

# MAC Integrated Research & Extension Agricultural Projects: 2005–2006

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## **MAC64: Growing Winter Tender, High Value Fruit in High Tunnels**

**Principle Investigator(s): David Handley, James F. Dill, Fumiomi Takeda**

### **Background:**

Blackberries and related hybrids (Boysenberries, Loganberries, etc.) are not commercially grown in Maine because of their poor winter survival and long growing season requirements. However, the demand for specialty fruit such as these is very high and would command profitable prices at local markets. Hence, interest in growing blackberries is high among small and part-time farmers looking for crops with a market niche and the potential for high returns on investment. Recent development of high tunnel production technology to extend the growing season and improve yield and quality of high value crops may offer an opportunity for production of winter-tender crops, such as blackberries. Early tomato production in the Northeast has been revolutionized by the adoption of high tunnel technology, allowing the production of extra high quality fruit earlier than field grown fruit is available, without investing in expensive heating systems required for greenhouse production. Cucumbers, peppers, lettuce, and other crops have also been demonstrated to be profitable when grown in high tunnels, but little work has been done to evaluate the potential of perennial fruit crops in these structures. The near year-round availability of strawberries from other parts of the country, plus the relatively low yield of fruit grown in tunnels in the northeast has prevented this crop from being successful in this system, but raspberries have been successfully produced in high tunnels and are now being grown on a limited scale in the northeast. But this crop is grown in a perennial hedgerow and requires year round occupation of a tunnel, not allowing another crop to be grown when the raspberries are not fruiting. Crown suckering brambles, such as thornless blackberries, can be grown in pots, and moved in and out of the high tunnel according to the fruiting cycle, opening the house for another cash crop, such as tomatoes or cucumbers, during the remainder of the season, and allowing the plants to be put into protected storage during the winter to prevent injury. Growing blackberries in high tunnels, utilizing pots that allow the plants to be moved out of the tunnel for winter protection and the summer growing period, could provide a relatively low-cost, high return option for vegetable and fruit growers, and encourages growers to maximize tunnel utilization and profitability by allowing other crops to be grown in the same tunnel.

### **Research Description:**

To determine the feasibility of growing blackberries in a succession high tunnel system, five varieties of blackberries will be planted into 10.2 liter pots and grown outdoors on landscape fabric in the spring of 2005 at Highmoor Farm, the Maine Agricultural Experiment Station in Monmouth. The plants will be pruned to 4-6 floricanes per pot and placed into cold storage at 0°C in early to mid December. The plants will be removed from storage and spaced 1.5 meters apart in a high tunnel (double layer plastic over 28' x 94' frame). A temporary string trellis will be set up to support the fruiting canes and ease harvest operations. New cane growth will be suppressed until the floricanes are in bloom. Harvest data including yield, date, and fruit quality characteristics will be taken for each variety. Plants will be evaluated for establishment, vigor, and survival. After harvest, the plants will be moved out of the tunnel and grown on landscape fabric until being pruned and moved to storage as in year 1. Harvest and growth data will be taken for the 2005 through the 2007 seasons. As part of an extended study, we will evaluate timing of placing the dormant plants into the high tunnel in the spring, the number of fruiting canes allowed per pot, and how new cane suppression affects subsequent growth and yield.

### **Projected Outcomes:**

Results of this study will be presented to growers through presentations at meetings, including the Maine Vegetable and Small Fruit Growers Annual Meeting, the New England Vegetable & Berry Growers Winter Meetings and the North American Bramble Growers Association Meeting. The results will also be presented in the statewide Extension Vegetable & Berry Newsletter, and other New England Extension newsletters. The results will also be posted on the UMCE Pest Management web site. Growers and Master Gardeners will have an opportunity to view the experiment first-hand and discuss the treatments during field days to be held at Highmoor Farm from 2005 through 2007 at Highmoor Farm, the Maine Agricultural Experiment Station in Monmouth. Results will be presented to agricultural research and extension staff at scientific meetings including the American Society for Horticultural Science.

No termination report provided at this time

## **MAC 065: Maine Maple Products Marketing**

**Principle Investigator(s): George K. Criner, Kathryn Hopkins**

### **Background:**

Recent Maine maple products marketing research (Maine Maple Marketing Plan by Burgess Advertising Associates, Inc.) states that Maine produced syrup has a value near million, but that the vast majority of the syrup is sold in bulk, rather than in retail packaging. Thus, tremendous opportunity exists for adding value through repackaging and retailing. A maple marketing problem (and opportunity) is that most people, even in New England, do not regularly consume maple syrup and other products. The purpose of this research is to carryout a two-year research project investigating Maine maple products marketing. The project will be broken into two distinct phases with each phase having specific objectives.

### **Research Description:**

#### **Year-one objectives**

1. Investigate the feasibility of expanding maple syrup/products sales through restaurants using a variety of maple products themes and events.
2. Work with the Maine maple industry, Cooperative Extension and Maine Department of Agriculture, Food and Rural Resources to prioritize a year-two research agenda for the project.
3. Review and collect information on Canadian and Quebec maple syrup/products production and marketing, including any cooperative efforts with Maine.
4. Build databases appropriate for carrying out the year-two research.
5. Research results will be shared with Maine maple producers at their annual meeting at the Agricultural Trade Show in Jan. 2005.

Last year Professor Criner spent the year in Quebec on sabbatical. In Quebec, there are maple syrup/ products businesses that are fully integrated with a restaurant. These Quebec enterprises are similar to the Maine's Maple Sunday sugar shacks that serve a meal, but these Quebec businesses are open for a much longer season. Typically, these restaurants would serve full (maple-based) meals, have childrens' activities, and after supper all those interested can take a horse sleigh ride. Clients are frequently families and groups. Such a mix of selling product and fun has been called "entertailing" as it combines retailing and entertainment. Selling products in this fashion is often promoted, as it is a way of selling via a quality product rather than the lowest cost product. The level of entertainment provided can be quite varied. For example, providing sleigh rides may not be practical for many restaurants.

A few points regarding this retailing format are warranted:

- The maple-theme for meals could be for just one week at an existing Maine restaurant, or it could be the core component of a restaurant for its entire year or seasonal operation.
- Any maple-theme restaurants or maple-theme meals do not need to be tied to the maple sap season. In fact, maple-theme restaurants, with the family fun component, could be a great activity for summer tourists. Maple syrup production could be simulated, and sleigh rides could be replaced with hay rides.
- With planning, tour buses would likely stop at these facilities as part of a Maine or New England tour.
- It is not expected that many Maine sugar-shacks will become restaurants (although some may choose to), but rather, some existing as well as some new restaurants will adopt a maple-theme, for at least a week or more per year. Restaurateurs have the expertise in running restaurants, and it is this group that might see a maple-theme as an appropriate niche. Partnerships between restaurants and maple syrup producers should be possible.
- If a restaurant has a maple-theme week, this presents two opportunities. First, the customers are exposed to maple products and may begin to cook these items at home, and secondly, it is possible that some maple-based items may become part of the regular restaurant menu.
- A Maine agriculture spill-over effect is that maple-syrup-theme restaurants would not only increase sales of Maine maple syrup, but these restaurants would likely use more Maine produced agricultural products than

national chain restaurants. Meals sold in Maine-based restaurants would likely generate higher Maine economic multipliers for employment and income than meals sold in Maine by national restaurant chains. In addition, expanded maple syrup production can help maintain Maine forestlands and provide a supplemental income to wood lot owners.

### Year-two objectives

In year-two of the project, the researchers will investigate the impact of the Quebec maple syrup production quota on the Maine maple syrup market. Canada produces approximately 85% of the North American maple syrup production, and Quebec produces approximately 90% of Canada's total. Thus, Quebec is responsible for roughly three-quarters of total North American production. An effective production quota system, recently put in place in Quebec, will impact prices with potential positive benefits to Maine producers.

Other research objectives for the second year will depend on the prioritization resulting from working with Maine maple producers, Cooperative Extension and the Maine Department of Agriculture, Food and Rural Resources. Other possible research topics include:

- The impact of product adulteration on Maine producers,
- Expanded use of maple products in schools (for example, the University of Maine recently had a "Maine potato" day where most sections of the food court featured a different potato dish. Why not a "Maine maple day"?),
- Survey or interview restaurant cooks to gather information on the use of maple products, including use in sauces for cooking meats, The importance of Maine branding
- Research results will be shared with Maine maple producers at their annual meeting at the Agricultural Trade Show in Jan. 2006.

### Projected Outcomes:

Extension Educator Kathryn Hopkins will be working on the project 5% of her time over the two-year project. She will also serve on the master's thesis committee of the M.S. student who will be working on the project. This will ensure that the Cooperative Extension collaborative relation is firm and continuous. The University of Maine Cooperative Extension will assist in: working with, assessing the marketing research priorities of, the Maine maple producers, providing pragmatic input into research hypotheses and methods, and helping to disseminate results to clients. Expected Outcomes Project outcomes include recommendations regarding the use of a maple-based theme in restaurants (for example for one week, one month, or entire maple season). Another project outcome will be estimates of how the new Quebec maple syrup quota will likely impact on the Maine maple syrup market. Other research/extension outcomes will depend on the objectives determined for year-two of the project.

### Abstract:

Although this MAC maple research/extension project has officially terminated June 30, 2006, the actual project is bigger in scope and will be on-going for at least one more year. This project was co-funded by MAC (,650), Cooperative Extension (5% Kathryn Hopkins plus travel, etc.), REP (,000), and the Canadian-American Center (,000). Because this project, from the beginning, was designed to incorporate a Masters student (through the Canadian-American Center), we knew the time-table would span two years. Further, because Masters students takes more courses in their first year, and conduct more research in the second year, we must report that while we have accomplished a significant amount of work, most final outcomes will be forthcoming. A final preliminary note here is that the project recently received a ,000 donation pledge from the Somerset Sugarmakers Association, reflecting a positive attitude of producers regarding the project.

### Objectives Made:

#### Year-one objectives:

1. Investigate the feasibility of expanding maple syrup/products sales through restaurants using a variety of maple products themes and events.
2. Work with the Maine maple industry, Cooperative Extension and Maine Department of Agriculture, Food and Rural Resources to prioritize a year-two research agenda for the project..

3. Review and collect information on Canadian and Quebec maple syrup/products production and marketing, including any cooperative efforts with Maine.
4. Build databases appropriate for carrying out the year-two research.
5. Research results will be shared with Maine maple producers at their annual meeting at the Agricultural Trade Show in Jan. 2006.

### **Year-two objectives:**

1. Estimate the impact of the Quebec maple syrup production quota on the Maine maple syrup market.
2. Other research objectives for the second year will depend on the prioritization resulting from working with Maine maple producers, Cooperative Extension and the Maine Department of Agriculture, Food and Rural Resources.
3. Research results will be shared with Maine maple producers at their annual meeting at the Agricultural Trade Show in Jan. 2007.

### **Objectives Not Made:**

Work is on-going on all five year-one objectives, with objectives 2 and 5 being completed. A demonstration of a maple-based week at a restaurant was conducted. Several lessons were learned including a suggestion that the menu focus on a limited number of maple-recipes items, with these being pre-tested. A GIS study of matching Maine citizens with Franco-American heritage with Maine maple producers who participate in "Maine Maple Sunday" was conducted. The purpose of this analysis was to identify Maine maple producers who served maple meals on Maine Maple Sunday, who are near clusters of Maine citizens with Franco-American heritage. The information on spatial distribution of this group of citizens would be useful for marketing of Maine Maple Sunday and other maple related events. Both the GIS and the restaurant marketing demonstration project was presented at the 2006 Maine Agricultural Trade Show.

In another effort researchers tried to identify target markets for Maine maple syrup using a multinomial logit regression model. It was estimated to explain the relationship between demographics and a set of specific maple syrup attributes (100% pure, produced in New England, grade and color, low price and sweet maple taste). The results suggest that Maine producers market their syrup as 100% pure to women in New England.

In working with the Maine Maple Producers Association, a second year research agenda has been established which includes a survey of producers and associated budgeting analyzes. For example, we will estimate costs of production for various size producers and estimate break-even quantities (taps or gallons) for various technologies (e.g. reverse osmosis, pre-heating). We are in the middle of a survey of Maine maple producers. This has already resulted in a vastly improved current list of maple producers. This survey is the first survey of the entire population of Maine maple producers in recent memory, and will contribute to the database of year-one objective 4. In addition to completing the budget and associated analyzes, the researchers will examine the likely impact of the Quebec maple syrup quota to estimate potential marketing implications. As in 2006, the researchers will present results at the 2007 Maine Agricultural Trade Show. At the completion of this larger project, we shall submit an overall project termination report and will forward reprints to the MAC office.

### **Methods Used to Evaluate Outcomes:**

Budgeting and breakeven, multinomial logit regression, survey methods, participatory research with restaurants, supply response (with the Quebec quota analysis).

### **Integration of Research and Extension Activities:**

There has been excellent integration between research and extension on this project. The Masters student has been doing the bulk of the leg-work under the supervision of both the Extension and Research faculty. Kathy Hopkins has been appointed as an Adjunct Graduate Faculty in the Department of Resource Economics and Policy to help advise on the M.S. thesis work. Data will be analyzed in depths that would not have been possible previously and at the same time, there is input into the research from producer groups which is facilitated by Extension.

**Outputs:**

One completed and one scheduled presentation at Maine Ag. Trade Shows (2006 and 2007). Presentation at the 2006 North American Maple Producers Association meeting in Three-Rivers, Quebec. Improved mailing list and improved survey design for Maine maple producers.

## **MAC66: Diagnostic Ultrasonography of the Thyroid Gland: Predictive Value for the Identification of Dairy Cows at Risk for Metabolic Disease during Early Lactation**

**Principle Investigator(s): Jim Weber, Charles Wallace**

### **Background:**

The most metabolically stressful period in an adult dairy cow's life occurs during early lactation, when milk production abruptly rises and a huge metabolic drain is imposed on the body. During the first two months of lactation, most cows cannot consume enough feed to satisfy the metabolic demands of milk production, and they subsequently lose weight and body condition. High-producing cows at this stage are susceptible to metabolic imbalances and infections, and many experience a delay in their return to normal reproductive cyclicity. Although most cows weather this period without overt signs of clinical disease, a significant percentage are culled during the first two months of lactation due to metabolic or infectious diseases such as infectious mastitis, milk fever, displaced abomasum and ketosis. With current technology, it is not possible to identify at-risk cows before these conditions occur, so the only option for the producer is to treat animals after they become ill. This often results in either a decrease in milk production over the course of the lactation or loss of the cow to death or culling. An accurate predictive method for identifying these at-risk cows is urgently needed by the dairy industry.

Thyroid hormones play a key role in the up-regulation of a variety of metabolically-related processes such as body temperature, metabolism of energy stores, heart rate, cellular repair and milk production. In dairy cattle, early lactation stimulates thyroid gland activity by increasing the binding of thyroid hormone to metabolically active hepatic and mammary cells. When metabolic demand is high, the thyroid gland is stimulated by thyroid stimulating hormone (TSH) to secrete thyroxine (T4), which circulates throughout the body but has no metabolic effect. Thyroxine is converted to metabolically active tri-iodothyronine (T3) by tissue-specific enzymes called deiodinases, where it binds to nuclear receptors in target tissues. In a classic negative feedback loop, low systemic levels of T3 stimulate the secretion of additional TSH. In lactating dairy cows, levels of milk production over the course of lactation are negatively correlated with blood levels of T4 and T3, with the lowest thyroid hormone levels associated with high producing cows during early lactation. Reproductive function appears to be influenced by a cow's thyroid status during early lactation, and cows with low blood T4 and T3 concentrations during the early postpartum period had delayed resumption of ovarian cyclicity when compared to cows with normal postpartum thyroid values. A number of infectious diseases and inflammatory conditions of cattle have also been shown to be associated with decreased blood concentrations of thyroid hormone during the early post-partum period, possibly because thyroid hormone is necessary for the stimulation of immune function.

Periods of metabolic stress that are associated high levels of TSH and low levels of T3 and T4 are known as "Thyroid Sick Syndrome", a condition where the thyroid gland is unable to keep up with the body's use of thyroid hormone. A diagnostic test that detects abnormal thyroid hormone patterns during the peripartum and early lactational periods could be useful for identifying cows with Thyroid Sick Syndrome that might be at risk for clinical disease later in lactation. However, blood hormone assays are expensive and generally take several days for results. Because of these drawbacks, the use of thyroid hormone assays as diagnostic tools for monitoring the health of dairy cows has not gained acceptance in commercial settings, especially when most of the herd would need to be tested on a regular basis.

Under conditions of increased TSH stimulation, the thyroid gland actually hypertrophies and increases in volume. This increase occurs when thyroid hormone production drops below the needs of the body for an extended period, and reflects either TSH-induced stimulation of T4 synthesis or a lack of iodine for production of T4. The thyroid lobes of cattle are located lateral to the trachea just below the larynx, and can be visualized non-invasively with diagnostic ultrasonography. Although ultrasound-based reports detailing the size, shape and ultrastructure of the bovine thyroid gland have been published, no accounts of changes in its size and appearance during the lactational cycle are available. The hypothesis of the proposed experiment is that changes over time in the size and ultrasonographic appearance of the bovine thyroid gland during late pregnancy and early lactation are associated with stress-related changes in TSH, T4 and T3 concentrations. Our objective is to determine whether ultrasonographically-measured

changes in thyroid gland parameters can be used to estimate thyroid status and to predict a cow's susceptibility to metabolic disease during early lactation. Diagnostic ultrasonography is gaining increasing acceptance as an important tool in cattle reproduction and to non-invasively predict carcass traits, and many dairy veterinarians now have access to an ultrasound machine. The same equipment used for these purposes could also be valuable for monitoring the bovine thyroid gland, if a link could be established between thyroid gland characteristics and susceptibility of a cow to metabolic or infectious disease.

### **Research Description:**

This project will be conducted on approximately 25 lactating cows at the Witter Center dairy from June 2005 to April 2006. In our experimental design, the dimensions and ultrasonographic appearance of each cow's thyroid gland will be obtained at 14 day intervals from the sixth month of pregnancy through the third month of the subsequent lactation (a veterinary ultrasound unit already in use by Dr. Weber will be used to take these measurements). On the same sampling days, serum and milk (when available) samples will also be taken from cows for analysis of TSH, total T4 and T3, and free T4 and T3. The following stress-associated data will be collected during the first 90 days of each cow's lactation: body condition score, daily milk production, days to resumption of ovarian cyclicity, and days to establishment of pregnancy (measured at weekly intervals); presence/ absence of lactation-specific diseases (retained placenta, milk fever, infectious mastitis, clinical ketosis, displaced abomasum, or cystic ovarian disease).

The presence of a temporal relationship between thyroid gland dimensions and thyroid hormone values will be determined by regression analysis, and analysis of variance procedures will be used to compare mean thyroid gland measurements and thyroid hormone values among groups of cows that had unhealthy, moderately stressed or healthy values for each lactational stressor. This data analysis should identify whether increases in thyroid gland dimensions during the period immediately preceding or just after the beginning of lactation are associated with thyroid hormone profiles that indicate excessive metabolic demands, or are predictive of impending metabolic disease during the subsequent lactation.

### **Projected Outcomes:**

Based on a number of published reports, thyroid hormone concentrations in cattle vary in a predictable pattern during pregnancy and lactation, with values that are indicative of thyroidal stress from about the time of calving through the first month of lactation. We expect that our measurements will follow this pattern, though values in individual cows may vary due to differences in their lactational potential and level of metabolic stress. Thyroid hormone values in the proposed study should be within the ranges reported for dairy cows in the literature. We expect that thyroid hormone patterns indicative of metabolic stress (high TSH and low T4 and T3 concentrations) will be present during early lactation and will be especially severe in animals that are experiencing metabolic disease during this period. Measurement of thyroid values is already a routine procedure in Dr. Wallace's lab, and he has extensive experience in the radioimmunoassay procedures that will be used to measure thyroid hormone levels. Measurement of thyroid gland dimensions with ultrasonography should produce results similar to those in published studies. We expect that these values will be accurate and repeatable, because coefficients of variation less than 5% were reported in the first descriptive study where ultrasonography was used to measure thyroid gland parameters, and because Dr. Weber has over 15 years of experience with veterinary ultrasonography and has published several original reports that used ultrasonography in a research setting. Our hypothesis that increases in thyroid gland dimensions will be associated with thyroid hormone patterns indicative of metabolic stress is based on known physiological changes that occur in the thyroid gland under these conditions. Cows at risk for metabolic disease during early lactation are likely to experience hypertrophied thyroid glands and thyroid hormone imbalances, but it is not known whether thyroid-associated changes will be predictive of future metabolic disease.

Our plan is to test the proposed hypothesis on the University research herd during the next year, then partner with Dairy Extension Specialists to identify one or more large dairies in the State where we can apply what we learned on a commercial scale. The results of this experiment will be incorporated into an Experiment Station publication, will be presented at local and national dairy science meetings, and will be used as preliminary information for a USDA research grant proposal. If diagnostic ultrasonography shows potential for the prediction of impending metabolic disease during early lactation, we will use this tool to investigate methods that mitigate the effects of stress on dairy cattle, possibly by increasing the ability of the thyroid gland to keep up with systemic demands during early lactation.



The Maine dairy industry loses thousands of cows each year due to culling for metabolically-related diseases during early lactation. This loss occurs despite the widespread use of “Dry Cow” feeding programs designed to reduce the risk of metabolic disease. The drawback to these programs is that they treat all cows equally, and do not identify and concentrate on the at-risk animals. The Maine dairy industry would be more profitable if preventative strategies were incorporated that concentrated on animals that were identified as at-risk by techniques such as the one described in this proposal.

### **Abstract:**

In dairy cattle, as in humans, hypothyroidism can markedly affect a number of day to day metabolic functions. Dairy cows experience a sudden and dramatic metabolic drain at the end of pregnancy when lactation begins. These cows, which are in negative energy balance and losing weight for the first weeks to months of lactation, become functionally hypothyroid for during this period. Workers in the Experiment Station are examining the thyroid hormone profiles of dairy cows during late pregnancy and early lactation to determine whether the timing and extent of the decline from normal thyroid function to hypothyroidism could be used as a predictive test to identify cows at high risk of metabolic diseases such as milk fever, ketosis, fatty livers, displaced abomasums or cystic ovarian disease. Early results are encouraging, and suggest that first calf heifers experience a greater decrease than older cows, and that cows that subsequently have metabolic disease have larger and earlier decreases in thyroxine concentrations, on average, than cows that remained metabolically healthy during lactation.

### **Objectives Made:**

This MAC study was initiated to develop diagnostic tools that could be used to identify dairy cows that were at high risk of developing metabolic disease during the early lactational period, or that would experience decreased fertility during the breeding period associated with that lactation. Dairy farmers in Maine experience huge economic losses due to metabolic and reproductive dysfunction during lactation, and a useful predictive test would allow them to identify at-risk cows in time to treat and prevent metabolic diseases such as milk fever, displaced abomasums and ketosis.

Our overall objective was to determine whether ultrasonographically-measured changes in thyroid gland parameters or thyroid hormone status during late pregnancy and early lactation could be used to estimate thyroid status and to predict a cow's susceptibility to metabolic disease during early lactation. We planned to utilize “fresh” dairy cows at the Witter Center as experimental animals, and predicted that we would collect data sets on about 25 cows during late pregnancy and early lactation. In fact, we collected 20 sets of data from Witter cows from September 2005 to June 2006. Blood samples and ultrasound measurements were collected in these animals at two-week intervals from 30 days pre-birth to 70 days after birth. In addition to measurements of thyroid gland dimensions, we measured body condition scores and serum thyroxine and tri-iodothyronine concentrations. Records of each cow's lactation number, milk production and health records were collected and added to the database.

Our first objective was to develop a method to quantitatively estimate thyroid gland volume in live animals. This objective was not met. Although published reports that described the ultrasonographic anatomy of the bovine thyroid exist, none had attempted to measure thyroid gland dimensions over time. The bovine thyroid is a compressible organ, and is located lateral to the trachea under skin and several muscle bellies. We found that transdermal images of the thyroid could only be produced when we placed the ultrasound transducer on the skin and applied considerable downward pressure. Repeated measures of thyroid gland dimensions using this technique (10 measures of the same thyroid lobe on the same cow over a 30 minute period) in 10 cows resulted in a coefficient of variability of 32%. This large variation in measurement was likely due to 1) variability in our compression of the thyroid gland with the ultrasound probe, and 2) slightly different angles of visualization of the thyroid gland from exam to exam. Since expected differences in thyroid gland dimensions between euthyroid and hypothyroid humans are in the order of 25%, we felt that ultrasonography was not a sufficiently sensitive and repeatable technique in our hands to be a useful diagnostic tool.

After this initial project, we modified our objective. Our new objective was to determine whether thyroid hormone status during late pregnancy and early lactation could be used as a diagnostic tool to estimate thyroid health and the animal's metabolic status. Further, we wanted to determine whether a cow's peripartum thyroid status could be used

to predict a cow's susceptibility to metabolic disease during early lactation. This project was completed on 20 cows at the Witter Center, and the hormone assays were completed in Dr. Wallace's lab during the summer of 2006. We are still analyzing the data, but we have found that all of our cows experienced a sudden drop in blood thyroxine concentrations during the period of about ten days on either side of the day of birth. The exact timing and extent of this drop varied among individual cows. We found that first calf heifers have a more severe drop in thyroxine levels than older cows, and that cows that later experienced some sort of metabolic disease had an earlier average drop compared to cows that were metabolically healthy during the subsequent lactation. We are currently determining whether a relationship exists between thyroid hormone profiles and milk production, time to first insemination, number of inseminations per pregnancy and days in milk at conception. Although this was a preliminary study based on small numbers, the results indicate that measurement of the timing and extent of thyroid hormone drop during the peripartum period might be a useful tool for predicting cows at risk for metabolic disease.

The study at Witter was limited by the small size of our dairy, so we approached a commercial dairy in Exeter (Stonyvale Farm, 850 milking cows) about conducting a similar study with larger numbers of animals. This dairy keeps excellent computerized records, and is one of the most efficient farms in the state, so we felt that we could duplicate many of the goals that we met in the Witter study with numbers that were large enough to analyze statistically. The Stonyvale project was conducted from February to June of 2006. We collected approximately 400 blood samples on about 150 cows, and concentrated our efforts on the dry period and the first month of lactation, because this was the period when we saw the greatest contrasts in thyroid levels in the Witter study. While sampling for this study is complete, the last Thyroid hormone RIA was completed only about two weeks ago, so we have not yet had an opportunity to analyze this data set.

#### **Integration of Research and Extension Activities:**

Neither Wallace nor I have Extension appointments, so we considered this to be a strictly research-oriented project. However, if this project results in a useful method for identifying cows at risk for metabolic disease, dairy extension specialists would have a management tool that they could offer to farmers as an aid in mitigating the negative effect of metabolic disease on the efficiency of their dairies.

#### **Outputs:**

We anticipate that the results of this MAC project will lead to a manuscript for submission to a peer-reviewed journal of dairy science or veterinary diagnostics. At this early stage, however, we have not submitted any of this work. Any publications or presentations resulting from this work will be forwarded to the Experiment Station for your records.

## MAC67: Growing by Design: Evaluating Organic Cropping Systems for Improved Feed and Reduced Weed Pressure

**Principle Investigator(s): John Jemison, Heather Darby**

### Research Description:

This project is an extension to MAC 057. Proposal information remains the same. Will terminate MAC 057 and MAC 067 in one document in 6/30/2006.

### Objectives Made:

Producing quality forage with minimal weed pressure is a goal of organic dairy producers. Growers need new tools that include effective crop rotations, and timely cultivation. An experiment was initiated in 2004 to evaluate an alternative cropping system strategy for organic dairy producers that would better balance crop emergence, growth, and time to canopy closure compared to silage corn.

Our interest was to: 1) quantify yield, quality, and weed pressure of winter and spring small grains and brown midrib sorghum sudan grass (BMRSS) double crops; 2) quantify yield, quality and weed pressure of organic corn produced using two tine and two row cultivations; and 3) determine if crop ecology and use of narrow crop row spacing would more effectively control weeds compared to cultivation under organic production systems.

### Methods Used to Evaluate Outcomes:

In year two, we planted five small grains on 25 September 2004: winter rye, winter triticale, winter barley, winter wheat and oats at approximately 120 lbs/ac. Manure was applied at 16 tons/ac, and was disked in immediately to supply approximately 70 lbs of N, 96 lb P2O5 and 128 lbs K2O/acre. In the spring, we disked in the winter-killed oats and sowed spring barley at the same plant density. Grains were harvested at soft dough. Winter barley was harvested 9 days prior to the winter wheat, triticale and winter rye. Manure was applied to the stubble and disked in immediately. A Brillion seeder was used to drill in BRMSS seed which led to a poor stand in this treatment, but the extra nine days of growth did influence total yield. Due in part to fluctuating extremely hot and cold periods in June, spring wheat was shorter in 2005 than in 2004, and it matured almost three weeks earlier than in 2004 at roughly the same time as the winter wheat, triticale and rye. The remaining grains were harvested at the same time. Following small grain harvest, manure was applied at the same rate and disked in immediately. Another area was sown to BMRSS without manure applied. This was done to test BMRSS response to the second manure application and to provide a comparison to 2004. On 8 July 2005, we drilled the remaining BMRSS plots with a grain drill. Due in part to a warmer than normal autumn, two cuts were taken from the BMRSS (1st on 22 August, 2nd on 21 October). All grain samples were dried and weighed. Samples were ground and NIR was used to assess forage quality.

Corn yield was significantly affected by intensity of cultivation (Table 1). With four cultivations (2 tine and 2 row cultivations), corn yield was 11,838 lbs dry matter/ac or 19.7 tons/ac at 30% dry matter. Weed biomass (predominantly red root pigweed, lambsquarters and yellow foxtail) was 1733 lbs dry matter/ac or roughly 12.3% of total (weed + forage) dry matter yield, and this was considerably lower percentage compared to 2004. Soil conditions were drier at the time of cultivation which greatly improved the effectiveness of the tine cultivations. Yields of winter rye, triticale and wheat were excellent in 2005 (Table 2). Winter barley appeared to be damaged by a period of extreme cold following snow melt; seed heads were very small, and the plants were stunted. As well, spring barley yields were lower than in 2004 in part due to early heading apparently caused by fluctuating extremes of temperature. Yield of BMRSS was influenced more by manure than by planting date, although given the very low

Table 1. Yield of Silage Corn - 2005

Cultivations	Dry Matter Yield	Weed Biomass (%)
4 cultivations (2 tine - 2 row cultivators - 2 direction w/tine)	12335 a	8.0 b
4 cultivations (2 tine - 2 row)	11838 a	12.3 b
3 cultivations (1 tine - 2 row) c	11036 a	16.8 b
2 cultivations (2 row)	10855 a	13.9 b
1 cultivation (1 row cultivation at canopy closure)	6727 b	31.0 a
LSD (0.05)	2489	10.3

Table 2. Yield of Small Grains - 2005

Small Grain	Dry Matter Yield (lbs/ac)	Weed Biomass (%)
Winter Rye	9199 a	1.86 b
Triticale	8244 ab	0.44 c
Winter Wheat	7410 b	0.18 c
Spring Barley	4001 c	2.75 ab
Winter Barley (type)	3855 c	3.12 a
LSD (0.05)	970	0.93

BMRSS population, it is possible that with optimum germination, yield of the earlier planted BMRSS could have been greater (Table 3). Weed pressure was significantly greater in the BMRSS sewn with the Brillion, again due to poor population.

Table 3. Yield of First Cut - Brown Midrib Sorghum Sudan Grass - 2005

BMRSS	Dry Matter Yield (lbs/ac)	Weed Biomass (%)
BMRSS - (29 June 2005)	3359 a	27.8 a
BMRSS - (8 July 2005) +M	3518 a	5.6 b
BMRSS - (8 July 2005) - M	1743 b	2.7 b
LSD (0.05)	797	3.6

Feed quality of the various forages is presented in Table 4. Winter wheat has an excellent feed profile with some of the highest values for nonstructural carbohydrates (NSC), NSC yield, total digestible nutrients (TDN) and TDN yield. In

Table 4. Nutrient content of various forages - 2005.

Feed	C.P. (%)	C.P. Yield (lbs DM/ac)	T.D.N. (%)	T.D.N. Yield (lbs DM/ac)	N.E.L. (%)	N.E.L. Yield (lbs DM/ac)	N.S.C. (%)	N.S.C. Yield	RFV (%)
Silage Corn	7.6 --	858.3 --	63.8 --	7583 --	0.62 --	7261 --	30.0 --	3585 --	***
W. Rye	5.0 d	457.0 a	59.8 c	5496 a	0.54 c	4969 a	24.8 b	2282 a	93.5 c
W. Triticale	6.1 c	506.1 a	63.0 b	5198 ab	0.60 b	4958 a	27.7 b	2298 a	109.8 b
W. Wheat	6.7 c	495.4 a	65.0 a	4814 b	0.64 a	4717 a	33.6 a	2479 a	124.2 a
W. Barley	7.9 b	301.6 b	66.0 a	2544 c	0.66 a	2553 b	35.6 a	1374 b	131.5 a
Spring barley	11.6 a	466.2 a	59.0 c	2361 c	0.55 c	2206 b	19.1 c	774 c	101.2 bc
BMRSS +M*	10.6 -	373.5 --	53.0 --	1859 --	0.45 --	1587 --	13.4 --	324 --	81.5 --
LSD (0.05)	0.98	101.4	1.7	656	0.026	669	5.0	428	9.6

\* 1<sup>st</sup> cut BMRSS - harvested 28 August - 2<sup>nd</sup> cut BMRSS not figured into calculations

2004, spring barley gave similar values, but this year's early heading reduced quality. In Table 5, one can compare silage corn to a winter wheat + BMRSS or triticale + BMRSS double crop

system (accounting for only one cut of the BMRSS). With these comparisons, one finds that the alternative cropping system provides an excellent quality feed and the total production loss (TDN yield or NSC yield) is between 8 and 15% lower than with that of silage corn. The weed biomass in the alternative system is considerably lower (similar to that found in 2004), but this year we performed no physical weed control in the alternative system. Weed management in the corn would have cost approximately \$40.00/ac. The other added feature is that the weeds in the corn system go to seed; in the alternative system, the cuts are made before the plants go to seed, and the plants are young, very digestible (TDN - 50% and crude protein of 16%). So, in this case the weeds are much less problematic. The alternative system requires one additional manure application, harvest operation, and tillage. Seed costs of open-pollinated corn compared to small grains and BMRSS are fairly similar. So, in short, the alternative forage system provides a cropping system that has lower weed pressure, efficient yields, and quality forage. More work is needed to see how the system holds up over diverse winter weather conditions in the upper Northeast.

Table 5. Comparison of Corn to Small Grain - BMRSS double crop (one cut considered)

Feed Comparison	Crude Protein Yield (lbs DM/ac)	T.D.N. Yield (lbs DM/ac)	N.E.L. Yield (lbs DM/ac)	N.S.C. Yield (lbs DM/ac)
Silage Corn	858.3	7583	7261	3585
Triticale + BMRSS	879.6	7057	6545	3072
W. Wheat + BMRSS	868.9	6673	6304	3254
W. Barley + BMRSS	675.1	4403	4104	2147
S. Barley + BMRSS	839.7	4220	3793	2184

Additional Work: This work was started with a MAC grant in 2004. We did a no-cost extension in 2005. And, we are continuing to do the work in 2006. These data have been combined in with the organic systems trial work, and the work of Tim Griffin and has helped give a realistic picture of the good, the bad, and the ugly associated with organic forage systems. Ultimately, my hope is to have 4 site years with spring barley, and three site years with winter grains and BMRSS. This will be summarized into a publication to be submitted to the Agronomy Journal.

**Integration of Research and Extension Activities:**

This project has been presented in a number of venues: Northeast Weed Science Society, the National Water Quality Conference (2007), In-service training for Ag Service Providers, and other extension meetings. As yet, peer-reviewed publications have come from this, but I will be working on one shortly.

## **MAC68: Determining Consumer Preferences of Beefsteak type Tomatoes**

**Principle Investigator(s): Mark Hutton, David Handley**

### **Background:**

Maine has a relatively large and diverse group of vegetable growers that farm in excess of 11,000 acres and are responsible for over 20 million dollars in gross revenue. Maine vegetable growers face several difficult challenges to economically viable vegetable production, not least of which, is Maine's short growing season. Maine growers utilize many methods to extend the growing season including unheated greenhouse structures commonly referred to as high tunnels. High tunnels are commonly used to grow high value warm season crops such as tomatoes.

Farmers growing tomatoes in high tunnels have two pools of varieties to choose among when selecting varieties to grow in high tunnels. The first group is the older indeterminate varieties, which are difficult to grow profitably outdoors in Maine due to their need to be trellised and their long growing season requirement. The advantage to this group of varieties, when grown in high tunnels, is that they are generally considered to produce good yields of high quality, excellent, tasting fruit. The disadvantage of these varieties is that they lack the disease tolerances necessary for production in high tunnels. The second group is the European greenhouse tomatoes. These varieties were developed for production in greenhouses where growing conditions are tightly controlled. Like the first group, they produce good yields of high quality tomatoes. The greenhouse varieties possess the disease resistances necessary for good production in controlled environments; however, the seed is very expensive (in some cases .25 per seed) and not all greenhouse varieties are adapted to high tunnel production. Growers are hesitant to invest in these types of varieties without an idea of how they will perform in high tunnels.

This study seeks to identify tomato varieties that have excellent horticultural attributes and superior eating quality suitable for Maine growers producing tomatoes in high tunnels.

### **Research Description:**

Fifteen commercial tomato varieties will be grown in one of the Highmoor Farm high tunnels. The varieties chosen for this study represent two classes of material. The 'standard' indeterminate open field varieties grown in high tunnels on many Maine farms and also a group of 'newer' varieties developed for European greenhouse production. The varieties will be grown in randomized complete blocks with five replications. The tomatoes will be seeded and grown in the greenhouse beginning in late March of 2005. The seedlings will be transplanted in the high tunnel in mid-May, into raised beds covered with black plastic mulch. The plants will be fertilized, pruned, and trellised according to the guidelines in the New England Vegetable Management Guide. Fruit will be harvested at vine ripe maturity and data collected on fruit size, number and quality. Samples of each variety will be taken at peak harvest (late July) and immediately transported to the Food Science Center at the University of Maine campus in Orono for sensory analysis. Sensory evaluations will be conducted. Horticultural and sensory evaluation data will be statically analyzed and summarized for publication.

### **Projected Outcomes:**

Results of these vegetable variety trials will be statistically analyzed and summarized for presentation to growers at meeting such as the Maine Vegetable and Small Fruit Growers Association Meeting and the New England Vegetable and Berry Growers Winter Meeting. The results will also be presented in the statewide Extension Vegetable Newsletter and posted on the UMCE Pest Management web site. Growers and Master Gardeners will have the opportunity to view the experiments first-hand and discuss the varieties during the summer field day.

### **Methods Used to Evaluate Outcomes:**

Sixteen commercial tomato varieties were grown in one of the Highmoor Farm high tunnels. The varieties chosen for this study represent two classes of material. The "standard" indeterminate open field cultivars grown in high tunnels on many Maine farms and a group of "newer" varieties developed for European greenhouse production.

- Open Field Varieties: Jet Star, Supersonic, Ultrasonic, First Lady II, Big Beef, Lady Red, Ultraboy, Better Boy, Brilliance

- Greenhouse Varieties: Boa , Cobra, Buffalo, Trust, Geronomo

The varieties were grown in randomized complete blocks with four replications of three plants per plot. The tomatoes were seeded and grown in the greenhouse March 24, 2005. The seedlings were transplanted in the high tunnel in May 15, into raised beds covered with black plastic mulch. The plants will be fertilized, pruned to a single stem, and trellised according to the guidelines in the New England Vegetable Management Guide. Fruit were harvested at vine ripe maturity and data collected on fruit size, number and quality. Samples of each variety were taken to the Food Science Center at the University of Maine campus in Orono for sensory analysis. Each cultivar was evaluated by at least 25 persons, who rated the fruit for fruit color, appearance, taste, overall rating, and purchase intent.

Jet Star had the greatest yields of premium quality fruit and combined total marketable fruit. Brilliante had the second highest yields of premium quality fruit; however, the combined marketable yield was only in the middle of the pack. Supersonic produced the greatest amount of total yield but most fruit were rated as only marketable. In general the open field cultivars had higher yields than the cultivars developed fro greenhouse production.

Data analysis of the taste panel revealed Betterboy and Jet Star had the most preferred color; while, Trust was liked the least. Betterboy flavor was rated higher than any other cultivar, followed by Big Beef, Brilliante, First Lady II and Jet Star. Betterboy was also liked best overall. Fruit color and appearance were correlated indicating people are strongly attracted to tomato fruit color; while, overall consumer rating was most influenced by fruit flavor. Betterboy scored the best in all consumer preference ratings and Brilliante is the next best.

Determining the 'best' tomato to grow in a hoop house from these experiments is difficult. In our determination we feel Jet Star may be the top choice, followed by Brilliante and then Cobra. Here is our reasoning. We ranked all the cultivars based on yield; quality of the yield (percentage of culls, marketable fruit, and premium fruit); disease rating average of the four plots; and sensory evaluation. Total yield was thought to be twice the importance of all other factors.

Table 1. Sensory evaluations of Highmoor hoop house tomatoes.

Cultivar	Color	Appearance	Taste	Overall Rating	Purchase Intent
Betterboy	7.8 b	7.7 b	8.0 d	7.9 c	1.56 c
Brilliante	7.5 ab	7.1 ab	7.0 c	6.9 b	1.12 bc
Cobra	7.3 ab	7.1 ab	6.8 b	6.9 b	0.76 ab
First Lady II	7.2 ab	6.6 a	7.0 c	6.8 b	0.88 ab
Jet Star	7.8 b	7.4 ab	6.7 bc	6.6 ab	0.92 b
Ultraboy	7.6 ab	7.2 ab	6.4 a	6.6 ab	0.70 ab
Big Beef	7.6 ab	6.8 ab	6.2 abc	6.3 ab	0.48 a
Ultrasonic	7.4 ab	7.3 ab	6.4 a	6.3 ab	0.48 a
Trust	6.9 a	6.7 a	5.9 ab	6.2 ab	0.48 a
Boa	7.3 ab	6.7 ab	5.6 a	5.7 a	0.31 a

Table 2. Final Rankings of Ten Tomatoes Grown in Highmoor High Tunnel, 2005

Variety	Yield	Quality	Disease	Sensory	Total	Open Field or Greenhouse
Jet Star	1	2	6	4	14	OF
Brilliante	6	1	1	2	16	OF
Cobra	5	2	3	3	18	GH
First Lady II	2	6	6	4	20	OF
Boa	3	4	3	10	23	GH
Big Beef	4	5	10	7	30	OF
Ultraboy	8	9	3	6	34	OF
Trust	9	8	1	9	36	GH
Ultrasonic	7	7	8	7	36	OF
Better Boy	10	10	8	1	39	OF

## **MAC69: Nutritional Effect on the Occurrence of Soft Scald of 'Honeycrisp' Apple**

**Principle Investigator(s): Renae Moran, Mary Ellen Camire**

### **Background:**

Honeycrisp is an apple variety in high demand because of its excellent eating quality at harvest and after long-term storage. Unlike many other varieties, Honeycrisp remains crisp and juicy during the storage period and during unrefrigerated conditions that typically occur in marketing. Because of this, it has great appeal to both apple growers and to consumers. It is currently being planted by many Maine apple growers for both a farmstand and wholesale market. However, its susceptibility to soft scald limits wide scale production because it can lead to large losses for growers.

Soft scald results in large, brown areas on the surface of the fruit that develop after two to three months in storage. It is a chilling injury that occurs when sensitive varieties are stored at temperatures below 36EF. Storage temperatures above 36EF can prevent it, but lead to loss of flavor and the development of greasy skin. Holding fruit for a week at temperatures in the range of 50-70EF prior to placing in cold storage prevents soft scald (DeLong et al., 2004; Watkins et al., 2004), but is not always effective. In Maine, a five-day delay in cooling completely prevented scald in a year when occurrence would have been approximately 30%, but was not effective in a year with over 80%.

The occurrence of soft scald is unpredictable (Tong et al., 2003; Watkins et al, 2005). In Maine, almost none occurred in 2003, whereas in 2004, over 80% of the fruit were affected. It appears to be more severe in years with above average rainfall as in 2004. Soft scald is also variable between different orchards. Some orchards develop it every year, and others more sporadically. Occurrence of soft scald is related to levels of nutrients in the fruit after harvest (Tong et al., 2003). However, controlled studies on the role of nutrition have not been conducted. If the level of foliar or fruit nutrients affects the occurrence of soft scald, this would allow growers to adjust fertilizer practices to prevent soft scald. The goal of this project is to identify the role of irrigation and nutrition in the occurrence of soft scald.

### **Research Description:**

Fruit will be harvested from six different orchards, one with a history of severe soft scald, one little or none and the rest with average levels. Within three of the orchards, three trees will be irrigated every other week and three will be unirrigated. To irrigate trees, 5-10 gallons per tree will be added depending on tree size. During weeks with more than one inch of rainfall, trees will not be irrigated to avoid overwatering. Relative soil moisture will be measured weekly with tensiometers at a depth of 8 inches. One bushel from each orchard will be harvested when starch index is in the range of 6.0 to 6.5. Fruit will be placed in cold storage immediately after harvest to encourage the development of soft scald. Temperature in storage will be maintained in the range of 32-34EF and will be measured daily. Fruit will be stored until January at which time quality and occurrence of disorders will be measured. The study will have a randomized block design with five single-tree replications of each treatment.

Leaf and soil samples will be collected from each orchard in late July for nutrient analysis. Leaf samples will be washed and dried before analysis for N, P, K, Ca, Mg, B, Zn, Mn, Fe and Cu. A sample of ten fruit will be used to measure fruit levels of N, P, K, Ca, Mg, B, Zn, Mn, Fe and Cu. Starch index, internal ethylene and fruit quality will be measured on ten fruit following harvest. Additional treatments will compare storage practices for their effects on fruit quality and occurrence of soft scald after long-term storage. Controlled atmosphere (CA) storage and MCP (SmartFresh™) are current methods to maintain quality and flavor of apples in long-term storage. CA storage is not recommended for Honeycrisp because it increases the occurrence of chilling injury. MCP can maintain flavor of Honeycrisp without increasing chilling injury. Fruit will be harvested at a starch index of 5.0 to 5.5 and subjected to one of the following treatments:

1. Check, regular air storage at 33EF
2. 5-day delayed storage followed by regular air storage
3. 5-day delayed storage + MCP followed by regular air storage
4. 5-day delayed storage + MCP + CA storage
5. CA storage
6. MCP + CA storage

For the five-day delayed storage, fruit will be held at 60EF. MCP will be applied prior to the five-day delay. To establish CA conditions, fruit will be placed inside airtight plastic bags. The oxygen concentration will be maintained at 2.5% and carbon dioxide at 1.5%. Fruit will be stored until March at which time quality and occurrence of disorders will be measured. Fruit will be held at room temperature for seven days after which firmness and ethylene will be measured on ten fruit. Another set of 12 fruit will be delivered to the Consumer Testing Center in Orono to be evaluated for eating quality by a panel of 30 people who regularly eat apples. The consumer panel will be evaluating color, flavor, texture, appearance and overall quality. Fruit will be rated on a hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely. Occurrence of disorders will be measured on 30 fruit after seven days at room temperature.

The trees are 'Honeycrisp'/M.26 located the Highmoor Farm in Monmouth, ME. The study will have a randomized block design with four single-tree replications of each treatment.

### **Projected Outcomes:**

This project will identify pre- and postharvest storage protocol for maintaining optimum fruit quality based on conditions in Maine. The results of this project will enable growers to market high quality apples with minimum loss to soft 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 in HortScience.

### **Abstract:**

Storage methods that prevent or reduce the occurrence of a storage disorder, soft scald, did not impair fruit quality or cause a greater incidence of other storage disorders. A five-day delay in cooling reduced the incidence of soft scald of Honeycrisp without reducing eating quality. Irrigation and nutritional differences did not appear to predispose fruit to soft scald.

### **Objectives Made:**

The goal of this project was to identify the role of irrigation and nutrition in the occurrence of soft scald.

The 2005 season was not dry, so large differences in soil water did not occur. Irrigation had no effect on soft scald which occurred in 43% of the fruit, but reduced soggy breakdown from 11% to 3%. Fruit were harvested from six different orchards that varied in fertility. There were large variations between orchards in occurrence of soft scald, but no significant correlation with foliar levels of nutrients (N, P, K, Mg, Ca, B, Zn, Mn, Fe and Cu). The highest incidence occurred in fruit from Highmoor Farm, 62%, and the lowest incidence from an organic orchard, 6%.

Storage practices prevented soft scald without impairing fruit quality of Honeycrisp after four months in refrigerated storage or controlled atmosphere storage (CA; 2.5% oxygen). A five-day delayed cooling reduced soft scald to 7% compared to 41% of the control fruit. There was also a lower incidence in CA-stored fruit, but this was most likely a result of the warmer storage temperature. None of the treatments reduced the occurrence of soggy breakdown. Mean hedonic scores from sensory evaluation were not reduced by delayed cooling and did not vary between treatments for appearance, color, flavor, texture and overall rating.

### **Methods Used to Evaluate Outcomes:**

Growers who store Honeycrisp will be surveyed to determine the number who have implemented storage practices that prevent soft scald. Observations will be made of the number of growers who request assistance with storing Honeycrisp or the number who lose fruit to soft scald.

### **Integration of Research and Extension Activities:**

A presentation will be made to Maine apple growers in January 2007 and a paper will be published in Fruit Notes of New England in winter 2007.

### **Outputs:**

Multistate Project NE-1018 Report for Maine - Postharvest Biology of Fruits Annual Meeting. Simsbury, CT, July 2006.



## **MAC70: A Molecular Tool for Characterizing Wild Blueberry Clones**

**Principle Investigator(s): Seanna Annis, Frank Drummond**

### **Background:**

The objective of this research is to adapt molecular methods for characterizing different genotypes of *Vaccinium* species to wild lowbush blueberry (*Vaccinium angustifolium*). This is a key first step to understanding field-level susceptibility to disease and insect pests, and the potential maximum yield of different fields.

Wild lowbush blueberries are an important crop to the state of Maine. Lowbush blueberry fields consist of wild clonal plants that have been managed to produce a commercial crop. These fields are comprised of a patchwork of genetically diverse clones, predominantly of *Vaccinium angustifolium* Ait. and some interspersed plants of *V. myrtilloides* Michx. Three morphological types of *V. angustifolium* have been distinguished, but they readily interbreed producing multiple hybridizations ranging between the types. Clones can be differentiated by morphological characteristics and have varying yield potential. Most individual clones are self infertile resulting in the production of diverse offspring. Clones in managed fields have initially been established from seedlings and increase in diameter by vegetative growth via rhizomes.

Clones may also vary in disease resistance and their suitability as a food source for pests. The incidence of mummy berry leaf blight, caused by *Monilinia vaccinii-corymbosi*, significantly varies among clones of *V. angustifolium* in an individual field and is significantly correlated to the timing of leaf bud development of the clones. Some of these clones may be avoiding disease but others may have biochemical or physical variations that produce resistance, such as has been found in highbush blueberry clones. Drummond (unpublished research) has found evidence of differences in blueberry spanworm development and survival on different lowbush blueberry clones.

Molecular techniques can be used to identify individuals and trace genetic similarity between individuals. Cultivars of rabbiteye and highbush blueberries can be identified using the molecular technique of RAPDs (Random Amplified Polymorphic DNA) and EST-PCR (Expressed sequence tags-polymerase chain reaction) markers. However RAPDs could not be used to determine the genetic relationships between the highbush cultivars studied. Burgher et al. (2002) have also used RAPDs to differentiate between clones of lowbush blueberry collected from fields in New Brunswick.

We propose to examine the genetic diversity of blueberry clones using molecular and morphological techniques. The development of such a tool will enable us to compare the disease resistance, insect susceptibility, development and pollination among different clones. Even though growers may not be able to alter the genetic diversity in their fields (since fields are not planted), we believe that it will be very useful to identify deleterious clones which can be rogued, or at least identify fields that have the highest potential for superior yields. We foresee growers being able to construct a genetic clone composition of their field to assess overall susceptibility to disease, blueberry spanworm, and pollination potential, based upon what we learn about the genetic basis to these processes. If funded, we expect to present our research results to blueberry growers at the winter Extension Blueberry School held in March and the summer Blueberry Field Day in July. This research will also result in publications and presentations at international meetings and provide the basis for funding applications to the Wild Blueberry Research Council, and national USDA funding programs.

### **Research Description:**

Clones of *V. angustifolium* in lowbush blueberry fields were identified and marked using global positioning and by stakes in the blueberry barrens near Cherryfield, ME. These clones have been used to study mummyberry blight or effects on blueberry spanworm. Cuttings from multiple blueberry clones from multiple fields have been established in pots. DNA will be extracted from young leaf tissue taken from the field in May or from potted plants. Multiple stems within a clone will be fingerprinted to confirm uniformity of the clone. Clones with different morphological types will be used to try to link morphological traits with genotype and disease or insect resistance. Clones of *V. angustifolium* will be DNA fingerprinted using either EST-PCR or amplified fragment length polymorphisms (AFLP) which has been used in the Annis lab to identify genetic diversity within species of fungi. Data analysis will allow us to determine similarities between the clones and distinguish individual genotypes.

## Objectives Made:

The objective of this research was to adapt molecular methods for characterizing different genotypes of *Vaccinium* species to wild lowbush blueberry (*Vaccinium angustifolium*). This is a key first step to understanding field-level susceptibility to disease and insect pests, and the potential maximum yield of different fields.

## Methods Used to Evaluate Outcomes:

Daniel Bell is the PhD graduate student who conducted all research outlined in this report.

Lowbush blueberry (*Vaccinium angustifolium*) clones were sampled in the summer of 2005. Stems with young developing leaf tissue were collected and frozen at -80C. Leaf tissue was ground three times with sand and then DNA was extracted following a protocol by Doyle and Doyle. DNA was then run on an agarose gel to look for the condition and quality of the DNA. Various modifications of the DNA extraction procedure were tried with some improvements in DNA quality. Attempts to amplify the DNA with EST primers using polymerase chain reactions (PCR) showed some band differences between clones but consistent banding patterns were difficult to produce due to poor DNA quality.

In the summer of 2006, forty-five clones were sampled from 3 lowbush blueberry populations in Maine. Fresh leaf material was collected from each clone and sent fresh on ice and as frozen preparations on dry ice to the lab of Dr. Jeannine Rowland, USDA-ARS, Beltsville, MD. Rowland designed the EST markers used in this study and is a collaborator on this project. In August 2006, Bell traveled to the USDA labs to do DNA extractions and PCR amplifications using primers designed by Dr. Rowland's lab. The DNA extraction protocol is a modification of the Doyle and Doyle (1990) procedure.

DNA from 25 clones was extracted with 9 clones producing DNA of sufficient quality to allow PCR amplification. DNA from these 9 clones were amplified with EST primers and produced polymorphic bands. In total, 24 EST-PCR primers were screened. PCR conditions were as described

previously (Rowland et al., 2003a; 2003b). The primers were originally obtained from an EST library of cDNA generated from cold acclimatized highbush blueberries. Of all 24 primers used, 21 showed repeatable polymorphic bands when DNA from the 9 clones were screened two times. Between 1 and 6 polymorphic bands were generated with each primer. Bands were scored by eye using photographed gels of PCR amplifications (Figure 1). Bell did the first scoring and later corroborated his scoring with E. Ogden, a research scientist in Rowland's lab. Amplifications were repeated and scored independently. If bands were not duplicated in identical reactions, they were not scored. Polymorphic bands were scored as either present or absent and compared across all of the DNA samples to produce a matrix of similarity. This data was put into the NTSYS v. 2.2 (Sokal) software program to generate DICE similarity coefficients and dendrograms showing relatedness between clones (Figure 2).

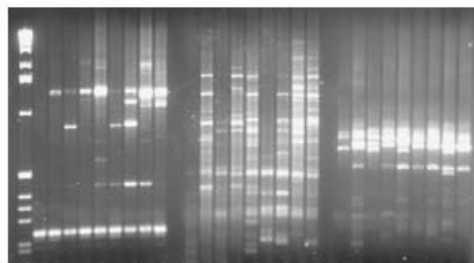


Figure 1. PCR amplifications of 9 clones with three EST-primers. Lane 1, standard; 2 to 10, amplifications with primer 1; 11, no DNA check; 12 to 20, amplifications with primer 2; 21 no DNA check; 22 to 30, amplifications with primer 3; lane 31 no DNA check.

There were two main groups of isolates with an overall similarity of approximately 21%. There were two clusters, one containing clones A and D, and a larger cluster containing the other 7 clones. The highest similarity found between two clones was a 69% similarity between B and E. It is too early to make definitive conclusions about the biology or evolutionary process that may be occurring but it is clear from this summer's advance that the EST primers are robust and polymorphic and do result in strong, repeatable data that can discern genetic relationships in this system.

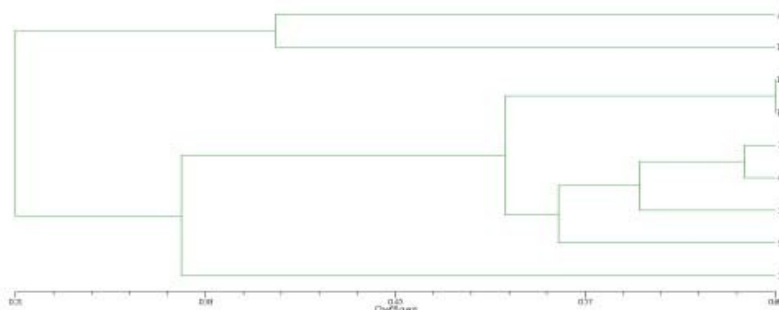


Figure 2. Dendrogram showing relatedness amongst 9 lowbush blueberry clones designated A, B, D, E, 1, 2, 3, 4 and 5 using DICE correlation coefficients.

## **MAC71: Agri-tourism in Maine: Opportunities, Challenges and Linkages**

**Principle Investigator(s): Todd Gabe, Tom Allen, James McConnon, Deanne Herman**

### **Background:**

Agri-tourism is growing in importance in the United States both as a diversification strategy for smaller farms and as a source of economic development in rural communities. Between 1997 and 2007, nature and agricultural-based tourism is expected to grow by 30 percent, making it the fastest growing segment of the travel and tourism industry (Purdue Tourism and Hospitality Center). According to a 2001 study by the Travel Industry Association, more than three-fourths of urban residents visit rural areas for a unique vacation experience, and nature tourists in the U.S. spend more than .5 billion on travel alone (TIA). In Vermont, income from agri-tourism during 2002 totaled .5 million, an increase of more than 85 percent over agri-tourism income in 2000. Although that figure represented only four percent of total farm income in Vermont in 2002, approximately one-third of Vermont's farms received an average of ,900 of income from agri-tourism -- up from ,000 in 2000 (National Agricultural Statistics Service, 2004).

Several recent initiatives underscore the growing interest in agri-tourism in this state.

- A bill presently under consideration by the current Legislature would add one industry member to the Maine Tourism Commission to represent agricultural producers in the state (LD 673).
- In 2003, the Governor's Conference on Tourism highlighted nature-based tourism (and specifically agri-tourism) as a significant and developing sector of tourism in Maine. Also, the Governor's top award for Tourism Excellence was presented to the Harris Farm and Cross-Country Skiing Center in Dayton.
- The Maine Tourism Commission has established a new (2004) working committee focused on nature-based tourism development, which recognizes agri-tourism as a significant component of this growing sector.
- The Maine Department of Agriculture (MDOA) and the Maine Office of Tourism are currently collaborating on an effort to promote Maine agri-tourism to travelers from "away." This kind of collaboration might not have been possible five years ago.
- The Maine Tourism Association is supporting agri-tourism interests on many fronts, including providing space at the State Tourism Information Centers for displays and literature promoting Maine farms; dedicating considerable editorial space in "Maine Invites You" to Maine food and farms; and having Information Center staff hand out Pomological Society apples and orchard maps in the fall.
- The MDOA maintains an extensive database of detailed information on farm businesses and their agri-tourism activities, used both for business assistance and promotional purposes, which include searchable farm listings on [www.getrealmaine.com](http://www.getrealmaine.com).

Among its advantages, agri-tourism provides opportunities for the farm sector to increase options for farm diversification, improve general awareness of local agricultural production, develop new agricultural market niches, provide farm families with on-site employment opportunities, and strengthen the long-term sustainability of smaller farms. For rural communities, agri-tourism presents a viable economic development strategy for job creation and producing an expanded and diversified economic base.

### **Research Description:**

The heightened level of interest in Maine agri-tourism suggests a clear need for better information to support policy and program development aimed at encouraging the growth of agri-tourism at the farm level. In collaboration with the MDOA, we propose to conduct a study of Maine farmers who are currently involved in agri-tourism. Working with the MDOA, and using their database to identify farms engaged in agricultural tourism activities, we plan to send a survey to each farm and collect information that will enable us to (1) develop a profile of farms in Maine that are involved in agri-tourism, (2) assess the importance of agri-tourism-related activities to farm income, (3) identify the business development and promotional needs of farmers engaged in agri-tourism, (4) explore the existence and potential for agri-tourism clustering and networking among agri-tourism farms and with other non-farm tourism resources, (5) develop information that will help Maine farmers determine the economic feasibility of developing agri-tourism activities, and (6) establish baseline data for agri-tourism activity in Maine to track changes over time.

Some of the specific questions this research hopes to answer include:

- What kinds of (and how much) agri-tourism takes place on these farms?
- How much does agri-tourism contribute to farm income?
- Do farmers desire to expand these activities?
- What are farms currently doing to promote agri-tourism activities?
- What kinds of assistance do farms need to further develop agri-tourism activities?

Based on a preliminary review of the mailing list, we estimate that 800 to 1,000 farmers will be involved in the study through a self-administered mail survey. The survey methodology will include multiple contacts with non-respondents to increase response rates. The principal investigators have considerable experience in conducting industry surveys.

### **Projected Outcomes:**

The survey will be conducted during Fall/Winter 2005/2006. Final results and all project reports will be completed by June 30, 2006. In addition to the project summary required by MAC, the final products will include a detailed report based on data collected through the mail survey and a summary “fact sheet”. We plan to disseminate the results of this study through the newly formed University of Maine Center of Tourism Research and Outreach (CentRO), the Maine Department of Agriculture, and the University of Maine Cooperative Extension. We will seek to present the results at the 2006 Governor’s Conference on Tourism and at the 2006 annual meeting of the Northeast Agricultural and Resource Economics Association. A fact sheet will be created for statewide dissemination through Maine Cooperative Extension to support field staff’s efforts in sustainable agriculture and tourism business development. Information gleaned from the research will enable the Maine Department of Agriculture, the Maine Tourism Office, and others to identify and include more farms in their promotional programs targeting tourists. It will also drive interagency development and delivery of information, training and networking resources and opportunities for farmers. Identifying existing or potential agri-tourism clusters will generate high-quality information to be used as the Maine-based component of a 3-year regional project, recently funded by the USDA, to study agricultural clusters. Finally, the project also complements a proposal under discussion for submission to the USDA’s Risk Management Agency for development of a decision support tool that will enable farmers and agriculture support providers to assess farm-level potential for establishment or expansion of agri-tourism enterprises.

### **Objectives Made:**

The study was conducted in cooperation with the Maine Department of Agriculture. During January and February of 2006, a seven page, self administered survey was mailed to all farms in Maine that were known to be engaged in one or more agri-tourism enterprises (i.e., agri-tourism farms). Initially, 792 surveys were mailed to farmers included on a mailing list provided by the Maine Department of Agriculture. Twenty five surveys were returned as non applicable to the addressee (e.g., addressee was deceased; no longer farming, etc.); one survey was returned as non-deliverable. Reminders and repeat mailing were made to non respondents. Of the net mailout of 766 surveys, 456 were completed and returned for a response rate of 60%.

1. Specific research questions that were posited in the project proposal are as follows:

What kinds of (and how much) agri-tourism takes place on these farms?

- Agri-tourism farms engage in the following types of activities:
  - Roadside stands 36.9%
  - On-farm retail store 33.6%
  - Pick-your-own 28.7%
  - Farmers markets 26.8%
  - On-farm recreation sales 7.0%
  - On-farm restaurant/snack bar 2.9%
  - Lodging and accommodations 1.3%

How much does agri-tourism contribute to farm income?

- In 2005, agri-tourism farms had total farm sales of .6 million: of that total, .3 million (43.1%) came from agri-tourism activities.
- 5.1% of total farm sales in Maine come from agri-tourism activities
- Including the multiplier effect, agri-tourism is responsible for .8 million of economic output and 1,927 full- and part time jobs.

Do farmers desire to expand these activities?

- 28% of agri-tourism farmers plan to initiate a new agri-tourism enterprise within the next 12 months
- 48% of agri-tourism farmers have a long term interest in developing a new agri-tourism enterprise

What are farms currently doing to promote agri-tourism activities?

- The primary promotional activities currently used by agri-tourism farmers include: word of mouth, 84%; listings in printed directories, 54%; advertising in local media, 53%; listings in others' web pages, 51%.
- 30% of agri-tourism farms have their own web page; 21% communicate with customers by email; and only 3% package their products with other tourism businesses.

What kinds of assistance do farms need to further develop agri-tourism activities? Among the issues that presented "somewhat" or "major" obstacles to establishing or expanding agri-tourism are:

- Finding adequate time 49%
  - Insurance availability or costs 29%
  - Finding qualified workers 27%
  - Taxes 22%
  - Agri-tourism farmers are most interested in learning about:
    - How to price their agri-tourism products 33%
    - Internet marketing 29%
    - Advertising and promotion 29%
    - Web site and search engines 22%
    - Combining products with other businesses 22%
2. Several of the proposed data analyses have not been completed due to time constraints. The mail survey was conducted later than initially proposed in order to avoid surveying farmers during the growing or harvesting seasons. These analyses will be completed in the near term.
  3. Once the results are made available to our research partners at the Maine Department of Agriculture, we expect the agency to provide assistance with the issues identified in the survey. The ultimate outcome of interest would be more profitable farming operations and increases in the offerings of agri-tourism activities. Some measures of project impact are: 1) increased profile of agri-tourism in Maine, 2) an increase in the amount of agri-tourism activities offered by Maine farms, 3) an increase in farm revenue that is attributed to agri-tourism. An evaluation of outcomes 2) and 3) would likely require future survey work.
  4. A UM Cooperative Extension business specialist and Maine Dept of Agriculture market development manager were co principal investigators. An Extension "Fact Sheet" will be developed for distribution to Extension agents throughout Maine. The information generated by the project will be used to develop and/or refine ME Dept. of Agriculture programs.
  5. "The Economic Contribution of Agri-tourism to the Maine Economy", REP Staff Paper #563, Thomas Allen, Todd Gabe and James McConnon. Other reports are forthcoming. In addition, results will be presented at the 2007 annual meeting of the National Association of Community Development Extension Professionals.

## **MAC72: Sanitation and Microbial Control for Maine Potatoes and Maine Wild Blueberries**

**Principle Investigator(s): Vivian Wu, Alfred Bushway**

### **Background:**

In the process of growing, harvesting, storing and shipping, potatoes are exposed to many conditions that may result in food-safety problems. The contaminants such as microorganisms can either reduce the quality of the potatoes or actually make them unsafe for consumers. Production processes from the fresh potato to appetizing potato chips/fries require the most stringent control to ensure food safety and quality.

Mesophilic bacteria such as *Corynebacterium* spp., *Arthrobacter* spp., *Microbacterium* spp., and *Agromyces ramosus* are the predominant microorganisms in the potato processing environment. Foodborne pathogens such as *Listeria monocytogenes*, *Yersinia enterocolitica*, and *Campylobacter* spp. have been reported isolated from potatoes. An outbreak of botulism in El Paso, Texas was attributed to foil-wrapped, baked potatoes. Pathogens involved with potatoes may also cause bacterial ring rot and other potato diseases. Recently, the P.I. and the co-P.I. were contacted by a Maine potato grower who was interested in a new line of value added potato products. A major concern with these products was how to increase product shelf life and insure microbial food safety. Microbial spoilage was the major factor that needed to be addressed. This lifts up the need of developing simple and effective microbial control methods for Maine Potato industry.

To prevent and/or reduce microbial contamination, potato post-harvest washing treatments should be used. Potato storage areas, equipment and environment in a plant as well as in all work areas must be sanitized before potatoes are stored or processed. Potato pathogens may survive on surfaces contacted during storage. Careful cleaning and disinfestations of potato storage and handling equipment can eliminate microbial contamination and prevent the spread of bacterial ring rot and other diseases. Currently, post-harvest washing procedures may not be applied effectively due to the lack of sufficient disinfectants/microbiocides. It is also in need for the education of microbial control strategies through extension programs in Maine potato industry.

Outbreaks of human disease associated with the consumption of raw fruits and vegetables have become more and more frequent over the pass decade. Wild blueberries are one of the major agricultural products and make a major contribution to Maine's economy. Prevention of microbial contamination in order to produce safe products is essential for Maine Wild Blueberry industry.

Chlorine dioxide is one of the disinfectants used increasingly to control microbiological growth in a number of different industries. Chlorine dioxide is a water-soluble, strong oxidizing agent with an oxidation potential 2.6 times higher than that of chlorine and less affected by pH and organic matter. The USDA and EPA have approved chlorine dioxide for use as a safe food disinfectant and an eco-friendly agent for water treatment. The FDA has also approved it for use as a food additive. The generation of chlorine dioxide traditionally needs either reaction with acid or on-site instruments such as an applicator or generator. Therefore, it is very inconvenient, relatively expensive, and has not been widely used by Maine's food processing industry. However, in this research, a new pouch system to deliver chlorine dioxide will be developed and tested in microbial decontamination of Maine potatoes and wild blueberries. It is designed to be done easily by putting a pouch containing all necessary chemicals to generate 500 to 1000 ppm of chlorine dioxide in one liter of water. The successful results of chlorine dioxide pouch washing treatment will provide the Maine potato industry and Maine wild blueberry industry with an efficient and non-expensive microbial decontamination method for post-harvest treatment. Washing with chlorine dioxide may also remove or inactivate a significant portion of organophosphate pesticide residue more efficiently than chlorine.

This research helps Maine potato industry and Maine wild blueberry industry to provide the safest products to compete with other states and regions. Specific elimination of foodborne pathogens will also ensure a safer food supply for Maine consumer. The proposed research will be integrated with extension and outreach activities for the education of Maine's food processing industry. The results will promote Maine agricultural products and monitor food safety.

### Research Description:

1. To develop a new method using one-step chlorine dioxide pouch system to control microbial contamination in the post-harvest Maine potatoes and Maine wild blueberries. (Quantitative study of the approach in terms of efficiency, ease of use and cost). It has been reported that chlorine dioxide is capable of reducing the spread of late blight and secondary soft rot in stored potatoes but the effect was not consistent due to the generation methods. Traditional generation of chlorine dioxide is very inconvenient and expensive, not to mention inapplicable for small agriculture businesses. In this project, a new simple pouch system to deliver chlorine dioxide will be developed and tested in the microbial decontamination for Maine potatoes and Maine wild blueberries. A pouch containing all necessary chemicals to generate 500 to 1000 ppm of chlorine dioxide in one liter of water was developed in the preliminary study but has not been tested on agriculture commodities. For testing in Maine potatoes and Maine wild blueberries, the following experimental design will be used: A. Microbial decontamination of harvested potatoes/wild blueberries: Chlorine dioxide delivered by the simple pouch system will be added in wash water for microbial decontamination of potatoes and wild blueberries. The efficacy of different concentrations (0, 1ppm, 5ppm, 10ppm, 20ppm, and 30ppm) of chlorine dioxide and various times (1, 3, 5, 10, and 15 min) of contact for controlling microorganisms will be studied. The “total viable cell counts” and “mold and yeast counts” of the washed potato and wild blueberries will be evaluated. *Pseudomonas* counts and pathogens counts such as *Listeria monocytogenes*, *Salmonella* spp. and *Yersinia enterocolitica* will be also evaluated. The suitable concentration of chlorine dioxide and treating time will be applied in the later field study. B. The new pouch chlorine dioxide method will be evaluated for potato and wild blueberry sanitation by cleaning up the equipment and the processing environment. Microbial counts will be evaluated as described previously.
2. To provide outreach activities with Maine potato industry and Maine wild blueberry industry using the new non-expensive sanitary method to promote food safety. Outreach activities will be conducted with Maine potato industry and Maine wild blueberry industry in developing microbial control strategies and sanitation programs. Knowledge in controlling and eliminating foodborne pathogens will be shared with Maine agriculture and 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. A brief non-technical summary will also be published in the Maine Agricultural Center Newsletter.

### Projected Outcomes:

Chlorine dioxide with > 1ppm is expected to effectively reduce the level of microorganisms. The results will provide processors with information on the effectiveness of the new pouch system of chlorine dioxide with simple and non-expensive application.

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 be published in scientific refereed journals, where MAC will be acknowledged. The outcomes are expected to benefit the local, regional, and state agricultural community, the food producing industry.

### Objectives Made:

1. To develop a new method using one-step chlorine dioxide pouch system to control microbial contamination in the post-harvest Maine potatoes and Maine wild blueberries. (Quantitative study of the approach in terms of efficiency, ease of use and cost).

Chlorine dioxide (ClO<sub>2</sub>) is a sanitizer with an oxidation capacity 2.5 times higher than that of chlorine. The FDA has approved the use of aqueous ClO<sub>2</sub> in washing fruits and vegetables. The generation of ClO<sub>2</sub> usually requires either a reaction with acid or on-site instruments such as an applicator or generator. For wide application of ClO<sub>2</sub>, simple and inexpensive sanitizing procedures are necessary. In this study we have developed and investigated bactericidal effectiveness of a simple and cheap ClO<sub>2</sub> method on four foodborne pathogens, *Salmonella Typhimurium*, *Listeria monocytogenes*, *Yersinia enterocolitica*, and *Pseudomonas aeruginosa* that potentially associate with potatoes or wild blueberries. Very short treatment times such as 10 seconds could reduce *S. Typhimurium*, *Y. enterocolitica*, *P. aeruginosa*, and *L. monocytogenes* by 1.28, 2.55, 1.52, and 1.91 log CFU/ml, respectively. ClO<sub>2</sub> was the most effective on *Y. enterocolitica* and *L. monocytogenes*. ClO<sub>2</sub> treatment for 10 minutes resulted in the reduction of 4.71 and 5.08

log CFU/ml for *Y. enterocolitica* and *L. monocytogenes*, respectively. ClO<sub>2</sub> showed promise as a sanitizer for killing foodborne pathogens. The high bactericidal effectiveness of aqueous ClO<sub>2</sub> with efficient treatment time provides an advantage to producers who do not want any changes in the appearance of their produce after sanitization. Our results suggest that aqueous ClO<sub>2</sub> is a highly effective microbial decontamination method for different foodborne pathogens and can be adopted for Maine potatoes and wild blueberries.

We studied bactericidal effectiveness of this method on five pathogens inoculated on blueberries as well as natural flora on blueberries such as yeasts and molds. A sachet (2g size) containing all necessary chemicals was used to generate approximately 320ppm of ClO<sub>2</sub> in 7.6 liter of distilled water. *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Salmonella Typhimurium*, *Staphylococcus aureus*, or *Yersinia enterocolitica* was spot-inoculated on blueberries. The efficacy of different concentrations (0, 1, 3, 5, 10, and 15ppm) of ClO<sub>2</sub> and various times of contact (10 sec, 1, 5, 10, 15, 20, 30 min, 1 hr, and 2 hr) were studied. Reductions of all pathogens on blueberries by ClO<sub>2</sub> treatments were achieved. *S. Typhimurium* was significantly reduced ( $P < 0.05$ ) by 3.21 log and 3.32 CFU/g when treated with 10ppm of ClO<sub>2</sub> for 30 min and with 15ppm for 20 min, respectively. Treated with 5ppm of ClO<sub>2</sub> for 20 min, 30 min, 1 hr, and 2 hr, *Y. enterocolitica* was reduced by 1.38, 1.97, 2.91, and 3.49 log CFU/g, respectively. *P. aeruginosa* was reduced by 2.16 log CFU/g ( $P < 0.05$ ) even after 5min when treated by 15ppm of ClO<sub>2</sub>. The simple ClO<sub>2</sub> method showed promise as a sanitizer for controlling foodborne pathogens, although the efficacy of ClO<sub>2</sub> treatments varies among different pathogens. The strong bactericidal efficacy of ClO<sub>2</sub> provides advantages to producers who do not want significant changes in the appearance of the produce after the sanitization procedure. This ClO<sub>2</sub> method has much potential to be an effective microbial decontaminant for produce such as potatoes and wild blueberries.

2. To provide outreach activities with Maine potato industry and Maine wild blueberry industry using the new non-expensive sanitary method to promote food safety. Outreach activities are conducted with Maine's wild blueberry and potato industries in developing efficient microbial denomination methods. Knowledge in using the new non-expensive chlorine dioxide sanitary method is also shared with the industry. Information is shared with the industry through meetings with the Maine Wild Blueberry Research Committee and Maine Potato Board, 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.

### 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, outreach activities and interactions with the food industry. Our simple, inexpensive microbial decontamination protocol utilizing the strong bactericidal method, ClO<sub>2</sub> treatment provides advantage to Maine producers who do not want change of their produce appearance after sanitization procedures. 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:

- Kim, Bs and V.C.H., Wu\*. 2006. Bactericidal effectiveness of aqueous chlorine dioxide on salmonella typhimurium, listeria monocytogenes, yersinia enterocolitica, and pseudomonas aeruginosa. Abstract publication. Poster Presentation. IFT annual meeting. Orlando FL.
- Kim, Bs and V.C.H., Wu\*. 2006. Effectiveness of a simple chlorine dioxide method for controlling *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Salmonella Typhimurium*, *Staphylococcus aureus*, and *Yersinia enterocolitica* on blueberries. Abstract publication. Poster Presentation. IAFP annual meeting. Alberta, Canada.
- Kim, Bs and V.C.H., Wu\*. 2006. Aqueous chlorine dioxide as a sanitizer for controlling five foodborne pathogens, yeasts and molds on blueberries. Int. J. Food Microbiol. In review.



- Wu, V.C.H. March. 21, 2006. Microbial Control Using a New Sanitary method for Maine Wild Blueberries. Presentation. Wild Blueberry Research Advisory Committee. Maine.
- Wu, V.C.H. Feb. 15, 2006. Strategies for prevention of potato spoilage during storage and application of Maine potatoes from the microbiology aspect. Presentation. Maine Potato Board. Maine.
- Wu, V.C.H. Nov. 2, 2005. Microbial Control for Maine Wild Blueberries. Presentation. Wild Blueberry Research Advisory Committee. Maine.

## **MAC73: Commercial Quinoa Production in Maine as a Cash and Rotational Crop for Farmers**

**Principle Investigator(s): Mark G. Hutton**

### **Background:**

Initial experiments in commercial grower fields located in Western Maine and at the University of Maine's Highmoor Farm, demonstrate that quinoa can be grown in Maine as a commercial crop, and be used successfully in rotation with potatoes and corn. Quinoa, a high quality and high value crop, replaces oats or rye, both low value crops, currently used in traditional rotations. Trials to date have yielded promising, though mixed results. A number of production barriers presented themselves when trying to adapt western developed quinoa strains to Maine. Pest infestations from tarnished plant bug and diamond back moth, weed control, and our short growing season are significant obstacles.

### **Research Description:**

We propose to develop a Maine strain of quinoa adapted to Maine's growing conditions. In 2003, University of Maine's researchers began development of a Maine strain of quinoa and associated production management techniques. This work continued in 2004. In 2005, we will be evaluating five elite selections and three populations for plant growth, yield and pest infestation. The initial development phase of Maine quinoa strains is expected to be complete in two to three more years at which time small plot trials will then begin by a group of row crop farmers. Strain selection will continue on growers' farms to develop elite strains. Details regarding insect and weed control, fertility, moisture management, and planting and harvesting techniques will be investigated in research station experiments and on grower's farms.

### **Methods Used to Evaluate Outcomes:**

In both 2005 and 2006 the crop was lost due to poor conditions at the time of planting. The issue associated with the 2005 crop was poor stands and tremendous weed pressure. In 2006, the planting date was delayed due to wet field conditions until it was too late in the season to plant and still expect a harvest. We intend to try again to make a crop this year.