Conservation Innovation Grant
Final Performance Report [9/1/2006 –8/3/2009]

Grantee Name: Penn State Cooperative Extension of Adams County
Project Title: Field Tests on Systems Approaches for Retooling Mid-Atlantic Orchards with Innovative Conservation Technologies (grant agreement number 68-3A75-5-119)
Project Director: Tara A. Baugher (formerly Katheryn M. Lesser)
Contact Information: (717) 334-6271, ext. 314, tab36@psu.edu
670 Old Harrisburg Road, Gettysburg, PA 17325
Period Covered by Report: 9/1/2006 –8/3/2009
Project End Date: 8/3/2009

Summarize the work performed:

Preplant Preparation Period [9/1/2006 – 3/1/2008]

Final site preparations were completed and the ground was in excellent condition to be planted

- Growers disked the cover crop into the soil to increase organic matter (late February/early March 2008)
- Growers planted Kentucky-31 Fescue (K-31 Fescue) grass seed in the drive row (early March, or just after planting). This is the permanent sod that prevents soil erosion
- Collected 4th sample for nematode, nutrient, pH, and organic matter analyses; submitted to Dr. John Halbrendt, Penn State Fruit Research & Extension Center, Biglerville, PA for nematode assays and to Dr. Ann Wolf, Penn State Agricultural Analytical Services Laboratory, University Park, PA for soil nutrient content (collected samples late March/early April)

Tree Planting & Training Period [3/1/2008 – 8/3/2009]

- Growers planted trees (by first week of April, 2008)
- Growers pounded posts, installed wire for support of trees (by mid-June, 2008)
- Growers began tree training of innovative systems through pruning, pinching, and tying trees to trellis wires. This is a multi-step project and was carried out through Spring & Summer 2009
- Growers painted the trunks of trees with white latex paint or installed trunk guards to protect young bark from chemical drift and rodents
- Growers installed deer deterrents
- Growers used advanced Integrated Pest Management (IPM) strategies to monitor for pests and applied timely control methods
- Growers installed energy efficient irrigation systems

Additional Activities performed by the Project Team [May 2008 – August 2009]

- A GPS auto-steered tractor was tested for accuracy (see detailed description below in "Educational Opportunities for CIG Growers & Industry Members," and the associated PowerPoint presentations, posters, and reports which were included with the 4th bi-annual report)

- A *Fuel Consumption Calculator* (in Microsoft Excel) was developed by ag engineering intern, Alex Leslie, to allow growers to compare their fuel consumption in a conventional orchard versus an innovative high-density orchard (using the parameters of the CIG planting). Growers can manipulate the Excel file to include their current orchard spacings and tractor equipment, and then compare that fuel consumption with the consumption in a CIG high-density orchard block using more fuel efficient equipment. Hardcopies of the worksheets were included in the 4th report.
- Assessments were also made on the nematode, nutrient, pH, and organic matter analyses over the two year soil preparation period. Analyses conducted were:
    - Dagger Nematodes in CIG Plantings
    - Dagger Nematodes following Rapeseed Rotation
    - Root-Lesion Nematodes in CIG Plantings
    - Root-Lesion Nematodes Following Rapeseed Rotation
    - Total Nematode Counts in CIG Plantings
    - Total Nematode Counts Following Rapeseed Rotation
    - pH in CIG Plantings
    - Phosphate in CIG Plantings
    - Potash in CIG Plantings
    - Magnesium in CIG Plantings
    - Calcium in CIG Plantings
    - Cation Exchange Capacity in CIG Plantings
    - Organic Matter in CIG Plantings
    - Organic Matter in CIG Plantings with the use of Various Cover Crops

  Graphs were included in the 4th report.
- Two members of the CIG research team attended Interpoma, an international tradeshow on the production, storage, and marketing of apples. They saw innovative equipment that is applicable to the management of the CIG planting systems, and have purchased an orchard platform to conduct research in the CIG plantings.

Educational Opportunities for CIG Growers & Industry Members (October 2007 – August 2009)

- *Coordinated a discussion luncheon for all participating growers in Pennsylvania and Maryland to discuss with researchers the final steps in pre-plant preparation (October 23, 2007)*

  Growers and researchers discussed the final pre-plant preparation. Growers were instructed to incorporate their cover crop to increase organic matter, how to spot treat for weeds, and were informed about the planting strategy with the GPS steered tractor. An Extension educator in ag engineering attended the meeting to also talk about components to consider when installing a trellis. Growers were also given a list of trellis materials that they need to pick up from the supplier.

- *Coordinated an afternoon training for all participating growers in Pennsylvania and Maryland to see the GPS auto-steer tractor planting the Honeycrisp and Cameo CIG trees at a participating grower's commercial orchard (March 18, 2008)*

Growers and researchers gathered to see the GPS auto-steer tractor planting in a CIG block, and learned how to operate the equipment for their own plantings. However, there were conflicts with the installation, the set-up, and programming of the GPS and auto-steer systems which resulted in inadequate performance. Engineering trials were subsequently set up to assess optimum use of GPS for establishing straight rows in orchards and reducing labor inputs.

The research is described on page 3 and was shared with the CIG growers and the fruit industry at large.

- *Grower luncheon and tree training demonstration (April 21, 2008)*
  CIG growers had a sit-down lunch with six researchers to discuss important management practices for the new plantings. Dr. Jim Travis highlighted diseases which tend to be problematic for young trees and how to use advanced weather monitoring strategies to predict infection. Dr. Larry Hull discussed advanced IPM monitoring and management strategies for insect pests. Dr. Rob Crassweller advised growers to put tree guards or white latex paint around the trunks to protect trees from rodents; he also gave recommendations on cost-effective orchard floor management programs. Dr. John Halbrendt discussed the integrated management of broadleaf weeds that serve as virus and nematodes reservoirs. Drs. Jim Schupp and Tara Baugher talked about "best management" tree training and pruning strategies. After lunch the group went to Corey McCleaf's CIG planting where researchers demonstrated how to properly prune young trees and different training strategies to encourage maximum branching and growth in the first year. Then the guest speaker, Todd Smith, from Finger Lakes Trellis Supply Company in Syracuse, New York, gave a demonstration on trellis installation and provided safety tips to growers. The day was well received by growers and all thought that it was a productive discussion.

- *Orchard Twilight Meeting at McCleaf's Orchard (May 7, 2008)*
  Growers from throughout the mid-Atlantic region met at Corey McCleaf's Orchard to learn about the innovative CIG training systems procedure and advanced integrated pest management. Growers also toured the greenhouses, high tunnels, and vegetable plantings of Corey's small family farm. The evening concluded with researcher updates.

- *Ag engineering student assesses GPS technologies in orchards (May 12 – June 30, 2008)*
  Since the GPS auto-steer tractor did not perform to expectations, the project team wanted to learn more about the potential technology in orchard systems, especially pertaining to orchard establishment. Growers who had land available to test the tractor on provided recommendations and input on the new technology. Their recommendations are noted as follows. The GPS auto-steer tractor is better suited for large scale plantings (5 acres or more) rather than a 1 acre planting because growers should be able to grid the planting on a small scale more easily than on a large scale planting. The time that is saved in labor on large plantings would be significantly greater than on smaller plantings. The GPS auto-steer tractor would also be useful during ground preparation (i.e. chisel plowing, rotovating, disking, etc.). Growers were also curious to learn if the GPS auto-steer tractor had better accuracy at different speeds and what the correctional lag time would be if the

tractor hit an obstacle (i.e. a rock or ground hog hole) and was set off course. Growers wanted to know the distance that it takes for the GPS auto-steer tractor to become centered on the target line; this will determine the distance needed prior to the start of the tree row to straighten the tractor before trees can be planted.

An ag engineering student from Penn State University worked in the Extension office for six weeks and one of his projects was to investigate some of the growers' notions about the GPS auto-steer tractor's accuracy. Alex Leslie addressed the growers' questions in his investigations and research paper, and it was included in the 4th bi-annual report. He also wrote articles describing the project and his findings which were published in the *Pennsylvania Fruit News* (distributed to growers primarily in Pennsylvania and Maryland, but also across the mid-Atlantic region), and the *Gettysburg Times*. Alex also designed and created a poster which was presented at a grower field day on June 25, 2008 which over 200 growers from Pennsylvania, Maryland, New York, New Jersey, and Canada attended. Alex also gave a poster presentation at the Northeast Agricultural and Biological Engineering Conference (NABEC), held in Aberdeen, Maryland, from July 27-30, 2008. He has also created a PowerPoint presentation which was given at the Cumberland Shenandoah Fruit Workers Conference in November 2008 in Winchester, Virginia.

- *Orchard Twilight Meeting at Gardenhour Orchards (June 11, 2008)*
  Bill Gardenhour hosted mid-Atlantic growers at his farm where they saw the CIG planting and Drs. Jim Schupp and Tara Baugher talked about best management practices in high density orchards. The evening concluded with researcher updates, both from Maryland, Pennsylvania, and West Virginia.

- *CIG Grower education session on Spring tree training (June 22, 2008)*
  Bruce Hollabaugh hosted an educational demonstration where we continued discussions on tree training (pinching and tying trees to wire) and other best management practices. Growers shared how they accomplished the same goals through varying strategies and discussed what worked, what didn't, and why.

- *CIG Grower education session on Summer tree training (July 24, 2008)*
  Brian, Kevin, and Kyle know hosted an educational demonstration where we continued tree training discussions (limb bending and spreading) and demonstrations. Growers also focused conversations on integrated management of deer, insects, and diseases. The latter two CIG grower meetings were great because growers led the discussion and it showed that they had practiced the conservation guidelines and recommendations the researchers gave them at the April 21st meeting.

- *CIG Grower education session on pruning mature trees (November 17, 2008)*
  Dr. Jim Schupp lead a discussion on how to prune mature apple trees trained to a 4-wire, high density system. Even though the trees are not at a mature age, it is important for growers to understand the ultimate tree structure goal they are aiming to attain. Training and pruning starts within the first year, and will have a permanent affect on the final tree

structure. Dr. Schupp also incorporated techniques which he learned on a trip to the apple producing regions of Italy and Germany.

- *In-Depth Fruit School focuses on automation and orchard systems which are compatible with up and coming technology innovations (January 28, 2009)*

  Dr. Jim Schupp and Tara Baugher reviewed technologies that are being developed by engineers and the types of orchard systems which are compatible with these technologies. Dr. Schupp outlined the orchard blueprint system which was developed partially on behalf of the CIG project. Four participating growers of the CIG project participated in a panel discussion where they shared their experiences so far with the CIG plantings, lessons learned, and advice for growers who are thinking about planting high density systems, or about installing multi-wired trellis systems. The audience was very open to the equipment used such as the GPS-steered tractor and its potential in pre-plant preparation, and planting. The CIG panel discussion was probably the most enthusiastic and informative discussion yet held at an In-Depth Fruit School meeting. The group of 90 growers then went to the PSU Fruit Research & Extension Center for a pruning demonstration on high density systems using the minimal-pruning approach.

  Workshop participants were surveyed after the fruit school via *Survey Monkey* and 82% indicated they learned a great deal about new strategies of pruning for efficiency in intensive fruit plantings. Also 82, 82 and 73% (respectively) are making the following plans as an outcome of what they learned at the workshop: 1) planting new competitive orchard systems at higher tree densities, 2) establishing new competitive orchard support systems, and 3) adopting peach pruning and training strategies for targeting fruit size and yield. As a result of attending the workshop, 80% rated their level of comfort with transitioning to high value cultivars planted in competitive orchard systems as "very comfortable."

  - *CIG Orchard Visitations (March, 2009)*

    Members of the research team visited each CIG grower to instruct them on the two pruning strategies to be tested for improved physiological efficiency and automation compatibility

- *PA Pilot Orchard Session at Hollabaugh Orchards (May 2, 2009)*

  J. Schupp, T. Baugher, B. Hollabaugh, B. Hollabaugh, and K. Ellis provided training on minimal pruning/tree training strategies to reduce labor requirements, increase tree physiology efficiency, and enhance opportunities for automation.

- *Classroom in the Field at Hollabaugh Orchards Conservation Innovation Grant (CIG) Planting for 50 growers (June 2)*

  J. Schupp, R. Crassweller, T. Baugher, L. Hull, and H. Ngugi discussed advanced integrated orchard management strategies and two tree architecture systems for adaptability with automation.

- *Engineering Solutions Field Day at C&G Orchards CIG Planting for 20 growers (June 25, 2009)*

  Carnegie Mellon, USDA-ARS Appalachian Fruit Research Station, Purdue University and Penn State engineers and plant scientists demonstrated SCRI Comprehensive Automation strategies including disease sensing for targeted pest control applications, weed sensing for saving 60 to 90% in chemical usage, stress sensing for improved irrigation management, and automated insect traps for fuel savings.

- *Penn State Fruit Research and Extension Center Field Day (July 22, 2009)*

  J. Schupp, T. Baugher, K. Ellis, L. Hull, S. Singh, J. Travis, M. Glenn, A. Leslie, S. Wolford, R. Rohrbaugh, T. Kon, R. Dise, H. Ngugi, and B. Lehman discussed preliminary results from Specialty Crop Research Initiative Grant awarded in 2008 that will be utilized to continue researching/demonstrating conservation innovation strategies in the CIG pilot plantings.

  - *Leaf Sampling from each CIG Planting for Leaf Nutrient Analysis (July 2009)*
    Best management fertilizer practices will be based on fruit tree foliar analyses.

  - *Cost/Benefit and Partial Budget Analyses Conducted to Compare High Density Sustainable Orchard Systems to Conventional Systems (June 2009)*
    The summary table is below, and a calculator for growers is posted at the Penn State Extension in Adams County web site (copies included with this report).

Income Summary

Year	Net Income		Cumulative Net Income		Discounted Cumulative Net Income	
	m-9	mm-111	m-9	mm-111	m-9	mm-111
0	($9,615.00)	($2,052.20)	($9,615.14)	($2,052.20)	($9,615.14)	($2,052.20)
1	($1,114.35)	($686.90)	($10,729.00)	($2,739.10)	($10,707.64)	($2,725.63)
2	($193.68)	($789.90)	($10,923.17)	($3,529.00)	($10,893.80)	($3,484.86)
3	$1,037.00	($926.89)	($9,885.84)	($4,455.89)	($9,916.30)	($4,358.29)
4	$2,776.85	($1,083.09)	($7,108.99)	($5,538.98)	($7,350.92)	($5,358.90)
5	$3,744.14	($411.66)	($3,364.86)	($5,950.64)	($3,959.74)	($5,731.75)
6	$6,423.03	$130.84	$3,058.17	($5,819.80)	$1,743.72	($5,615.57)
7	$7,387.07	$1,393.94	$10,445.24	($4,425.86)	$8,174.61	($4,402.06)
8	$7,947.97	$3,684.09	$18,393.21	($741.77)	$14,958.13	($1,257.72)
9	$8,035.61	$4,073.03	$26,428.82	$3,144.34	$21,681.96	$2,150.41
10	$6,817.41	$6,302.41	$33,246.23	$9,633.67	$27,274.61	$7,320.58

m-9, NPV	8%	14429.24
m-9, IRR		22%
mm-111, NPV	8%	2665.47
mm-111, IRR		14%

Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

The project action plan and timeline were met in full during the grant period.

- "Growers prepare planting site using sustainable practices [9/1/2006 – 3/1/2008]"
    - The 3rd soil sample was collected from each site for nematode, nutrient, pH, and organic matter analyses.
    - Nematode suppression and increased nutrient levels due to green manure crops were quantified (by regressing nematodes vs. rapeseed biofumigation and nutrient levels vs. organic matter content).
    - Recommended soil amendments were incorporated and then a permanent sod was established.
- "Growers plant trees and install support systems [3/1/2008-6/1/2008]"
    - Growers planted trees, installed support systems, and water and energy efficient irrigation systems
- "Project team develops system for conducting energy audits in orchards [5/1/2008 – 12/1/2008]"
    - Extension intern, Alex Leslie, designed an Excel workbook for growers to compare the energy inputs in conventional orchards vs. innovative high-density orchards.
- "Project team and university pest management specialists provide advanced integrated orchard management and energy audit assistance to grower cooperators [2008 – 2009]"
    - During the meetings, demonstrations, and discussions on October 23, 2007, April 21, May 7, June 11, June 22, July 24, November 17, 2008, and January 28, 2009, Penn State scientists advised growers on all aspects of advanced integrated orchard management and environmental conservation. The research team and scientists will continue to visit the CIG orchard plantings and provide input and recommendations to participating growers. Grower cooperators also received a digital copy of the Energy Audit workbook.
- "Pilot project results shared with growers through field days, newsletters, and grower journals; and with other university extension workers through training programs/fruit worker conferences [2008 – 2009]"
    - CIG growers have attended a total of 13 educational activities pertaining to the CIG plantings, and will continue to have and attend these educational opportunities.
    - Growers in the mid-Atlantic region have had the opportunity to attend seven educational events hosted at the CIG plantings, hearing about the GPS auto-steer tractor project, learning how to prepare and care for their high-density sustainable systems, and will continue to have and attend these educational opportunities.
    - Publications about the GPS auto-steer tractor project have been featured in the Pennsylvania Fruit News, and in the Gettysburg Times.
    - A summary of the conservation benefits of the CIG project has been published in the Adams County Fruit Growers Association newsletter, written by a retired Extension Director, the Gettysburg Times, the PA Fruit News, the Penn State Extension in Adams County Annual Report, the Penn State Fruit Research and Extension Field Day Bi-annual Report, and in Penn State Extension fact sheets.

Specified tasks were continued through on-site visitations with growers, one-on-one interaction, and educational meetings and luncheons with researchers and Extension educators, and industry members. These types of interactions and recommendations allow the project team to teach growers the proper innovative management practices and tree training strategies which are environmentally sound, ecologically beneficial, and crucial for tree establishment success, as well as inform them of the trellis components, training designs, and precision technologies which were utilized in the pilot orchards during planting and will continue as the CIG plantings reaches maturity.

In the space below, provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. *A listing of EQIP-eligible producers involved in the project.*

Producer Name	Operation Name
Seth & Dan Boyer	Ridgetop Orchards
Ken Guise (owner)/Dave Cox (manager)	C&G Orchards Ltd.
Tony & Terry Fetters	Fetters Orchard
Michael Flinchbaugh	Flinchbaugh's Orchard & Farm Market
Bill Gardenhour	Gardenhour Orchards Inc.
Dave Garretson	Beechwood Orchards
Brad & Bruce Hollabaugh	Hollabaugh Bros. Fruit Farm & Market
Brian Jacques	Edgemont Orchards, Inc.
Brian & Kevin Knouse	Knouse Fruitlands Inc.
Corey & Vicky McCleaf	McCleaf's Orchards
Neil Starner	Fruit Haven
Ed & Justin Weaver	Weaver's Orchards Inc.

2. *The dollar amount of any direct or indirect payment made to each individual producer or entity for structural, vegetative, or management practices. Both semiannual and cumulative payment amounts must be submitted.*

1st Bi-Annual Matching Costs Summary [8/4/06 – 2/4/2007]		
8/4/06- 2/4/07	Penn State Matching Costs (Salary)	$5,836.00
10/18/2006	Nematode Assays (12) (soil preparation management)	$180.00
10/23/2006	Organic Matter Tests (12) (soil preparation management)	$60.00
10/23/2006	Mehlich 3 Fertility Tests (12) (soil preparation management)	$108.00
10/16/2006	Parcel Postage for soil samples	$6.76
1/11/2007	Mehlich 3 Fertility Tests (8) (soil preparation management) Once trees were removed, subsoil samples were taken a second time	$64.80
(Expenses paid by Penn State Cooperative Extension of Adams County through other grant resources)		
1/17/2007	GPS mapping data collection (management practice)	$174.92
1/19/2007	GPS mapping data collection (management practice)	$303.34
1/26, 27, 29/07	GPS mapping analysis (management practice)	$100.00
(In-kind contribution)		
	1st Bi-Annual Report Subtotal	**$6,833.82**

2nd Bi-Annual Matching Costs Summary [2/5/2007 – 8/4/2007]		
2/5/2007 – 8/4/2007	Penn State Matching Costs (Salary)	$5,836.00
8/4/2006 – 8/4/2007	Partnering Grower Expenses	$8,281.48
7/25/2007 – 7/27/2007	GPS mapping data collection (management practice)	$80.00
(In-kind contribution)	**2nd Bi-Annual Report Subtotal**	**$14,197.48**

3rd Bi-Annual Matching Costs Summary [8/5/2007 – 2/4/2008]		
8/5/2007 – 2/4/2008	Penn State Matching Costs (Salary)	$6,040.50
8/5/2007 – 2/4/2008	Partnering Grower Expenses	$9,906.66
9/4/2007	Mehlich 3 Fertility (12) (soil preparation management)	$108.00
9/4/2007	Organic Matter Tests (12) (soil preparation management)	$60.00
	3nd Bi-Annual Report Subtotal	**$16,115.16**

4th Bi-Annual Matching Costs Summary [2/4/2008 – 8/4/2008]		
2/4/2008 – 8/4/2008	Penn State Matching Costs (Salary)	$6,040.50
2/4/2008 – 8/4/2008	Partnering Grower Expenses	$16,550.00
3/12/2008	Nematode Assays (11) (soil preparation management)	$150.00
5/12/2008	Mehlich 3 Fertility (11) (post-planting soil management)	$99.00
5/12/2008	Organic Matter Tests (11) (post-planting soil management)	$55.00
6/10/2008	Soil Test Kits	$151.20
2/4/2008 – 8/4/2008	Parcel Postage for soil samples and grower mailings	$46.38
	4th Bi-Annual Report Subtotal	**$23,092.08**

5th Bi-Annual Matching Costs Summary [8/4/2008 – 2/4/2009]		
8/4/2008 – 2/4/2009	Penn State Matching Costs (Salary)	$6,203.00
8/4/2008 – 2/4/2009	Partnering Grower Expenses	$58,276.07
	5th Bi-Annual Report Subtotal	**$64,479.07**

Matching Costs TOTAL	**$124,717.61**

Required matching costs of $122,274 were met during the 5th bi-annual period.

3. *A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.*

The self-certification statements indicating that each individual participating in the CIG project is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill were submitted in the first Bi-Annual Progress Report [8/4/2006 – 2/4/2007].