Current Issues in Organic Fruit Production

Where: Grand Gallery (main level) Room C

Recertification credits: 2 (1C, COMM CORE, PRIV CORE)

CCA Credits: PM(1.5) CM(1.0)

Moderator: Matt Grieshop, Entomology Dept., MSU

1:00 pm  Update on Fungal and Nematode Based Biopesticides
  - Pete Nelson, Entomology Dept., MSU
  - Mark Whalon, Entomology Dept., MSU

1:15 pm  Tending the Orchard Floor in Organic Systems
  - David Granatstein, Tree Fruit Research and Extension Center, Washington State Univ.

2:00 pm  Year Two of the MSU Organic High Tunnel Raspberry Project
  - Ben Gluck, Horticulture Dept., MSU
  - Eric Hanson, Horticulture Dept., MSU

2:15 pm  Update on the Apple Flea Weevil
  - Matt Grieshop, Entomology Dept., MSU
  - Anne Nielson, Entomology Dept., MSU
  - John Pote, Entomology Dept., MSU

2:30 pm  Organic Management of Fire Blight Roundtable
  - Jim Koan, Al-Mar Orchards, Flushing, MI
  - George Sundin, Plant Pathology Dept., MSU
  - David Granatstein, Tree Fruit Research and Extension Center, Washington State Univ.
  - Matt Grieshop, Entomology Dept., MSU
Tending the Orchard Floor in Organic Systems
David Granatstein, Center for Sustaining Agriculture and Natural Resources, Washington State University, Wenatchee, WA 98810 USA; granats@wsu.edu

Organic producers face more challenges in orchard floor management than do their conventional counterparts (Granatstein and Sanchez, 2009; Weibel and Häseli, 2003). Both weed control and tree fertilization can be achieved quite easily and with relatively low cost in conventional production using herbicides and synthetic fertilizers. This is not the case in organic systems, where poorly controlled weeds can compete with the trees for already slow-release and expensive nutrient inputs. Options for control of rodent pests are limited in organic systems, and these pests (e.g., voles) can in turn limit options for weed control and nutrient management. In addition, organic standards require that growers maintain or improve soil quality, which can be easily degraded by mechanical tillage, a common weed control method. The orchard floor provides an important ecological space for trying to enhance functions such as biological pest control as well. Thus, for the organic grower, developing an orchard floor management system involves balancing a number of needs and constraints to come up with an acceptable solution.

The orchard floor performs several important functions for an orchard system. These include:

- Physical support for tree growth, machinery operation
- Water intake/storage/transfer
- Nutrient cycling/storage (including litter decomposition)
- Gas exchange for roots
- Habitat (micro and macro fauna)
- Micro-climate (e.g., heat exchange)

These functions are impacted by various management practices, such as choice of understory species, tree architecture, irrigation system, nutrient inputs, spray drip, and weed control. In looking to design orchard floor management for improved sustainability, trade-offs routinely occur (Granatstein et al., 2010). For example, while a vegetative cover under the trees might maximize soil quality, it will negatively affect tree performance. Therefore, continued research and grower experimentation are needed to test combinations of orchard floor management practices that can optimize the organic tree fruit system. Two aspects are discussed below: weed control and growing nitrogen in the orchard.

Weed Control

Weed control is a necessary practice in orchards in order to limit competition for water and nutrients, minimize pest habitat (especially voles), and maintain good water distribution from irrigation systems. Fruit trees on dwarfing rootstocks have low root density in comparison with broadleaf and grassy weeds (Neilsen and Neilsen, 2003), and optimal tree performance requires minimal intermingling of other plant roots with those of the tree (Merwin and Ray, 1997). Organic growers have several weed control options to choose from (Table 1). The most common management for weed control in organic orchards is tillage in the weed strip. It is relatively inexpensive but can negatively impact tree performance and soil quality (Merwin and Stiles, 1994; Merwin et al., 1994). A number of different tillage implements are available that vary in speed, aggressiveness, and potential damage to trees and roots. Another technique is thermal weed control, typically using open propane-fired burners aimed at the weed strip and base of the tree.
While low in cost, many weeds are not well controlled by flaming (Rifai et al., 1999; Praat, 2002). Several organic compliant herbicides are now available, but they suffer from high cost, low effectiveness, and in some cases no crop use label. All are contact post-emergent materials that require frequent application and do not sufficiently control perennial weeds such as dandelion or quackgrass. Mulching is used by some organic growers, both organic materials such as wood chips as well as synthetic weed fabrics. In various research trials, mulching frequently leads to improvements in tree growth, fruit yield, fruit size, water conservation, or soil quality (Granatstein and Mullinix, 2008). However, this practice can be quite expensive. And many mulches (fabrics yes, wood chips no) provide excellent habitat for voles. Continual mowing of the weed strip is another option that requires machinery that can work between the trunks. Mowing tends to select for perennial species and may not adequately suppress competition in young trees. Living mulches are cover crops planted in the weed strip to displace weeds. These can provide nitrogen fixation or beneficial insect habitat, but often still compete more with the trees than desirable (Merwin and Stiles, 1994; Mullinix and Granatstein, 2011; Granatstein and Mullinix, 2008).

Table 1. Orchard floor weed control options for organic systems: pros and cons.

<table>
<thead>
<tr>
<th></th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage</td>
<td>Effective</td>
<td>Reduced tree growth, fruit size</td>
</tr>
<tr>
<td></td>
<td>Reduces rodent habitat</td>
<td>Costly in young orchards</td>
</tr>
<tr>
<td></td>
<td>Relatively low cost</td>
<td>Can damage roots and trunks, irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can degrade soil quality, deplete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>organic matter</td>
</tr>
<tr>
<td>Flaming</td>
<td>Can control weeds around</td>
<td>Potential tree injury</td>
</tr>
<tr>
<td></td>
<td>trunk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduces rodent habitat</td>
<td>Not good for older weeds, perennials</td>
</tr>
<tr>
<td></td>
<td>Relatively low cost</td>
<td>Uses fossil fuels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Irrigation system damage</td>
</tr>
<tr>
<td>Inert mulches</td>
<td>Effective for most weeds</td>
<td>Costly to apply</td>
</tr>
<tr>
<td></td>
<td>Can improve soil quality</td>
<td>Can tie up N</td>
</tr>
<tr>
<td></td>
<td>Conserves moisture</td>
<td>May be hard to source</td>
</tr>
<tr>
<td></td>
<td>Improved tree growth, yield</td>
<td></td>
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<tr>
<td>Living mulches</td>
<td>Add biodiversity</td>
<td>Compete with trees</td>
</tr>
<tr>
<td></td>
<td>Benefit soil quality</td>
<td>Rodent habitat</td>
</tr>
<tr>
<td></td>
<td>Legumes can fix N</td>
<td>Variable persistence</td>
</tr>
<tr>
<td></td>
<td>Theoretically low</td>
<td>Variable ability to compete</td>
</tr>
<tr>
<td></td>
<td>maintenance</td>
<td>with weeds</td>
</tr>
<tr>
<td>Organic herbicides</td>
<td>Can control weeds around trunk</td>
<td>Expensive</td>
</tr>
<tr>
<td></td>
<td>No physical damage to</td>
<td>Inconsistent effectiveness</td>
</tr>
<tr>
<td></td>
<td>tree, roots</td>
<td>May need many applications</td>
</tr>
<tr>
<td></td>
<td>Reduce rodent habitat</td>
<td>Few registered products</td>
</tr>
<tr>
<td>Mowing</td>
<td>No root or soil disturbance</td>
<td>Difficult to control weeds by trunks</td>
</tr>
<tr>
<td></td>
<td>Inexpensive</td>
<td>Not effective for young trees</td>
</tr>
</tbody>
</table>

Adapted from Granatstein and Mullinix, 2008.
Organic growers often combine several of these techniques to achieve acceptable weed control as no one of them is fully satisfactory. Choices will depend on tree age, weed species, availability of machinery and labor, and cost. Estimates of costs for various organic weed control techniques are presented in Table 2.

Table 2. Cost estimates for various organic weed control techniques.

<table>
<thead>
<tr>
<th>Method</th>
<th>Rate</th>
<th>Frequency</th>
<th>Cost ($/ac/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicide</strong>* (glyphosate)</td>
<td>0.5 L</td>
<td>4x/yr</td>
<td>24</td>
</tr>
<tr>
<td>Weed fabric</td>
<td>5’ x 3750’</td>
<td>1 in 6 yr</td>
<td>286</td>
</tr>
<tr>
<td>Alfalfa hay mulch</td>
<td>8.5 tons</td>
<td>1 in 2 yr</td>
<td>319</td>
</tr>
<tr>
<td>Wood chip mulch</td>
<td>100 cu.yd.</td>
<td>1 in 3 yr</td>
<td>200</td>
</tr>
<tr>
<td>Flaming</td>
<td>48 lb propane</td>
<td>3x/yr</td>
<td>36</td>
</tr>
<tr>
<td>Tillage (Wonder Weeder)</td>
<td>0.25 hr</td>
<td>4x/yr</td>
<td>0</td>
</tr>
</tbody>
</table>


When evaluating the cost of organic weed control, one must keep in mind the entire system, not just the costs of the weed control activities themselves. For examples, while tillage is often a low cost system, it can negatively impact tree performance, which in turn may reduce gross revenue. This was the case in a comparison of tillage (Wonder Weeder), undisturbed control (mowed with weedeater), and wood chip mulch in mature ‘Gala’/M.26 apples, where mulching tended to increase tree growth, yield and fruit size such that gross revenue increased more than the costs of the mulching. Tillage tended to do the opposite (Granatstein et al., 2010).

**Growing Nitrogen in the Orchard**

Most organic orchards require regular additions of nitrogen for tree nutrition. Organic sources can be costly, ranging from $1.50/lb N (dry basis) for composts to over $7.00/lb N for concentrated sources such as bloodmeal or feathermeal. Legumes can be planted in the orchard to fix atmospheric N and provide a lower cost source for a portion of the nitrogen need.

Legumes can be planted in the weed strip as a living mulch. White clover successfully suppressed weeds, and increased tree leaf N, tree growth and fruit yield in a mature ‘Red Delicious/M.26 apple block in Washington State. A test of N mineralization showed that mowed clover released over 45 lb N/ac over a three-week period (Mullinix and Granatstein, 2011), representing a significant portion of tree need (approx. 60-70 lb N/ac/yr). However, it is a highly preferred food source for voles and they destroyed the stand during the second winter after planting.

To minimize the vole problem, and to provide greater ability to control N inputs and timing, a trial was established in mature ‘Gala’/M.26 apples in Washington State to compare N inputs from four legume species (Ladino white clover, alfalfa, birdsfoot trefoil, kura clover) direct seeded into the center of the orchard drive alley (D. Granatstein, unpublished). All species successfully established and were mowed and blown on to the tree row. By year 3, alfalfa and trefoil were providing the greatest biomass (Fig. 1) and total N (40-45 lb N/ac). Soil tests showed elevated nitrate levels after the mow and blow operation. The cost to plant a 4-ft strip of the legumes was $84/ac. Assuming a 5-yr life of the planting, the cost of available nitrogen was estimated to be $0.65/lb N, considerably less than other organic nitrogen sources. The mow and blow system also adds carbon to the weed strip where the bulk of the tree roots are, adding
to soil quality over time. And the blown on residue can build up a mulch layer that provides some
benefits for suppressing weeds and conserving water as well. The direct seed system worked well
without any herbicide suppression of the existing alley vegetation, making it a viable option in an organic
system and eliminating the undesirable effects of tillage to create a seedbed.

Figure 1. Biomass dry matter (DM) for legume cover crops planted in the orchard drive alley, with and
without pre-plant herbicide suppression of existing alley vegetation. Mature ‘Gala’/M.26 apples,
Washington State.

<table>
<thead>
<tr>
<th>Cover Crop Biomass, 2008-10</th>
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</thead>
<tbody>
<tr>
<td>Biomass DM (kg/ha)</td>
</tr>
<tr>
<td>2008</td>
</tr>
<tr>
<td>Alfalfa</td>
</tr>
<tr>
<td>Spray</td>
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<td>0</td>
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</tbody>
</table>

Conclusion
No perfect system of orchard floor management has been developed for organic systems. New tools and
knowledge are continually becoming available to help growers design a system to fit their specific needs
and situations. Systems that incorporate legumes, add organic matter, keep the soil covered, and
minimize soil disturbance are possible. Perennial weed infestations and voles are constraints that move
management towards more tillage-based systems that may negatively impact tree performance despite
providing good weed control.

For further reading on orchard floor management, see the references below, especially Granatstein and
Sanchez (2009), Merwin (2003), and Hogue and Neilsen (1987). Also visit the organic orchard floor

Literature Cited
Granatstein, D. and E. Sanchez. 2009. Research knowledge and needs for orchard floor management in
Year Two of the MSU Organic High Tunnel Raspberry Project

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This is an update on a project underway at the Horticulture Teaching and Research Center on the MSU campus. It is part of a larger project involving other researchers from Horticulture (John Biernbaum, Dan Brainard, Greg Lang), Entomology (Matt Grieshop) and Plant Pathology (Annemiek Schilder). Funding sources include AgBioResearch, The CERES Trust, NIFA Organic Research Initiative Award, and Haygrove Tunnels Inc.

We have found under conventional management that tunnels tend to reduce the amount of damage from some insect pests and diseases that are key challenges to growing raspberries organically in the Midwest. The goal of this project is to develop management practices for organic raspberries, using multi-bay high tunnels. Three 26 by 200 foot bays were planted in May 2010 with one row each of the primocane-fruiting varieties Himbo Top, Joan J, and Polka. Plants are being managed for fall production only. Our bays are covered with plastic from May to late October. Below are some observations describing soil fertility, irrigation, varieties, pests, and shading options.

Fertility

Organic growers typically rely on cover crops, compost, dry organic fertilizers and crop rotation to manage soil fertility and soil health. In high tunnel production of perennials, soil and nutrient management is limited by a lack of rainfall, the inability to incorporate amendments and an extended growing season.

We are evaluating the effect of dairy compost and a dry organic fertilizer on soil and plant nutrition. An important question is whether or not these materials can provide season long fertility when rain is excluded. Each bay is split into eight sub-plots that are receiving either a low or high rate of a dairy-based compost or an organic fertilizer. These were incorporated before planting (2010) and top-dressed in April (2011).

Early indications are that these treatments tend to supply adequate nutrition in the summer, but that they may begin running out late in the summer. We also learned that incorporating high-salt compost at higher rates before planting can injure young plants through salt stress. Leaving the tunnels uncovered during winter likely leaches excess salts, including plant nutrients, out of the root zone.

Irrigation

Since tunnels are covered and rain is excluded during most of the growing season, irrigation is required to meet crop water needs. Understanding irrigation requirements may also prevent over irrigation and leaching which prematurely depletes nutrients applied as compost or fertilizer. In tunnels, drip irrigation is preferred because it is efficient and minimizes leaf wetness. Each plant row can be irrigated with a single drip irrigation tube with emitters spaced 2ft apart. Between May and October of 2011, we applied irrigation at a rate of at least 300,000 gallons per acre. Studies are being developed to help determine irrigation requirements of raspberries in tunnels.
Varieties

Polka, Joan J and Himbo top were chosen for early, mid and late season, respectively. Polka and Joan J began fruiting in the second week of August and Himbo Top began a week or two later. Each variety had strengths and drawbacks. Polka was early with excellent flavor and a medium red glossy surface, but plants were very prone to Japanese beetle and potato leafhopper injury. Joan J also had excellent flavor but its fruit were quite dark red. Its dense foliage also made picking somewhat slower. Himbo Top produced large fruit with an attractive lighter red color that were more acidic (tart) than the other types. Its canes were somewhat spindly making picking easy.

Insect pests

Pest pressure has varied at different times throughout growing season and included potato leaf hopper, raspberry sawfly, Japanese beetle, spider mites and spotted wing drosophila. Significant populations of leaf hoppers, Japanese beetles and sawflies were evident begging in June, 2011. Spider mites were problematic in 2010. Predatory mites were introduced that year and spider mites were not a problem in 2011.

Tunnels were monitored in 2011 for spotted wing drosophila with vinegar-baited traps. Flies were trapped in early September and severe fruit infestation was apparent one week later. Once infested fruit were detected a program of alternating sprays of Entrust and Pyganic, along with timely, thorough harvest, largely controlled the infestation.

Shading

Raspberries prefer moderate summer temperatures, and tunnel temperatures in Michigan likely exceed desired levels. One strategy to reduce temperatures is to apply shade cloth or reflective netting over the plastic. From mid June through August, A 30% black shade netting and Aluminet 30% shading were placed over the plastic on separate bays to try to reduce maximum daily temperatures. Maximum temperatures during sunny days were 6-10 F warmer in tunnels than outside. Shade materials reduced this difference by about half.
Alternative Fire Blight Control Materials to Replace Antibiotics

The antibiotics streptomycin and oxytetracycline are the primary tools used by conventional and organic growers to prevent fire blight (*Erwinia amylovora*) infection of apple and pear trees during periods of high risk. Use of these materials is guided by disease models tailored to different regions of the country (e.g., COUGARBLIGHT, MARYBLYT, Thomson-Schroth Average Temperature Model, Zoller Degree Hour Model). Treatments are not applied in those situations when the models do not indicate sufficient risk. Growers deploy other practices as part of a fire blight management program, but antibiotics are the last line of defense when infection risk is high. Once infected, no available materials provide a curative effect; the antibiotics act in a preventative mode only.

The National Organic Program has included antibiotics for use only on fire blight on apples and pears as part of the National List of Allowed Synthetics since the program began in 2002. The National Organic Standards Board has now set October 21, 2014, as the expiration date for their use and has requested information on the status of alternative controls. Research on biological controls of fire blight has been ongoing since the 1980s (Vanneste, 2011). Blight Ban A506 and Serenade were introduced in the 1990s, and Blight Ban C9-1 was registered, while Bloomtime Biological was put on the market in the 2000s. These developments have been supported by over $600,000 in grower funds on research for non-antibiotic controls and practices that would be organic compliant. The USDA-ARS supports at least three key research programs on alternative fire blight control (Wenatchee, WA; Kearneysville, WV; Geneva, NY for resistant rootstocks), with a cumulative investment of over $5 million. Other USDA grants funds have totaled over $1 million. There has been no lack of effort and support for developing non-antibiotic alternatives, just a lack of clear success with the alternatives.

The primary three biocontrol products that are EPA registered for fire blight, and that are OMRI-approved, are Blight Ban A506 (*Pseudomonas fluorescens*), Bloomtime Biological (*Pantoea agglomerans*), and Serenade Max (preparations of *Bacillus subtilis* QST 713). Several of the organisms in these products are antibiotic producers. These have been tested extensively as stand-alone replacements for streptomycin or oxytetracycline in different regions of the country. Sundin et al. (2009) tested these products over 7 years in Michigan, Virginia, and New York. These materials exhibited low efficacy and high year-to-year and location-to-location variability. They did show promise when used in sequence with antibiotics, and were able to reduce the number of antibiotic sprays needed. Based on their results, the researchers concluded that “…the prospects for biological control of fire blight in the eastern United States are currently not high”. The experience has been similar in Washington, Oregon, and California (Smith, 2011; Zoller, 2011). A complicating factor that has not been extensively explored is the interaction between other management practices used by organic growers, such as scab (*Venturia inequalis*) control or fruit thinning (Wend, 2011), and the use of biological control organisms (Lindow et al., 2008). This is especially critical for Midwest and Eastern U.S. growers where scab is the dominant disease challenge that occurs every year.

Recently, Oregon researchers developed an integrated control concept for fire blight that recognized differential control of the disease when on the stigma versus the nectary of the fruit tree blossom (Stockwell et al., 2008). They defined ‘integrated’ as the sequencing of a biological control followed by an antibiotic control, based on their hypothesis that the biological materials controlled the pathogen on the stigma in the early stage of bloom, and the antibiotic controlled it when on the nectary later in bloom. They were able to achieve control similar to an antibiotic-only regime, but reduced antibiotic use by half. A similar regime without antibiotics has been tried by a number of eastern Washington organic growers who have reported satisfactory results from non-replicated tests.
A new biocontrol material was commercialized in Germany several years ago (Kunz et al., 2011) and is now being tested in the U.S. Blossom Protect is a live formulation of *Aureobasidium pullulans*, a naturally occurring yeast that is commonly found in orchards. In field trials in Oregon, a regime of Bloomtime Biological followed by Blossom Protect provided fire blight control similar to regimes that included antibiotics (K. Johnson, unpublished data). The Bloomtime Biological protected the stigma and the Blossom Protect protected the nectary, following the integrated control concept described above. Interactions of these controls with organic fruit thinning using lime sulfur plus fish oil are being evaluated as well (Fig. 1).

Field trials in eastern Washington have also evaluated Blossom Protect on apples and found it to provide control similar to oxytetracycline (Fig. 2; Smith, 2011). One year of testing on pears in California yielded positive results (Adaskaveg et al., 2010). In Michigan, Blossom Protect (63-64% control) on apples did not provide similar control to streptomycin (97-98% control) in two of three years when disease pressure was moderate and high, using 4 applications of Blossom Protect (Sundin et al., 2009, 2010). Similar tests in Eastern states have not been identified.

A USDA OREI project funded in 2011 (K. Johnson, principal investigator) will continue the work described above in Oregon, Washington, and California to further validate efficacy, design suitable integrated control programs, and educate growers. This is a 4-year activity that will begin with the 2012 field season.
Figure 2. Summary of “percent control” of blossom infection in the past 10 years of similar fire blight control material trials in eastern Washington. Not all are organic-compliant. [Strep=streptomycin; ASM= acibenzolar-s-methyl; Blos. Pro.=Blossom Protect; SAR=systemic acquired resistance; inoc.=inoculated]

Certain copper products are already used by organic growers during the dormant season to help suppress fire blight bacteria in cankers on the trees. New copper formulations are being tested for use during bloom and have shown positive results (Fig. 2). More experience is needed to allay concerns about fruit russetting (which renders the fruit unmarketable), particularly in pears. It is also unknown if these products will be available to organic growers. Long term, coppers are not a suitable replacement for antibiotics. Copper is an essential plant micronutrient, but it is also a heavy metal and potential environmental contaminant that persists in soils. Organic farms in Europe have relied on repeated use of copper for disease control, which led to elevated soil copper levels far above what was considered normal and into ranges where scientific studies have shown potential for inhibition of soil microorganisms (Bogomolov et al., 1996). Thus, soil monitoring is needed when using these materials.

Research on the biology of fire blight and other possible controls is on-going as well (Johnson et al., 2009; Pusey et al., 2009; Johnson et al., 2000). This includes identifying stigma exudates and their role as a microbial food source, water dynamics and osmoadaptation possibilities, and use of bacteriophages attached to other biocontrol organisms (L. Pusey, pers. comm.). Also, the use of plant defense stimulators to help trees ward off infection is being actively investigated (Deckers et al., 2011).

Alternatives to antibiotics have been actively pursued by researchers and industry for several decades, with a significant infusion of grower funds for their evaluation. Several biological control materials are now registered for use by organic growers. However, availability does not equate to demonstrated equivalence with the material they are intended to replace, as shown above. At this time, the tools for non-antibiotic control of fire blight for organic apple and pear growers are not sufficiently proven to replace the antibiotic controls use when indicated by disease development models. Some growers have reported success with non-antibiotic regimes, but these regimes have not been widely tested in the diverse growing environments across the country. The new Blossom Protect material shows promise but is not currently EPA registered (scheduled for February 2012) and thus not yet available for grower use.
As new materials become available, researchers validate them under different conditions and within overall orchard management systems to reduce the risk of failure or unanticipated side effects in grower orchards. This process is then followed by a period of education and grower experience to again refine the use of the materials in the diverse settings and environments encountered in commercial orchards. The process of moving a material from being available, to proving its efficacy, to integrating its use into an overall management system, to educating growers, is a multi-year effort (often 5 or more years) that needs to be recognized by bodies such as the National Organic Standards Board when making a decision to phase out a critical control option. Given the time required, it is questionable whether organic apple and pear growers will have in place a suitable and nationally applicable alternative management regime for fire blight by the October 21, 2014 date set by NOSB for expiration of antibiotic use.

Citations


Drafted by David Granatstein on behalf of the Organic Tree Fruit Industry Work Group; November 2011.