MAC Integrated Research & Extension Agricultural Projects: 2004–2005

MAC50: Study of Antimicrobial Properties of Cranberries and Wild Blueberries for Controlling Foodborne Pathogens (*Escherichia coli* O157:H7, *Listeria monocytogenes, Salmonella Typhimurium,* and *Staphylococcus aureus*)

Principle Investigator(s): Vivian Chi-Hua Wu

Background:

Food safety and pathogen control have become a central concern in modern food science due to outbreaks of foodborne infections/intoxications and the potential of bioterrorism attacks. Foodborne disease is caused by consuming contaminated foods or beverages. The majority of cases of foodborne disease are caused by bacterial agents. Hence, the control of foodborne pathogens in foods and the reduction of potential health risks to consumers from pathogens are important to the food industry in Maine.

Physical, chemical, and biological methods have been used to control foodborne pathogens in foods. Chemical agents with antimicrobial activity have been used as one of the most traditional techniques. Concerns about the use of chemical antimicrobial agents in food products have been raised in the general public for the past decades. The demand for both more natural foods and greater convenience has caused the search for alternative antimicrobial agents in the food industry and researchers. Major natural antimicrobial compounds can be found in plants, animals, and microorganisms. Some of these systems are already employed for food preservation while others are just being studied for use in foods. Phenolic compounds are a major class of natural antioxidants. They have been used as antimicrobial or antiseptic compounds.

Maine's small fruit industry provides advantages in the research area of utilizing natural ingredients to promote food safety. The natural compounds extracted from cranberries and blueberries, such as phenolics (ex. hydroxycinnamates, chlorogenic acid, etc.) and anthocyanins, would provide a new source of antioxidants and antimicrobial substances. The chance to kill, control or suppress foodborne pathogens is high. The USDA is extremely interested in identifying sources of natural antimicrobial compounds that could be incorporated into meat and poultry products. The discovery of antimicrobial properties of cranberries and blueberries in this project will allow the food industry in Maine to utilize these valuable natural ingredients to control foodborne pathogens and may also improve food quality.

Specific elimination of foodborne pathogens will ensure a safer food supply for Maine consumer. Also, utilizing cranberries and blueberries in Maine to control and prevent foodborne pathogens will promote Maine's products with additional functions. It will increase sale and utilization of cranberries and blueberries produced in Maine. The proposed research will be integrated with extension and outreach programs to promote Maine agriculture products and monitor food safety. The successful outcomes will be very helpful for food industry and general consumers nationally and internationally.

Research Description:

Objectives

1. To study antimicrobial properties (suppressing and killing effects) of cranberries and the combination of cranberries and wild blueberries for controlling Escherichia coli O157:H7, Listeria monocytogenes, Salmonella Typhimurium, and Staphylococcus aureus
2. To provide outreach activities with Maine cranberry and wild blueberry industry in developing multiple functions of natural ingredients and to promote food safety to food industry

Objective 1

Four foodborne pathogens will be used: E. coli O157:H7, L. monocytogenes, S. Typhimurium, and S. aureus. All cultures will be checked for purity and authenticity by Gram reactions and commercial biochemical diagnostic kits. Cultures will be kept under refrigeration (4oC) as stock cultures and transferred weekly to maintain viability. The four-organism cocktail will be prepared by growing each organism separately in 100 ml of Brain Heart Infusion (BHI) broth and incubated at 35° C for 24 h. The cultures will then be centrifuged at 15,300 x g for 20 minutes at 4oC, the supernatant will be removed and the pellets will be resuspended with 100 ml of 0.1% sterile peptone water. The

numbers of cells will be adjusted with diluent (0.1 % sterile peptone water) to ca. 6 log CFU/ml. A pathogen cocktail will be made by combining four individual cultures in a sterile tube (2.5 ml of each culture) prior to use (ca. 6 log CFU/ml). Target concentration in distilled water and liquid medium will be 4 log CFU/ml. The "cocktail" system is chosen because studying individual pathogens will make the project too large to handle. Also in the natural environment mixed culture is the norm in most food systems.

The efficacy of different concentrations of puree, powder or concentrate from cranberries and various times of contact for controlling E. coli O157:H7, L. monocytogenes, S. Typhimurium, and S. aureus will be evaluated in distilled water and liquid medium. For puree, powder or concentrate from cranberries, to be called "extract" from now on, six concentration levels (0, 1, 2.5, 5, 7.5, and 10% w/v) will be prepared in distilled water (DW, final volume 100ml) in order to study its killing effect, and in Brain Heart Infusion (BHI, final volume 100ml) broth for the suppressive effect. Both DW and BHI at each concentration level will be inoculated with 1 ml of 6 log CFU/ml of the four organisms cocktail to reach the target initial concentration, 4 log CFU/ml. After thoroughly mixing, the bottles will be set at room temperature for 1 hour prior to testing. Incubation of the distilled water and liquid media with or without the extract will be done at 7oC and 21oC. The 7oC incubation is choice to simulate a slight abused refrigerated condition. The 21oC incubation is designed to observe the growth of these pathogens at room temperature. Pathogen counts will made for the DW experiments at 0, 1, 5, 7, and 24 hr, and for the BHI cultures on days 0, 1, 3, and 5. The viable cell count of the four pathogens will be made in a recovery method, Four-compartment Thin Agar Layer (4-TAL) method, which P.I. has developed to simultaneously recover four pathogens from liquid and solid food systems for study of injured and non-injured cells. MacConkey Sorbitol Agar (MSA, Difco, Detroit, MI.) is for E. coli O157:H7, Modified Oxford Medium (MOX, Difco) is for L. monocytogenes, Xylose Lysine Deoxycholate (XLD, Difco) is for S. Typhimurium, and Baird-Parker Agar (BP, Difco) is for S. aureus. The total number of bacteria will be monitored by Tryptic Soy Agar (TSA, Difco). The Spiral Plater instrument (Autoplate® 4000, Spiral Biotech, Bethesda, MD) will be used to plate the samples on 4-TAL and TSA for viable cell counts. Specific pathogens can be recognized by the typical colony morphology and color on the pathogen specific selective agar and 4-TAL plates. Secondary methods, such as immunological tests and biochemical tests, will be used to confirm the authenticity of selected colonies on these plates. Preliminary studies have discovered that 5 % of wild blueberry concentrate and powder caused one log reduction of E. coli O157:H7 in BHI broth. The combination of cranberries and wild blueberries for controlling E. coli O157:H7, L. monocytogenes, S. Typhimurium, and S. aureus will be also evaluated.

Objective 2:

Outreach activities will be conducted with Maine cranberry and wild blueberry industry in developing multiple functions of natural ingredients. Knowledge in controlling and eliminating foodborne pathogens such as E. coli O157:H7, L. monocytogenes, S. Typhimurium, and S. aureus will be shared with food industry to promote food safety and security. Educational materials in the form of fact sheets and newsletters will be developed and mailed to industry in Maine.

Projected Outcomes:

It is expected that at 2.5% or higher level of extracts from cranberries, or the combination of cranberries and blueberries, there will have inhibitory or suppressive effect on inoculated pathogens in liquid medium. As the concentration increases, the effect will be more pronounced. The natural ingredients from cranberries and blueberries can be used as natural additives to control foodborne pathogens.

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

Objectives Made:

1. To study antimicrobial properties (suppressing and killing effects) of cranberries and the combination of cranberries and wild blueberries for controlling Escherichia coli O157:H7, *Listeria monocytogenes*, *Salmonella Typhimurium*, and *Staphylococcus aureus*.

We investigated the antimicrobial effects of cranberry concentrate on four foodborne pathogens, *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella Typhimurium* , and *Staphylococcus aureus* in both water and growth media.

Cranberry concentrate at five concentration levels (0, 2.5, 5.0, 7.5, and 10% w/v) were prepared in distilled water (DW) in order to study its killing effect, and in Brain Heart Infusion (BHI) broth for the suppressive effect. Pathogen cocktail was inoculated (4 log CFU/ml) in both DW and BHI at each concentration level and incubated at 7oC and 21oC. Pathogen counts were made for the DW at 0, 1, 5, 7, and 24 hr, and for the BHI on days 0, 1, 3, and 5.

Results from the DW experiments showed that while no reduction of pathogens was observed in pure DW (0% treatment) at 7oC or 21oC, killing effects on four pathogens started at 1 hr in 10% and at 7 hr in 2.5, 5.0, and 7.5% concentrate. At 24 hr, no pathogens were recovered from the 10 % treatments. Both *S. Typhimurium* and *L. monocytogenes*, were reduced to non-detectable level at 5 hrs in 10% cranberry concentrate at both 7oC and 21oC. BHI data indicated that the growth of all pathogens tested was reduced compared to the negative control at both temperatures. No colonies were observed for *S. Typhimurium* at 10 % after 5 days at both 7oC and 21oC.

The cranberry concentrate has significant killing and suppression effects on the foodborn pathogens tested. Based on various heath benefits and antimicrobial effects, cranberries may be considered for potential food applications, such as food preservatives.

We also investigated the synergistic antimicrobial effects of cranberries and blueberries for foodborne pathogens, *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella Typhimurium*, and *Staphylococcus aureus*, in both water and growth media.

According to our preliminary results, a berry concentrate mixture [5 % (v/v) blueberry and 5% cranberry concentrate] was prepared in distilled water (DW) for the study of the bactericidal effect, and in Brain Heart Infusion (BHI) broth for the suppressive effect. Pathogen cocktail was inoculated (4 log CFU/ml) in both DW and BHI and incubated at 7oC and 21oC. Pathogen counts were made for the DW at 0, 1, 5, 7, and 24 hr, and for the BHI on day 0, 1, 3, and 5. A synergistic berry powder blend (10% w/v) was also evaluated.

Results from the DW experiments showed that while no reduction of pathogens was observed in pure DW at 7oC or 21oC, bactericidal effects on four pathogens started at 1 hr in berry concentrate mixture and berry powder blend. At 24 hr, no *L. monocytogenes*, *S. Typhimurium* and *S. aureus* were recovered from the berry concentrate mixture treatments. The berry powder blend which was developed for enhancing gastro-intestinal health showed 2 log CFU/ml reduction of *E. coli* O157:H7. BHI data indicated that the growth of all pathogens tested was reduced (4 to 9 log CFU/ml difference) compared to the negative control at both temperatures. The synergistic effects of cranberries and blueberries have not only heath benefits but significant antimicrobial effects. It may be considered for food applications.

2. To provide outreach activities with Maine cranberry and wild blueberry industry in developing multiple functions of natural ingredients and to promote food safety to food industry

Outreach activities are conducted with Maine's wild blueberry and cranberry industry in developing multiple functions of natural ingredients. Knowledge in controlling and eliminating foodborne pathogens such as *E. coli O157:H7*, *L. monocytogenes*, *S. Typhimurium*, and *S. aureus* is also shared with food industry to promote food safety and security. Information is shared with the industry through meetings of the Maine Wild Blueberry Research Committee and the Wild Blueberry Association of North America (WBANA), as well as presentations at state, national and international conferences. Results of this research will be made available to Dr. Beth Calder, the Food Science Extension Specialist, and Dr. Dave Yarborough, Blueberry Extension Specialists for dissemination to processors and growers.

Methods Used to Evaluate Outcomes:

Among the methods of evaluating outcomes to be used are request for assistance, presentations in national and international meetings and publications in scientific journals.

Integration of Research and Extension Activities:

The outcomes of the research project are shared through extension and outreach activities. The antimicrobial properties of cranberries and wild blueberries have potential for industry to promote safe and nutritious foods from natural products of Maine. The results have also been presented in international meetings (Institute of Food Technologists; International Association for Food Protection) and will be published in refereed scientific journals. The outcomes are specially expected to benefit local, regional, and state.

Outputs:

- Wu, V.C.H., X. Qiu, and A. Bushway. 2005. Killing and suppressive effects of Cranberries on Escherichia coli O157:H7, Salmonella Typhimurium, Staphylococcus aureus, and Listeria monocytogenes. Poster Presentation at IFT annual meeting July, 2005. Manuscript under preparation.
- Wu, V.C.H. and X. Qiu. 2005. Killing and suppressive effects of the combination of cranberries and wild blueberries on Escherichia coli O157:H7, Listeria monocytogenes, Salmonella Typhimurium, and Staphylococcus aureus. Poster Presentation at IAFP annual meeting, August, 2005. Manuscript under preparation.

MAC51: Epidemiological *Approaches for Controlling Escherichia coli O157:H7, Listeria monocytogenes,* and *Salmonella* spp. in Dairy Farms in Maine to Promote Food Safety from Farm to Fork

Principle Investigator(s): Vivian Chi-Hua Wu

Background:

The importance of food security to our national health and national economy cannot be overemphasized. The Centers for Disease Control and Prevention (CDC) estimated that 76 million persons contract foodborne illnesses each year in the United States. About 5,000 people in the United States die each year from illnesses related to foodborne pathogens, and around 325,000 serious illnesses resulted in hospitalization. Due to the outbreaks of foodborne diseases and homeland security issues, food safety has become more and more important to the people in Maine. The control of foodborne pathogens in foods and the reduction of potential health risks to consumers from pathogens are important to the food industry in Maine.

The microbiological safety of food originates at farms, where pathogenic microorganisms can potentially contaminate livestock, water, fruits and vegetables. Environmental persistence of Escherichia coli O157:H7, Listeria monocytogenes, and Salmonella spp. are critical in its epidemiology on farms. Persistence of these foodborne pathogens can potentially act as a source of re-infection of cattle, birds, flies, and rodents, which, in turn can act as vectors of foodborne pathogens to increase the risk of food contamination. Animal feed is the beginning of the food safety chain in the "farm-to-fork" model. Farm animals can acquire foodborne pathogens by ingestion of contaminated feeds. Elimination of E. coli O15:7H7 L. monocytogenes and Salmonella spp. in feeds at farms will potentially shut down a major source of infection to animals, thereby leading to reduced food contamination. Cattle have been implicated as the principal reservoir of E. coli O157:H7. Outbreaks have been traced to consumption of hamburger and raw (unpasteurized) milk. L. monocytogenes is highly prevalent in the dairy environment. Animals that carry Salmonella can be a potential source of human infections. Several studies have shown that Salmonella spp. are carried by livestock, especially cattle. Although a few prevalence studies on E. coli O157:H7 and Salmonella spp. on farms have been conducted in certain parts of the United States, the data from Maine is limited. Further, limited extension activities on reducing the transmission of foodborne pathogens at farm level have been conducted in Maine. Therefore, epidemiological studies and outreach activities are needed to control major foodborne pathogens in farms and to prevent food contaminations. The research efforts of this study will determine the prevalence of E. coli O157:H7, L. monocytogenes, and Salmonella spp. in dairy farms in Maine. Understanding the prevalence of these pathogens in farms will provide critical baseline data necessary for developing on-farm control programs to reduce their risk in Maine dairy farms.

Research Description:

1. To determine the prevalence of E. coli O157:H7, L. monocytogenes, and Salmonella spp. in dairy farms in Maine using optimized enrichment broths in conjunction with the Pathatrix system
2. To provide extension programs and educational materials designed to control the risk of E. coli O157:H7, L. monocytogenes, and Salmonella spp. in dairy farms in Maine

Objective 1

Twenty dairy farms will be sampled in Maine. Eight samples/farm will be analyzed for E. coli O157:H7, L. monocytogenes and Salmonella spp. At each of the farms, triplicate samples from eight management areas will be sampled. The sampling protocol and isolation of E. coli O157:H7, L. monocytogenes and Salmonella spp. will be done according to the FDA/BAM manual with modifications using optimized enrichment broths in conjunction with the Pathatrix system (Matrix MicroSciene Inc. Golden, CO).

Optimized enrichment broths for three pathogens will be developed while samples are analyzed. The results will be applied in conjunction with the Pathatrix system (Matrix MicroSciene Inc. Golden, CO), a novel immuno-capture method, to reduce the time for sample preparation and enrichment. Pathatrix (Matrix MicroSciene Inc. Golden, CO) has a unique feature that the entire sample (250 ml) plus pre-enrichment are re-circulated over antibody-coated paramagnetic beads to concentrate target organisms. The target microorganisms captured on the beads could be

subjected to further analysis by detection methods such as plating on selective medium or coupled with other rapid detection methods (e.g. ELISA methods, DNA/RNA Probes, Polymerase Chain Reaction). Previous studies conducted by the P.I in detecting E. coli O157: H7 from 25 ground beef indicated that a combination of shaking pre-incubation (4.5 hr) and immuno-magnetic capture on a Pathatrix unit (0.5 h) reduced the enrichment time (18 hr to 5 hr) prior to further detection methods

The partially purified membrane fragments from Escherichia coli are commercially available as Oxyrase®. This oxygen reducing membrane fraction has been used to remove dissolved oxygen from media for culturing anaerobes and to stimulate growth of pathogenic facultative anaerobes such as L. monocytogenes, Campylobacter, etc. This compound will be added to the Universal pre-enrichment broth (UPB), which has been used as a pre-enrichment step for E. coli O157:H7, L. monocytogenes and Salmonella spp., to evaluate the efficiency of enrichment compared with broths without Oxyrase®.

VIP (BioControl Systems, Inc. WA) is a lateral flow immunoprecipitate assay for the detection of food pathogens (Salmonella, Listeria, EHEC, and Campylobacter). The results can be obtained in 10 minutes after sample enrichment. This can be coupled with optimized Pathatrix sampling preparation protocol to achieve truly rapid detection of low pathogen levels.

Objective 2:

Based on the results of the Epidemiological study, educational materials in the form of group presentation, fact sheets, and newsletters will be developed and mailed to dairy farmers in Maine. Extension education programs in the form of meeting/conference on risks associated with E. coli O157:H7, L. monocytogenes and Salmonella spp. in dairy farms will be conducted. These results will form the basis for continuing education of veterinarians in Maine. The use of this multiplier puts U Maine data at the farm level, delivered by the attending veterinarians.

Dr. Vivian C. H. Wu will be in charge of the research activities. Dr. Gary Anderson and Dr. Russell Hazen from Cooperative Extension will be in charge of the extension and outreach activities.

Projected Outcomes:

It is expected that the prevalence rate of E. coli O157:H7, L. monocytogenes, and Salmonella spp. in dairy farms in Maine will be determined. The optimized enrichment broths in conjunction with the Pathatrix system is expected to reduce detection time compared with traditional methods. It is expected that dairy producers would increase their knowledge of the transmission of foodborne pathogens on farms. The extension and outreach activities would provide education for the farms to control major foodbrone pathogens. The Outcomes of the project will be shared through extension activities. The results will also be presented in national and international meetings and published in scientific refereed journals. Outcomes are specially expected to benefit local, regional, and state.

Objectives Made:

1. To determine the prevalence of E. coli O157:H7, L. monocytogenes, and Salmonella spp. in dairy farms in Maine using optimized enrichment broths in conjunction with the Pathatrix system

We were interested in determining if E. coli O157:H7, L. monocytogenes Salmonella species could be found in various locations on operating dairy farms, if there was a relationship of where positive samples were found, and what the sensitivities of any isolates to several antibiotics were. Environmental samples were taken from eight different areas on a total of fifteen commercial dairy farms. Sterile gauze pads were soaked with evaporated skim milk and environmental swabs taken. The milk served both as a sticky substance to hold potential bacteria as well as a moist incubation media. After collection, swabs were placed into sterile whirlpak bags and more sterile evaporated milk so that swabs were submerged in liquid. Bags were kept on ice until returned to the laboratory.

Common areas sampled on dairy farms were the calving area, the fresh cow pen, milking parlor, milk house floor, calf pens, manure handling equipment, silo floor and total mixed ration. Only farms that had clinically sick animals were positive for Salmonella spp. Salmonella serovars detected on farms were Typhimurium, Typhimurium var. Copenhagen, and Newport. Additionally, isolated serovars were tested for sensitivity to various antibiotics representing a variety of different classes of antibiotics. All serovars were resistant to ampicillin and streptomycin

using the Kirby-Bauer method of testing. All isolates except one Typhimurium var. copenhagen serovar were resistant to tetracycline. All serovars were sensitive to sulfamethazine and sensitive or indeterminate to gentamycin and ceftriaxone. The Salmonella Newport isolates were resistant to ampicillin, chloramphenicol, streptomycin, tetracycline, amoxicillin/clavulinic acid, cephalothin, cefoxitin, cetiofur and penicillin.

Once clinically sick cows were identified on a farm, environmental samples were positive in a variety of locations reflecting movement of organisms to several areas on the farm by animate and inanimate vectors.

A traditional enrichment procedure followed by a detection method to screen the presence of foodborne pathogens needs more than one day. The Principal Investigator has developed a rapid protocol (5.25 h) for the detection of Escherichia coli O157:H7 in raw ground beef by using a Pathatrix System (an immuno-capture-circulating method) in conjunction with a colorimetric assay (Colortrix). However, the reliable and rapid detection of low pathogen levels or injured pathogens in a complex food matrix has not been achieved yet for Listeria spp.

This study developed a new enrichment protocol that improved traditional enrichment procedures (primary and secondary enrichments) by the use of a Pathatrix system. Rapid, sensitive, and reliable detection of Listeria monocytogenes was achieved with a following immunoassay test.

Pathatrix has a unique feature that the entire sample is re-circulated over antibody-coated paramagnetic beads to concentrate target organisms. To optimize the Pathatrix protocol for L. monocytogenes, Universal Pre-enrichment Broth (UPB), Buffered Peptone Water (BPW) and Listeria Enrichment Broth (LEB) were first evaluated for the efficiency of enrichment of heat-injured (57.2oC, 20 min) cells (initial 100 to 102 CFU/ml) and low inocula (101, 100, and10-1 CFU/ml). Microbial counts of enriched cultures were taken at 0, 1, 2, 4, 6, 8, 10, 12, and 24 hr. The best broth was added with and without Oxyrase (an oxygen reducing membrane) and then was evaluated for enrichment of heat-injured cells and low inocula.

The resultant enrichment broth was processed in the Pathatrix system to generate the concentration and selective-enrichment of target cells, which could be relatively detected by an immunoassay test. UPE was the most effective among three broths and showed a significant recovery of injured cells and low inocula compared to LEB. With the addition of Oxyrase, Universal Pre-enrichment Oxyrase Broth (UPEO) was better than UPE (1 to 2 log difference). The UPEO was processed in the Pathatrix System and then followed by immunoassay detection. A same day protocol for detecting of L. monocytogenes was developed.

This study offers an efficient enrichment protocol which provides a significant benefit for the industry to detect L. monocytogenes (low numbers or injured cells) in food products and environment samples.

2. To provide extension programs and educational materials designed to control the risk of E. coli O157:H7, L. monocytogenes, and Salmonella spp. in dairy farms in Maine.

This information obtained from this project helps dairy producers to increase their knowledge of the transmission of foodborne pathogens on farms. The extension and outreach activities provide education for the farms to control major foodborne pathogens. The Outcomes of the project shared through extension activities by Dr. Anderson. The results were also presented in AOAC international meetings by Dr. Wu and manuscript for publication is under preparation. Outcomes are specially expected to benefit local, regional, and state.

3. Brief summary of the integration of research and extension activities that occurred with the project:

Based on the results from the epidemiological study and the development of efficient protocol for detecting foodborne pathogens, educational materials in the form of presentation and meeting are conducted. Fact sheets and newsletters will be sent to dairy farmers in Maine. The information provides a significant benefit for the industry. These results can also form the basis for continuing education of veterinarians in Maine. The use of this multiplier puts U Maine data at the farm level, delivered by the attending veterinarians.

Methods Used to Evaluate Outcomes:

Among the methods of evaluating outcomes to be used are request for assistance, presentations in national and international meetings and publications in scientific journals.

Outputs:

List of publications, presentations, and other outputs resulting from the terminated project:

- Wu, V.C.H., D. Kary, E. Pope, B. Kim, and G. Andersonc. 2005. Development of rapid protocol for the detection of Listeria monocytogenes by optimal enrichment procedures with immuno-capture systems. Poster Presentation at AOAC for the annual meeting, September, 2005, in Orlando FL. Manuscript under preparation.

MAC52: Maximizing Effectiveness of MCP for Maintaining Peak Quality and Preventing Superficial Scald of New England Apple Varieties

Principle Investigator(s): Renae E. Moran

Background:

Consumers prefer crisp apples with a firmness of 15 pounds (Harker, 2003). New England apple varieties, particularly McIntosh, soften very quickly during storage, and most are sold when firmness has dropped to 12 pounds. This is below optimum and the main reason why New England varieties lose competitiveness with other varieties after December. MCP (1-methylcyclopropene) is a new growth regulator that can maintain the firmness of McIntosh near optimum through January. As a result, it has the potential to increase competitiveness and possibly consumption of New England apple varieties. MCP has been registered for use on apples in Maine and is sold under the name, SmartFresh7.

Previous research has been done with MCP being applied within 24 hours of harvest. This is unrealistic for most apple growers. To apply MCP, a storage room must first be filled with fruit which can take as long as seven days. However, preliminary research indicates that high ethylene producing varieties such as McIntosh should be treated within five days of harvest to get maximum efficacy. It is not clearly known how much time growers have to apply MCP after harvest to maximum efficacy on maintaining fruit quality. The dominant varieties, McIntosh and Cortland, are highly susceptible to superficial scald, a disorder which causes the skin to brown after a few months in storage. To prevent it, apples are drenched after harvest with the antioxidant, diphenylamine (DPA). Drenching wets the fruit and leads to postharvest rots, so a fungicide is included in the drench. These postharvest chemicals can account for 47% of detectable pesticide residues in apples (Kuchler et al, 1997). MCP prevents superficial scald on McIntosh and would potentially eliminate the use of postharvest drenching and pesticide residues. Since it is applied as a gas, fruit are not wetted, thus eliminating the need for postharvest fungicides. MCP is applied at very low concentrations and has minimal toxicity, providing growers with a better alternative to DPA.

It has not been clearly established that MCP can prevent superficial scald on Cortland. Growers are reluctant to stop using DPA, particularly on Cortland, because of concerns about superficial scald and postharvest disease control. The objective of this project is to evaluate the effect of delayed treatment on efficacy of MCP for maintaining quality and preventing superficial scald of McIntosh, Cortland and Red Delicious apples.

Research Description:

In fall 2004, McIntosh, Cortland and Red Delicious will be harvested at optimum maturity for long-term storage. Red Delicious will be included as a standard for comparison. Fruit will be stored at 33EF until MCP application. MCP will be applied 1, 4, 8 or 12 days after harvest. Additional fruit will be left untreated as a check. To apply MCP, fruit will be placed in airtight coolers and exposed to 1 ppm MCP for 20 hours. A second set of fruit will be drenched with a solution of diphenylamine (No-Scald) one day after harvest at a commercial packing house. The drenched Cortland fruit will be held in cold storage until treated with MCP at 1, 4, 8, or 12 days after harvest. Following application, McIntosh, Cortland and Red Delicious will be placed in controlled atmosphere (CA) storage at 33EF for five months. Flesh firmness, soluble solids, starch index and internal ethylene will be measured at harvest and at the time of MCP treatment. After storage, fruit will be held at room temperature for one and seven days after which firmness, soluble solids and internal ethylene will be measured on ten fruit. Occurrence of superficial scald and other disorders will be measured on 20 fruit per plot after seven days at room temperature. Temperature in each cold room will be measured daily. For the CA treatment, fruit in bushel boxes will be placed inside a large plastic bag specially designed for CA storage. The bag will be sealed and N2 added to bring O2 concentration down to 3%. The concentration of CO2 will be maintained near 3% with hydrated lime placed inside the plastic bag. The concentration of O2 and CO2 will be measured daily and adjusted as needed with N2 or CO2. The trees will be >McIntosh=/MM111 EMLA, Cortland/MM111 and Red Delicious/ MM111 located at the Highmoor Farm in Monmouth, ME. Additional fruit from a commercial orchard may also be used. The study will have a randomized block design with five-tree blocks replicated five times. Proposed treatments: 1. Untreated check 2. MCP at 1 day 3. MCP at 4 days 4. MCP at 8 days 5. MCP at 12 days 6. DPA at 1 day 7. DPA + MCP at 1 day (Cortland only) 8. DPA at 1 day + MCP at 4 days (Cortland only) 9. DPA at 1 day + MCP at 8 days (Cortland only) 10. DPA at 1 day + MCP at 12 days (Cortland only)

Projected Outcomes:

This project will identify harvest and storage protocol for maintaining optimum fruit quality of varieties grown in Maine. The results of this project will enable growers to market high quality apples with minimum loss to superficial scald. 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. Outcomes will be evaluated by observing the number and type of changes in the industry. During consultations, growers will be interviewed to find out the number of growers who successfully use MCP while eliminating the use of DPA and fungicides. Outcomes will also be evaluated by the number and type of requests for technical assistance.

Abstract:

To maintain fruit quality in storage, MCP should be applied to apples soon after harvest. Application is typically delayed until a certain volume is harvested, which in some cases may be longer than the recommended five days. This project was conducted to determine when MCP is nolonger effective in maintaining fruit quality or preventing superficial scald in three varieties of apple. MCP was most effective when applied one day after harvest for McIntosh and Golden Delicious and one to seven days for Cortland. MCP was still effective in maintaining fruit quality when applied ten days after harvest in all three varieties.

Objectives Made:

- To determine how soon after harvest MCP should be applied for effectiveness in maintaining fruit firmness

Methods Used to Evaluate Outcomes:

MCP was effective in maintaining firmness of all three varieties. MCP was most effective when applied one day after harvest with McIntosh and Golden Delicious. For Cortland, maximum effectiveness occurred with application one to seven days after harvest. MCP was still effective when applied ten days after harvest in all three varieties, but firmness was 1.5 lbs. softer than in fruit treated one day after harvest. This occurred after both 125 and 220 days of controlled atmosphere storage. Golden Delicious became too dehydrated for fruit quality analysis after 125 days of storage.

After 125 days storage, MCP applied one day after harvest prevented superficial scald in Cortland. Application at four or seven days resulted in some scald 2-8% of the fruit. Application at ten days did not reduce the occurrence of scald which occurred in 40% of the fruit. After 220 days storage, scald of Cortland was not effectively prevented by any of the MCP applications. Scald did not occur in Golden Delicious or McIntosh. When apples were harvested and stored before MCP application, internal ethylene increased from undetectable levels at harvest to as high as 190 ppm by ten days after harvest. A significant increase did not occur until ten days after harvest in Cortland, but occurred by seven days in McIntosh and Golden Delicious. By seven days after harvest, internal ethylene was greatest in McIntosh.

Integration of Research and Extension Activities:

Current commercial use of MCP is estimated at 200,000 bushels or 25% of production in Maine. Growers will be surveyed to determine how soon they apply MCP after harvest. The current recommended time is within five days after harvest, but may be extended to seven to ten days.

Outputs:

This was an applied research project conducted at the request of Maine apple growers. Results were presented to 20 apple growers from Maine in winter 2005 and will be reported at future meetings.

Publications:

• One paper is being prepared for publication in a refereed journal and one for publication in a trade journal.

Presentations:

• Using SmartFresh on New England Apple Varieties, March 9, 2005, March Meeting, Monmouth, ME.

MAC53: Impact and Management of Strawberry Bud Weevil (*Anthonomus signatus*) on Raspberry

Principle Investigator(s): David T. Handley, James F. Dill

Background:

Raspberries are a high value crop in Maine and throughout New England. Acreage of this crop is relatively low, but the number of farms growing raspberries is fairly high because most plantings are very small (one acre or less). With net profit potential of ,000 to ,000 per acre, there has much interest in increasing raspberry acreage, but farmer track records with this crop are often poor. Although it appears that raspberries have the potential to be a viable commodity, very few growers have been able to make this crop sustainable for long-term production and profit. This is due, at least in part, to a lack of workable pest management options. One of the most important insect management issues currently facing raspberry growers in Maine is the degree to which a recently recognized pest of brambles, strawberry bud weevil (*Anthonomus signatus*) is a factor in reducing potential yield, and at what point control strategies are justified. Despite its potential to be a devastating pest, very little is known about strawberry bud weevil in raspberries. Strawberry bud weevil or "clipper" is a serious pest of strawberries. This insect girdles flower buds and causes significant yield reductions. While raspberries have been recognized as a host for clipper, it has not been regarded as an important pest of this crop, despite observations by entomologists in the region suggesting that clipper may be responsible for yield losses approaching 75%. Very few growers appear to recognize the problem and most raspberry publications don't mention this insect as a potential pest. A thorough study of this insect on raspberries and its impact on yield will provide the information needed to develop appropriate integrated pest management strategies and lead to improved viability of raspberry production in the Northeast.

Research Description:

Our objectives include

- Determine the importance of strawberry bud weevil as a pest on raspberries in Maine.
- Develop integrated pest management strategies to keep the impact of this insect below economically damaging levels.

Based on observations of severe raspberry bud injury in the field, regional pest management guides have recently begun making control recommendations for strawberry bud weevil on raspberry. However, there is no published work specifically addressing strawberry bud weevil biology on raspberry, nor any analysis of its impact as a pest of this crop.

Raspberry plantings on four grower-cooperator farms will be monitored weekly for strawberry bud weevil populations and bud injury levels during the late spring and early summer of 2005. Raspberry harvest data will be collected and analyzed with clipper and bud data to determine interrelationships between clipper populations, bud injury and fruit yield.

Recent research on strawberries suggests that these plants can compensate for buds lost to clippers by increasing the size of the remaining fruit, thus negating much of the potential yield reduction. However, this compensation potential has not been studied in raspberry and needs to be evaluated as part of a management strategy for this insect. Raspberry plants will be grown in greenhouse facilities at the Agricultural Experiment Station in Monmouth, ME during the fall and winter of 2004-2005. Replicated flower bud removal treatments will be applied, based on similar work recently carried out on strawberries, varying the number of buds removed and the bud position on the inflorescence, to determine to what degree, if any, that raspberries can compensate for bud removal by increased size fruit from remaining, uninjured buds.

Projected Outcomes:

Data from these studies will be used to develop management recommendations for clipper on raspberry that will be incorporated into the New England Small Fruit Pest Management Guide and publicized in regional newsletters, web pages and a fact sheet. These recommendations will impact over 600 farmers throughout Maine and New England

who utilize this resource for making pest management decisions. One farmer/cooperator site will host a grower meeting where clipper injury and management will be discussed and demonstrated. Results of this study will be presented to growers through presentations at meetings, such as the Maine Vegetable and Small Fruit Growers Annual Meeting and the New England Vegetable & Berry Growers Winter Meetings. The results will also be presented in a statewide Extension Vegetable & Berry Newsletter. The results will also be posted on the UMCE Pest Management web site. Results will also be presented and published for other agricultural research and extension staff through scientific associations such as the American Society for Horticultural Science and the American Pomological Society. Improved understanding of strawberry bud weevil biology on raspberries will lead to appropriate management of this insect, and potentially improve the viability of raspberry production in Maine. The greenhouse study will be completed during the fall and winter of 2004-2005. The field survey will take place during the spring and summer of 2005. We seek funding at this time because we anticipate hiring a graduate student to initiate the project in the fall of 2004, and will need this start-up money help to fund the student's work during the fall, 2004 semester.

MAC54: Strawberry Plant Management in a High Density Plasticulture System

Principle Investigator(s): David T. Handley, Renae Moran, David Pike

Background:

Strawberries are the most important cultivated small fruit crop grown in Maine. Currently, about 150 farms produce nearly 3.2 million pounds of fruit, valued at .5 million. Strawberries in Maine are typically produced in matted rows, a perennial system that is not harvested in the planting year, and is carried on for three to five years before being replanted. This system typically produces about 6,000 to 10,000 pounds of fruit per harvest year and nets profits of ,000 to ,000 per acre. In the mid-Atlantic United States, strawberry production has moved away from the matted row system and adopted an annual, fall-planted plasticulture system based on production systems developed for California and Florida. This system allows for extended plant growth into the fall, winter and spring seasons and utilizes high yielding, but winter-tender varieties. Harvests under this system have exceeded 25,000 pounds per acre of high quality fruit and profits have well-exceeded matted row returns in that region. Attempts to adapt this system to the Northeastern United States have met with very limited success. In most cases, the very short growing season and severe winter temperatures are not conducive to adequate plant growth and flower bud development to make this system successful. However, growers in search of higher yields and improved fruit quality have continued to experiment with variations of the system to make it work in the climate of northern New England. It has become clear that in order to assure adequate plant growth in this system, growers in Maine must plant significantly earlier in the year than growers in the south. One of the major drawbacks of this is that the plants will produce numerous runner plants (stolons) under long day, high temperature conditions of the summer, whereas few, if any, runner plants are produced when the plants are established in the fall. Runner plants are a liability in a plasticulture system. They tap the mother plants for nutrients and water, reducing resources that otherwise could support fruit bud development. They interfere with cultivation and pest management operations in the field, and they often root in the planting holes or along the edge of the plastic mulch, creating significant plant competition and essentially becoming weeds. Removing runner plants by hand is extremely labor intensive, and has resulted in growers abandoning these plantings. Developing growing techniques that allow Maine farmers to plant strawberries in a plasticulture system that allows for adequate plant growth, but does not create undo labor burdens associated with runner removal could significantly improve the yield and quality of strawberry production in Maine and significantly improve the profitability of this crop for Maine farmers.

Research Description:

Our objectives include

- Determine optimum timing for runner removal to improve strawberry plant growth and yield in a plasticulture system.
- Evaluate the efficacy of prohexadione calcium to reduce runner development and determine its effect upon strawberry plant growth, yield and crop quality.

David Pike, an established commercial strawberry grower in Farmington, Maine, has been testing and refining a plasticulture system for strawberries for several years. While crop yield and quality from the system have been significantly improved over the conventional matted row system, he believes the labor demands of runner plant removal must be addressed in order for it to become practical for more growers in Maine. Previous research on strawberry has shown that removing runners from plants stimulates further runner production, increasing the labor needed to keep runners under control. Proper timing of runner removal may reduce this problem. Removing runners late in the season does not stimulate as much regrowth as removal early in the season. However, late removal is more labor intensive, because the runners are larger, and may have already rooted. In addition, allowing the runners to remain on the plants may result in stress, reducing yields. A synthetic plant growth regulator, prohexadione calcium (Apogeeâ), which is used on apple trees to control shoot growth, has recently been tested on strawberries in Canada and Florida to reduce branch crown growth and vegetative vigor. Preliminary results in Maine suggest that this product might also significantly reduce runner plant production. In this project we will look at reducing the labor required for runner control in a plasticulture strawberry system by varying the timing and frequency of manual

removal, and testing different application rates and timing of prohexadione calcium to reduce runner plant development.

Strawberry plants will be established in a high-density plasticulture system at Pike's farm in Farmington Maine during early July of 2004. Two varieties, and heavy runner producing type (Jewel), and a low runner producing type (Canoga), will have runners manually removed at varying frequencies (every 14 days, 28 days, or 86 days). Prohexadione calcium will be applied to the same varieties in separate plots at varying rates (50, 100, 150 ppm) and frequencies (14 days, 28 days, 86 days). These treatments will be used to determine how frequency of runner removal and chemical inhibition of runner development affects subsequent runner growth, plant vigor (2004) and crop yield (2005).

Projected Outcomes:

There is a high level of interest in adopting plasticulture for strawberries in Maine. Most vegetable growers are familiar with the use and benefits of plastic mulch and would like to apply this technology to strawberries, if a system can be developed for this region that improves crop quality and yield. This study will address one of the major concerns regarding plasticulture for strawberries in Maine and will provide the nearly 300 commercial strawberry growers in the state with information they need to determine if such a system is feasible for their operation. Potential yield and quality benefits of adopting plasticulture could improve profitability by an estimated 20%. The results of this research will be presented to growers through presentations at meetings, such as the Maine Vegetable and Small Fruit Growers Annual Meeting and the New England Vegetable & Berry Growers Winter Meetings. Field days for interested growers at Pike's farm will be held at the end of the 2004 growing season, to observe the effects of the treatments on the plants and again in the summer of 2005 to observe the effects of the treatments on crop yield. The results will also be utilized for an anticipated update of the Strawberry Production Guide, published by NRAES, and will be presented in a statewide Extension Vegetable & Berry Newsletter. The results will also be posted on the UMCE Pest Management web site. Results will also be presented and published for other agricultural research and extension staff through scientific associations such as the American Society for Horticultural Science and the American Pomological Society. The Maine Vegetable and Small Fruit Growers Association and the New England Vegetable and Berry Growers association have contributed funding to support this research in 2004. David Pike, the cooperating grower in this project, will contribute much of the materials and plants to be used in the research. Mr. Pike has applied for a Farmer Partnership Grant through the Northeast SARE Program, with David Handley serving as his University Advisor. We further intend to submit a funding request to the North American Strawberry Growers Association in the fall of 2004. The plants will be established in 2004 but not harvested until June of 2005. We anticipate that complete analysis of the data will take some time following the harvest.

Abstract:

David Pike, an established commercial strawberry grower in Farmington, Maine has been testing and refining a plasticulture system for strawberries for several years. While crop yield and quality from the system have been significantly improved over the conventional matted row system, he believes the labor demands of runner plant removal must be addressed in order for it to become practical for more growers in Maine. Previous research on strawberry has shown that removing runners from plants stimulates further runner production, increasing the labor needed to keep runners under control.

Proper timing of runner removal may reduce this problem. Removing runners late in the season does not stimulate as much regrowth as removal early in the season. However, late removal is more labor intensive, because the runners are larger, and may have already rooted. In addition, allowing the runners to remain on the plants may result in stress, reducing yields. A synthetic plant growth regulator, prohexadione calcium (Apogee), which is used on apple trees to control shoot growth, has recently been tested on strawberries in Canada and Florida to reduce branch crown growth and vegetative vigor. Preliminary results in Maine suggest that this product might also significantly reduce runner plant production. In this project we will look at reducing the labor required for runner control in a plasticulture strawberry system by varying the timing and frequency of manual removal, and testing different application rates and timing of prohexadione calcium to reduce runner plant development.

Runner plants are a liability in a plasticulture system. They tap the mother plants for nutrients and water, reducing resources that otherwise could support fruit bud development. They interfere with cultivation and pest management operations in the field, and they often root in the planting holes or along the edge of the plastic mulch, creating

significant plant competition and essentially becoming weeds. Removing runner plants by hand is extremely labor intensive, and has resulted in growers abandoning these plantings. Developing growing techniques that allow Maine farmers to plant strawberries in a plasticulture system that allows for adequate plant growth, but does not create undo labor burdens associated with runner removal could significantly improve the yield and quality of strawberry production in Maine and significantly improve the profitability of this crop for Maine farmers.

Methods Used to Evaluate Outcomes:

Strawberry plants will be established in a high-density plasticulture system at Pike's farm in Farmington Maine during early July of 2004. Two varieties, and heavy runner producing type (Jewel), and a low runner producing type (Canoga), will have runners manually removed at varying frequencies (every 14 days, 28 days, or 86 days). Prohexadione calcium will be applied to the same varieties in separate plots at varying rates (50, 100, 150 ppm) and frequencies (14 days, 28 days, 86 days). These treatments will be used to determine how frequency of runner removal and chemical inhibition of runner development affects subsequent runner growth, plant vigor (2004) and crop yield (2005).

Expected Outcomes:

There is a high level of interest in adopting plasticulture for strawberries in Maine. Most vegetable growers are familiar with the use and benefits of plastic mulch and would like to be able to apply this technology to strawberries, if a system can be developed for this region that will improve crop quality and yield. This study will address one of the major concerns regarding plasticulture for strawberries in Maine and will provide the nearly 300 commercial strawberry growers in the state with information they need to determine if such a system is feasible for their farm operation. Potential yield and crop quality benefits of adopting plasticulture could improve profitability by an estimated 20%. The results of this research will be presented to growers through presentations at meetings, such as the Maine Vegetable and Small Fruit Growers Annual Meeting and the New England Vegetable & Berry Growers Winter Meetings. Field days for interested growers at Pike?s farm will be held at the end of the 2004 growing season, to observe the effects of the treatments on the plants, and again in the summer of 2005 to observe the effects of the treatments on crop yield. The results will also be utilized for an anticipated update of the Strawberry Production Guide, published by NRAES, and will be presented in a statewide Extension Vegetable & Berry Newsletter. The results will also be posted on the UMCE Pest Management web site. Results will also be presented and published for other agricultural research and extension staff through scientific associations such as the American Society for Horticultural Science and the American Pomological Society.

The Maine Vegetable and Small Fruit Growers Association and the New England Vegetable and Berry Growers association have contributed funding to support this research in 2004. David Pike, the cooperating grower in this project, will contribute much of the materials and plants to be used in the research. Mr. Pike has applied for a Farmer Partnership Grant through the Northeast SARE Program, with David Handley serving as his University Advisor. We further intend to submit a funding request to the North American Strawberry Growers Association in the fall of 2004.

MAC55: Evaluation of forage production and related stocker calf performance in Maine

Principle Investigator(s): Kenneth M. Andries

Background:

Beef production in Maine has traditionally been cow-calf production with a small stocker and feeding industry. Climatic conditions make cow-calf production systems marginally profitable. However, Maine has the ability to produce large amounts of forage during the summer. This ability can be utilized in a summer stocker program.

This project will look at the productivity of forage and the subsequent performance of stocker steers and heifers on pasture in Maine. Stocker programs are very successful in other parts of the country where there is an abundance of forage during a specific season of year.

The lack of a ready market in the past has kept this type of production system from growing. With the growth of the Maine feedlot industry, through programs like Wolfe's Neck Natural Beef, the need for high quality feeder calves in the 700 to 800 lb weight range has increased. Maine has added two feedlots in the past year and Wolfe's Neck Farm is looking for over 8,000 finished calves for their program. This demand cannot be met by the current production in Maine. This increase in demand along with the forage production potential of Maine combine to give stocker production a high potential for profit in Maine.

This project will start to answer several of the questions being asked by producers that are considering changing to this type of production system. This is also a type of production system that may fit very well into an existing dairy operation as a means of diversification or for farms looking for alternatives to dairy production. Stocker programs have been used very profitably in Oklahoma on winter wheat and in eastern Kansas on native pasture. Maine has the potential to produce larger volumes of forage during the summer than Kansas and we should be able to rival Oklahoma's wheat pasture during our growing season. This project will start to look at our production potential and this should lead to the growth of a very sustainable beef production system in Maine.

Research Description:

Objectives

The objectives of this project will be to evaluate the nutritional value and volume of forage produced during the grazing season in Maine while monitoring and determining the performance that can be expected through the use of managed grazing systems.

- Determine the tonnage of forage produced per acre
- Determine the nutrient per acre produced by this forage over the growing season
- Evaluate calf performance on this forage in a managed grazing system.

Project Description

This project will be conducted at Wolfe's Neck Farm in Freeport Maine. Wolfe's Neck Farm is currently changing their production system from a cow-calf system to a stocker system. They have agreed to provide the cattle; they are currently planning on 300 stocker calves, and will provide the land, calves, and pasture management for this project.

The calves will be weighed upon arrival and twice during the grazing period. A final weight will also be taken at the end of the grazing season. Calves will be managed on a rotational grazing system. We are looking at the possibility of utilizing two levels of intensity as part of this project but management time may not allow for this comparison at this time.

We will measure forage on each pasture before animals are moved to a new pasture and on the pasture they are being removed from through the use of a forage availability stick provided by NRCS. This will allow us to determine the amount of forage harvested by the animals through the grazing season on each pasture as well as the total productivity of forage for the season.

Clippings of pastures will be randomly taken before calves are turned out onto pasture and monthly throughout the grazing season to determine the nutrient content of the available forage. Samples will be sent into the Dairy One lab for analysis. This will be done for consistency of the analysis.

A randomly selected group of calves will have ultrasound measurement taken of their loin eye area and fat thickness to determine muscle and fat changes through the grazing period.

These ultrasounded calves will be followed through the feeding program as well with weights being collected at the end of the feeding period and carcass data provided on the animals. This will allow for a better understanding of performance of these calves through the system.

Data will be analyzed to help evaluate stocking rates, rate of gain and relationships between these factors. This will give us a better understanding of the potential for stocker beef operations in Maine and a base for future research projects into managed grazing and stocker production in Maine. We will try to also keep track of economic cost of the program to allow for better budgeting information to be presented to producers.

Projected Outcomes:

Calves will be purchased in April and May to start the grazing season. Calves will be marketed at the end of the grazing season in late October or November. An extension fact sheet and experiment station publication on forage productivity and calve performance will be developed using this data. This information will also be utilized by Cooperative Extension and Wolfe's Neck Farm to help producers evaluate the potential for this type of production system on their land. Presentations of this information are also possible at the Beef Conference, Agriculture Trade Show, and Beef Expo. I will also provide information on this project to producers through newsletter articles.

Industry Support:

This is an area of interest expressed by the Maine Beef Producers Association and their members. It is also supported by Wolfe's Neck Farm through the use of their land, animals, and management.

MAC56: Production of Powdery Mildew Free Herbaceous Plants

Principle Investigator(s): Donglin Zhang, Lois Berg Stack

Background:

Powdery mildew is a widely distributed fungal disease caused by several groups of fungi. It spreads quickly under high-moisture conditions such as those found in Maine's production greenhouses and during Maine's summer growing seasons. Ornamental plants infected by powdery mildew lose value, and must often be discarded. Growers suffer financial loss, while consumers lose interest in many popular garden plants. Several commercial fungicides are available in the trade, but their effectiveness in controlling powdery mildew is not complete. During the 2002 growing season, an experiment was set up to test plant growth regulators for height control of Rudbeckia hirta 'Plainview Farm', to enable its use as a potted flower crop. All plants treated with plant growth regulators were powdery mildew free, while untreated plants were heavily infected with powdery mildew. This was corroborated by subsequent laboratory tests conducted by Dr. David Lambert. During an oral presentation at a national conference in October 2003, this result garnered much positive attention. A research project is desperately needed to further investigate the effectiveness of plant growth regulators in preventing powdery mildew diseases.

Horticulture, including floriculture, is the fastest growing sector of American agriculture, with Maine ornamental plant sales valued at 1 million in 2001. While it is impossible to assign a value to the financial loss caused by powdery mildew, individual growers lose part or all of specific crops due to this disease every year. Powdery mildew is a significant problem for both growers and gardeners. This study explores the possibility of controlling powdery mildew through use of plant growth regulators rather than fungicides. Producing powdery mildew free plants will not only increase plant sales, but also improve the customers' confidence in popular garden plants such as Phlox paniculata and Rudbeckia hirta, both highly susceptible species. The objectives of this project are to:

- Establish trial plantings at Rogers Farm, Littlefield Gardens, and the UM campus;
- Investigate plant growth regulators, application timing, and concentrations on the control of powdery mildew; and
- Propose strategies for producing powdery mildew free plants for the market.

Research Description:

Seedlings of Plainview Farm Daisy (Rudbeckia hirta 'Plainview Farm') will be produced in a tissue culture lab and rooted in Pro-Mix BX media in the Roger Clapp Greenhouses. Root divisions of Phlox (Phlox paniculata 'Starfire') will be obtained from a commercial nursery and transplanted into one-gallon containers in Pro-Mix BX. Before field planting, two plant growth regulators, Ancymidol (A-Rest) and Paclobutrazol (Bonzi), will be applied to the plants at 2, 4, and 6 ppm drench. For the Plainview Farm Daisy, plant growth regulators will be applied to the media before rooting (in the tissue culture lab tubes) and after rooting (in the soilless media). For the Phlox, plant growth regulators will be applied to the growth media just before shoots emerge and after the 10-leaf stage. All plants will be planted in the three field sites in early summer.

A randomized complete block design will be employed in this experiment. A total of six sites (six blocks/replicates) will be planted for each taxon. Data will be recorded every three weeks through summer 2004. The sampling parameters will be 1) powdery mildew infestation (% of a plant); 2) plant growth (height in cm); 3) days to first bloom and full bloom; and 4) overall performance of plants. All data will be analyzed using SAS procedures.

Preliminary data will be shared with growers through a Rogers Farm field day in August 2004. First-year data will be shared at the greenhouse growers' educational program at the January 2005 Maine Agricultural Trades Show; and through a trade article in the Maine State Florists' and Growers' Association Newsletter in winter 2004/05. Upon final completion of this project (in 2005 or 2006, after 1-2 years of additional data collection), this project's findings will be developed into a web-based Extension fact sheet for growers.

Projected Outcomes:

Specific research outcomes of this project are:

- Establishment of research field trials at Rogers Farm, Littlefield Gardens and UM campus;
- Collection of production and performance data from the above three sites, related to plant growth regulator application and powdery mildew incidence; and
- Interpretation of information and recommendations for growers and gardeners.

These outcomes will be shared by the following methods:

- Growers will learn from a field day, growers' meeting and trade article as described under "Proposed Extension and Education Activities" above;
- A web-based Extension publication will be made available to growers and public after completion of this project (2-3 years of data); and
- Trial plantings will incorporate interpretive signs, to allow growers and home gardeners to learn independently from this project.

Industry Support:

Commercial growers welcome research projects that address problems they have encountered. The Maine Landscape and Nursery Association has contributed 00 for this project. The Mid Maine Greenhouse Growers Association has contributed toward this project. A letter of support for this project is forthcoming from the owner of one of Maine's largest greenhouses: Scott Longfellow, Longfellow's Greenhouses, Manchester ME.

Objectives Made:

1. Establish trial plantings at Rogers Farm, Littlefield Gardens, and the UM campus;
2. Investigate plant growth regulators, application timing, and concentrations on the control of powdery mildew; and
3. Propose strategies for producing powdery mildew free plants for the market.

Methods Used to Evaluate Outcomes:

In the 2004 growing season, three sites of field trials were established at the University of Maine: between the bays of the Roger Clapp Greenhouses, at the Lyle Littlefield Trial Gardens, and at Rogers Farm. Two taxa, Phlox paniculata 'Frans Schubert' and Rudbeckia hirta 'UMaine', were planted at all three sites. During the 2005 growing season, field trial beds from year 2004 were maintained. Also in 2005, experiments for Phlox paniculata 'Blue Boy', Phlox paniculata 'Star Fire', Phlox paniculata 'Sandra' and Rudbeckia hirta 'UMaine' were established inside the Roger Clapp Greenhouses and outdoors in the nursery adjacent to the Roger Clapp Greenhouses.

Preliminary results indicate that plant growth regulators had significant effect in controlling powdery mildew infections. For Phlox paniculata 'Frans Schubert', plants treated with both ancymidol (A-Rest) and paclobutrazol (Bonzi) displayed less powdery mildew infection than control plants. Plants treated with 4ppm Bonzi after transplanting displayed less than 45% powdery mildew infection. Plants treated with 4ppm A-Rest before transplanting were significantly shorter than control plants. No treatments had a significant impact on number of shoots or number of leaves.

For Rudbeckia hirta 'UMaine', application of Bonzi (both 30ppm spray and 4 ppm drench) completely prevented powdery mildew. Other growth regulators, A-Rest and ethephon (Florel), did not reduce powdery mildew infection. Plants treated with both Bonzi and A-Rest were significantly shorter than plants in other treatements.

These results indicate that plant growth regulators can control powdery mildew infection on herbaceous plants during the growing season.

MAC57: Growing by Design: Evaluating Organic Cropping Systems for Improved Feed and Reduced Weed Pressure

Principle Investigator(s): John M. Jemison, Jr., Heather Darby

Background:

Interest in organic dairy production is growing faster in New England than in any other part of the country. Indicators of this growth include: 1) the large numbers of dairy farmers converting to organic production (17% and 8% of the Maine and Vermont industry respectively); 2) the development of farmer/grower groups like the Maine Organic Milk Producers (MOMP); and 3) interest from organic milk companies to bottle milk in Maine as well as Vermont. Recently, New England extension agronomists identified the need to help organic dairy farmers produce quality feed with minimal impact on water quality as a priority research/extension area for the next four years.

The rapid development of the industry has caused growing pains. Dairy producers have many questions related to organic crop management. The risk of crop failure due to poor weed control is infinitely higher in organic production systems because there is nothing but emergency cultivation to save a crop from failed weed control. Many converting dairy farmers have only grown conventional corn and hay for feed; they have not had to explore alternatives. Now, they are facing new weed management issues. These new producers have two options: 1) develop new cropping systems that utilize crop ecological factors such as emergence timing and canopy cover to control weeds; and 2) develop new and improved systems of physical weed management to improve cultivation efficiency.

Cropping system design can have a tremendous impact on water and environmental quality. For example, barley is generally planted in late April or early May before warmer season weed species have germinated. An advantage of using barley in the rotation is that by the time warm season weeds would normally begin to emerge, the barley has reached canopy closure. Barley silage, chopped in late milk/early dough stage, is a nutritious high quality feed. If one immediately follows the small grain with a crop like brown midrib sorghum-sudan grass (BMRSS), weed growth will also be reduced because this crop (a warm season C-4 plant) will be planted into warm soils and also reach canopy closure quickly. It is possible to further reduce the potential for weed competition by no-till planting directly into the barley stubble; this also reduces soil loss due to erosion. If the BMRSS is planted at the end of June, it can likely be chopped twice by early September, and then triticale or winter wheat can be planted which will provide soil cover, reduce erosion, and provide an early forage source the following spring.

Barley and BMRSS contain more protein than corn silage. Growing high protein feed on the farm could greatly reduce the need for additional feed purchases such as organic soybean meal which now costs over 00 per ton. Because of its high digestibility, BMRSS has the potential to become an integral part of a feed program. A reduction in grain imports could reduce the excessive quantities of phosphorus that are presently imported as a component of feed. This is only a short list of the potential benefits this type of diversified cropping system can provide to the agroecosystem. We need to study these types of cropping systems and provide this type of information to our growers so that they will have the greatest chance at success.

The second area of need is organic corn production. As mentioned previously, many growers want to continue to produce corn. Following up on our work with open pollinated corn, organic producers would like to continue to receive information on these varieties compared to standard untreated corn hybrids. A bigger issue is weed management. Many growers do not understand the importance cultivation timing. While we have delivered programs on the importance of timely tine and row cultivation, most organic producers are not getting adequate weed control. We have proposed two new schemes to help growers know when to cultivate: one is an empirical method, and the other uses a grower-friendly computer model to judge when to cultivate. We would like to compare these two methods to a calendar-based approach. The idea behind the empirical method is that we will create a warmer than normal conditions using Tupperware containers placed into the field after planting. These containers will create a microclimate such that weeds should germinate and grow more quickly. When the farmer can see green weeds in the Tupperware container, it is time to cultivate the field. At this stage growers should be able to control most broadleaf weeds because they will still be in the thread stage of development (outside of the Tupperware container). The computer model works in a similar way; by taking growing degree day information, the model predicts emergence times for specific weeds which could be used by growers to determine timing of cultivation. We propose to compare

each of these improved tools to a calendar-based system of cultivation (between five and seven days after planting for the tine cultivator and a second cultivation five to seven days after the first cultivation). We will rate weed control, take measurements of weed biomass, and study the effect on plant growth and development and ultimately yield.

Research Description:

Our goal is to evaluate these two production systems in two field experiments in Maine and Vermont. I am proposing to compare the barley/BMRSS/winter wheat system compared to organically-produced corn silage in one experiment, and to study the cultivation timing in another. The goals of the first trial are to determine: 1) which cropping system produces the most biomass; 2) determine the forage quality of that biomass; 3) assess the potential of no-till planting BMRSS to reduce weed germination compared to tilled soil; and 4) which system produces less weed competition. The goals of the second trial are to determine 1) if the empirical or computer model approach will provide different cultivation timing than a calendar-based approach; 2) will one system provide better weed control than another; and 3) if the different weed pressures will affect yield and quality.

Heather will conduct only the first trial at Guy Choiniere's farm in Highgate, Vermont. She is conducting two other trials at that farm in conjunction with Sid Bosworth. They are planning a field day to communicate this information to their organic dairy farmers. We will be able to deliver two site years of information from the first trial in the first year. We will ask the Maine Ag Center to support Heather's forage analyses. In Maine, organic producers will see this work at the Maine Sustainable Ag Field Day in early July. We will present the results of this work to the MOMP producers next winter. The results of this trial will be submitted to a publication called Forager (a pier-reviewed publication based out of Wisconsin). We will also write mass media articles for Country Folks and similar style publications.

Objectives Not Made:

This project was originally 5/1/2004-6/30/05 but they did not use funds and requested that the funds be rolled over to fund the project this year. Their request was approved. New number MAC067.

MAC58: Evaluating the Effects of Weed Management on Weed Seed Predators

Principle Investigator(s): Amanda Sherin, Chris Reberg-Horton, Eric Gallandt

Background:

Weed management remains the top research priority among diversified vegetable growers in Maine (Handley, 1999). Due to the variety of crops produced, vegetable growers are often left with few herbicide options and must rely instead on alternative forms of weed control. Furthermore, organic growers are restricted from using herbicides and must rely entirely on cultural, physical, and biological weed management strategies. Organic and conventional vegetable growers frequently use cover crops and soil disturbance to manage weeds. Cover crops not only suppress weeds but also contribute to overall soil health by adding nutrients and biomass, reducing erosion, and improving soil tilth. Frequent soil disturbance, however, controls weeds at the expense of soil structure and beneficial soil-dwelling invertebrates. A project funded by the Northeast Regional IPM center is examining several cover crop and weed management strategies to understand what approach is most effective for the northeast. MAC support is requested to help extend research findings from that project and to study aspects of weed seed dynamics that are of immediate help to Maine farmers. This summer, the impact of cover cropping and soil disturbance on invertebrate weed seed predators will be assessed at Roger's farm and 10 volunteer farms. Practical methods of incorporating seed predator conservation onto Maine farms will be developed and disseminated.

Seed predators, such as rodents and beetles, can remove a significant portion of the weed seedbank. Invertebrates tend to dominate predation during the warm growing season while vertebrates predominate in winter. In corn, for example, invertebrates may remove 12% of weed seeds daily from the soil surface while vertebrates remove about 2% daily (Menalled, 2000). Over time, this cumulative predation could lead to a significant reduction in the weed seedbank. In Maine, one ground beetle species in particular, Harpalus rufipes, accounts for up to 78.5% of all invertebrate species (Zhang, 1993). H. rufipes is a denizen of disturbed habitats and is capable of consuming up to 90% of the seeds of certain weed species (Zhang, 1993). As the density of H. rufipes increases, a corresponding increase in seed predation is also observed (Zhang, 1993). The mechanism by which H. rufipes can be promoted in agricultural settings is not well understood, though they appear to prefer habitats with vegetative ground cover and moderate disturbance levels (Kromp, 1999; Dritschilo and Wanner, 1990).

Cover cropping and cultivation typically target weed seedlings rather than weed seeds. Complete seedling mortality is difficult to achieve using these methods. A single Amaranthus retroflexus (redroot pigweed) plant left in a field, for example, can produce up to 100,000 seeds. When cover cropping and disturbance fail to kill all weeds, a backup plan is necessary to deal with the resulting seed rain. At high densities, invertebrate weed seed predators may be the ideal tool for managing seed rain. Furthermore, weed seed predators require no economic input in that they are naturally abundant in the agroecosystem. Research, however, is needed to determine what production practices promote invertebrate seed predator populations for use as a weed management tool.

Research Description:

Objectives

- To evaluate the impacts of weed management systems on beneficial invertebrate weed seed predators.
- To evaluate the contributions of invertebrate weed seed predators to weed management.
- To demonstrate the role of weed seed predators to 10 Maine growers via on-farm trials.

Project Description

This project will evaluate the impacts of different weed management strategies on invertebrate weed seed predators. Furthermore, the relative efficacy of invertebrate seed predators as a weed management tool will be analyzed. Initial trials will be conducted at the University of Maine's Rogers Farm in Stillwater, Maine. In May 2004, 5 different weed management systems will be applied to an experimental field with 4 replications per system (20 plots total). Each management system will utilize a unique combination of cover crops (none/fallow; winter rye/hairy vetch; oat/pea and winter rye/hairy vetch; red clover/perennial ryegrass; or brassica/buckwheat/brassica) and soil disturbances (from 2 to 5 disturbances per plot) for weed control.

Two methods will be used to evaluate soil invertebrate population densities. Adult populations will be measured using 4 pitfall traps per plot. Traps will be deployed in May 2004 and checked weekly until November 2004, when beetles cease surface activity. Invertebrate larval populations will be measured by examining 4 biweekly soil cores per plot from May until November. This frequent sampling schedule is necessary in order to document any acute density changes due to soil disturbance events.

Invertebrate and vertebrate seed predation rates will be ascertained using 3 feeding stations per plot from September 2004 through November 2004 to coincide with the natural seed rain of many weed species. Each feeding station will consist of a petri dish lined with clean sand and baited with 50 seeds of each of the following weeds: Setaria glauca (yellow foxtail), Abutilon theophrasti (common lambsquarter), and Chenopodium album (common lambsquarters). Each station will be placed flush with the ground and protected by a rain cover. In order to observe seed predation rates of different classes of seed predators, wire screening (exclosures) will be placed around the cages to allow access to the seeds by both vertebrates and invertebrates, invertebrates only, or no access. Traps will be checked weekly for number of seeds removed and baited with fresh seeds.

Finally, the aforementioned techniques to access invertebrate populations and seed predation rates will be replicated by several local growers. In doing so, growers will have the opportunity to observe invertebrate predation first hand. Furthermore, grower participation will generate data across a greater diversity of weed management systems and environments. Combining this data with that from Rogers Farm will paint a more comprehensive picture of invertebrate seed predators in Maine agroecosystems.

Projected Outcomes:

While interest in seed predation is growing amongst farmers, few have observed its effects firsthand. After a presentation by Chris Reberg-Horton at the 2003 New England Vegetable and Berry Conference, several farmers were eager to have exclosure cages placed in their fields so they could assess the rate of weed seed predation on their farms. We will make these cages available to up to ten farmers in 2004 so they can directly observe the impact of seed predators. Several teaching tools specific to Harpalus rufipes will also be developed with the support of this grant. We will create a plaster cast of one of their burrows that will highlight the ecology of an organism that most farmers have never noticed. Casts and exclosure cages will be shown at the Sustainable Agriculture Field Day, Highmoor Vegetable Field Day, and Maine Farm Days. If funded, this project will complement a project funded by the Northeast Regional IPM Center to study the impact of various cover cropping strategies on weed seed banks. Information generated by this MAC grant will be combined with data from the larger project to create three fact sheets on the use of cover crops in Maine. Funding for those factsheets has already been obtained.

Objectives Made:

1. To evaluate the impacts of weed management systems on beneficial invertebrate weed seed predators.

Cover crop-based weed management systems appear to attract and retain significantly greater numbers of Maine's dominant invertebrate weed seed predator, the ground beetle Harpalus rufipes. We decided to focus most of our work on H. rufipes, as it was the most abundant species throughout the duration of our research. On average, background H. rufipes populations were three times higher in fields planted with a pea-oat cover crop than in fallow fields. Pea-oat fields acted as refuges for beetles released in fallow fields. Within one week, greater than half of all beetles released in fallow fields moved into pea-oat fields. Over 90% of beetles released in pea-oat fields did not move into other fields. This finding supports the use of vegetated refuges as a way to preserve H. rufipes during periods of intense disturbance. In contrast, the presence or absence of a cover crop did not affect the abundance of H. rufipes adults emerging from pupation in the soil during June and July. This suggests that other factors are responsible for determining where immature H. rufipes develop.

We also compared H. rufipes abundance in four additional cover crop-based weed management systems (buckwheat/brassica/buckwheat rotation, pea-oat/rye-vetch rotation, snap beans/rye-vetch rotation, and a clover-oat mix) to a fallow control. Significantly more beetles were found in the pea-oat/rye-vetch rotation than in the other cover crop and fallow systems. The pea-oat system is intermediately disturbed in comparison with the other systems. In contrast, the fallow control and buckwheat/brassica/buckwheat rotation endure greater soil disturbance while the snap beans/rye-vetch rotation and clover-oat mix receive less. This suggests that while the presence of vegetation

alone encourages adult H. rufipes populations, some level of soil disturbance is needed to achieve even higher densities. We are currently evaluating additional factors (weed density, aboveground biomass, temperature, humidity, etc.) that may have also contributed to higher H. rufipes populations in the pea-oat/rye-vetch rotation.

The impact of disturbance independent of cover cropping is currently under investigation at both Rogers and Aroostook Farms. Adult H. rufipes density is measured following disturbance (chisel plow, moldboard plow, and rototillage) versus an undisturbed control. No significant differences have been detected between control and disturbance treatments; however, higher adult densities have been observed in the chisel plowed and rototilled plots. Furthermore, greater numbers of adults emerging from pupation have been noted in the control plots versus the three disturbances combined. This observation suggests that the softer-bodied, newly emerged adults may be more sensitive to disturbance than the fully sclerotized older adults. We will analyze this data further when this study concludes at the end of September 2005.

2. To evaluate the contributions of invertebrate weed seed predators to weed management.

We used the software program STELLA to model the contribution of H. rufipes to overall weed management. Using adult density, dispersal, and colonization rates obtained via our first objective, we calculated the maximum predation rate on Chenopodium album (common lambsquarters) seeds by H. rufipes in a fallow versus cover cropped field over one growing season. Our cover cropped system assumed a higher H. rufipes density, less dispersal, greater colonization, and higher background C. album seed density and fall seed rain. The fallow system assumed a lower H. rufipes density, higher dispersal, lower colonization, and a lower background C. album density and fall seed rain. The model predicted that H. rufipes would consume 44% of the C. album seeds in the cover crop system versus 35% in the fallow system. Final C. album seed density, however, was higher in the cover crop system than in the fallow. This finding stresses the importance of integrated weed management, where additional control measures taken in the cover crop system could potentially eradicate the remaining C. album seeds. We hope to expand this model to account for additional sources of weed seed loss. Additionally, we hope to predict H. rufipes population densities over multiple years under several different weed management regimes.

Objectives Not Made:

3. To demonstrate the role of weed seed predators to 10 Maine growers via on-farm trials. While we were unable to implement on-farm trials in this phase of the project, we reached a far greater number of growers via field days and conferences (see Integration of Research and Extension Activities). We also developed weed seed predator kits that can be deployed on-farm to test for the presence of invertebrate seed predators as well as relative amounts of seed predation. We will evaluate the effectiveness of these test kits in 2006 via interviews with growers and extension agents. While on-farm trials could have supported experimental data collected at Rogers Farm, the seed predator test kits will be more effective in conveying the concepts of weed seed predation to a wider audience.

Methods Used to Evaluate Outcomes:

We evaluated the effectiveness of our extension activities using survey forms given to participants at the Rogers Farm Sustainable Agriculture Fields Days in 2004 and 2005. Personal interviews with county extension agents and growers will be conducted in 2006 as part of a newly funded project that will demonstrate weed seed predation in both Maine and Pennsylvania.

Integration of Research and Extension Activities:

MAC funding allowed us to integrate weed seed predation research with several extension activities. We introduced approximately sixty participants to weed seed predation at the Rogers Farm Sustainable Agriculture Field Day in July 2004. Attendees also participated in a hands-on demonstration illustrating the behavior of and sampling techniques for the seed predator H. rufipes. At the 2005 Rogers Farm Sustainable Agriculture Field Day on July 27, approximately seventy participants utilized a novel seed predation test kit. These kits allow growers to identify major seed predators commonly found on farms in the northeast as well as estimate predation rates using research techniques from this project. The kits will soon be available to county extension agents and will include valuable information on weed seed predation as well as the tools necessary to measure seed predation and predator species composition on-farm. Using ideas that emerged from this project, we will expand our seed predation extension activities through a recently secured Sustainable Agriculture Research and Extension (SARE) grant in collaboration with Pennsylvania State

University (Curran, W.S., D.A. Mortensen, M.E. Barbercheck, T.S. Hoover, A.G. Hulting, R.J. Hoover, S.C. Reberg-Horton and E.R. Gallandt. 2005. "Using cover crops and crop diversity to optimize ecologically-based weed management" SARE 98,000 dollars). Under this grant, we will demonstrate impacts of four cover cover-based weed management strategies on weed seed predation at two field days in both Maine and Pennsylvania.

Outputs: Results from this project were presented at several professional and public events. Initial findings from this project were incorporated into a presentation titled "Ecologically-based Weed Management" at the Maine Dairy Forage Conference on November 18, 2004. A poster titled "Cover Crop Management Impacts on the Weed Seed Predator Harpalus rufipes" was presented on January 6, 2005, at the Northeastern Weed Science Society Annual Meeting (see attached abstract). This poster received first place in the graduate student poster competition. On June 28, 2005, twenty-five high school students from Maine and New York participated in weed seed predation experiments as part of a Future Teachers of America summer course. Through interactive presentations and small on-farm research trials, the students formulated and tested hypotheses as to how cover cropping systems affect weed seed predators. They also learned to identify several key weed seed predators using guides developed as part of this project. Most recently, the project was presented on July 18, 2005, in a talk titled "Cover Cropping and Cultivation Impacts on the Weed Seed Predator Harpalus rufipes" at the American Society for Horticulture Science Annual Conference. The abstract for this presentation is published in HortScience (see attached abstract). The following publications were produced from this project:

1. Shearin, A. and S.C. Reberg-Horton. 2005. Cover crop management impacts on the weed seed predator Harpalus rufipes. Proceedings of the Annual Meeting - Northeastern Weed Science Society 59: 77
2. Shearin, A. F., S.C. Reberg-Horton, E.R. Gallandt, and F.A. Drummond. 2005. Cover crop and cultivation impacts on the weed seed predator Harpalus rufipes. Programs and Abstracts of the Annual Meeting - American Society for Horticultural Science. Hortscience 40(1): 1102.

MAC59: Development of a Certified Maple Grader Program for New England

Principle Investigator(s): Kathryn Hopkins, Henry Marckres, David Gagnon, Sumner Dole

Background:

Maple syrup production in New England has increased from 563,000 gallons in 2001 to 795,000 gallons in 2003. New England's syrup production represents 54% of the United States syrup production. Of the 795,00 gallons produced in New England in 2003, Maine and Vermont produced 695,000 gallons valued at ,960,000. This agricultural production has traditionally been viewed as a seasonal utilitarian commodity but is increasingly being marketed as a gourmet food item. Additionally, value-added food products such as candy, cream, jellies and mixed products such as salad dressings, barbecue sauces and ice cream toppings are becoming more popular and offer producers opportunities to enter a high-end market. These value-added products offer higher profit levels as long as emphasis is placed on the purity and naturalness of maple products to achieve the price differential between commodity pricing and gourmet food product pricing. Currently, Maine sells 90% of its maple syrup crop at bulk prices to out-of state dealers and processors. It is vitally important to Maine producers to have their syrup graded accurately in order to receive the most favorable bulk price possible.

Increasingly, challenges to this purity are also threatening the price differential. Examples of recent syrup or syrup products that are mislabeled or incorrectly graded include the sales of Shady Maple Syrup in the US, which was removed from Maine store shelves by a Maine Department of Agriculture, Food and Rural Resources action. BJ's Wholesale Club, Inc. was fined 00 by the New Hampshire Department of Agriculture, Markets and Food for selling grade B syrup in containers labeled US Grade A Dark Amber. Maple Grove Farms of Vermont packed the syrup. In another incident in Massachusetts, Trader Joe's was found to be selling syrup that was a lower grade than the grade printed on the label. These incidences of mislabeling threaten the integrity of the maple syrup industry by confusing consumers who purchase what they think is a quality product and then receive a lower quality product. These incidents are the result of an expanding industry and confusion about different state regulations and how to grade syrup. Confusion about grading processes and regulations exist because each state establishes or does not establish laws as in the case of Connecticut about maple syrup production, licensing and grading. While USDA has established legal grades for maple syrup, each state can adjust its statues within certain boundaries to accomplish its own goals. In addition, as the number of fairs and syrup contests increase in New England, the need for qualified syrup judges increases. Often these people are not trained in specific methodology for grading and evaluating syrup. In Vermont, the need for qualified judges exceeds the supply. For their annual maple events they require at least 34 judges. New Hampshire and Maine require 16. Other New England states have similar needs.

Research Description:

To provide consistency to and education about the maple grading and certification process, we intend to organize a maple grading school that would target three audiences: Department of Agriculture certified maple graders, Extension personnel and fair or farm show judges and wholesale buyers. One day of the school would focus on Department of Agriculture personnel who are responsible for certifying grades of syrup for sales and the second day would focus on techniques and levels of accuracy required for show and/or fair judging of maple syrup. A school of this nature has never existed and to establish this training would provide consistency across the maple syrup industry and elevate the level of expertise among those involved with the maple industry. It would also allow the state of Maine to take a leadership role in the syrup industry.

Our specific objectives include

- Develop a maple grading training curriculum
- Establish a 2-day maple grading school and present a workshop in November of 2004
- Establish a pool of certified judges in each state
- Establish a comparative resource and online database of state and province grade standards for use by graders and wholesale buyers
- Produce a peer-reviewed manual for use by certified graders and fair or farm show judges

Research Priorities

To establish a certification process for training assorted personnel, a survey of the standards each state uses and establishing which states do not have standards will be done. Because Canada also produces and ships syrup to the US, a survey of Canadian grade standards and certification processes will be done. This work will be valuable for the maple industry as a whole and was endorsed by the North American Maple Syrup Council and International Maple Syrup Institute at their annual meetings in Nova Scotia in October 2003. Our specific objectives include:

- Evaluation of state and province grade standards
- Establish standard protocols for using maple grading equipment

Projected Outcomes:

- Design and implement a training for Department of Agriculture staff, Extension staff, and syrup judges
- Develop a publication and website for a maple grading manual to be located on Maine's Maple Quality Control Manual website at http://www.umaine.edu/umext/maplesyrupproduction/ The written publication will be funded by the Maine Department of Agriculture, Food and Rural Resources Division of Quality Assurance and Regulation.
- Develop a poster and oral presentation at the North American Maple Syrup Council and International Maple Syrup Institute annual meetings in Quebec in 2005.

Objectives Made:

- Developed a maple grading training curriculum
- Established a 2-day maple grading school in December of 2004 with a second scheduled for December 2005
- Established a pool of certified judges in each state
- Evaluated and compared state and provincial grade standards
- Established standard protocols for using maple grading equipment

Objectives Not Made:

- Establish a comparative resource and online database of state and province grade standards for use by graders and wholesale buyers
- Produce a peer-reviewed manual for use by certified graders and fair or farm show judges

Methods Used to Evaluate Outcomes:

A three-day Maple Grading School was developed and advertised to the maple community. The school was held in Lancaster, New Hampshire from December 8-10, 2004 and participants included Department of Agriculture inspectors, Extension personnel and commercial packers and processors. Participants from seven states and two provinces attended. The goals were for participants to acquire knowledge and skills in the techniques and methods of grading maple syrup. A combination of lecture, handouts and experiential activities were designed to enable participants to learn and adopt correct techniques for grading maple syrup. Impacts from a post training evaluation include the following: 4% of the 31 attendees felt that accurate grading of maple syrup was crucial in their business; 90% felt that the workshop was moderately to very effective; 87% were very likely to recommend this workshop to someone else; 94% increased their confidence level about their ability to use correct maple grading and quality control techniques; 20 people are on the waiting list for the next class of 30. A comment after the workshop from one participant expressed the value of this workshop, "I just want to personally thank you for putting this on. A lot of this I already knew. I learned a lot and it provided validation for me about what I know and what I'm doing!"

Outputs:

- Presented a seminar on maple grading at the January 2005 Ag Trade Show for the Maine Maple Producers.
- Presented a workshop on grading for the Southern Maine Maple Producers Association in January 2005
- This project was documented in several newspaper articles (Country Folks, Coos County Democrat) and featured in the June 2005 issue of The Maple Digest, an industry publication. These publications reached thousands of readers.
- Developed a poster and oral presentation for the North American Maple Syrup Council and International Maple Syrup Institute annual meetings in Quebec in 2005.

MAC60: Compost Trials for Large Animal Carcasses

Principle Investigator(s): Mark Hutchinson, Bill Seekins, Mark King

Background:

Maine dairy farms experience an estimated 3.5% annual mortality rate. Since bovine spongiform encephalopathy (BSE) has been found in the USA, changes in slaughtering and rendering regulations are probable and as a result, this percent is likely to increase. These changes have also made it difficult for dairy/livestock farmers and custom butchers to dispose of their animal mortalities and residual waste in a safe, economical fashion. With disposal costs in 2002 ranging up to per cow, 0/horse, /pig and /barrel of butcher residuals, options are desperately needed for Maine's dairy/livestock industry. The only environmentally sound method of carcass disposal is with proper composting. Currently few farms in Maine utilize this method. This project will provide knowledge on different compost materials for on-farm composting of mortalities.

Through research and educational outreach, 100 Maine dairy/livestock operations will adopted composting as a disposal method for livestock mortalities resulting in a net financial savings. The research trials and educational outreach will be conducted by the Maine Compost Team.

Research Description:

To determine the effect of different compost materials on the heating and rate of breakdown of large animal carcasses in a composting process. The intent is to determine if there are preferred ingredients for composting large animal carcasses with the intention of developing recommendations for farms facing losses of animals due disease. There is a need for this type of information for cows and other animals susceptible to Foot and Mouth Disease since it appears that composting would be the preferred method of disposal in the event of a disease outbreak as a result of previous trials conducted by the Maine Compost Team in 2001 through 2003. Although the disease issue has not been raised regarding horse carcasses, there has been interest in using composting as a method of managing them as well. No research has been conducted in Maine on materials that would work best for this purpose in our environment.

The type of carcasses proposed for the trials are the carcasses of adult dairy cows and large heifers. Additional trials using horse carcasses should also be undertaken if there are sufficient resources to undertake these trials as well. The materials to be tried would include:

1. horse bedding, which is generally a mix of sawdust and/or shavings with urine and feces.
2. heifer/calf bedding
3. a mixture of unused sawdust and shavings
4. wood chips
5. active municipal sludge compost
6. previously mixed compost made of leaves, manure and vegetative wastes.

Of the materials listed, only the heifer/calf bedding and municipal sludge compost have been used in Maine carcass compost trials. New York has reported success with using woodchips for this purpose, while operations in the Midwest have reported using sawdust/wood shaving piles to compost hog carcasses. Horse bedding has been used in Maine successfully to compost a similar material, offal (waste from slaughterhouses). Only the leaf/manure/ vegetative waste compost has not been reported for such purposes, but may be widely available since many communities now have leaf compost operations. No trials have been reported that have compared the performance of all these potential compost media under the same conditions with the same type(s) of carcasses.

Treatments

Six different compost media are being proposed for this trial with one or two types of carcasses. See table below. This would result in a total of twelve different treatments. Ideally, each treatment should be replicated. This would result in twenty- four individual trials. This may be limited by availability of materials (especially carcasses within a limited time frame), labor and equipment time available for conducting the trials.

CARCASS COMPOST TRIALS: TRIAL #s

Trials will be done at Highmoor Farm during the summer and fall of 2004.

Measurements/Data to Be Collected

The following measurements would be required:

- Pile temperatures at one and three foot depths and internal carcass temperatures; measured on a five day a week basis for 90 days.
- Pile volume (height plus two diameter measurements) for each pile measured at start, 15, 30, 60 and 90 days.
- Extent of deterioration at 60 and 90 days. Visual assessment and photo record.

	Cattle	Horses
Horse bedding	C1	H1
Calf/Heifer bedding	C2	H2
Sawdust/shavings	C3	H3
Woodchips	C4	H4
Municipal Sludge Compost	C5	H5
Leaf/Manure/Vegetative Waste	C6	H6

Analyses Needed

An analysis of each of the primary feedstocks will be needed at the start of the process. These will include all the parameters noted above (nutrient content, C:N ratio, moisture content, bulk density, conductivity, pH, volatile solids content). There would be a total of 6 analyses for the feedstocks. The same parameters above (nutrient content, C:N ratio, moisture content, bulk density, conductivity, pH, volatile solids content) will need to be tested again at 90 days for each treatment. Depending on whether there are 12 or 24 individual trials, there would be 12 or 24 sets of analyses of the compost materials. (A total of 18 or 30 analyses would be needed in total.)

Projected Outcomes:

- A summer and fall field days will be conducted for dairy and livestock operators to view and learn about the research trials.
- A technical bulletin will be developed.
- Professional presentations will be given at the Maine Agricultural Tradeshow and industry meetings.

Abstract:

Disposal of routine livestock mortalities on-farms continues to be a growing concern among Maine's dairy industry. The Maine Compost Team (University of Maine Cooperative Extension, Maine Department of Agriculture, Food and Rural Resources and Environmental Protection) has identified composting as a viable option for disposal in both routine and catastrophic events. Determining the proper compost media is a critical factor in successfully composting a carcass. This project evaluated different on farm or readily available compost media at the University of Maine Experimental Station in Monmouth during 2004. A total of 22 trials were completed between May and December using the following media; horse bedding, calf/heifer bedding, sawdust/shavings, woodchips, municipal sludge compost, leaf/manure/vegetable waste compost, Nviro Soil, and on farm waste food (spoils) or a combinations of these materials.

The Maine Compost Team determined that a mixture of two thirds heifer bedding and one third spoils was the best recipe for rapid decomposition of the carcass based on pile temperatures (Figure 1-2) and excavation of the carcasses. Woodchips, spoils, and sawdust/shavings, when used individually would not be suitable for composting mortalites.

In general, it appeared that the conditions achieved in the compost media made a bigger difference than the actual media itself. Some examples:

- Municipal sludge compost performed very well in terms of both peak temperatures and duration of temperatures when it was relatively fresh, ie had only been composting/curing for about 3 to 4 weeks. Older municipal sludge compost (over four months old) from the same facility did not have as much energy and so did not result in internal temperatures as high or for as long.
- A spoiled silage/ bedding mix proved to be the best overall performer in all the trials while another spoiled silage/ bedding mix turned out to be one of the most disappointing performers. The one with the poor performance was mostly grass silage which was very wet and dense with very poor structure. Consequently, the air space collapsed out of the pile within a day or two, causing the pile to cool down and resulting in a number of other nuisance problems.
- Two 400 lb. foals were buried in two piles of Nviro soil. (Nviro soil is a soil amendment made from municipal sludge, wood ash and lime.) One of these was the worst performer in terms of peak temperature achieved, only reaching about 102° F. The other was among the top eight performers, achieving temperatures of over 140° F and maintaining temperatures over 130° F for over a month. The difference being that the second carcass had a bed of woodchips underneath for better aeration.
- One leaf/ chicken manure compost mix was among the poorest performers while another was among the top eight. The difference being that the better performer was a relatively new mix with a low C:N ratio that still had a lot of energy, while the poorer one was several months old with a higher C:N ratio and no longer able to sustain the higher temperatures.

Methods Used to Evaluate Outcomes:

Animal carcasses can be successfully composted in a variety of media. The ability to achieve temperatures proven (131o F) to kill most pathogens will depend more on the conditions in the media than on the source of the media. Those conditions that appear to be most conducive to rapid and sustained heating are:

- Porosity - Piles with very fine textures or very wet materials fail to heat due to lack of oxygen. Piles with a very high porosity, such as wood chips, heat rapidly but are unable to sustain the high temperatures as long as materials with a little less air space. Textures with particles between ¼ inch and ½ inch appear to give the optimum results.
- C:N ratio - As with all composting, piles with C:N ratios too high (over 40:1) tend to heat slower, in general than those with a lower C:N. One exception to this is the woodchip piles in which there is very little available carbon due to the coarse texture.
- Age - Piles with materials that have been mixed and composting for several months do not have the amount of energy or activity needed to sustain the temperatures within the carcasses when compared to relatively fresh active compost piles.

Outputs:

- Symposium on Composting Mortalities and Slaughterhouse Residuals. Portland, ME May, 2005. National symposium was presented by the Maine Compost team for regulatory personnel and decision makers responsible for carcass disposal in their geographic region. 104 people attended the symposium.
- A professional presentation was given at Nutrient Management Training, August 2005. The training was to expose Certified Nutrient Management Planners to this new method of on farm mortality disposal.
- A demonstration project was established during 2005 Maine Farm Days for the farm tour. Over 500 people received information about carcass composting.

Presentations:

- Hutchinson, M., B. Seekins, 2005. "On Farm Carcass Composting, What's the Reality?" Nutrient Management Training. Sidney, ME
- Hutchinson, M., B. Seekins, 2005 "Livestock Mortality Composting Demonstration" 2005 Maine Farm Days. Clinton, ME
- King, M., B. Seekins, and M. Hutchinson, 2005. "Observations of Large Animal Carcass Composting with Different Media". Symposium on Composting Mortalities and Slaughterhouse Residuals. Portland, ME May.
- Seekins. B., M. Hutchinson, and M. King, 2005. Large Animal Mortality Carcass Composting Field Trials: 2001-2005. Symposium on Composting Mortalities and Slaughterhouse Residuals. Portland, ME May 2005.

Publications:

- King, M., B. Seekins, and M. Hutchinson, 2005. "Observations of Large Animal Carcass Composting with Different Media". Conference Proceedings: Symposium on Composting Mortalities and Slaughterhouse Residuals.
- Seekins, B., M. Hutchinson and M. King, 2005 Large Animal Mortality Carcass Composting Field Trials: 2001-2005? Conference Proceedings: Symposium on Composting Mortalities and Slaughterhouse Residuals.

MAC61: Imidacloprid Resistance in the Colorado Potato Beetle: Addressing the Problem before It Gets out of Control

Principle Investigator(s): Andrei Alyokhin

Background:

Colorado potato beetle, Leptinotarsa decemlineata (Say), is the most important insect defoliator of potatoes (Weber and Ferro 1994). None of the control techniques developed against this pest during the past 135 years has provided long-term protection of potato crops (Casagrande 1987), and the beetle continues to be a major threat to potato production. High fecundity, a diverse and flexible life history, and a remarkable ability to develop insecticide resistance make Colorado potato beetle management a challenging task.

Imidacloprid is a systemic neonicotinoid insecticide used for controlling a wide variety of arthropod pests. High imidacloprid efficacy has led to its wide acceptance by Maine potato farmers, with most non-organic growers currently using this compound. Potato growers usually apply systemic formulation of imidacloprid (AdmireÒ) at planting to the whole field. This maximizes plant coverage and significantly increases insecticide persistence in potato foliage. However, whole-field systemic applications also create strong selection pressure on insect populations, eventually resulting in their resistance to this compound.

Colorado potato beetle resistance to imidacloprid on commercial potato farms has already been reported in scientific literature (Zhao et al. 2000, Olson et al. 2000). There is a good reason to believe that it will spread throughout presently susceptible beetle populations (Forgash 1985), as has previously happened with its resistance to 40 (!) other insecticides. A rather limited number of chemicals can still control this pest, most of which are either highly toxic to non-target organisms (including humans), or expensive and cumbersome to use, or closely related to imidacloprid and thus likely to be neutralized by the same resistance mechanism. Therefore, imidacloprid failure will have really dire consequences for the Maine potato industry.

The first instances of Colorado potato beetle resistance to imidacloprid are already happening in Maine. Applications of this compound on two commercial potato farms in Southern Maine no longer prevent economically significant damage caused by the beetles. Laboratory assays conducted on our request at the University of Massachusetts revealed 58-fold decrease in imidacloprid susceptibility in the beetles collected from that area compared to the reference population that has never been exposed to imidacloprid (population ME1 on Fig. 1).

Even more disturbingly, we found a few surviving larvae in imidacloprid-treated commercial potato field in Aroostook County. A subsequent laboratory bioassay detected 25-fold decrease in their susceptibility to imidacloprid at that field (population ME2 on Fig. 1). Although density of the resistant Aroostook population was still too low to cause substantial damage, our finding indicates that resistant genes are very likely to be already present in the population, and it is only a matter of time before beetles reach economically damaging levels. Clearly, an urgent action is required before imidacloprid resistance becomes a widespread problem for Maine potato growers.

Research Description:

Objectives:

The major objectives of the present study are (1) assist growers on the affected farms in Southern Maine to protect their crop from Colorado potato beetle damage, and (2) to develop a resistance management plan that can be implemented by potato growers throughout the state.

Research Activities:

First, preliminary laboratory investigations showed that imidacloprid-resistant beetles from Southern Maine are still susceptible to DiSyston and Spintor. Therefore, we propose that the growers in the affected area attempt using these compounds instead of imidacloprid during the 2004 growing season. However, laboratory findings might not be directly applicable in the field. We will conduct replicated field trials of other foliar and systemic insecticides currently registered for the Colorado potato beetle control. Experimental plots will be set up on the farm that has a resistant beetle population. The plots will be arranged in a randomized complete block design. Twenty plants will be randomly

selected at weekly intervals from each plot, and the number of Colorado potato beetles at all life stages will be recorded. This will allow selecting for the future use the chemical that is most efficient in controlling imidacloprid-resistant beetles.

Secondly, we propose to test the possibility of using high dose-refugium approach for delaying the evolution of imidacloprid resistance. Leaving a small area of the field untreated allows build-up of susceptible Colorado potato beetles. If susceptible insects then mate with the resistant insects, the resulting offspring are significantly less resistant than the offspring of two resistant insects mating with each other. Therefore, these offspring can be effectively killed by imidacloprid applied at the recommended rate. We propose creating at least three refugia at the fields with resistant beetle populations, and then measuring beetle density and resistance at those fields at the end of the season and comparing it to the density and resistance at the fields completely treated with imidacloprid.

Third, we propose to start surveying Maine Colorado potato beetles for the signs of resistance. Eggs will be collected from commercial potato fields and adjacent volunteer plants around the state and assessed for their susceptibility to imidacloprid by our colleagues at the University of Maryland and the University of Massachusetts. This will allow detecting the onset of resistance in beetle populations before their densities reach economically damaging levels.

Projected Outcomes:

Upon the completion of this study, we expect to be able to manage Colorado potato beetle resistance to imidacloprid before it has become a major problem for Maine potato growers. Results of the study will be published in Spudlines, presented at Maine Potato Conference, and posted at the Cooperative Extension website.

Objectives Made:

1. To assist growers on the affected farms in Southern Maine to protect their crop from Colorado potato beetle damage
2. To develop a resistance management plan that can be implemented by potato growers throughout the state

Both objectives were met.

Methods Used to Evaluate Outcomes:

The major outcome of the completed study is successful Colorado potato beetle control on the affected farms in Southern Maine. Weekly scouting reports documenting the Colorado potato beetle density on commercial potato fields and experimental plots, yield evaluations at the end of each season, and feedback provided by affected growers indicate that implemented resistance management plan was indeed a success (see also Fig. 1). Also, imidacloprid resistance dropped within the first season without neonicotinoid applications, and then somewhat stabilized at a lower level during the second season (Dively, unpublished).

We tested effects of seven different insecticidal treatments (Admire, Platinum, Admire followed by Spintor, Di-Syston, Novaluron, Vydate, and untreated control) on imidacloprid-resistant Colorado potato beetles during the 2004 growing season. Vydate and Spintor provided the best Colorado potato beetle control, distantly followed by Di-Syston. Novaluron was somewhat of a disappointment, although it did reduce the number of large larvae. There was little difference between the plots treated with Admire or Platinum and untreated control.

In 2004, beetles were controlled on commercial fields by in-furrow application of Di-Syston, followed by alternating applications of Vydate and Spintor. In 2005, no Di-Syston was applied to most fields because previous year's results showed such applications to be unnecessary. Vydate and Di-Syston applications were supplemented with Agrimek applications as a precaution against beetle developing resistance to the former two compounds. Growers used our scouting reports to target applications in space and time. In both years, pest management program proved to be successful. In 2004, adult populations exceeded economic threshold at least once during the season at 14 fields (47% of fields surveyed), populations of small larvae exceeded threshold only at eight fields (27%), and populations of large larvae exceeded threshold only at two fields (7%). Only five fields (17%) had beetle problems on more than 3 sampling dates. In 2005, populations of adults and small larvae exceeded economic threshold at least once during the season at only 2 fields each (10% of fields surveyed), and populations of large larvae exceeded threshold at seven

fields (35%). Only one field (5%) had beetle problems on more than 2 sampling dates, and none of the fields had problems on more than 2 sampling dates.

Colorado potato beetle populations were tested for imidacloprid resistance throughout the state. Unfortunately, several previously susceptible populations in Southern and Central Maine tested positive. I will be discussing implementation of an alternative beetle management plan developed as a result of this proposal with the affected growers once they start planning the next growing season.

Integration of Research and Extension Activities:

In 2004, I had weekly meetings with growers on the affected farms discussing beetle pressure and management options. In 2005, the frequency of our meetings was reduced to once every 2-3 weeks. I also made a number of presentations during grower meetings and published an article in Spudlines (see below). Results of this project were shared with Bayer Corporation (manufacturer of imidacloprid) and used by their technical support and sales personnel when communicating with growers.

Outputs:

- Alyokhin, A. V. 2005. Colorado potato beetle resistance management. 2005 New Brunswick Potato Conference and Trade Show, Grand Falls, NB, Canada.
- Alyokhin, A. V. 2005. Pesticide resistance. 64th Annual Maine Agricultural Trades Show, Augusta, ME.
- Alyokhin, A. V. 2004. Colorado potato beetle resistance studies in Maine and Northeast. 2004 Potato Pest Management Conference, Presque Isle, ME.
- Alyokhin, A. V. and G. Sewell. 2004. Resistance to imidacloprid in Colorado potato beetle. 19th Annual Maine Potato Conference, Caribou, ME.

MAC62: Dairy Task Force Response Team

Principle Investigator(s): Gary Anderson

Research Description:

This project will complete several activities in support of the dairy industry. While many of the activities will not be widely visible, there will be a significant amount of work to lay a strong foundation for future work. The Dairy Response team will conduct research under the theme of risk management in working with issues facing the dairy industry; we feel that one of the best educational approaches is to provide information with which people can make informed decisions. We will conduct bulk tank testing program for environmental and contagious organisms that may be found in farm bulk milk and will follow up with producers and their veterinarians on management practices to reduce risk. We will sponsor programs in estate planning for producers at a variety of ages to inform younger producers about steps they can take in preparing for estate planning as well as for those who are ready to transition out of farming and completing an estate plan to again minimize risk in transferring assets.

The Dairy Response team will set up protocols for the Veterinary Diagnostic Lab and have a vision and plan to carry out the vision to enhance the capabilities of the lab for the benefit of Maine producers. Similarly, the Farm Account Book will be completely rewritten and copies of the new spiral bound format will be made available across the state. Several staff on the agronomic side will be working on studies of crop rotations, their economic cost and return, and the benefit to the dairy industry. A main thrust of this work is for the benefit of organic producers, but the results will be of benefit to all. Rick Kersbergen and Tim Dalton are working on a cost of production study to provide data to the dairy industry and Rick is additionally collecting information on milk quality and mastitis treatment on organic dairy farms.

In the health area, a multi-farm study of salmonella and work with bovine leukemia virus will be conducted.

Methods Used to Evaluate Outcomes:

This past year has been busy with several activities in support of the dairy industry. While many of the activities have not been widely visible, there has been a significant amount of work to lay a strong foundation for future work. We have continued under the theme of risk management in working with issues facing the dairy industry; we feel that one of the best educational approaches is to provide information with which people can make informed decisions. We have continued our bulk tank testing program for environmental and contagious organisms that may be found in farm bulk milk and have followed up with producers and their veterinarians on management practices to reduce risk. We have sponsored programs in estate planning for producers at a variety of ages to inform younger producers about steps they can take in preparing for estate planning as well as for those who are ready to transition out of farming and completing an estate plan to again minimize risk in transferring assets.

There has been a significant amount of effort expended in setting up protocols for the Veterinary Diagnostic Lab and we have a vision and plan to carry out the vision to enhance the capabilities of the lab for the benefit of Maine producers. Similarly, the Farm Account Book has been completely rewritten and copies of the new spiral bound format are available across the state. We have sponsored meetings with extension multipliers in the financial area to make them aware of our financial and business planning goals and how we hope to complete them. Several staff on the agronomic side are working on studies of crop rotations, their economic cost and return, and the benefit to the dairy industry. A main thrust of this work is for the benefit of organic producers, but the results will be of benefit to all. Rick Kersbergen and Tim Dalton are working on a cost of production study to provide data to the dairy industry and Rick is additionally collecting information on milk quality and mastitis treatment on organic dairy farms.

In the health area, we have completed a multi farm study of salmonella and are now completing work with bovine leukemia virus. It has been our pleasure to have senior students working on these projects to benefit everyone involved.

MAC63: Cut Flower Production in a High Tunnel

Principle Investigator(s): Barbara Murphy

Background:

High tunnel crop production in horticulture is rapidly expanding in Maine and throughout the world. Cut flowers are one of the crops that can benefit from the season extension and weather protection provided by a high tunnel. As part of a crop diversification plan, cut flowers have the potential to raise farm profitability. For example, when compared to other crops commonly grown in high tunnels, cut flowers consistently had higher returns per square foot than any other crop. In 1998, the Noble Foundation concluded, “Of all the hoop house crops evaluated, none came close to matching cut flowers in terms of profit potential.” (Hoop House cut Flower Trial, 1998 www.noble.org/ag/horticulture.cutflowertrial-98).

In addition to the return per square foot, high tunnels have the potential to benefit growers by providing more control over farm income. By providing protection from early and late season frosts and from damage due to excessive rain or hail, the tunnels reduce the chance of crop failure. Finally, research from Pennsylvania State University indicates that when compared to the same flowers grown in the field, flowers grown in high tunnels produce a greater percentage of retail quality flowers.

Research Description:

Objectives

- For the educator to develop expertise in the production of cut flowers in high tunnels.
- To determine what flowers perform well in high tunnels under western Maine environmental conditions.
- To note any insect and/or disease problems which occur in high tunnel production. Research and/or Extension Activities to be Conducted
- Determine cultivars to be trialed and develop a planting methodology.
- Record stem length, and number of marketable flowers per plant of both field grown and high tunnel production.
- Determine return per square foot by having two local florists value the crop.

Projected Outcomes:

- Enhance my skill level of cut flower production.
- Draw preliminary conclusions of the results of one season of production.
- Hold at least one public meeting for Oxford County and surrounding counties growers to discuss high tunnel construction, cut flower production, and results of the trial.
- Write up results of first year and present findings via poster or workshop at ag trade show.
- Publish results in the statewide Master Gardener newsletter.
- In the following years I will continue to collect plant growth data and provide Extension programs on high tunnel production for local growers.

Abstract:

Based on funding received from Vice-President of Research, Michael Eckert, and the Maine Agricultural Center, a statewide need assessment was completed on the interest in using unheated high tunnels for cut flower production. The assessment was sent to 62 self-identified cut flower growers and 33 returned the survey indicating interest in the proposal. The following research goals were then determined:

1. To become familiar with the techniques of growing, harvesting and marketing cut flowers, both in the field and in a high tunnel environment.
2. To establish a network of cut flower growers to provide to provide feedback on research results and future plans.

In the survey, the growers suggested the following flowers be trialed due to their popularity and relative ease of production: Sweet Pea 'Mammoth Choice Mix' (*Lathyrus odoratus*); China Asters 'Matsumoto Formula Mix'

(*Callistephus chinensis*); Bells of Ireland (*Moluccella laevis*); Celosia 'Cramers Burgundy' (*Celosia argentea cristata*); Godetia 'Flamingo Series' (*Clarkia amoena*); Lisianthus 'Blue Rim' (*Eustoma grandiflorum*); Zinnia 'Benary's Giant Mix' (*Zinnia elegans*); Snapdragon 'Apollo' 'Echo White' (*Antirrhinum majus*); Sunflower 'Sunbright' (*Helianthus annuus*). Due to lack of appropriate space and propagating facilities, the majority of seeds were started at a commercial greenhouse and delivered at the appropriate planting time.

Methods Used to Evaluate Outcomes:

- The cold, wet spring muted the growth enhancing effects of the high tunnel. Low temperatures and overcast skies kept soil temperatures cold, thus preventing early planting and growth of the high tunnel flowers. (Table 1.)
- The cold wet spring also led to germination and disease problems. Poor germination of Bells of Ireland and sunflower resulted in fewer plants, and were planted in the high tunnel only. The celosia were eliminated from the trial due to severe botrytis. The field grown sweet pea seeds rotted before germinating.

Table 1. Planting and First Harvest Dates of Cut Flowers

Plant/Harvest Dates	High Tunnel Plant/Harvest Dates	Field
Sweet Pea	April 8/July 18	April 27/ crop failure
Godetia	May 9/July 22	June 1/July 14
Lisianthus	May 17/October 11	May 19/October 5
Zinnia	May 17/October 14	May 28/October 11
Asters	May 19/August 27	June 1/August 27
Snapdragon	June 25/October 14	June 26/October 14

- Despite these setbacks, the high tunnel produced over twice as many marketable flowers as compared to the field. (Table 2.)
- The harvest season was ended on October 14th to set up the high tunnel for off- season temperature data collection. On that date, the zinnia, snapdragon and lisianthus (high tunnel only) were still in production. The first frost occurred on October 20 and would have eliminated outdoor production, but not necessarily the high tunnel flowers.

Table 2. Total Harvest of Marketable Flower Stems, South Paris, Maine

	High Tunnel		Field	
	Stem length <18"	Stem length ≥18"	Stem length <18"	Stem length ≥18"
Godetia	2037	1303	597	25
Zinnia	503	258	524	398
Aster	104	270	229	168
Snapdragon	48	264	76	110
Lisianthus	35	193	15	144
Grand Total	5436		2286	

- The monetary value of cut flowers depends on how they are sold. Florists for example pay a high price for very long stems (usually greater than 18 inches) and place little to no value on short-stemmed flowers. In contrast, for bouquets and table vases, short stems have value and high quality flowers can demand a premium price for these products. In addition, there is tremendous difference in the wholesale and retail value of the same flowers. For example, one lisianthus stem sold to a florist may be worth ninety cents. However, that same stem in a bouquet sold at the farmers? market may be worth $1.50.
- Fewer flowers had insect damage in the high tunnel as compared to the field. Japanese beetle damage on the field grown godetia significantly reduced the number of harvested stems.
- I have met with some Maine cut flower growers and am putting together an advisory committee.
- As part of the outreach effort, I held a twilight meeting in August and am planning on speaking at the agricultural trade show in January. I have written a newsletter article for Maine Master Gardeners on the project and a local newspaper reported on the research.

I believe the project has potential to augment income on small, diversified Maine farms. Therefore, in 2006, I plan to replicate the flower trials at Highmoor Farm to determine if a different growing zone and soil type has an effect on harvest quality and quantity. Planting schedules will be designed to further maximize the growing season. My goal is to harvest flowers from mid-April through October. In addition, Extension Professor, Gleason Gray will be gathering winter soil and air temperature data to measure the potential for enhancing solar gain in raised beds in an unheated high tunnel using three soil treatments.