

# Maine Agricultural Center Integrated Research and Extension Projects: 2006–2007

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## **MAC74: Effects of Phosphorus on *Scaevola aemula* Quality, Morphology, and Foliar Nutrient Concentrations**

**Investigator(s): Stephanie Burnett, Donglin Zhang, Lois Berg Stack, Zhongqi He (consultant)**

### **Issue/Priority:**

Scaevola or fan flower is a popular annual that is usually grown in hanging baskets. Many ornamental plants, including scaevola, may not require as much phosphorus as greenhouse growers would apply using industry standard water soluble fertilizer formulations (i.e. 20-10-20).

Previous research (Zhang, Moran and Stack, 2004) indicates that scaevola produces optimum early growth with low phosphorus fertility. Excess phosphorus may be leached from greenhouse substrates and ultimately impact water quality. Crop specific fertilizer guidelines would reduce fertilizer waste, leaching of excess phosphorus, and ultimately, non-point source pollution.

Although previous research did examine the effects of phosphorus on scaevola growth (Zhang, Moran and Stack, 2004), growing medium pH was not controlled in that study. So, it was unclear whether scaevola growth was negatively impacted by phosphorus or pH. For this reason, it is essential to further research this problem in order to provide growers with specific, detailed fertilizer requirements so they may grow high quality scaevola hanging baskets and reduce fertilizer waste.

Therefore, the objectives of our research are:

1. Determine how scaevola growth and foliar nutrient concentration are affected by phosphorus under consistent pH in hydroponics.
2. Produce data that can be used as a basis for further research on the effects of phosphorus on scaevola growth in hanging baskets.
3. Develop fertilizer recommendations for commercial production of scaevola.

### **Project Description:**

Rooted cuttings of scaevola will be washed to remove growing media and transplanted into a hydroponics system. They will be grown in a modified, half-strength Hoagland solution (Hoagland and Arnon, 1950). Phosphorus ( $\text{NH}_4\text{H}_2\text{PO}_4$ ) will be added to Hoagland solutions at the following concentrations: 0, 20, 40, 60, or 80 mg·L<sup>-1</sup>. Ammonium will be added at appropriate concentrations as  $\text{NH}_4\text{Cl}$  so that the amount of ammonium in each container is equal. Plants will be grown hydroponically rather than in growing media to more easily isolate phosphorus. In addition, it will be easier to control pH in hydroponics which is essential since pH affects phosphorus availability.

Plants will be arranged in a randomized complete block design with four replications. One experimental unit will be a plastic container filled with Hoagland solution. Eight plants will be grown in each container. Every three weeks, two plants will be destructively harvested until there are no remaining plants. We will measure stem length, root and shoot dry weight and foliar nutrient concentration.

### **Sharing Outcomes:**

1. Determine appropriate phosphorus concentrations for scaevola growth in hydroponics
2. Use this information to further test scaevola's response to phosphorus in growing Media.
3. Develop and test a hydroponic system that may be used to evaluate nutrient requirements of other horticultural crops.
4. Results from this study will be shared with Maine bedding plant producers at an annual field day at Rogers Farm, Stillwater ME, in August 2006.
5. Results will be shared with New England's greenhouse industry at the New England Greenhouse Conference, Worcester MA, in November 2006.
6. Results will be published in a regional or national trade magazine.

## Termination Report

Our research objectives were:

1. Determine how scaevola growth and foliar nutrient concentration are affected by phosphorus under consistent pH in hydroponics.
2. Produce data that can be used as a basis for further research on the effects of phosphorus on scaevola growth in hanging baskets.
3. Develop fertilizer recommendations for commercial production of scaevola.

We met these objectives as follows:

1. Plants fertilized with either the highest ( $80 \text{ mg}\cdot\text{L}^{-1}$ ) or lowest ( $0 \text{ mg}\cdot\text{L}^{-1}$ ) phosphorus concentrations had significantly shorter stems, smaller shoot dry masses, and leaf areas than plants fertilized with  $20\text{-}60 \text{ mg}\cdot\text{L}^{-1}$ . Plants receiving no supplemental phosphorus had longer roots than those receiving any phosphorus and had greater root dry masses than plants receiving all other phosphorus concentrations except  $20 \text{ mg}\cdot\text{L}^{-1}$ . Foliar nutrient analysis indicated that phosphorus treatments significantly affected foliar concentrations of at least some essential macro- and micronutrients, but, concentrations of all essential elements except phosphorus were within or very near recommended ranges. Foliar phosphorus concentrations exceeded 1% in fan flower fertilized with even the lowest phosphorus concentration, but leaf chlorosis was only observed in plants grown in  $60\text{-}80 \text{ mg}\cdot\text{L}^{-1}$  phosphorus.
2. Future research should determine whether phosphorus concentrations lower than  $20 \text{ mg}\cdot\text{L}^{-1}$  P may be used in fan flower plant production. Further, it would be of interest to determine the mechanism behind this plant's phosphorus sensitivity.
3. Due to rapid accumulation of phosphorus in fan flower foliage and subsequent reductions in flower number and shoot elongation, fan flower should be fertilized with no more than  $20 \text{ mg}\cdot\text{L}^{-1}$  of phosphorus.

## Outcome Evaluation:

The outcomes of our project were:

1. We designed and built a hydroponic system for evaluating plant nutrition problems.
2. We used this system to develop phosphorus recommendations for fertilizing a popular specialty annual, fan flower.
3. Accurate phosphorus recommendations such as those developed for fan flower in this project will optimize plant growth, and minimize phosphorus over-use in commercial greenhouses throughout Maine. It is vital to use phosphorus efficiently since non-point source phosphorus pollution causes eutrophication in bodies of water.

## Integration of Research and Extension:

Commercial greenhouse growers commonly fertilize plants with water soluble fertilizers containing either balanced concentrations of nitrogen and  $\text{P}_2\text{O}_5$  or half the concentration of  $\text{P}_2\text{O}_5$  compared to nitrogen. Fan flower plants, which are a relatively new, but extremely popular ornamental plant, exhibited poor growth when fertilized using these 'standard' phosphorus concentrations. This research project was driven by grower interest in determining what phosphorus concentration is optimal for fertilization of fan flower plants.

Results from this project were shared with Maine greenhouse growers at a field day at Roger's Farm on August 28, 2008.

We've informed wholesale greenhouse producers of our research equipment and experimental design to advise them of its potential to address fertility problems of other crops.

**Publications:**

1. Burnett, S.E., D. Zhang, L.B. Stack, and Z. He. Effects of phosphorus on morphology and foliar nutrient concentrations of hydroponically-grown *Scaevola aemula* R. Br. 'Whirlwind Blue'. HortScience (Under Review).
2. Burnett, S., D. Zhang, L. Stack, and Z. He. 2007. Effects of phosphorus on morphology of *Scaevola aemula* R. Br. 'Whirlwind Blue'. HortScience 42:874 *Abstract*.

**Presentations:**

1. Effects of phosphorus on morphology of *Scaevola aemula* R. Br. 'Whirlwind Blue'. (Stephanie Burnett was presenting author with co-authors Donglin Zhang, Lois Stack, and Zhong-qi He). 2007. American Society for Horticultural Science Meeting, Scottsdale, Arizona.

**Non-technical research summary:**

*Scaevola aemula* or fan flower plants are specialty annuals that are popular for use in hanging baskets, mixed containers, or as a ground cover in landscapes. Fan flower plants are native to Western Australia where the soils are naturally phosphorus replete. Growers have observed that fan flower plants exhibit poor growth and flower development when they are fertilized with traditional rates of phosphorus that are often used to fertilize a wide variety of ornamental plants. Thus, our objective was to confirm grower observations and develop phosphorus recommendations for fan flower plants for commercial greenhouse growers. Fan flower plants were grown hydroponically in solutions containing 0, 20, 40, 60, or 80 ppm of phosphorus. Plants fertilized with no phosphorus had longer roots, but smaller shoots and fewer flowers compared to plants fertilized with 20 ppm phosphorus. But, plants fertilized with 60-80 ppm of phosphorus developed phosphorus toxicity symptoms and had shorter roots, poor shoot growth, and fewer flowers than plants fertilized with the lowest phosphorus concentration. Fan flower fertilized with more than 20 ppm of phosphorus had 'toxic' foliar concentrations of phosphorus. Thus, we recommend fertilizing scaevola with no more than 20 ppm of phosphorus.

## **MAC75: Effectiveness of Sodium Acid Sulfate (SAS) to Reduce Enzymatic Browning and Acrylamide Formation in Maine Potatoes**

**Principle Investigator(s): Beth Calder, L. Brian Perkins**

### **Issue/Priority:**

Enzymatic browning is considered to be one of the biggest challenges in maintaining quality of fresh produce (Whitaker and Lee, 1995) and is one of the most limiting factors on the shelf-life of fresh cut products (Garcia and Barrett, 2002). PPO (polyphenol oxidase), naturally occurring enzymes, are the major factor responsible for the browning of fresh-cut potatoes.

Enzymatic browning can be controlled by several chemical and physical methods, including the use of antibrowning agents such as acidulants. They are effective in controlling enzymatic browning in fresh cut produce. By lowering the pH, acidulants provide an acidic environment that slows the activity of PPO, thereby slowing the production of brown pigments.

Sodium acid sulfate (SAS), a new acidulant, received GRAS status in 1998. Not only does SAS effectively lower pH, but it can also be used as a leavening agent and processing aid in other food applications. SAS does not contain sulfites and should not be an issue with sensitivities to sulfites. Not only does SAS lower pH more effectively than citric acid, but it does not impart a sour taste to foods. Preliminary research conducted by Jones-Hamilton Co., manufacturer of SAS, has shown promising results in using SAS as an anti-browning agent for fresh-cut potatoes. At the current time, no research has investigated SAS's potential for fruit and vegetable applications to reduce enzymatic browning.

Acrylamide, a neurotoxic and potential cancer-causing agent, has been found in a wide range of fried, starchy foods, such as french fries. Recent research has shown that lowering the pH by citric acid dips has lowered acrylamide formation by 73-80% (Jung et al., 2003). The P.I. and collaborators would like to investigate the effectiveness of SAS treatments in lowering the acrylamide content of fried potatoes.

### **Project Description:**

The research will be conducted by Dr. Beth Calder at the University of Maine Department of Food Science and Human Nutrition at the new Pilot Plant facilities located in Hitchner Hall. The research will be supervised under the guidance of Dr. Alfred Bushway, Professor, Department of Food Science and Human Nutrition, who has 27 years of fruit and vegetable research experience. Benjamin Williams, Research Project Leader; Jones, Hamilton Co., Walbridge, Ohio, has agreed to provide direction and guidance as well to support this project. A work-study student will be hired to assist Dr. Calder and Dr. Perkins, which will also provide research experience for a University of Maine undergraduate student.

The experimental design to determine SAS's effectiveness will be to expose fresh-cut, cubed Maine potatoes to four concentrations of SAS dips (0, 2, 4, 6%) at three different contact times (2, 4, 6 minutes) at room temperature. Colormetric analyses will be conducted to measure the degree of browning as the change of L-value over contact time. Texture analyses will be performed to determine any potential changes in potato texture due to the proposed treatments or contact times. One-pound batches of potatoes will be packaged from each treatment/contact time and will be stored at 38-40 degrees F for 21 days. Microbial analyses will be performed at days 0, 3, 7, 14, and 21 to determine any changes in standard microbial plate counts, and the degree of browning will again be measured at these storage times to determine degree of browning over storage time.

Dr. Perkins will determine a method to detect acrylamide content in fried potatoes using GC or LC-MS. SAS-treated potatoes (using the same treatments previously mentioned) will be analyzed to determine if SAS is effective in reducing the acrylamide content of fried potatoes.

## Sharing Outcomes:

Dr. Calder intends to network with Maine potato processors as part of her Extension responsibilities. If the results are promising, Dr. Calder would share this new technology as part of her outreach, and also create a research bulletin for the potato industry. If SAS is a successful anti-browning agent, it may rival the whitening benefits of sulfites without the issues of potential food allergies or sensitivities, which would provide the Maine potato industry with an advantage in the fresh-cut market. The Maine potato industry may also use this research as a tremendous marketing advantage in selling healthier french fry slices containing a lower acrylamide content upon frying. The project findings and results intend to be published and also presented at the annual Institute of Food Technologists meeting in 2007.

## Objectives:

### Study one:

1. To determine the effectiveness of sodium acid sulfate (SAS) as an anti-browning agent for fresh-cut Maine potatoes.

### Study two:

2. To determine if sodium acid sulfate is effective in lowering the acrylamide content of fried potatoes.

## Significant Findings of Study One:

Three-percent SAS treatments had significantly ( $p < 0.05$ ) higher L-values at days 7 and 14 than all other treatments, which indicated SAS was more effective in maintaining a whiter fry color. SAS also seemed to retain better textural properties and had similarly low microbial counts compared to citric acid treatments during refrigerated storage. Preliminary results indicate that SAS is an effective browning inhibitor under refrigerated storage for a two week period compared to the control French fries that started to show signs of browning only hours after the fries were processed.

## Significant Findings of Study Two:

Similar to other published studies, our results indicate an overall trend of increased acrylamide formation as frying temperatures increase. At the lowest frying temperature (160 °C), both 3% SAS and citric acid treatments significantly ( $p < 0.05$ ) inhibited acrylamide formation. The most effective treatment appeared to be 3% SAS treated fries when fried at 160 °C. This treatment inhibited approximately 88% of acrylamide formation. Frying temperature appeared to be a strong factor in influencing the effectiveness of these acidulants. At the highest frying temperature (180 °C), neither acidulant appeared to work effectively, possibly due to the rapid rate of acrylamide formation surpassing the acidulants' inhibitory capacity. Overall, the preliminary results indicate that sodium acid sulfate is a more effective treatment in lowering acrylamide formation than citric acid.

## Research Outcomes:

The research outcomes have not been formally evaluated. We did attempt to provide outreach to a national company with a processing facility in Maine. However, we were not successful in our attempts to meet with this company in regards to discussing the implications of this research. Although preliminary results are promising, more research will be needed to perfect the optimal dip, time and product applications. More data will help justify to Maine processors and other food companies that this new acidulant, as a dip application, is effective for inhibiting enzymatic browning in fresh-cut potato products. Interest was generated at a poster presentation at the annual Institute of Food Technologist meeting in July-August 2007. Food industry consultants, industry and university researchers and also a mushroom company were interested in learning more information about the application of SAS to inhibit enzymatic browning in foods.

## Integration of Research Activities:

As the result of this grant, Dr. Brian Perkins and Dr. Rodney Bushway were able to fund a Ph.D. student to work on the acrylamide portion of this research project. Byungchul Kim has utilized an existing method to detect acrylamide formation in French fries as the result of this research. He is also interested in developing a new way of detecting

acrylamide formation in French fries by incorporating two existing GC-MS methods. This research opportunity has helped further graduate student research education and will be a part of Byungchul's dissertation.

### **Publications and Presentations:**

We intend to publish two papers from this research in 2008, with preference in publishing to the Journal of Food Science.

A research poster was presented based on the research of Study one at the annual & international Institute of Food Technologists (IFT) meeting in Chicago, IL in July-August 2007. The poster was displayed under the Fruits & Vegetable Products: Processing section.

Byungchul intends to present a research poster at the upcoming IFT meeting in 2008 in the acrylamide area of this research project.

### **Non-technical Summary of Research Work:**

Sodium acid sulfate or SAS has been approved by the FDA as a GRAS (generally recognized as safe) food additive. New research steps were conducted at the UMaine's Department of Food Science and Human Nutrition to examine the potential use of this food additive as a dip application to inhibit the browning of fresh-cut potatoes. SAS was compared to a control and citric acid, an industry standard. Maine Russet Burbank potatoes were processed into raw French fry slices and two studies were conducted. The first study focused on color, texture and microbial changes during refrigerated storage over time. The second study was to determine if SAS treated French fries had lower acrylamide formation during the frying process. Acrylamide is a potentially cancer-causing compound found in high levels of fried and oven baked foods.

Results from these studies indicate that SAS treated French fries maintained a whiter fry color and retained textural properties better than the other treatments over the refrigerated storage time. SAS also appeared to be more effective in inhibiting acrylamide formation better than the other treatments at lower frying temperatures. Results from these two preliminary studies appear promising to fruit and vegetable processors for a potential new dip application to prevent enzymatic browning.

## **MAC76: Cold Temperature Tolerance of Apple Rootstocks**

**Principle Investigator(s): Renae E. Moran, Donglin Zhang**

### **Issue/Priority:**

Winter injury to the root systems of fruit trees and other perennial plants causes significant losses and yield reductions in the northern regions of the United States and Canada. Following the 2004 winter, apple growers in Maine lost as many as 75% of their trees from winter injury to the roots (McAdam, Ricker and Wallingford, person communication). Lethal soil temperatures have occurred periodically in the northeast with the most recent tree losses occurring in 1979, 1981, 1992 and 2004 (Estabrook, 1981; Lord and Veneman, 1981; Privé and LeBlanc, 1999; Robinson et al., 2005). This type of winter injury occurs periodically in the northeast and is likely to occur again.

Injury occurs when there is insufficient snow to insulate the soil from severely cold air temperature causing soil temperature to drop as low as -17 °C (Wildung, 1973). In severe cases, injury to roots leads to tree death. Replanting is the only option when significant tree losses occur (15% or more), causing substantial financial losses for the grower. Milder injury, although not lethal, reduces profitability because of stunted tree growth, yield reductions and small fruit size.

The roots are the least cold tolerant portion of the tree with the level of hardiness level ranging from -7 to -12 °C in apple (Embree, 1988; Wildung, 1973). Most commercial orchards in the US are planted to tender Malling rootstocks which lack cold tolerance compared to other rootstocks (Embree 1988; Robinson, 2005). Several rootstocks with potentially greater cold tolerance have recently become available for commercial production, but their level of hardiness has not been systematically evaluated. Controlled studies are needed to determine the level of cold hardiness in the root tissues of Geneva rootstocks.

### **Project Description:**

Ungrafted rootstocks, purchased from a commercial nursery, will be planted outdoors at a spacing of two feet in spring 2006. In November, trees will be dug up and roots washed. Rootstocks will be wrapped in plastic and placed in cold storage at a temperature of 0 °C until analysis in December. Injury of four rootstocks, M.26, G.30, G.16 and G.5935, will be compared following exposure to temperatures ranging from -8 to -20 °C. These rootstocks have been released for commercial production and are now available to growers.

Freezing of whole plants will be conducted using a programmable freezer (LoCold Freezer 40-914, ScienTemp, Adrian, MI). An initial test will be conducted to determine the range of temperatures needed for lethal injury. The amount of root damage will be measured by separating living and dead root tissue for dry weight analysis. An additional set of trees will be planted in pots and placed in a heated greenhouse to assess recovery from injury based on the amount of shoot and root growth after four months.

### **Sharing Outcomes:**

This project will identify cold hardy rootstocks that are suitable for commercial production. Results of this project will be used to develop a recommendation for Maine apple growers. Fewer tree losses and greater productivity following winters with cold soil temperatures will be the outcome of this project.

Results will be communicated to growers through an article in Fruit Notes and at the Highmoor Farm Summer Tour. Results will be communicated to other extension specialists and researchers at scientific meetings (American Society for Horticultural Science Annual Conference), and through a peer reviewed article in HortScience.

## **Termination Report**

### **Summary:**

G.16 and G.5935 were as cold hardy as M.26, a widely planted apple rootstock. Significant root death (>10%) occurred at temperatures of -12 °C (10 °F) in all three rootstocks. Tree growth of G.16, G.5935 and M.26 was reduced by



exposure to temperatures of -10 °C and below, but not by -8 °C. Tree growth was severely stunted by exposure to -14 °C. Most of the trees did not survive exposure to -12 °C or below.

**Objectives That Were Met and Significant Findings:**

G.16 is winter hardy to -10 °C and is as hardy as M.26, a popular rootstock widely used by the apple industry in Maine.

**Objectives That Were Not Met:**

Testing the level of cold hardiness in the rootstock G.30 was not completed because the nursery did not supply any trees of this type. Testing of G.5935 was incomplete because an insufficient number was supplied by the nursery. Testing of G.5935 will continue in 2008.

**Methods Used to Evaluate Outcomes:**

Surveys will be conducted to measure the number of growers using winter hardy rootstocks.

**Integrated Research and Extension Activities:**

Results from this project will be incorporated into publications and verbal recommendations for new apple plantings.

**Publications, Presentations and Other Outputs:**

Future presentations will be made at local meetings with the industry.

## **MAC77: Beef Bedding Trial**

**Principal Investigator(s): Dee Potter**

### **Issue/Priority:**

It is well documented that maintenance requirements for cattle on feed can be 15% lower if their hides and hair coats are clean. Also, there is lower incidence of calf scours and illness in animals housed in a clean environment. Providing adequate space and bedding is how animals are kept clean and managed. Typical bedding material used in Maine is straw, sawdust and wood shavings. All of these materials are expensive (cost of shavings is \$40/ton plus trucking) and depending upon location, there is strong competition for bedding materials which keeps them in short supply. The challenge to livestock producers becomes access to a constant, affordable supply of bedding materials for their animals.

A new possible bedding material has been identified. This project is a proposal to evaluate short paper fiber (SPF) as a material for livestock bedding. Short paper fiber (SPF) is a by-product of the paper making industry. It is available from paper mills throughout the state. Here in Maine, SPF has been researched for its properties as a soil conditioner, surface mulch and liming agent (Jemison and Reberg-Horton, 2003 UMCE factsheet). Along with its soil amendment properties, the dry matter of SPF is similar to sawdust, allowing it to absorb urine and manure. It has a higher pH than wood shavings which has positive implications for landspreading on pastures and other agronomic crops. It is also relatively high in organic matter and unlike wood shavings does not require nitrogen to breakdown which also adds to its potential as a soil amendment. This project proposes conducting an on farm trial using SPF as a bedding material. The trial will compare SPF to the traditional bedding material of sawdust and wood shavings. The evaluation will include both the bedding properties of SPF from a management and animal use perspective as well as its nutritive and soil amendment properties once used as bedding. Extensive analysis will be done to determine levels of metals and other contaminants, assuring a safe and environmentally sound material. Currently SPF that is not land spread is disposed of by incineration and landfills. Finding an alternative use for SPF will help reduce it from the waste stream.

### **Project Description:**

The project will be conducted as an on farm trial that will compare bedding properties of SPF to wood shavings. The trial will be comparative in nature. Three different bedding packs will be established, a traditional wood shavings pack, a 50/50 wood shavings to SPF pack and a straight SPF pack. During the course of the winter while animals are bedding each pack will be assessed for properties of water absorption, handling ease/limitations, duration of pack and costs. In the spring each pack will be analyzed for organic matter, dry matter, pH and nutrient content prior to land spreading. Issues around land application of the bedding materials will also be documented.

### **Sharing Outcomes:**

Results will be presented at Maine's annual beef conference. A report of the findings will be published and printed in periodicals and publications read by producers. The trial summary results will also be made available through the Extension livestock web site.

As a residuals management company Synagro will be instrumental in working with the paper mills and acquiring SPF for the trial. Additional cooperators will include producers running the bedding trial, who are yet to be determined.

### **Termination Report**

Project did not materialize, no expenses occurred.

## **MAC78: Evaluation of Resistance to Lily Leaf Beetle in *Lilium* spp. Cultivars**

**Investigators: Eleanor Groden, Lois Berg Stack**

### **Issue/Priority:**

Garden lilies (*Lilium* species and hybrids) are a popular and irreplaceable addition to gardeners' summer and early fall perennial gardens. They are also an important commercial commodity for bulb vendors, garden centers, landscapers and landscape gardeners. With many cultivars to choose from, commercial growers market a variety of flower colors and plant habits and sizes. However, an invasive beetle threatens the use of both native and exotic lilies in our region.

The lily leaf beetle (LLB), *Lilioceris lili* Scapoli, is a serious pest of native and exotic lilies throughout New England. Native to Europe, LLB was introduced to the eastern U.S. in 1992 and first appeared in southern Maine in 1997. Since then, it has steadily moved northward and is currently a limiting factor in lily growth and production in central Maine. Larvae and adult beetles attack all above-ground plant parts and defoliation reduces plant vigor and flowering, and greatly diminishes the aesthetic quality of the plant. Insecticides are registered for LLB control, but limited work has been conducted to determine alternative LLB management strategies that may be more environmentally sustainable. An important tactic in Integrated Pest Management (IPM) to reduce dependence on pesticides is the use of insect resistant/tolerant plants. To date, limited studies have been conducted on resistance or tolerance of lily cultivars for LLB.

A preliminary investigation of LLB resistance/tolerance in the Oriental lily cultivar 'Black Beauty' was conducted by researchers at the University of Rhode Island, who found a lower survival rate of larvae compared to the control. Anecdotal reports of lily resistance to LLB are also reported. We propose to evaluate ten hybrid lily cultivars to determine levels of host resistance that could provide a first defense tactic in an overall IPM strategy for gardeners and commercial growers.

### **Project Description:**

Ten lily hybrids will be selected for study in a no-choice experiment designed to assess the level of feeding, egg-laying and survival of LLB. Lily bulbs will be potted in spring for production of sufficient foliage for beetle colonization in early summer. Cages will be built to accommodate two potted lilies of the same hybrid in each cage. There will be two replicate cages per hybrid. Caged plants will be maintained outside under ambient conditions and watered and fertilized regularly. LLB adults will be collected in late spring as they colonize local lily plantings in the Bangor area (the PI's are aware of a number of sites where beetles have been a problem in the past two years). Male and female beetles will be paired and placed in Petri dishes with lily foliage and held in growth chambers to allow for mating and initial egg laying. As soon as eggs begin to be laid, three mated pairs of LLB adults will be removed from the dishes and placed on the lily foliage inside each cage. After 4-5 days, adults will be removed and all eggs will be counted on plants. Regular observations will be made to determine egg hatch, the number of larvae and their stage of development (first through fourth instars), pupation and adult emergence. Visual relative defoliation ratings will be made once in mid-summer and again at the end of the experiment after adult emergence.

### **Sharing Outcomes:**

Research findings and management recommendations resulting from this study will be shared in the following ways:

- Presentation at the UM Cooperative Extension Field Day for Home Gardeners, Rogers Farm (Stillwater ME), August 19, 2006.
- Presentation to greenhouse, nursery and garden center professionals at mid-August 2006 field day at Rogers Farm.
- Sign discussing lily leaf beetle projects in the Penobscot County Master Gardener Demonstration Garden at Rogers Farm.
- Poster at the Maine Landscape and Nursery Association (MeLNA) Annual Meeting, January 2007.

If this project and related LLB projects yield data that are useful for commercial growers, garden centers, landscapers and home gardeners, a fact sheet sharing those results will be developed and distributed (beyond the scope of this proposed project).

## **Termination Report**

Project investigators received funds in 2006 to evaluate lily cultivar resistance to lily leaf beetle (LLB), a serious invasive garden pest for homeowners, commercial growers and landscapers. Our long-term research goal is to reduce pesticide use on garden lilies by incorporating host plant resistance into an Integrated Pest Management strategy. This project's objectives were two-fold:

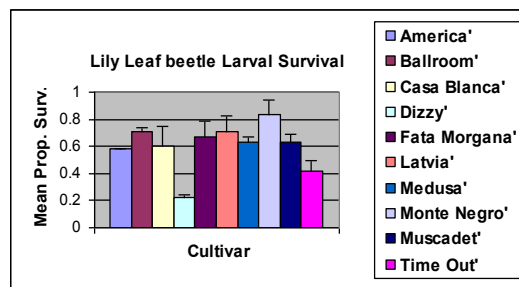
- 1) To evaluate ten commercially popular and available lily hybrids for resistance to LLB feeding and LLB adult and larval survival; and
- 2) To report to home gardeners and commercial growers findings on lily host plant resistance to LLB.

## **Research Methods**

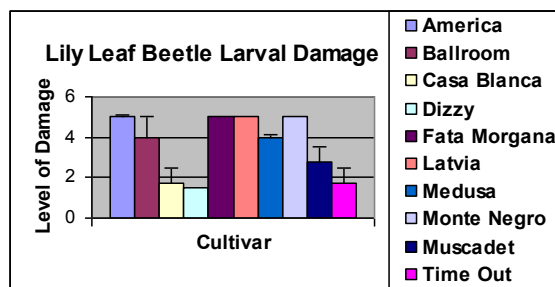
Ten lily cultivars were selected in a study designed to assess LLB egg-laying and larval survival, and feeding damage caused by LLB larvae and adults. The list of lilies included four Asiatic hybrids ('America', 'Fata Morgana', 'Latvia', and 'Monte Negro'); five Oriental hybrids ('Casa Blanca', 'Dizzy', 'Medusa', 'Muscadet' and 'Time Out'); and one LA hybrid, 'Ballroom'. Lily plants were purchased from a local nursery. Cages were constructed to accommodate two potted lilies of the same hybrid in each cage. There were two replicate cages per hybrid. Plants were maintained outside under ambient conditions and watered and fertilized as needed. LLB adults were collected in late spring as they colonized local lily plantings in the Bangor area. Male and female beetles were paired and placed in Petri dishes with lily foliage for mating and initial egg laying. As soon as eggs were laid, three mated pairs of LLB adults were removed from the dishes and placed on the lily foliage inside each cage. After five days, adults were removed and all eggs were counted. Subsequent weekly observations determined egg hatch, number of larvae and stage of development (first through fourth instars), pupation and adult emergence. Visual relative defoliation ratings were made once in mid summer and again after adult emergence.

## **Results and Discussion**

All Asiatic lily cultivars were preferred hosts for LLB development and feeding. Mean proportional larval survival at peak density was greatest in the Asiatic cultivars. The Oriental cultivars 'Dizzy' and 'Time Out' had significantly lower LLB survival (Fig.1). The Oriental cultivars 'Casa Blanca', 'Time Out' and 'Dizzy' had significantly lower larval feeding damage, with 'Dizzy' exhibiting the least foliar damage of all types (Fig.2). These results suggest that Asiatic hybrids are highly susceptible to LLB. Consequently, timely controls are required to maintain plant health and aesthetic quality. Overall, Oriental hybrids are less susceptible, and there is considerable variation among cultivars. 'Dizzy' and 'Time Out' exhibit possible resistance to larval development and feeding. Our work encourages further testing of these cultivars and others with similar parentage, as well as various native species. This study should be considered a preliminary research effort. As a matter of culture, all commercial bulb growers (the majority of which are in Holland) dip lily bulbs after field digging and before shipping to brokers with the systemic insecticide imidacloprid. The residual effect of this material may have implications for accurately assessing resistance in various types of lilies. Additional studies are required to assess levels of imidacloprid in bulbs and its effect on LLB larval survival and influence on plant responses.



**Fig. 1.** Mean proportional survival from egg to peak larval densities on selected Oriental and Asiatic hybrid lily cultivars.



**Fig. 2.** Relative damage estimates of selected Oriental and Asiatic hybrid lily cultivars. Range: 1 = no damage to 5 = complete defoliation

### Additional Related Grant Funding

We received our second research and extension grant in January 2007 from New England Floriculture, Inc., to fund our project titled: "Biological Control of the Lily Leaf Beetle (*Lilioceris lili*) in Maine". This cooperative research project with the University of Rhode Island, evaluating wasp parasitoids for biological control of LLB, is in progress at various local sites (Rogers Farm, Witter Center, UM campus). We received a Northeast IPM Center grant in February 2007, to partially fund our project titled: "Lily Host Resistance to Lily Leaf Beetle."

### Extension Education and Outreach Activities

We shared results of our 2006 study through these industry and home gardener presentations:

- Stack, P.A., E. Groden, R. Casagrande, L. Tewksbury and L.B. Stack. Dec. 2006. (Poster) Research investigations for management of lily leaf beetle (*Lilioceris lili*). Invasive Plants Workshop for Maine's Green Industry. Portland, ME
- Stack, P.A. Nov. 2006. Biological control of lily leaf beetle. (Lecture) UM's Page Farm and Home Museum, Orono, ME
- Stack, P.A. Aug. 2006. Meet the beetles. (Workshop) A Garden Gathering. UM's Rogers Farm, Stillwater, ME
- Stack, P.A. April 2006. Lily leaf beetle research. (Entomology-HRT-121 Lecture) Southern Maine Community College, So. Portland, ME

Participants at these events were enthusiastic about our work toward non chemical LLB management. In 2006, we collaborated with University of Rhode Island entomologists on biological control of LLB using Hymenopteran parasitoids. Together, these lines of research form a potential IPM strategy benefiting the New England region.

## **MAC79: Maine Berries as Natural Preservatives and the Consumer Acceptability**

**Principal Investigator(s): Vivian Chi-Hua Wu, Alfred Bushway, Mary Ellen Camire,**

### **Issue/Priority:**

Concerns about the use of chemical antimicrobial agents in food products have been raised in the general public for the past decade. The demand for both more natural foods and greater convenience has caused the search for alternative antimicrobial agents by researchers in the food industry and in academic. The Maine wild blueberry and cranberry industries are in advance in the research of utilizing natural ingredients to promote food safety. The natural compounds extracted from wild blueberries and cranberries, such as phenolics (ex. hydroxycinnamates, chlorogenic acid, etc.) and anthocyanins, provide a new source of antioxidants and antimicrobial substances. With the support by the Maine Agriculture Center, we have investigated the synergistic antimicrobial effects of cranberries and wild blueberries for foodborne pathogens (*Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella* Typhimurium, and *Staphylococcus aureus*). Results showed that while no reduction of pathogens was observed in pure distilled water at 7 °C and 21 °C, significant bactericidal effects of berry concentrate mixture were observed. Starting from 7 h, no *L. monocytogenes* were recovered from the treatments at both 7 °C and 21 °C. BHI data indicated that the growth of all pathogens tested was reduced (4 to 9 log CFU/ml difference) compared to the negative control at both temperatures. The synergistic effects of cranberries and blueberries have not only health benefits but significant antimicrobial effects. It can be considered for food applications, and will allow the food industry to utilize these valuable natural ingredients and to use them as “natural” preservatives in food to control foodborne pathogens. The successful outcomes will be very helpful for food industry and general consumers nationally and internationally. It will also increase sale of wild blueberries produced in Maine.

In this project, we propose to study the consumer acceptability of ground beef products added with natural preservatives, the Maine berries (wild blueberries and cranberries). The utilization of the fullest antimicrobial properties of Maine wild blueberries and cranberries in this project will promote Maine’s products with multiple functions and will allow the food industry to utilize the most effective natural ingredients to control foodborne pathogens. It can be further applied into other food products to improve the safety and quality of products. The proposed research will be integrated with extension and outreach programs to promote Maine agriculture products and monitor food safety. The successful outcomes will be very helpful for food industry and general consumers nationally and internationally.

### **Project Description:**

We will use the cranberry concentrate and the berry concentrate mixture [5% (v/v) blueberry and 5% cranberry concentrate] which contain antimicrobial properties as natural preservatives in ground beef products. Ground beef patties (90% lean) will be added with the cranberry concentrate or the berry concentrate mixture and cooked in electric skillets to internal temperature around 71°C (160°F). To prevent cross contamination, treatment and control will be cooked in different skillets. 1.27cm<sup>2</sup> will be served to panelists during the sensory evaluation.

Two acceptability tests with about 50 consumers each time from the Bangor/Orono community will be held. Consumers will be presented with four samples each time (cooked ground beef patties added with 0, 2.5, 5, and 7.5% cranberry concentrates or berry mixtures). The nine-point hedonic scale (1 = dislike extremely, 9 = like extremely) will be used for color, flavor, texture and overall acceptability.

Two focus groups to determine coloring and nutritional expectations of potential consumers will be held. Each focus group will consist of 12 members of the local community who would be interested in buying berry-ground-beef patties. Focus group members will be recruited via the First Class campus computer conferencing system and campus press releases. One focus group will consist of young adults of 18-25 year old who participate in outdoor activities. The other group will consist of adults aged 30-55 who are trying to increase their consumption of healthy food. Focus group participants will be asked for their opinions on nutritional, color and characteristics of the proposed product.

## Sharing Outcomes:

It is expected that our study on consumer acceptability of berry-added ground beef products will promote Maine wild blueberries and cranberries with the multiple functionalities to national and international markets. The natural ingredients from wild blueberries and cranberries can be used as natural additives to control foodborne pathogens.

The outcomes of the project will be shared through extension and outreach activities. The results will also be presented in national and international meetings and published in scientific refereed journals, where MAC will be acknowledged. The outcomes are specially expected to benefit local, regional, and state agriculture and the food industry.

## Termination Report

### Objectives Made:

1. To study consumer acceptability of ground beef products naturally preserved by Maine wild blueberries and cranberries.

Concerns about the use of chemical antimicrobial agents in food products have been raised in the general public for the past decade. The demand for both more natural foods and greater convenience has caused the search for alternative antimicrobial agents by researchers in the food industry and in academic. The Maine wild blueberry and cranberry industries are in advance in the research of utilizing natural ingredients to promote food safety. The natural compounds extracted from wild blueberries and cranberries, such as phenolics (ex. hydroxycinnamates, chlorogenic acid, etc.) and anthocyanins, provide a new source of antioxidants and antimicrobial substances. With the support by the Maine Agriculture Center, we have previously discovered the synergistic antimicrobial effects of cranberries and wild blueberries for foodborne pathogens. In this project, we studied the consumer acceptability of ground beef products added with natural preservatives, the Maine berries (wild blueberries and cranberries). Ground beef combined with cranberry and blueberry concentrate (0%, 2.5%, 5%, and 7.5%) were evaluated by panelists at the University of Maine Consumer Testing Center. Results showed burgers with 2.5% and 5% had no significant differences from control burgers (0% cranberry concentrate) in appearance, flavor, and texture, and overall acceptability. Burgers with cranberry concentrate and blueberry concentrate (2.5%) had the highest score and were liked moderately by panelists. Considering the antimicrobial effects and other health benefits of cranberries and blueberries, burgers supplemented with berry mixture may be a potential safe and healthy product preferred by consumers.

2. To provide outreach activities with Maine wild blueberry industry and Maine cranberry industry in developing multiple functions of Maine wild blueberries and cranberries as well as expanding the markets.

The synergistic effects of cranberries and blueberries have not only health benefits but significant antimicrobial effects. It can be considered for food applications, and will allow the food industry to utilize these valuable natural ingredients and to use them as "natural" preservatives in food to control foodborne pathogens. The P.I. has received significant attention and contact from the food industry, media/press, and consumers regarding the antimicrobial properties of cranberries/blueberries and the application of natural preservatives to food products. The P.I. was recently interviewed by the Wall Street Journal on her natural antimicrobial research utilizing Maine berries.

The P.I. was also interviewed by many other media/press regarding her research finding in sharing the outcomes and benefits of her research finding to the public. Outreach activities are conducted with Maine wild blueberry industry, Wild Blueberry Association of North America, Cranberry Institute, Ocean Spray in promoting blueberries and cranberries. Information is also shared with the food industry through international meetings and presentations at state, national and international conferences. Our berry research has attracted significant attention and interests from people and industries all over the world. Results of this research will be made available to Dr. Beth Calder, the Food Science Extension Specialist and Dr. Al Bushway (extension appointment).



### Methods Used to Evaluate Outcomes:

Among the methods of evaluating outcomes to be used are request for assistance, presentations in national and international meetings, invited presentation by the berry industry, interviews by the media/press and publications in scientific journals.

### Integration of Research and Extension Activities:

The outcomes of the research project are shared through extension, outreach activities and interactions with the food industry. Our positive results from consumer acceptability of berry-added ground beef products promote Maine wild blueberries and cranberries with the multiple functionalities to national and international markets. The natural ingredients from wild blueberries and cranberries can be used as natural additives to control foodborne pathogens. The P.I. has received significant attention and contact from the food industry, media/press, and consumers regarding the antimicrobial properties of cranberries/blueberries and the application of natural preservatives to food products. The P.I. was recently interviewed by the Wall Street Journal on her natural antimicrobial research utilizing Maine berries. The P.I. was also interviewed by many other media/press regarding her research finding to share the outcomes and benefits of her research finding to the public. Outreach activities are conducted with Maine wild blueberry industry, Wild Blueberry Association of North America, Cranberry Institute, Ocean Spray in promoting blueberries and cranberries. The results have also been presented in international meetings and will be published in refereed scientific journals. The outcomes are specially expected to benefit local, regional, and state.

### Outputs:

- Qiu, Xs. and V.C.H., Wu\*. 2007. Evaluation of Escherichia coli O157:H7, Listeria monocytogenes, Salmonella Typhimurium, and Staphylococcus aureus in ground beef with cranberry concentrate by Thin Agar Layer Method. J. Rapid Methods and Auto. in Microbiol. 15 (3). 280-292.
- Qiu, Xs. and V.C.H., Wu\*. 2007. The potential application of cranberry concentrate to control Escherichia coli O157:H7 in ground beef. Abstract publication. Poster Presentation. IFT annual meeting. Chicago, IL.
- Wu, V.C.H. Aug 15, 2007. The Potential Application of Cranberry Concentrate as a Natural Preservative to Protect Human Health against Food Poisoning. Invited Presentation. Ocean Spr
- ay, Lakeville-Middleboro, MA.
- Wu, V.C.H. March 27, 2007. Microbial Control and Antimicrobial Properties Study for Maine Wild Blueberries. Presentation. Wild Blueberry Research Advisory Committee. Maine.
- Wu, V.C.H. Nov. 8, 2006. Microbial Control and Antimicrobial Properties Study for Maine Wild Blueberries. Presentation. Wild Blueberry Research Advisory Committee. Orono, Maine.
- Wu, V.C.H. Oct. 25, 2006. The Potential Application of Cranberry Concentrate as a Natural Preservative in Food. Invited Presentation. Cranberry Health Conference/Cranberry Institute. Charleston, SC.
- Wu, V.C.H. interviewed by media/press such as Wall Street Journal, Direct TV , Obesity, Fitness & Wellness Week, Biotech Week, Science Letter, Pharma Business Week, Life Science Weekly, Health & Medicine Week, Gastroenterology Week, Toronto News release, Boston.com, Associated Content.com, FEAST, Food Naigator.com, Zhenjiang Daily, Radio interviews.



## **MAC 80: Extension and Research Needs of Maine's Medicinal Herb Industry**

**Principal Investigator(s):** Mary Ellen Camire and Beth Calder

### **Issue/Priority:**

Maine has an abundance of native plants used for healing purposes. Many farms grow medicinal herbs, both native and imported, but the industry itself is not yet mature. Since the passage of the landmark U.S. legislation Dietary Supplement Health and Education Act of 1994 (DSHEA), consumer and producer interest in medicinal plants have grown. DSHEA ruled that herbal dietary supplements are considered foods, and specified labeling and claim requirements that are quite different than those required for foods and drugs. PI Camire has extensive experience in dietary supplement labeling and regulations.

The Maine ginseng growers have formed an association, but otherwise Maine herb growers are not organized as a state-wide industry. Many farms are organic and are members of the Maine Organic Farmers and Gardeners Association (MOFGA). The Department of Food Science and Human Nutrition has provided technical assistance in the form of chemical analyses, *in vitro* assays of herb functionality, and human clinical trials to establish efficacy for several Maine companies and for the ginseng growers group. Thus far, however, this assistance has been initiated by the growers and no comprehensive plan for assisting this industry has been developed within the Department. An improved understanding of the needs of herb growers, distributors and processors will enable faculty to develop research and extension programs that allow Maine businesses to grow without concern for intervention from the U.S. Food and Drug Administration and Federal Trade Commission. Among the services we anticipate will be needed are workshops on dietary supplement labeling requirements, optimization of herb extraction processes, design of human clinical trials, and assistance with preparation of SBIR and STTR proposals.

### **Project Description:**

A pilot survey will be created with Websurveyor software during the summer of 2006 with the assistance of industry leaders. The pilot survey will be pre-tested with UM extension, horticulture and food science faculty and staff. The actual survey will be made available in the fall of 2006 after harvest is largely completed to ensure the highest possible participation rate by industry members. Letters of invitation will be mailed to all growers, distributors and processors identified by MOFGA, the Maine Ginseng Growers Association, the Maine Department of Agriculture, Internet searches, and word-of-mouth. The website for the on-line survey will be available for one month. Interested participants who do not have Internet access will be provided with locations that have free Internet access or paper copies of the survey will be mailed to them and added to the database by the investigators. The software will tabulate submissions, reducing staff time in report generation. Findings of the survey will be presented at a MOFGA members meeting, and at other opportunities in the state to be determined. Once a list of needs has been generated, a second survey will be created to prioritize needs. This project has a broader scope of interest, thus we are also requesting funds to present the project's results at the 2007 Institute of Food Technologists (IFT) annual meeting in Chicago, Illinois. Findings will be used to develop a proposal to the Maine Technology Institute to implement the services identified as most needed by the industry.

Mary Ellen Camire will create and maintain the surveys, submit an application to conduct research with human subjects as required, and perform statistical analyses of the survey data. Beth Calder will help identify persons to participate in the pre-test as well as businesses eligible for the survey. Both investigators will disseminate survey results.

### **Sharing Outcomes:**

We expect that growers will want more information about marketing, processing, and distribution and that processors will want more assistance with labeling and supplement claims. We hope to secure a grant from MTI to finance the activities most needed by the Maine herb industry. A press release will be written describing the survey during the recruitment phase, and a second press release will be issued with survey findings. The long-term outcome should be increased profitability for herb growers and processors in Maine.

**Termination Report**

We designed a web-based survey, but had poor (N=4) response. A paper ballot will be mailed to herb producers later this year using the same ballot questions. The Maine Organic Farmers and Gardeners Association has been supportive of the project and mentioned the project in its annual newsletter as an indication of the University's support for the association.

## **MAC81: Evaluating Bt Corn for Yield and Silage Quality**

**Investigator(s):** John M. Jemison Jr. and Lauchlin Titus

### **Introduction:**

In 1998, the Monsanto Corporation requested the Maine Board of Pesticides Control (BPC) to approve the use of a genetically engineered (GE) corn designed to produce bacillus thuringiensis (Bt) to reduce the impact of European corn borer (ECB). The Bt corn hybrid was engineered to produce a specific “event” protein Cry1Ab in all plant cells, such that when an ECB ate the corn stalk, the protein would cause crystals to form in the gut, and the ECB would stop feeding and die. The BPC had previously approved the use of Bt potatoes primarily to control Colorado potato beetles because of the potential reduction in the use of more harmful pesticides. Although the GE potatoes were not overly commercially successful due to a number of problems, in most corn growing states, Bt corn was found to be reasonably successful. The greater the ECB pressure, the greater the difference in yield. The benefits were principally found with grain corn. The registrants tried to use this information to sway the BPC to approve Bt corn. However, concern over the potential loss of effectiveness of surface applied Bt for organic growers (due to resistance), and the fact that growers were not treating silage corn for ECB control, the BPC denied the registration. The BPC requested further study to evaluate some of these hybrids during the 1998 season to determine their utility. The researchers did not find significant benefit with the hybrids, and since this time there have been no further applications brought before the BPC for approval.

Over the past eight years, the industry has released different genetically engineered (GE) “events”, a term used to describe a novel protein combination designed to effect a reaction in a plant. In addition to Roundup-ready corn and soybeans (which do not require a board-approved registration) and the Cry 1Ab standard Bt corn, Monsanto, Dow Chemical, and Syngenta have developed other events to broaden the scope of control these plants offer growers. Included in these are the Cry 1F lines which provide control of European Corn Borer (ECB), Southwestern corn borer (SWCB), black cutworm, and fall armyworm. In 2003, the EPA approved several other events (Cry 3Bb1, and the first “stacked” Bt lines (Cry 3Bb1 + Cry 1Ab). Since this time, other multiply stacked lines have been approved that read like a veritable alphabet soup. These new lines provide growers with rootworm, corn borer, black cutworm, fall armyworm, western bean cutworm, and corn earworm suppression. Many of our larger growers, particularly those who are land limited, want to be able to use these lines.

There are advantages and disadvantages to Bt corn lines. Potential advantages include: 1) reduced exposure to insecticides used to control ECB or cutworms; 2) improved timing due to constant activity within the plant; 3) potentially improved compatibility with biological control systems and less non-target insect damage as broad-spectrum chemical application is reduced; 4) improved silage quality due to lower mycotoxin contamination; and 5) less pest monitoring is needed. Potential disadvantages include: 1) increased seed corn costs; 2) benefits occur if insect populations are present; 3) increased risk of issues with organic producers; 4) development of resistance to Bt if refugia label requirements are ignored; and 5) variation in second generation insect effectiveness (Bessin, 2004).

Many studies have been conducted to evaluate the agronomic benefits of Bt hybrids, and results have been varied. Some studies evaluating grain corn have been positive (Graeber et al., 1999; Lauer and Wedberg, 1999), while others like Ma and Subedi (2005) recently found yield benefits only when there was significant stalk lodging and breakage.

To date, most of the benefits in terms of reduced pesticide use have been found in the Bt crop lines (Benbrook, 2003). Herbicide resistant lines have generally increased pesticide use. While dairy farmers who grow corn still do not spray for ECB, they commonly spray for cutworms. The presence of mycotoxins in silage feed is also a concern as cow milk production can drop. Over the years that Lauchlin and I have evaluated corn fields in Maine, we have seen occasional significant ECB and some rootworm damage. With climatic variability expected to continue, if not increase, we can likely expect more insect issues in the future. To effectively answer growers’ questions about the benefits of Bt corn, we would like to conduct an intensive evaluation of different Bt corn lines and their non-GE isolines that are currently being grown in neighboring states. It would be particularly useful to evaluate these fields with regular crop rotation as

well as those in continuous corn. We propose to conduct a trial in at least two locations comparing a minimum of three Bt lines compared to their non-Bt isolines.

### Goals and Objectives:

1. Goal 1. To help guide future BPC decision-making, provide the BPC useful information about effectiveness of Bt corn for Maine growers.
  - Objective 1a. Determine yield of three Bt corn hybrids and their non-GE isolines in fields which have been in continuous corn and fields with corn as part of a regular crop rotation.
  - Objective 1b. Evaluate insect damage on Bt hybrids and non-GE isolines at three stages of development: at two leaf stage to assess impact on cutworms, at canopy closure and before silking to assess impact on ECB.
  - Objective 1c. Test Bt lines and non-GE isoline silage for the presence of mycotoxins.
2. Goal 2. Growers will understand the financial cost and benefit of Bt corn systems.
  - Objective 2. Perform a simple cost-benefit analysis on the Bt corn hybrids and their non-GE isolines for the single year evaluation.
  - Objective 2b. Compare costs to simple silage blends.
3. Goal 3. Growers will learn about the results of this study through standard Cooperative Extension training opportunities.
  - Objective 3a. Results of the trial will be presented at the Agricultural Trades Show, and to at least one regular meeting of the large herd group.
  - Objective 3b. A report will be prepared and presented to the BPC at a regular monthly meeting.

### Termination Report

#### Introduction:

In 1998, the Maine Board of Pesticides Control voted to not accept a petition to allow *Bacillus thuringiensis* (Bt) corn to be grown in Maine. Reasons for this decision included: 1) no insecticidal spraying was being done for corn borer control in silage corn; 2) concern over Bt resistance issues; and 3) lack of local data to support the need for these hybrids. With renewed interest from dairy producers and new Bt events coming into the market, we evaluated three hybrids (with and without the Bt gene) compared to a silage blend at two locations in Maine to provide growers and state decision makers with information on the cost and benefits of these new lines. One location was a field that had been in continuous corn for over ten years, and the other field had been in corn the previous year, but was regularly rotated with potatoes.

#### Methods:

Study hybrids included Golden Harvest H6395 and H6466 CB/GT, Monsanto DK440 and DK4442Bt, Pioneer 38H67 and 38H64Bt, and a Pioneer silage blend (37D02). The Pioneer Bt line provided corn borer and cut worm control. The other two lines had corn borer control. No lines selected provided activity against root worms. Data collected included population, cutworm damage, insect damage (stalk, leaf, and tassel), yield, silage quality and mycotoxin levels in silage. Corn was planted at both sites on 31 May 2006. Harvest was taken on 18 September 2006 on the rotated field and 25 September 2006 on the continuous corn field.

#### Results:

Insect pressure at both locations was light to moderate. We found significantly higher cutworm (and apparent cutworm) activity in the continuous corn field compared to the field in rotation with potatoes. However, mortality in the most heavily impacted hybrids was less than 2.5 percent of that planted, and this damage did not affect yield. Across locations, there was significantly less insect feeding damage in the leaf or the stalk with the hybrids containing Bt (Table 1). We found leaf miner, northern corn root worm adults, and corn borer insects during our evaluations. There was significantly higher overall insect pressure in the rotated field compared to the continuous corn field.

Yields of Bt isolines across locations were not significantly higher than the non Bt isolines. Yields were significantly higher in the rotated corn field likely due to apparently higher fertility. Maturity of the Pioneer and DeKalb hybrids were significantly longer than the Golden Harvest hybrids which likely affected overall corn silage yield and quality. If Bt corn is approved for use in the state, Maine producers should consider lines that are shorter in maturity to match the typical growing season climate. Despite the significantly reduced insect pressure likely caused by the presence of Bt, we did not find silage with significantly reduced levels of vomitoxin. Grain corn growers have typically found yield benefit with Bt lines in years with significant corn borer pressure, but silage corn growers have seen less benefit (Ma and Subedi, 2005). A potential secondary benefit could be improved silage mycotoxin levels (Wu, 2006). However, we found no significant improvement in Bt isolate silage quality.

**Table 1.** Insect feeding damage, yield, and silage toxin levels as affected by hybrid.

Hybrid	CBL (#/1000 ft row)	CBS (#/1000 ft row)	CBT (#/1000 ft row)	Yield 30% DM	Vomitoxin
H6466cb/gt	7.2	0.9	0.6	19.8	0.5
H6395	12.8	3.5	0.5	19.2	0.6
DK4442bt	17.9	0.9	0.1	17.4	1.3
DK440	23.9	5.2	1.2	17.0	0.5
38H64bt	3.9	0.1	0.0	17.9	0.5
38H67	10.0	4.4	0.3	19.1	2.1
37D02	8.6	3.7	1.2	18.4	0.5
LSD (0.05)	3.8	3.6	NS	2.5	NS

## References

- Ma, B.L. and K.D. Subedi. 2005. Development, yield, grain moisture, and nitrogen uptake of Bt corn hybrids and their conventional near-isolines. *Field crops research* 93:199-211.
- Wu, F. 2006. Mycotoxin reduction in Bt corn: potential economic, health, and regulatory impacts. *Transgenic research* 15:277-289.

## Outreach Component of this Project:

I presented our results at the Board of Pesticides Control meeting on 12/15. A petition has been developed and was submitted to the board for Bt corn approval. These data were important to meet this end. As well, I delivered a presentation of this material at the Pest Management Conference, my INT 482 class, the Northeast Weed Science Society Meeting in Baltimore (1/5/07) and our regional In-service training for agricultural service providers.

## **MAC 82: Optimum Use of Solar Gain Available in High Tunnels and Greenhouses in Maine**

**Principle Investigator(s): Gleason Gray, Barbara Murphy**

### **Issue/Priority:**

All high tunnels and conventional greenhouses are designed to collect solar energy to provide warm temperatures for the crops being grown. The structures frequently capture more energy than is required. The structures also continue to collect solar energy during non-production periods. The purpose of this project is to design, install and demonstrate systems for storing the excess energy collected for either extending the growing season in unheated high tunnels or reducing energy costs in conventional greenhouses

There are 629 licensed greenhouse producers, 145 greenhouse vegetable growers and 684 vegetable producers in Maine. (It is estimated that there are 366 vegetable growers using high tunnels). Many of these businesses are moving toward the use of high tunnels to extend their growing season and to add products to their crop mix. All of these Maine businesses can benefit from either an extended growing season in a high tunnel or reduced energy costs in a conventional greenhouse.

This project will utilize an existing high tunnel at the South Paris Extension office where cut flower research is being conducted by Barbara Murphy, Extension Educator and Dr. Mark Hutton, Extension Vegetable Specialist.

### **Project Description:**

A prototype of the system will be tested in the summer of 2006. The complete system will be installed in the fall of 2006. Data will be collected through May 2007 to verify the season extension possibilities of the collection system. The system will be used in future years as the cut flower research continues. Season extension results will be observed and reported as part of the cut flower research activities. System modifications will be made to further enhance the collection efficiency of the system in the future. In 2007, additional energy conservation equipment such as air to water heat pumps will be investigated to determine how they may be used to compliment solar collection.

At least two grower meetings will be held during the first year of this project to present the findings to growers. The resulting system from this project will be displayed and discussed in subsequent years at grower meetings related to the ongoing cut flower work.

A report will be prepared including information on the design of the system and results of the soil temperature advantages. Sketches and photos of the installation will be included. The report will be distributed at grower meetings held on site and at other presentations of the project results. The report will also be available through normal UMCE distribution channels.

### **Sharing Outcomes:**

- A recommendation for a system to extend the growing season in a high tunnel using collected solar energy.
- Projected fuel savings for conventional greenhouses using collected solar energy.
- A system in place at the Oxford County high tunnel that can be used to extend the growing season and allow some soil temperature variation among the four growing beds.

### **Termination Report**

Funds from this account, 5400983-12-5600110, were used to fulfill some of the objectives of a larger, long term investigation of the collection and use of solar energy to heat high tunnels and greenhouses in Maine. The objectives of this grant were addressed from June 2006 to June 2007. Data from earlier 2006 work was used to make comparisons of the effects of the system installed and further data collection after June 2007 is and will be used to make final recommendations for a system for growers to use.

## Objectives Met:

### 1. To design and test an active solar energy collection system.

A pilot system using 100ft<sup>2</sup> of roof area was used during the summer of 2006 to verify this design of a collection system made up of groups of four .25 inch diameter collection tubes attached to the individual high tunnel rafters. A 300 gallon tank and associated pumps and plumbing were used to circulate water through the collection system.

The pilot system indicated a successful design and collection tubes were installed in the remaining high tunnel roof utilizing about 1300 ft<sup>2</sup> of roof area. A tank was constructed in the floor under the center aisle of the structure using wood framing, plywood sheathing, and polyetelent wiring. The tank was 35' wide x 4' deep x 52' long with a comfortable captivity of 4300 gallons of water. The size of the tank was based on information from a literature search identifying a need for 3 gallons of water storage for each square foot of collection surface. The tank was installed in October 2006 following removal of the 2006 cut flower crop. Both the tank design and the collection system design have proved to function as intended.

### 2. To install typical "in floor" heating components in raised growing beds in the high tunnel.

The raised beds in the high tunnel were reformed and framed with 2 x 8 planks following the construction of the in-ground storage tank. A heating system consisting of a grid of buried heat tubes installed 8" below the bed surfaces was put in place. A typical reverse return hydronic piping system was used to supply heated water to the beds from the storage tank. The pump for the system was controlled based on soil temperature in the beds. Each individual bed could be manually shut off by closing valves to the reverse return heating loop. The system functioned as intended with results indicated under objective 3 below.

### 3. To monitor the soil temperatures in the heated beds to determine planting dates and document season extension possibilities.

Temperatures have been monitored in the high tunnel at the Oxford County Extension office since November 2005 and are still being monitored for future work. Temperature records have been maintained for soil and air temperature both inside the structure and in a replicated set of plots outside of the structure. Air temperatures at the rafter collection points and water temperatures in the collection/distribution system have been monitored since installation of each component. To fulfill this objective soil temperature data from the winter/spring of 2006 was compared to data from the winter/spring 2007. The soil was not heated using the collection system in 2006. The findings were: a 50 degrees F on March 12, 2007 compared with 50 degrees F on April 1, 2006 indicating a potential of about 3 weeks using the solar collection system. It is important to note also that in 2007 the water temperature in the tank had not reached its full potential temperature by March 12 because of the short duration of the test run. So three weeks appears to be a minimum season extension expectation. Future data should indicate better results. The fall of 2007 will be the first opportunity to test the system for fall season extension. It is expected to be similar to the findings in the spring of 2007.

### 4. To collect data on stored energy available to produce plans for using the system tested in the high tunnel to release fuel use in environmental greenhouses.

Data has been collected to verify that the pumping system in the storage tank maintains uniform temperatures throughout the tank (good warm water mixing). Data also shows that the current system can heat the water tank to approximately 100°F. Seasonal timing has not been such that recovery rate for the tank temperature can be documented. The collection system has been running 24 hours per day since September 10, 2007 to "waste heat" at night so the recovery rate can be determined before the fall bed heating season starts. When fall heating starts the collection system will be put back on thermostats to run only when roof temperatures are high enough for efficient collection when that data is collected an accurate estimate of reduce fuel use in conventional greenhouses will be possible.

### Evaluating Outcomes:

The expected outcomes for the project included designs for a collection system, an in ground storage system, and a soil heating system. The evaluation of the design involved primarily temperature monitoring to verify that the system components work as intended using continuous temperature monitoring we have determined:

1. The pumping system designed to return the heated water to the tank and to mix it thoroughly works well. No significant temperature differences were recorded at 4 separate locations in the tank.
2. The structural design for the tank is adequate and easy to construct on site.
3. A heavy pond liner material is recommended instead of the 6 mil poly used in the existing tank.
4. The soil heating component is readily constructed from "off the shelf" components available from greenhouse supply companies.
5. Soil temperature measurements indicate the length of season extension possible for growers installing a similar system.

### Integration of Extension and Research Activities

The high tunnel being used for this work is also the site for the Cut Flower Research plots in Oxford County. Data from that work will be used to help growers make crop selection decisions. The solar research component has been discussed above.

Two Extension meetings for growers have been held at the research site one in October 2006 and one in August 2007. Over 30 growers attended each meeting. Several growers have come to this site for one-on-one consultation about the feasibility of solar collection/cut flower production.

The cut flower advisory committee working with the investigators has provided direction for the project and word of mouth publicity about the project.

### Presentation and Outputs

The work done on this project has been presented at:

- The NH vegetable growers meeting \_\_\_\_\_ Portsmouth NH.
- Maine Ag Trade Show \_\_\_\_\_ Augusta
- Maine vegetable growers meeting \_\_\_\_\_ York County
- Maine vegetable growers meeting \_\_\_\_\_ Waterville

A grower in Harrison is constructing a new 28' x 96' high tunnel to include a solar collection and storage system like the one used in this project. The investigators are working with the grower on the design for the facility. Construction will start in October 2007.



## **MAC83: Effect of Compost and Cover Crops on Soil Health in an Organic Vegetable Productions System When Combined with Minimal Tillage.**

**Principal Investigator(s): Mark Hutchinson**

### **Issue/Priority:**

Maine's organic vegetable and dairy industry continues to be a significant portion of Maine's farm economy. Organic vegetable production is often limited by soil fertility and weed control. National organic standards recognize the importance of soil organic matter (SOM) in maintaining healthy and fertile soils. Cover crops and compost are used in organic systems to increase or maintain soil organic matter content. However, continuous tillage practices can have a detrimental effect on SOM.

Tillage practices also affect soil health. Numerous studies have shown that reduced tillage has a positive effect on soil structure, soil compaction and SOM, all things related to good soil health. Soil organic matter is readily oxidized when traditional tillage practices are used, often reducing the benefits of cover crops or compost amendments.

One method of reduced tillage is zone or strip tillage. Zone tillage is widely used in traditional row crop production in the Midwest. Zone tillage is used in conjunction with cover crops or crop residual and herbicides for weed control. The instrument creates a narrow strip of tilled ground, (7 inches) in the crop residual creating a narrow seed bed. Between the rows, crop residual protects the soil. This practice has been adapted by a conventional vegetable grower in Maine to grow sweet corn, pumpkins, string beans, peas, and winter squash.

Maine organic growers are interested in this method because of the soil health benefits. Because of the perceived need to use herbicides for weed control, no organic grower in Maine has adopted the method. There are several obstacles preventing growers from implementing the practice; development of alternative weed control methods and handling large amounts of crop residue from legume cover crops.

Meg McGrath, Cornell Cooperative Extension, conducted initial trials using zone tillage for pumpkins. Mark Hutton, University of Maine Cooperative Extension, conducted reduced tillage pumpkin trials at Highmoor Farm in 2005. Neither of these studies addressed weed nor crop residual issues.

### **Project Description:**

A replicated study will be developed at Goranson Farm, a certified organic operation in Dresden, Maine. Side by side plots with conventional and reduced tillage will be developed. Andy Williamson, County Fair Farm, has committed the use of a two row zone till cart to the project, which was developed as part of a SARE project in 2002. Two different cover crops and two compost application rates will be used to compare different sources of organic matter and its effect on SOM. SOM samples will be collected weekly and analyzed at the Maine Soils Lab in Orono. Soil health parameters will be determined by utilizing the Soil Health Card developed by NRCS. Three different crops; pumpkins, string beans, and winter squash will be used in the trials. Marketable crop yields will be determined for each crop.

Different weed control methods to be considered are: mowing, fine tooth harrow, flaming, hand weeding and mechanical tine weeder. Weed pressure and composition will be tracked throughout the growing season.

### **Sharing Outcomes:**

Through educational programs, 150 Maine growers will be exposed to reduced tillage practices, cover crops and compost practices. Of the 150, ten will change a management practice to increase soil organic matter.

Four growers will adopt reduced tillage practices after attending educational programs.

## Termination Report

This primary objective, “To develop an on-farm demonstration that illustrates and educates the impact of tillage practices and different organic amendments in an organic vegetable production system” was met.

An organic farm located in Dresden, ME was the site of the study. The soil was Allagash fine sandy loam in a field that was previously cropped to a cover crop of oats and hairy vetch in summer of 2005. Soil quality of each plot was evaluated before tillage and planting and after harvest using the Maine Soil Quality Assessment Card. Tillage treatments were tilling entire row width or tilling only the seed row using a zone till cart. The compost rate was 9 cubic yards/acre and non-compost plots not receiving additional amendment.

Carnival squash (*Delicata*) was planted on June 15<sup>th</sup> 2006. Squash was harvested on three dates, Sept 19, Sept 26, and October 4 counted and evaluated for marketable and non-marketable squash. Yields were based on marketable squash only. Soils from each plot were sampled on October 4 and analyzed by the University of Maine Soil Lab.

A second objective was to identify potential weed control practices. This objective was met. Weeds were removed from the plots twice during the growing season using hand labor within the row and mowing between rows. Plots were also mechanically weeded once, using a basket weeder. Mowing was done with a walk behind string trimmer. Adjacent cucurbit plantings that had multiple weedings with the basket weeder had a significant increase in weed pressure. Mowing was identified by the grower as an acceptable weed control method for reduced tillage.

The soil assessment card evaluation of each plot was conducted on May 26, 2006. Ten indicators were used. Some indicators require an over-the-season evaluation such as for standing crops. Those observations were noted during visits to the plots during the growing season. One additional observation, the percentage of plot showing a winter kill was recorded.

All indicators are scored from 1 to 10 with 10 being the worst and 1 being the best condition. In general, the plot soils ranked 3 or lower (good quality) for erosion, crusting, tilth and ranked 7 or higher (poor quality) for soil color/organic matter content, soil structure and biological activity. Infiltration varied across the plots and will be reported later.

Infiltration of approximately one pint of water added into a 6 inch cylinder driven two inches into the soil ranged from approximately 5 minutes to greater than 45 minutes when recordings were stopped. Compaction was similarly varied across the plots when tested in May. On August 1, the following plant observation was made. Conventional plots mended with compost had more vegetation. Compost did not affect the vegetation in reduced tillage plots.

On August 22, there were no differences in vegetation noted with compost in either tillage method. Blocks 5 and 6, both reduced tillage plots, appeared flooded after the previous day's rain.

Conventional tillage had higher yields than reduced tillage, but statistical analysis showed no significant tillage effect. Compost amendment appeared to increase yield in both treatments and statistical analysis indicated a significant compost effect at the  $p=0.1$  level of confidence, a reasonable level for field studies. However, infiltration characteristics of the plots may have overshadowed the yield results. The plots that had the higher infiltration time, i. e. more time for water to infiltrate, had the lower yields. Other soil quality indicators such as penetration or winter kill did not appear to correlate to the yield data.

The soil quality score card provided insight into how crops may respond to treatments. Low infiltration rate, no visible biological activity and poor soil structure may reduce yields significantly with time. Amelioration of these poor conditions should be considered when planning future crop rotations and tillage operations for some fields.

Tillage did not affect yields of squash. The addition of compost did increase yields. Plot infiltration rate may have affected yield results more than tillage or compost amendment. The Maine Soil Quality Assessment card evaluation should be done by the same individual throughout the year to be consistent. Determination of soil organic matter by color may be affected by mineral content and associated color of minerals. Soil analysis determines better the organic matter content of the soils.

As a result of this project, Goranson farm has increased from less than 0.5 acres to over 4.0 acres planted using reduced tillage. They expect to continue to increase the number of crops and acres as their knowledge of the system expands.

The farm hosted a SARE organic vegetable tour in September 2006. The reduced tillage demonstration was part of their educational program. Over 30 people from the Northeast, interacted with the farmer and researchers about reduced tillage for sustainable vegetable production. The project will be presented at the 2008 Maine Vegetable School.

## **MAC84: Maine Maple Syrup Production Costs**

**Principal Investigators:** Stewart N. Smith, Kathryn Hopkins, and Aaron K. Hoshide

### **Background**

Maple syrup production is unique to Quebec, Ontario, and the Maritime Provinces, Canada, and the north central and northeastern U.S. In 2004, about 80% of the 7,371,000 gallons of maple syrup produced in these regions was from Canada (USDA, NASS, 2006; SC, 2004). While U.S. maple syrup was only 20% of this total, it was about 27% of the total value of world production due to a higher percentage of retail sales in the U.S. compared to Canada.

Unlike other states, Maine maple syrup production has been steadily increasing over the past two decades due to better record keeping, smaller producers entering the industry, and increased production especially from larger operations (Hopkins, 2000). For the past six years, the average annual gallons of maple syrup produced in Maine (253,000) has surpassed New York state (220,000) and is second of all states to Vermont (427,000), the U.S. industry leader (USDA, NEASS, 1996, 2003; USDA, NASS, 2006).

Hopkins (2000) had 78 of 325 Maine producers respond to a maple syrup survey. Farms were clustered in two size ranges, small (under 1600 taps) and larger (between 2400 and 40,000 taps). About half of surveyed producers in Maine had fewer than 800 taps. Half of surveyed farmers used buckets to harvest sap with some using up to 400 buckets. Fewer producers used reverse osmosis (12%), sap pre-heaters (32%), and vacuum (26%). Surveyed producers used a variety of retail outlets as well as wholesale and bulk markets.

Maple syrup production is extremely sensitive to scale economies due to a high proportion of fixed costs (CFBMC, 2000). Huyler (2000) showed that producers broke even at 900 and 1500 taps with sap at 3% and 2.5% sugar respectively, which suggests most Maine producers may not be producing at a large enough scale to be profitable. Buckets were found less profitable than tubing due to higher labor costs (CFBMC, 2000). However in this Canadian study, the smallest operation size was 500 taps, about 100 taps more than the largest bucket operations in Maine. Prior economic research has focused on comparing different fuel types used in evaporators (Huyler, 1979), not on technologies which can reduce evaporator fuel use such as reverse osmosis, sap pre-heaters, and air injection.

### **Objectives**

A cost of production survey will be developed with and administered through University of Maine Cooperative Extension, Somerset County. Cooperating Maine maple syrup producers will receive a maple syrup farm business management program (MapleEc) from Cornell University Cooperative Extension after completing this survey. MapleEc is used by New York State maple syrup producers, keeping track of production costs, profitability, economic indicators, and cash flow (Dufresne, 2000).

Data from surveys and other sources will be used to construct representative maple syrup enterprise budgets, including operating and ownership costs. Budget analyses will:

1. Determine the profitability and cost of producing maple syrup for small (100 and 500 taps), medium (1000 and 5000 taps), large (10,000 and 50,000 taps), and extra-large (75,000 and 100,000 taps) operations. Representative enterprise budgets will be constructed for all eight sizes. Different maple syrup prices will be used to determine returns for small (retail), medium (retail and wholesale), large (retail, wholesale, and bulk), and extra-large (wholesale and bulk) producers.
2. Compare the profitability of using buckets compared to tubing for maple sap harvest for small producers. Representative enterprise budgets for tubing harvest will be constructed for all eight sizes. Separate enterprise budgets for bucket sap harvest will be developed for operations with 100 and 500 taps.
3. Using partial budgets, determine if using artificial vacuum, reverse osmosis, pre-heating, and air injection equipment are cost effective for producers of all sizes.

## Research and Extension Activities

Project outputs and activities would include:

1. Publication of MAFES Bulletin summarizing maple syrup enterprise budgets for small, medium, and larger operations.
2. Fact sheets for producers and trade journals focusing on general project overview and results plus comparisons of production scale economies, buckets and tubing, different types of artificial vacuum, and reverse osmosis, pre-heating, and air injection.
3. Presentation of preliminary survey results at the Maine Maple Producers Association annual meeting at the Agricultural Trade Show in Augusta, Maine.

## Expected Outcomes

This project will improve understanding of the cost of producing maple syrup at various scales using bucket or tubing for harvesting sap in Maine. The cost effectiveness of using vacuum, reverse osmosis, pre-heating, and air injection equipment for smaller and larger producers will be determined. Different sized producers will better understand maple syrup production costs and the profitability of using different equipment during sap harvest and boiling.

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## Termination Report

### Results:

Most Maine maple syrup producers were surveyed for information about their costs of producing maple syrup in June 2006. Since the initial survey was very detailed, a shorter version was sent out in November 2006. Surveys were mailed to an original list of 321 producers obtained from University of Maine Cooperative Extension. Of those on the original list, 26 replied that they no longer produced maple syrup. Total respondents for both surveys were 26 out of 295 for a response rate of about 9%.

Using data collected from both production costs surveys, representative maple syrup enterprise budgets were developed for small 300 tap, medium 3000 tap, and large 30,000 tap operations. All representative budgets allow any mix of bucket and/or tubing collection and track both operating and ownership costs. Extension, industry groups, and producers can customize representative budgets to a particular producer's operation. Budgets also allow recording of maple syrup production by the container and/or drum.

Net farm income or NFI for representative small, medium, and large maple syrup operations using tubing collection are -\$5,529, \$5,379, and \$47,283 respectively. Since all sizes assume use of only family labor, this labor cost is captured in NFI. For small and medium-sized operations, bucket collection has lower equipment costs compared to tubing. However if family labor is included as a cost at an assumed shadow price of \$12.36 per hour, tubing collection for small and medium-sized operations are \$525 and \$14,653 more profitable since less labor is used compared to bucket collection. Large operations are more profitable using tubing rather than buckets due to both lower equipment costs and lower labor costs.

## Objectives

### Objectives met:

- Developed two 2006 Maine Maple Syrup Production Costs Surveys mailed to Maine maple syrup producers in June and November 2006
- Distributed copy of Cornell University Cooperative Extension's MapleEc farm business management program to all survey participants
- Summarized and averaged survey data by producer size class for use in developing representative maple syrup enterprise budgets
- Engineered representative maple syrup enterprise budgets for small (300 tap), medium (3000 tap), and large (30,000 tap) operations using both *bucket* and *tubing* collection for use by producers, Extension, and other interested parties

### Objectives not met:

- Cost effectiveness of artificial vacuum, reverse osmosis, pre-heating, and air injection equipment not determined due to insufficient survey data
- Peer-reviewed publications summarizing research results are in process

## Outreach Activities:

Extension outreach objectives included the following:

### Completed Activities:

- Presentation about survey at annual meeting of the Somerset County Sugarmakers Association on September 9, 2006, in Jackman, Maine
- Promoted the survey to encourage additional responses at the January 2007 Ag Trade Show in Augusta
- Summary presentation at annual meeting of the Somerset County Sugarmakers Association on September 15, 2007, in Jackman, Maine
- Summary report in fall issue of Maine Maple Producers Association Newsletter

### Ongoing Activities:

- Poster presentation for the North American Maple Syrup Council and International Maple Syrup Institute annual meetings in Ohio on October 21-24, 2007
- Results presentation at the January 2008 Ag Trade Show in Augusta
- Presentation at the North American Maple Syrup Council and International Maple Syrup Institute annual meetings in Massachusetts in October of 2008

In addition to support from the Maine Agricultural Center, the North American Maple Syrup Council contributed \$2000 in funding to support this project from September to December, 2007.