin is the most effective antibiotic for use on apple and is likely to remain as such; therefore it is imperative to identify cases of antibiotic resistance early before bacterial populations become established. The development of streptomycin resistant fire blight in New York is more of a question of WHEN, not IF. It is the responsibility of the agricultural community to make a concerted effort to prevent resistance in order to safeguard the valuable effectiveness of streptomycin for future use.

Nicole Russo is a post doctoral research associate in the Dept. of Plant Pathology at Geneva who recently completed her PhD on fire blight and the mechanisms of resistance to fire blight. Herb Aldwinckle is a professor of plant pathology who specializes in fire blight and its chemical and genetic control.