## Project Summary

Apple replant disease (ARD) is a serious disorder that reduces tree growth and cumulative yield on affected trees planted on previous orchard sites. ARD is caused by a complex of soil fungi, bacteria, and nematodes that may act synergistically to cause disease. This complex is variable by orchard site and management history, so blanket management recommendations are difficult. Historically, ARD was managed with preplant soil fumigation with methyl bromide or application of broad-spectrum biocides that had significant negative environmental and human health impacts. As those materials have been phased out of use, other preplant practices, including cover crops, application of composts, and fallow periods have replaced them, with varying success. Northeast apple growers are replacing old orchards with high density modern plantings that may improve orchard profitability and sustainability. Many of these orchards are affected by ARD, and few post-plant ARD mitigation practices are available. Biopesticides are biologically-derived materials that may control pests or diseases on many crops. However, many registered materials have not been tested for efficacy on specific crops and diseases. This project will assess tree growth and crop yield improvements from two promising and commercially-available biological control materials in two ARD-affected orchards in Vermont. Cropping differences will be translated into potential opportunity costs associated with increased orchard performance.
2014 NE SARE Partnership Grant
IDENTIFICATION AND SIGNOFF PAGE

Farmer Cooperators
List the farmer cooperators who have agreed to participate in your project. Give name, phone number, and email address if available. A letter from each farmer cooperator must be attached to this application.

1. Ron Hackett, Farmer: (802)372-5555, hackettsorchard@myfairpoint.net

Other Cooperators
List any other cooperators who will work on the project. Give name, phone number, and email address.

None Listed

Institutional sign-off. We require evidence that your project has been approved by the institutional official in charge of grants and contracts. If you are affiliated with a nonprofit organization, the signature of the authorized official of your governing board is required.

Signature: Jennifer Gagnon Date: November 18, 2013
Authorized individual: Jennifer Gagnon Title: Interim Associate Vice President for Research Administration
Institution: University of Vermont
Address: 340 Waterman Building, 85 South Prospect Street, Burlington, Vermont 05405
Telephone: (802)656-3360
E-mail address: spa@uvm.edu

Project leader signature: Date: 11/18/2013
**Project Title:**

Biological Management of Apple Replant Disease

**SARE request:** $14,314

**PROJECT SUMMARY**

Apple replant disease (ARD) is a serious disorder that reduces tree growth and cumulative yield on affected trees planted on previous orchard sites. ARD is caused by a complex of soil fungi, bacteria, and nematodes that may act synergistically to cause disease. This complex is variable by orchard site and management history, so blanket management recommendations are difficult. Historically, ARD was managed with preplant soil fumigation with methyl bromide or application of broad-spectrum biocides that had significant negative environmental and human health impacts. As those materials have been phased out of use, other preplant practices, including cover crops, application of composts, and fallow periods have replaced them, with varying success. Northeast apple growers are replacing old orchards with high density modern plantings that may improve orchard profitability and sustainability. Many of these orchards are affected by ARD, and few post-plant ARD mitigation practices are available. Biopesticides are biologically-derived materials that may control pests or diseases on many crops. However, many registered materials have not been tested for efficacy on specific crops and diseases. This project will assess tree growth and crop yield improvements from two promising and commercially-available biological control materials in two ARD-affected orchards in Vermont. Cropping differences will be translated into potential opportunity costs associated with increased orchard performance.

**WHAT IS THE PROBLEM AND WHY IS IT IMPORTANT?**

Apples are an important component of the agricultural economy in the northeast, where over 14,000 acres of orchards generate approximately $66 million in farmgate receipts annually (NASS 2013). In Vermont, orchards contribute nearly $20 million to the local economy, and are the second-most important specialty food crop, after maple (USDA 2007). However, apple production systems are not static, and orchards have seen significant changes in varieties and planting systems over the past several decades. Orchards are increasingly being planted to smaller trees on dwarfing rootstocks and higher tree densities per acre, with increased up-front establishment costs over traditional, lower-density plantings (Robinson 2004). Increased planting costs are offset by increased precocity and greater yield at maturity, but management problems during early orchard establishment may reduce overall profitability of these systems (Robinson 2005). Apple replant disease (ARD) is a disorder caused by a complex of fungal, bacterial, and nematode pathogens that affect tree fruit crops when planted on sites where those crops were previously (Mazzola and Manici 2011). In past years, ARD was managed with preplant soil fumigation with methyl bromide or treatment with organophosphate biocides (Mai and Abawi 1981), but those materials have been or are being phased out due to environmental concerns. Presently recommended practices to mitigate ARD in new orchards include preplant cover cropping, multi-year fallow periods, and use of resistant rootstocks (Merwin, Byard et al. 2001), but those practices are not always effective in supporting optimum tree growth (Robinson 2007). In many cases, growers are planting new orchards on old orchard sites without adequate ARD mitigation because they cannot afford multiple years of lost production during mitigation, and resistant rootstocks are not as commercially available as more common dwarfing rootstocks (Robinson 2006). Few post-plant ARD treatments are available to growers, and some treatments that are available are inadequately tested on orchard crops. As a result, local growers are investing in modern plantings that are being affected by ARD, which compromises overall profitability of the orchard, and may jeopardize long-term sustainability of the industry in the region.

**WHAT IS YOUR PROPOSED SOLUTION?**

Fruit growers, who may be good stewards of the land with interests in overall orchard, and maybe even soil, ecology, are primarily interested in attaining optimum tree growth and fruit yield in their plantings in order to optimize profitability. Given the limitations in funding for this program, and the focus on farm-level impacts that improve productivity and increase farm income; conserve soil and improve water quality; reduce environmental and health risks; prevent agricultural pollution; and improve the quality of life for farmers, this project proposes to assess horticultural impacts on tree growth and fruit yield from application of two biopesticide products in two ARD-affected orchards in Vermont. By completing this research, effective mitigation tactics for ARD-affected orchards in New England may be identified to assist growers in managing this disorder.
WHAT ARE YOUR PROJECT METHODS?
This project proposes to assess two commercially-available biopesticide products, alone and in combination, in two orchards planted in 2011 that exhibit ARD symptoms. Trees in both orchards that are planted on sites where apple trees were grown previously show visible reduction in growth and fruit yield compared to neighboring trees in the same planting that were planted in drive rows or other land where trees were not present in the previous planting. One site has previously shown presence of P. penetrans nematodes in a previous study, and trees planted where apple trees had been present prior to orchard establishment showed symptoms of the disease (Costante, Mai et al. 1987).

The first orchard is located at the University of Vermont Horticulture Research Center in South Burlington, VT (HRC). The soil is a Windsor Adams loamy sand. A previous orchard was maintained on the planting site from 1990 through 2009. After removing trees in fall 2009, the site was plowed, limed, and cover cropped with sudan grass followed by oilseed mustard, which were incorporated into the soil prior to planting. Tree rows were subsoiled and preplant compost was applied at 16 tons per acre. ‘Royal Empire’ trees grafted to Bud. 9 dwarfing rootstocks were planted in 2011 in a tall spindle training system with tree density of 1210 trees per acre (3 ft x 12 ft tree spacing). Standard management practices including weed control, irrigation, and pest management sprays have been performed since orchard establishment. The second planting is located at a commercial orchard in South Hero, VT (SHVT) on Amenia and Kendall silt loam soils. The previous orchard was maintained on the site from 1900 to 2009. Trees were removed in 2009 and drainage was performed (installed) prior to replanting. In 2011, 150 trees on EMLA-26 rootstock were planted at a tree density of 350 trees per acre. Standard horticultural practices have been applied since planting.

At each site, four treatments will be applied to five single-tree replicates per treatment in a completely randomized design. Treatments will include: 1) non-treated control; 2) MeloCon at four lbs/acre; 3) Actinovate AG at 12 oz/acre; and 4) MeloCon and Actinovate AG combined. Treatments will be applied as a soil drench within the drip line of individual trees in the equivalent of 100 gallons of water per acre. Treatments will begin at pink bud stage (roughly May 1) and will be repeated every 60 days, or roughly on July 1 and September 1, for a total of three treatments per season. Treatments will be repeated on the same trees for two growing seasons.

Measured variables will include tree growth (trunk cross-sectional area (TCSA) at the beginning and end of each season, and vegetative shoot length and canopy size each season), fruit yield (bushels per acre equivalent), and fruit size. Additionally, soil will be analyzed for trophic diversity of nematode communities (Neher and Lee Campbell 1994) at the end of the project. This data will not only measure effects of treatments on nematode...
populations, including plant parasitic species, but trophic nematode indices are a measure of soil ecological condition (Freckman 1988, Bongers 1990). All data will undergo an analysis of variance (SAS Institute Inc. 2002-2004) to determine effects of experimental treatments on measured parameters. In addition, changes in fruit yield and size will be correlated to potential changes in income per acre in order to allow commercial growers to assess treatment impacts on their businesses.

WHAT IS THE PROJECT TIMETABLE?
The proposed project will be conducted over two growing seasons because tree growth and fruit yield impacts attributable to ARD management practices tend be measurable after multiple field seasons (M. Mazzola, pers. conv.). Project activities will occur according to the following timeline. All activities will be performed by the principal investigator unless referenced otherwise.

May 2014: Apply initial treatments to for 2014 season orchards.
July 2014: Apply second treatments to orchards.
September 2014: Apply third treatments to orchards. Collect yield and fruit size data.
October 2014: Measure tree growth (TCSA and shoot length).
Winter 2014-2015: Analyze initial data. Present results at winter grower meetings and in online publications.

May 2015: Apply initial treatments for 2015 season to orchards.
July 2015: Apply second treatments to orchards.
September 2015: Apply third treatments to orchards. Collect yield and fruit size data.
October 2015: Measure tree growth (TCSA, shoot length, tree canopy volume). Collect soil for nematode community analysis (Neher lab, University of Vermont).
Winter 2015-2016: Analyze data. Present results at winter grower meetings and in online publications.

HOW WILL YOU DISSEMINATE YOUR PROJECT RESULTS?
The proposed project is oriented toward supporting apple growers, and outreach materials will be geared toward that audience. Throughout the project, updates will be broadcast via existing outreach channels. These include a website (http://orchard.uvm.edu), YouTube channel (http://www.youtube.com/channel/UCWqkQRn17gChsTnV80zWSRw) and a grower email database that includes over 350 subscribers in Vermont and within the region. In winter 2013-2014, the UVM Apple Program is conducting a redesign of its communications platform to modernize its website (Bradshaw 2013) and to develop social media platforms via Facebook and Twitter; these platforms will also be used to publicize the project. The UVM Apple Program is highly-regarded by regional apple growers, with 75% of growers indicating that information provided by the program was useful or very useful in their overall farm management (Bradshaw and Berkett 2013). Beginning with the 2014 growing season, responsibility for the overall operations of the program are being transferred to Terence Bradshaw, with support from USDA E-IPM grants program. However, while electronic communications are important in dissemination of information to growers, results from field trials may best be seen by observing the plantings. In summer 2015, a grower field day will be held at the HRC site (funded by E-IPM grant), where this project will be presented. Final results from the project will also be presented at regional meetings in winter 2015 (e.g. Vermont Tree Fruit Growers Association annual meeting, New England Vegetable and Fruit Meeting).

WHAT ARE YOUR QUALIFICATIONS?
Terence Bradshaw, M.S., has worked with the UVM Apple team since 1995, presently as a Research Specialist and director of the UVM Horticulture Research Center, and has been President of Vermont Tree Fruit Growers Association since 2009. Past projects relevant to this proposal as collaborator, graduate student, or principal investigator have included:
• Research on potential reduction in fungicide use through adoption of apple scab-resistant cultivars (Merwin, Brown et al. 1994).
Crassweller et al. 2007, Hampson, McNew et al. 2007, Miller, McNew et al. 2007, Autio, Robinson et al. 2011)
• Assessment of horticultural and pest management impacts of a novel organic pest management product that showed promise to manage key pests previously though unmanageable with organic methods (Garcia, Berkett et al. 2002, Berkett, Garcia et al. 2005).
• Effects of organic kelp-derived biostimulant products on tree growth, crop yield, and pest incidence in organic orchards (Bradshaw, Berkett et al. 2013, Bradshaw, Berkett et al. 2013, Bradshaw, Berkett et al. 2013)

WHO ARE THE PROJECT’S COOPERATING FARMERS AND KEY COLLABORATORS?
The primary grower collaborator for this project is Ron Hackett, owner of Hackett’s orchard since 1967. The orchard is located on 50 acres in South Hero, VT in the unique Lake Champlain Islands growing region, and sells fruit primarily through its retail stand and as pick-your-own. The Hackett’s have completed farm transition planning through the Vermont Farm Viability Program and are in the process of transitioning management, and eventual ownership, to their children and grandchildren.
<table>
<thead>
<tr>
<th>Category</th>
<th>Line Item Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>Salary and wages</td>
<td>$4,868</td>
</tr>
<tr>
<td></td>
<td>Fringe</td>
<td>$2,128</td>
</tr>
<tr>
<td>Materials and Supplies</td>
<td>Spray materials</td>
<td>$500</td>
</tr>
<tr>
<td>Travel</td>
<td>PI travel to grower orchard</td>
<td>$137</td>
</tr>
<tr>
<td>Printing and Publications</td>
<td>None</td>
<td>$0</td>
</tr>
<tr>
<td>Other Direct Costs</td>
<td>Nematode Community Assessment</td>
<td>$5,250</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td>UVM F&amp;A</td>
<td>$1,431</td>
</tr>
<tr>
<td><strong>Total Request</strong></td>
<td></td>
<td><strong>$14,314</strong></td>
</tr>
</tbody>
</table>
## Budget Justification and Narrative

Enter narrative text and values in blank cells. Add rows and adjust row height as needed. Multi-year projects must complete a justification for each year. Subtotals (total for each major category, indicated as subtotal below) should be entered in the on-line application template under budget summary.

### Funding Categories / Item Name | Narrative justification of expense | Unit | Quantity | $ per unit | Quantity x $ =
---|---|---|---|---|---

#### Personnel:
Only persons employed by the recipient organization should be listed in this category. Those employed elsewhere would be listed under Other Direct Costs, as consultants or stipend payments, or if providing professional services or custom work, listed under services. If individuals are to be paid by another institution via a subcontracted portion of a project, they should be included in a separate subcontract budget and the subcontract total should be listed under Other Direct Costs.

#### Salaries and Wages
Show FTE and salary for each year or hourly wage times number of hours = [total $].

<table>
<thead>
<tr>
<th>Project Leader / Major Participants</th>
<th>5% FTE as Principal Investigator</th>
<th>FTE</th>
<th>.05</th>
<th>$ 47,965.00</th>
<th>$ 2,398.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terence Bradshaw, year 1</td>
<td>5% FTE as Principal Investigator</td>
<td>FTE</td>
<td>.05</td>
<td>$ 49,403.95</td>
<td>$ 2,470.20</td>
</tr>
</tbody>
</table>

#### Student Wages (Tuition Remission unallowable)

#### Support Staff

#### Other hired labor

Subtotal: Salaries and wages (rounded to the nearest dollar) $4,868

#### Fringe Benefits
If applicable, show the fringe rate and total of allowable fringe benefits.

<table>
<thead>
<tr>
<th>UVM benefit rate, 2014</th>
<th>.43</th>
<th>$ 2,398.25</th>
<th>$ 1,031.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVM benefit rate, 2015</td>
<td>.444</td>
<td>$ 2,470.20</td>
<td>$ 1,096.77</td>
</tr>
</tbody>
</table>

Subtotal: Fringe Benefits (rounded to the nearest dollar) $2,128

Personnel total (Salaries, hourly labor, and fringe benefits) $6,996

#### Non-Personnel:

##### Materials and Supplies
This could be anything from educational to field research supplies, but these items must be project specific and able to be tracked as being used for the project. General use items such as office supplies are usually not allowable; but if these items can be tracked and itemized for a project specific purpose, they would be allowed. Indicate the items with quantity and estimated costs. For items that are not typical materials and supplies, like specialized small equipment, a brief narrative or justification should be included on how the item fits the project and is needed, and is not otherwise available through the organization.

<table>
<thead>
<tr>
<th>Spray materials</th>
<th>Estimated costs quoted by CPS, Addison, VT</th>
<th>est</th>
<th>1</th>
<th>$ 500.00</th>
<th>$ 500.00</th>
</tr>
</thead>
</table>

Subtotal: Materials and Supplies (rounded to the nearest dollar) $500

#### Travel
destination, purpose, who is traveling, number of travelers, mileage (miles x rate [which cannot be more than the current federal rate]), lodging rate x # nights, and estimated cost per trip.

<table>
<thead>
<tr>
<th>Travel to Hackett's Orchard</th>
<th>Four trips from UVM to South Hero @ 30 miles ea.</th>
<th>miles</th>
<th>120</th>
<th>$ 0.570</th>
<th>$68.40</th>
</tr>
</thead>
<tbody>
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<td>Travel to Hackett's Orchard</td>
<td>Four trips from UVM to South Hero @ 30 miles ea.</td>
<td>miles</td>
<td>120</td>
<td>$ 0.570</td>
<td>$68.40</td>
</tr>
</tbody>
</table>

Subtotal: Travel (rounded to the nearest dollar) $137

#### Publications/Printing:
the publishing of an article in a scientific or technical journal or other type of field/program related publication or for commercial printing of brochures and program materials. Photocopying costs should be included under the Other Direct Costs category.

Subtotal: Publications (rounded to the nearest dollar) $-

---
<table>
<thead>
<tr>
<th>Other Direct Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communications - mailings, postage, conference calls.</strong> Cell phone charges are unallowable.</td>
</tr>
<tr>
<td><strong>Photocopying - In-house photocopying.</strong></td>
</tr>
<tr>
<td><strong>Consultants: name of consultant and consultant’s organization, statement of work, and breakdown of number of days of service, rate of pay, etc. Add attachment, if necessary.</strong></td>
</tr>
<tr>
<td><strong>Services: For non-contracted services rendered for the project. Provide details.</strong></td>
</tr>
<tr>
<td>Nematode analysis, Neher lab Quoted charges for 30 samples @ $175 each sample 30 $175.00 5,250.00</td>
</tr>
<tr>
<td><strong>Conferences/Meetings/Workshops: include rental of facilities, equipment for the meeting, fees for guest speakers, travel and per diem for participants and speakers. Costs for attending conferences should not be include here, but can be included under Travel.</strong></td>
</tr>
<tr>
<td><strong>Speaker / trainer: include name, fee, and description of the services they are providing.</strong></td>
</tr>
<tr>
<td><strong>Stipends: Provide information regarding the amount (rate of pay) and what the person is doing to earn the stipend. (These charges may be more appropriate under Speaker / Trainer Fees or Consultants.)</strong></td>
</tr>
<tr>
<td><strong>Off-site office rental: only allowable if necessary for a project specific purpose and this cost is not part of the organization’s indirect cost calculation</strong></td>
</tr>
<tr>
<td><strong>Land use charges</strong></td>
</tr>
<tr>
<td><strong>Fabrication of Equipment</strong></td>
</tr>
<tr>
<td><strong>Other / Miscellaneous: These costs must always be identified in order to be allowed.</strong></td>
</tr>
<tr>
<td><strong>Subcontracts (Please attach subcontractor's work proposal, budget summary, and budget justification/narrative.)</strong></td>
</tr>
<tr>
<td>Subtotal: Other Direct Costs (rounded to the nearest dollar) $5,250</td>
</tr>
<tr>
<td>Non-Personnel total $5,887</td>
</tr>
<tr>
<td>TOTAL DIRECT COSTS $12,883</td>
</tr>
<tr>
<td>Indirect Costs, if applicable; no more than 10% of Total SARE request * (use whole dollar amount, but do not round up if amount would be more than 10% of Total SARE Request) $1,431</td>
</tr>
<tr>
<td>TOTAL SARE Request $14,314</td>
</tr>
</tbody>
</table>

* The USDA/NIFA allowed rate for Partnership, Graduate Student, and Research and Education grants is a maximum of 10% of the total request, which can be estimated as 11.11% of direct costs. Only organizations with a federally negotiated indirect cost rate may claim indirect costs, up to their negotiated rate or 10% of requested funds, whichever is less. USDA/NIFA currently does not allow indirect cost recovery for Professional Development Program grants and State Program funding.

Form corrected 8-12-13
Cited References


To the review committee:

I would like to offer my full support and offer of collaboration to Terence Bradshaw’s proposed Northeast SARE Partnership Grants Project “Biological management of apple replant disease”. This project is important and timely for our farm and for other growers in our region who are adopting modern orchard planting systems in order to improve profitability, reduce chemical inputs, and improve the quality of life for our family and farm workers. We have recently participated in the Vermont Farm Viability Program as we plan to transition the farm to the next generation, and this process required an evaluation of the farm, including its plantings, infrastructure, and business practices. We identified as a top priority the need to replant some of our orchards, most of which are older, low-density, plantings that are not as efficient or productive as modern high-density orchards. This transition from older to more modern orchards is critical out children and grandchildren’s success with the farm.

In 2011, we installed a new block of trees on a replant site on our farm. Although we tried to mitigate the potential for replant problems by ripping the soil, removing all previous tree roots, and leaving the site fallow for two years prior to replanting, we are seeing symptoms of replant disease in the planting. Apple growers generally have limited land on which to rotate their orchards, and the reality is that most will replant on previous apple soil as we transition our orchards to modern systems. Preplant preparation will always be the best means to mitigate replant disease, but we also need post-planting alternatives that can help improve tree growth on affected sites. This project is promising in that it will field test commercially-available products that have been shown effective in limited studies on other crops. Therefore, positive results can be easily transferred to the farm level to help growers who are modernizing their orchards but must deal with replant problems. We are happy to host this trial as a test orchard, and enthusiastic to see its results.

Sincerely,

Ron Hackett