V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Plant Sciences

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms	0%		17%	
202	Plant Genetic Resources	0%		5%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%		9%	
204	Plant Product Quality and Utility (Preharvest)	10%		5%	
205	Plant Management Systems	45%		10%	
206	Basic Plant Biology	10%		10%	
211	Insects, Mites, and Other Arthropods Affecting Plants	5%		13%	
212	Diseases and Nematodes Affecting Plants	5%		11%	
215	Biological Control of Pests Affecting Plants	5%		5%	
216	Integrated Pest Management Systems	10%		15%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	30.1	0.0	19.0	0.0
Actual Paid	34.0	0.0	22.8	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1655340	0	2144342	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1655340	0	2169985	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	7792493	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research programs to:

• Develop improved varieties of dry beans, tart and sweet cherries, potatoes, wheat, rice, soybeans, oats, barley, canola, turfgrass, apples, strawberries, blueberries, floriculture crops, chestnuts, vegetable crops, and conifers for Michigan growers.
• Continue to identify genes and genetic pathways that control plant response to environmental stresses and develop techniques to insert these pathways into at-risk plants.
• Identify and isolate novel genes, markers and genetic pathways that can benefit crops important to Michigan agriculture through higher yields, improved quality, and better insect and disease resistance.
• Identify and isolate novel genes, enzymes and other phytochemicals that may have benefits for human health and determine how these beneficial compounds can be made available to people.
• Develop integrated management strategies and provide education programs for producers of fruit, field, vegetable, floriculture, Christmas tree and forestry crops that use the lowest possible inputs of resources and improve yield and quality, while minimizing environmental effects, such as leaching and run-off.
• Develop cultural, management and insect and disease control strategies for crops that meet USDA certified organic standards so Michigan growers can take advantage of this growing market, if they choose to do so.
• Continue to develop biological controls for pest insects and diseases to minimize effects on the environment.
• Continue variety trials for crops important to Michigan, including wheat, corn, soybeans and forages.

Extension actitivities to:

• Conduct educational programs to help farm producers control weeds and more effectively manage high-cost fertilizer inputs while optimizing crop production.
• Develop plant disease prediction models.
• Conduct educational programs to help plant producers control disease caused by pathogens and nematodes and teach integrated pest management methods.
• Provide green industry professionals and homeowners with scientifically sound information to enable them to safely and effectively manage their turf, landscapes and gardens, improving efficiency of resources and controlling pests, while reducing pesticide and fertilizer use.
• Train Native American adults in sustainable agriculture.

2. Brief description of the target audience

Michigan growers (traditional and organic), commodity groups, agriculture and natural resources industry representatives (including herbicide, pesticide and insecticide suppliers), green industry/landscape/turf professionals, state agricultural agencies, Native American growers and the interested public.

3. How was eXtension used?

All MSUE field educators and specialists are encourage to be involved in eXtension through both the Ask an Expert and Communities of Practice (CoP). A total 16.56 fte's were involved in this area of plant sciences with 8.77 fte's funded through 3bc funds.
An example is one educator reports he/she was involved in the Blueberries CoP where a Michigan Blueberry Facts sheet with an Ask an Expert Widget generated over 200 Ask an Expert queries with about half originating outside of Michigan.
For example,
Title of question: **blueberry soil ph**
Question: willl a soil ph of 6.5 will n/p/k still be available to the plant? is availability of all nutrients and micronutrients tied up and unavailable with a high soil ph in blueberries?
Response: Yes N-P-K will still be available. At that pH the plants show a severe iron deficiency with yellow leaves and poor growth. Blueberry only uses ammonium nitrogen so nitrate is unavailable.
Extension Fruit Educator Michigan State University Extension
Another example,
Title of Question: Energy Crops for Biogas Feedstock
Question: Which type of energy crop seems best suited as a feedstock for biogas production (anaerobic digestion)? I realize there are many variables, so to narrow the field, let's say the crop is to be grown in the upper Midwest on marginal soils (say reclaimed mine lands).
Response:
You have asked a question we are trying to answer. The Europeans would say the answer to your question is maize (corn). Corn produces a great deal of biogas in a high solids digester. As you know, we grow corn very well in the Upper Midwest. However, there are to many competing uses for corn, so growing it as an energy crop is not an option in my opinion. The caveat you make is growing an energy crop on marginal land. We know how to grow switchgrass in Michigan. We have established test plots now going on five years. It will grow on marginal land. I know switchgrass has been successfully grown in Illinois. I have successfully produced biogas from ensiled switchgrass. This has encouraged me to try to determine where, in the growth of the switchgrass, is the best time to harvest for maximum biogas production. As you know, the more mature a plant gets, the more lignin and cellulose content there is. Lignin and cellulose are not broken down in a digester. Feel free to contact me if you want to discuss this further.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	16021	48063	8604	25812

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2014
Actual:	30

Patents listed

MICL01832: Management of Turfgrass Diseases #14/101,723 (12-10-13)& #8623111 (1/7/14); MICL02278: Molecular Genetics of Plant Defense Against Insects #2,586,048 (3.11.14); MICL02141: Molecular Insights Into Geobacter Biofilms #61/989,922 (5/7/14); #14/193,943 (2/28/14); #8729233 (5/20/14); MICL02304: Effects of nitrogen deposition on the ecology and evolution of the legum e-rhizobium mutualism #2737704 (11/19/13); #2011201768 (5/24/14); MICL01814: Elucidating the mechanisms of insect mating disruption and trapping #61/961,526 (10/17/13); #14/229,388 (3/28/14); #14/044,748 (10/2/13); #14/061,460 (10/23/14); #14/077,897 (11/12/13); #8735633 (5/27/14); #2507200 (2/12/14); #8,613,780 (12/24/13); #258051 (11/28/13); MICL02258: Biology and Management of Insects in Michigan Field Crops: #2823249 (8/6/13); MICL01806: Enhancing Potato Quality through Genetic Improvement and Variety Development: #201400226 (3/13/14); MICL02283: New Arthropod Pest Conotrols and Management Strategies for Michigan Tree Fruit Production Systems: #13/805,926 (7/18/13); MICL02166:Chemical Catalysis and Processing for Advanced Biofuels and Biochemicals : #13/805,926 (7/18/13); MICL01810: Genetic Improvement of Strawberries and Blueberries: #13/998,453 (11/1/13); #13/998,457 (11/1/13); #13519002 (12/17/13); MICL02265:Genetic and Genomic-Based Approaches for Exploring Biology and Evolution in the Solanaceae Family :#14/130,890 (4/11/14); MICL02133 : The convergence and activation of abiotic and biotic stress signaling in plants #14/384,094(9/9/14); MICL02299: Role of the Plant Secretory Pathway in Growth and Response to Stress #61/842,077 (7/2/13); #PCT/US2014/044662 (6/27/14); MICL01779: The Physiology and Biochemistry of Herbicide Action, Selectivity, and Degradation #61/949,475 (3/7/14); MICL02315: Exploring Sporulation and Spore Dispersal in Fungal Pathogens: #62/008,673 (6/6/14)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	1	56	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research projects on plant sciences.

Year	Actual
2014	83

Output #2

Output Measure

- Number of adult participants trained in plant management systems.

Year	Actual
2014	14965

Output #3

Output Measure

- Number of youth participants trained in plant management systems.

Year	Actual
2014	8604

Output #4

Output Measure

- Number of adult participants trained in integrated pest management (IPM).

Year	Actual
2014	1056

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of adult participants with increased knowledge of integrated pest management (IPM).
2	Number of research programs to develop insect and disease control and/or cultural and management strategies for organic crops.
3	Number of research programs to develop biological controls for pest insects and diseases to minimize any effects on the environment.
4	Number of research programs to develop integrated management strategies for fruit, field, vegetable, floriculture and forestry crops that use the lowest amounts of nutrients possible and improve yield and quality.
5	Number of research programs to identify and isolate novel genes, markers and genetic pathways that can benefit crops important to Michigan agriculture through higher yields, improved quality, and better insect and disease resistance.
6	Number of research programs to identify genes and genetic pathways that control plant response to environmental stresses and develop techniques to insert these pathways into at-risk plants.
7	Number of research programs to develop improved varieties of economically important crops for Michigan and the region.
8	Number of adult participants with increased knowledge of plant management systems.
9	Number of research programs to develop weed control methodologies, protocols and practices.
10	Number of research programs to develop controls for pathogens and nematodes affecting plants.
11	Number of research programs to develop production protocols and environmental and cultural strategies for the floriculture/nursery industry.
12	Number of research programs to develop more effective post-harvest protocols and practices to minimize loss and enhance quality.

Outcome #1

1. Outcome Measures

Number of adult participants with increased knowledge of integrated pest management (IPM).

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	951

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Integrated pest management (IPM) offers agriculture a sustainable approach to deal with evolving pest challenges such as new invasive species, climate change, and pesticide resistance. An advisory group of farmers and representatives of the target audience helped develop the content to ensure a relevant curriculum and well attended program.

What has been done
One example is the IPM Academy that is a two-day professional development program covering fundamentals of pest management and identifying resources and technology for sustainable agriculture practitioners. In 2014, the program focused on training sustainable agriculture educators and advisors from public and private sectors. The targeted audience included crop consultants, Michigan Department of Agriculture and Rural Development personnel, Natural Resource Conservation Service employees, chemical representatives, and early-adopters from Michigan and surrounding states.

Results
Over 100 participants attended the training with participants planned to utilize, expand or improve your use of any of the following IPM practices based on the IPM Academy:
- 77% (n=43) Access MSU IPM resources online
- 79% (n=44) Scouting for insects and diseases
- 71% (n=40) Scouting for beneficial insects
- 50% (n=28) Referencing weather modeling to make management decisions (e.g. Enviroweather)
- 54% (n=30) Only treating for pests when the economic threshold is reached, as applicable
- 54% (n=30) Supporting beneficial insect habitat to promote pest control via natural enemies

- 55% (n=31) Selection of pest resistant varieties or cultivars
- 45% (n=25) Alternative weed control strategies (e.g., cultivation)
- 52% (n=29) Alternative ground cover management (e.g., cover cropping)
- 34% (n=19) Sanitation practices (removal of inoculum, sterilizing implements etc.)
- 50% (n=28) Protecting native pollinators (mowing before spraying, spraying at night, etc.)
- 61% (n=34) Soil or tissue to make nutrient management decisions
- 68% (n=38) MSU information and management practices related to invasive pest management

Evaluation results found over 30,000 acres were committed to change as a result of this initiative.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
216	Integrated Pest Management Systems

Outcome #2

1. Outcome Measures

Number of research programs to develop insect and disease control and/or cultural and management strategies for organic crops.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
American organic farmers represent only 1 percent of total U.S. farms, with 14,540 farms out of 2.2 million, and 4.1 million acres of land out of 922 million, with organic farms in all 50 states. Despite their smaller numbers, the sector grew by 8 percent in 2010, dramatically outpacing the food industry as a whole which grew at less than 1 percent in 2010. Overall, the industry has grown from $3.6 billion in 1997 to $29 billion in 2010, demonstrating that the organic sector will continue to play a contributing role in revitalizing America's economy through diversity in agriculture. Given this, research to help these producers increase production and marketing

efficiencies and control pests with methods that conform to organic standards is critical.

What has been done
Research to: optimize the production and use of thermophilic compost and vermicompost as important tools for organic and sustainable production and management of vegetable transplants and high tunnels for year round vegetable production and marketing on rural and urban farms; and to develop a methodology for quantifying multi-trophic crop/pest beneficial interactions.

Results
A laboratory vermicomposting feeding trial was conducted using plastic trays containing 300 grams of worms in bedding. Six feedstocks covered with leafmold included: 1) pulped pineapple skin, 2)pulped melon rind, 3) pulped carrot peels and carrots, 4) pulped onion skins and spoiled onions, 5) coffee grounds, 6) a mixture of the five feedstocks, and 7) only leaf mold were added twice per week for five weeks followed by three weeks of no additional feeding. The final vermicompost pH, EC,
nutrient content and biological diversity were determined. Worm populations remained stable in all feedstocks. Onions have previously been reported as detrimental to worm populations.

A total of 20 related outreach presentations to farmers, urban agriculture practitioners and composters were made in Michigan and nationally with an emphasis on high tunnel soil fertility and health management, organic transplant fertility management, and compost and vermicompost production and use. Printed handouts were distributed at most events and are available at the PI website: www.hrt.msu.edu/john-biernbaum/pg4

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #3

1. Outcome Measures

Number of research programs to develop biological controls for pest insects and diseases to minimize any effects on the environment.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	12

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Biological control is the use of living organisms to suppress pest populations, making them less damaging than they would be otherwise. Biological control can be used against all types of pests, such as vertebrates, plant pathogens, weeds and insects. Insects that were of little economic importance can become damaging pests. When a non-toxic control method is used, natural enemies are more likely to survive and reduce the numbers and damage of potential pest species

What has been done
Research to: develop and deliver Integrated Pest Management strategies for insects in Michigan vegetable crops; develop stable, sustainable management strategies for vegetable insect pests; determine the effectiveness of currently registered and experimental products for control of insect pests in small fruit crops; improve control of moth pests by pheromone disruption; increase knowledge about mode of actions or effects of pests and diseases on honey bees to achieve better control and to gain increased honey production and more effective pollination of agricultural crops; to develop biological and cultural tactics based on vegetation management; to increase knowledge about the plant defense genetics; and to use new pest controls for tree fruit production.

Results
A new effort was initiated in March of 2014 to develop: (1) a communications strategy for informing consumers about the safety of garden center plants to bees, (2) a method for identifying nursery production practices and landscape maintenance practices that could be harmful to pollinators, (3) a set of alternative pest management practices for greenhouse and nursery growers that are emphasize safety to bees and other pollinators after plants are sold in garden centers, and (4) a set of experiments designed to determine the hazard of imidacloprid soil drenches to pollinators, using bumble bees as the test species.

The insect and arthropod collections of the A.J. Cook Arthropod Research Collection at Michigan State University contains over 1.1 million pinned and labeled specimens. In addition, the collection contains specimens in 114,000 vials and 47,000 on slides. Approximately a third of the specimens are from Michigan with many historically important specimens dating to the 1870's. There are extensive national and international holdings, including significant South American and Mexican material for Lepidoptera, Hymenoptera and Coleoptera. The ARC provides data directly to visiting scientists, in form of specimen loans, and responds to data requests. ARC also

supports the MSU Bug House, 4-H activities, MSU Ag-Expo and other outreach and extension events on and off campus with insect displays, and staff knowledgeable in insect natural history. Hence, this collection is used by national and international research scientist, supports agricultural, forestry, ornamental plant industries within the state, and helps to educate the general public from children to adults. In general, bark beetles function ecologically as decomposers of wood. However, some aggressive species and, to a lesser extent, benign species kill live trees, especially during periods of environmental stress. These pests cause severe economic and ecological losses, which often equates to millions of dollars. However, efforts to study and/or control this group are
hampered by a lack of taxonomic knowledge. Hence the PI's current taxonomic research of tropical bark beetles increases the knowledge of species diversity, the relationships among the species, and results in better means for their identification. Other scientists and diagnosticians use these results to improve surveys for potential pests. In addition, the PI educates national and international technicians, undergraduates, and graduate students in the identification and systematics of bark beetles. Thereby, perpetuating knowledge of these beetles through space and time. The PI participates annually in the survey and taxonomy of exotic and pestiferous bark beetles provides for the earlier detection and rapid response of potential exotic bark beetle pests. For 2013-2014, several thousand specimens collected in Florida, Guam, Illinois, Pennsylvania, and Puerto Rico were identified. Three species new to Puerto Rico were detected. Success with this survey resulted continuous US- Forest
Service funding at MSU since 2007. In addition, the PI improved the ability to identify North American Scolytus species through the development of new taxonomic expertise, new identification methods and the improvement of taxonomic understanding of these beetles.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
212	Diseases and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #4

1. Outcome Measures

Number of research programs to develop integrated management strategies for fruit, field, vegetable, floriculture and forestry crops that use the lowest amounts of nutrients possible and improve yield and quality.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	13

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Growers' livelihoods depend on production systems that are healthy and sustainable -- environmentally, ecologically and economically. Farmers in Michigan grow a diversity of crops second only to California, a state almost three times the size of Michigan. This world-class diversity necessitates a unique mixture of research and Extension programs to meet the needs of the state's growers, who produce more than 200 commercially grown commodities

What has been done
Research to: identify and characterize phloem-associated lipids and lipid-binding proteins and identify their role in plant development and pathogen defense response; optimize protocols for honeycrisp storage in air and in controlled atmospheres; utilize and integrate physiological, genetic and horticultural approaches for understanding and improving Great Lakes region high value fruit production; decrease reliance on conventional crop protection practices by using low environmental impact fungicides in combination with host resistance; and to improve row crop nitrogen management to optimize economic returns and reduce environmental impacts

Results
Ongoing research has demonstrated potential tradeoffs between soil and weed management objectives associated with tillage and cover crop practices. For example, reductions in tillage in vegetable cropping systems has been observed to result in increases in perennial weed species such as horsenettle, and shifts in weed communities towards winter annual and grass species. Adjustments in weed management practices to address these challenges will be necessary to facilitate greater adoption of reduced tillage. Towards that end, we continue to work on developing integrated weed management systems for reduced tillage production practices which integrate chemical, biological and mechanical methods. For example, we have initiated a new study in 2014 to examine the efficacy of various "in-row" cultivation tools including torsion-weeders, finger-weeders and flex tine cultivators which may provide growers with options?other than increased herbicide use?for addressing weed management challenges.

Testing of pest control products has been ongoing in the past year in laboratory and field settings, and these have been used to inform our recommendations to growers. This information has also informed our input to US-EPA regarding pesticide registrations in response to the urgent need to control spotted wing Drosophila. We have published results on projects to evaluate the response of beneficial insects to habitat manipulation, with important findings of increased blueberry yield adjacent to these wildflower plantings. On-farm demonstrations of programs have provided venues for growers and extension educators to see the quality of the fruit first hand, and this has a large impact on grower perception of program performance. Growers have reported excellent

fruit quality where our IPM programs have been adopted appropriately. Growers are now very aware of Spotted Wing Drosophila and are using our information to guide their management of this damaging new pest. This includes information on insecticide residual activity and performance of the insecticides in laboratory and field settings.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
206	Basic Plant Biology

Outcome #5

1. Outcome Measures

Number of research programs to identify and isolate novel genes, markers and genetic pathways that can benefit crops important to Michigan agriculture through higher yields, improved quality, and better insect and disease resistance.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	18

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As the world population increases and the demand for food and fuel relies more heavily on agricultural products, efficient methods of plant transformation will be required. Although conventional breeding will fulfill a part of this need, these techniques are limited to the gene pool of the species involved. In contrast, the tools of genetic engineering significantly expand the resources that can be used for variety improvement. Further, current transformation techniques are not applicable to all plant species.

What has been done
Research to: identify molecular markers for traits that are important in highbush blueberries; identify high-yielding oat, barley and canola cultivars for Michigan; provide guidance on disease

control and crop health to the Christmas tree and chestnut industries; determine the biochemical mechanisms involved in turfgrass disease control; develop production methods to increase net returns to Michigan berry producers; elucidate molecular and biochemical mechanisms of plant resistance to arthropod herbivores; determination of how to better control for fungal and bacterial diseases of plants; and to develop improved analytical methods for the profiling of metabolites to assist in comprehensive measurements of biomarkers related to plant and animal health.

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
205	Plant Management Systems
206	Basic Plant Biology

Outcome #6

1. Outcome Measures

Number of research programs to identify genes and genetic pathways that control plant response to environmental stresses and develop techniques to insert these pathways into at-risk plants.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Research on plant resistance to environmental stress is essential to sustainable agriculture. Determining how to develop or enhance resistance is a critical research area. Before plant varieties that are insect- or disease-resistant can be developed, scientists have to find a source of plant resistance and then determine how to cross-breed plants or isolate the responsible genes and then move them from one plant to another.

What has been done
Research to: better understand disease resistance signaling in plants; determine foliage thresholds based on the assimilation and storage of carbon; improve the efficiency of crop production through increased understanding of the genetics controlling plant growth and development; determine the effects of stress on plant metabolism; and to understand the genetic mechanism by which plants tolerate environmental stresses.

Results
In our recent work, we investigated the extent to which cold induction of the CBF regulon is regulated by transcription factors other than CBF1, CBF2 and CBF3, and whether freezing tolerance is dependent on a functional CBF-CRT/DRE regulatory module. To address these issues we generated transgenic lines that constitutively overexpressed a truncated version of CBF2 that had dominant negative effects on the function of the CBF-CRT/DRE regulatory module, and 11 transcription factors encoded by genes that were rapidly cold-induced in parallel with the "first-wave" CBF genes, and determined the effects that
overexpressing these proteins had on global gene expression and freezing tolerance. Our results indicate that cold regulation
of the CBF regulon involves extensive co-regulation by other first-wave transcription factors; that the low temperature regulatory network beyond the CBF pathway is complex and highly interconnected; and that the increase in freezing tolerance that occurs with cold acclimation is only partially dependent on the CBF-CRT/DRE regulatory module.

Greenhouse screening protocols revealed that leaf photosynthesis and conductance decreased earlier in response to drought stress in more drought tolerant varieties, but drought susceptible varieties maintained higher gas exchange rates under well watered conditions. When exposed to exogenously applied abscisic acid (ABA), a hormone
involved in abiotic stress signaling, drought tolerant varieties more severely decreased conductance at lower ABA concentrations. Drought tolerant varieties also accumulated more organic acids and soluble sugars when exposed to drought stress: leaf samples contained three to seven-fold more malic acid, inositol, fructose, and glucose than well watered controls. To more closely separate root and shoot influences on drought tolerances, reciprocal interspecific grafts were made between
a drought susceptible P. vulgaris variety and drought tolerant P. acutifolius. As grafted plants were exposed to increasing drought, scion identity played a greater role in early and moderate drought tolerance while root identity had a greater impact on severe drought tolerance and recovery. Overall, drought tolerant Phaseolus varieties and species take a more conservative approach to growth; their photosynthetic and conductance rates are lower under ideal conditions, and they respond more quickly to drought stress.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
206	Basic Plant Biology
216	Integrated Pest Management Systems

Outcome #7

1. Outcome Measures

Number of research programs to develop improved varieties of economically important crops for Michigan and the region.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	13

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Agriculture is Michigan's No. 2 industry. The state's agrifood system accounts for $71.3 billion in total economic activity and 600,000 jobs. Michigan is also one of the most diverse agricultural industries in the United States, growing more than 200 commodities. As the world population increases and demand for food and fuel relies more heavily on agricultural products, efficient methods of plant transformation will be required. Developing improved crop varieties is critical to sustaining an economically viable agriculture industry.

What has been done
Research to: identify the genes critical for the replication and repair of chloroplast DNA; understand the patterns of evolution of flora forms that contributes to the reproduction and persistence of Michigan plants; increase the environmental and economic sustainability of small fruit production through management of diseases in Michigan; understand the central plant metabolism and transport in plant systems well enough to rationally manage and engineer them for human benefit; develop a data-driven protocol for culture of juice grape cultivars as well as fruit plant canopies and management systems that fit into these advances to achieve maximum efficiency; and to discover genes that are co-expressed with genes known for amino acid biosynthetic and catabolic enzymes.

Results
In the past two years, western bean cutworm populations have declined throughout Michigan. Egg masses are difficult to find, and damage has decreased except in dry beans in the Upper Peninsula (UP) of Michigan. Thus in 2014, interest in trapping much more limited that in previous seasons. Flight began in early July and, with the cool summer, extended into September. Peak

flight was difficult to determine. A recommendation was made in late August for UP dry bean producers to scout fields for pod-feeding to determine the need for treatment; spraying was suggested only for these producers, and not for dry bean
growers elsewhere in the state. Information on actual damage this season is not yet available to determine if the spray recommendation was correct, as harvest is ongoing. On the educational side, the Handy Bt Trait Table, the regional extension bulletin which keeps track of the commercially available Bt traits in corn, was revised in April 2014. The table was provided gratis upon request for use by other universities and agribusinesses, and posted electronically. Another pest in corn, the western corn rootworm, was targeted in 2014 for early detection of unexplained damage to Bt corn, as potential resistance
was identified in central Michigan in 2013. Sixteen extension talks and a webinar around the state discussed Bt resistance and encouraged people to report field problems. A special grower meeting was held in the county where potential resistance was found in 2013. As a result, several of the fields with potential resistance were rotated out of corn in 2014. The PI was the lead author of a white paper contrasting rootworm Bt resistance in the eastern corn belt, the so-called 'fringe', with the current main Bt resistance area in the Midwest. This white paper was submitted as a public comment to an EPA Scientific Advisory Panel examining rootworm resistance monitoring. The paper was acknowledged by the Panel members in their final report, and it informed their recommendations to EPA about how resistance should be monitored, reported, and handled in the east versus the Midwestern corn belt. Spring weather conditions were such that corn was planted late and field were very wet. Rootworm populations were thus very low in the potential resistance area in early August, and no new problem fields were reported as of September. Soybean aphid populations were negligible during the field season, except in a limited number of late-planted or potassium deficient fields at the end of August. Extension education was done in mid to later August to reiterate soybean aphid threshold values, explain why only certain fields were infested, and recommend spray applications only to the locations where needed. Aphid suction traps running during the season detected a late fall flight, and aphids were confirmed on buckthorn in late September. As of the writing of this report, an overwintering egg population has not been found. Discovery of, and studies on, aphid-resistant germplasm continue in cooperation with the MSU soybean breeding program. The PI is responsible for doing the field collections to establish aphid colonies to use in experimental infestations of the breeder's lines.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
206	Basic Plant Biology

Outcome #8

1. Outcome Measures

Number of adult participants with increased knowledge of plant management systems.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	12721

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example, soybean yield increases have not kept pace with those of corn, wheat and sugar beets. On average, soybean producers are losing 1 to 2 bushels per acre due to harvest losses. Soybean producers that irrigate their beans are not satisfied with their irrigated soybean yields. In some cases, dryland yields are higher than irrigated yields. On-farm research and education may help soybean producers overcome these challenges.

What has been done
MSUE planned, promoted, conducted and evaluated three, high-profile educational programs in 2014.
- 2014 SMaRT (Soybean Management and Research Technology) Meetings (Dundee, Caro, Dowagiac and Hamilton)
- 2014 Soybean Harvest Equipment Field Day (Yale)
- Multi-state program titled "Producing High-yielding Soybean on Irrigated Coarse-textured Soils" (Shipshewana, IN)

Results
The results from follow-up surveys designed to measure and document the actual educational and financial impacts from these three programs found in the highlights below:

Evaluation results from the 2014 SMaRT Meetings (41 of 157 responded) indicated:

-83% said that they utilized the information they learned at the programs on their farms in 2014.
-Twenty three (23) producers indicated that they actually earned additional money in 2014 by implementing the new information they learned at the programs.

-The average amount of additional income realized by implementing the new information was $13.40 per acre. Because the new information was implemented on 5,338 acres, the actual financial impact of the programs was $71,529 in 2014 alone.
-The participants also provided specific changes they made and listed soybean topics they wanted to learn more about.

Evaluation results (44 of 163 farmers)fromthe Producing High-yielding Soybean on Irrigated Coarse-textured Soils indicated:

-75% said that they utilized the information they learned during the 2014 growing season.
-Twenty three (23) producers said they actually earned additional money by implementing the new information they learned at the program.
-The average amount of additional income was $13.15 per acre applied to 27,073 acres, producing an actual financial impact of $356,045 in 2014 alone.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

Outcome #9

1. Outcome Measures

Number of research programs to develop weed control methodologies, protocols and practices.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Weed control is an essential part of all crop production systems. Weeds reduce yields by competing with crops for water, nutrients and sunlight. Weeds may also reduce profits by hindering harvest operations, lowering crop quality and producing chemicals harmful to crop

plants. Weeds left uncontrolled may harbor insects and diseases and produce seed or rootstocks that infest fields and affect future crops. Weeds are a major source of yield loss for growers in Michigan and in the North Central Region. It is estimated that losses due to weeds left uncontrolled exceed $7.5 billion in the United States.

What has been done

Research to: help define management strategies that address shifts in weed populations; understand the degree to which weeds affect crop establishment and production in traditional and emerging cropping systems; identify effective practices for weed control in annual and perennial horticultural crops; determine the mode of action and basis for selectivity and fate of new or potentially new herbicides for weed control in Michigan; and identify the fundamental factors in cultural and chemical weed control, weed composition and weed life cycles.

Results

As a result of our research, new labels were approved for several herbicide uses for fruit and vegetable crops. Linuron was
labeled for celeriac, cilantro, dill, horseradish, parsley, peas, rhubarb, and edamame. The fomesafen label was expanded to
include edamame, pea, pepper, tomato, pumpkin, and squash. The pendimethalin label was expanded to include green onions, and a separate state label allows a double rate on high-organic soils. S-metolachor was labeled for edamame. Prometryn was labeled for celeriac, okra, parsley, rhubarb, and dill. Clomazone was labeled for banana pepper with a state label. The oxyfluorfen onion label
was modified for use in Michigan at higher rates at the onion one-leaf stage. Halosulfuron was labeled for caneberry and blueberry. Quinclorac was labeled for cranberry and rhubarb. Imazosulfuron was labeled for nutsedge control in pepper and tomato. Carfentrazone was labeled for hops. Sulfentrazone was labeled for use in blueberry, caneberry, and grape. Growers have adopted these new herbicide uses rapidly. Onion growers were able to prevent serious yield loss from ladysthumb
(Polygonum persicaria) competition by use of oxyfluorfen at the onion one-leaf stage. This label increased grower returns by over $1 million as a result of increased yield. Linuron and prometryn labels for dill, cilantro, and parsley resulted in large reductions in hand labor for weed control and greater yields and profits. The clomazone label for banana pepper resulted in a 10-20% yield enhancement and reduced labor costs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
216	Integrated Pest Management Systems

Outcome #10

1. Outcome Measures

Number of research programs to develop controls for pathogens and nematodes affecting plants.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Nematodes are among the parasites that attack numerous economically important plants, substantially reducing their yield potential by destroying their root system. Pathogen epidemics are a constant problem for agriculture and are known to influence natural ecosystems, especially when alien pathogens successfully invade new areas.

What has been done
Research to: examine methods and problems associated with controlling disease in agriculture; gain a strategic understanding of the complexity of nematode problems and necessary disciplinary interactions; develop new, safer methods of insect control by using baculovirus biotechnology to either improve the insecticidal properties of baculoviruses or as a tool for designing safer chemical insecticides; to develop, assess and deliver effective IPM programs in cherry, apple, peach and some row crop conventional and organic commodities in the Upper Midwest; and to employ ecological and evolutionary perspectives to understand the dynamics of plant disease

Results
The Arthropod Pesticide Resistance Database has received an increasing number of visitors of which more than half are new on a monthly basis. The database itself is also growing: roughly 1,800 new cases of resistance have been reported worldwide during the past year, sourced from more than 80 scientific articles. Each case of resistance in the database contains critical information such as the species involved, active ingredient of resistance, the origin of the resistance (field or
lab selected), and location of resistance including country, state/province, city, and latitude and longitude coordinates, if

published. Each case entry also houses information pertaining to the bioassay used to determine resistance, including doses,life stage of arthropod, method, and date of test. The information contained in the database is accessible to anyone with internet access, and new cases can be submitted by authorized users. A user may become authorized by applying online,and the cases that users submit must go through a peer-reviewed submission process before they are published to the
database.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
206	Basic Plant Biology
212	Diseases and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #11

1. Outcome Measures

Number of research programs to develop production protocols and environmental and cultural strategies for the floriculture/nursery industry.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	7

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The wholesale value of floriculture crops produced in Michigan is more than $400 million annually. Michigan's 625 commercial floriculture companies showed an estimated value of $402.7 million, with over half of them reporting wholesale sales of more than $100,000. Total greenhouse cover is about 50 million square feet, with an additional 3,600+ acres of open ground for floriculture production. Research in this area is critical to keeping this industry viable and profitable.

What has been done
Research to: improve control over quality loss in horticultural produce; evaluate turfgrass species and mixes for their adaptation to athletic field turf and to assess the effects of cultural practices;improve the environmental sustainability of the Michigan landscape tree industry by optimizing water and nutrient inputs and determining the utility and potential impacts of organic fertilizers;
investigate nitrogen fate in turfgrass; evaluate several perennial semi-aquatic or aquatic plants for use in the phytoremediation of nursery runoff water; and to develop protocols that growers and retailers can use to produce and profitably sell perennials as new floriculture crops while

Results
Plant performance in coir and pulp alternative containers were compared with standard HDPE containers. Water use, EC and pH of substrates was determined. Container physical properties were determined. Plant growth was not different between container types when irrigated based on water use. Water use was higher for coir and pulp containers, due to porous side walls, than HDPE containers.

we investigated the effects of high-intensity blue (B) light, alone or when added to R and FR light, on flowering and growth of several long- and short-day plants including corepsis, petunia, rudbeckia, and chrysanthemum. Plants were grown in a greenhouse under a 9-hour natural short day with or without 5.5-hour day-extension and/or 4-hour night-interruption lighting from LEDs. Blue light was delivered at three intensities, with or without R+W+FR light. Blue light alone at the highest intensity created long days in all crops as effectively as low-intensity R+W+FR light. There were some height differences among lighting treatments in some crops but not others. We conclude that night-interruption lighting with high-intensity B light, alone and when added to R and FR light, can regulate flowering of a wide range of photoperiodic crops.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #12

1. Outcome Measures

Number of research programs to develop more effective post-harvest protocols and practices to minimize loss and enhance quality.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Farmers and food sellers have been concerned about losses since agriculture began. Yet the problem of how much food is lost after harvest to processing, spoilage, insects and rodents or to other factors takes on greater importance as world food demand grows. Cutting postharvest losses could add a sizable quantity to the global food supply and reduce the need to intensify production in the future. Estimates of total postharvest food loss are controversial and range widely, generally from about 10 percent to as high as 40 percent

What has been done
Research to: Improve orchard and vineyard postharvest technologies and postharvest recovery of sugars and pectic polysaccharides from plants

Results
The third year of pruning treatments was implemented in a study in managing canopy volume in tart cherry for high density orchard plantations. Treatments were imposed on tart trees in two plots located at Oxley's Orchard, Marcellus and at the Northwest Research and Extension Center. Two rows of Montmorency trees spaced at 6 X 19 feet were pruned twice in 2014 on April 29 and June 26 (45 days post bloom) at the Oxley Orchard. Trees were topped and hedged on the sides according to 4 different canopy and 1 root pruning (bloom) treatments compared to control to force laterals and begin a process of developing a narrow hedge. Hedging was accomplished using hand-held electric-powered hedging shears. Canopies of treated trees were smaller and more compact which readily accommodated the harvester at Oxley Orchard. Fruit was harvested on July 11 using the owners Korvan (Oxbo) 9000 berry harvester per tree. Data analysis not completed as of this reporting time. The crop was abnormally small, at 10-15% due to a winter freeze episode. The harvester was successful in removing all fruit with little canopy or fruit damage, equally, while moving at 1.5 miles per hour. At the Northwest Research Center, the pruning treatments were established on dormant trees of 3 compact scion varieties compared to Montmorency which had been planted in Spring 2011 at a spacing of 4.9 X 13.1 feet. Pruning treatments were control, root pruning (bloom), winter hedging cuts and hedging cuts during the summer on June 7 (45 days post bloom). Hedging was accomplished using hand-held electric-powered hedging shears. A summer hedging treatment was imposed at both locations. Fruit was harvested at Oxley Farms by machine on July 11 and by hand at the NWHRC on July 28. The most productive variety and treatment in 2014 was Montmorency on Mahaleb control at over 18 pounds per tree. This variety and treatment has reached its maximum space and volume allowed by a berry harvester (5 x 8 feet tunnel dimension) and may not be harvestable in 2015 using a proposed berry harvester. Montmorency in the summer hedge treatment averaged 12 pounds per tree with less canopy volume (data currently being collected). Guard trees of Montmorency on the

MSU rootstocks Cass and Clinton surpassed 16 pounds per tree but with canopy volumes estimated at less than 50% of trees propagated on the standard commercial rootstock, Mahaleb. Root pruning at bloom reduced canopy volume without sacrificing crop demonstrating future potential as
an alternative approach to maintaining a compact canopy. Currently, we have three early-adopter growers amounting to 45-50 acres planted since spring 2011 in Michigan. The Michigan cherry industry is planning to support future work as this approach will require less labor, improved fruit quality and improve profitability.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in

the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion annually.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Research
As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.
Extension
Another example of evaluation for Extension in this area include:
Issue (who cares and why)?
Friends of the Detroit River and partners secured a grant for $471,079 to conduct a comprehensive invasive species control and outreach plan for Belle Isle. This project will conduct a comprehensive aquatic invasive species control and outreach program on Belle Isle, an historic island park and significant recreation area in the Detroit River. Youth-based employment groups and interested public will engage in invasive species control and habitat restoration actions to protect the island's diverse ecosystem and the two recent Great Lakes Restoration Initiative funded habitat restoration projects. A Science and Education Advisory Board will also oversee the development of Aquatic Invasive Species outreach/education exhibits and programming on the island focused on a suite of aquatic invasive species threatening the Detroit River system and the Great Lakes.
Belle Isle is prominently positioned at the "Gateway" to the Detroit River. Here, the river's water quality is at its best, clear and fast-flowing from Lake St. Clair. The islands rich

diversity of plants associated with its unique, 200-acre, wet mesic flatwood forest and penetrating canals provide a haven for migratory and local birds and an important nursery habitat for larval fish species. However invasive aquatic plants are encroaching the area and pose an ominous threat.
What has been done? I assisted FDR in writing the grant and identifying project partners. I also committed to serve on the Science and Education Advisory Board and to supply the Belle Isle Aquarium and Belle Isle Nature Zoo with Michigan Sea Grant educational materials as needed for the project implementation.
Results/Impact? $471,079 grant secured for Belle Isle Aquatic Invasive Species Project
What difference did it make - public value? Public knowledge of problems and solutions associated with aquatic invasive species will be increased through the incorporation of aquatic invasive species displays at Belle Isle Aquarium and Belle Isle Nature Zoo. An aquatic invasive species management plan for the island will be developed. The plan will allow for more effective management of the invasive species and better coordination of volunteers who routinely offer their services to remove invasive species.

Key Items of Evaluation

Research
Since the early 1900s, blueberries have been commercially grown in Michigan, and today the tiny berries are big business. In 2011, the Michigan blueberry industry spanned 18,000 acres and yielded 72 million pounds of fruit valued at more than $118 million.
Few MSU plant breeders have been more successful than MSU AgBioResearch scientist **James Hancock**. A professor of horticulture and recipient of the 2014 MSU Innovation Center Technology Transfer Achievement Award for excellence in applying innovation to create real-world solutions, Hancock developed four of the world's most widely planted northern highbush blueberry varieties: Aurora, Draper, Huron and Liberty (20 million plants of these varieties have been sold), along with several other successful cultivars during the past three decades at MSU.
Working closely with U.S. Department of Agriculture blueberry breeder Arlen Draper, in honor of whom Hancock named the Draper variety, Hancock realized the need for new varieties in Michigan. In 1979, Michigan farmers were planting 30- to 60-year-old varieties such as Bluecrop, which thrives in midseason but left sizable gaps at both the beginning and the end of the growing season.
After 14 years of trials, Hancock emerged with results that exceeded his expectations: six varieties of MSU blueberries that together span the entire growing season.
Blueberry varieties developed by James Hancock

- Aurora (2004) - latest ripening season of any northern highbush
- Liberty (2004) - late-season, high yields, exceptional flavor
- Draper (2004) - midseason, high yields, unusual fruit crispness, exceptional storage life
- Huron (2012) - early-season, excellent taste
- Osorno (2014) - late midseason, exceptional fruit quality, unusual heat tolerance
- Calypso (2014) - late midseason, high yields, excellent flavor

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. Work Teams in this area found:
Institute of Agriculture and Agri-Business

- 43,762 acres adopting practices that manage risks
- 24,430 acres adopting technology or tools to manage risks
- 391,368 acres adopting practices to increase yield, improve quality, or decrease inputs
- 4,133 new acres under irrigation management
- 707 farms adopting practices that manage risks
- 139 farms adopting technology or tools to manage risks
- 200 farms adopting practices to increase yield, improve quality, or decrease inputs
- 7,084 farms adopting tools or technology to increase yield, improve quality, or decrease inputs
- 238 improved existing irrigation system
- 123 new Enviroweather users
- **Children and Youth Institute**

- 3,337 youth demonstrated the ability to apply science knowledge and problem solving, critical thinking, and decision-making life skills.
- 483 adults and teen leaders indicated the ability to apply knowledge to engage youth in experiential, inquiry based science learning.
- 1,591 youth participants indicated an increase in awareness of life skills and indicate the ability to identify the life skills acquired.
- 1,472 youth participants set a goal for their career or job.
- 1,574 youth participants increased self-awareness as it relates to future career possibilities.