

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Climate Change- low-impact alternatives for ornamental crop production

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
133	Pollution Prevention and Mitigation				25%
211	Insects, Mites, and Other Arthropods Affecting Plants				25%
212	Pathogens and Nematodes Affecting Plants				25%
605	Natural Resource and Environmental Economics				25%
	Total				100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	0.0	15.7
Actual Paid Professional	0.0	0.0	0.0	14.1
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
0	0	0	640529
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	0	640529
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	0	684679

V(D). Planned Program (Activity)

1. Brief description of the Activity

Identify new pesticide, biopesticide, and treatment methodologies for container and field-grown nursery stock to manage disease and insect problems.

Determine the lowest effective rates for synthetic petroleum-based pesticides and develop new reduced rate insecticide / biopesticide combinations.

Identify new biopesticides that can substitute for synthetic petroleum-based pesticides and reduce worker exposure risk and environmental impact.

Release phorid-decapitating flies in Tennessee to provide imported fire ant biological control.

Provide extension training and literature to producers on imported fire ant and Japanese beetle management and train students in pest management and research techniques.

Provide data to support new treatments in the Domestic Japanese Beetle Harmonization Plan and the Federal Imported Fire Ant Quarantine, as well as data to support new insecticide label amendments.

Conduct assessment of current and future energy use by greenhouse and nursery businesses.

Identify alternative energy sources for the greenhouse and nursery industry.

Hold focus group meetings with greenhouse and nursery business owners.

2. Brief description of the target audience

Nursery growers, extension specialists, consumers and policy makers.

Regulatory agencies (e.g., U.S. Environmental Protection Agency, USDA-APHIS, Tennessee Department of Agriculture).

Agrochemical manufacturers.

3. How was eXtension used?

The program was involved in reviews of web content for the eXtension Imported Fire Ant Community of Practice (IFA-CoP), including the new OnyxPro Insecticide regulation change that is described under Outcome #5 and now promoted on eXtension. New fire ant related extension publications were shared with the leader of the IFA-CoP for evaluation and consideration for posting on eXtension. The TSU scientist on this project is a leader of the IFA-CoP (<http://www.extension.org/pages/12258/imported-fire-ants-leadership>), and his activities and involvement in the IFA-CoP are described online as follows: "Dr. Oliver leads the fire ant eXtension activities for Tennessee, and is assisting in engaging the public via webinars. He will provide content for various work teams." The 2012 webinar given by Dr. Oliver and reported during the last reporting period is still archived and available for continued public viewing (<http://www.extension.org/pages/33719/fire-ant-webinars>). This program also promoted eXtension to growers and stakeholders at all educational workshops during this evaluation period.

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1300	28550	1050	110

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

Patent Applications Submitted

Year: 2013
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	6	10	16

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Workshops to inform producers about alternative insect control methodologies.

Year	Actual
2013	3

Output #2

Output Measure

- Disease resistant cultivars developed.

Year	Actual
2013	2

Output #3

Output Measure

- Extension factsheets about alternative methods to control disease and insects in nursery production.

Year	Actual
2013	4

Output #4

Output Measure

- Workshops held to inform/encourage nursery producers about alternative energy use.

Year	Actual
2013	2

Output #5

Output Measure

- Extension publications to inform nursery and greenhouse growers about alternative energy options.

Year	Actual
2013	0

Output #6

Output Measure

- Research publications low-impact alternatives for ornamental crop production.

Year	Actual
2013	17

Output #7

Output Measure

- Presentations relating to research on low-impact alternatives for ornamental crop production

Year	Actual
2013	20

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Producers educated on proper management of invasive pests through presentations and workshops.
2	Producers educated on proper management of invasive pests through publications and factsheets.
3	New treatments for invasive pests.
4	New reduced-risk treatments developed for invasive pests.
5	New treatments for invasive pests approved by quarantine regulatory agencies.
6	Confirmed establishments of new invasive pest parasites.
7	Producers are informed about new or emerging diseases.
8	Producers are informed about new biological control treatments.
9	Producers that are informed about new sources of host resistance.
10	New cultivars exhibiting disease resistance available to growers.
11	Nursery/greenhouse operators trained in alternative energy use.
12	Nursery/greenhouse operators utilizing alternative energy.
13	Organisms identified as potential biocontrol candidates.

Outcome #1

1. Outcome Measures

Producers educated on proper management of invasive pests through presentations and workshops.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	1100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Invasive pest species disrupt natural ecosystems and are detrimental to agriculture because they exhibit rapid population growth that can cause greater crop damage and harm to human health and welfare. Multiple invasive pests now impact the U.S. nursery industry. Many producers must manage multiple invasive pests simultaneously with limited, ineffective, and costly treatments, which threatens economic viability and undermines integrated pest management efforts. Producer education via workshops and other training outlets is essential for providing up to date information on rapidly evolving modifications to agro-ecosystems and guidance on successful and profitable control tactics.

What has been done

Research was conducted control of imported fire ant, Asian ambrosia beetle and other invasive insects. Producers and other agricultural stakeholders were trained at workshops, field day demonstrations, and educational venues on the latest management techniques developed from field research on invasive insects.

Results

Producers were educated on research results guiding proper management of invasive insects at several local, regional and national workshops. Total number of growers/stakeholders educated at workshop and field day trainings during this reporting period was about 1,111. In addition, the project had about 1,469 and 28,444 adult direct and indirect contacts, respectively pertaining to information on pest management by producers, stakeholders, and extension personnel and another 1,005 and 100 direct and indirect non-producer youth contacts.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #2

1. Outcome Measures

Producers educated on proper management of invasive pests through publications and factsheets.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	600

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Due to time constraints with managing and running farm operations, as well as expense, some producers are not able to physically attend educational workshops to obtain information on management of invasive insects. As a result, publications, factsheets, and internet available materials are another route to indirectly reach these producers and stakeholders with guidance, training, and the latest successful measures for effective and sustainable pest management.

What has been done

Producers and stakeholders were educated on new techniques developed via our research by multiple printed and internet based outlets.

Results

Producers/stakeholders were educated by three new publications that were developed and placed online. One of those eXtension web contents highlighted the new OnyxPro Insecticide regulation changes described under Outcome #5, which was new and important information to relay to growers. Research data results from this project have been posted on the USDA-APHIS Imported Fire Ant website, where it is publicly available to agricultural producers and other stakeholders. The program documented 1,508 information requests from producers during this reporting period either from direct requests or via other extension personnel.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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133 Pollution Prevention and Mitigation
211 Insects, Mites, and Other Arthropods Affecting Plants

Outcome #3

1. Outcome Measures

New treatments for invasive pests.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Treatment methods for cleansing nursery stock of imported fire ant, Japanese beetle, and numerous non-indigenous ambrosia beetles are expensive, hazardous, impractical or ineffective, and often require shipping delays. Imported fire ant treatment methods like the Federal drench protocol are hazardous due to producer handling exposure and early site re-entries, labor intensive, and expensive. Most treatments for these pests rely on only a few active ingredients (i.e., chlorpyrifos, imidacloprid, or permethrin), providing producers with only limited alternatives. New biopesticide treatments that are under development may have a role in reducing climate change by offering producer alternatives for synthetic petroleum based agrochemical inputs. Invasive borers also have major impacts on forest systems and landscape plantings supplied by the nursery industry, which serve as important carbon-sinks, so improved treatments for borers may indirectly reduce climate change. It is also important that new treatments that are developed are made available to producers through modifications of federal and state regulations governing these quarantine pests.

What has been done

Research with a new in-field drench treatment for imported fire ant and Japanese beetle (JB) larvae utilizing common grower accessible items was repeated for a second season during this reporting period. The same biopesticides and conventional pesticides tested in the last reporting period were repeated in combination with a pesticide synergist. Data from IFA studies are being shared with the USDA-APHIS person responsible for regulatory decisions (i.e., Anne-Marie Callcott; Entomologist and Biloxi Station Coordinator). JB data will be shared with the U.S. Domestic Japanese Beetle Harmonization Plan (JBHP) Regulatory Treatments Committee for consideration as new treatments in the JBHP, but more data is required before results can be

shared. A flatheaded borer multi-rate imidacloprid test examining insecticide interaction with herbicides has been initiated at a commercial nursery during this reporting period.

Results

Rates and drench volumes for the in-field chemigation studies performed in 2013 were highly effective at controlling Japanese beetle (JB) for most products at rates lower than had previously worked. The Exponent pesticide synergist appears to have increased potency of insecticides against JB at rates much lower than normally effective. In addition, one biopesticide (Armorex) appears to have also been synergized by the Exponent product for JB control.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #4

1. Outcome Measures

New reduced-risk treatments developed for invasive pests.

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

New treatments for invasive pests approved by quarantine regulatory agencies.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Imported fire ants (IFA) have expanded their range into multiple nursery production systems in the southern United States. Currently, only three IFA quarantine treatments are approved for

fieldgrown nurseries. All treatments are expensive, rely on one active ingredient (chlorpyrifos), and the post-harvest treatments are hazardous. More options are available for Japanese beetle quarantines than IFA quarantines, but treatments are still expensive for producers due to the limited number of options.

What has been done

Data on pre-harvest banding of three generic imidacloprid products for Japanese beetle control in field-grown nurseries were published in the Journal of Economic Entomology. Subsequently, the published data were shared with the U.S. Domestic Japanese Beetle Harmonization Plan Treatment Review Committee. Data on management of imported fire ants were also shared with the USDA-APHIS.

Results

Pre-harvest imidacloprid research published in 2013 enabled the U.S. Domestic Japanese Beetle Harmonization Plan (JBHP) Treatment Review Committee to approve 3 new nursery treatments in JBHP. The new generic treatments are saving producers about \$0.06-\$0.33 / treated plant over existing protocols.

In addition to these outcomes, USDA-APHIS approved 2 new regulations in the Federal IFA Quarantine (FIFAQ) with project data support, including 1) a new IFA nursery plant immersion treatment and 2) a new IFA sod treatment. The bifenthrin immersion treatment allows producers to certify balled and burlapped nursery plants for 6 months, instead of the 1 month with the currently approved chlorpyrifos.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #6

1. Outcome Measures

Confirmed establishments of new invasive pest parasites.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Imported fire ants (IFA) cause billions of dollars in damage in the United States each year and are a human, livestock, and wildlife health threat. To slow IFA spread and provide region-wide sustainable suppression of IFA populations, the USDA has an on-going classical biocontrol program to establish phorid-decapitating fly parasitoids of IFA from South America into the United States. There are about 20 species of these flies in South America, therefore, to effectively manage IFA with Pseudacteon flies, it will likely require introductions of a suite of fly species.

What has been done

We made the largest phorid-decapitating fly release (~20,830 flies) to date in summer 2013. Multiple Pseudacteon species also have been released in Tennessee over several years, including *P. obtusus* (23,288 flies between 2009-2012), *P. curvatus* Formosan biotype (8,840 flies between 2004-2008), *P. curvatus* Los Flores biotype (18,000 flies between 2000-2003), mixtures of *P. curvatus* biotypes (2,856 flies between 2011-2012), and *P. tricuspis* (10,812 flies between 1999-2006 and 2011-2012).

Results

Efforts to recollect and confirm establishment of *P. obtusus* from the 2013 and previous releases been unsuccessful to date. We have also not recovered *P. tricuspis* from previous releases. We have recovered large numbers of *P. curvatus* at all sites checked and *P. curvatus* is now established statewide. It may take several years for the newly released *P. obtusus* species to reach levels where field detections are possible.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #7

1. Outcome Measures

Producers are informed about new or emerging diseases.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
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2013

35

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Nursery growers need to be informed about new and emerging diseases so that they can be prepared for the disease by taking preventive measures and minimize the potential economic impact of the disease.

What has been done

Research was performed on the epidemiology of nursery diseases i.e Cherry Leaf spot and Boxwood Blight. Studies on the source of initial infection and the timing of infection establishment were performed to confirm previous results.

Results

Studies on this disease have shown the source of initial infection and how to avoid economic impact from this disease. Disease management strategies developed have confirmed previous results on effective fungicides and the timing of fungicide applications as well as cultural practices that can reduce disease incidence.

Research-based information on disease control was communicated to nursery producers. Information on boxwood disease was well received by nursery growers and they are informed on how to recognize the disease and what to do in case they notice the disease in their production system.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Pathogens and Nematodes Affecting Plants

Outcome #8

1. Outcome Measures

Producers are informed about new biological control treatments.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Nursery production systems use high rates of chemical fungicides to control powdery mildew of dogwood; this is detrimental to the environment and grower income by increasing dogwood production costs. Alternatives to chemical fungicides would be desirable.

What has been done

Microorganisms selected for bioactivity against powdery mildew of dogwood were evaluated on other pathogens, whether they interact with each other, and their mechanism of action.

Results

Results confirmed previous studies on bioactivity against powdery mildew; improved plant growth, bioactivity against other pathogens and the involvement of secondary chemical metabolites in their bioactivity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Pathogens and Nematodes Affecting Plants

Outcome #9

1. Outcome Measures

Producers that are informed about new sources of host resistance.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Growers need to know options they can use to minimize plant damage from diseases.

What has been done

New plants that display powdery mildew resistance were generated through conventional crossing between plants and mechanism of resistance was determined; resistant as well as moderately resistant offspring were identified and await resistance confirmation.

Results

Growers were informed about research results that support the availability of disease resistance and biological microorganism that can be used in integrated disease management system.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Pathogens and Nematodes Affecting Plants

Outcome #10

1. Outcome Measures

New cultivars exhibiting disease resistance available to growers.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Disease resistance is the best method for disease control by farmers. New generation of cultivars that are resistant to powdery mildew would be a great contribution to nursery growers in that they would not require routine fungicide applications.

What has been done

Powdery mildew resistant selections have been identified and characterized for release as new disease resistant cultivars.

Results

Two selections are ready for release as new powdery mildew resistant cultivars and five other lines are under evaluation.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Pathogens and Nematodes Affecting Plants

Outcome #11

1. Outcome Measures

Nursery/greenhouse operators trained in alternative energy use.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Increase in energy cost has raised the cost of operating nursery/green house operations in the last few years. This has a negative impact on profitability of their operations as well as on other issues such as employment and capacity utilization. Energy use is essential especially for Green house growers as plants require heating during the winter and cooling during the summer. Thus, there is need to address the issue by examining alternative energy sources that are cost effective. Understanding growers' intentions in adopting them is also important.

What has been done

A database of certified greenhouse and nursery growers was used to conduct a survey of certified greenhouse and nursery growers to assess their current energy use and preferred alternatives for the future.

Results

Descriptive analysis shows that rising energy cost is the second most important factor affecting profitability of nursery/greenhouse operations after the economic downturn. Availability of skilled personnel in the areas of management and sales represents another challenge. Despite the challenges they face the growers indicated that they will stay in the nursery/greenhouse business. Further analysis of the data will be conducted.

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

Outcome #12

1. Outcome Measures

Nursery/greenhouse operators utilizing alternative energy.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	22

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Exploring alternative sources of energy is needed to identify lower cost sources. Sources range from bioenergy operated by an individual operator to others available through private businesses in the energy business. There are also various public sector stakeholders.

What has been done

This project introduced research in an important emerging area. It can promote efficient and cost effective management practices that can overcome some of the challenges faced by the nursery/greenhouse growers.

Results

Preliminary results show that in addition to those already utilizing alternative energy, a majority of the respondents will consider adopting alternative energy sources.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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605 Natural Resource and Environmental Economics

Outcome #13

1. Outcome Measures

Organisms identified as potential biocontrol candidates.

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Alternatives to fungicides in powdery mildew control are needed to reduce the amount of fungicide used in production. Biopesticides and biological agents provide good alternatives to chemical fungicide either individually or as part of an integrated disease management system.

What has been done

Research on how to integrate biological organisms or biodegradable biopesticides with host resistance was initiated.

Results

The integration of moderate resistance with biological agents and with biopesticides improved disease control. Results are preliminary at this stage.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Government Regulations

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Research impact and relevance was measured by one-on-one interaction with nursery growers in educational workshops and at field research sites, counting the number of requests from producers for research-related information or assistance, and surveying producers for impact and content relevance at workshops and meetings. One-on-one interactions with nursery producers, the Tennessee State University Nursery Advisory Group, and regulatory stakeholders has indicated our research objectives are addressing their critical needs and our outcomes are reducing their costs. Direct requests from producers or related stakeholders for research-related information during the 2012 to 2013 reporting period totaled 1,237 in-person, 105 phone, and 1,220 email requests. Information exchanges with nursery growers and extension personnel included 647 grower and 737 extension exchange events. We estimate indirect contacts at 28,844. A survey given to nursery growers during this evaluation period at the

Tennessee Master Nursery Program class revealed 100% were somewhat to very satisfied with relevance of program to their needs, 91.2% agreed or strongly agreed that they would plan to adopt information, and 85.3% agreed or strongly agreed that information would save their business money. The estimated savings by nursery growers to their businesses included \$500 (n=1), \$501-\$1,000 (n=5), \$1,001-\$5,000 (n=17), \$5,001-\$10,000 (n=8), and >\$10,000 (n=3).

In addition to this survey, nursery extension has informed our program that 12 Tennessee nursery growers have adopted flatheaded borer systemic insecticide treatments that our program research has demonstrated to be effective. The grower reasons for adopting the research-based results was because the treatments were preventing tree losses, had lower labor costs, and were saving their businesses money. It was also learned that the growers adopted the new systemic treatments as either a direct result of attending educational workshop trainings by our program or from second-hand experiences of other satisfied growers. It is anticipated that the use of the research supported borer treatments will increase as this core group of growers relay their financial benefit and gains to other growers, as well as exposure to continued educational trainings by our program and nursery extension relaying the information.

Key Items of Evaluation

