

Maine Agricultural Center Integrated Research and Extension Projects: 2010–2011

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MAC116: Detecting and Preventing Prototheca Bovine Mastitis in Maine

Principal Investigator: Anne Lichtenwalner

Background:

The goal of this project is to expand ongoing work to develop screening methods for prototheca, an emerging mastitis pathogen in Maine, and to apply this tool to help Maine dairies. The outcomes of this project will include:

1. validation of a new diagnostic method to sensitively and specifically detect prototheca mastitis in dairy animals
2. evaluation of the prevalence of pathogenic species of prototheca in Maine dairies
3. development and dissemination of information regarding prevention and treatment of prototheca mastitis.

In 2009, prototheca, a colorless algae, was detected in cows with mastitis (infection of the udder tissue) on several of Maine's dairies. Numerous species of prototheca exist, of which only a few are known to be pathogens. While prototheca has been described in veterinary literature as a cause of mastitis in the past (Bodenhoff and Madsen, 1978), the incidence of this pathogen in dairy cattle is expected to be higher in tropical than in temperate regions such as Maine (Jajnosi et al., 2001). It is often described as an environmental problem, harbored in standing fresh water and directly infecting cattle (Scaccabarozzi et al., 2008). However, it can also become systemic in cattle, presumably via the oral route (Thompson et al., 2009), and may be transmitted via bovine feces between cows (fecal-oral route) or via milking equipment (fecal-mammary route) (Osterstock et al., 2005; Yamamura et al., 2008). In a recent outbreak in Vermont, the infective prototheca species was not determined, but prototheca infection appeared to be linked to *Staphylococcus aureus* intramammary infection (Zurakowski M, personal communication 2010). Large scale outbreaks of prototheca mastitis have been reported in tropical regions, such as Brazil (Bueno et al., 2006), but also in more temperate regions, such as Portugal, Italy and Japan (Buzzini et al., 2004; Lopes et al., 2008; Osumi et al., 2008). Although investigation of treatment methods is ongoing, the veterinary literature has in the past recommended culling of infected cows without attempting treatment. In a recent Maine case, over 13 cows were culled for this reason on a small dairy, a loss of over \$15,000 with lost production and replacement costs considered. Early detection prior to spread of this organism will help protect Maine's dairy economy. As well, prototheca can cause human infection (Lass-Florl and Mayr, 2007) and can be resistant to pasteurization in milk (Melville et al., 1999). For this reason, and because sales of raw milk are increasing in Maine, screening for pathogenic strains of this organism will be a valuable tool to Maine's dairy industry.

Description of Project:

A nested PCR for detection and species identification of *Prototheca zopfii*, *P. wickerhamii* and *P. blaschkaeae*, the species documented to cause mastitis in cattle and pathogenic infections in man and other mammals, is under development in our lab at this time. Briefly, we will design primers based on prototheca 18S rDNA sequences to detect prototheca DNA in samples, then will identify the species using restriction enzyme to yield characteristic RFLP patterns. Prototheca strains will be ordered from the ATCC collection. Optimization of the assay (extraction and nested-PCR), specificity/sensitivity and quality control using "gold standard" culture and phenotypic methods will be assessed prior to diagnostic use of the assay. This project is currently underway in our lab, and is expected to take 4-6 months to complete. We believe that molecular methods will allow more sensitive and specific identification of problem strains of this organism, and may allow further investigation of the sources and transmission of the disease.

In the second, application phase of the project, dairy farms in Maine will be contacted using telephone or email (UM Cooperative Extension contact lists). Bulk tank filters will be collected from up to 100 collaborating dairies after discussion of the project, confidentiality, and the expected outcomes. Where possible, a walking tour of the facility will be conducted with the goal of finding possible sites for environmental contamination and transmission of prototheca on the farm. Farms will be notified of the bulk tank findings, and will be advised as to possible ways of responding to this information with assistance from Gary Anderson and Dave Marcinkowski of UMCE. All cultures will be accompanied by PCR data, and the results will be compared to assess reliability of the PCR assay. This nested PCR, designed to detect and differentiate pathogenic, mastitis-causing prototheca species, is currently under development

in our laboratory. The proposed project will strengthen the new PCR assay for further use in our diagnostic laboratory, and will help individual farmers detect and deal with, or prevent, prototheca mastitis in their herds. As well, it will provide an estimate of the prevalence of this emerging disease in Maine.

Outcomes and Extension Outreach:

The new prototheca PCR assay will be used in conjunction with conventional bulk tank filter cultures to screen 100 Maine dairies for prototheca, which will further the validation process for the new PCR assay for prototheca, at the same time as these 100 Maine dairies find out if they have a need to evaluate individual cows or equipment. These 100 dairies will have the added benefit of an on-site evaluation for prototheca risk factors on their dairy. The findings of this project will be summarized, submitted for publication in a peer-reviewed journal, and presented at local and regional vet and dairy conferences. The dairy community will benefit by learning more about risk factors for this emerging mastitis pathogen. Regional veterinarians will benefit by having more information to assist dairies with eliminating this disease. A collaboration with Cornell University is in preparation (Dr. Mike Zurakowski of Quality Milk), with the expected outcome of application for USDA funding for a more regional study.

Nontechnical summary

Prototheca, a colorless algae, can cause untreatable mastitis (infection of the udder tissue). In 2009 and 10, an unusually large number of cases were detected in Maine. Numerous species of prototheca exist, of which only a few are known to be pathogens. Some prototheca can also infect humans. Therefore, knowing which species is present will assist dairy farmers in controlling spread of this disease. Dairy farms in Maine will be confidentially screened for prototheca. 100 cooperating farms will have bulk tank filters collected, and will have the option of on-farm evaluation for sources of prototheca infections. A new test will be used to help detect the species of prototheca in each case. The results of the new polymerase chain reaction (PCR) test will be compared with that of conventional culture to assist in validating the new PCR assay. As well, farmers will be informed about methods of avoiding this disease, and results of the screening test will be summarized to help determine how to prevent spread of prototheca in Maine dairies.

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Final Report

List of original project objectives that were met and significant findings for each of these objectives:

- 1. Develop nested PCR for detection and species identification of *Prototheca zopfii*, *P. wickerhamii* and *P. blaschkeae***

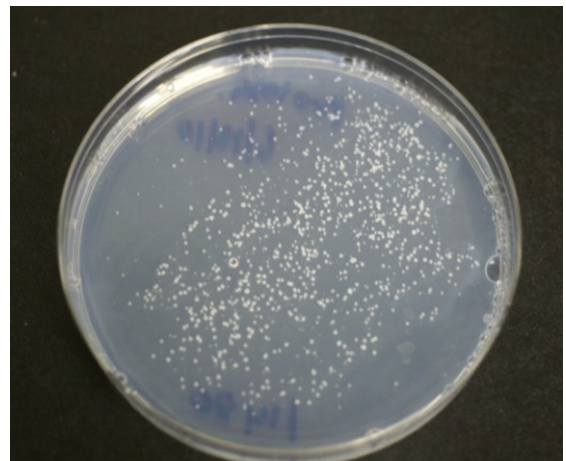
Standard isolates were obtained from the ATCC (American Type Culture Collection) and from European and US collaborators. A nested PCR was developed and implemented in the lab. Validation of the method with trainees in the lab is underway.

- 2. Develop standard culture techniques for isolation of prototheca for bulk tank filters**

Standard operating procedures (SOP's) for bulk tank filter storage/extraction of DNA/culture were developed. A selective medium (*Prototheca* isolation media; PIM) and a nutrient agar were utilized for cultures.

- 3. Implement standard culture and nested PCR to survey Maine dairies for prototheca shedding into milk**

During 2010-11, 350 Maine dairies were contacted, and 65 dairies from a wide region of Maine were included in the bulk tank filter project. Filters were successfully collected at visits to these farms (in order to preserve confidentiality, milk processor reps or other personnel were not asked to collect samples). Filters were kept frozen, then thawed at the lab and selectively cultured for prototheca; the filter DNA was extracted for prototheca PCR. Of 78 filters tested, 11 were positive for prototheca. Nine of the 11 prototheca DNA positives were identified as *Prototheca zopfii* genotype II, and 2 were not positively identified as to species of prototheca.



- 4. Report findings to Maine dairy industry groups along with recommendations for prevention**

Presentations:

During 2010, two presentations were made to the Mastitis Research Workers conference in Atlanta, GA. Three presentations were made to Maine dairy producers in 2010-1.

Scholarly work:

- A Master's thesis project was developed from this work (Tanya Farrington, 2011), and a second is in development (Nirajan Adhikari, 2013). 3 publications for peer-reviewed journals are in preparation. Funding proposals: One proposal was developed as part of a larger, multistate proposal, but was not funded.

- An additional project, evaluating sensitivity of Maine prototheca isolates to pasteurization, was conducted (Farrington 2011) and will be repeated during fall 2011 to evaluate whether cell:cell adhesion contributes to prototheca pasteurization resistance.
- An on-farm study of reservoirs of prototheca associated with chronic mastitis was conducted in 2010-11, and will continue in 2011-12. Recommendations for management practices to eliminate prototheca, or to reduce infection risk, were made directly to these farmers during 2010.

List of original project objectives that were *not* met:

The outreach component of the project was not as strong as anticipated. Of the original goal of 100 participants, we were able to enroll only 65, and were able to collect and process 78 filters (some farms were sampled multiple times). However, this response was large enough (65 of 350 dairies; ~19%), and geographically widespread enough, to be considered representative of Maine dairies. Both very small and large dairies participated.

Description of methods used to evaluate outcomes:

The best method for evaluation of the effectiveness of prevention would be to continue prototheca screening of bulk tank filters. On 3 farms, this program has been partially implemented. In the absence of continued funding, the program will need to be paid for by the farms.

Integration of research and extension activities:

Contacts for dairy farm participation in the study were made in collaboration with the MECHAP program and the state veterinarians. The UMCE Animal Health Laboratory provided sample storage, some assistance with sample processing, and the instrumentation for conducting the nested PCR technique. We dealt with a clinical problem (increasing incidence of protothecal mastitis) by evaluating its prevalence, and by reporting directly to the dairy industry in Maine. On several positive farms, ongoing testing and discussion of prevention strategies is conducted. We are developing the pasteurization project and continuing to evaluate methods of spread (culturing some wild bird populations, feed bunks, and other on-farm possible reservoirs/vectors).

List of external funding both sought and received:

- Mastitis Research Workers: 2010 MASCAP Application : Individual project: “Detecting and Preventing Bovine Protothecal Mastitis” Requested support for 2 years: \$219,248 requested. Overall USDA multistate project not funded.

List of educational material, publications, and programs:

Presentations:

1. The Presence of Pathogenic Prototheca sp. on a Dairy Farm in Maine, USA: Lichtenwalner and Barker (Atlanta GA, 11-2010)
2. Development of a Prototheca Nested PCR: Barker and Lichtenwalner (Atlanta GA, 11-2010)
3. Pasteurization: Effective control of Prototheca human health risks?: Farrington-Thomason and Lichtenwalner (Waterville ME, 3-15-2011)
4. Prototheca Presence on Maine Dairy Farms: Lichtenwalner and Barker (Waterville ME, 3-15-2011)
5. Prototheca Presence on Maine Dairy Farms: Lichtenwalner and Barker (Oakhurst Dairy Seminar, Augusta ME)

Fact sheet:

Frequently Asked Questions: Protothecal mastitis. In peer review, 9-2011.

Program:

At least one large dairy is aware of this emerging problem, and several smaller dairies that have had the disease are beginning to screen for it. We are working with the state/USDA agencies to encourage reduction of wild bird exposure on dairies, as the organism was isolated from some wild birds on local, prototheca-positive dairies. A comprehensive program for risk reduction is in development.

MAC117: Mycorrhizal Fungi Colonization of Leeks

Principal Investigator: Frank S. Wertheim

Background

Frank S. Wertheim is an Associate Extension Professor of Agriculture/Horticulture with the University of Maine Cooperative Extension based in their York County office. He has had a successful 23 year career with Cooperative Extension, developing educational programs and projects with and for the farming community. Wertheim has developed and continues to nurture the York County Farmers' Network, created to build a community of farmers that promotes supports and strengthens local agriculture through informal gatherings, demonstrations, and information and resource sharing. His on-farm research experience includes a Use of Red Mulch in Tomatoes study conducted in 1999-2000 and On-farm Colonization of Tomatoes by Mycorrhizal Fungi in 2008 and 2009.

Brief description of research and/or extension education activities

Situation:

Historically, before the advent of modern conventional agriculture with a reliance on off-farm inputs such as chemical fertilizers, productive farming systems depended on a closed system of recycling nutrients within the farm, building soil organic matter and enhancing conditions to maximize the agricultural ecology. The symbiotic associations of a majority of crops with mycorrhizal fungi are one example of working within the natural agricultural ecosystem to maximize production. Mycorrhizal fungi have been demonstrated to enhance crops' ability to mobilize and take up soil nutrients, particularly phosphorus, aid in water uptake and reduce disease pressures. Mycorrhizal fungi have also been shown to produce a glycoprotein, glomalin, which is believed to play a key role in the stabilization of soil aggregates.



High soil phosphorus, from chemical fertilizer or from long term use of soil amendments such as compost and manures, has been shown to inhibit the colonization of crop roots by mycorrhizal fungi. Excessive soil phosphorus is also a pollution threat to fresh water bodies where erosion of high phosphorus soils is known to stimulate algae bloom. Organic sources of phosphorus fertilizers have traditionally been a high cost input for organic growers as compared to chemical fertilizers. However, the cost of petroleum-based chemical fertilizers has been on a steady increase in recent years. It is logical then, that avoiding a buildup of excessive soil phosphorus, decreasing dependence on expensive sources of either organic or petroleum-based fertilizers by maximizing access to existing but often immobile sources of phosphorus on the farm through crop/mycorrhizal relations, would serve as a benefit to low input sustainable farming practices.

Purpose:

The purpose of this study is to evaluate the potential of mycorrhizal fungi in field grown leeks to reduce fertilizer inputs and/or boost yields.

Leeks are one of many vegetable crops which have mycorrhizal fungi symbiotic relationships; others include the alliums (onion, leek, garlic), nightshades (tomatoes, peppers, potatoes, eggplant), Compositae (lettuce, endive, radicchio), Umbelliferae (carrots, celery, parsnip, fennel), Gramineae (corn), and Cucurbitaceae (cucumbers, squash, pumpkins, melons) families of vegetable crops. Leeks were chosen for this study for their low pest profile, market value, and ease of harvest and data collection.

Work Proposed:

On-farm field research trials will be designed and conducted to evaluate the potential for mycorrhizae to increase yields in leeks. The field study will be replicated at two sites, Wolf Pine Farm, a certified organic CSA located in Alfred, Maine, and the Highmoor Farm Field Experiment Station located in Monmouth, Maine. Collaborators include: David Handley, UMaine Extension Vegetable and Small Fruit Specialist; Mark Hutton, UMaine Extension Vegetable Specialist; David Douds, research scientist located at USDA-ARS Eastern Regional Research Center in Wyndmoor, PA; and Amy Sprague, owner/operator of Wolf Pine Farm.

Methods:

The project has two phases.

Phase 1: On-Farm Mycorrhizal Production:

Conducted during the 2009 growing season to produce an on-farm source of mycorrhizal fungi to be used in the field study this year. In June of 2009, bahiagrass (*Paspalum notatum* Flugge) seedling plugs from the ARS research center colonized by *Glomus claroideum*; *Glomus mosseae*; or *Glomus intraradices*; and non-mycorrhizal (15 plants each) were shipped to University of Maine Cooperative Extension, York County for planting on-farm in a greenhouse at Wolf Pine Farm in Alfred, ME. The inoculated bahiagrass plants which are excellent colonizers of mycorrhizal fungi were grown in 7 gallon grow bags containing 9 parts vermiculite to 1 part compost through the fall when until they winter killed. Bahiagrass seedlings which were not inoculated were also grown simultaneously with the inoculated plants, to serve as a control study and for an additional treatment, in which a commercially produced inoculum will be added for the 3 different experiment treatments (explained in detail below). Soil media from the grow bags was sent to the ARS research station to document colonization and spores/gram concentration. In 2010 the soil media from the bags of the three species will be mixed together to create a blend of all three species of mycorrhizae. The inoculum free bahiagrass grow bag medium was also stored for use in 2010.

Phase 2: Leek Mycorrhizae Field Study:

Soil Media. Seedling soilless medium typically used at each farm location: Living Acres, Komplete at Wolfpine Farm and Metromix Growing Media at Highmoor Farm, will be used in this experiment.

- *Treatment 1- Mycorrhizal On Farm Inoculum:* The soil media described above will be mixed 9 parts media to 1 part of the compost/vermiculite mix containing the on-farm produced mycorrhizal fungi inoculum. Leeks will be seeded in the greenhouse at each farm location in mid-May, into the described media, in standard trays with 72 1-inch cells per flat.
- *Treatment 2 - Mycorrhizal:* The soil media described above will be mixed 9 parts media to 1 part of the compost/vermiculite mix from the non-inoculated bahiagrass plants and mixed with the commercially produced inoculum at a rate to come as close as possible to the number of spores per gram found in the on-farm produced media.
- *Control Treatment 3:* The soil media described above will be mixed 9 parts media to 1 part of the compost/vermiculite mix from the non-inoculated bahiagrass plants.

The seedlings will be watered in a greenhouse at each of the two farm locations as needed and supplemental fertilizer will be added via watering once weekly. An important consideration in mycorrhizal fungus production is the level of available phosphorus in the media in which the host plants are initially grown in the greenhouse before transplanting to the field. Care will be taken in fertilizing the seedlings in the greenhouse to use low phosphorus supplemental fertilizer to avoid inhibiting mycorrhizae colonization. At Wolf Pine Farm we will use Biogrow, a certified organic fertilizer which has an N-P-K analysis of 2 % N - 0.1% P - 6.6% K. At Highmoor Farm a chemical fertilizer regimen will be used with low phosphorus levels.

Field Experimental Design: In early late June – early July the inoculated and control seedlings will be planted in the field at each farm location using standard farm field practices including pre-plant additions of (Wolf Pine farm) organic fertilizers such as rock phosphate and fish meal, and (Highmoor farm) a complete commercial fertilizer blend,

per soil test recommendations. At the same time the plants are being set out in the field, root samples from additional plants from the same treatments will be taken and sent to the ARS for analysis to document the colonization of the leek plant roots. The field research plots will be set out in a randomized split block experimental design with 14 plants per replication of each treatment for total of 42 plants per replication. There will be 6 replicate blocks at each of the two farm sites. The plants will be spaced at 6 inch intervals in the row with 18 inches between rows. The plants will be weeded and fertilized according to standard farm practices.

During the growing season the plants will be visually monitored for growth and any incidence of pathology. If there is any notable disease development, plant leaf samples will be taken for diagnosis at the University of Maine Cooperative Extension Pathology lab in Orono. Each farm will use standard pest management practices as they normally would. As the leeks mature in approximately mid-October, data will be collected from the middle 10 plants in each of the 6 plant replicate block, which will be harvested, graded as # 1 for market, # 2 for non market home use and # 3 for culls, and a pre-trimming weight per plant will noted. At the end of the harvest a statistical data analysis will be performed to determine if there are significant differences between treatments.

Results Shared:

I will share the results of this research with farmers via the Maine Vegetable and Small Fruit Growers Association and MOFGA, and with researchers and Extension professionals via print and online publications, trade shows and conference presentations in Maine and the Northeast. I am currently scheduled to present my work with mycorrhizae to farmers at this fall's Common Ground Fair. In addition a University of Maine Cooperative Extension online and print publication will be created for dissemination.

Expected Outcomes:

Previous studies have indicated the potential for up to a 20% increase in yield using mycorrhizal fungi inoculated seedlings of some vegetable crops, though this work has not been done in New England. We hope to determine the potential use of mycorrhizal fungi as an agricultural practice that is economical to perform, environmentally friendly, and results in increased profits.

In previous studies performed by Wertheim in 2008-2009 funded by a SARE grant with tomatoes inoculated by mycorrhizal fungi resulted in a 7% yield increase in 2008 but the results were not statistically significant. One reason for this may have been due to the incidence of septoria leaf spot of tomatoes on the experiment done at Wolf Pine Farm that year. In 2009 the field trials with tomatoes at Wolf Pine Farm and Highmoor Farm both succumbed to Late Blight of Tomatoes and the plants had to be destroyed before any data could be taken. This was one of the reasons for switching to a crop with a smaller pest profile such as leeks.

Final Report

Objectives/Performance Targets

Objective:

Evaluate whether inoculating leeks with mycorrhizal fungi at the time of seeding in flats would lead to an increase in yield, using two sources of inocula, farm raised, commercially produced, and comparing them to a control (uninoculated) at two farm sites, Wolf Pine Farm in Alfred, ME and Highmoor Farm Experimental Station in Monmouth, Maine. These objectives were completed during a successful 2010 field studies at both farms.

Performance Targets Achieved:

- On Farm Production of Mycorrhizal Fungi Inocula using technique developed by USDA-ARS Research Station in Wyndmoor, PA
- Leeks grown in seedling flats with three treatments: 1. Farm Raised Inocula; 2. Commercially Produced Inocula; 3. Control (no inocula)
- Field Planting in Randomized Complete Blocks experimental using standard agricultural practices for each farm (conventional at Highmoor Farm and organic at Wolf Pine).

- Data collected at harvest included weight of rinsed leeks, length, diameter, and evaluation of disease.
- Data analyzed

Description of methods used to evaluate outcomes:

Leeks inoculated with the farm raised mycorrhizal inocula using a method developed at the USDA-ARS Research Station in Wyndmoor, PA yielded a higher mean weight of 21%, combined for both farms, compared to the control treatment (see table 1). The leeks from the commercially produced inocula did not produce a higher mean weight as compared to the control treatment. It was interesting to note that before planting in the field we had plants from all three treatments at both farms analyzed for presence of mycorrhizal colonization on the roots at the USDA-ARS Research Center in Wyndmoor, PA. The leeks treated with the commercially produced inocula had 0 colonization by mycorrhizal fungi, where the farm raised inocula treatment had abundant colonization by mycorrhizae.

Brief summary of the integration of research and extension activities:

Reporting on findings at meetings such as MOFGA Common Ground Fair (September 2010), York County Farmers Network Meeting, December, 2010, Master Gardener Volunteers, April, 2010. Will report on final study after 2011 field data analyzed at NE Fruit and Vegetable Growers Northeast Regional Meeting.

Educational material, publications, and programs:

Am repeating this study in 2011 to see if I can get similar positive results in two different years in the field study. Publication of results will be pursued following analysis of the 2011 study.

MAC118: Red and Specialty Potato Evaluation

Principal Investigators: John M. Jemison, Greg Porter, Mary Ellen Camire

Introduction

Opportunities exist for growth in the tablestock potato industry. While most of the potatoes grown in Maine go to the processing industry for the French fry and potato chip market, many farmers are exploring other/additional options. We had found the Carola potato to be attractive to customers during our 2005/2006 consumer survey testing that we conducted around the state. Keith LaBrie of St. Agatha, a member of the U.S. Potato Board, has developed a specialty market with the Carola potato, and these potatoes are being sold in 5 lb specialty bags between December and March. Another producer Danny Lejoie of Caribou has developed a market for JetBlue Airlines with their 'All Blue' potatoes. Given the interest in restaurants for special potato lines to add color and flavor to entrée offerings, Greg and I want to continue our evaluations of red and specialty potato varieties, and we want to continue to evaluate several lines from Kathy Haynes potato development program from Beltsville.



The Maine Potato Board (MPB) currently funds several research projects that that Greg and I have submitted, and they provide a significant amount of grant funding each year to support the potato breeding and variety testing programs upon which this grant is built (as described below several activities related to this project are funded by the MPB and USDA-NIFA). We did not submit this grant proposal for specialty potato evaluation at Rogers Farm to the MPB because we feel that it is most immediately applicable to market farmers, organic growers, and market gardeners rather than large-scale potato producers. Given the multiple audiences this information benefits, we come to the Maine Agricultural Center for funding this project.

We propose to plant 8 hills for each of 30-40 clones (reds and purples) from Greg's program at Rogers Farm, Stillwater, ME. We will perform quality analysis to see if we can identify high quality, attractive, high-antioxidant potatoes. Samples will be tested for boiled quality and tuber glycoalkaloid (TGA) levels at the Department of Food Science and Human Nutrition Using USDA-NIFA and Maine Potato Board funding obtained by Greg's program, these clones are also being tested in northern ME (Presque Isle and St. Agatha), FL, NC, and NJ to determine regional adaptation and potential for our seed markets. With the information from the six sites, we should have a good handle on appearance, external and internal quality, scab resistance, and specific gravity at the end of the 2010 growing season. We will need to use this information plus the TGA levels and cooking quality (at least boiled tests) to determine which to move forward with from this group. Phytochemical content will be determined for the most promising clones identified in the project. We'll have another group of new clones coming along each year to select from, too. So this could run two or more years and result in an array of reds, purples, and colored flesh clones that will appeal to consumers. In addition to this, I'll evaluate a dozen of Kathy Haynes varieties that showed promise last year.

Goals and Objectives

1. Goal 1. From approximately 50 new red/specialty potato lines from the University of Maine and USDA-ARS Beltsville breeding programs, find several promising potatoes to move forward toward commercialization on small- and large-scale farms.

- Objective 1a. Plant and evaluate between 40 and 50 red and specialty potatoes for yield, quality, and phytochemical content (total glycoalkaloid, total antioxidant level, ascorbic acid and dehydroascorbic acid).
- 2. Goal 2. Further evaluate potatoes found to have the highest nutritional content in 2009.
 - Objective 2a. Assess if they remain high in year two, and see how they perform in a (hopefully) more normal production year.
 - Objective 2b. Evaluate for disease resistance, herbicide tolerance and other potato production issues.
- 3. Goal 3. Growers will learn about the results of this study through standard Cooperative Extension training opportunities.
 - Objective 3a. Results of both trials will be presented at the Agricultural Trades Show, and the potato conference.
 - Objective 3b. An article will be prepared for Spudlines and the UMCE blog.

Final Report

List of original project objectives that were met and significant findings:

1. Goal 1. From approximately 50 new red/specialty potato lines from the University of Maine and USDA-ARS Beltsville breeding programs, find several promising potatoes to move forward toward commercialization on small- and large-scale farms.
 - Objective 1a. Plant and evaluate between 40 and 50 red and specialty potatoes for yield, quality, and phytochemical content (total glycoalkaloid, total antioxidant level, ascorbic acid and dehydroascorbic acid).
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 - Objective 3a. Results of both trials will be presented at the Agricultural Trades Show, and the potato conference.
 - Objective 3b. An article will be prepared for Spudlines and the UMCE blog.

List of original project objectives that were *not* met:

- Objective 3a. Results of both trials will be presented at the Agricultural Trades Show, and the potato conference.

We meet with a potato advisory group in October to set the potato conference agenda. I proposed this topic to them, and since most there are processing growers, it got a luke-warm response. So only an article for spudlines was done.

Description of methods used to evaluate outcomes:

After the field was fertilized and prepared for planting, rows were marked by the planter and potatoes were hand-planted on 12 May 2010 with a 9 inch spacing. We planted forty 8-hill plots of Greg's and Kathy Haynes (Beltsville, MD) new red and specialty varieties. In addition we planted 11 4-row (20 ft long) plots of potatoes from varieties that had made the 8-hill cut the previous years. Growing these provides additional information for Greg and the breeding team to make further decisions on their potential success in Maine. *This met the first objective above.*

Following planting, Sencor and Dual were used to control weeds, and fungicides were applied on an as-directed by the Pest Management Staff recommendations. Colorado potato beetles were the primary insect pest in the project and imidichloprid (Platinum) was used along with Coragen to control these.

Evaluations were made a month after planting to assess Sencor susceptibility, and early growth and development. We monitored stand, early vigor, foliage color, and herbicide injury. In early July, we repeated these evaluations for stand, quality, uniformity of growth, and overall vigor. *This met part of objective of 2b above.*

At harvest, we took yield and quality measurements for all the 8 hill plots, and from one row of the four row plots. We rated potatoes for percent misshapen, scab, rhizoctonia, silver scurf, net necrosis, and any other characteristic useful to know whether these potatoes should move forward or be dropped from consideration. Potatoes were also assessed for nutritional quality (Antioxidant and Phenolic properties) as well as glycoalkaloids. *This met the remainder of objective of 1a and 2b above.*

The Rogers farm site was highly useful as we found conditions with our varieties that weren't seen on other sites. I had one particular favorite line we evaluated last year – it was the pinto bean potato. Mark Guzzi at Peacemeal farm is growing it. We will assess customer interest in a few weeks. We also found several of the 8-hill varieties that had higher than average nutritional properties. This was factored in along with yield and quality information for making selections to do further evaluation in 2011.

Integration of research and extension activities:

- Potatoes were featured at the Sustainable Agriculture Field Day at Rogers Farm. An article on potato nutritional quality was posted on the UM blog.

MAC119: Quality of Direct Cut Vacuum Silage (DCVS) for the Northeast

Principal investigators: Richard Kersbergen, Martin Stokes

Background and Objectives:

A major issue limiting the profitability of small farms in the Maine is the cost of forage and feed supplements during the winter or non-grazing season. Harvesting and storing high quality forages is essential to sustainable production of meat, milk and fiber by ruminant animals. High quality forage reduces the need for expensive purchased energy and protein supplements. By reducing the need for these supplements, producers can feed more quality forages that are healthier for ruminants as well as reducing the fuel transportation costs associated with importing grain.

Work at the University of Illinois (Ricketts, G. E. et al, Management Guidelines for Efficient Sheep Production, North Central Regional Extension Publication 240, University of Illinois, Urbana-Champaign, 1993) has shown that sheep feed costs can be reduced by as much as 50% when forage testing 16% protein or higher on a dry matter basis is supplied during the winter months.



In order to maximize the quality of stored forages, harvest needs to begin in May. At this stage the “leaf to stem” ratio in grasses is at the optimum as measured by protein and energy content of the plant material. To store this material as dry hay is difficult in the northeast due to the low probability of 2-3 consecutive dry days to adequately desiccate the hay to a level that is safe for storage. Grass/legumes mixes are commonly 80% moisture when harvested and need to dry to 20% to prevent mold/spoilage from taking place. Not only is the weather a factor, but the quality of the final product is often diminished due to the number of times the material must be handled (tedded and raked).

Large farms that are trying to maximize stored forage quality deal with this challenge by not trying to produce hay but instead by producing silage. To produce silage the crop is cut and processed the same day. For round bale silage it is common to cut, let lie for a few hours to wilt and bale same day. Similar procedures are used for grass silage that will be stored in an upright or bunker silo. All of the silage making procedures depend upon the soluble carbohydrates in the forages being anaerobically fermented. The fermentation produces organic acids that act as preservatives to prevent mold and putrefaction. The overall benefit of silage production is to harvest forages at prime nutrient content (early maturity) with a procedure that is much less weather dependent than making dry hay.

Unfortunately, for small farms, the capital equipment costs associated with these systems is often prohibitive. For example, the equipment to produce round bale silage: a mower/conditioner, baler, bale wrapper and a transport system, have an estimated new cost of \$80,000.

In the last few years an alternative, lower cost silage system has become available in the United States. It was designed in New Zealand and has been in common use for producing silage for dairy, beef and sheep in that country. The process is called the “direct cut vacuum silage (DCVS) system” and has a capital investment of about one-half that needed to make round bale silage. Some work has been done to evaluate the capital and operational costs of the DCVS system but little has been done to evaluate the nutritional value of the silage compared to the more capital expensive round bale silage process.

This Maine Agriculture Center Project will collaborate with a funded project submitted by Seth Kroeck from Crystal Spring farm in Brunswick, and Tom Settlemire from Brunswick to the Northeast Sustainable Agriculture Research and

Education (SARE) Farmer/Grower program. The project will have several objectives. The project will address the questions:

1. Can high quality stored forages be produced using direct cut vacuum silage in the Northeast
2. What potential fermentation and quality issues might need to be addressed with this alternative fermentation process, including the possibility of harmful organisms being in the silage (Clostridium)?
3. What low cost additives might be able to be incorporated into this system to provide both a high quality protein feed, but also forage with a high level of digestible energy?

The final objective of the project will be to compare the costs per unit of harvested protein and energy with the DCVS system with that of round bale silage.

Brief description of research and extension activities:



This MAC funded project will expand on activities and research already planned at Crystal Spring Farm in Brunswick as part of the SARE funded proposal. Equipment to produce DCVS will be leased from an equipment supplier in Illinois. In order to better evaluate the direct cut process, the control will be to hire a local farmer to make round bale silage from the same fields at the same time the direct cut silage is harvested. Specifically, MAC funding will be used to evaluate sugar and grain additives to the fermentation process. These additives are anticipated to improve fermentation and improve feed quality at a minimal cost. Additionally, MAC funds will be used to cover expenses associated with travel to the research site and additional quality testing for nutritional quality and for harmful organisms and/or toxic end products.

Forage material to be harvested will come from several different fields, each representing a different mix of grass/legumes. By harvesting from several fields growing different grass/legumes mixes we will be able to describe whether forage type has an influence on quality in the direct cut /round bale silage comparison.

Samples of the material will be taken at harvest time and at timed intervals during the fermentation process from the direct cut silage and round bale silage. All samples will be analyzed for energy and protein as well as a fermentation profile for acetic, butyric and lactic acids and ammonia nitrogen. Analysis will be done at the Dairy One Lab, Ithaca, NY. A scoring method developed by Hutton (Evaluating Silage Quality, Government of Alberta, Agriculture and Rural Development 2008) will be used to rank the forages. Additional sampling will be done for Clostridium organisms.

Cooperative Extension will work with Crystal Spring Farm to conduct several field days and workshops associated with this project. Both Crystal Spring Farm and Tom Settlemire have a proven track record with extension education, including pasture walks, presentations at meetings and intensive research. In addition, materials for publication in popular press and trade magazines will be produced. Crystal Spring farm also anticipates producing a video on the process.

Expected project outcomes:

1. An economic evaluation of the DVCS for forage preservation.
2. Increased evaluation of fermentation products associated with DCVS.
3. An evaluation of low cost silage additives to the DCVS system.
4. A potential new system for small farms to produce quality forages.

Final Report

List of original project objectives that were met and significant findings:

Expected project outcomes:

Our goal for this project was to work collaboratively with Crystal Springs Farm in Brunswick to investigate Direct Cut Vacuum Silage as a viable low cost option for small farms to produce high quality silage to feed their livestock during the winter months. We tested this process using leased equipment from the midwest and compared it to round bale wrap systems currently in use in our area.



1. An economic evaluation of the DCVS system for forage preservation.

We used custom harvest rates from Iowa and Pennsylvania to calculate the cost of preserving this feed using a direct cut system as compared to a round bale silage process. Time cost 1.75 hours to cut and pile 2 acres alfalfa. Using 2010 Iowa Farm machinery calculator at an average rate of \$60/hr. for flail chopping (the closest application to running the vacuum silage “lacerator”) this would equal \$105 for 8 tons of forage, or a little more than \$13/ton. Additional costs of plastic and vacuum extraction were a little more difficult to estimate, but were approximated at \$9.00 per ton for a total cost of \$22/ton. Round baling silage estimates are \$17.00 per ton for baling, \$12 per ton for mowing and \$13.00 per ton for baling for a total cost of \$42/ton. While this process is cheaper, there were some additional “hidden” costs. “Piles” need to be made near the field due to nature of the process. These piles may or may not be located near the winter feeding area, so additional transportation costs may be necessary.

2. Increased evaluation of fermentation products associated with DCVS.

We evaluated two fermentation additives. The first was simple granulated sugar and the second was a propionic based preservative. Distributors of the commercially available preservatives were very wary of us using their product since they were not designed or evaluated under such high moisture conditions. Most refused to sell us their products when we told them of how we were going to use them. From our data, it seems that the availability of fermentable sugars in enough concentration was a significant issue with feeds (especially alfalfa) at the high moisture content used in this system. Since sugar was the most limiting of all fermentation products entering the system, the only benefit we saw was when we used the simple granulated sugar as an additive.

3. An evaluation of low cost silage additives to the DCVS system.

Sugar was the only low cost fermentation product we tested in our trials

4. A potential new system for small farms to produce quality forages.

The vacuum ensiling process worked well with one of the six piles that were made. A combination of “learning process” mistakes and environmental conditions caused five of the piles to either not ensile correctly or become spoiled after ensiling.

Our first piles made in June 2010 included a pure stand of alfalfa with sugar additive or a commercial preservative as well as a perennial ryegrass stand with sugar or a commercial preservative. Additionally, we round baled the alfalfa (after wilting) and rye grass as comparisons. In this trial, none of the DCV alfalfa fermented properly and had to be composted. Volatile fatty acid profiles indicated that the feed would be potentially toxic to feed to animals. High butyric acid levels indicated that clostridial growth would have been extensive throughout the pile. The perennial ryegrass pile did ferment well, but was destroyed by birds that made holes in the piles shortly after construction and allowed oxygen to enter the system. Both the wilted alfalfa and the ryegrass round bales “check” fermented properly.

Having learned more about the system failures we made a successful pile from a late season cutting of alfalfa that was cut with a mower conditioner and allowed to wilt (increasing the sugar concentration by reducing the moisture). While this added cost (\$12/acre) the high moisture content, low sugar content and high buffering capacity of the alfalfa appears to make this step necessary. Using granulated sugar improved the fermentation as well. While this pile ensiled successfully and was fed out to the farm's ewe flock in January 2011, feed analysis did show that the process could be improved. Both lactic and acetic acid levels were lower than optimum as was the ratio between the two. The pH level was also slightly higher than "normal silage". The analysis for butyric acid, an indicator of poor quality silage was low, a good sign that the process used maintained anaerobic condition during fermentation and the substrate had enough fermentable carbohydrates.

Description of methods used to evaluate outcomes:

By making many silage piles in several locations with different forages we were able to assess this silage method and understand the variables that make it successful. We also tested various additives designed to improve the fermentation process. The low cost of this method both in capital and operational expense are in many ways balanced against a higher degree of complexity in using it to successfully make silage. Having the opportunity with this grant and a USDA SARE Farmer/Grower grant to explore the variables involved in using this system has allowed us to understand and adjust recommendations for any potential future use of this technology.

Integration of research and extension activities:

This project was a great example of on-farm participatory research. Driven by producers asking the question, UMaine researchers and extension faculty helped to conduct the trials and take appropriate samples for evaluation and testing. With MAC funding and SARE funding, important questions were answered for producers who were interested in adopting this technology on their farm.

List of external funding:

- SARE Farmer/Rancher Project FNE10-690 The Analysis of the Cost and Quality of Direct Cut Vacuum Silage for the Northeast. \$8442 Submitted by Seth Kroeck, Crystal Springs Farm, Brunswick, ME

List of educational material, publications, and programs:

Outreach for this project was three presentations of the vacuum silage process.

- The first was a field day on October 2nd at Crystal Spring Farm in Brunswick, Maine. There were 15 attendees at this event in addition to our technical advisors and the equipment supplier, Alpha-Ag. We spent 30 minutes looking at the equipment and talking about the process. We then went to the field and cut a few thousand square feet of forage and made a pile.
- On October 6th, we hosted the SARE "fellows" tour with 12 Extension faculty from across the nation and demonstrated the machinery and discussed the results of the project.
- The third presentation was done by Rick Kersbergen at the Maine Agricultural Trades Show Augusta, Maine on January 12th. The powerpoint document for this presentation is attached in a separate file.

MAC120: Evaluation of Scape Removal on Garlic Yield and Storability

Principle Investigator(s): Steven B. Johnson, David Fuller

Background:

Garlic has been cultivated for thousands of years and is widely used in many cultures. Hardneck garlic varieties (*Allium sativum* var. *ophioscorodon*) produce a flower stalk, technically a scape. The garlic grown in Maine is predominately the hardneck garlic varieties. There are over 70 commercial garlic growers in Maine representing all 16 counties (<http://www.mofga.org/>). Most garlic producers in Maine are market gardeners producing many crops. However, the contribution to farm income from garlic is disproportionately large when compared to the area planted. Garlic is an important portion of their farm income. There are several garlic growers in Maine that have over 80 percent of their farm income from garlic. The value of scape removal has not been clearly delineated in other garlic-growing areas. At present, there is no current locally data on the effect of scape removal on garlic performance and storage. Several environments will be evaluated for long-term garlic storage

Research Description:

Experiments will be conducted at two sites: the Maine Agricultural Experiment Station in Presque Isle (Aroostook Farm), and on a garlic farm near Farmington Maine. The Aroostook Farm site has four varieties and the Farmington site has one of the four varieties from the Aroostook Farm. Plots were established in September of 2009. Plots will be grown under appropriate conditions for the crop. The plot arrangement will be randomized such that a T-test can be performed on resultant data. As the scape reaches near full development, it will be removed in the appropriate plots. Field observations on the plots with intact and removed scapes will be collected. At harvest, yield and quality measurements will be taken. Garlic bulbs from plots will be placed into environmental conditions of varying temperature and relative humidity conditions. Period assessments of the weight and quality change will be noted. Data from the trial will be statistically analyzed and summarized for publication.

Projected Outcomes:

Results of this study will be presented to growers through presentations at meetings, which may include the Maine Vegetable and Small Fruit Growers Annual Meeting, and the New England Vegetable & Berry Growers Winter Meeting, MOFGA annual meeting, Master Gardener meetings, as well as local producer meetings. The results will be available to Master Gardeners. There may be opportunities to have the data in other media forms such as print.

Final Report

Original project objectives that were met and significant findings:

- Objective 1 was to investigate the effect of garlic scape removal on garlic yield.

	Harvest mean weight of bulbs (g)		
	Scape removed	Scape remained	Weight increase
Aroostook Farm			
Chesnok Red	22.55	18.13	+17%
Romanian Red	34.19	23.70	+29%
Music	54.62	40.76	+47%
German Extra Hardy	63.74	46.87	+36%
Farmington			
German Extra Hardy	30.01	20.25	+48%

All differences were statistically significant ($p=0.001$).

- Objective 2 was to investigate the effect of garlic scape removal on garlic storability.

	Bulb mean weight difference (descaped vs. with scape)				
	(research) storage 1	storage 2	(new wing) storage 3	storage 4	storage 5
Chesnok Red	-0.0127	+0.0462	-0.0054		
Romanian Red	-0.0405	-0.0585	+0.0421		
Music	+0.0047	-0.0128	-0.0053		
German Extra Hardy	-0.0091	-0.0127	+0.0017	+0.0270	+0.0158

All differences were not statistically significant ($p=0.001$).

Description of methods used to evaluate outcomes.

Experiments were conducted at two sites: the Maine Agricultural Experiment Station in Presque Isle (Aroostook Farm), and on a garlic farm near Farmington Maine. The Aroostook Farm site had four varieties and the Farmington site had one of the four varieties at the Aroostook Farm. Plots were established in September of 2009 and the garlic crop was grown under appropriate conditions for the crop.

As the garlic scape emerged, it was removed in the appropriate plots. Scapes were removed on June 30 at the Aroostook Farm site and on June 20 at the Farmington site. Plots consisted of 5-bulb units and were arranged so that a T-test can be performed on resultant harvest data. The Aroostook Farm site was harvested on August 10 and the Farmington site was harvested on July 28. At each site, appropriated drying was performed. At the conclusion of drying, the bulb weight of each plot were measured.

Data from these studies show a 20 to 48% increase in bulb yield (variety dependant) resulting from scape removal. These local data will be incorporated into garlic-growing presentations and can return up to 48% to the grower.

Selected plots were placed into separate storages. Three separate storage conditions were maintained at the Aroostook Farm. These consisted of 42F with 90% RH (storage 1), 60F with 60% RH (storage 2), and 60F with 30% RH (storage 3). Two separate storage conditions were maintained at the Farmington area farm. These consisted of 60F with 30% RH (storage 4), 60F with 40% RH (storage 5)

Data from these studies show no difference in storability as measured by moisture loss. These local data demonstrate that growers can remove the scape and not suffer reduced garlic bulb storability. These local data will be incorporated into garlic-growing presentations.

Integration of research and extension activities:

An outreach effort of this project is the Maine Garlic Project, a participatory research project where 236 people have signed up to plant garlic, record and share data. A monthly newsletter has been delivered to these Maine Garlic Project participants. Further research objectives have been solicited from this group of garlic growers.

List of external funding:

A grant covering 3 years, LNE11-306, Increased profits from disease-free garlic planting stock, was submitted to and funded by NE SARE (\$121,341).

MAC121: The Economics of Producing Grass-Finished and Natural Beef in Maine

Principal Investigators: Stewart N. Smith, Andrew Plant, Dee Potter, Aaron K. Hoshide

Background

Recently consumer demand has grown for both grass-finished and natural beef raised without antibiotics and hormones. Health benefits such as lower saturated fat and potentially higher amounts of conjugated linoleic acid explain why consumers are willing to pay more for grass-fed beef (Umberger et al., 2009). Also, local grass-finished and natural beef use no antibiotics/hormones and slower line speeds at slaughtering facilities minimize *E. coli* contamination. Maine has exemplified this growth in natural and grass-finished beef especially in Aroostook County. Over the past dozen years, the beef herd in Aroostook has substantially increased from 2895 head (USDA, NEASS, 1997) to roughly 8000. This growth has happened while the past 30 years has seen a 50% decline in American consumer demand for beef resulting in a 60% reduction in revenues to U.S. beef producers (Marsh, 2003).

Basic economic budgeting research is lacking for the Maine beef industry. The proposed research is especially timely since beef is an agricultural industry in Maine that has more than doubled in the past decade due primarily to one of the Northeastern U.S.'s largest cattle grazing and feedlot operations in Fort Fairfield, Maine. Many other agricultural sectors in the state have declined or remained stable. The potential to expand Maine's cattle industry is relatively large but Ramsey et al. (2005) found farm size, amount of feed, capital investments, breeding, and cull rates impacting financial performance of beef herds in the Southwest and those issues are also concerns in Maine. A study in Greece showed revenues from beef farming covered only 55% of total costs (Kitso-panidis, 2004). Maine beef producers confirm such inconsistent to unsatisfactory profits.

How can profitability and risk be improved for beef producers? Evans et al. (2007) showed greater profits and less risk with intensive pasture management. Grass-feeding and grass-finishing take advantage of Maine's grass base. Underutilized dairy farms may be able to diversify into direct marketing beef. Natural beef feed lots need to balance economies of scale while minimizing impacts of confined feeding. Disposing of manure is essential and selling composted feed lot bedding may solve that problem, diversify revenues, and make significant contributions to the agricultural community. However, the cost effectiveness of spreading composted manure impacts not only the feasibility of better integrating potato and beef cropping systems in Aroostook County but of diversifying organic agricultural amendments throughout the state as well.

Objectives

A simple cow/calf budget based on an Aroostook County beef farmer from a previous study will be used to understand the expanding grass-finished and natural beef industry in Maine. While this budget is useful, it does not model larger farm sizes nor any sort of cattle finishing program. Information from cooperating farmers, finishers, and researchers as well as other sources will be used to update and construct representative beef enterprise budgets, including operating and ownership costs. Budget analyses will:

1. Determine the profitability and cost of raising and finishing beef for small (20 head), medium (100 head), and large (500 head) farms or operations. Representative enterprise budgets will be constructed for all three sizes based on an adaptable master budget template.
2. Compare the profitability of finishing beef using rotational grazing and/or grass silage for all farm sizes. Contrast with the profitability of grain finished beef for small, medium, and large operations.
3. Both on-farm and off-farm finishing will be budgeted for all farm/operation sizes. Grain finishing budgets will explore results when concentrated feed is purchased and when the ration is mixed at the feeding location with or without using cull potatoes. If possible, representative enterprise budgets will account for typical differences in weight gain for grass versus grain finishing.
4. Using partial budgets for small, medium, and large feedlots, determine costs of stacking, composting, and spreading manure on nearby cropland used to grow concentrates.

Research and Extension Activities

Project outputs and activities would include:

1. Representative budgets available via UMaine Cooperative Extension website for download by producers, finishers, researchers, and other interested parties.
2. Fact sheets for grass-fed and natural beef producers summarizing budget results.
3. Presentation of results and distribution of adaptable budgets on CD-RW at December 2010 beef conference or January 2011 Ag Trades Show in Augusta, Maine and at Field Days in Aroostook County during spring/summer of 2011.

Expected Outcomes

This project will improve understanding of the economics of raising and finishing grass-finished and natural beef for three farm sizes using both on-farm and off-farm finishing. The relative profitability of raising and finishing beef under these scenarios will be determined. Potential areas and avenues for reducing costs will be identified. Beef producers will better understand the economics of beef production as well as ways to improve the profitability and sustainability of their farms and operations.

Final Report

List of original project objectives that were met and significant findings:

1. Determine the profitability and cost of raising and finishing beef for small (30 head), medium (100 head), and large (500 head) farms. Representative enterprise budgets will be constructed for all three sizes based on an adaptable master budget template.

A generalized master budget template for beef production was developed which was then altered to model different farm sizes to meet Objectives 1 and 2a. Net farm income (NFI) for natural grass-fed beef sold as either feeder beef or mature cattle was sensitive to economies of scale. Feeder beef profitability was determined where operators sold year-old beef cattle to local feedlots. According to cooperating producers, most feeder beef cattle in Maine are sold to feedlots and not to backgrounders. NFI measures total farm profitability and is equal to total revenues minus both variable and fixed costs. Representative beef budgets were developed for small (30 head of young stock), medium (100 head of young stock), and large (500 head of young stock) operations. Revenues were from both feeder cattle sold to local feedlots and cull cattle assuming a 10% cull rate. Total farm NFI increased annually from -\$8,240 to \$10,169 to \$28,387 going from small to medium to large.

2. (a) Compare the profitability of finishing beef using rotational grazing and/or grass silage for all farm sizes.

Representative budget models were also created for retail (small) and wholesale (medium and large) marketing of mature beef cattle. Small (30 head of mature cattle) farms that sold directly to consumers had higher labor costs for marketing and slaughtering. Medium (100 head of mature cattle) and large (500 head of mature cattle) farms sold mature cattle wholesale to retailers who would then sell to consumers. Cull cattle also contributed to farm revenue. Total farm NFI improved for all model sizes increasing to -\$6,357, \$24,003, and \$97,556 for small, medium, and large respectively. The economies of scale demonstrated for both natural feeder and mature beef cattle suggest that most beef producers in Maine are not operating at efficient scale to support a family on income earned exclusively from producing beef.

List of original project objectives that were not met:

- 2b. Contrast with the profitability of grain finished beef for small, medium, and large operations.
3. Both on-farm and off-farm finishing will be budgeted for all farm/operation sizes. Grain finishing budgets will explore results when concentrated feed is purchased and when the ration is mixed at the feeding location with or without using cull potatoes. If possible, representative enterprise budgets will account for typical differences in weight gain for grass versus grain finishing.

4. Using partial budgets for small, medium, and large feedlots, determine costs of stacking, composting, and spreading manure on nearby cropland used to grow concentrates.

Objective 2b as well as Objectives 3 and 4 were not met due to a request by a major beef finisher to keep feedlot ration, pricing, and capital investment cost data confidential due to the limited number of finishing operations in Maine. The representative budgets generated by this project are designed so that on-farm and independent feedlots can use one of the three sized budget models most appropriately scaled to their operation to enter their revenues and cost structures to determine feedlot-specific budgets for their operations.

Description of methods used to evaluate outcomes:

Currently beef producers have used simple one-page whole-farm budgets to determine overall farm profitability. While this is a simple, rapid way of seeing overall farm profitability, it does not capture more detailed information about animal prices and weights by age and sex, revenue streams, specific labor operations and fuel use for these operations for crop and livestock management, as well as a complete itemized equipment depreciation schedule for all capital investments. The representative budgets developed through this MAC project allow specification of all the above detailed information for producers to customize to their individual operations.

Integration of research and extension activities:

Extension outreach programs through the Knowledge Transfer Alliance during the 2011 Maine Ag Trade Show and during the Spring of 2011 assisted in developing one-page budget templates for grass-based beef for each participating farmer. Three grass-based beef operations (one in each size category) and one beef finisher were interviewed and surveyed for this project. Beef producers will develop farm-specific budgets off of the more complex multiple-worksheet representative budgets produced through this MAC project both on-farm as well as during the upcoming 2012 Maine Ag Trade Show.

External funding both sought and received:

- Criner, Mahon, Stevens (Hoshide contracted). Knowledge Transfer Alliance (Maine Agriculture). U.S. Dept. of Commerce/Economic Development Administration. \$1,820,000. 9/1/09-8/31/12. Extension outreach to Maine beef producers funded by the Knowledge Transfer Alliance above was instrumental in completion of this MAC project for beef cost of production.

Educational material, publications, and programs:

Cooperating beef producers in Maine will be using these 3 representative budget templates to upgrade their baseline one-page budgets in the third and final year of the Knowledge Transfer Alliance during extension outreach over the phone and during the 2012 Maine Ag Trade Show. All three representative Excel budgets will be further refined with cooperating producer input and initial and revised versions of these representative budgets will be publicly available for other beef farmers and local feedlots outside of Maine to use and adapt to their specific circumstances for beef production.

MAC122: Economic Impact of Maine Agriculture

Principal investigators: Todd Gabe, James C. McConnon Jr., Richard Kersbergen

Background and project objectives:

The agricultural sector—broadly defined to include producers, service providers and support organizations, processors, transporters, wholesalers, and direct-to-consumer retailers—is a major contributor to the Maine economy. Agricultural goods and services generate substantial revenue, much of which comes from out-of-state sales that enhance Maine’s export base. Maine agriculture provides employment to thousands of sole proprietors and workers that support families and communities across the entire state. While this sector is clearly important to the Maine economy, its economic impact has not been fully explored or quantified.

The purpose of this study is to examine the economic impact of the Maine agricultural sector. Specific objectives are to (1) develop a clear and widely-accepted “definition” of the agricultural sector; (2) determine the sales revenue, employment and income that are directly related to the Maine agricultural sector; (3) estimate the “multiplier effects” associated with the activities of Maine agriculture; and (4) disseminate study findings to industry stakeholders.

Brief description of research and extension activities:

The study will be completed in four steps, each corresponding to one of the project objectives listed above. The first step involves defining the agricultural industry. Although this may seem like a simple task, the agricultural sector includes a diverse group of producers, service providers and support organizations, processors, transporters, wholesalers, and direct-to-consumer retailers. In order to arrive at an economic impact figure that is supported by the industry, we will need to engage stakeholders to determine the types of agricultural-related activities to include in the analysis. This will be done through a review of the literature and a series of meetings conducted with agricultural interests across the state.

Step two of the project involves determining the sales revenue, employment and income that are directly related to the Maine agricultural sector (as defined in step one). This information will come from a variety of data sources including the Census of Agriculture, County Business Patterns of the U.S. Census Bureau, Occupational Employment Statistics of the U.S. Department of Labor, the American Community Survey of the U.S. Census Bureau, and various reports on sub-sectors of the Maine agricultural industry (e.g., *The Creative Agricultural Economy*, 2008; *A Survey of the Maine Potato Industry: Its Economic Impact*, 2003, etc.). When compiling and combining data from several sources, special attention will be required to assure that we provide a thorough coverage of the agricultural industry (based on how it is defined in the study) without “double counting.”

Step three of the project involves estimating the “multiplier effects” associated with the Maine agricultural industry. These are the additional impacts—to other sectors of the Maine economy—generated by the spending of households and businesses that are directly related to the agricultural industry. Multiplier effects will be estimated using an input-output model (e.g., IMPLAN) of the Maine economy.

The final step of the project involves disseminating study findings to industry stakeholders. This will be done through a series of meetings—in some cases, revisiting groups and individuals who provided input into the definition of Maine agriculture—as well as a final report that outlines key study findings.

Expected project outcomes:

The most important outcome of the study will be a better understanding of the economic importance of the Maine agricultural industry. As noted previously, this information will be disseminated to industry stakeholders and other interested parties through a series of meetings and the release of a project report. Results of this study will likely be used by other University of Maine researchers and extension faculty in applying for NIFA and other grants focused on supporting Maine agriculture.

Final Report

Original project objectives that were met and significant findings:

2. Determine the sales revenue, employment and income that are directly related to the Maine agricultural sector. The Maine food industry has a direct economic contribution of \$7.5 billion in sales revenue, 77,857 full- and part-time jobs, and \$1.7 billion in labor income.
3. Estimate the “multiplier effects” associated with the activities of Maine agriculture. The multiplier effects associated with the Maine food industry are \$4.0 billion in sales revenue, 34,817 full- and part-time jobs, and \$1.4 billion in labor income.
4. Disseminate study findings to industry stakeholders. We published the findings from our study in a *Maine Policy Review* special issue (released in July of 2011) on food in Maine.

Original project objectives that were not met:

1. Develop a clear and widely accepted “definition” of the agricultural sector. Early in the project, we were given the opportunity to submit a journal article on the economic impact of the Maine food industry, which is broader than the agricultural sector. Although the study considered a more comprehensive industry than agriculture, information presented in the article focuses on agricultural sales as a sub-sector of the food industry.

Description of methods used to evaluate outcomes:

This is in progress. The journal article was released in July of 2011, so it’s too early to evaluate outcomes. With that in mind, we received—prior to the article’s formal release—several requests for our study. The information from the study will likely be used by a variety of stakeholders throughout Maine.

Integration of research and extension activities:

University researchers and extension faculty collaborated on the project. Extension will play a key role in outreach efforts associated with the project.

Educational material, publications, and programs:

- Results of the study will be presented to an audience of Northeast U.S. extension / research faculty at a conference scheduled for September 18-20, 2011, in Philadelphia, PA. In addition, we plan to share results of the study at a national extension conference (NACDEP) in May 2012.