Winter grain and short-season corn double crop forage systems: an integrated weed management strategy for organic dairy producers

John Jemison – University of Maine Cooperative Extension
and
Heather Darby – University of Vermont Extension

As a result of this multi-state research and extension project, organic dairy producers will adopt an environmentally sustainable winter grain, short-season corn double crop forage production system as an alternative to intensively cultivated full-season silage corn. Organic dairy production is a strong growth area of Northeast agriculture, but sustainability of this growth is largely dependent on production of high quality feed while minimizing weed pressure. Due to high feed costs, producers must maximize on-farm forage and grain production. Field trials will be conducted at two university experiment stations and two organic dairy farms. The weed management IPM program that is the product of this work is primarily designed for northeast organic dairy producers, but it is applicable to all dairy producers. This project meets many goals identified by NE IPM including working with underserved audiences, and the development of easily implemented IPM systems and non-chemical pest management strategies where few alternatives exist. Growers will understand and implement this production system through involvement in an effective extensive Extension outreach program. Organic producers will attend grower field day presentations, on-farm twilight meetings, and other educational meetings. Production system fact sheets and a web site will be developed for this project, and information will be incorporated into an eXtension organic communities of practice led by co-PI Heather Darby. Within two years of project completion, 40% of organic dairy growers that grow corn will use this system, improve weed management, and produce high quality forages which will lead to increased milk production and improved economic and environmental sustainability.

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Project Narrative

i) Problem, Background and Justification

Over the past three decades, many conventional dairy farms in the Northeast US have been forced out of business due to poor farm profitability. However, Maine milk production remains close to 600 million pounds of milk per year because a majority of the remaining dairy farms increased in size. The same trend has been observed in Vermont. As farm animal numbers increase, the potential for environmental impact increases. In contrast, organic production milk price premiums have allowed some farms to remain profitable with fewer animal numbers. Organic dairy production is one of the strongest growth areas of New England agriculture. According to the USDA, Maine had the highest percentage and Vermont the greatest number of organic dairies in the country in 2000 (Greene and Kremen, 2003). As of 2007, Maine and Vermont have over 280 certified organic dairies, and more farms are in the process of transitioning to organic production methods. Organic production offers an excellent way to reduce human and grower exposure to synthetic pesticides compared to conventional forage production practices, but fertilization and pest management constraints make production of high quality forages with manageable weed pressure extremely challenging (Dimitri and Greene, 2002). Feed is the single largest expense for organic dairies; as such, organic growers must maximize on-farm production of energy and protein (Parsons et al., 2007). Costs of organic grains are reported to be 1.7 to 2.3 times the cost of conventional grain (McCrory, 2001). While many organic producers grow corn and hay-based rotations, other growers are looking for alternative cropping systems that make better use of crop ecology to compete with weeds.

Small successful farms have the potential to be more sustainable. With more on-farm forage and grain production, there will be less imported feed, thus reducing nutrient loading. If farms increase profitability, less land will likely be converted to development, further improving water quality. Organic production systems may prove to be more sustainable because: 1) reduced purchased inputs (fertilizer and pesticides) and increased milk premiums may improve overall profitability; 2) diverse rotations reduce weed pressure and improve soil quality; and 3) there is reduced human exposure to synthetic pesticides through food and water. Given these benefits, Cooperative Extension and university research programs should explore ways to improve the effectiveness of organic dairy systems in New England. A stated goal of the Northeast IPM pest management priorities is to develop and implement integrated pest management (IPM) practices, tactics, and systems for specific pest problems while reducing human and environmental risks. This project will meet this goal by improving weed management in organic forage production.

Background and Justification

The first farms to convert to organic production methods were principally small grass-based operations. Now, as larger farms with annual-based cropping systems become certified organic, weed management in their forage production systems is becoming increasingly difficult. Information from the Maine Organic Farmers and Gardeners Association (MOFGA), the Maine Organic Milk Producers (MOMP), and the Vermont Organic Farmers Association (NOFA-VT) documents the degree of concern that these producers have about weeds and their impact on the long-term sustainability of organic forage systems (Allen, 2004; Morrison, personal communication). The Vermont silage corn crop profile document has also identified cultivation,

crop rotation, and intercropping strategies as ways to reduce weed pressure in organic corn (http://www.ipmcenters.org/cropprofiles/docs/vtcorn-field.html). Considerable research has been conducted in New England evaluating cultivation methods, intensity, and timing in organic silage corn, and results of this work have been summarized in a regional weed control guide for silage corn (Jemison and Bowmik, 2007). But, growers need to implement a systems approach to adequately control weeds in organic systems (Jemison and Reberg-Horton, 2006).

While most Northeast US dairy producers rely on conventionally produced silage corn and hay for their feed programs, organic producers frequently rely on a variety of cropping systems, rotations, and planting strategies to better manage weeds (Forcella et al., 1993; Mohler, 2001). While weeds have always been a problem for corn growers, one can argue that organic farmers produce a higher value commodity and have to fight pests with new tools and methods. Many growers have expressed the need for information on alternative forage systems that can utilize narrow rows and early emergence to out-compete weeds. We recently completed a three-year winter grain / summer annual grass double crop forage experiment where we compared forage yield and quality and weed competition in the double crop system compared to organic silage corn cultivated four times. We found that the double crop forage system had significantly (three to four times) lower total weed biomass with no cultivation compared to the full-season organic silage corn cultivated four times. However, we also found that the double crop forage energy (net energy at lactation/nonstructural carbohydrates) was significantly lower than the organic corn silage. Growers need high energy feed to have productive milking animals. A possible solution to the low feed energy would be to double crop winter grains with a short-season corn. Compared to full-season organic corn, winter small grains have full canopy closure reducing weed germination during the summer annual weed flush. The later-planted corn should emerge much faster than corn planted in middle to late May, and it too should be more competitive with emerging weeds (Liebman and Staver, 2001). Research is needed to evaluate if late-planted corn (following winter grains harvested at the boot or soft dough stage) would have similar weed competition as normally planted full-season corn. While many agronomists and university staff promote full season corn, we rarely find that long-season corn significantly out yields shorter season corn, and in most years, feed quality of short-season corn is equivalent or better than full-season corn. Short-season corn hybrids were evaluated on Maine and Vermont research trials in 2007, and most produced above the long-term state average of 18 tons/ac. If the winter grain short-season corn (WGSSC) double crop is effective, we may provide growers with a cost effective cover crop, improved yields, reduced weed pressure, and improved forage quality. This research needs to be conducted in diverse environments, soil types, and fields with different weed species. If it is shown that weed competition is reduced in this double crop system, it is easily adaptable to all farms currently growing corn organically. It may be equally applicable to any dairy farm in the Northeast. Conventional growers may find increased yields, less soil and nutrient loss, and reduced weed pressure. It is conceivable to expect high rates of adoption of the practice due to its wide potential applicability across much of the Northeast US.

Project success will also depend on successful technical transfer of the research results. The Extension component of this project will involve development of an information package focused on alternative methods of weed control in organic corn. This will include information on the WGSSC double cropping system, summary of the strengths and weaknesses of past double crop research, cultivation timing and frequency information in field corn, and other

factors influencing weed management. This educational outreach will help Northeast organic dairy producers learn the most effective weed management options available to them. The research information generated in this work plus the previously published information on organic weed control for corn summarized in the regional weed control guide for corn (Jemison and Bowmik, 2007) will be made available through the internet through the University of Maine and University of Vermont websites and to growers through eXtension.

How Project Addresses Northeast IPM Center Long-Term Goals:

The Northeast IPM Center (http://northeastipm.org/regu_regional.cfm) recently identified and prioritized pest management issues. In addition to being a previously identified Vermont priority, this project specifically addresses several of the following identified priorities:

General IPM Priorities for the Northeast – 2006:

Weed IPM: Research/extension demonstrations of weed management in sustainable/organic crop systems

Northeast Research, Extension and Academic Program Committee for IPM:

Use of web-based technologies for IPM decision making

IPM packages for diversified, high value crop producers

Pest Management Alternative Practices - 2007:

Develop or improve IPM options for weed management, including weed identification, for agricultural settings

Assess, develop, and distribute new or improved methods for pest monitoring systems

2006 Livestock/Field Crop IPM Priorities – NY state:

C. Integrated Management of Significant Pests Affecting Field Corn - Research on organic weed control methods

F. Integrated Management of Significant Weed problems in Field Crop Systems - improve efficacy, economics, and information on organic weed control

In addition to this, the Maine Organic Milk Producers (MOMP) have identified alternative weed management practices as a high priority issue (see accompanying letter of support). This group of organic dairy producers and other organic groups are underserved in New England as they have traditionally received less support than commodity farmers from USDA. This type of research support can help their farms become more sustainable.

As a result of this project, Northeast US organic dairy producers will adopt the WGSSC double crop forage production system that will reduce weed pressure, provide winter cover, and yield high quality feed for long-term dairy herd productivity and health. Compared to the traditional silage corn/hay feeding program, these alternative cropping systems take advantage of cultural practices (narrow rows) and crop ecology (planting timing and rapid growth to miss annual weed flush) to produce high quality and high energy forages with lower weed pressure. Use of these methods by organic dairy farmers will lead to reduced human exposure to pesticides, improved water quality, and improved farm sustainability.

ii) Project Goals and Objectives

Based on the needs and issues presented above, we have identified the following research and outreach goals and objectives for this project:

Goal: Develop a WGSSC double crop system that yields equivalently to full-season corn with lower weed pressure that can readily be adopted by organic growers.

Research Objective 1. We will evaluate the effectiveness of a winter small grain/short-season corn (WGSSC) double-crop forage system as a possible replacement for intensively cultivated full-season corn over a two-year period.

Research Method 1a. We will complete a five site-year comparison of the WGSSC double crop system to typical full-season organic silage corn at the University of Maine Rogers Farm Experiment Station and at the University of Vermont research farm at Alburg. Weeds in both full and short-season corn will be controlled using cultivation methods outlined in the New England weed control guide for corn. One site year will have been completed at the University of Maine Rogers Farm funded by the Maine Agricultural Center by the start of these trials.

Research Method 1a-1: Winter cereal survival.

- Evaluate winter survival of four winter cereals: winter barley, winter triticale, winter spelt, and winter wheat.

Research Method 1a-2: Winter cereal forage yield and quality.

- Assess forage yield at the boot and soft dough stages
- Test forages for nutrient quality and forage nutrient/energy yield.

Research Method 1a-3: Short-season corn growth and development:

- Compare growth and development of short-season corn planted following boot and soft dough stage cereal harvests to full-season corn planted in May.
- Document if later planting dates shortens time to canopy closure
- Compare short-season corn data to the yield and forage quality of full-season corn planted at standard NE corn planting dates.

Research Method 1a-4: Cropping system impacts on weed competition.

- Assess the effect of winter cereal variety (phenology) and winter survival on weed composition and biomass
- Assess the effect of winter cereal harvest timing (boot and soft dough stages) on weed composition and weed biomass in the short-season corn double crop. Weed samples will be collected at canopy closure and harvest.
- Compare weed composition and biomass of short and full-season corn cultivated twice using a tine cultivator and twice with a row cultivator
- Test the hypothesis that later planted corn will have a reduced flush of annual weeds compared to a standard corn planting date.

Research Method 1b: On-farm comparisons. In year two, we will initiate on-farm trials comparing yield and forage quality of the best two performing winter cereals (harvested again at boot and soft dough stage) with short-season corn variety to standard organic silage corn planted at a typical planting date on two organic dairies (one in Maine and one in Vermont).

Research Method 1b-1. Information from on-farm trials.

- a) Assess winter grain survival and determine yield at boot and soft dough
- b) Assess winter grain feed quality and nutrient/energy yield
- c) Assess time to canopy closure for short and full-season corn
- d) Assess short-season corn feed quality and nutrient/energy yield
- e) Assess weed composition and biomass at canopy closure and harvest in the short and full-season corn

Extension Outreach Objective 1. As a result of showcasing the short-season cropping systems to growers, growers will gain an understanding of the usefulness of this innovative method. They will understand potential for forage yield and quality, changes in weed competition, improved nutrient management and fit for USDA farm subsidy programs.

Extension Outreach Method 1a.

- Conduct winter educational programs for dairy farmers in Vermont and Maine
- Conduct summer field day educational programs at experiment station and cooperating farms for dairy farmers in Vermont and Maine
- At cooperating farm, demonstrate alternative cultural practices to enhance weed control such as cross planting to hasten canopy closure, winter grain seeding densities to assess effect on weed populations, and the use of some light cultivation in the best double crop systems
- Conduct training for agricultural service providers who work with the organic production community about the WGSSC double crop system
- Present research results at regional weed science meetings

Extension Outreach Method 1b. Develop an information package including organic production fact sheet series that summarizes the results from these projects and provides growers key information to implement these systems on their farms.

Extension Outreach Method 1b-1. Adapt these educational materials for the organic eXtension currently led by Heather Darby in Vermont.

Impact Objective 1. Northeast organic dairy producers will adopt WGSSC double cropping system that fit their farms and provide sustainable forage yield, quality, and weed management,

Impact Objective 1a. 40% of organic dairy producers currently growing silage corn will adopt the WGSSC double crop system within 2 years of the end of the study.

Impact Objective 1b. 50% of those producers adopting these double crop systems will find reduced weed pressure in problem fields.

Anticipated Impacts:

With completion of the research and extension objectives listed above, organic dairy producers who grow corn will understand the benefits of a four-season cropping system that will provide quality forage, reduced weed pressure, and improve the likelihood of the organic dairy industry to succeed. In Table 1, specific impacts associated with the adoption of this IPM practice are presented.

Table 1 – Connection of project objectives, outputs and outcomes to long-term IPM goals

Specific Objective	Output	Connection to specific IPM goals	Outcome
Research Objective 1	Complete 5 site-years of research – 2 site-years on producer fields to develop science-based weed management strategies	Multi-state partnership of two NE state organic agriculture programs – results are applicable across the NE region	Regional research efforts increase credibility Extending research to entire region – results applicable to all organic farmers growing corn in region
Research Objective 1	Complete trials of winter small grain survival in various soils and climatic conditions	Improve long-term crop rotation, improve soil health, and improve water quality through reduced soil erosion	Growers will grow winter cereals that provide qality forage and preserve long-term soil health.
Research Objective 1	a) Determine optimum time to harvest winter cereals b) Study effect of later planting date on short-season corn growth and development	Improve understanding of effective crop rotations	Increase capacity to produce quality forages, reduce purchase of off-farm feed, increased profits, reduce nutrient loading improving long-term soil nutrient balance
Research Objective 1	Assess effect of corn planting date on weed composition and pressure	Conduct research on how to suppress weed problems through cultural and biological production practices	More successful organic farms, less exposure by public to herbicides, less grower exposure to toxins
Research Objective 1b	On-farm evaluations of best production systems	Demonstration of research outcomes through on-farm trials	Increased likelihood of farmer adoption (ME/VT and NE region)
Extension Outreach Objective 1	Conduct winter educational trainings and summer field day demonstrations of WGSSC cropping system	Conduct research/extension demonstrations in sustainable/organic	Growers will see the cropping system - ask pertinent questions of researchers and

		cropping systems	cooperating farmers – increased likelihood of adoption
Extension Outreach Objective 1	Develop outreach materials (factsheets and web-based / eXtension materials) on cropping system research results and farming system implications	Develop organic IPM packages for high value crops, develop recommendations and disseminate information in usable form to farmers	Through multiple methods, growers will learn about WCSSC double cropping system Growers adopt the system and increase farm profitability
Impact Objective 1	***	Growers will adopt IPM methods to enhance success or organic farming systems	When 40% of producers adopt the system, we will see improved profitability of underserved organic dairy farmers

iii) Research, Education and Technology Transfer Plan: Approach and Procedures

To achieve the goals and objectives outlined in this project, a complete description of the methods used in this project is presented outlining the research and educational/technology transfer components of the project.

Phase One: Research–Experiment Station

To understand the strengths and limitations of the WGSSC double crop system, we will conduct field plot research at two locations (University of Maine Rogers Farm at Stillwater ME and the University of Vermont Research Farm in Alburg, VT) in year one. In early September, 2008, we will initiate field work. Using certified organic production land on both research farms, we will lay out a field experiment using a randomized complete block design with four replications. A plot plan for the design is provided in Appendix A. Manure will be applied using a small plot spreader to supply the nitrogen requirement of the winter grains, incorporated immediately and the ground prepared for small grain seeding. The four winter grains (wheat, triticale, spelt and barley) will be drilled at 150 – 175 lbs seed ac^{-1}. At dormancy, crop yield, weed composition, and total weed biomass will be collected from four (0.25 m^2) areas per plot. Plant material will be separated into crop and total weeds. This sampling protocol will be repeated in the spring to assess winter kill. We will be able to identify if one grain is particularly susceptible to the harsh NE winter, and in doing so, we will accomplish research goal 1a-1.

As soon as weather allows, (likely early May), manure will be applied and incorporated to the full-season corn. Field corn (maturity rating between 85 and 90 days for Maine, and 100 – 105 days for Vermont) will be planted at 34,000 seeds ac^{-1}. Field corn will be cultivated using a tine weeder once in the first four to six days after planting (when soil conditions are optimum) and again between the spike and two leaf stage. A row cultivator will be used to control weeds at the third to fourth leaf stage, and again at the fifth or sixth leaf stage of development. We will record days required for full-season and short-season corn to reach canopy closure. Weed counts

and biomass by species will be measured just following canopy closure and prior to harvest. As well, weed height at harvest by species will be assessed as a measure of potential weed seed rain.

Based on our previous winter grain research, no cultivation will be used in the winter grains. To assess yield and weed biomass, two (0.5 m^2) samples per plot will be harvested at both growth stages (boot and soft dough) for yield. Forage and weeds will be separated and dried. Weed composition and total biomass will be determined and expressed as percent of total yield. Forage samples will be ground and submitted to Dairy One for nutrient analysis. Wet chemistry analysis will be used on the small grains to determine plant constituents such as protein, neutral detergent fiber and acid detergent fiber digestibility. Following each harvest, plots will be disked and manure applied to meet the N requirement of corn. The short-season corn will be selected based on the results of the Maine Ag Center research in 2007/2008, and short-season corn hybrid yield trials conducted in Maine and Vermont in 2007. We will plant the short season corn following harvest of the boot and soft dough stage winter grains. Methods used for cultivation and weed sampling will be the same as described above. We will record the number of days required to reach canopy closure with short-season corn. These steps will allow us to meet research goal 1a-2, 1a-3, and 1a-4.

Corn yield will be assessed by harvesting the two center rows of each plot. Eight corn plants will be shredded, subsampled, and dried for moisture and nutrient analysis. Corn forage quality analysis will be done through Dairy One using NIR. Forage nutrient yield will be assessed by multiplying dry matter yield by components of the nutrient analysis (protein, acid detergent fiber, neutral detergent fiber, net energy at lactation, and nonstructural carbohydrates). Yield, nutrient components and nutrient yield will be analyzed using the general linear model procedure of SAS and mean separation using protected least significant difference techniques. We hope to identify a winter grain and short-season corn combination that provides significantly higher yield, forage quality, and reduced weed pressure compared to full-season corn.

Phase II - Research–Experiment Station

In Phase Two, the field research described above will be repeated in the same fields at each location starting in the fall of 2009.

Phase II – Research-On-Farm

In addition to the station experiments, in year two we will initiate an on-farm research component on two farms (one in Maine and one in Vermont). We will select the two highest yielding, highest forage quality winter grains from phase one, and plant them in large replicated blocks in production fields. We will double crop those winter grain plots with short-season corn as described above. Likewise, the same process will be done on the full-season corn experimental plots. A plot plan for this is located in Appendix A. The same data will be collected on this larger scale plot trial as was done in the station trials, and similar statistical approaches will be utilized. Four growers (two in Maine and two in Vermont) have expressed interest in evaluating alternative double crop systems for their farm (Spencer Aitel, S. China , Maine; Henry Perkins, Albion, Maine; Joe Hescock, Shoreham, VT; and Guy Choiniere, Highgate Center, VT). All of these producers are well known in the organic dairy production community. Mr. Aitel has been certified organic for six years and is an active participant with Maine Organic Farmers and Gardeners Association (MOFGA). Mr. Perkins has been a dairy

farmer for 35 years and is the president of MOMP. Both Vermont producers have been quite active in recent organic dairy meetings and on-farm research sponsored by UVM Extension. All of these producers grow organic corn and have the necessary cultivation equipment. As well, all have an interest to try alternative systems to improve weed management. We will use large replicated strip plots. We will take small and large scale measurements on the farm studies. The farmers have agreed to conduct the field work involved in the study/demonstration. Project staff will be responsible for all data measurements with assistance from the producers. Completing the on-farm components of this project will allow us to complete research goal 1b-1.

Phase Three: Educational Outreach and Technology Transfer

A key piece to this project is a strong educational outreach program. Maine and Vermont organic dairy producers have established organizations through which we will reach our audiences. Examples of these include MOMP, NOFA-VT, the Maine Sustainable Agriculture Society, Maine Dairy Improvement Association, and MOFGA. The University of Maine Cooperative Extension (UMCE) conducts an annual winter training for agricultural service providers each winter, and this project will be featured there. Research results will be disseminated through newsletters, meeting presentations, association annual meetings, and MOFGA's Farmer to Farmer training in November. In Maine, farmers will also be able to see this research at two field day presentations: the Sustainable Agriculture Field Day in early July (Phase One), and at a twilight meeting at the on-farm trial location (Phase Two). In Vermont, a summer field day will be conducted at the research farm in Alburg (also Phase One) and another grower meeting will be planned for their on-farm trial. A key component of the on-farm presentations will be to have the growers discuss their impressions of the WGSCC system.

Printed material is important to reach growers who do not typically attend meetings. We will develop an organic forage fact sheet series covering key research results. The factsheet will be available to other growers through Maine and Vermont's Cooperative Extension website (www.umext.maine.edu and http://pss.uvm.edu/vtcrops/), and links will be available to access these fact sheets from the CSREES Region One water quality website (www.usawaterquality.org) as well. Finally, newsletter articles will be published in Cows and Crops, as well as in MOMP and NOFA-VT and Northeast Organic Dairy Producers Alliance (NODPA) newsletters. In addition, a dedicated project website (with links from the UMaine and CSREES Region One websites) will be developed in the fall of 2009, and we will post all news articles, research findings, fact sheets and workshop/field day announcements pertaining to the project. This will be housed as part of the UVM Vermont Crops and Soils webpage (http://pss.uvm.edu/vtcrops/).

Time Table for Start and Completion of Project Tasks

Objective	Description	Phase	Tasks	Completed by
Research method 1a-1	Winter cereal survival assessment	I	Collect biomass prior to winter and following	Initiated 10/30/08 Completed 5/1/09
Research method 1a-2	Determine optimum time for winter cereal harvest - effect of later planting date on short-season corn development	I	Harvest at boot stage and soft dough	Late June 09 and Early July 09

Research method 1a-3a	Compare time to canopy closure between full and short-season corn	I	Track planting date and time through leaf stages	May 09 – August 09
Research method 1a-3b	Compare short-season corn yield and quality to full-season corn yield and quality	I	Harvest, dry, grind, and prepare samples for analysis	September and October 2009
Research method 1a-4	Cropping system impacts on weed competition	I	Collect winter cereal yield and weed biomass	Late June 09 and Early July 09
Research method 1a-4	Cropping system impacts on weed competition	I	Collect weed information at short season corn canopy closure and at harvest	Late July and September 09 Early August 09 and September 09
Research methods 1a-1 and 1b-1-a	Winter cereal survival assessment	II	Collect biomass prior to winter and following	Initiated 10/30/2009 Completed 5/1/2010
Research Methods 1a-2 and 1b-1-b	Determine optimum time for winter cereal harvest - effect of later planting date on short-season corn development	II	Harvest at boot stage and soft dough	Late June 2010 and Early July 2010
Research Methods 1a-3a and 1b-1-c	Compare time to canopy closure between full and short-season corn	II	Track planting date and time through leaf stages	May 2010 – August 2010
Research Methods 1a-3b and 1b-1-c	Compare short-season corn yield and quality to full-season corn yield and quality	II	Harvest, dry, grind, and prepare samples for analysis	September and October 2010
Research Methods 1a-4 and 1b-1-d	Cropping system impacts on weed competition	II	Collect winter cereal yield and weed biomass	Late June 2010 and Early July 2010
Research Methods 1a-4 and 1b-1-e	Cropping system impacts on weed competition	II	Collect weed information at short-season corn canopy closure and at harvest	Late July and September 2010 Early August 2010 and September 2010
Extension	Conduct winter educational	III	Three trainings:	* 11/2009

Outreach Method 1a-1 Part a.	programs for Maine dairy farmers		* Farmer to Farmer * Ag Trades Show * Regional Ag Service Provider	* 1/2010 * 2/2010
Extension Outreach Method 1a-1 Part a.	Conduct winter educational programs for Vermont dairy farmers	III	Program Names	Fill these Heather
Extension Outreach Method 1a-1 Part b.	Conduct summer field day training for Maine dairy farmers and ag service providers	III	UM Ag Field Day UM field day cooperating farmer	7/2009 7/2010
Extension Outreach Method 1a-1 Part b.	Conduct summer field day training for Vermont dairy farmers and ag service providers	III	UVM Ag Field Day UVM field day cooperating farmer	7/2009 7/2010
Extension Outreach Method 1b-1	Develop outreach fact sheets and eXtension e-Organic materials	III	Fact Sheet eXtension e-organic material development	12/2010 12/2010
Program Evaluation	Complete development of evaluation instruments and approvals	IV	Develop program review materials	9/2008 5/2010
	Evaluate growers interest in WGSSC double crop sysem	IV	Phone interviews	8/2010
Impact Method 1a	Document number of farms adopting practice	IV	Visit farms and document	8/2010
	Develop project final report	IV	Final Report Preparation	11/2010
	Submit to NE IPM	IV	Final report	12/2010

Phase IV: Project Evaluation

One of our long-term project goals is to develop a WGSSC double crop system to produce high yielding /quality forages with reduced weed pressure on northeastern organic dairy farms, we have developed the following methods to evaluate success with our the research goals:

Evaluation of Research Component of the Project

- With the inclusion of the 2007 experiment station trial data, we will statistically compare yield and quality of the forages from the WGSSC and full-season corn from five site years. Success will be statically higher yields, higher quality forages, and statistically lower weeds in the WGSSC system.
- Same measure of success will be used for the on-farm component of these trials.
- A final measure of success will be to document that the on-farm growers will continue with the WGSSC system after completion of the trials

Evaluation of Extension Component of the Project

- Success with the extension component of this project will be found with documented increased understanding of how to best utilize the WGSSC double crop system and why the WGSSC system is necessary as a result of attending training opportunities.
- Growers attending the training sessions will be given a survey about their experience and impressions of using double crop systems as methods for increasing forage production and minimizing weeds. A post program evaluation will test for change in attitude/impressions of the WGSSC system, as well as willingness to try to implement it.
- We intend to reach users through web based eXtension information and web-based fact sheets. Throughout the project, we will track recipients of fact sheets, and those that utilize the eXtension related materials to monitor improved understanding of the system and benefits to weed management. We will survey those growers to determine how many have adopted these practices.
- We will determine numbers of producers implementing these methods, assess any problems, and determine if growers are realizing improved production (yield and quality) and lower weed pressure. Toward the end of the project, a brief phone survey will be conducted with 50% of the organic dairy producers in Vermont and Maine who grow corn to assess how the project affected their cropping systems decisions.
- Within two years of project completion, we will phone survey organic dairy growers to test if 40% of growers will have adopted this IPM system for weed management and quality forage production.

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Key Personnel

Successful completion of the goals and objectives of this project will be principally dependent on the coordinated efforts of the two project directors: John M. Jemison, Jr., and Heather Darby.

Dr. John Jemison – Extension Water Quality and Soils Specialist. Dr. Jemison will take responsibility for conducting the Maine experiment station and on-farm trials, and supervising the undergraduate students' data collection for this project. Both project directors will work closely with the cooperating farmers to conduct the on-farm trials. We will lay out the experiments, collect and analyze data, and prepare reports. John will be responsible for fact sheet development, newsletter articles, and educational program development components of the project. John will take primary responsibility for the evaluation of this project.

Dr. Heather Darby – UVM Extension Agronomist. Dr. Darby will be responsible for coordinating with the University of Maine to conduct the project. She will oversee the implementation and completion of the replicated field trials in Vermont. In addition Heather will work with one farm in Vermont to implement an on-farm version of the on-station trials. She will also oversee study design, data collection, and analysis. Heather will organize the Vermont field days and educational program design and evaluation in Vermont.

Karen Hills – UVM Crops and Soils Technician. Karen Hills will work with Dr. Darby to implement field trials. She will be responsible for data collection from the replicated and on-farm trials in Vermont. She will also assist with the outreach and education portion of this project in Vermont.

Project Relevance Document

A. Project Directors: John M. Jemison, Jr. and Heather Darby
University of Maine Cooperative Extension and University of Vermont Extension

B. Project Title: Winter grain and short-season corn double crop forage systems: an integrated weed management strategy for organic dairy producers

C. Project Type: Joint Research and Extension Project

D. Project Summary:

As a result of this multi-state research and extension project, organic dairy producers will adopt an environmentally sustainable winter grain, short-season corn double crop forage production system as an alternative to intensively cultivated full-season silage corn. Organic dairy production is a strong growth area of Northeast agriculture, but sustainability of this growth is largely dependent on production of high quality feed while minimizing weed pressure. Due to high feed costs, producers must maximize on-farm forage and grain production. Field trials will be conducted at two university experiment stations and two organic dairy farms. The weed management IPM program that is the product of this work is primarily designed for northeast organic dairy producers, but it is applicable to all dairy producers. This project meets many goals identified by NE IPM including working with underserved audiences, and the development of easily implemented IPM systems and non-chemical pest management strategies where few alternatives exist. Growers will understand and implement this production system through involvement in an effective extensive Extension outreach program. Organic producers will attend grower field day presentations, on-farm twilight meetings, and other educational meetings. Production system fact sheets and a web site will be developed for this project, and information will be incorporated into an eXtension organic communities of practice led by co-PI Heather Darby. Within two years of project completion, 40% of organic dairy growers that grow corn will use this system, improve weed management, and produce high quality forages which will lead to increased milk production and improved economic and environmental sustainability.

E. Project Description, Background and Justification

Over the past three decades, many conventional dairy farms in the Northeast US have been forced out of business due to poor farm profitability. However, Maine and Vermont milk production remains close to historical levels because a majority of the remaining dairy farms have increased in size. As farm animal numbers increase, the potential for negative environmental impacts increase. In contrast, organic production milk price premiums have allowed some farms to remain profitable with fewer animal numbers. Organic dairy production is one of the strongest growth areas of New England agriculture. There are over 280 certified organic dairies in Maine and Vermont, and more farms are transitioning to certified organic production each year. Organic production offers a way to reduce human and grower exposure to synthetic pesticides compared to conventional forage production practices, but fertilization and pest management constraints make production of high quality forages with manageable weed pressure extremely challenging. Feed is the single largest expense for organic dairies, and organic growers must maximize on-farm production of energy and protein. While many organic

producers grow corn and hay-based rotations, other growers are looking for alternative cropping systems that make better use of crop ecology to compete with weeds.

Small successful farms have the potential to be more sustainable. With more on-farm forage and grain production, there will be less imported feed, thus reducing nutrient loading. Organic production systems may prove to be more sustainable because: 1) reduced purchased inputs (fertilizer and pesticides) and increased milk premiums may improve overall profitability; 2) diverse rotations reduce weed pressure and improve soil quality; and 3) there is reduced human exposure to synthetic pesticides through food and water. Given these benefits, Cooperative Extension and university research programs should explore ways to improve the effectiveness of organic dairy systems in New England. A stated goal of the Northeast IPM pest management priorities is to develop and implement integrated pest management (IPM) practices, tactics, and systems for specific pest problems while reducing human and environmental risks. This project will meet this goal by improving weed management in organic forage production.

While most conventional Northeast US dairy producers rely on silage corn and hay for their feed programs, organic producers frequently rely on a variety of cropping systems, rotations, and planting strategies to better manage weeds. While weeds have always been a problem for corn growers, organic farmers produce a higher value commodity and have to fight pests with new tools and methods. Many growers have expressed the need for information on alternative forage systems that can utilize narrow rows, early emergence, or delayed planting times to miss weed flushes. We recently completed a three-year winter grain / summer annual grass double crop forage experiment where we compared forage yield and quality and weed competition in the double crop system compared to organic silage corn cultivated four times. We found that the double crop forage system had significantly (three to four times) lower total weed biomass with no cultivation than full-season organic silage corn cultivated four times. But, the double crop forage energy content was significantly lower than the organic corn silage. Growers need high energy feed to have productive milking animals. A possible solution to the low feed energy would be to double crop winter grains with a short-season corn. Compared to full-season organic corn, winter small grains would have full canopy closure during the summer annual weed flush. Later planted corn should emerge much faster than corn planted in middle to late May making it more competitive with emerging weeds. Research is needed to see if late-planted corn (following winter grains harvested at the boot or soft dough stage) would have similar weed competition as normally planted full-season corn. While many agronomists and university staff promote full season corn, we rarely find that full-season corn significantly out yields short-season corn in our climate, and in most years, feed quality of short-season corn is equivalent or better than full-season corn. If the winter grain short-season corn (WGSSC) double crop is effective, we can provide growers with a cost effective cover crop, improved yields, reduced weed pressure, and improved forage quality. This interdisciplinary research needs to be conducted in diverse environments, soils, and fields with different weed species. If it is shown that weed competition is reduced in this double crop system, it is easily adaptable by any producer growing organic or convention corn. It is conceivable to expect high rates of adoption of the practice due to its wide potential applicability across much of the Northeast US.

Project success will depend on successful technical transfer of the research results. The projects extension component will involve development of an information package focused on

alternative methods of weed control in organic corn. This will include information on the WGSSC double cropping system, summary of the strengths and weaknesses of past double crop research, cultivation timing and frequency information in field corn, and other factors influencing weed management. This educational outreach will help northeast organic dairy producers learn and adopt the most effective weed management options. The research information generated in this work will be made available through the internet through the University of Maine and University of Vermont websites and to growers through eXtension.

D. Regional Priorities: How this project meets Northeast IPM Center goals:

The Northeast IPM Center (http://northeastipm.org/regu_regional.cfm) recently identified and prioritized pest management issues. In addition to being a previously identified Vermont priority, this project specifically addresses several of the following identified priorities:

General IPM Priorities for the Northeast – 2006:
Weed IPM: Research/extension demonstrations of weed management in sustainable/organic crop systems.

Northeast Research, Extension and Academic Program Committee for IPM:
Use of web-based technologies for IPM decision making
IPM packages for diversified, high value crop producers

Pest Management Alternative Practices - 2007:
Develop or improve IPM options for weed management, including weed identification, for agricultural settings
Assess, develop, and distribute new or improved methods for pest monitoring systems

2006 Livestock/Field Crop IPM Priorities – NY state:
C. Integrated Management of Significant Pests Affecting Field Corn - Research on organic weed control methods
F. Integrated Management of Significant Weed problems in Field Crop Systems - improve efficacy, economics, and information on weed control methods including those appropriate for organic.

Additional ways project addresses Northeast IPM Center goals:

In addition to this, the Maine Organic Milk Producers (MOMP) have identified alternative weed management practices as a high priority issue. This group and other organic producers are underserved in New England as they have traditionally received less support than commodity farmers from USDA. This type of research support can help their farms become more sustainable. In summary, Northeast US organic dairy producers will adopt the WGSSC double crop forage production system that will reduce weed pressure, provide winter cover, and yield high quality feed for long-term dairy herd productivity and health as a result of this project. Compared to the traditional silage corn/hay feed production programs, these alternative systems take advantage of cultural practices (narrow rows) and crop ecology (planting timing and rapid growth to miss annual weed flush) to produce high quality/energy forages with lower weed pressure. Farmer use of the WGSSC double crop system will result in reduced human exposure to pesticides, improved water quality, and improved long-term farm sustainability.