Maine Agricultural Center Integrated Research and Extension Projects: 2008–2009

MAC97: Effects of Varying Light Levels on Heuchera and Coleus Variegation

Principal Investigators: Lois Berg Stack, Donglin Zhang, Stephanie Burrnett, Katherine Garland

Background of Issue Addressed and Project Objectives:

Ornamental plants that are grown for beautiful foliage to complement the flowers of nearby plants are becoming more popular in horticulture. Gardeners have come to appreciate perennials and annuals with unique leaf coloration because they provide visual interest in the garden throughout the season. Unfortunately, the leaf variegation that foliage plants are prized for is rather unpredictable, changing under different light levels. Thus, it would not be unusual for plant variegation to be lost or greatly altered when foliage plants are grown under inappropriate light levels. This issue is further complicated by the fact that effects of light on growth and variegation are often species specific. For example, *Hedera helix* (English ivy) plants have less variegation under low light than under high light; conversely, the *greatest* variegation and quality of *Dracaena sanderana* 'Ribbon' is observed under low light (Pennisi et al., 2005; Vladimirova et al., 1997).

Unfortunately, most of the research examining the effects of light on foliar variegation has been conducted on houseplants, which are a minor crop for Maine growers and landscapers. We wish to determine how varying light levels impacts foliar variegation of two plants that are popular and economically important in Maine: Coleus and Heuchera. Both of these plants have diminutive flowers and are used primarily for their unique foliar colors and variegation. Cultivars of coleus, for example, have vibrant foliar variegation with combinations of colors including red, orange, green, white, and yellow. Preliminary observations of both of these plants in landscapes indicate that variegation changes or is lost when light levels change.

Therefore, the objectives of our project are:

1. Grow Coleus and Heuchera under different light levels
2. Use digital image analysis to quantify how different light levels impact variegation of both species

Research Methodology:

In spring, 2008, more than 75 Coleus cultivars will be grown in field trials at Rogers Farm in Stillwater ME. These plants will be assigned a quality rating based on vigor and aesthetic appeal. These field trials are funded by a New England Floriculture, Inc., grant. Based on the results of these field trials, the top three cultivars for Maine landscapes will be selected for further analysis of the effects of light on variegation. We will use one cultivar of Heuchera, *Heuchera americana* 'Dale's Strain'. This cultivar was selected because it is part of a national marketing program, *American Beauties*. This campaign promotes the use of native plants in the landscape and is a collaboration among the National Wildlife Federation, Pride's Corner Farm, and North Creek Nursery.

Coleus and Heuchera plugs will be transplanted into one gallon containers and grown in a greenhouse in Orono ME. Plants will be grown under free-standing PVC shade structures (dimensions = 2'×2'×2') with the following shade percentages: 0, 30, 60, or 90%. Four replications of each shade treatment will ensure that treatment responses are not caused by greenhouse microclimates. Light levels within each of the sixteen shade structures will be continually measured using quantum light sensors connected to a datalogger. Daily light integral will be calculated every day. To minimize possible interactions between light and substrate moisture content (moisture content = volume of water in a given volume of substrate), plants will be maintained at 30% moisture content using a moisture sensor-automated irrigation system (van Iersel and Nemali, 2006). Once a week, for six weeks, plant height and greatest width will be measured manually. After six weeks, the experiment will be terminated. At that time, total leaf area, shoot dry weight, and total leaf number will be recorded. For Heuchera only, light and CO_2 response curves will be developed for each light treatment using a LI-6400 photosynthesis meter to determine which light level results in maximum photosynthetic rate. Digital images will be made of representative leaves from plants grown under each light level. These images will be analyzed using Adobe Photoshop to determine the total percentage of leaf surface area that is variegated (refer to Pennisi et al., 2005 for similar methodology).

References:

- Nemali, K. and M. van Iersel. 2006. An automated system for controlling drought stress and irrigation in potted plants. Sci. Hort. 110:292-297.
- Pennisi, S.V., M.W. van Iersel, and S.E. Burnett. 2005. Photosynthetic irradiance and nutrition effects on growth of English ivy in subirrigation systems. HortScience 40:1740-1745.
- Vladimirova, S.V., D.B. McConnell, M.E. Kane, and R.W. Henley. 1997. Morphological plasticity of *Dracaena sanderana* 'Ribbon' in response to four light intensities. HortScience 32:1049-1052.

Expected Outcomes and Methods for Sharing the Outcomes:

Specific research outcomes are:

1. We will determine optimum light levels for the greatest leaf variegation of three Coleus cultivars and one Heuchera cultivar.
2. We will build shade structures and obtain quantum sensors for future research on the effects of light on growth, morphology, and variegation of ornamental plants.

These outcomes will be shared with green industry members by the following methods:

1. Results will be presented to the Maine State Florists' and Growers' Association at their annual greenhouse grower meeting in January 2009. This will reach Maine greenhouse growers and retailers.
2. Katherine Garland will use the Heuchera data in her Master's thesis. The results will be published in one to two refereed journal articles in a horticulture journal such as HortScience or The Journal of the American Society for Horticultural Science. This will add to the basic knowledge about these plants.
3. We will summarize results in a poster that will be presented to growers at field days and meetings in 2009. This will reach small scale Maine greenhouse growers.
4. Results will be summarized in a web-based Extension bulletin for industry members and their clients. This will provide information for retailers, landscapers, and gardeners.
5. A summary of results will be posted on the UMass Floriculture Program's website (http://www.umass.edu/umext/floriculture). This will reach greenhouse growers in New England and beyond.

Industry Support for Project:

We have asked Scott Longfellow, Longfellow's Greenhouses, Manchester ME; and Chad Skillin, Skillin's Greenhouses, Falmouth ME, to send letters directly to MAC.

Termination Report

Our research objectives were:

1. Grow Coleus and Heuchera under different light levels
2. Use digital image analysis to quantify how different light levels impact variegation of both species.

We met these objectives as follows:

1. Investigators evaluated the influence daily light integral (DLI) on the growth characteristics of three ornamental foliage crops: *Heuchera americana* 'Dale's Strain' (heuchera), *Solenostemon scutellarioides* 'Kong Red' (coleus) and *S. scutellarioides* 'Wizard Coral Sunrise'. Heuchera performed best under a DLI of 14.9 $mol \cdot m^{-2} \cdot d^{-1}$, exhibiting greater crown width, number of leaves, shoot dry weight, and total leaf area. Plants grown under the highest light level, 21.8 $mol \cdot m^{-2} \cdot d^{-1}$, had fewer leaves, reduced crown width, less leaf area, and no change in shoot dry weight, indicating that the treatments reached supraoptimal light levels. Both cultivars of coleus followed similar trends in response to DLI and are thus, summarized together. Coleus performed significantly better (taller, wider, and more highly branched) under the highest light level provided

(10.0 $mol \cdot m^{-2} \cdot d^{-1}$). Ambient light levels during this investigation were not high enough to determine whether higher light levels may or may not further enhance these growth characteristics.

2. Quantitative variegation analysis was performed on leaves of two cultivars of coleus grown under the four different light levels. Leaves of both cultivars had less variegation when grown under lower DLIs. In other words, plants exposed to less light had a greater amount of green area per leaf.

Objectives not met:

Quantitative variegation analysis for Heuchera did not take place because the images obtained at harvest were too low in resolution. In this instance, pictures were taken of the leaves, rather than using scanned images. The coleus investigation took place at a later date, which provided us time and experience to refine our methods for obtaining quality images for quantitative variegation analysis of the coleus leaves.

Outcome Evaluation:

The outcomes of our project were:

1. We determined that at least 15 or 10 $mol \cdot m^{-2} \cdot d^{-1}$ of light is required for optimum growth of heuchera and coleus, respectively. Coleus could benefit from higher light levels than it was possible to test during this experiment due to low ambient light. In Maine greenhouses, light levels may be as low as 10 $mol \cdot m^{-2} \cdot d^{-1}$ in the early spring production period. Thus, growers may consider supplemental lighting for these crops.
2. Coleus variegation increased with increasing light level. Since this crop is marketed primarily for its vibrant foliar coloration, at least 10 $mol \cdot m^{-2} \cdot d^{-1}$ of light are necessary.

Integration of Research and Extension:

- We presented results at the annual American Society for Horticultural Science meeting in St. Louis, Missouri.
- Results of a related coleus field trial were published in UMass Floral Notes.
- A poster will be presented to approximately 75 Maine greenhouse growers at annual educational meeting of Maine State Florists' and Growers' Association, Agricultural Trades Show, Augusta ME on January 13, 2010.

Publications & Presentations:

1. Heuchera and coleus data were presented in a seminar conducted by Katherine Garland in partial fulfillment of the requirements for the degree of Master of Science in Horticulture.
2. Coleus data were presented in a poster competition at the 2009 national conference for the American Society for Horticultural Science.
3. Garland, K., S.E. Burnett, L.B. Stack, and D. Zhang. 2009. Abstract: Influence of Daily Light Integral on Coleus Morphology and Leaf Variegation. HortScience. 44:1116-1117.
4. Three refereed journals based on this research will be submitted for publication.
5. Katherine Garland will include the results in her thesis in partial fulfillment of the requirements for the degree of Master of Science in Horticulture.

MAC98: Alternative Susceptibility Trends for Microbial Isolates from Organic Dairy

Principal Investigators: Robert C. Causey, Gary Anderson, Beth Calder, Richard Kersbergen, Brenda Kennedy-Wade

Objectives:

- To determine the antimicrobial action of herbal tinctures or essential oils in vitro.
- To determine the Minimal Inhibitory Concentrations (MIC) for the herbal tinctures or essential oils against common mastitis causing bacterial species: i.e., Streptococcus agalactiae, Streptococcus dysgalactiae, Streptococcus uberis Staphylococcus epidermis Staphylococcsu xylosus and Staphylococcus intermedius, using a disc diffusion approach.
- Utilize the MIC findings to aid in defining dose, efficacy, safety and treatment course of the herbal treatment used for further experiments.

Background:

Mastitis is the most prevalent and costly disease affecting the dairy industry. In the US and Canada, it is thought that 50% of cows have one or more infected quarters (Duval, 1997). Estimated monetary loss in 1998 based on somatic cell counts (SCC) was $222/cow/year in Maine (Miller and Norman, 1998). “Mastitis is inflammation of the mammary gland due to either infection or trauma and typified by one or all of the following: loss of milk production, increase in inflammatory cells, abnormal milk, changes in gland size and/or consistency and occasionally systemic illness or death of the animal” (Rainard and Riollet, 2006). Mastitis costs accumulate due to reduced production, potential source of contagious organisms for other cattle in the herd, loss of milk sales, cost of treatments, cost of veterinary assistance and increased labor to treat animals. Mastitis in dairy cows can cause major economic losses through reduction in milk yield and milk discarded not safe for human consumption. Prevention and treatment of mastitis is the most prominent issue facing dairy farmers whether they are organic or conventional producers. Treatment and prevention of mastitis is of especially great concern to organic dairy producers because antibiotic use in organic livestock removes the animal from the organic herd (Duval, 1997; MOFGA Certification Services, LLC. 2006). Treatment is important for organic dairy farmers to be able to remain profitable and ecologically sound. While conventional producers have some antibiotic treatments available to them, the organic producer has other preventative and curative measures available, but most lack data concerning efficacy or safety. Many of the treatments that are available are reported to enhance the activity of the immune system, but lack data on their efficacy.

Herbal remedies are being administered for mastitis by practicing naturopathic veterinarians and organic dairy farmers. Most of the evidence that these treatments are effective is anecdotal through centuries or decades of practical use and not scientifically based.

Research:

The purpose of the proposed research is to determine in vitro, the effects of various herbal extracts on growth of the major mastitis causing organisms. This project will attempt to thoroughly investigate three or four of the most commonly used herbal substances currently used for treatment of mastitis. These are all Generally Recognized as Safe (GRAS) compounds such as garlic, aloe, wintergreen, licorice and thymol.

We will prepare saturated extracts of several herbs using available scientific information such as the Merck Index, USP Pharmacopeia and the National Formulary for our initial standard. There are no saturated extracts in the marketplace nor are there good analytical techniques to quantify concentration of these herbal extracts. We will use the initial standard as a 100% solution and then dilute it serially to prepare 50%, 25% and 12.5% standards. These four dilutions will then be used in screening various herbal extracts on the sensitivity/resistance to growth of mastitis causing organisms. At this time, we are most interested in their action against the environmental organisms Streptococcus dysgalactiae, Streptococcus uberis, Staphylococcus epidermis, Staphylococcus xylosus and Staphylococcus intermedius. While we are most interested in environmental organisms, we will evaluate activity against the contagious organism, Streptococcus agalactiae. We do not plan to evaluate any activity against Staphylococcus aureus

or any coliforms since they are very difficult to treat even with antimicrobial therapy. This strategy will give a wide range of herbal extract concentration tested and will provide a standard curve of concentration against millimeters of inhibition of growth.

We plan to use a modification of the Kirby-Bauer method to determine anti-microbial resistance as a screening tool. Minimum inhibitory concentrations (MIC) will be assessed using the Kirby-Bauer disc diffusion method on Mueller Hinton agar plates. Paper discs, 6mm in size, will be infused/impregnated with 0.02 milliliters of each of the herbal standards at 100%, 50%, 25%, 12.5% concentration. In vitro sensitivity/resistance will be evaluated by the absence of growth in zones around these discs and will be measured in millimeters. These data will be collected on standard cultures obtained from the American Type Culture Collection (ATCC) as well as isolates from milk samples submitted to the University of Maine Veterinary Diagnostic Lab. The most promising herbal or homeopathic extracts will be further assessed by developing a more accurate in vitro method to determine effectiveness.

These data will be important base information for organic farmers and their veterinarians to make informed decisions as to what treatments might be most effective for these types of mastitis. Those individuals that would benefit most would be the organic farmers, the practicing naturopathic veterinarians. Conventional farmers that are considering changing over to organic dairy practices or conventional farmers who just want to use less antibiotics and more natural remedies could also benefit. Those individuals that consume organic milk and organic milk products would be more assured that their product is safe. Extension and the private sector will be able to benefit from educational opportunities through research and workshops. These programs will improve their understanding of the biology of the cow, the development of mastitis and the availability of alternative treatments.

Outcomes:

These data can be substantial scientific evidence for the entire organic dairy industry on the possible effectiveness of herbal treatments for mastitis. If the results are positive they can serve as a starting point on how to treat mastitis using herbals. This data will be published in existing newsletters such as Northeast Organic Dairy Producers Assoc. (NODPA) and Maine Organic Milk Producers (MOMP). Extension outreach will be conducted in Maine to the dairy community at the Maine Agricultural trade show, Maine Organic Farmers and Gardeners Assoc. (MOFGA), and New England Spring Dairy Seminars. A research bulletin will be created as a guideline for dairy farmers on how to treat organic cows with mastitis using herbal remedies. An Animal and Veterinary Sciences student will be hired to assist in this research project which will provide research experience.

References:

- Duval, J., Treating Mastitis Without Antibiotics. Ecological Agriculture Projects publication 1997; 69; 1-29. Loriam, VMD, editor, 1996. Antibiotics in Laboratory Medicine., 4th edition.
- Miller, R.H. and Norman, H. D. Somatic Cell Counts of Milk from 1998 Dairy Herd Improvement Herds. USDA Animal Improvement Programs Laboratory Research Report, SCC I(12-49
- MOFGA Certification Services, L. L. C. Organic Certification Practice Manual, A Guide for Producers. 2006.
- Rainard, P., and C. Riollet, Innate Immunity of the Bovine Mammary Gland. Vet .Res. 2006; 37:369-400.
- Shim, E.H., R. D. Shanks, and D. E. Morin, Milk Loss and Treatment Costs Associated with Two Treatment Protocols for Clinical Mastitis in Dairy Cows. J. Dairy Sci. 2004; 87:2702-2708.

MAC99: Equine Assisted Activities at UMaine—a Feasibility Study

Principal Investigator: Robert C. Causey

Project Summary

This project will bring together collaborators at UMaine and the surrounding community to assess the feasibility of establishing an equine assisted activity (EAA) program at UMaine to assess the effectiveness and sustainability of providing goal-oriented EAA to veterans in need. Equine EAA could provide an alternative source of income to small farm operators throughout Maine, while at the same time, increasing the demand for gentle, well-trained horses and horse farms as the use of EAA increases. The University of Maine Witter Center could also serve as a resource center on sustainability of EAA for small farm operators and other interested community members.

Statement of Need

Small farms often struggle to remain profitable and are increasingly diversifying to meet the demands of a changing economy. Such diversification includes offering EAA programs to various participants including veterans. There are currently 10 North American Riding for the Handicapped Association (NARHA) registered EAA centers in Maine, and the PI is aware of 4 unregistered facilities in the Bangor area alone. This suggests that the number of farms in Maine using EAA probably greatly exceeds the 10 that are registered. These farms represent a significant component of the equine industry which, as a whole, was estimated by the Maine Farm Bureau to contribute $364,000,000 in 2006 to Maine's economy. To the PI's knowledge, the University of Maine has not provided significant teaching, research or outreach activities to meet the specific needs of EAA centers. The purpose of this proposal is to take the first step towards promoting the sustainability and profitability of EAA in Maine, with an initial focus on assessing programs for veterans.

Objectives

The primary objectives of this project are to:

1. Assess the feasibility of a possible equine animal assisted therapy at UMaine in addressing the needs of participating,
2. Evaluate EAA as an alternative source of income and horse use for small farms throughout Maine,
3. Explore establishing UMaine as a research and information center to inform farm operators and EAA practitioners about current trends and best practice in equine animal assisted activities.

Project Details

This project will bring together UMaine collaborators in the Animal and Veterinary Science, Social Work, Counselor Education, School of Business, and UMaine's Counseling Center to develop a sustainable NARHA program of EAA at UMaine's Witter Center. First developed in the late 1960's, EAA has become an established treatment modality that has been demonstrated to be effective in addressing certain physical and mental health needs. However, even though EAA has been recognized by MaineCare and therapy organizations as an effective treatment modality, practitioners use many different models and formats of implementation.

Description of Research

Literature Review

A literature review will be conducted to assess current theory of EAA, and in particular, EAA. We will also review current models of best practice. This literature will inform program development, and constitute a peer-reviewed publication from the Maine Agricultural Center.

Key Informant Interviews

In addition to the information gained through a literature review, we will also identify current EAA programs across the state. We will conduct semi-structured interviews with selected horse owners and EAA practitioners to help identify program strengths, as well as challenges they face in providing EAA.

Project Timeline

Spring and Summer 2008

- Conduct literature review
- Identify existing EAA programs and conduct key informant interviews
- Identify potential program participants
- Complete feasibility study, addressing specific study objectives

Winter 2008-2009

- Provide summary of project results to MAC
- Serve as resource center for small farm operators and others interested in EAA

Dissemination of Results

At the conclusion of the study, we will analyze the collected data, and discuss strengths and challenges of establishing an EAA program at UMaine. We will also propose a model of sustainable EAA that could be implemented at UMaine in partnership with qualified mental health practitioners. Such a program, once implemented, would serve as model to assist small Maine Farms to implement for themselves sustainable EAA programs. We will develop printed materials available to the public outlining this model and identifying additional resources. We will also conduct presentations to interested EAA providers, farm operators, horse owners, mental health practitioners, students, and other community members on EAA. The University of Maine Witter Farm will continue to serve as a resource center for information about EAA throughout the duration of this project and beyond. In the future, the Witter center would be a convenient field site for interns in Social Work and Counselor Education.

Capacity and Expertise

The University of Maine Witter Center has the necessary facilities, and animals, to be the subject of the feasibility study. In addition, UMaine has contacts with veterans groups through the School of Social Work, the Counseling Center and Cutler Health Center**.** UMaine also has the necessary expertise in animal welfare, behavior, human health, and rural economic analysis.

Objectives Met:

1. Assess the feasibility of a possible equine animal assisted therapy at UMaine in addressing the needs of participating veterans.
2. Evaluate EAA as an alternative source of income and horse use for small farms throughout
3. Maine.
4. Explore establishing UMaine as a research and information center to inform farm operators and EAA practitioners about current trends and best practice in equine animal assisted activities.

Methods Used to Evaluate Outcomes:

1. A working group was formed to assess the suitability of using the Witter Center as a site for conducting Equine Assisted Activities (EAA) with veterans. The working group concluded that EAA activities with veterans should be piloted first off-site, at a facility with EAA experience, and with a population of horses specifically trained for EAA. Both conditions were met by Northern Maine Riding Adventures (NMRA). Following off-site development of EAA protocols, the program could potentially be moved to UMaine.
2. The working group concluded that NMRA, a typical Maine facility, would also be a suitable test-site for evaluating economic issues associated with EAA. Funds for private EAA programs could be included in grant applications by UMaine collaborators, or paid by insurance in clinical cases.

3. The working group drafted an intramural grant application for submission within Togus VA, preliminary to a major submission to DoD. The scientific questions posed by the working group fall within DoD?s mission to explore alternative methods for treatment of PTSD, and could provide answers to support Maine's EAA providers.

Integration of Research and Extension Activities:

EAA protocols were developed within and for Maine's business environment. The attached draft literature review and EAA lesson plan represent valuable information which, after final editing, could be shared with Maine EAA providers.

Outputs:

- Cross-Strehlke J. Integrated Riding: Enhancing the Mind /Body Connection Equine Partnership
- Program with Togus VA Center, The University of Maine and Northern Maine Riding Adventures -O verview of 8 week lesson plan.
- Causey et.al. Therapeutic Riding for the Treatment of Post-traumatic Stress Symptoms in Veterans -Draft grant proposal to VA administration.
- Hofmann A. Therapeutic Riding for the Treatment of Post-traumatic Stress Symptoms in Veterans -
- Literature Review.
- Hofmann A. Equine-Facilitated Therapy as an Alternate form of Animal-Assisted Psychotherapy for Veterans with Post-Traumatic Stress Disorder—Master's Proposal Presentation.
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MAC100: Demonstration and Hands-on Evaluation of Scale-Appropriate Weed Control Tools for the Small Farm

Principal Investigator: Eric Gallandt

Background: Weed control on small (<4 acre) farms

In 2005, there were 1.7 million small farms in the U.S., i.e., farms with < $10,000 in gross sales. This number is likely to increase with the continued growth in demand for organic foods, particularly those produced locally. Considering weed control tools, there is a broad array of innovative tools—basket and finger weeders, torsion bars, sweeps and the like—that are available for tractor-mounted tool bars. However, many small growers, particularly diversified vegetable farms of 4 acres or less, do not own a tractor. Instead, they rely on walk-behind tractors or tillers, sometimes horses, to prepare seedbeds and often push-seeders for planting. Weed control is accomplished with the same tools that have been used for the past century: wheel hoes, long-and short-handled hoes and lastly, of course, hand weeding.

During the PI's recent sabbatical in Denmark, he collaborated with Europe's leading weed scientists in the area of physical and cultural weed management and was introduced to an innovative set of improvements to the old "wheel hoe" idea, incorporating two wheels, a tool bar, and lightweight cultivator attachments, some of which have a parallel-linkage design. This collection of tools is the first transfer of physical weed control technologies, including sweeps, rolling disks, finger and torsion weeders, from the tractor tool bars of larger farms, to a hand tool appropriate for a farmer of 4 acres or less. Two notable features of this tool represent real innovation in this otherwise vintage implement. First, using two wheels and a scaled-down toolbar provides lateral stability and adjustment flexibility, e.g., to cultivate both sides of a crop row, that is generally not possible using a traditional wheel-hoe. Second, lightweight parallelograms offer precise depth control, and thus the opportunity to optimize soil movement (weed control) and draft or effort required to push the implement.

Physical weed control is a topic of great interest to Maine organic growers. A session offered by the PI this past November ("Innovations in Physical Weed Control," 3 November 2007, Bethel, Maine) drew an audience of sixty, mostly growers. It was the considerable interest among growers at this meeting that motivated this proposal. Notable was the sentiment that while the equipment looked very appealing, few, if any, would risk the investment without first trying one on their farm, or at least hearing what another grower with first-hand experience thought of the tools.

Methods

We will purchase a set of cultivation equipment from Finland, demonstrate the equipment on three Maine farms, and then allow the farmer-evaluators to use the equipment over a period of weeks. Their detailed evaluations will (i) form the basis for a Fact Sheet, (ii) be presented at field days on their farm, and (iii) be presented at a conference for organic farmers. In these ways we will ensure that their experiences are shared with other farmers. The equipment will be housed at the University of Maine Rogers Farm and will be available for on-site testing or loan to interested growers. When not on loan, the equipment will be used by the undergraduate students of the Black Bear Food Guild, a student-run, 40-share certified organic CSA that operates at the farm.

Expected Outcomes

The goal of this project is to facilitate grower experience with innovative cultivation equipment and extend their experiences to as wide an audience of growers as possible. Four products will ensure that we reach this goal.

- Fact Sheet. Detailed evaluations will be drafted by the three grower-evaluators. Coming from growers with first-hand experience with the tools, we consider their evaluations central to educating other growers about this innovative equipment. The Fact Sheets will be available for download from UMCE Publications, MOFGA Technical Services, and the UM Weed Ecology websites.
- Field Days. A field day demonstration of the equipment will be held on each participating growers' farm at the end of their three-week evaluation period, and prior to moving the equipment to the next farm.

- Common Ground Country Fair Demonstration. MOFGA's Common Ground Country Fair, held each September at their facility in Unity, Maine, has an attendance of over 60,000 during the Fair's three days of events. Within the "Agricultural Demonstrations" area of the fair, we will offer Saturday morning and afternoon demonstrations of the equipment
- Farmer-to-Farmer Conference. Jointly sponsored by UMCE and MOFGA, the Farmer-to-Farmer Conference is an ideal venue to bring together the farmer-evaluators for presentations and a Panel Discussion summarizing their work. Held in November, we will use this session to both prepare an aggregate summary of the growers' experiences (for the Fact Sheet) and to disseminate results and experiences to other growers. In December through February 2009 we will complete final editing and publishing of Fact Sheet.

Abstract:

Innovative weed control tools from Finland show promise for small- to medium-scale organic vegetable farmers. Three Maine farms evaluated the Weed Master, a set of manual weeding implements scaled appropriately for a manually pushed tool bar. Purchased with support from the Maine Agricultural Center, and evaluated during the 2009 growing season with support from the Northeast Sustainable Agriculture Research and Education Partnership Grant Program, this is the first set of tools to be imported to North America. Although the tools alone will not solve their weed problems, most growers have been impressed with the intuitive adjustment of the tools and fast working rates. Compared to a traditional wheel hoe at 3 minutes per 100 foot of row, the Weed Master took less than a minute (hand weeding took 21 minutes). Weed control was generally similar among the various methods. Farmers will share their experiences with these and other hand tools at the Farmer-to-Farmer Conference, sponsored by the Maine Organic Farmers and Gardeners Association and University of Maine Cooperative Extension (November 6-8, 2009). For more information about this project and others related to weed management on organic farms contact Eric Gallandt, University of Maine Weed Ecologist (gallandt@maine.edu).

Termination Report:

Small-scale farmers are in great need of scale-appropriate weed management tools. In this project we imported from Finland the Weed Master®, an innovative set of cultivation and flameweeding equipment, designed and built by a team of Finnish small-scale organic farmers. This is the first unit to be imported to North America. Farmers have been generally impressed. Our onfarm field evaluations, as well as a replicated comparison with widely available weeding tools indicates that efficacy of weed control with the Weed Master is equal to hand weeding, hoeing or using a wheel hoe, but 60% to many times more efficient when working time is considered. The dramatically greater working speed translates directly into dollars saved weeding, and offers growers opportunity to cultivate several times to achieve a high levelof weed control if necessary.

The MAC-supported purchase of this equipment was essential to the success of the project as other funding agencies were not enthusiastic about purchasing quipment. We leveraged this funding into a ESARE Partnership Project and have (i) evaluated the equipment on three diversified organic vegetable farms; (ii) demonstrated the equipment at the Maine Agricultural Trades Show, a UMCE field day in southern Maine, at a MOFGA Apprentice Summer Meeting Field Day at the Peacemeal Farm in Dixmont, and at MOFGA's Common Ground Country Fair; (iii) explored an innovative mechanism for sharing results through a research blog (see: gallandt.wordpress.com), which, since launching in May, 2009, has had 1,088 visitors, with 68 on the busiest day, July 28, 2009, shortly after an article in the MOF&G featuring the demonstration at the Peacemal Farm; (iv) and have developed a new YouTube Channel, "Zeroseedrain" which features our preliminary evaluations of the Weed Master (126 and 92 views as of 10/1/2009 for our two videos. Lastly, in concluding our MAC project and the related NESARE partnership project, we will host a session on weed control tools for the small farm at the 2009 UMCE / MOFGA Farmer to Farmer Conference during which the lead PI and the participating farmers will summarize our experiences with these tools.

The promising results to date have led to discussions with personnel at the Innovations Center, a machine shop owner in Charleston, Maine, and the head of tools and equipment for Johnny's Selected Seeds. We are hopeful that a business strategy can be developed to commercialize this equipment to make it more affordable for farmers on North America. At present, the cost of importing the tools from Finland has been considered too expensive by most

growers, at least for some of the less technical parts (e.g., the frame and wheels). Petri Leinonen, the Finnish farmer and owner of the company selling the Weed Master has enthusiastically endorsed this initiative.

Objectives Met:

Our goal is to facilitate small-scale farmer evaluation and, where appropriate, adoption of novel and innovative physical weed control tools. To encourage grower evaluation of this new generation of hand-tools appropriately scaled for the small farm, we will satisfy the following objectives:

1. Facilitate hands-on farmer evaluation of innovative physical weed control tools from Finland;
2. Publish grower evaluations of the equipment; and
3. Distribute project results via field day demonstrations and grower meetings.

As noted in the above narrative, we have met or exceeded the stated objectives, although with the additional support of NESARE funding. The original MAC budget underestimated the labor and travel necessary to conduct in depth on-farm evaluations of the tools.

MAC101: Investigation of Semiochemical Inhibitors for Lily Leaf Beetle: Exploration for Future Resistance in Commercial Lily (Lilium) Cultivars

Principal Investigators: Eleanor Groden, Lois Berg Stack, Bekka S. Brodie

Background of Issue Addressed and Project Objectives:

Lilies (Lilium spp. and hybrids) are popular perennials in summer and early fall gardens and also valuable commercial cut flowers. The lily leaf beetle (LLB), Lilioceris lilii Scapoli, is a serious pest of native and exotic lilies in Maine and causes economic and aesthetic losses for commercial growers and gardeners. This invasive beetle threatens the use of lilies in Maine gardens and cut flower fields. Evidence suggests that the damage caused by LLB has resulted in many gardeners eliminating lilies from their garden choices (Folsom 2006 pers. comm.).

LLB, a European insect, was introduced to the eastern U.S. in 1992 and first appeared in southern Maine in 1997 (Folsom 2006 pers. comm., Livingston et al. 1996). Since then, it has steadily moved northward and is currently the limiting factor in lily growth and production in Maine. Larvae and adult beetles attack all aboveground plant parts, and defoliation reduces vigor and flowering, greatly diminishing the aesthetic quality of the plant. In addition, even limited feeding by larvae reduces quality, as all larval stages envelop themselves with a fecal shield for predator protection. Insecticides are registered for LLB control. However, risks to non target organisms associated with these materials require efforts to investigate alternative LLB management strategies. We have preliminary evidence that host plant resistance can play a significant role in reducing the impact of LLB, as well as reducing pesticide use in commercial and home settings.

We received a MAC grant for the 2006 field season to investigate host resistance in ten popular lily hybrids. We found significant differences in plant resistance to LLB in two Oriental lily cultivars. This study provided us with preliminary evidence to expand choice and non-choice host plant resistance field studies in 2007 in a project supported with an external grant from the Northeast IPM Center. We also received funding from MAC in 2007 to address a potential obstacle to continuing this work, which was that commercial bulb producers dip lily bulbs in systemic insecticides that could interfere with our evaluation of host plant resistance (Miller 2007 pers. comm.). We have now verified that if there are any residual insecticides on commercial bulbs at the time that we receive them for our studies, levels in the foliage when we initiate our experiments have no detectable impact on beetle host plant selection, feeding, and survival. (See accompanying report for our 2007 MAC project.) With this issue clarified, we were able to find significant reductions in beetle survival and feeding damage on three of the cultivars that we tested in our no-choice field studies in 2007, in which larvae were restricted on the plants (Table 1). Only one of these cultivars ('Madame Butterfly'), however, had reduced egg-laying by adults and reduced feeding damage in our choice experiments in which adults could select the cultivars on which they fed and laid eggs. At this point, the mechanism of this resistance, whether chemical or physical, is unknown, but it holds considerable promise for plant breeding programs, which could incorporate this trait into commercial cultivars as a nonchemical, preventive method to deal with this devastating pest.

Table 1. Comparative lily leaf beetle density, survival and damage on cultivars evaluated in 2007 in Hampden, Maine.

	Choice Experiment			No-Choice Experiment
Cultivar	Adults/Plant∗ (mean)	Eggs/Plant∗ (mean)	Larval Survival∗ (%)	Damage∗ (rank 1-5)
Black Beauty	0.96 abc	108 b	0 a	1.7 a
Madame Butterfly	0.50 a	3 a	0 a	1.7 a
Uchida	2.50 abcd	55 b	0 a	2.0 a
Casa Blanca	4.00 cd	68 b	19 b	2.8 b
Time Out	2.25 abcd	39 b	8 b	2.8 b
Dizzy	6.25 d	67 b	21 b	3.0 bc
Stargazer	0.85 ab	45 b	19 bc	3.3 c
Siberia	4.75 bcd	70 b	27 c	4.0 d

* Values followed by the same letter are not significantly different from one another (? = 0.05).

The research objective of our proposed MAC project is to conduct preliminary experiments to explore the mechanism of resistance of three lily cultivars ('Madame Butterfly', 'Uchida' and 'Black Beauty') to LLB. These preliminary experiments will provide the initial data needed to prepare a more extensive proposal for external funding to support a project in this new direction of our work.

Research Methodology:

Plants of resistant lily cultivars plus two susceptible cultivars that were planted at study sites in Hampden and Old Town ME for our 2007 NE-IPM study will be maintained and used as a source for plant material and beetles for this study in the summer of 2008. Leaf measurements taken regularly throughout the field season will compare the length, width and thickness of leaves, and any other characters that may interfere with LLB larval attachment and feeding. In addition, the cuticular wax layer of the leaf, which could provide both physical and chemical barriers to feeding, will be quantified, and initial sampling of relative chemical compounds that can act as repellents, feeding deterrents, or toxins will be assessed as follows:

a) Quantifying cuticular lily leaf wax: Leaves will be allowed to wilt prior to cuticular wax extraction. This keeps the epidermis attached to the cuticle so that it can be stripped from the intracellular tissue (Fernandes et al. 1964). Following wilting, sample points will be selected and removed via hole punch from leaves as follows: middle, center; outer-edge, center; leaf base, edge; leaf base, center; and leaf apex. Sample points will then be extracted using 0.5 mL immersion with hexane for 30 seconds. The solvent will then be evaporated with nitrogen and paraffin weighed.

b) Measuring chemical resistance to LLB: Cuticular compounds will be sampled and compared using a solid phase micro-extraction fiber (SPME). Six cultivars of lily species (5 hybrids) will be sampled for 15 seconds on both the dorsal and ventral leaf, for a total of 30 seconds, with a SPME fiber. Lilies will be sampled with 4 treatments: prior to and post LLB egg-laying, LLB feeding damaged and undamaged plants. The fiber will then be brought back to the lab for gas chromatography mass spectroscopy (GC-MS) analysis. The ratios and numbers of hydrocarbons will be compared between sub-species. Cuticular hydrocarbons that are present in greater numbers or in resistant lilies will then be identified for further experiments.

Extension Education and Outreach Activities:

Although preliminary in nature, the findings of this study will be shared via these methods with hobby and commercial horticulturists, who avidly seek nonchemical control methods for LLB infestations:

- Presentation at the 15 July 2008 UM Cooperative Extension Field Day for Home Gardeners, Rogers Farm (Stillwater ME);
- Presentation to greenhouse, nursery and garden center professionals at August 2008 field day at Rogers Farm;
- Sign explaining LLB projects in the Penobscot County Master Gardener Demonstration Garden at Rogers Farm; and
- Poster at the Maine Landscape and Nursery Association (MeLNA) Annual Meeting, Jan 2009.

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

Non-Technical Summary

The lily leaf beetle (LLB), is a serious pest of lilies in Maine and causes economic and aesthetic losses for commercial growers and gardeners by defoliating all aboveground plant parts. First appearing in southern Maine in 1997, the

beetle has steadily moved northward and is currently the limiting factor in lily growth and production. With funding provided by previous MAC grants (2006 and 2007), we identified three lily cultivars, 'Madame Butterfly', 'Uchida', and 'Black Beauty', that resulted in reduced survival of LLB larvae in caged and field trials. The objective of our 2008 MAC grant was to explore whether there are differences in the chemical make-up of the lily leaves between cultivars that inhibit feeding and growth of LLB larvae. In 2008 and 2009 we extracted the chemistry from the leaves of resistant cultivars ('Madame Butterfly', 'Uchida', and 'Black Beauty') and transferred them to leaves of a susceptible variety ('Time-Out'). The beetles were then allowed to feed on disks with the resistant chemical extracts. After 5-6 hours of feeding, the beetles were removed, weighed and the remaining portions of the leaf disk were measured and compared. In 2008, LLB larval feeding was reduced on the 'Black Beauty' leaf disks. In 2009, there was no reduction in feeding for any of the extracts. Thus, we were unable to transfer and identify the resistance factor in these cultivars.

Methods:

Experiments were conducted to assess whether chemicals in the leaves of resistant cultivars were present and could be extracted and inhibit feeding when transferred to a susceptible cultivar. Plants of the resistant lily cultivars plus a susceptible cultivar, 'Time-Out', planted in Hampden, ME, for our 2007 field study, were used in 2008 and 2009 laboratory bioassays. These plants were maintained throughout the field season free of lily leaf beetles by regularly hand removing any colonizing beetles. Leaves from these plants were collected twice during 2008 for bioassays. Lilly leaf beetle larvae used in the bioassays were collected from local lily plantings in the greater Bangor area. In 2008 we extracted the chemistry from the cuticular surface of the leaves of the resistant cultivars to evaluate their impact on larval feeding. Leaf disks were cut from the collected leaves and placed in pentane briefly to dissolve the cuticle. The pentane was then evaporated off with nitrogen, and the extracts were re-suspended in acetone for the bioassays. Extract treatments included cuticle from the resistant cultivars, 'Madame Butterfly', 'Uchida', and 'Black Beauty', and the susceptible cultivar, 'Time-Out'. Each of these extracts was pippetted onto 1 cm leaf disks cut from the susceptible cultivar, 'Time-Out'. Control treatments included leaf disks cut from the resistant cultivar, 'Black Beauty' and the susceptible cultivar, 'Time-Out', treated with the solvent (acetone) alone. Leaf disks were then put individually in petri dishes with one pre-weighed lilly leaf beetle larva. Each treatment was replicated five times, and larvae were monitored hourly and allowed to feed for 5-6 hrs. The bioassay was ended before any of the leaf disks had been completely consumed. At the end of the assay, each larva was weighed, and the remaining portion of the leaf disk was measured either manually or by scanning and using image analysis software. The entire trial was repeated a second time.

In 2009, we extracted the chemistry from the entire leaf tissue to test against larvae. Leaf disks were ground and suspended in pentane for several minutes. The solution was then filtered before the solvent was evaporated with nitrogen. Bioassay procedures were similar to 2008 protocols, but in 2009 treatments included both high and low concentrations of extracts of each cultivar ('Madame Butterfly', 'Uchida', 'Black Beauty', and 'Time-Out') plus additional controls of the solvent (acetone) on each of these same cultivars. The bioassays were replicated three times in 2009.

Results:

In the 2008 trial, lily leaf beetle larval feeding was significantly reduced ($p=0.04$) on the 'Black Beauty' leaf disks, but was not reduced on any of the extract treatments or the control. There were no differences in weight gain between larvae fed the different extracts. In the 2009 trial, there were no significant reductions in feeding ($p=0.17$) or differences in weight gain ($p=0.58$) between larvae fed leaf disks with the different extracts.

Extract on Leaf Disk	Concentration	Proportion of Leaf Disk Eaten (mean ± SE)	
		2008	2009
'Black Beauty' on 'Time-Out'	Low	0.55 ± 0.06	0.66 ± 0.20
'Black Beauty' on 'Time-Out'	High	---	0.69 ± 0.16
'Madame Butterfly' on 'Time-Out	Low	0.49 ± 0.05	0.66 ± 0.17
'Madame Butterfly' on 'Time-Out	High	---	0.64 ± 0.16
'Uchida' on 'Time-Out'	Low	0.67 ± 0.10	0.56 ± 0.14
'Uchida' on 'Time-Out'	High	---	0.80 ± 0.33
'Time-Out' on 'Time-Out'	Low	0.49 ± 0.07	0.69 ± 0.18
'Time-Out' on 'Time-Out'	High	---	0.84 ± 0.28

Acetone on 'Black Beauty' (Control)	---	0.10 ± 0.003	0.74 ± 0.16
Acetone on 'Madame Butterfly' (Control)	---	---	0.81 ± 0.23
Acetone on 'Uchida' (Control)	---	---	0.63 ± 0.13
Acetone on 'Time-Out' (Control)	---	0.57 ± 0.07	0.67 ± 0.19

Conclusion:

Although we have had evidence for significant resistance to lily leaf beetle in the lily cultivars, 'Madame Butterfly', 'Uchida', and 'Black Beauty' in past field studies, we were not able to successfully demonstrate a chemical mechanism for resistance in our laboratory bioassays. Extracts of the leaf cuticle and extracts from the whole leaves of the resistant cultivars did not confer resistance to susceptible varieties when they were placed on the leaves of the susceptible variety. This could be because the mechanism by which these cultivars reduce feeding and survival of larvae is more physically than chemically based, i.e. the leaves are tougher and present more of a physical barrier. However, it may also be the case that there is a chemical basis for the resistance, but our extraction procedures did not successfully capture the chemical defenses of the resistant plant, and hence they were not transferred to the susceptible variety. Future studies are necessary to determine whether different extraction methods and/or physical characteristics of these cultivars are responsible for resistance and could possibly be transferred to other lily cultivars.

Results Extended:

Posters:

- Stack, P., E. Groden, L. Berg Stack, and J. Lund. December 2008. Lily Host Resistance to Lily Leaf Beetle, *Lilioceris lilii* (Coleoptera: Chrysomelidae). Entomological Society of America Annual Meeting, Reno, NV
- Stack, P., E. Groden, L. Berg Stack, and J. Lund. October 2009. Lily Host Resistance to Lily Leaf Beetle, *Lilioceris lilii* (Coleoptera: Chrysomelidae). Maine Invasive Species Network Meeting, Augusta, Maine

Interactive events for green industry:

- Stack, L.B., M. Brand, K. Carroll, B. Maynard, C. Neal and L.P. Perry. 2008. *Great Ideas!* Pavilion. 6-8 Feb 2008. New England Grows. Boston MA.
- Stack, L.B. and J. Dill. IPM Jeopardy! 10 Jan 2007. Greenhouse Growers Program, Maine State Florists' and Growers' Association (Ag Trades Show).

Interactive events for home gardeners:

- Burnett, S., J. Dill, C. Kirby, B. Watt and L.B. Stack. 21 Jul 2009. Problem solving in the garden. Field Day at the Penobscot County Master Gardener Demonstration Garden, Rogers Farm. Stillwater ME.
- Stack, P.A. and L.B. Stack. 13 Aug 2008. Problem solving in the garden: bugs, weeds & disease. Moosehead Lake Garden Club. Greenville Junction ME.

Literature Cited

- Folsom, R. 2006. Maine Department of Agriculture, Food and Rural Resources, Augusta, ME. Personal communication.
- Livingston, S.B. 1996. Biology, control, and host range of *Lilioceris lilii*: a new ornamental
- pest in the USA. MS thesis, University of Rhode Island, Kingston, RI 78 pp.
- Miller, W. 2007. Department of Horticulture, Cornell Univ., Ithaca, NY. Personal communication.

MAC102: Improving Carola Potato Size Distribution through Seed Spacing and Appropriate Nitrogen Fertilizer Rate

Principal Investigators: John M. Jemison, Peter Sexton

Introduction

Most of the potatoes grown in Maine are contracted to McCain Foods and Frito Lay for the food service market. Chipping varieties are grown for the chip market, and Russet Burbank and Shepody potatoes are grown for the French fry market. While Maine used to be a major tablestock potato producer, this has been replaced by the processing industry over the past couple of decades.

Over the past few years, there have been discussions about opening another potato processing plant which would require more acres of potatoes be grown. This has not happened. While the demand for processed potatoes has been constant, it is hard to imagine that demand will increase. With increasing fuel costs, people may reduce travel which could also lead to reduced fast-food restaurant use. This will reduce demand for processed potatoes.

We believe there is a potential for increased demand for quality tablestock potatoes. In 2005 and 2006, 285 potato surveys were collected from people at four events evaluating different attractive tablestock potatoes. Based only on visual appearance, Carola potatoes were the most popular white skinned yellow flesh potato. People also discussed the need for a high quality Maine-grown tablestock potato (Jemison et al., 2008). Based on this work, Carola potatoes were included in a tasting evaluation conducted by Peter and Mary Ellen Camire. In this work, Carola potatoes were found to be among the best in the taste and texture.

Based on these results, we met with several growers and shippers of potatoes in March 2007 to discuss the possibility of developing a market for higher value tablestock varieties. From this meeting we developed a plan to grow Carola potatoes and pilot market them. Mr. Andy Yaeger of Smith Packing worked to get the variety test marketed at a number of Hannaford Brothers stores. We obtained a grant from MTI to develop and print paper bags that would be distinctive and attractive in the marketplace. Keith Labrie, a farmer in St. Agatha, Maine, grew two acres of Carola last summer, and these were kept in storage through the winter. . In February 2008, the potatoes were bagged and shipped to Hannaford Brothers. They sold out quickly. We have just summarized the evaluations from this project, and the results are highly favorable. Of the 66 cards returned, 64 said that they would buy this potato again if they saw them in the store again. When asked if they would eat more fresh potatoes if they saw this bag in the store again, roughly 2/3rd of the respondents said yes. When asked to rate the flavor of this variety, 75% of the respondents rated it as “great”; 22% rated it as “good”; 3% rated it as “fair”; no one rated it as having poor flavor. We are very optimistic about these results.

There has been very little agronomic evaluation on this potato. While Keith was reasonably pleased with the yield and quality of the potato, he was less impressed with the size profile. He would like to see improvement in the size profile with more larger potatoes. Nitrogen rate and seed spacing are important factors that influence potato size profile (Ittani, 1983; Rowberry, 1966). No work has been done to evaluate these criteria with Carola potatoes. We propose to do two trials (one on-station and the other on-farm) to determine optimum spacing and N rate to achieve optimum size distribution.

Goals and Objectives

1. Goal 1. Continue to build interest in Carola potatoes in Maine.
    - Objective 1a. Work with Andy Yeager and Hannaford Brothers to do a larger evaluation in 2008/2009.
    - Objective 1b. Deliver presentation at the potato conference on this project and future directions.
2. Goal 2. Complete two studies evaluating means of improving Carola size profile.
    - Objective 2a. Initiate a trial at Rogers farm assessing the effect of seed spacing and nitrogen rate on Carola yield and quality.
    - Objective 2b. Repeat the Rogers trial in an on-farm project at Keith Labrie’s field in St. Agatha.

- Objective 2c. Feature the potato trial at the U.M. Sustainable Agriculture Field Day and present overall success of the project.
- Objective 2d. Report findings of the research project at the potato conference in Caribou.

3. Goal 3. Gain support from the Maine Potato Board to fund a second year of the size profile work, and help build interest in the project overall.
   - Objective 3a. Apply for a second year of funding from the Maine Potato Board in 2009 to support 2009 field work.
   - Objective 3b. Write an Extension fact sheet describing optimum N rates and seed spacing to achieve optimum yields. Publish on the UMCE web site.
   - Objective 3c. Keep the Maine Potato Board aware of results of trial, progress of the evaluations, and overall success of the project.

Termination Report

Introduction

There is renewed interest in tablestock potatoes with specific characteristics. In 2008, we initiated a trial to determine the optimum N rate and spacing for Carola potatoes. The experiment was conducted. However, late blight infected the crop and the data were essentially lost. In 2009, we repeated the trial to determine optimum N rate and spacing. Potatoes were grown either with one rate of N and three seed spacings or they were planted on one spacing and provided nitrogen (N) fertilizer in five rates 0 – 200 lbs N ac^{-1} in 50 lb ac^{-1} increments.

Environmental Conditions

In 2009, we had near record rainfall which caused production to be lower than expected, but we were able to grow and crop and get the potatoes harvested. Record rainfall likely led to significant leaching and denitrification loss in 2009.

Methods

On May 28, 2009 potatoes were planted at Rogers farm to initiate this experiment. Potatoes were grown either with one rate of N and three seed spacings or they were planted on 12 inch spacing and provided nitrogen (N) fertilizer in five rates 0 – 200 lbs N ac^{-1} in 50 lb ac^{-1} increments. The field received a broadcast application of 150 lbs of P_2O_5 and K_20. This was disked in. The upper part of the field where the spacing trial was placed, an at planting application of 150 lbs N ac-1 was also applied.

The field received regular fungicide applications in 2009. Potatoes were harvested in late September three weeks after receiving top kill. Potatoes were bagged, graded. All US #1 potatoes were graded according to size: 0-4 oz, 4-8 oz, 8 – 12 oz, and 12-16 oz sizes.

Regression analysis was used to assess N response.

Results

Seed Spacing Study

We found no significant differences by seed spacing. Yields and number of tubers were generally highest at the 12 inch spacing, but due to the high rainfall year, there was increased variability in these studies. In discussions with Keith LaBrie a producer in St. Agatha, he said that this was the spacing he was using in his production. There appears to be no benefit in going to a longer spacing than 12 inches between seed pieces.

Table 1. Yield and Number by Spacing

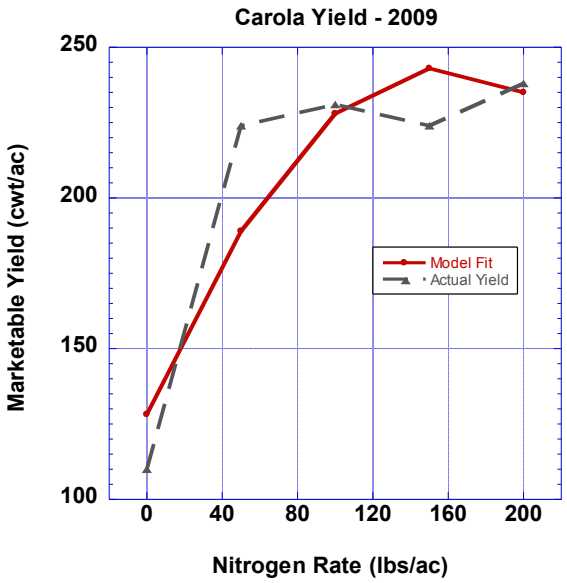
Variety	Total marketable yield	0-4	4-8	8-12	12-16
	Cwt/ac	No / cwt/ac per size category			
9	273	26 / 34	60 / 137	17 / 66	7 /35
12	286	24 / 30	56 / 144	18.5 /70	6 / 43
15	237	23 / 30	56 / 127	13 / 50	5 / 29
LSD (0.05)	NS	NS	NS	NS	NS

N Rate Study

Again, given the tremendous rainfall, this part of the study should be taken with some degree of circumspection. We did find significant differences in this part of the study. Again we broke up the yield as we did in Table 1. Overall we found only a significant curvilinear response to N in the total marketable yield: Yield = 128.2 + 1.46 (Nrate) – 0.00462 (Nrate*Nrate). This was significant at the 95% level of confidence. Yields are found in Figure 1.

There was no significant difference in N rate in the first (0-4 oz) category.

We did find a significant linear response in the 4 – 8 oz category by N rate. We found a significant curvilinear response with the 8 – 12 oz tuber size category in both weight and number indicating that there is a signicant curvilinear response to N and the yield peaks at around 150 lbs N/ac.



Overall Conclusions

Despite a difficult year, we did find significant results in our studies. We have confirmed that the 12 inch spacing is optimum for Carola potatoes, and yield and optimum size is obtained by keeping N application rates at around 140 – 160 lbs N/ac.

MAC103: The Influence Rainfall on the Occurrence of Soft Scald in Honeycrisp Apples

Principal Investigator: Renae E. Moran

Abstract

Honeycrisp production is rapidly increasing in Maine and is expected to approach 7% of production on an acreage basis with the fruit having an estimated wholesale value of $2.2 million. In most years, Honeycrisp apples succumb to the disorder soft scald, a chilling injury that results in large, brown areas on the surface of the fruit. Understanding the causes may allow us to predict and prevent its occurrence. Based on six years of observations, lack of rainfall in the weeks before harvest appears to increase the number of fruit with soft scald. The goal of this project is to confirm that rainfall prior to harvest protects fruit from soft scald. In order to maximize the profitability of this apple variety, growers need methods that prevent postharvest losses that also maintain the best eating quality.

Issue/Priority

Honeycrisp is an apple variety in high demand because of its excellent eating quality at harvest and after long-term storage. Maine-grown Honeycrisp apples are currently sold at both farmstands and supermarkets. Because of its profitability, production in Maine increases each year and is currently 6% of the total acres planted to apple trees.

Honeycrisp apples frequently succumb to the disorder soft scald. Soft scald is a chilling injury that results in large, brown areas on the surface of the fruit after one month in storage. To prevent it, apples are given a special postharvest treatment of delayed cooling before being placed in cold storage. Holding fruit for a week at temperatures in the range of 50° to 70° F prior to placing in cold storage prevents soft scald (DeLong et al., 2004; Watkins et al., 2004), but increases bitter pit in some cases and also causes flavor loss. Shorter durations of delayed cooling can lessen the adverse effects of this treatment, but are ineffective when incidence is severe or greater than 50%.

The severity of soft scald is highly variable from year to year (Tong et al., 2003; Watkins et al, 2005). In Maine, severity ranges from nearly 100% of the fruit being affected in some years to less than 5% in others. Environmental variables may be the cause for such wide variation. Temperature, rainfall and humidity have been measured along with the incidence of soft scald at the Highmoor Farm. Based on these measurements, there appears to be a relationship between lack of rainfall and incidence of soft scald that may be used to predict future occurrence.

There is a strong correlation between soft scald severity and lack of rainfall in the days before harvest (Moran, unpublished data). In years when rainfall occurred immediately before harvest, there was almost no soft scald, but in years when seven or more days without rain occurred, soft scald was very severe. Confirming this relationship with controlled studies may provide growers with a method to predict its occurrence. The ability to predict soft scald would give growers the opportunity make appropriate storage and marketing conditions such as implementing delayed cooling or the immediate sale of apples. If this relationship can be confirmed, irrigation may be used to prevent the occurrence of soft scald.

The goal of this project is to determine if rainfall has an impact on the occurrence of soft scald in Honeycrisp apples.

Project Description

The study will be conducted on fully-bearing Honeycrisp apple trees at the Highmoor Farm Maine Ag. and Forest Experiment Station. Trees will be irrigated to simulate rainfall at varying intervals prior to harvest. A portable drip irrigation system will be used to irrigate trees. Plastic tarps will be placed under trees to prevent rainfall infiltration and to ensure the soil remains dry for the specified period. The following treatments will be applied:

1. Irrigation immediately prior to harvest
2. One day without rainfall (irrigation 2 days prior to harvest)
3. Three days without rainfall (irrigation 4 days prior to harvest)
4. Six days without rainfall (irrigation 7 days prior to harvest)

5. Ten days without rainfall (irrigation 11 days prior to harvest)

Trees will be given sufficient water to supply 5 gallons per day per tree, or to bring soil moisture tension up to a reading of -20 cbars. Treatments will be applied to guard trees on either side of the experimental tree to ensure adequate depletion of soil water. Soil moisture will be measured weekly during the growing season and daily in the two weeks before harvest using tensiometers at a depth of 6-8 inches.

One bushel from each tree will be harvested when starch index is near 6.0, the stage when they are sensitive to soft scald. Fruit will be placed in cold storage immediately after harvest to encourage the development of soft scald. Temperature in storage will be maintained in the range of 32-34°F and will be measured daily. Fruit will be stored until late December at which time quality and occurrence of disorders will be measured.

The study will have a randomized block design with five single-tree replications of each treatment.

References:

- Delong, J.M., R.K. Prange, and P. Harrison. 2004. The influence of pre-storage delayed cooling on quality and disorder incidence in “Honeycrisp’ apple fruit. Postharvest Biology and Technology 33:175-180.
- Tong, C., D. Bedford, J. Luby, F. Propsom, R. Beaudy, J. Mattheis, C. Watkins, and S. Weis. 2003. Location and temperature effects on soft scald in ‘Honeycrisp’ Apples. HortScience 38:1153-1155.
- Watkins, C.B., J. Nock. S. Weis, S. Jayanty, R. Beaudry. 2004. Storage temperature, diphenylamine, and pres-storage delay effects on soft scald, soggy breakdown and bitter pit of ‘Honeycrisp’ apples. Postharvest Biology and Technology 32:213-224.
- Watkins, C.B., M. Erkan, J. Nock, K. Iungerman, R. Beaudry, and R. Moran. 2005. Harvest date effects on maturity, quality, and storage disorders of ‘Honeycrisp’ apples. HortScience 40:164-169.

Sharing Outcomes

This project will identify preharvest factors that contribute to postharvest losses of Honeycrisp apples. The results of this project will enable growers to market high quality apples with minimum loss to soft scald and quality loss. 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.

Termination Report

Summary:

Two goals of this project were to determine if weather is related to soft scald and to test harvest and storage practices that prevent soft scald. Weather variables that were most strongly correlated with soft scald incidence were precipitation in the month before harvest, midseason air temperature and relative humidity. Confirmation of this relationship will allow us to predict when soft scald will be severe. Delayed cooling, the recommended method for preventing soft scald, is not effective when apples are harvested before they are fully ripe. In addition, with an early harvest, delayed cooling increased the number of apples that succumbed to a similar chilling disorder, soggy breakdown.

Objectives That Were Not Met:

A controlled field trial using irrigation and rain out shelters to create different levels of soil moisture was not conducted. Substantial rainfall occurred weeks prior to harvest which prevented the soil moisture from becoming depleted. Dry soil conditions could not be created in this or the following season.

Objectives That Were Met and Significant Findings:

Since the primary objective could not be completed, an additional year of data was collected for comparison with weather records in order to determine if there is an effect of weather on occurrence of soft scald. Weather variables

that were most strongly correlated with soft scald incidence were precipitation in the month before harvest, midseason air temperature and relative humidity. The relationship to preharvest weather can be confirmed by future observations in order to predict when soft scald will be severe.

Delayed cooling and early harvest are the recommended methods of preventing soft scald, but reports of their ineffectiveness in the northeast and Europe have caused concern that early harvest may interfere with preventative measures. Apples from two orchards were harvested one week early and at the normal harvest time when they are nearly fully ripe. Fruit from both harvests and both orchards were subjected to one week of delayed cooling for comparison with immediate cold storage. The results of this study confirmed that delayed cooling does not prevent soft scald in apples harvested one week earlier than normal. In addition, with an early harvest, delayed cooling increased the number of apples that succumbed to another related chilling disorder, soggy breakdown.

These findings will be shared with apple growers so that they can reduce the risk of crop loss.

Methods Used to Evaluate Outcomes:

Growers were informally surveyed to determine the number who will store Honeycrisp and are at risk for losing apples to soft scald. Two growers with large plantings will put Honeycrisp in long term storage in order to market apples at a time when scarce supply increases the price. Most growers will sell their 2009 crop within two months of harvest, but are following the recommendation of either warmer storage temperatures or delayed cooling.

Observations were made of the number of growers who requested information on storing Honeycrisp (eight) and the number who lost fruit to soft scald last year (none).

Integrated Research and Extension Activities:

A presentation was made to Maine apple growers in January 2009 at the Maine Ag. Trades Show in Augusta, ME and a future presentation will be made in December 2009 at the New England Fruit and Vegetable Growers Meeting in Manchester, NH. A paper was accepted for publication in HortScience which will disseminate results to other extension workers in the United States and Canada. Results were shared with Maine apple growers during consultations and in a newsletter.

Publications, Presentations and Other Outputs:

- Moran, R. Multistate Project NE-1036 Report for Maine - Postharvest Biology of Fruits Annual Meeting. Ithaca, NY, June 2009.
- Moran, R., J. DeEll and W. Haltman. In press. Effects of preharvest precipitation, air temperature, and humidity on the occurrence of soft scald in ‘Honeycrisp’ apples. HortScience.

MAC104: Ozone Treatment to Extend Refrigerated Shelf Life of Fresh-Cut Maine Potatoes

Principal Investigators: Denise Skonberg, Beth Calder, Kathy Davis-Dentici

Background Information:

Consumption of fresh-cut produce is growing rapidly, fueled by consumer desires for health and convenience. According to Fresh Cut Magazine, fresh-cut produce currently accounts for approximately $12 billion annually, with the retail market showing the most significant upward trend. This presents an excellent opportunity for Maine's potato industry to market fresh-cut, ready-to-use potatoes, for the retail and foodservice sectors.

The biggest challenge in producing pre-cut potato products is the limited refrigerated shelf-life. Pre-peeled and cut potatoes exhibit undesirable and immediate enzymatic browning which consumers find objectionable. Microbial growth during refrigerated storage is also significant, and the combination of enzymatic browning and bacterial spoilage limits refrigerated storage in untreated fresh-cut potatoes to approximately one week. A minimum shelf-life of three weeks is necessary to market fresh produce, to allow adequate time for transportation and distribution to the end-user.

Current technologies for reducing browning in pre-peeled and/or pre-cut potatoes include the use of sulfites (food allergens), modified-atmosphere packaging (expensive), and acidulants, which should be used in synergistic mixtures for maximum efficacy. Pre-cut products can also be blanched to reduce browning; however blanched products may not carry the "Fresh" label preferred by consumers. The most widely used method for reducing pathogens and increasing microbial shelf life, is the application of chlorine based sanitizers. However, chlorine has not been reported to be effective in the reduction of enzymatic browning in potatoes. In contrast, ozone has antimicrobial effects in various fruits and vegetables and holds promise as an anti-browning treatment for fresh-cut potatoes.

Ozone, a potent oxidant and strong antimicrobial agent, has been granted GRAS (Generally recognized as safe) status by the FDA since 1982. When dissolved in water, ozone can be used to wash vegetables and food processing surfaces to reduce microbial growth. The benefits of ozone also include its rapid decomposition to oxygen, leaving no toxic residue, and the National Organic Program's final ruling permitting the use of ozone in the processing of food products that are intended to be labeled as "organic" or "made with organic ingredients." Recent research on the use of ozonated water treatment to improve refrigerated shelf-life of fresh-cut lettuce indicated that ozonated water decreased bacterial counts and reduced activities of polyphenol oxidase and peroxidase, which are the enzymes primarily responsible for browning in fresh-cut fruits and vegetables. A literature search revealed only one previous study on the use of ozonated water to improve quality of potatoes. The researchers found that ozonated water treatment in combination with vacuum packaging was effective in reducing enzymatic browning in fresh cut potatoes for the length of the two week study.

The preliminary studies on aqueous ozone are promising, and serve as the foundation for this proposed research on fresh-cut potato products. This study will build on our previous experience with evaluating the effectiveness of ozone as an antimicrobial in Atlantic salmon fillets and low-bush blueberries. We plan to address the following questions important for moving this technology forward:

1. Can we obtain an increased shelf life of preferably four weeks for fresh-cut potatoes?
2. Can we prevent enzymatic browning and reduce microbial growth in potatoes treated with ozone alone, without the addition of vacuum packaging technology?
3. What are the optimal treatments for applying ozonated water to fresh-cut potatoes?
4. Does potato variety or method of cutting influence efficacy of the ozone treatment?
5. Can ozone be used synergistically with commonly used acidulants?

Research Plan:

A collaborative research study will be designed to address the questions above. Denise Skonberg, Beth Calder, and Katherine Davis-Dentici (Food Science & Human Nutrition) will consult with Randy Smith (Aroostook Farms) and Greg Porter (Plant, Soil and Environmental Sciences) to determine the most appropriate potato varieties for these studies. Randy Smith has also agreed to provide potatoes. Dr. Skonberg will be responsible for the ozone processing technology, Dr. Calder will be responsible for the chemical and physical quality evaluation of the potatoes, and Ms. Davis-Dentici will be responsible for the microbial analyses. A student laboratory aide will be hired to assist throughout the research project.

A series of studies will be conducted to assess the effects of treatment variables on enzymatic browning and microbial quality of fresh-cut Maine potatoes. The following treatment variables will be evaluated: Ozone concentration (0.5, 1.0, or 2.0 ppm in water), dipping/washing period (1, 3, or 5 minutes), packaging method (vacuum or air), potato variety (possibly Katahdin or Russet Burbank), cut shape (cubed or sliced), and acidulant treatments (ozone combined with citric acid or sodium acid sulfate application). Potatoes will be processed in the Dr. Matthew Highlands Food Pilot Plant in triplicate one pound batches and stored at 5° C for 28 days. Quality analyses will be performed on days 0, 7, 14, 21, and 28 to assess the degree of enzymatic browning (instrumental colorimetric analyses), microbial growth (standard plate counts), polyphenol oxidase activity, and textural attributes (instrumental texture analyses) of the treated potatoes. We anticipate that the project would start Fall, 2008 and be completed by August, 2009.

Outcomes:

If aqueous ozone proves to be an effective anti-browning and anti-microbial technology for fresh-cut potatoes, it can provide Maine's value-added potato processors with an extended high quality shelf-life without the use of sulfites or chlorine treatment. Ozone-treated, fresh cut potatoes also have the advantage of fitting into the organic niche market.

A student laboratory aide will be hired to assist in this research project to promote increased research exposure and training of Food Science & Human Nutrition students. Results will be published in the Journal of Food Science and presented at the Institute of Food Technologists (IFT) Annual Meeting, which will help us reach several audiences including other food scientists and food processors. Beth Calder will help disseminate the research findings to the Maine potato industry. We will approach the Maine Potato Board to publish the findings in the "Maine Potato News" and also the University of Maine Cooperative Extension's "Spudlines". There are two potato industry conferences held in Aroostook County, where the research can be presented more directly to potato growers/processors. If this technology shows extreme promise, we will strongly encourage a Maine processor to partner with us on a future Maine Technology Institute proposal to scale-up the technology for industrial application.

Objectives Met:

Assess the effects of aqueous ozone concentration and application method on enzymatic browning and microbial quality of fresh-cut potatoes during refrigerated storage.

Determine whether aqueous ozone can be used synergistically with acidulant treatments to increase shelf life of fresh-cut potatoes.

Objectives Not Met:

The preliminary pilot study demonstrated that sliced Russet Burbank potatoes exhibited much higher levels of enzymatic browning activity when compared to other potato varieties or cutting methods, so we focused on developing anti-browning treatments for those potatoes.

Methods used to Evaluate Outcomes:

We met those objectives as follows:

- A series of experiments were conducted on fresh-cut Russet Burbank potatoes which assessed the effects of different concentrations of ascorbic acid, citric acid, catechin, green tea extract, proteases, sodium acid sulfate (SAS), and NatureSeal (commercial antibrowning treatment) on refrigerated shelf life.
- Treatments were evaluated singly and in combinations. Aqueous ozone treatments (0.5 – 2 ppm) were applied alone and in combination with the acidulant, antioxidant, and enzyme treatments.
- The effects of contact time and pre-wash treatments were also evaluated. Potatoes were treated and kept under refrigerated storage for up to 28 days, and samples were periodically evaluated for color, microbial quality, polyphenol oxidaseactivity andtotal phenolicscontent.

The outcomes of our project were:

- A 2 ppm aqueous ozone application for 1 minute was effective in significantly reducing brown/red color development in the sliced potatoes during refrigerated storage, however it did not improve microbial quality of the potatoes compared to the controls. Of the various treatments tested, the SAS acidulant and the NatureSeal treatments were the most effective in maintaining a lighter potato color and lower microbial counts during storage. Potatoes treated with the SAS or NatureSeal also xhibited significantly lower polyphenol oxidase activity during storage than all other treatments. For best fresh cut potato quality during refrigerated aerobic storage, potatoes should be pre-rinsed to remove surface starch, then subjected to a 2ppm aqueous ozone application, and then treated with SAS or NatureSeal. Potatoes treated with ozone can be labeled as “organic”, while those treated with SAS or NatureSeal are considered natural.
- These treatments are more consumer-friendly than sulfites, and don’t require the application of a
- pre-blanching step.

Integration of Research and Extension Activities:

This was a collaborative project between researchers at the Department of Food Science & Human Nutrition and UMaine Cooperative Extension. Research results have been presented at a national conference, and shared with colleagues at Aroostook Farm. Dr. Calder will be disseminating our findings to the Maine potato industry in an upcoming article in UMCE’s publication “Spudlines.”

Outputs:

1. Calder, BL, Skonberg, DI, Davis-Dentici, K, Hughes, BH. 2010. The effectiveness of ozone and acidulant treatments to extend the refrigerated shelf-life of fresh-cut potatoes. Institute of Food Technologists Annual Meeting, Chicago, Illinois.
2. A refereed journal article based on this research will be submitted to Journal of Food Science
3. Knowledge gained from this study was instrumental in the preparation of a recent proposal to the National Fisheries Institute titled “Use of ozone, peracetic acid, and sodium bisulfate for shelf life extension of Northern Shrimp, Pandalus borealis”.

MAC105: Determining Breeding Soundness and Incidence of Venereal Diseases in Maine Bulls

Principal Investigators: Jim Weber, Dee Potter

Background:

The beef cattle industry in Maine and in many other states relies primarily on on-farm bulls to produce the next generation of offspring. A number of management techniques to optimize reproduction using live cover have been widely disseminated within the beef industry and are currently in use in most of the United States. These include annual pre-breeding testing of bulls for both breeding soundness and for the presence of venereal diseases that have a negative effect on cow fertility (these tests are also completed regularly as part of many veterinary pre-purchase examinations of bulls). However, few if any beef farmers in Maine are currently doing any kind of pre-breeding fertility or disease checks on their animals (this statement is based on conversations among the authors and representative beef producers and large animal veterinarians in Maine). Furthermore, cooperative initiatives among beef producers may actually increase their risk from sub-fertile or infected bulls. For example, the Aroostook Beef Producers, led by Gene Lawlor of Smyrna Mills, received a grant from the Maine Department of Agriculture in 2006 to fund the Maine Beef Cattle Genetic Improvement Program. Part of this program was the purchase and importation into Maine of a group of genetically superior breeding bulls. These bulls, which are not tested prior to their movement between farms in Maine, were moved from farm to farm during the 2007 breeding season. This practice greatly increases a producer's potential risk of low calf crop due to bull infertility or venereal disease.

Failure to perform pre-breeding examinations puts beef producers at risk of reduced pregnancy rates in their breeding operations. Bulls with reduced scrotal circumference, low sperm counts or viability, or that are persistently infected with *Tritrichomonas foetus* (Trich) or *Campylobacter fetus* (Vibrio) have been shown to have reduced fertility, and the use of a sub-fertile or infected bull will often result in greatly reduced calving rates and extended calving seasons. While there are no data on the prevalence of venereal diseases in Maine bulls, many Maine beef farmers import bulls from states that have documented cases of both Trich and Vibrio. Consequently, Maine beef farmers who do not practice pre-breeding exams run an increased risk of economic losses. The reasons for producers' lack of awareness about the importance of bull infertility and disease are not clear, but may be due to; a lack of Maine veterinarians with expertise and interest in beef reproduction; absence of centralized, easily accessible testing facilities for either breeding soundness or venereal diseases of bulls; or lack of in-State access to information about these subjects from sources such as Cooperative Extension Services, the Maine Department of Agriculture and the University of Maine. We plan to address these deficiencies in the work described in this proposal.

Objectives and Methods:

The primary objective of the proposed project is to increase the awareness of a high percentage of Maine beef producers about the economic benefits of an annual pre-breeding exam for their breeding bulls. This objective will be accomplished by; 1) performing no-cost bull breeding soundness examinations, including both fertility and disease investigations, on a representative sample of 50 Maine bulls in three widely separated areas of the State (Aroostook County, Western Maine and central coastal Maine) during 2008, 2) using the diagnostic data from these exams to estimate the incidence of Trich and Vibrio infections in Maine, 3) establishing procedures for the culture and diagnosis of these diseases in the Maine Veterinary Diagnostic Laboratory, 4) introducing undergraduate pre-veterinary students and practicing large animal veterinarians in Maine to "best practices" of breeding bull evaluation and diagnostics, and 5) dissemination of a report of our findings and educational material related to both bull infertility and venereal disease to beef producers through Extension presentations at producer meetings and educational seminars such as the Maine Beef Conference.

We plan to accomplish the stated objectives through a series of on-farm bull breeding soundness clinics. These clinics will be open to the public, and will be centered around meetings of regional beef producer's groups in widely separated geographic regions of Maine. We plan to examine a total of 50 bulls during these clinics. In addition to Weber and Potter, two to five undergraduate students will participate in the collection of data for the project. Two

large animal veterinarians have expressed interest in adding bull reproductive diagnostics to their practices, and have also been invited to participate in the proposed clinics.

Each bull will be restrained in a squeeze chute, and then will be subjected to the following procedures: measurement of total scrotal circumference and pelvic width and height, collection of semen by trans-rectal electro-ejaculation, evaluation of seminal parameters (volume, sperm concentration, semen gross motility and sperm progressive motility, evaluation of sperm cellular defects), and collection of preputial samples to be cultured using selective medium for both *Tritrichomonas foetus* and *Campylobacter fetus*. In order to validate diagnostic procedures that are new to the Maine Veterinary Diagnostic Laboratory, we plan to compare diagnostic results from *Trichomonas* and *Campylobacter* cultures grown in our lab with cultures grown in the North Dakota Veterinary Diagnostic laboratory, which is accredited by the American Association of Veterinary Laboratory Diagnosticians (AAVLD), and routinely diagnoses cases of these diseases in North Dakota. Any positive *Tritrichomonas foetus* cultures will be positively identified using a species-specific diagnostic PCR test, which will also be compared between the Maine and North Dakota labs. We also plan to work with Debbie Bouchard of the Maine Aquatic Animal Health Lab to determine whether the Biolog diagnostic system has diagnostic value in confirming the genus and species of presumptive cultures of *Tritrichomonas foetus* and *Campylobacter fetus*.

Data collected on the fertility or disease status of individual bulls during the clinics will be shared with the bull's owner, but will otherwise be treated as confidential. Pooled data from bull exams will be compiled and the overall fertility of each group of bulls will be estimated. The incidence of reproductive disease in the tested bulls will also be estimated based on the positive cultures that were confirmed by positive culture and PCR tests from the North Dakota lab. The estimated false positive and false negative rates and the predictive value of diagnostic tests from the UMaine lab will be estimated based on differences in test results with the North Dakota lab, which will be considered the "gold standard" for diagnosis of these diseases. Results from this study will be developed into an Extension report and presentation for dissemination to beef producers during local and State meetings.

We expect to complete all of the beef breeding soundness exams by August 2008. All diagnostic tests will be completed by September 2008. We plan to compile the data and develop teaching materials by the time of the next Beef Expo (December 2008).

Two prominent Maine beef breeders, Ron Howard and Gene Lawlor, who are also leaders in their local industry, have expressed their support for this project, and both plan to sponsor a bull BSE clinic in their local area (see following emails):

In addition to our planned work at the Northeast Beef Expo in May of 2008, we are working with several other producers /producer groups to set up bull testing. The Aroostook Beef Producers, a group of 50 commercial operators, is represented by Gene Lawlor, Lawlor Family Farm, Smyrna, Maine. Gene has offered to host bull collections for the Aroostook County farmers on his farm. Ralph Caldwell of Caldwell Farms in Turner, Maine, has agreed to the testing of ten of his beef bulls, and we plan to work with him during the summer of 2008. Kevin Woltemath of Pineland Farms Natural Beef in New Gloucester, Maine, has also approached Potter and Weber about fertility-checking their breeding bulls this summer. Finally, Dennis Wilk of "King and I Angus" in Industry, Maine, recently contacted us about testing a group of their bulls.

Termination Report

Objectives and How They Were Met:

The primary objective of the funded project was to increase the awareness of a high percentage of Maine beef producers about the economic benefits of an annual pre-breeding exam for their breeding bulls. This objective was accomplished by;

1. Performing no-cost bull breeding soundness examinations, including both fertility and disease investigations, on a representative sample of 50 Maine bulls in three widely separated areas of the State (Aroostook County, Western Maine and central coastal Maine) during 2008.

We performed complete breeding soundness exams on 47 different bulls from 10 different farms during the 2008 and 2009 breeding seasons. The actual number of farms affected was substantially greater, because 17 of these bulls were part of an Aroostook County Heifer Development Project that procured bulls for use on multiple beef operations in northern Maine. Southern, central and northern Maine farms were represented in this study, with exams conducted in Mars Hill, Houlton, Unity, Freeport, Hollis, Turner and Windsor, Maine. Forty-five of these bulls were on beef cattle operations, while two were used on a dairy farm. The mean age was 2.9 years, with a range of 15 months to 7 years. Thirty-nine of 47 bulls were classified as satisfactory potential breeders, and the remaining bulls were classified as either unsatisfactory breeders (n=3) or classification was deferred until the completion of a second exam later in the breeding season (n=5). While 3 of the unsatisfactory / deferred bulls were culled soon after the initial exam, none of the remaining bulls.

2. Using the diagnostic data from these exams to estimate the incidence of Trich and Vibrio infections in Maine.

Samples from all 47 bulls were submitted to the Maine Veterinary Diagnostic laboratory in Orono for microbiological culture of two bovine venereal diseases, *Tritrichomonas fetus* and *Campylobacter fetu*s. Based on the protocols used for isolation and detection of these two pathogens, we did not identify any chronically infected bulls in Maine.

3. Establishing procedures for the culture and diagnosis of these diseases in the Maine Veterinary Diagnostic Laboratory.

Procedures for specific culture, isolation and identification of *Tritrichomonas fetus* and *Campylobacter fetu*s were adapted from standard operating protocols used in the North Dakota State University Diagnostic lab. We obtained positive control samples for both organisms, and ran these parallel to our submitted samples. The positive controls consistently resulted in isolates of the inoculated pathogens. The microbiological procedures for detecting *Tritrichomonas fetus* and *Campylobacter fetu*s are now part of the MVDL's bacteriology SOP's.

4. Introducing undergraduate pre-veterinary students and practicing large animal veterinarians in Maine to "best practices" of breeding bull evaluation and diagnostics

Undergraduate students from UMaine's Department of Animal and Veterinary Sciences accompanied Dr. Weber during every scheduled farm visit during he breeding soundness project. Numbers of students were kept small during each visit, ranging from 3 to 6. Several students participated in multiple farm visits. A total of 15 undergraduates participated in at least one farm visit during the 2008 and 2009 breeding seasons.

5. Dissemination of a report of our findings and educational material related to both bull infertility and venereal disease to beef producers through Extension presentations at producer meetings and educational seminars such as the Maine Beef Conference.

Dr. Weber was recently invited to present a summary of results of the 2008-2009 Maine breeding soundness exams during the December 2009 Beef Conference in Bangor. We also plan to write and submit a White paper of our results to the MAFES Experiment Station.

All of the proposal objectives were met.

Methods Used to Evaluate Outcomes:

1. Number and location of bulls examined in this study. We attempted to sample a significant proportion of bulls used for breeding in Maine, and chose our examination sites to include bulls in all major beef cattle areas of the State.
2. Estimation of the prevalence of *Tritrichomonas fetus* and *Campylobacter fetu*s in the Maine beef cattle population. Beef bulls are the chronic carriers of these two venereal diseases, so a sampling of a representative sample would provide an estimate of the prevalence of these diseases in Maine cattle.

3. Estimation of bull fertility measured by examination of the reproductive organs and a sample of electroejaculated sperm cells. Bulls were classified as Satisfactory potential breeders, unsatisfactory potential breeders, or the classification was deferred pending he completion of a second exam at a later date.

Integration of Research and Extension Activity.

This project was a collaboration between Jim Weber of the AVS Department, and Dee Potter of Cooperative Extension. In addition, the Assistant State Veterinarian, Beth McAvoy and the State Beef Cattle Specialist, Cindy Kilgore, were present at many of the exams. Two of the BSE trips were held at the Northeast Livestock Expo in Windsor, mane, and were attended by fair participants, who were encouraged to watch the examinations and to ask questions. The results from this project will be presented at the 2009 meeting of the Maine Beef Expo.

No publications have been submitted for this project. We plan to complete a White Paper for submission to the University Maine Agricultural and Forest Experiment Station when the final exams are completed in June 2010.

Non-technical summary:

Forty-seven bulls used for breeding on 13 Maine farms were examined for general fertility and for the venereal diseases *Tritrichomonas fetus* and *Campylobacter fetu*s during the 2008 and 2009 breeding seasons. Bulls represented a variety of beef breeds, including Angus (30), Belted Galloway (8), Simmenthal (1), Gelbvieh (4) and Hereford (2). Two bulls were Holsteins used in dairy operations. The average age of bulls was 2.9 years, and ranged from 15 months to 6 years. All 47 bulls tested negative for the two venereal diseases. Thirty-nine of the 47 bulls were classified as satisfactory potential breeders, while 8 were classified as unsatisfactory potential breeders based on either insufficient testicular volume, high proportions of abnormal sperm cells, or physical defects of the penis or prepuce. Communication with owners of the bulls after completion of the exams revealed that several had made management or culling decisions based on information provided to them through the exams. All of the owners expressed interest in doing breeding soundness exams during future breeding seasons.

MAC106: Cold Temperature Tolerance of Apple Rootstocks

Principal Investigators: Donglin Zhang, Youping Sun, Renae E. Moran

Issue/Priority

Winter injury to the root systems of fruit trees and other perennial plants causes significant tree losses and yield reductions in the northern regions of the United States and Canada. This type of injury occurs periodically, on the average every twelve years. Replanting is the only option when significant tree losses occur, causing substantial financial losses for the grower. Planting apple trees grafted to winter hardy rootstocks can prevent economic losses cause by cold temperature injury.

Most commercial orchards in the US are planted to tender Malling rootstocks which lack cold tolerance compared to other types of rootstocks (Embree, 1988; Robinson et al., 2005). Previous testing has demonstrated that G.16 has similar cold hardy as M.26, but G.5935 has greater hardiness than M.26 (Moran, unpublished data). G.5935 provides growers with a size controlling semidwarfing rootstock that is well suited for commercial production. For vigorous varieties and high density plantings, a more dwarfing rootstock is needed that also has good winter hardiness. Historically, early bearing rootstocks such as Bud.9 and M.9, have not done well in Maine, and this may be due to their lack of winter hardiness. G.41 is a new dwarfing rootstock that potentially has more hardiness than other dwarfing rootstocks grown today. Controlled studies are needed to measure the relative hardiness of G.41. Rootstock selection is a cultural method that is likely to be adopted by growers and can potentially reduce tree losses.

Ornamental crab apples are grafted to the same rootstocks as used for dessert apples. A greater need for winter hardiness is needed for nursery trees that are stored with roots above ground which exposes the root system to extremely cold temperatures prior to planting. Loss of nursery plants to winter injury of the root system can be substantial.

Project Description

Ungrafted M.26 trees, purchased from a commercial nursery, and G.41 from Cornell University will be planted in pots and grown outdoors until late October. All potted trees will be placed in cold storage a temperature of 0 ºC until analysis in February. Injury to the root systems will be compared following exposure to temperatures ranging from -10 to -25 °C and an unfrozen control.

Freezing of whole plants will be conducted using a programmable freezer (LoCold Freezer 40-914, ScienTemp, Adrian, MI). Trees will be placed in plastic bags and held at set temperatures for one hour (-10, -15-, -20 and -25 ºC). The amount of root damage will be assessed by measuring electrical conductivity of root tissue and by growth analysis. Trees will be planted in pots and placed in a heated greenhouse to assess recovery from injury based on the amount of shoot after 40 days. The study will be replicated five times.

Sharing Outcomes

Results of this project will be used to develop a rootstock recommendation for Maine apple growers and nursery 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:

Abstract:

In late October, trunk tissues above ground had greater trunk hardiness than below ground, and G.5935 had less cold hardiness in bark tissue than M.26. Above ground trunk hardiness is important in autumn, and both rootstocks had

above-ground trunk hardiness to -24 °C. Nonfreezing temperatures during plant storage from November to February led to early loss of cold hardiness in root tissue of G.41 compared to M.26. G.5935 had greater cold hardiness than M.26 based on tree growth and survival after exposure to temperatures as cold as -21 °C.

Objectives Met:

Cold hardiness of the trunk was measured in late October in G.5935 and M.26 by visual examination for tissue browning. No difference occurred between the two rootstocks in trunk browning above the soil. Trunk tissue above ground had greater trunk hardiness than below ground. Below the soil, G.5935 had an increase in browning in the wood at temperatures below -9 °C whereas M.26 did not. Bark tissue below the soil showed more severe browning in G.5935 indicating a greater degree of damage.

Cold hardiness was evaluated in two rootstocks, M.26 and G.41 in February. Following cold storage at 4 °C, G.41 deacclimated (lost its cold temperature tolerance) and commenced growth. Geneva rootstocks require less chilling than Malling rootstocks to break dormancy and consequently begin growing sooner in springtime. Based on shoot growth, G.41 was injured by temperatures of -9 °C and colder, whereas, M.26 was injured by temperatures of -12 °C and colder. Midwinter loss of hardiness is rare in Maine, but could be a problem in warmer climates. G.5935, in the same study, was injured by temperatures of -15 °C and colder indicating greater winter hardiness than G.41 and M.26. However, trees were one year older which may affect cold hardiness. Significant tree deaths occurred at -18 °C and below in all three rootstocks.

Methods Used to Evaluate Outcomes:

Growers were interviewed during consultations (25 each year) to determine how many are planting new rootstocks. The new rootstocks, G.11, G.16 and G.30, are being planted on a trial basis in several orchards, but limited quantity from the nursery is preventing growers from planting them. Initial observations by the growers indicate greater yield, but a high occurrence of an unknown trunk injury that is killing trees.

Integration of Research and Extension Activities:

- Highmoor Farm Summer Tour. Fifty-one apple growers visited a demonstration site to learn about new apple rootstocks, July 29, 2008.
- "Summary of Apple Research". A presentation made to 60 apple growers at the Maine Ag. Tradeshow, Augusta, ME, January 14, 2009.

Outputs:

Publications:

- Moran, R., D. Zhang, and Y. Sun. (in press). Cold temperature tolerance of G.16 and G.5935 apple roots. Acta Horticulturae.
- Marini, R.P., B. Black, R.M. Crassweller, P.A. Domoto, C. Hampson, S. Johnson, K. Kosola, S. McCartney, J. Masabni, R. Moran, R. P. Quezada, T. Robinson, and C.R. Rom. 2009. Performance of 'Golden Delicious' apple on 23 rootstocks at 12 locations: a five-year summary of the 2003 NC-140 dwarf rootstock trial. J. Amer. Pomological Soc. 63:115-127.
- Marini, R.P., R. Moran, C. Hampson, M. Kushad, R.L. Perry, and T.L. Robinson. 2008. Effect of dwarf apple rootstocks on average 'Gala' fruit weight at six locations over three seasons. J. Amer. Pom. Soc. 62:129-136.

Presentations:

- Moran, R., D. Zhang and Y. Sun. August 2008. Poster presentation, 'Cold Temperature Tolerance of G.16 and G.5935 Apple Roots'. The 9th International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems, Geneva, NY.
- Moran, R. and S. Erich. January 2009. Oral presentation, 'Preplant Compost and Mycorrhizal Inoculation Improved Growth and Yield of Honeycrisp Apple Trees'. American Society for Horticultural Science -Northeast Region Annual Meeting, Newark, DE.