Maine Agricultural Center Integrated Research and Extension Projects: 2007–2008

MAC85: Determining Consumer Preferences of Beefsteak type Tomatoes Grown in High Tunnels, Part 2.

Principle Investigators: Mark G. Hutton, David T. Handley

Issue/Priority:

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 $0.25 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.

Project Description:

This is a replication of a study conducted in 2005. This purpose of repeating the experiment is to validate the initial results, test newly released varieties against proven winners. 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 2007. 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 from the two years will be statically analyzed and summarized for publication.

Sharing 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.

Please note: This is a continuation of a project from 2005. We attempted to repeat the project in 2006 with other funds but lost our tomato crop due to an equipment failure in the greenhouse early in the season.

Termination Report

Project objectives:

1. To compare plant quality, fruit yield and consumer acceptance of seven indeterminate open field tomato varieties and eight greenhouse indeterminate tomato varieties grown in the Highmoor Farm hoophouse.
2. Identify superior tomato varieties and make recommendations to Maine and New England growers choosing tomatoes for hoop house production.

All project objectives were met in 2008.

Methods and Outcomes:

Fifteen tomato cultivars were grown in a 26' X 95' hoop house at the University of Maine's Highmoor Farm in Monmouth. Four, 75' long rows of raised beds covered with plastic mulch were established in the house, and each row served as a replication. Plants were spaced 1' apart along the rows. The rows were divided into 15 plots, and each variety was randomly assigned one of the 15 plots. In total 300 seedlings were planted and each one had 6.5 square feet of space in which to grow.

The plants were started in the greenhouse on April 17, 2007 and transplanted to the hoop house on May 29th. All plants were trellised and pruned to one main stem. Plants that exceeded 7' in height were topped. The fruit were harvested at the red ripe stage beginning on August 6th and continuing until October 11th. Fruit were sorted into two marketable categories, A (premium), and B (small or slightly blemished) and one unmarketable category, C (cull). Fruit in each category were counted and weighed, and observations on disease and other problems were made. Samples of each cultivar were sent to the University of Maine Food Science Center for sensory analysis. The data was used to rank each cultivar's performance in yields, quality, and plant health.

The tomatoes grew well throughout the season with 2,964 lbs of marketable fruit harvested. In fact overall this seasons yields were 50% higher than they were in 2005 when a similar trial was undertaken. There are two possible explanations for this. First several poor performers from 2005 were replaced with different cultivars in 2007, some of which performed well. Additionally, in 2007 the seedlings were planted into the hoop house 2 weeks earlier than they were in 2005.

Significant differences were found in yields among the 15 cultivars. 'Arbason' and 'First Lady II' produced the greatest yields of marketable fruit, although 'Arbason' produced the highest yields of Grade A fruit, and much fewer grade B's, while 'First Lady II' produced a high yield of grade B fruit but fewer grade A's. 'Buffalo', 'Dundee' and 'Trust' were the poorest performers in terms of marketable yields.

Rankings for fruit quality were determined based on the percentages of the harvest that fell into each of the three grades (premium, marketable, and cull). Plant health rankings were determined by counting the number of incidences of fruit or plant disease per plot. The top five overall performers in the study were 'Mr. Ugly', 'Big Beef', 'Brilliante', 'First Lady II', and 'Arbason'. The five worst performing tomatoes grown were 'Betterboy', 'Buffalo', 'Ultra Boy', 'Trust', and 'Dundee'. Consumer taste preferences indicated that no tomato cultivar was clearly identified as a favorite

Integration of Research and Extension Activities:

More than 55 growers attended twilight meetings held at Highmoor Farm in 2007. Thirty Maine Organic Farmers and Gardeners Association interns, apprentices and growers attended the twilight meeting held August 21, 2007. Approximately, 25 Maine Vegetable and Small Fruit Growers Association members attended the Highmoor Farm twilight meeting held September 12, 2007. During each of these meetings more than 20 minutes were spent in the hoop house tomato trial discussing the cultivars and management practices used to grow the crop.

Results of this experiment were also presented at two meetings: The New England Vegetable and Berry Conference held December 11-13, 2007 in Manchester New Hampshire, and the annual meeting of the Maine Vegetable and

Small Fruit Growers Association, January 16, 2008, held in conjunction with the Maine Agricultural trade show. More than 180 growers received this information.

Results of the 2005 and 2007 hoop house tomato trials were the basis for decisions made concerning which tomato varieties to recommend in the 2008-2009 New England Vegetable Management Guide. A resource guide used by more than 1,800 vegetable growers in New England.

Presentations:

1. Highmoor Farm Twilight Meeting, MOFGA 8/21/07
2. Highmoor Farm Twilight Meeting, MVSFGA, 9/12/07
3. New England Vegetable and Berry Conference Tomato Session, 12/12/07
4. Maine Vegetable and Small Fruit Growers Association annual meeting, 1/16/08

Publications:

In preparation.

Table 1. Marketable Yields of Hoop House Grown Tomatoes In 2007, Highmoor Farm, Monmouth, ME.

Variety	Supplier[z]	Type[X]	Mean Wt of A's (kg)[W]	Ave size A's (kg)	Mean Wt of B's (kg)[W]	Ave size B's (kg)	Mean Wt of Mkt fruit (kg)[W]
Arbason	Johnny's	GH	20.9	0.272	10.0	0.237	30.8
First Lady II	Johnny's	OF	11.2	0.239	15.4	0.203	26.6
Mr. Ugly	Seedway	OF & GH	19.4	0.347	6.5	0.226	25.9
Geronimo	Stokes	GH	9.3	0.252	16.2	0.200	25.5
Cobra	Stokes	GH	16.2	0.295	8.3	0.250	24.5
Big Beef	Johnny's	OF	17.4	0.353	6.3	0.304	23.7
Brilliante	Stokes	OF	16.3	0.245	7.1	0.177	23.4
Zapata	Seedway	GH	13.8	0.277	8.5	0.259	22.3
Ultra Boy	Stokes	OF	9.0	0.284	13.2	0.238	22.2
Betterboy	Harris	OF	9.5	0.325	12.0	0.291	21.5
Ultra Sweet	Stokes	OF	13.7	0.315	7.6	0.207	21.3
Jet Star	Harris	OF	14.8	0.344	6.0	0.265	20.7
Trust	Johnny's	GH	10.1	0.307	9.0	0.263	19.2
Dundee	Stokes	GH	9.6	0.309	5.1	0.253	14.7
Buffalo	Johnny's	GH	9.0	0.297	5.6	0.230	14.6
			LSD = 4.249		LSD = 2.766		LSD = 4.449

[z] Harris Seeds (355 Paul Road; P.O. Box 24966; Rochester, NY 14624-0966), Johnny's Seeds (955 Benton Avenue; Winslow, ME 04901-2601), Seedway (99 Industrial Road; Elizabethtown, PA 17022), Stokes (Box 548; Buffalo, NY 14240-0548)

[X] GH – greenhouse, OF – open field

[W] LSD = data in this column must differ by this much to be considered statistically different

Table 2. Yield, Quality and Plant Health Rankings for 15 Tomato Cultivars Grown in a Hoop House at Highmoor Farm, Monmouth, ME, 2007

		Quality	Yield	Plant Health	Raw Total	Final
Variety	Type	A	B	C	A+2B+C	Ranking
Mr. Ugly	GH and OF	1	3	1	8	1
Big Beef	OF	4	6	2	18	2
Brilliante	GH	2	7	2	18	2
First Lady II	OF	9	2	5	18	2
Arbason	GH	5	1	12	19	5
Cobra	GH	6	5	8	24	6
Geronimo	GH	15	4	7	30	7
Jet Star	OF	3	12	6	33	8
Zapata	GH	8	8	13	37	9
Ultra Sweet	OF	7	11	8	37	9
Betterboy	OF	12	10	8	40	11
Buffalo	GH	9	15	4	43	12
Ultra Boy	OF	14	9	14	46	13
Trust	GH	13	13	11	50	14
Dundee	GH	11	14	15	54	15

Table 3. Brief Descriptions of Tomato Cultivars Evaluated at Highmoor Farm.

Variety	Shape	Color	Firmness	Unifomity	Comments
Arbason	flat round	glossy dark	firm	uniform	large vigorous plant
Betterboy	tall round	not good, not bad	soft	fairly uniform	cracking
Big Beef	flat round to round	glossy dark red	medium firm	variable	some with high shoulders, some cracking
Brilliante	round to tall round	dark red, not too glossy	firm	very uniform	shows more stink bug damage than other cultivars
Buffalo	variable	deep red	soft	variable	
Cobra	round	med red, slight orange	soft	variable	some yellow shoulder, some cracking, picks easily
Dundee	tall round	pale	hard	uniform	poor yields
First Lady II	rough	glossy medium red, sparkly	firm	fairly uniform	some green shoulder
Geronimo	flat round	orange red	firm	uniform	a lot of cracking, high shoulders, large vigorous plant
Jet Star	mostly deep round	orange/red glossy	soft	variable	some grey wall, slight cracking, slightly rough
Mr. Ugly	flat, ribbed with high shoulders	deep red	medium firm	variable	crew favorite, lg blossom scar, late season fruit developed some hollow centers
Trust	tall round	light	fair	uniform	few splitting fruit, green shoulder
Ultra Boy	round to flat round	good color red/orange	soft	variable	some cracking at stem end, most have green/yellow shoulder, weak plants with yellowed leaves
Ultra Sweet	slightly rough, raised shoulders	uniform red with slight orange tint	soft	variable	very little yellow shoulder, weak plants with yellowed leaves
Zapata	round	slightly orange	firm	uniform	some cracking, no shouldering

This work was funded in part through a University of Maine MAC grant. We would like to thank Harris Seeds, Johnny's Selected Seeds, Seedway Seeds and Stokes Seeds for the donation of seed for this project.

MAC86: Cold Temperature Tolerance of Apple Rootstocks

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

Issue/Priority:

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

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

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

Project Description:

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

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

Sharing Outcomes:

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

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

Termination Report

Summary:

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

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

Objectives That Were Met and Significant Findings:

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

Objectives That Were Not Met:

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

Methods Used to Evaluate Outcomes:

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

Integrated Research and Extension Activities:

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

Publications, Presentations and Other Outputs:

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

MAC87: Incidence of Endophyte Infected Fescue in Maine Horse Forage Sources

Principal Investigators: Donna Coffin

Background

In other parts of the country the effects of feeding endophyte infected forages to pregnant brood mares have been documented as a problem that needs to be avoided. [1] Some states provide testing facilities to allow livestock owners to monitor the level of infection in pastures so fields can be avoided with the highest infection level for their susceptible mares. Conserved forage has also been identified as a problem for susceptible animals.

Toxicity of endophyte infected fescue affects other livestock as well as horses. It has been found that the pregnancy rate of beef cows on pastures with high levels of endophyte infected fescue reduced pregnancy rates by 34%. [2]

Broodmares consuming endophyte-infected tall fescue in the last third of their pregnancy are more susceptible to prolonged gestation, foaling difficulty, thickened placenta, decrease of milk production and rebreeding difficulties. Foals may be born weak or dead. There now are endophyte free tall fescue varieties that farmers could use when reseeding their fields, however, few horse farms have the opportunity to reseed their pastures or hayfields.

Objectives

In Maine, we do not know if endophyte fungus has infected the tall fescue grass to a level that pregnant mares are at risk. Also, more and more breeding farms are importing hay from outside the State of Maine. Is this practice cause for concern among breeding farms and brood mare owners? Are native conserved forages fed to horses infected with endophyte fungus? What is the level of endophyte infected forage that is fed to horses in Maine?

This project will try to assess the level of endophyte infected fescue present in pasture and hays fed to broodmares.

Research and Extension Education Activities to Be Conducted During the Project

I have discussed this with Dr. Jim Weber and have his support for the project. We will be using the services of either a temporary part time worker, work study student or an undergraduate for their senior project to survey veterinarians and travel to selected farms to take samples. They will also assist in reviewing the final results of the study and preparing educational materials for distribution to the public.

Phase 1:

Veterinarians with a significant equine practice will be surveyed to determine if they suspect endophyte infected fescue may be causing problems for their clients animals. Mare owners with suspected problems with endophyte infected fescue will be asked to participate in the second phase of the project. Mare owners can also volunteer to be part of the phase 2 of the project if they suspect problems with endophyte infected fescue. An attempt will be made to select farms from different areas of the state.

Time line: May – June, 2007

Phase 2:

This project will work with ten farms to test their forage (hay and pasture) for the presence and level of endophyte infected tall fescue. Staff will travel to selected farms to take samples of hay and pasture and samples will be sent to a university lab for endophyte testing. An attempt will be made to identify grasses in the samples as fescue or non-

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[1] Freeman, D.; P. Pratt; R. Woods Jr.; Fescue Toxicity and Horses, Oklahoma Cooperative Extension Service Currant Report, CR – 3917; July 2002.

[2] Ball, D.; G. Lacefield; & C. Hoveland; The Fescue Endophyte Story, http://www.caf.wvu.edu~forage/fescue_endophyte/story.htm; accessed 10/24/06

fescue. A history of the breeding farm with attention to productivity of mares, loss of foals, foaling difficulties within the past two years will be recorded.

Time line: July – September, 2007

Expected outcomes and the method for sharing the outcomes of the project

Analyze results and prepare recommendations for broodmare owners in the state with regard to the suspected incidence of endophyte infected fescue in Maine will be shared through Extension educational meetings, newsletters and newspaper columns in equine related publications. Also, information will be posted on the University of Maine Cooperative Extension Equine Web site and the new HorseQuest national eXtension web site.

Proof of industry support for the project

Two broodmare owners have volunteered for this project before funding was secured. A large animal veterinarian has stated the need for this type of investigative study.

Termination Report

Progress/Summary Report: Spring and summer of 2007 I was unable to get a student worker to implement the data collection part of the project. Also, follow up discussions with colleagues have lead me to consider altering the project to test only hay samples since mares are primarily on a hay diet in the last three months of gestation when the affects of endophyte infested fescue might impact their pregnancy status.

Balance of Amount Awarded: $2,000

Action Recommended by PI: I recommend that this project be continued for another year so the prevalence of this organism in Maine forages can be determined.

Justification: A fall 2007 research project has connected me with four potential work study students who are interested in assisting with this project.

MAC88: Antioxidants in Potatoes: Does Variety Influence Levels and Does Information Influence Decision to Buy

Principal Investigators: John M. Jemison, Jr. and Mary Ellen Camire

Introduction

In 2005, the Potato Team initiated a project to study public receptivity to alternative potato varieties. We selected and grew 15 varieties (each with specific characteristics e.g. skin color or flesh color) over two growing seasons and evaluated yield and incidence of disease. We also used these potatoes in displays where we asked clients to tell us which potatoes were their favorite varieties among the various colored potatoes and why. We also asked the participants to tell us how often they ate fresh potatoes, what was important to them in their potato purchase decision, their favorite preparation method, and their impression on the healthiness of potatoes as a vegetable crop.

We have summarized this work, and it will be submitted to the American Journal of Potato Research shortly. As commonly happens with research, new questions were raised by the study. Most respondents (96%) said they thought that potatoes were a healthy crop, but a third stated that they would eat more potatoes if they thought they were a healthier product. This seems like a contradiction, but we felt that this was a direct effect of both the low-carb diet craze and a lack of understanding about the nutritional aspects of potatoes. Most people simply view potatoes as a starch, but they are also an excellent source of fiber, vitamin C, and some varieties of potatoes have been shown to have antioxidants which have positive health benefits. It is not well understood how varieties vary in their levels of these chemicals, or if this type of information would affect consumer purchase decisions.

We are requesting funding from the Maine Ag Center to continue working with alternative potato varieties. Specifically, we would like to study the effect of variety, skin color and flesh color on yield, disease resistance, and nutritional quality (fiber, vitamin C, and total antioxidant levels). We found Carolla and NY126 to be very popular varieties in our previous project. We would like to compare these two white skin/yellow flesh varieties to two white skin/white flesh varieties for nutritional characteristics. Further, we found consumers had a great deal of interest in a red skin/yellow fleshed variety called AF2393. We want to test nutritional content of this variety compared to Dark Red Norland a standard red skin/white flesh and to a red skin/red fleshed potato. Finally, we also found interest in the three purple varieties we evaluated in 2005 and 2006. If the nutritional levels of antioxidants are significantly higher with blue potatoes compared to other potatoes or as high as fruits recognized as having high concentrations of antioxidants like blueberries, consumer interest in these varieties will be even higher.

We propose to grow 16 potato varieties at the Rogers Farm in the summer of 2007. Four will be white potatoes designed for the soups, salads, and mashed potato market, six will be red skinned varieties, and the final six will be purple skinned varieties. We hypothesize that colored fleshed potatoes will be healthier to eat, and that this information would affect product choice. We also hope that this will increase consumption of Maine-grown potatoes.

Goals and Objectives

1. Goal 1. Determine the yield, incidence of disease, and the nutritional quality of at least 16 potato varieties.
    - Objective 1a. Harvest 10 feet of two rows of corn, grade and weigh, and subsample for nutritional analysis.
    - Objective 1b. Analyze samples for fiber, vitamin C, and antioxidant levels.
    - Objective 1c. Determine if there are significant differences in nutritional content among potato varieties. We wish to specifically assess whether white skin/yellow flesh potatoes are healthier than white skin/white flesh potatoes. Similarly, are colored fleshed reds and purples healthier than white fleshed potatoes.
3. Goal 2. Test the hypothesis that nutritional knowledge affects consumer choice.
    - Objective 2a. We will set up displays at a minimum of two events to evaluate consumer interest in these potatoes.

- Objective 2b. Two tables with eight potato varieties per table will be displayed. We will have participants evaluate which potato they like with no information on potato quality. Then, participants will see the same potatoes again, this time with information on the nutritional qualities. We will see if preferences change with additional information.

4. Goal 3. Share the results of this agricultural project with Extension nutrition staff.
   - Objective 3a. A minimum of two presentations on results of this project will be given at a Maine Extension nutrition program functions.
   - Objective 3b. Work with Dr. Camire to prepare a fact sheet on the nutritional qualities of diverse potato varieties.
   - Objective 3c. Summarize results for a journal article.

Termination Report

Introduction:

Interest in locally grown, healthy foods is growing in the US. With obesity rates climbing and climate change issues moving to the forefront in Maine and New England, the opportunity is ripe to make some in-roads and introduce new products that may capture the attention of Maine consumers. In 2007, we received Maine Ag Center funding to conduct trials to look at the yield and quality of niche market potato lines to determine which varieties yielded well, have higher levels of healthy antioxidants, and to then explore which potato lines to continue evaluations.

1. Goal 1. Determine the yield, incidence of disease, and the nutritional quality of at least 16 potato varieties.

Our first goal was to determine the yield, incidence of disease, and quality of at least 16 potato varieties. These are presented below:

Varieties	Yield (cwt/ac)	Scab / Rhizoctonia	Failing Grade	Further consideration	Reasons
Kennebec	193	12 9	100	***	Traditional variety
Katadin	180	5 2	30		
NY126	192	1.6 0	5		
Carola	225	1.4 0	5	***	Exceptional
Rose Gold	184	1.3 0	0	***	Interesting
DR Norland	195	4.8 1	30	***	Traditional
Aroostook Red	200	1.8 0	15	***	Yield
AF 2393-7	102	1.5 0.2	50		
Peter Wilcox	131	0 0	0	***	Color
Caribe	189	1.0 0.8	0	***	Skin color
Skagit Valley Gold	110	0 0	0		
Beet Reds	118	0.3 0	0		
Purple Majesty	261	0.3 0	55	***	Yield color
All Red	275	0.4 0	0	***	Yield quality
Red Cloud	256	0.5 0	0		
Huckleberry	185	0.2 0	0		
Purple Peruvians	112	0.1 0	50	***	Depth/intensity of color
All blues	122	1.3 0	50		

Secondly, we took several of these major varieties and conducted nutritional analysis of these. We looked at the potato skin, flesh and whole and tried to determine if there were differences in these components. We evaluated antioxidant content, phenolics, and anthocyanin content. Antioxidants have been shown to prevent cancer; anthocyanins are a specific antioxidant. Phenolics have been shown to slow cell oxidation.

Chemical composition

Purple Peruvian potatoes had the highest anthocyanin and phenolics content of all cultivars analyzed. Red- and purple-fleshed cultivars had greater anthocyanin levels than did the other types, but the pigments were localized in the skin for all colored types. Trends for phenolic composition differed from those for anthocyanins. The flesh of Aroostook Red (red skin/red flesh), Huckleberry (red skin, purple flesh), B1952-2 (purple skin, white flesh) and Purple Majesty (purple skin/purple flesh) had the highest values. Antioxidant activity was highest in the flesh and skin of the purple-skinned, purple-fleshed cultivars (Table 3).

5. Goal 2. Test the hypothesis that nutritional knowledge affects consumer choice.

Consumer attitudes

Two hundred and six surveys were administered at three locations - the Orono Town Days (September), Maine Fare in Camden (September 15-16) and Cumberland County Fair (September 29). Two tables were set up. At the first table cut and uncut samples of each potato were presented with three-digit codes. Order of evaluation was randomized in 6-person blocks. Subjects then moved to the second table and evaluated samples marked with different codes. The questionnaires on the second table noted the antioxidant content of the potatoes. We did not find that the antioxidant content greatly affected consumer decision-making.

Sensory evaluation

Selected cultivars were cooked and presented to 50 volunteers at the University of Maine Consumer Testing Center. A nine-point hedonic scale (1= dislike extremely, 5 = neither like nor dislike, 9= like extremely) was used to assess acceptability of overall quality, appearance, flavor and texture. Caribe, a cultivar with bright purple skin and white flesh, received the highest scores (Table 8) but was not different from Carola, a yellow-fleshed potato, and Huckleberry (red skin, light red flesh). Purple Peruvian a purple-skinned, purple-fleshed cultivar, had the lowest scores. Some people commented that it was bitter.

6. Goal 3. Share the results of this agricultural project with Extension nutrition staff.

This goal was met. Results were presented at the Ag Trades Show to vegetable growers, and it was summarized and shared with Extension nutrition staff.

Finally, this work has led to another project where we are specifically looking at red varieties and we are continuing to try to find red varieties for the fresh market that hold their color and have excellent nutritional qualities.

Papers, Reports, and Presentations:

- Jemison, J.M., Jr. and M.E. Camire. 2008. Does antioxidant content affect consumer decision-making with fresh market potatoes. Northeast Branch Crops, Soils, and Agronomy Conference – McGill University, Montreal Canada

We intend to prepare a paper on this work this winter for publication.

Figure 1. Purple Majesty Potatoes

MAC89: Evaluating Corn Silage Hybrids

Principal Investigators: Richard Kersbergen, Caragh Fitzgerald

Proposal Summary

Corn silage is a major row crop for dairy farms in Maine. According to NASS (National Ag Statistics Survey) Maine farmers planted nearly 25,000 acres of corn for silage in 2005 and harvested 440,000 tons of feed for their dairy cows. We propose to initiate variety trials with industry support to provide Maine farmers with local data to choose profitable and reliable hybrids that perform in our unique climate. To conduct these trials, we are requesting funds to purchase truck scales for measuring yields, climate collection tools and funds for forage analysis to evaluate nutritional components of the feed.

Background

Maine dairy farmers have relied on corn silage as a major portion of their cropping system for many years. Corn as a forage provides a high yield of total digestible nutrients per acre. Cows that consume corn silage as part of their diet tend to be less dependent on energy from corn grain grown in other parts of the country and transported to New England.

Most of the data concerning varieties most suitable for silage comes from extrapolating breeding programs focused on strictly corn grain production, not the whole plant as harvested for silage. While there has been more focus on silage breeding in recent years, most of the variety trials are done in much warmer climates and longer growing degree days.

Recent changes in breeding have also led to the development of Brown Mid Rib (BMR) corn silage varieties. These plants are highly digestible and provide additional fermentable energy to the cows that consume them. Data and experience with planting these varieties of corn in Maine is not available. Seed costs for these BMR corns are nearly double conventional seed corn prices, so producers are wary of trying them without good data.

Maine Farm Days is an annual event that takes place in August on a dairy farm in central Maine. This event draws hundreds of dairy farmers as well as thousands of others interested in farming in Maine. Each year the crops committee plants selections of corn seed from each of the major corn seed dealers in the state for farmers to look at in August. While these trials provide some visual appraisal for farmers to evaluate hybrids, yield and quality information is not available. The trials are not replicated and yields are not measured when the corn is harvested in September.

Proposal

The Crops committee of Maine Farm Days approached me about managing the variety demonstration at Misty Meadows Farm, home to this years' event. I have encouraged them to make the trials more meaningful by including replications, monitoring growth and measuring yield and quality. When this information is published, producers can make informed decisions when ordering seed for the following season.

The committee has already responded favorably, and each seed company has donated at least four varieties of seed, including some BMR and organic varieties. Planning is underway with John Stoughton of Misty Meadows farm (Kennebec County) to plant these in a replicated trial on a field near the Farm Days site.

In order for us to gather yield and quality data, we are requesting funds from the Maine Agriculture Center to purchase truck scales to measure yield in September when John begins his harvest. Truck scales will facilitate collection of data from replicated plots. Each plot can be harvested and the trucks weighed with little disruption to the process of harvesting the crop.

We are also requesting funds to collect weather data and to analyze the forage for nutritional qualities. These samples will be taken at harvest and mailed to the Dairy One lab in Ithaca NY for analysis. It is anticipated that after the first year of the trial, that industry support will provide the funding for forage analysis in future years.

Data from the project will be used to produce a summary that will be mailed to all dairy farms in the state and also be posted on the Extension livestock website. Presentations will be made at Farm Days, Maine Dairy Seminar, Certified Crop Advisors training sessions and dairy forage conferences held in the spring and fall of each year.

The truck scales purchased in this proposal would also facilitate data collection in other trials, both at the University Rogers Farm, Witter Farm and in trials with farmer/researchers. ("Expanding Grain Production and Use on Organic Dairy Farms in Maine and Vermont," 2006, USDA/SARE Research and Education Grant, R. Kersbergen, T. Griffin, H. Darby, S. Bosworth, $143,626; "Reducing Off-farm Grain Inputs on Northeast Organic Dairy Farms,"2005 USDA/CSREES Integrated Organic Program, $827,058).

Please note: Interest has been indicated by the Witter Farm to conduct a similar trial on the University Farm. There will be sufficient seed from the dealers to replicate this trial on the Witter farm and provide additional data for publication.

Peter Sexton recently received funding from the Maine Potato Board to evaluate short season corn hybrids for production in Aroostook County. We are working with Peter to include some of these short season hybrids on our trials as well.

If necessary, we would be able to conduct the yield measurements with two scales, although this will considerably slow down harvest. If this were chosen as the funding option, our MAC request would be $3,820.

Termination Report

Objectives:

1. Organize a corn silage variety trial in association with Maine corn seed dealers and Maine Farm Days

In April and May of 2007, we worked with Maine Farm days and representatives of several corn seed varieties to organize a replicated trial to evaluate corn silage varieties. Previously, this trial was a demonstration only. We hoped to provide a trial that would yield statistical data for farmers to make more educated decisions when purchasing corn seed for 2008 and beyond.

7. Plant and analyze data from variety trials.

Plots were planted at Misty Meadows Farm in Clinton on May 16th, 2007, using a six row corn planter. The experiment was harvested on September 21st. The predominant soil types were Woodbridge fine sandy loam and Monarda silt loam. Three replications of 33 varieties were planted in a randomized block design with plots being either 150 ft long (one block) or 300 feet long (two blocks). Selections of hybrids were from donations by seed companies and included relative maturity days from 60 to 115. Statistical analysis was only done on dry matter yields.

We targeted a planting density of 32,000 plants/acre. Growing degree days were recorded and resulted in 2086 GGD 50 base.

Weed control was fair with a pre-emergence herbicide program used for the entire research plot.

Harvest was done using a 6 row corn chopper with each plot loaded into a mixer wagon and weighed. Grab samples were taken for moisture and quality data. Forage samples were immediately sent to Dairy One forage lab for analysis, including digestibility.

8. Establish a self supporting mechanism for continuation of variety trial research.

The research of 2007 led to another trial in 2008 at Misty Meadows farm. Seed dealers who entered varieties in 2008 paid $50 per variety for inclusion in the trial. The number of varieties in 2008 increased to 44.

9. Research information dissemination.

The results of the trials in 2007 were published on-line and sent to the Maine Agriculture Experiment Station.

Researchers presented data to producers and other farm advisors at the following conferences:

- Jan 2008 Certified Crop Advisers in-service training, New Castle, NH
- Jan 2008 Maine Agricultural Trades Show, Augusta, ME
- March 2008 Blue Seal Annual Winter meetings, Augusta, ME
- August 2008 Maine Farm Days, Clinton, Me

Additionally, corn variety data from Maine, Vermont and NH is being collected to provide growers throughout the Northeast with resources to make better corn silage choices.

Research Conclusions

2007 was an excellent year for silage corn production in Maine with adequate rainfall and good heat units (>2000GDD).

Yield differences between maturity groups were slight as seen in Table 5.

	Ave. D.M. Yield	Ave. D.M.	Ave. % NDF	Ave. % NFC	Ave. N_eL Mcals/lb	Ave.% IVTD 30 hr
Short	6.65	28.1	41.1	39.5	.75	80.55
Mid	6.88	26.9	43.9	38.9	.74	80.3
Late	7.39	24.9	45.7	37.0	.74	80.4

Other notable trends were the higher moisture content of hybrids with increasing relative maturity. Very few hybrids fell into the suggested dry matter range for good fermentation (30-34% D.M.) when harvested on September 21. Since most farms in the area had started corn silage harvest, we followed typical management practices when we harvested all our plots. None of the corn harvested in the trials was hit by a killing frost. Producers may want to consider choosing hybrids based on the hybrid's ability to dry earlier in the season. There was a general trend for increasing fiber and reduced energy content with increased relative maturity. It should be noted that all hybrids were harvested on the same day despite their maturity.

Non-technical Summary

Researchers from Cooperative Extension and seed corn dealers from throughout the Northeast joined together at Maine Farm Days in Clinton Maine to establish variety trials to test corn hybrid performance in replicated trials. In 2007 33 varieties were tested for yield and quality for dairy feed performance. Researchers noted slight increases in yield with later maturing varieties Other notable trends were the higher moisture content of hybrids with increasing relative maturity. Very few hybrids fell into the suggested dry matter range for good fermentation (30-34% D.M.) when harvested on September 21. Since most farms in the area had started corn silage harvest, we followed typical management practices when we harvested all our plots. None of the corn harvested in the trials was hit by a killing frost. Producers may want to consider choosing hybrids based on the hybrid's ability to dry earlier in the season. There was a general trend for increasing fiber and reduced energy content with increased relative maturity. Researchers and dealers have 44 varieties currently in trial at Misty Meadows Farm in Clinton.

MAC90: A Four-Season Cropping System with Corn

Principal Investigators: John M. Jemison, Jr., Richard Kersbergen, and Caragh Fitzgerald

Introduction

The forage production systems familiar to most Maine dairy farmers (continuous corn for energy and hay for protein and fiber) do not work well for organic dairy. To meet the organic standards, producers must rotate fields and use intensive cultivation to control weeds. The intense weed pressure most organic producers face has pushed organic producers to explore other forage options. Over the past several years, we have evaluated a small grain and brown midrib sorghum sudan grass (BMRSS) double crop system. Through the use of these systems, growers avoid having tilled bare soil during the peak time of annual grass and broadleaf weed emergence. Further, the ground is covered for four seasons which is beneficial to water quality. We found the weed pressure in these alternative systems with no cultivation was about four times lower than corn cultivated four times (at a cost of at least $32/acre). The issue with the double crop system is low forage energy. While we can produce statistically equivalent tonnage, the lack of energy in the diet may limit milk production.

We request funding to evaluate a cropping system that provides many of the same production benefits of the small grain/BMRSS double crop system, but will hopefully yield more energy for the ration. We have found triticale to be the most consistently winter-hardy small grain over the two winters that we have evaluated small grains. Winter wheat was intermediate; it performed well in the first year, but suffered moderately damaged last winter. Winter barley, while it had the best forage quality, was completely killed in 2005/2006 and the stand was damaged badly in 2004/2005. We have a trial with these crops and spelt (an old wheat variety with useful physical characteristics) planted at Rogers Farm this year. If triticale and wheat outperform the other small grains, we would select these two to try in our four-season cropping system study.

The winter small grain protects the soil from erosion and provides a high quality high protein forage if harvested early, or a higher energy forage harvested at the soft dough stage of development. By planting in narrow rows in the fall, the crop reaches canopy closure and spring weeds are shaded out. If we follow the small grain with an extremely short-season corn, we will have missed the first flush of weed growth. Corn planted in May often has a stretch of cold wet weather where the soil is too wet to cultivate, the temperature is too cold for the corn to grow well, but doesn't limit weed growth. Thus, the weeds get a significant jump on the corn. By planting our corn in later June or early July, the soil will be very warm, the seed will germinate and grow through the early growth stages of corn, and we hope we'll be able to document a reduced need for intensive cultivation.

While some dairy producers have experience with late June and early July planted corn, the results have not been particularly good because they have used normal maturity hybrids. With new short maturity (65-70 day varieties) coming out of the Tilth Lab's (Iowa) breeding program, this opens up the possibility of a double crop production system that may have a higher energy feed than BMRSS. But, we need experience with this before we try to move this onto organic dairy farms in the state. We lack: 1) information on the yield and forage quality of late planted corn; 2) whether to recommend harvesting the small grains at boot stage or soft dough stage to maximize yield and energy of these systems; and 3) how much weed pressure is reduced by missing the first flush of weed growth;. We propose to conduct three trials to be able to provide organic dairy producers with better information on forage systems.

Goals and Objectives

2. Goal 1. Determine the yield of a four season cropping system that includes corn.
    - Objective 1a. Conduct a trial at the Rogers Farm to determine yield of three winter small grains (triticale, winter wheat, and winter spelt) harvested at boot stage or soft dough stage of development followed immediately by two varieties of short season corn.
    - Objective 1b. Compare this cropping system to a standard mid to late May planted silage corn.
    - Objective 1c. Two on-farm trials will be conducted to give us three site-year comparisons of these systems. Two small grains (harvested at boot and soft dough stage) and two corn varieties will be grown and compared to the grower's standard silage corn.

3. Goal 2. Determine the forage quality of these systems
    - Objective 2a. Forage quality samples will be collected for each harvest for all treatments of the study, and these will be submitted to DairyOne for analysis. As was done in the previous projects, we will principally determine protein and energy content and yield for each treatment to see if the addition of corn to the four-season cropping system will improve overall forage quality.
4. Goal 3. Assess the potential for a four-season cropping system to have a lower weed density than a standard mid/late May planted field corn.
    - Objective 3a. We will compare weed populations and density of the standard late May planted corn to the alternative four season cropping system.
    - Objective 3b. Weeds from 0.5 m^2 plots will be quantified, harvested, dried and weighed.

Termination Report

Traditional corn/hay forage production systems familiar to most Maine dairy farmers do not work well for organic dairy producers. To meet the organic standards, producers must rotate fields and use intensive cultivation to control weeds. The intense weed pressure facing most organic producers has pushed organic producers to explore other forage options. Over the past several years, we have evaluated a small grain and brown midrib sorghum sudan grass (BMRSS) double crop system. While the double crop system produced well, the issue with that system was low forage energy. While we can produce statistically equivalent tonnage, the lack of energy would reduce this forage system value.

We requested funding to evaluate a cropping system that provides many of the same production benefits of the small grain/BMRSS double crop system, but will hopefully yield more energy for the ration. We replaced the BMRSS with field corn, and we intensified the cultivation in the study compared to BMRSS.

Project Goals:

1. Determine the yield of a four season cropping system that includes corn.

We conducted our trial at the Rogers Farm in Orono. The 2008 season was environmentally challenging. It had somewhat of an impact on our yield results. But, what we found was interesting. The winter grain/short season corn double crop yielded on average almost 2 tons of dry matter more than the full season corn. We averaged about 12.5 tons dry matter compared to 9 for the full season corn. It yielded about two tons more than the best winter grain/sorghum sudan grass double crop in our previous work.

2. Determine the forage quality of these systems:

Our most important challenge with this trial was to see if we could increase the energy content of the double crop forages. In our previous work, we found that our double crop energy content was half that of silage corn. We found similar protein, TDN, levels as we had in our previous studies; ADF and NDF values were actually slightly higher, likely because the short season corn was more fibrous, but the NFC (measure of forage energy) averaged between 27 and 31% whereas the previous double crop averaged between 21 and 25% NFC. On a warmer year when the corn portion of this crop should reach a greater level of development, one would imagine the energy values to increase and the fiber levels to decrease.

3. Assess the potential for a four-season cropping system to have a lower weed density than a standard mid/late May planted field corn.

In our previous study, the weed biomass averaged between 1.7 and 3.6% of total crop yield. In this work, we evaluated weed by class (broadleaf, annual grass, sedge, and total weed biomass. In the 2008 season, the cultivation conditions were ideal. We were able to reduce the average full season corn weed biomass to 1.7% of total yield. This was much lower than the 11.7% that we found with the four-year average full season corn in the previous work. Our weed biomass in the double crop ranged from 1.3% in the spelt/corn double crop to 2.7% in the winter barley/corn

double crop. The winter barley weed biomass always seems higher due to the smaller size, smaller leaf, and increased winter kill common with winter barley.

Figure 1. Winter small grain component of the study.

Figure 2. Early planted corn following barley harvest.

Project Abstract

In the summer of 2008, research was conducted to evaluate a four-season cropping system that we hypothesized would provide organic dairy producers with a high-yielding, higher energy content forage than the previous double crop system evaluated from 2004 through 2007. We wanted to know yield from the winter grain/short season corn double crop, the forage quality, and the weed pressure to expect from this system. Despite challenging growing conditions, the best double crop system (winter wheat/corn) yielded about two tons more than the best winter grain/sorghum sudan grass double crop in our previous work. Under warmer and drier conditions, we might expect this yield difference to increase. We also found similar forage protein and TDN levels as we had in our previous studies, while ADF and NDF values were actually slightly higher, likely because the short season corn was more fibrous. The NFC (measure of forage energy) averaged between 27 and 31% whereas the previous double crop averaged between 21 and 25% NFC. Weed biomass levels were very low in the corn based double crop systems, indicative of good cultivation conditions. While more energy is required to cultivate the corn, the effectiveness was good. This system will be evaluated for two more years in Maine and Vermont due to new funding from the NE IPM program. Having had one year of this project funded was helpful in getting this project funded.

MAC91: Cover Crop Assessment for Vegetable Farms

Principle Investigator(s): Caragh Fitzgerald, Mark Hutchinson

Background:

Maine vegetable farmers are looking for new tools to assist in the management of weeds and other pests, improvement of soil quality, and supply of nitrogen. Most research in the Northeast has focused on traditional cover crops like hairy vetch, oats, and rye. Although some information about other cover crops is available (Sarrantonio, *Northeast Cover Crop Handbook*), many of these have not been evaluated locally, and there are also new cover crops available that appear to be able to provide additional benefits in the field. These include warm-season legumes for nitrogen supply and brassicas, which have the potential to reduce the incidence and severity of soil-borne pathogens for subsequent crops. Australian field trial studies on green manure crops by have shown that biofumigant green manure crops could increase marketable yields of subsequent lettuce crops by reducing tipburn, bacterial rot, and *Sclerotinia* disease. The benefits appear to depend on local soil conditions and the type of crop used (Horticulture Biofumigant Update Nov. 2002).

Objectives:

The purpose of this trial is to evaluate 12 non-traditional cover crop species for their potential benefits to vegetable crop production and soil quality. This is a preliminary study to develop baseline data for possible external funding.

The project will be conducted during the 2007 growing season at Johnny's Selected Seed (Albion) and Highmoor Farm (Monmouth). Prior to planting, soil types will be recorded and initial soil quality parameters including compaction and porosity will be evaluated. Cover crop species will include six summer legumes, four brassica, and two grasses that growers have requested. Large (12' x150') farm-scale plots will be planted with a no-till drill into bare fallow ground. Since this is a screening trial, the plots will not be replicated at each site. Seeding rates will be appropriate for each variety based on recommendations in the *Northeast Cover Crop Handbook* or personal communication with researchers who have planted these varieties for other reasons. Varieties are divided into spring and summer cover crops. Expected planting dates are early May and mid June for the two different groups. The cost of cover crop establishment will be recorded. Field preparation and seeding will be arranged by the farm manager at each location.

Every three weeks, total biomass samples will hand-collected from one 4 ft^2 section. Total biomass includes both above ground and below ground plant material. Above ground samples will be hand clipped. Below ground samples will be dug to a depth of 1foot. All biomass samples will be dried. Measurements of weed growth will also be made at this time. Biomass samples will be analyzed for carbon and nitrogen content using standard laboratory methods at the Maine Soils Lab in Orono. The dried residue will be saved for decomposition and mineralization research in the winter of 2007-2008 in collaboration with Dr. Timothy Griffin of USDA-ARS. Soil quality parameters will be evaluated again at the end of the trial.

Information from these trials will be shared with farmers, University personnel, and other agriculture service providers at a field day at Highmoor Farm Field Day in July, Johnny's Selected Seeds in August, and at the Maine Vegetable and Fruit School in the Spring of 2008. The information will also be shared through newsletter articles and presentations at winter meetings.

Outcomes:

As a result of this project, vegetable farmers will be better able to choose among the new cover crops that are available for use on their farms. This will help them to meet their goals economic and environmental sustainability by improving soil health, increasing soil organic matter, and reducing weed populations.

Termination Report

Project objectives:

1. **Plant 12 non-traditional cover crop species**

In 2007, twelve cover crops were planted in 12' x150' farm-scale plots at two locations (Highmoor Research Farm in Monmouth and Johnny's Research Farm in Albion). An air seed planter was used to plant cover crops into bare fallow soil. Group 1 cover crops (oats (125 lb/acre), wheat (125 lb/acre), chickling vetch (60 lb/acre), oilseed radish (14 lb/acre), Ida Gold mustard (11 lb/acre), and Pacific Gold mustard (6 lb/acre)) were planted on May 10. Group 2 cover crops (cowpeas (cvs. Iron and Clay, 70 lb/acre), soybeans (cv. Viking 1832, 60 lb/acre), sudangrass (cv. Piper, 35 lb/acre), hairy vetch (35 lb/acre), crimson clover (25 lb/acre), and red clover (cv. Mammoth, 18 lb/acre)) were planted on June 13.

2. **Evaluate potential benefits of these cover crops to vegetable crop production and soil quality**
   a Measure soil compaction and porosity prior to planting and after cover crop growth.

Due to field conditions at planting, this was not conducted.

b Make visual estimates of percent ground cover for cover crops and weeds.

Approximately 3 weeks after planting, plots were evaluated for percent ground cover of cover crops and weeds. For group 1, percent ground cover of the cover crop on May 30 ranged from 4% to 28%, while that of weeds ranged from 4% to 15%. In all cases the cover crop provided greater ground cover than the weeds were, indicating that the cover crops were becoming better established. For group 2, the weeds grew faster and became established more quickly than the cover crops. On July 9, group 2 cover crops had achieved from 1 to 61% ground cover (most were less than 50%), while the weeds had achieved from 32 to 96% (most were greater than 50%). At Johnny's, cowpea, sudangrass, and crimson clover achieved greater ground cover than weeds. At Highmoor, no cover crops achieved greater ground cover than the weeds did.

c Collect samples of the weeds and cover crops to evaluate for total biomass and carbon to nitrogen ratio.

Cover crop and plant samples were collected from Group 1 plants on June 18, July 9, and July 30 (chickling vetch only). On June 16, average carbon to nitrogen ratio of the above-ground portion of the cover crops ranged from 11 to 21. On July 9, the range was from 11 to 45 (Ida Gold mustard and oats were both greater than 35). Chickling vetch was sampled again on July 30 and had a C:N ratio of 15. Ratios lower than 30:1 are considered necessary to prevent the immobilization of soil nitrogen during the decay of plant residue.

By July 30, when it was time to sample the group 2 cover crops, all cover crops in group 2 showed more than 50% ground cover provided by weeds. This level of weed pressure is unacceptable for farmers. The weeds would have been plowed under before that time. Since the plots did not provide conditions similar to those found on a commercial farm, these cover crops were not sampled.

The failure of group 2 cover crops appeared to be caused by improper seeding conditions that led to a reduced stand and by very high weed pressure at both sites.

Group 1 cover crops produced the following amounts of biomass (lbs/acre, dry weight) (June 18, July 9): chickling vetch (120, 1139), Ida Gold mustard (1079, 1679), oats (720, 2399), oilseed radish (1079, 2279), Pacific Gold mustard (1139, 1139), and wheat (780, 1559).

d Develop baseline data for possible external funding.

Due to the failure of group 2 cover crops, additional work will need to be conducted prior to seeking external funding.

Research information dissemination

Observations from the experiment were shared at the New England Vegetable and Fruit Conference in December, 2007 ("Cover Crops: What is Their Relationship to Soil Health?") and at the Maine Association of County Agricultural Agents' tour of Johnny's Selected Seeds in August, 2007. Plant analysis information was not received until mid-March, 2007, which was at the end of the winter meeting season. A report from this work will be shared with farmers during the winter of 2008/2009.

Non-technical summary

Twelve spring- or summer-planted cover crops were tested at two locations in central Maine. Oats, wheat, chickling vetch, oilseed radish, Ida Gold mustard, and Pacific Gold mustard (group 1) were planted on May 10. Cowpeas, soybeans, sudangrass, hairy vetch, crimson clover, and red clover (group 2) were planted on June 13. On June 18, group 1 cover crops all showed carbon to nitrogen (C:N) ratios of less then 35, indicating that they would not cause immobilization of nitrogen during their decay. On July 9, Ida gold mustard and oats had C:N ratios higher than 35, but the remaining crops did not. Total biomass produced ranged from 120 to 1139 lbs/acre on June 18 and from 1139 to 2399 on July 9. Group 2 cover crops were not sampled due to unsuccessful seeding and growth.

MAC92: Establishing Normal Levels of Uterine Inflammation in Healthy Mares: A Collaborative Project Integrating Equine Reproductive Research, Veterinary Medical Education, and Recruitment of New Veterinarians to Maine

Principle Investigator(s): Robert C. Causey

Background:

Uterine infections in cycling mares have challenged veterinary clinicians and researchers for many years (Dimock and Edwards, 1928; Traub-Dargatz, et al., 1991). The cost of infertility to Maine's horse producers has increased with the recent growth of Maine's equine industry. Most of this infertility is caused by uterine infections. Mucus has been identified as a potential component of uterine defenses against infection (Dimock and Edwards, 1928; Causey, et al., 2000). Understanding endometrial inflammation, mucus function and dysfunction appear increasingly important in equine reproductive practice (LeBlanc, personal communication; Causey, et al., 2006).

Maine is also plagued by a shortage of large animals veterinarians, and of veterinarians who are comfortable with equine reproductive practice. Obtaining proficiency in the techniques of equine reproduction is time-consuming and dificult. Horses are valuable, and potentially dangerous, domestic animals, and equine reproductive techniques need to be conducted with care to protect both horse and veterinarian. Because of cost and safety, several veterinary colleges provide limited opportunities teaching equine reproductive techniques, and veterinarians often graduate lacking proficiency. The University of Maine has the facilities and expertise to provide such training safely.

Research Description:

The procedures are listed for each objective as follows:

1. Perform endometrial culture, cytology and biopsy of mares in the UMaine horse herd during the follicular and luteal phases of the estrous cycle.

During the 2007 breeding season (summer) reproductively sound mares in the UMaine Standardbred herd will be monitored by trans-rectal palpation and ultrasonography to detect when the mare is in the follicular phase (estrus) and the luteal phase (diestrus). Uterine culture, cytology and biopsy, will be performed on each mare during estrus and diestrus. In addition, uterine biopsy will be performed by introduction of a sterile uterine forceps into the uterus, followed by trans-rectal palpation to localize the forceps during tissue sampling. The tissue sample will then be submitted for histopathologic examination. Results from culture, cytology and biopsy will be compared to clinical specimens collected by Dr Michelle LeBlanc, a collaborator in a reproductive practice in Lexington Kentucky. Assessments will be made of the presence and numbers of bacteria (culture), inammation (cytology and biopsy) and mucus production (cytology and biopsy).

2. Train four veterinary students in the above techniques.

The samples will be collected by veterinary students under close supervision of the PI during the summer of 2007 over approximately a three month period. This will allow two pairs of students to attend for the period of a single clinical rotation (4-6 weeks). The PI will be present at all times, and ready to provide instruction and assistance as necessary. No procedures will take place in the PI's absence. Students may receive additional didactic training as they request. The goal will be for students to obtain proficiency in transrectal palpation, ultrasound, uterine culture, cytology and biopsy through repetition. Students will also participate in laboratory analysis of the samples, to the extent that they might be expected to as practitioners. Students may also participate in ongoing breeding activities at the farm. To facilitate recruitment, funding is requested to house students on campus.

3. Introduce these four veterinary students to local equine practitioners.

Work with mares will take place on a Monday, Wednesday and Friday schedule. Samples will not necessarily be taken every day. It is therefore anticipated that students will have time available to spend with local equine practitioners.

The PI will introduce students to practitioners, who may make use of the opportunity to recruit these students to their practices following graduation. Introductions may be performed in a small reception on campus for practitioners and students. Maine's equine practitioners are generally receptive to having veterinary students accompany them on farm-calls.

Projected Outcomes:

- Hiring by local practices of some of the visiting veterinary students. Presentation of findings at scientific meeting
- Publication in peer reviewed journal.

Objectives Met:

1. Perform endometrial culture, cytology and biopsy of mares during the follicular and luteal phases of the estrous cycle.

Comparison of endometrial biopsy and culture results from different horse herds has been completed. The major significant finding of the study is that chronic uterine infection or persistent inflammation in the mare is associated with hypersecretion of mucus and disruption of the architecture of the endometrial epithelium. These data are the basis of an abstract to be presented at the December 2008 American Association of Equine Practitioners Symposium in San Diego.

2. Train up to four veterinary students in the above techniques.

Dr Kristin Williams, a senior veterinary student at Tufts University, visited UMaine and received instruction in mare palpation as part of this project. She was trained in all the above techniques except uterine biopsy. She also was exposed to stallion collection, performed artificial insemination, and received didactic reviews of equine Theriogenology from the principal investigator.

3. Introduce these veterinary students to local equine practitioners to recruit them to practice in Maine.

Dr Williams was introduced to Dr Dennis Ruksznis as part of this project. As a result of this introduction she and her partner, Dr David Hernke, also a Tufts Graduate, were both offered and accepted positions at Foxcroft Veterinary Services where they are currently practicing Large Animal Veterinary Medicine.

Methods Used to Evaluate Outcomes:

Outcomes include numbers of successful placement of students in local veterinary practices (2), presentation of research findings at scientific meetings (1), and publication of a peer-reviewed article (manuscript in preparation), and press releases (1).

Integration of Research and Extension Activities:

The project involved successful recruitment of veterinary students to a local veterinary practice, while performing scientific research of value to Maine’s horse industry.

Outputs:

Causey RC, Miletello T, ODonnell L, Lyle SK, Paccamonti DL, Anderson KJ, Eilts BE, Morse S, LeBlanc MM. (2008). Pathologic Effects of Clinical Uterine Inflammation on the Equine Endometrial Mucosa. Proceedings of the American Association of Equine Practitioners. Abstract -- in press

MAC93: Assessment of the Research Needs of Maine's Current and Potential Organic Ornamental Bedding Plant Producers

Investigators: Stephanie Burnett and Lois Berg Stack

Background of Issue Addressed and Project Objectives:

Organic agriculture is a rapidly growing sector in agriculture (Nelson et al., 2004). Consumers choose organic food because it assumed to be healthier, but also because organics are considered better for the environment (Nelson et al., 2004). Maine has two hundred and eighty-eight certified organic farms, the tenth highest number of organic farms in the United States (USDA-ERS, 2006). This indicates that Maine has a thriving organic market. Nearly all of these farms are food producers, but it is likely that consumers in Maine and throughout the United States would be interested in organic bedding plants too, since organic production is perceived to be better for the environment. And, on a national level, some large ornamental greenhouse growers are beginning to integrate organic production into their facilities in anticipation of increased consumer interest in organically grown ornamental plants.

Despite indications that consumer interest in organically grown ornamental plants may increase, most, if not all, research projects involving organic growing methods focus on food crops. Organic bedding plants may be a new, profitable niche for growers in Maine. For this reason, research into growing bedding plants organically seems appropriate. We are interested in developing long-term projects that will fill whatever research gap may exist. Our first step is to determine the breadth and scope of research problems that organic bedding plant growers would face through a survey of Maine's organic and conventional growers.

Therefore, the objectives of our project are:

1. To survey the research needs of the organic industry in Maine;
2. To use this information to develop research protocols for organic bedding plant growers in Maine; and
3. To use this information in support of larger, regional research grant proposals.

Research Methodology:

In 2007, we will survey (1) greenhouse growers who are certified organic by the Maine Organic Farmers and Gardeners Association (MOFGA) and (2) conventional bedding plant growers in Maine. The survey will first attempt to quantify the size of the existing organic bedding plant production industry in Maine by determining how many growers are currently growing bedding plants organically. Organic growers will be asked to identify researchable problems they have encountered in production of ornamental bedding plants. Conventional bedding plant growers will be asked questions such as 'Have you considered converting a portion of your production to organics?' and 'What are the barriers to converting your production to organic methods?' Both groups will be asked to rank the largest problems in organic production numerically from a provided list. In the future, we will also attempt to develop an on-line survey that growers outside of Maine may access. We hope to solicit participants on a national level through commercial greenhouse trade magazines.

References:

Nelson, L., J. Giles, C. Macilwain, and V. Gewin. 2004. Organic FAQs. Nature 428:796-798.

USDA-ERS. 2006. Data sets: organic production. 26 March 2007. http://www.ers.usda.gov/Data/Organic/ .

Expected Outcomes and Methods for Sharing the Outcomes:

Specific research outcomes are:

1. We will estimate the size of the existing organic bedding plant industry in Maine.
2. We will develop a prioritized list of research needs for the current and potential organic bedding plant industry members.

3. We will compile this information for use in developing future regional grants to help address those research needs.

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

1. Results will be presented to the Maine Florists' and Growers' Association at their annual greenhouse grower meeting in January 2008.
2. We will share results with the public and MOFGA members at MOFGA's November 2008 Farmer-to-Farmer Conference.
3. The results will published in a refereed journal such as HortTechnology.
4. We will host a field day entitled 'Improving the Sustainability of Greenhouse Production in Maine' to share the results of this survey with approximately 300 greenhouse growers. Other potential topics include efficient heating systems, sustainable irrigation and fertilization systems, water quality, and high tunnel cut flower production.

Industry Support for Project:

Eric Sideman, Director of Technical Services, MOFGA, provided feedback for our survey and has sent a letter of support for the project to MAC.

A certified organic greenhouse bedding plant grower, (Richard Rudolf, owner of Rippling Water/Backyard Organics, Standish ME) has sent a second letter of support to MAC.

Objectives Met:

1. To survey the research needs of the organic industry in Maine;
2. To use this information to develop research protocols for organic bedding plant growers in Maine; and
3. To use this information in support of larger, regional research grant proposals.

Methods Used to Evaluate Outcomes:

1. Forty-four organic bedding plant growers and one hundred and fifty-nine conventional bedding plant growers responded to a survey mailed to them in the summer of 2007. When asked to identify the greatest production challenges facing them, sixty-one percent of organic growers considered insect and disease management a significant production challenge while fifty-five percent of growers reported that managing organic fertility or the growing media was a challenge.

Conventional growers were asked to identify the greatest barrier to conversion to organic production. Twenty-one percent of conventional growers reported that fertilizing bedding plants organically would be too big of a challenge. Thirteen percent of conventional growers considered insect and disease management to be the greatest barrier to conversion to organic production.

2. A companion survey of home gardeners in Maine indicated that gardeners have an interest of 7.3 on a scale from 1 to 10 in organic ornamentals (where 1 is low interest and 10 is high interest). Gardeners are willing to an average of thirteen percent more for organically grown ornamental bedding plants than conventional bedding plants. Both conventional and organic bedding plant growers consider organic fertility and substrates to be a challenge of organic production. For this reason, future research will develop protocols for fertilizing bedding plants organically. Many organic growers provide fertility through additions of compost to substrates; these growers often report that fertility is rapidly depleted from compost in container production. This results in poor plant health and nutrient deficiencies. In container production, leaching is a significant cause of nutrient loss; over-irrigation and the low anion holding capacity of most substrates causes leaching. In 2008 we will determine how several locally available compost-based growing media affect bedding plant growth and quality. In 2009, two bedding plant species will be grown in the two best composts under different irrigation regimes to determine whether efficient irrigation reduces substrate nutrient loss.

3. We applied for a Northeast Region Sustainable Agriculture Research and Education (NE-SARE) grant in the spring of 2008 using the results from this project as preliminary supportive data. Our project was selected for submission of a full proposal in October, 2008.

The outcomes of our project were:

1. We determined the top researchable problems facing current and future organic bedding plant growers.
2. We determined that organic bedding plant production may be a new, profitable niche for Maine greenhouse growers since home gardeners are willing to pay more for organically grown than conventionally grown bedding plants.
3. To help current organic growers and conventional growers interested in transitioning to organic production, we plan to research organic fertilizers and compost based substrates to develop production protocols for providing organic fertility to container-grown plants.

Integration of Research and Extension Activities:

1. We presented the results of our survey and information on sustainable greenhouse production to over one hundred greenhouse growers and several University of Maine students at a workshop in Manchester, Maine. This workshop was funded, in part, by a NE-SARE Speaker Fund Grant.
2. Results were shared with growers throughout the United States in the e-newsletter GMPRO greEn-Mail.
3. We are collaborating with greenhouse growers interested in transitioning to organic production in our NE-SARE grant proposal.

Outputs:

Publications:

1. Burnett, S.E. and L.B. Stack. Survey of the organic bedding plant industry in Maine. Hort Technology (To be submitted Fall 2008).

Presentations:

1. Stack, L.B. Summary of survey the organic bedding plant industry in Maine. Sustainable Greenhouse Workshop, Manchester Maine.

MAC94: Strategies to Prevent Foodborne Outbreaks Associated with Maine Fresh Produce

Principal Investigators: Vivian Chi-Hua Wu, Beth Calder

Background and Justification:

Consumption of fresh salad vegetables and fruits has increased in quantity and variety in recent years. With an increase in consumption has come an increased frequency of outbreaks of illness associated with raw or minimally processed fruits and vegetables. The recent outbreak of *Escherichia coli* O157:H7 in spinach was one example. Hundreds of cases, including three deaths, have been reported to CDC. Spinach growers had a considerable economic loss due to this outbreak. Therefore, prevention of microbial contamination in order to produce safe products is essential for the Maine fresh produce industry and the Maine organic fresh produce industry.

Pathogenic bacterial contamination originates from irrigation or washes water, animal or municipal sewage-based fertilizers, infected workers, and food processing facilities with poor sanitation. However, there is a general lack of efficacy of sanitizers in controlling the contaminations. This can be partially attributed to difficulties in delivering aqueous chemical sanitizers to areas on the surface of produce in which pathogens may be lodged. Currently, most produce is washed with chlorinated water (50 to 200 ppm of active chlorine) to reduce levels of microorganisms, but this treatment is less effective and may produce harmful by-products such as chloramines and trihalomethanes.

Chlorine dioxide (ClO_2) is one of the disinfectants used increasingly to control microbiological growth in a number of different industries. 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 National Organic Program has listed chlorine dioxide as one of the synthetic substances allowed for use in organic crop production. Gaseous ClO_2 has been explored as alternatives to aqueous chemicals for sanitizing produce because it does not leave residual moisture on fruits and vegetables, which may promote the growth of molds. The generation of gaseous chlorine dioxide traditionally needs on-site instruments such as an applicator or generator, resulting difficulties in using gaseous ClO_2 by the food industry and small farmers, such as the economic constraints of purchasing and operating complex machinery and the required technical expertise. Therefore, it is very inconvenient, relatively expensive, and has not been widely used by the Maine agricultural community especially the small-scale industry. For applications in the food industry, a sanitizing method that is simple and inexpensive is essential. In addition, fruits and vegetables, although sanitized, may harbor surviving microorganisms, including pathogens that can recover and grow during transportation and storage. Therefore, an effective sanitation method applicable to fruits and vegetables under those conditions should be investigated.

In this project, the P.I. is going to work with ICA TriNova, LLC (Forest Park, GA) to design chlorine dioxide gas release materials and develop a small, dry chemical sachet that can generate chlorine dioxide gas. Applications of this product once developed will be convenient and will have potential to provide continuous sanitation during storage and delivery of fresh produce. We will use spinach as a food model and investigate the feasibility of using gaseous chlorine dioxide generated by sachets to sanitize spinach leaves. The successful results will provide the Maine fresh produce industry and the Maine organic fresh produce industry with an efficient and non-expensive microbial decontamination method for post-harvest treatment. This research helps the Maine fresh produce industry and the Maine organic fresh produce industry to provide the safest products to compete with other states and regions and to eliminate any foodborne outbreak associated with Maine fresh produce. 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 the Maine's food processing industry. The results will help Maine fresh produce and organic fresh produce industries to sell the safest food products.

Objectives:

1. To develop a simple gaseous ClO_2 treatment for disinfection of fresh produce using spinach as a food model.

2. To provide outreach activities with the Maine fresh produce industry and the Maine organic fresh produce industry using the new non-expensive sanitary method to eliminate pathogen contaminations.

Approach:

Objective 1:

Traditional generation of ClO_2 is very inconvenient and expensive, not to mention inapplicable for small agriculture businesses. In this project, a simple gaseous ClO_2 will be developed. Spinach will be used as the food model in this study. *E. coli* O157:H7 will be used as the target pathogen. Spinach leaves trimmed to 25 g will be separated and placed on sterile aluminum foil in a laminar flow biosafety hood. For inoculation, 100 µl of the *E. coli* O157:H7 culture will be applied to the surface of spinach leaves by depositing droplets at 10 locations with a micropipetter. The leaves will be dried in the hood for 30 min with the fan running. The ClO_2 gas generating sachet will be activated by shaking and will be enclosed within the gas cabinet with 10 ml of sterile water (to maintain high humidity) along with inoculated spinach leaves and the fan turned on. Controls will be treated in the same manner, except that no ClO_2 generating sachet will be included. All tests will be performed at room temperature (25^{o}C). To investigate the visual effect of ClO_2 gas on spinach quality, treated spinach leaves will be placed in UV sterilized plastic zip lock bags and stored at 4 ^{o}C for 18 days.

Inoculated and chemically treated spinach leaves (25 g) will be placed in a stomacher bag containing 50 ml of buffered peptone water and homogenized for 2 min with a stomacher. After homogenization, aliquots (1 ml) of samples will be serially diluted in 9 ml of sterile buffered peptone water, and 0.1 ml of sample or diluent will be spread plated onto selective media. Sorbitol MacConkey agar (SMAC; Difco) will be used as a selective medium for the enumeration of *E. coli* O157:H7. All agar media will be incubated at 37 ^{o}C for 24 to 48 h, and then colonies will be enumerated. These enumerations will be performed before and at 30 min, 1 h, and 3 h after treatment.

Objective 2:

Outreach activities will be conducted with the Maine fresh produce industry and the Maine organic fresh produce industry in developing microbial control strategies and sanitation programs. Knowledge in controlling and eliminating foodborne pathogens will be shared with the Maine agriculture community and the food industry to prevent foodborne pathogen contaminations and promote food safety. Educational materials in the form of fact sheets and newsletters will be developed and mailed to the industry in Maine. A brief non-technical summary will also be published in the Maine Agricultural Center Newsletter.

Expected outcomes and the methods for sharing the outcomes:

Gaseous chlorine dioxide with low concentrations is expected to effectively reduce the level of *E. coli* O157:H7 on spinach leaves. The results will provide the Maine fresh produce industry and the organic industry information regarding the effectiveness of the simple gaseous chlorine dioxide method on controlling pathogen contaminations. The Maine fresh produce community can adopt this simple and non-expensive method to eliminate pathogen contaminations and prevent recalls and economic loss associated with foodborne outbreaks.

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, and the fresh produce industry. The project will highlight the research programs of Maine Agriculture Center in helping the fresh produce industry preventing foodborne outbreaks associated with their products.

Objectives Met:

1. To develop a simple gaseous ClO2 treatment for disinfection of fresh produce using spinach as a food model.

With an increase in consumption of fresh vegetables and fruits has come an increased frequency of foodborne outbreaks. The recent outbreak of Escherichia coli O157:H7 on spinach was one example. Prevention of microbial contamination in order to produce safe products is essential. Pathogenic bacterial contamination originates from

irrigation or washes water, animal or municipal sewage-based fertilizers, infected workers, and food processing facilities with poor sanitation. However, there is a general lack of efficacy of sanitizers in controlling the contaminations. This can be partially attributed to difficulties in delivering aqueous chemical sanitizers to areas on the surface of produce in which pathogens may be lodged. Currently, most produce is washed with chlorinated water (50 to 200 ppm of active chlorine) to reduce levels of microorganisms, but this treatment is less effective and may produce harmful by-products such as chloramines and trihalomethanes. Through the support by the Maine Agriculture Center, we worked with ICA TriNova, LLC (Forest Park, GA) to design chlorine dioxide gas release materials and developed a small, dry chemical sachet that can generate chlorine dioxide gas. Gaseous ClO2 was generated by combining an equal amount of impregnates sodium chloride and activating acids in a small sachet. After activation, the sachet was placed in a sealable bag containing E. coliO157:H7 inoculated spinach. A slowrelease gaseous ClO2 (ICA TriNova, LLC, Forest Park, GA) was used for spinach at a relatively low constant concentration of ClO2 gas over 7 day storage (2.7mg of ClO2) in a package bag model. Results were effective for the decontamination of E. coli O157:H7 on spinach using the slow release, showing a 3.4 log CFU/g reduction. The low concentration of ClO2 over 7 days did not affect visual quality of spinach leaves. Gaseous ClO2 could be an affective disinfectant against E. coli O157:H7 on spinach. This simple method can easily be incorporated into the existing process and provide advantages to producers who wish to preserve the appearance of their sanitized produce.

2. 2. To provide outreach activities with the Maine fresh produce industry and the Maine organic fresh produce industry using the new non-expensive sanitary method to eliminate pathogen contaminations.

Outreach activities are conducted with the Maine fresh produce industry and the Maine organic fresh produce industry in developing microbial control strategies and sanitation programs. Knowledge in controlling and eliminating foodborne pathogens are shared with the Maine agriculture community and the food industry to prevent foodborne pathogen contaminations and promote food safety. Our study has att racted interests and received contacts from the fresh produce industry in Maine. 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 used are request for assistance, presentations in national and international meetings, contacts from the fresh produce industry, and publications in scientific journals.

Termination Report

Integration of Research and Extension Activities:

The outcomes of the research project are shared through extension, outreach activities and interactions with the fresh produce industry. The P.I. received contacts from the fresh produce industry and consumers regarding the study and how to keep fresh produce safe. The results have also been presented at international meetings and will be published in refereed scientific journals. The outcomes are specially expected to benefit local, regional, and state.

Outputs:

Publications:

- Wu, V.C.H.*, L. Harpers, J. Shens, J. Gilberts, and M. Principes. 2008. Decontamination of Escherichia coli O157:H7 on spinach and blueberries through use of gaseous chlorine dioxide. Published abstract and poster presentation. IFT annual meeting. New Orleans, LA.
- Wu, V.C.H. Strategies to prevent foodborne outbreaks associated with Maine fresh produce. Presentation. Shanghai Ocean University. Shanghai, China. June 4, 2008.
- Wu, V.C.H.*, L. Harpers, J. Shens, J. Gilberts, and M. Principes. 2008. Decontamination of Escherichia coli O157:H7 on fresh produce through use of gaseous chlorine dioxide. Will be submitted to Int. J. Food Microbiol.

MAC95: Development of Portable Ant Nests for Biological Control within Maine Vegetable and Fruit Cropping Systems: A Novel Approach to Using Native Predatory ants for Insect Pest Management

Principle Investigator(s): Beth Ann Choate, Frank Drummond

Background:

Formica exsectoides Forel is a native North American species found primarily throughout the eastern United States (Andrews 1926). This ant forms thatched, bare mounds that are common throughout Maine lowbush blueberry fields, spruce/fir plantations, and old-field habitats (Andrews 1928, Campbell 1990). Our observations during periods of activity have shown that ants scavenge upon dead vertebrates and arthropods, and seeds; and prey upon most small arthropods they encounter. F. exsectoides can effectively control insect pests within jack pine stands with workers preying upon various stages of redheaded pine sawfly, jack pine budworm, gypsy moth, and white pine weevil (Campbell 1990). During the summer of 2006, we observed ants preying on various stages of pest Lepidoptera, Coleoptera, Homoptera, Orthoptera, Hymenoptera, and Diptera within lowbush blueberry fields. These results suggest that F. exsectoides may serve an important role in managing pest species in a variety of agroecosystems. Ants are have not been well studied as far as managed social insects for pest control, but their potential is huge when viewed in light of how successful management of the honey bee has been for pollination.

This proposal focuses on the manipulation of F. exsectoides colonies for use as biological control agents. During the summer of 2006, portable ant colonies were designed and developed within the laboratory and preliminary field studies demonstrated workers will forage naturally from portable colonies. Development of a portable ant nest allows for an innovative method of biological control with a native predator. Portable nests could be placed directly at the location of a pest outbreak as a strategy of inundative release. Traditional approaches to using predators as biocontrol agents involve the enhancement of native predator populations through conservation practices or inoculative or inundative releases of non-native or commercially produced native species dispersed throughout a field (Orr and Suh 1999, Pedigo and Rice 2006). We propose field evaluation of mobile portable F. exsectoides nests as an inundative release strategy for Maine fruit and vegetable production. The designed field experiments should allow calculation of colony stocking density necessary for control and the rate of pest consumption under field conditions in three crop systems, blueberry or cranberry, beans or cabbage, and apples.

Research Description:

The objectives of this research proposal are as follows:

- Create a Formica exsectoides extension fact sheet to educate farmers about the life history and benefits of conserving mounds throughout their cropping systems.
- Evaluate the effectiveness of F. exsectoides portable ant nests in controlling pests within a variety of Maine crop types.
- Estimate field-level stocking densities of ant colonies per acre.

Extension

F. exsectoides is an invaluable predator throughout lowbush blueberry cropping systems; however, many farmers believe foraging workers are pests, wanting to destroy mounds, not conserve them. The publication of an extension fact sheet would provide farmers with photographs of mounds and ants to identify the species, discuss the lifecycle of the colony, and express the importance of this species in regulating pest populations. Although the portable colony will not be complete for introduction to the farming community at this time, educating farmers about the importance and usefulness of this ant species is an important step in the future acceptance of this biological control method. We propose to develop a 1-page, color fact sheet providing farmers with the information necessary to gain a complete understanding of the role of F. exsectoides and its potential as a biological control agent.

Research

During the summer of 2006, portable nest prototypes were tested in the laboratory and the field. Five-gallon buckets were found to be the most effective material, in that workers continued to forage and return to the nest after retrieving prey. Twenty nests will be constructed from white, 5- gallon buckets and filled with at least one queen, 1500 workers and 500 brood. According to the literature and our observations in the field, colony size seems to be extremely variable; therefore, colony sizes found effective in previous portable nest studies are being used (Campbell et al. 1991). The queen will be confined within a queen excluder, an 11x8x5 cm container with 0.3 cm holes in the top, bottom and sides which are large enough to allow workers access to the queen. The nest-bucket contains holes at the top for forager passage (0.8 cm) and small holes in the lid and bottom for water drainage (0.2 cm)(Figure 1).

During the summer of 2007, crop fields experiencing pest outbreaks in Penobscot, Waldo, Hancock, and Lincoln Counties (Maine) will be located by survey and communication with Dr. David Yarborough, the University of Maine Cooperative Extension (UMCE) lowbush blueberry specialist, Mr. Charlie Armstrong, cranberry specialist (UMCE), and Dr. David Handley, small fruit and vegetable specialist (UMCE). Experiments will be conducted within three cropping systems and we will attempt to identify three fields of each crop with the same pest species to provide adequate replication of experiments. Upon locating a field, an initial survey will be conducted to map pest densities within the field and identify areas with the highest pest populations. Five portable nests will then be placed within high density pest areas throughout the field. Nests will be placed at least 30m apart to prevent overlap in the foraging areas of each nest (based upon our data in lowbush blueberry suggesting that nests have a likely maximum foraging radius of 16m) (Figure 2). The colony fragments in portable nests deployed in fields will be acclimated by providing sugar water and dead crickets for the first 24 hours. After 24 hours, all supplemental food will be removed and ants will be allowed to naturally forage on pests for seven days.

Two, four and seven days after deployment, linear transects will be established and the pest and forager densities evaluated. At 1.5, 3, 8, 15, and 23 meters from the portable nests and the five control locations (no nests), pest populations will be assessed using common methodology for the cropping system, i.e. sweep netting in lowbush blueberry and cranberry. Also at these distances, a 0.5 meter square grid will be placed on the vegetation and the number of foragers counted. All daily observations will be conducted midday to eliminate all factors other than the pest population which may lead to an increase or decrease in foragers. After nests spend seven days in a field, all five portable nests will be moved to another experimental field and the experiment repeated. For each experiment a one-way analysis of variance will be performed to compare pest populations at varying distances from the portable colonies. Nonlinear regression will be used to estimate nest stocking density (Stubbs and Drummond 1997).

Projected Outcomes:

The extension component will be completed by December of 2007, to allow for the inclusion of any further data determined while conducting the research component of this proposal. A F. exsectoides fact sheet will provide farmers with the information to establish a better understanding of the role of these ants throughout their cropping systems. The research component of this proposal will be completed by October of 2007. Results will aid in the development of a portable ant nest tactic for utilization of a native, natural enemy in fruit and vegetable cropping systems that can be reared and rented to farmers by small business entrepreneurs throughout Maine.

Termination Report

The objectives for the proposal that were completed are as follows:

1. Create a *Formica exsectoides* extension fact sheet to educate farmers about the life history and benefits of conserving mounds throughout their cropping systems.
2. Evaluate the effectiveness of *F. exsectoides* portable ant nests in controlling pests within a variety of Maine crop types.

For objective 1, I completed a *Formica exsectoides* extension fact sheet that is posted on the Wild Blueberry website maintained by the University of Maine Cooperative Extension. The fact sheet describes *F. exsectoides* colonies and colony members, the biology of the colony, and discusses the negative and positive impacts of these colonies on lowbush blueberry. Two color pictures are provided to aid in identification of colony workers and mounds.

I began completion of objective 2 by conducting laboratory experiments to determine the pest species that *F. exsectoides* will consume. In order to answer this question, two-chamber microcosms were constructed. Workers and larvae were placed within the largest chamber. Plastic tubing was used to connect the two chambers and prey were placed in the smaller chamber. Ants were starved for 24 hours prior to the addition of prey. Six prey species were chosen based on their prevalence in Maine cropping systems and include blueberry flea beetle larvae and pupae, blueberry leaf beetle adults, lily leaf beetle adults, cucumber beetle adults, and Mexican bean beetle larvae. Crickets served as the control. The number of repetitions for each trial varied due to the prevalence of the pest species.

The percentage of prey captured and consumed varied with prey species. Fifty-seven percent of all blueberry flea beetle larvae were consumed, yet only 11 % of all pupae were consumed. Eleven percent of blueberry leaf beetle, 32% of cucumber beetle adults, 50% of lily leaf beetle, and only 19% of Mexican bean beetle larvae were consumed. The greatest percentage of prey consumed was 58% of all crickets were consumed by ants. These laboratory experiments gave insight into the pests that would most likely be controlled by introduced *F. exsectoides* colonies; however, it did not evaluate the effectiveness of an actual portable colony.

The objectives for the proposal that were not completed are as follows:

2. Evaluate the effectiveness of *F.exsectoides* portable ant nests in controlling pests within a variety of Maine crop types.
3. Estimate field-level stocking densitites of ant colonies per acre.

The construction of portable ant colonies, necessary to complete objectives 2 and 3, began in the summer of 2007. In order to build a successful portable colony, it must contain workers, larvae and queens from a *F. exsectoides* colony. Mounds were located, excavated and returned to the lab. Ants, larvae and queens were removed from the nest soil, placed in separate containers and counted. During this process there were two factors that lead to an unsuccessful completion of these objectives: 1. Queens were rarely located when a colony was excavated and 2. Larvae would pupate almost immediately after the mound was excavated. There are multiple queens within a colony; however, they do move freely throughout the mound depending upon the temperature of the soil and air. Thus, there is no specific area within the nest to guarantee queen location. Also, workers are very protective of the queen and often carry her down further into the soil. Despite having dug until workers could no longer be seen crawling through the soil, often queens were not found within the nest soil when we returned to the lab. In addition to a lack of queens, upon bringing colonies into the lab many of the larvae would quickly pupate. Larvae are essential to a portable colony, since workers forage for protein in order to feed growing young. Often colony collections occurred on one day, colonies were left in the lab overnight and we began sorting them the following day. After approximately 2 days in the lab, all of the larvae in the colony would pupate. We then began only collecting very small, seemingly “young” larvae; however, we still found that the pupation rate was extremely rapid in the lab. I could not find any discussion of this phenomenon in the literature, but believe it may have been a result of colony disturbance or a lack of essential resources. Colonies were excavated throughout the summer; however, we were unable to construct a functional portable colony. Due to these issues with ant collection, it was not possible to create colonies to conduct experiments evaluating the effectiveness of portable colonies or estimate field-level stocking densities.

Although the development of portable colonies was unsuccessful, *F. exsectoides* did feed on a variety of pests in the laboratory. Thus, further research will focus on the ecology of this species as well as two other predaceous, mound-building Formica species prevalent throughout Maine lowbush blueberry fields. During the summer of

2008 I evaluated the impact of *F. exsectoides* nests throughout lowbush blueberry fields on both beneficial and pest insect species. The results of this study are still being compiled.

I presented the results of the laboratory feeding trials in conjunction with fieldwork identifying *F. exsectoides* prey at the Entomological Society of America meeting in November 2008. I also discussed the role of ants as naturally occurring biological control agents to blueberry farmers at the 2007 and 2008 Wild Blueberry Field Day. Many farmers view ants as pests and are extremely interested to learn that this species is protecting their crop. I have discussed with many small farmers the resources required to maintain mounds and the problems that would most likely arise if they removed this species from their land.

The presentations and publications associated with this research are as follows:

- Allegheny mound ant as a potential biological control agent. July 2007. Choate BA. Wild Blueberry Summer Field Day and Meeting. Blueberry Hill Farm, Jonesboro, ME.
- The foraging patterns of *Formica exsectoides* Forel throughout Maine lowbush blueberry fields. December 2007. Choate, BA and FA Drummond. Entomological Society of America National Meeting. San Diego, CA.
- Ants as predators of lowbush blueberry insect pests. July 2008. Choate BA. Wild Blueberry Summer Field Day and Meeting. Blueberry Hill Farm, Jonesboro, ME.
- Choate BA, Drummond F, Yarborough DE (2008). Beneficial Insect Series 1: The Allegheny Mound Ant. University of Maine Cooperative Extension Fact Sheet No. 195, UMaine Extension No. 2500.

I would like to thank the Maine Agricultural Center for the providing the funding to conduct this research. Although I was not successful in fully completing two of the original objectives, I did learn a great deal about *F. exsectoides* and its role in lowbush blueberry. As issues with the construction of a portable colony became apparent, many more questions were conceived, ultimately leading to a stronger research project. Future research will be conducted to assess the ecological role of *F. exsectoides* throughout lowbush blueberry and the interactions between this species and two other Formica species, *F. ulkei* and *F. glacialis*. I also hope to research the role of disturbance and resource depletion in forcing ant young to develop more quickly, despite the fact that smaller, less fit workers may be the result.

MAC96: Residual Imidacloprid Insecticide Activity on Commercial Lily (*Lilium*) Bulbs and Consequences for Lily Leaf Beetle Control, Insecticide Resistance and Future Studies

Investigators: Eleanor Groden and Lois Berg Stack

Background of Issue Addressed and Project Objectives:

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

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

We received a MAC grant for the 2006 field season to investigate host resistance in ten popular lily hybrids. We found significant differences in plant resistance to LLB in two Oriental cultivars tested. This study encouraged us to pursue additional funding from multiple sources to continue this work. We have received a Northeastern IPM Center regional grant for the 2007 field season to test Oriental hybrids and species lilies in choice and no-choice experiments to determine LLB survival and feeding damage. However, we have identified a significant obstacle in continuing this work that we must address. Commercial bulb producers, the majority of which are in Holland, dip lily bulbs in imidacloprid, a commercial insecticide that is systemic and residually active in leaves (Miller 2007 pers. comm.). It is primarily used against aphids and scales, but is also toxic to lily leaf beetle. This common cultural practice may have a significant effect on plant responses to LLB. Not only would toxic effects of imidacloprid on LLB affect results we achieve in our host plant resistance studies, it has also been shown to have oxicsignificant impacts on the survival of LLB biological control agents[3] (Casagrande 2006, pers. comm.). If residual imidacloprid levels do persist in commercial bulbs, this also has consequences for development of resistance to nicotinyl insecticides in LLB. Foliar treatments with similar compounds on top of residual activity from treated bulbs can result in increased selection pressure and a faster rate of resistance development. Several formulations of imidacloprid foliar treatments are routinely used in the ornamental industry (Miller 2007 pers. comm.). Alternative materials should be considered if bulb residual activity is significant.

We have found it difficult to locate sources for untreated bulbs. It is important, therefore, that we begin to test commercial bulbs for imidacloprid residue levels and the effect these treated bulbs may have on LLB survival and leaf feeding.

The research objective of our proposed MAC project is to determine the residual activity of imidacloprid in commercial lily bulbs through their measured impact on lily leaf beetle survival.

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[3] We are currently funded by the New England Greenhouse Conference to assess potential establishment of biological agents of lily leaf beetle in Maine.

Research Methodology:

Residual imidacloprid activity against LLB will be assessed by comparing LLB egg, larvae and adult survival on foliage of two popular lily hybrids. We will compare residual activity on foliage from bulbs obtained from: 1) three suppliers of treated lily bulbs, 2) two suppliers of untreated bulbs, and 3) untreated bulbs that we will treat with a known dose of imidacloprid. Prior to planting, these untreated bulbs will be manually dipped in an imidacloprid solution using the same methodology as commercial growers. Two bulbs of each variety per supplier will be potted in early spring, 2007. LLB adults will be collected in early May as they colonize local lily plantings. Male and female beetles will be paired and placed in Petri dishes with untreated lily foliage to allow for mating and initial egg laying. Lilies will be placed in individual cages. Caged plants will be maintained outdoors and watered and fertilized as needed. When eggs begin to be laid, five mated pairs of LLB adults will be placed on lily foliage inside each cage. After 5 days, adults will be counted and removed and all eggs will be counted on plants. Regular observations will determine the amount of successful egg hatch and subsequent survival of larvae.

This preliminary study will generate data for a future proposal for external funding for a project designed to quantify imidacloprid residue in foliage through aqn HPLC analysis. This is beyond the scope of this project, but samples of foliage from this study will be collected and stored for the future project.

Project Support from Maine Agricultural Community:

Letters of support have been sent by the following industry members:

- Scott Longfellow, Owner, Longfellow's Greenhouses, Inc., Manchester ME
- Steven Palmer, Owner, Plainview Nurseries, North Yarmouth ME

Extension Education and Outreach Activities:

Research findings and management recommendations resulting from this study will be shared via:

- Presentation at the 2007 UM Cooperative Extension Field Day for Home Gardeners, Rogers Farm (Stillwater ME).
- Presentation to greenhouse, nursery and garden center professionals at Aug., 2007 field day at Rogers Farm.
- Sign discussing lily leaf beetle projects in the Penobscot County Master Gardener Demonstration Garden at Rogers Farm.
- Poster at the Maine Landscape and Nursery Association (MeLNA) Annual Meeting, Jan., 2008.

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

Termination Report

Objectives Met:

The research objective of this MAC project was to determine the residual activity of imidacloprid in commercial lily bulbs through their measured impact on LLB larvae survival.

Methods Used to Evaluate Outcomes:

Six bulbs of each of the popular garden lily cultivars, 'Stargazer?' and 'Casa Blanca' that had never been treated with imidacloprid ("organic"), were purchased from Northwest Bulb Co., Estacada OR. Three bulbs of each variety were dipped in a 1.7% concentration of imidacloprid (Provado Flowable, Bayer, Corp.) for 4 seconds, after which all of the bulbs (dipped and not) were planted in twogallon containers and provided with water and fertilizer as required. Lily plants grown from commercial bulbs of these cultivars were purchased from two local suppliers in Bangor ME: one greenhouse/nursery and one discount garden center (n=3 plants per cultivar from each supplier). Plants from both local sources were grown from imported bulbs that had been treated with imidacloprid prior to importation. Plants

were provided with water and fertilizer as required. All lily plants (treated and untreated) had vigorous vegetative growth with normal leaf size before testing for residual insecticide activity. First instar LLB larvae were collected from caged lily plants of the same cultivars tested. Two healthy, vigorous leaves were excised from individual plants and placed on moist filter paper in Petri dishes with 10 newly hatched LLB larvae, five larvae per leaf. Fresh leaves were provided every other day and the filter paper was moistened as needed. The number of larvae surviving per dish was monitored until those that survived reached the fourth instar. The total number of larvae surviving was then recorded.

Integration of Research and Extension Activities:

No residual activity of imidacloprid was detected against the LLB larvae feeding on the locally purchased lily plants or on those grown from the untreated ("organic") bulbs in this study. Survival of larvae was significantly reduced when fed on leaves grown from bulbs that were dipped in imidacloprid solution just prior to planting ($p < 0.0001$). Survival of larvae was significantly lower on the 'Casa Blanca' cultivar compared with 'Stargazer' ($p = 0.04$), however there was no interaction between cultivar and source or treatment of bulbs/plant ($p = 0.73$).

No residual activity from pre-shipment insecticide treatments were detectable when imported lily bulbs had been purchased and planted by local growers and suppliers, and resold at retail outlets. However, when bulbs were treated with the recommended rate of imidaclorid just prior to planting, residual activity was significant. These results simplify our studies of host plant resistance to LLB, as unknown residual insecticide activity is not likely to confound our assessments of cultivar resistance to LLB. Also, we can assume that with no detectable residual activity, local LLB exposure to this insecticide is limitedprior to any local treatments. Therefore, growers and homeowners who may treat lily plants with an imidacloprid insecticide will not be accelerating resistance if judicious use of this material is practiced.

Outputs:

Ideas and findings of this study and of previous years' work were shared with commercial and home horticulture audiences through the following events: Interactive display at commercial horticulture event:

- Stack, L.B., M. Brand, K. Carroll, B. Maynard, C. Neal and L.P. Perry. 6-8 Feb 2007. Great Ideas! Pavilion. New England Grows. Boston MA.

Presentations to noncommercial gardening groups:

- Stack, L.B. 18 Oct 2007. Reducing your garden?s carbon footprint: choosing plants. Limited-Petroleum Gardening Program. South Paris ME.
- Stack, L.B. Perennials. 20 Sep 2007. Aroostook County Master Gardeners. Presque Isle ME.
- Stack, L.B. 16 Sep 2007. Native Plants: a perfect choice for Maine gardens. Coastal Maine Botanical Garden Annual Meeting. Boothbay Harbor ME.
- Stack, L.B. 13 Sep 2007. Meet the garden. Moosehead Lake Garden Club. Penobscot County Master Gardener Demonstration Garden, Rogers Farm. Stillwater ME.
- Betterley, P. and L.B. Stack. 21 Aug 2007. New plants, new ideas. Field Day at the Penobscot County Master Gardener Demonstration Garden, Rogers Farm. Stillwater ME.
- Gray, G., H.A. Arevalo-Rodriquez, S. Burnett, S., J. Dill, E. Groden, C. Kirby, L.B. Stack, P. Stack and B. Watt. 26 Jun 2007. Problem solving in the garden. Field Day at the Penobscot County Master Gardener Demonstration Garden, Rogers Farm. Stillwater ME.
- Stack, L.B. 21 Jun 2007. Gardening in a watershed. Kennebunkport Conservation Commission Public Meeting. Kennebunkport ME.
- Stack, L.B. 11 Jun 2007. Diagnosing plant problems. Piscataquis County Master Gardeners. Dover-Foxcroft ME.
- Stack, L.B. 2 Jun 2007. Perennials. Piscataquis County Master Gardeners. Dover-Foxcroft ME.
- Stack, L.B. 14 May 2007. Perennials. Wildridge Garden Club. Standish ME.

- Stack, L.B. 14 Apr 2007. Planning for beauty and success in the garden. Longfellow's Greenhouses Open House. Manchester ME.
- Stack, L.B. 4 Apr 2007. The invasive species problem: five positive things you can do. Owls Head Garden Club. Owls Head ME.

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- Folsom, R. 2006. Maine Department of Agriculture, Food and Rural Resources, Augusta, ME. Personal communication.
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