Final Report: Increasing use of sustainable plants in production and landscape design
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Summary
This project brought Horticulturists and Pest Management Specialists together in a concerted effort to better identify and increase interest in better-adapted, low input plants for the southeastern U.S. Hundreds of ornamental plants and turf grass selections were evaluated for the ability to resist or tolerate common and newly invasive pests. Better-adapted species and cultivars were identified and mechanisms conferring resistance were in some cases able to be further elucidated, informing plant-breeding efforts. Industry surveys in three states revealed that lawn care and landscape maintenance professionals largely believe that insect- and disease- resistant plants will benefit their businesses and should result in increased client satisfaction. Recommendations developed as a result of research conducted in this project have been formatted to populate a web-based plant selection tool "Gardensource"

Introduction

The purpose of this project was to increase the production and establishment of low- input, pest resistant plants for the landscape. Use of sustainable plants from production through establishment should greatly reduce the pollution potential associated with high pesticide use necessary to maintain pest- susceptible turf and ornamental plants during production and in the landscape. Urban agriculture including nursery and sod production and the value added components of landscape installation and maintenance have increased at a phenomenal rate during the last twenty years. Plants were historically developed for their aesthetic, horticultural attributes. Recently, greater emphasis has been placed on development and use of pest-resistant and other low-input plants (e.g., Braman et al. 2005, 2004, 2003, 2002a,b, 2000ab,, Braman and Latimer 2002, Braman and Ruter 1997, Pettis et al. 2005, Shortman et al. 2002, Hodges et al. 2001, Townsend et al. 1999, Gillman et al. 1999, Wang et al. 1998, Smith -Fiola 1995, Raupp et al. 1992). Interest in learning about pest-resistant plants was clearly demonstrated in a Georgia survey where 72% of GA homeowners expressed an interest in knowing more about pest resistant plants as an alternative to pesticide use (Varlamoff et al. 2000). In that survey, respondents' interest in learning about alternatives to pesticides showed opportunities for distinguishing targeted educational messages. Women, for example, were far more interested in acquiring new knowledge about alternatives to pesticides and pest-resistant plants in that survey.

Research (including that conducted under our earlier SARE project, AS95-023) has demonstrated opportunities to reduce pollution potential in production and value added segments of the diverse urban agricultural industry by using pest-resistant plants (Latimer et al. 1996a,b, Braman et al. 1997, Braman et al. 2000c). Impediments to implementation of host plant resistance as a sustainable strategy include the lack of sufficient information on resistant plants that research component 1 of this proposal addressed. The continual identification of appropriate sustainable plant material is necessary because of the diversity of plant/pest combinations experienced in typical southeastern landscapes and because of the constant threat of invasive species. Projects proposal participants addressed included relatively recent invasives in the south such as hemlock wooly adelgid, as well as long established non-native species (Japanese beetle) or native pests (two lined spittlebug). Perhaps even more important is the diversity of audiences influencing decision making. Garber and Bondari (1992), for example, identified landscape architects as having key impact on demand for plant material, yet few research or extension initiatives have addressed this critical link.

Our research and education project investigates the potential and addresses the impediments to using the environmentally sound practice of host plant resistance as a foundational management strategy for pests in urban agricultural production of amenity crops. The project extends to activities in the landscape, the ultimate site of the plant material of interest, because these two segments of the industry affect each other and the potential impact of changing consumer plant choices on environmental stewardship and sustainability is large.

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Objectives/Performance Targets

The goal of our project was to increase production and ultimate use of low-input, especially pest -resistant plants in the southeastern U.S. The objectives of this project were to: 1)identify optimal plant material (from both low input and aesthetic viewpoints), 2) facilitate pest-resistant plant production and availability, 3) enhance the likelihood that resistant plants will be specified in landscape design, and 4) provide a tool that will make locating desired sustainable plants easier.
The research component of this project 1) identified and developed pest-resistant or other stress tolerant plant material suitable for the southeast and 2) investigated, through survey, interview and facilitated conferences, the most appropriate methods to achieve components 2, 3 and 4 of the plan above.

Materials and Methods

To meet the objectives of the grant research and education activities were designed to:
1) identify and develop pest-resistant or other stress tolerant plant material suitable for the southeast
Multidisciplinary teams in four states (GA,TN, FL, and AL) collaborated in the evaluation and development of ornamentals and turf selections that are resistant or tolerant of pests that also have strong aesthetic appeal. Exact evaluation methods

varied for each plant/pest combination but generally involved a series of lab and field assessments.

2) facilitate resistant plant production and availability- A portion of the studies were conducted on nursery sites and Research and Education facilities open to industry and the general public. The Center for Applied Nursery Research at McCorkles Nursery, hosts a number of research projects including a crape myrtle study with many of the 41 cvs used in projects herein. On site identification of optimal plant material showcased at annual open houses and field days was one way to increase likelihood that plants would be requested and grown for sale.

3) enhanced the likelihood that resistant plants will be specified in landscape design- investigated, through surveys, interviews and facilitated conferences and workshops, the most appropriate methods to reach traditional and important, but nontraditional outlets with technology developed to increase environmental stewardship.

4) provided a tool that will make locating desired sustainable plants easier. Relevant existing documented data on pest resistant plants was compiled and evaluated for appropriateness to the region. A web-based searchable application featuring low-input plants was developed. The illustrated guide allows the user to "replace" a pest-prone plant with one of similar horticultural characteristics, but a better sustainable profile.

Results and Discussion/Milestones

Literally hundreds of ornamental and turfgrass taxa were evaluated for their resistance characteristics to traditional or newly invasive pests. Highlights of the projects are profiled below:

Japanese Beetle on Crapemyrtle

The Japanese beetle, *Popillia japonica* Newman, is recognized as the most widespread and destructive pest of turf, landscape and nursery crops in the eastern

United States. Forty-one crape myrtle cultivars representing a range of flower color and heights were planted on 15 foot centers at the University of Georgia Mountain Station in Blairsville. The cultivars that showed significantly lower percent leaf damage on three or more sample dates were 'Centennial', 'Chickasaw', 'Choctaw', 'Lipan', 'Pecos', 'Potomac', 'Raspberry Sundae', 'Tonto', 'Wichita' and 'Tuscarora'.

The cultivars that consistently had significantly fewer or no beetles on two or more sample dates were 'Apalachee', 'Chickasaw', 'Hardy Lavender', 'Lipan' 'Pocomoke', 'Potomac', 'Raspberry Sundae', 'Tonto', 'Tuscarora', and 'Wichita'. The cultivars that were among the most damaged on three or more sample dates were 'Biloxi', 'Byer's Wonderful White', 'Comanche', 'Dynamite', 'Hopi', 'Miami, 'Natchez', 'Regal Red', 'Sioux' and 'Zuni'; and the cultivars that consistently had significantly higher numbers of beetles on two or more sample dates were 'Byer's Wonderful White', 'Catawba', 'Comanche', 'Hopi', 'Miami', 'Natchez', 'Osage', 'Regal Red', 'Sioux', and 'Zuni'.

Lesser canna leafroller and Japanese beetle on Canna

Twenty-two cultivars of canna lilies, *Canna* x *generalis*, were evaluated for potential resistance to the lesser canna lily leafroller, *Geshna cannalis*, and the Japanese beetle, *Popillia japonica*. Both of these pests cause defoliation of the plants resulting in reduced plant fitness and aesthetic injury. Cultivars sustaining the most damage by leafrollers were 'Richard Wallace', 'Firebird', and 'Black Knight'. While Japanese beetle injury varied, cultivars most consistently damaged by beetles were 'Lenape', 'Scarlet Wave', 'Dawn Pink', and 'Crimson Beauty'. While all plants sustained at least some injury, cultivars that consistently had the least amount of damage by leafrollers were 'Maudie Malcolm', 'Striped Beauty', and 'Journey's End'. 'Maudie Malcolm' and 'Striped Beauty' were similarly avoided by Japanese beetles, while 'Journey's End' sustained moderate injury from this pest. Tall cultivars with red or orange flowers and some red in their foliage were especially vulnerable to infestation by the lesser canna leafroller.

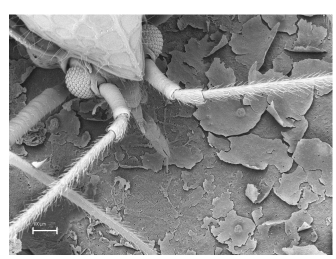
Lace bugs on *Pennisetum* ornamental grasses

Leptodictya plana Heidemann is an emerging pest on ornamental grasses in the southern United States. Thirty-two selections of commercially available ornamental grasses and sedges and five trial accessions of Pennisetum purpureum were evaluated for susceptibility to L. plana feeding and oviposition. No- choice studies were conducted in a greenhouse by securing four lace bugs to leaf blades of each plant using clip cages. Lace bugs stayed attached for five days. Damage and number eggs were recorded. Choice studies were conducted in the

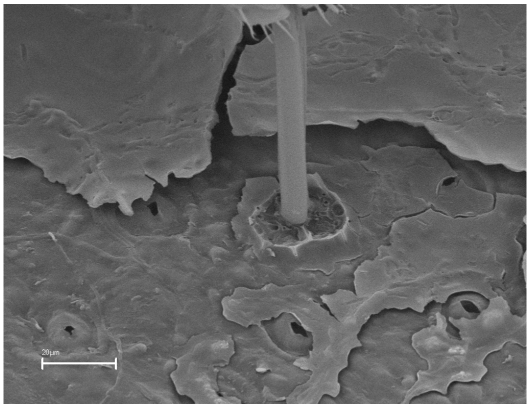
laboratory by placing leaf blades from each genus of plant species into a large petri dish in a spoke pattern. There were no plants tested that consistently received zero percent damage in either trial. Plants that sustained the least damage included *Acorus* spp., *Cordyline* spp., and *Panicum* spp. *Pennisetum* spp. entries exhibited the highest overall percent damage and were the only genera of plants that supported oviposition.

Lace bugs on *Pieris*

Stephanitis takeyai Drake and Maa (Hemiptera: Tingidae), the Andromeda lace bug, is an important pest of *Pieris* D. Don spp., a popular landscape plant. Cultivated *Pieris* taxa have not been evaluated for their pest resistance and this information would be useful to growers as well as breeders. The azalea lace bug, *S. pyrioides* was included in the study because of its importance as the major economic and cosmopolitan tingid species which is also known to infest other ericaceous hosts. Both lace bugs are Asian indigenes as are most cultivated *Pieris* currently in production. Over 60 *Pieris* taxa were evaluated for their susceptibility to the two species of lace bugs based on leaf damage, adult survival on leaves and emergence of nymphs using no-choice Petri dish assays. The taxa *P. phillyreifolia* and *P. japonica* 'Variegata' were consistently resistant to both species of lace bugs while *P. japonica* 'Cavatine' was consistently susceptible to both. *P. japonica* 'Temple Bells' and was notable in being highly susceptible to *S. takeyai*, but resistant to *S. pyrioides*. Oviposition was noted only with *S. takeyai* on some *Pieris* taxa, whereas *S. pyrioides* did not oviposit on any of the *Pieris* taxa. Choice assays (with 10 *Pieris* taxa) and whole plant assays (with 5 *Pieris* taxa) using *S. takeyai* alone were also conducted, confirming the resistance of *P. phillyreifolia* and susceptibility of *P. japonica* 'Temple Bells'. Wide variability in leaf shape, size, texture, color and growth habit exists among *Pieris* taxa, even among taxa within the same species. Screening of *Pieris* taxa for their reaction to *Stephanitis* lace bugs (Hemiptera: Tingidae) revealed gradients in susceptibility to the lace bugs. This study also examined some of the potential mechanisms of resistance in selected *Pieris* taxa to *S. takeyai*, based on their differences in lace bug susceptibility and also the possible role of leaf parameters in plant resistance. Experiments with extracts of leaf-surface lipids revealed that *Pieris* leaf wax does not have a role in resistance. Leaf wax extracts from the resistant species *P. phillyreifolia* applied on leaves of the susceptible cultivar *P. japonica* 'Temple Bells' did not



affect feeding, oviposition or survival of *S. takeyai*, and neither did the reverse affect

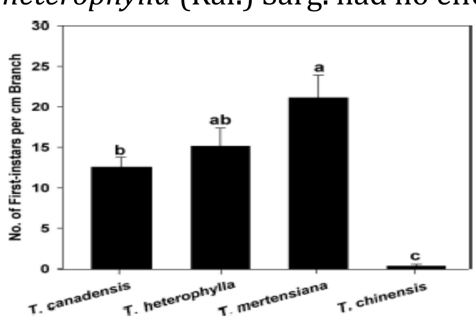


the resistance of *P. phillyreifolia*. Leaf penetrometer measurements indicated significantly higher force was required to puncture *P. phillyreifolia* leaves. This species also had higher fiber, lignin and cellulose content and lower leaf moisture content. Ultrastructural studies on leaves of selected *Pieris* taxa revealed significant differences in the number and size of stomata. *P. phillyreifolia* leaves had the highest number of stomata per unit area but they were the smallest in size, whereas *P. japonica* 'Temple Bells' leaves had a lower number but the largest stomata. Resistance in *Pieris* taxa to *S. takeyai* may be attributed to a combination of different factors among which leaf toughness, moisture and stomatal characters may have a significant role.

Hemlock wooly adelgid and their predators on hemlock

Understanding how fertilization affects host resistance to hemlock woolly adelgid, *Adelges tsugae* Annand (Hemiptera: Adelgidae), is important since fertilizers are often used to grow resistant selections to a suitable size for testing. We evaluated four hemlock species under three different fertilizer regimes to assess whether or not fertility affected resistance to the adelgid and to determine if feeding

preferences of the predators *Laricobius nigrinus* Fender and *Sasajiscymnus tsugae* (Sasaji & McClure) based on eggs obtained from adelgids raised on plants fertilized or not. Treatments were long-term fertility (June 2008 to June 2009), short-term fertility (March to June 2009), and no fertilizer. Plants were fertilized with 240 ppm N using water soluble fertilizer (NPK: 20-20-20) in a biweekly interval. Plants (> 1-yr old) were artificially infested with adelgids on 31 March 2009. Among unfertilized hemlocks (n = 10/species), foliar N content was highest in *Tsuga mertensiana* (Bong.) Carrière, and lowest in *T. chinensis* (Franch.) E. Pritz. Significantly more progredien ovisacs or sisten eggs were present on *T. mertensiana* than on the other hemlock species with none on unfertilized T. chinensis. Fertilizing *T. heterophylla* (Raf.) Sarg. had no effect on adult *A. tsugae* feeding. However,



densities of developing A. tsugae nymphs, were higher on unfertilized T. *heterophylla* than on fertilized *T. heterophylla* regardless of fertilizer. Both *L. nigrinus* and *S. tsugae* consumed more adelgid eggs that developed on fertilized *T. canadensis* than from unfertilized ones. This predatory preference was not noted on *T. heterophylla* or *T. mertensiana*.

Dogwood Sawfly on *Cornus* spp.

Dogwood sawfly (*Macremphytus tarsatus* Say) is a native, phytophagous insect that relies on *Cornus* sp. host plants for larval development. Feeding injury by dogwood sawflies is primarily aesthetic and seldom results in host plant death. Still, native and non-native dogwoods have not been evaluated for susceptibility to larval feeding by this aesthetically damaging wasp. Ten species or cultivars of dogwoods that are either naturalized native plants or economically significant landscape plants were assayed for host suitability to dogwood sawfly larvae in no-choice and choice experiments. Flowering, kousa and cornelian cherry dogwoods were consistently ranked among the least susceptible host plants while 'Sibirica' tatarian, gray, and 'Flaviramea' golden-twig dogwoods were highly preferred hosts. Preliminary GC/MS comparisons of foliar metabolite extracts from all 10 species have identified five peaks of interest that varied between resistant and susceptible hosts. These results suggest that certain chemical constituents in foliage of dogwood species may be important predictors of host palatability. More research is needed to confirm this hypothesis before crossbreeding for sawfly resistance can proceed.

Florida wax scale on Hollies

33 taxa of potted hollies were represented by six plants (replications). Plant taxa were selected to provide varieties within four landscape use groups; trees, large shrubs, medium shrubs, and small shrubs. The intended purpose of the groupings was for easier incorporation into the plant use database, also an objective of this project. For example, if this research determines that Ilex crenata ‘Hoogendorn’ (small shrub group) is more susceptible to this scale, then a resistant variety in the same use group would be suggested by the software as a substitute.

In mid-May 2009 and 2010, potted plants were infested with Florida wax scale (FWS), *Ceroplastes floridensis* . Stems were tethered into each potted plant using parafilm. Foliage was sampled to determine nitrogen and water content, leaf thickness and toughness, and an assessment of crawler density was also taken. All varieties hosted crawlers but crawler density showed significant variation among cultivars and species. Among use groups, the tree had the most significant variation in crawler density. Data also suggest thickness and toughness are significant factors in wax scale crawler density. In fall 2010, gravid females were sampled from each plant to determine the number of offspring (eggs or crawlers) on each respective cultivar.

Based on 2009 data, crawlers will settle on all varieties of holly in this trial. Fecundity evaluated in 2010 explained the rapid buildup on populations on certain hollies in the field. These differences have been previously reported without fully understanding how these population outbreaks occur. This should provide landscape architects and growers with the needed information to select less susceptible cultivars within each use group for production or planting designs.

Rose evaluations

Sales and use of shrub roses has increased dramatically but information on performance in Florida and the SE is lacking, especially under low maintenance conditions. An evaluation of 12 shrub rose cultivars was conducted at 3 sites in Florida. After 40 weeks, Knock Out received the highest average cumulative visual quality ratings in north and central Florida, and Knock Out and Home Run had the highest ratings in south Florida. The largest average cumulative flowering occurred with Knock Out in south Florida, Knock Out, Home Run and 'Bailey Red' in central Florida, and Knock Out and Home Run in north Florida. Ratings in central Florida declined in late summer and fall in association with damage from chilli thrips (*Scirtothrips dorsalis*). Peak flowering of most cultivars occurred in July in south and central Florida and Aug. through Nov. in north Florida.

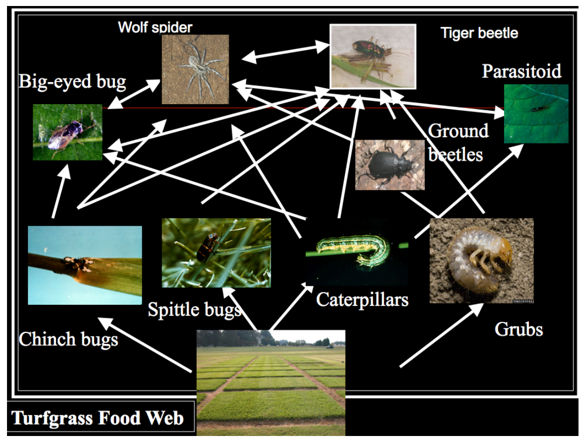
Chinch bugs on St. Augustine

Field and greenhouse studies were conducted in Georgia and South Carolina to determine the tolerance and antibiosis effects of 15 St. Augustinegrass genotypes against the southern chinch bug. 'Floratam' and 'Floralawn' cultivars were highly resistant to southern chinch bug populations in South Carolina and Georgia. When southern chinch bugs were caged on Floratam for 37 days in a greenhouse study, both survivorship and adult reproduction were either stopped or significantly reduced. Color and quality ratings of heavily infested field plantings of 'Raleigh' were not significantly reduced even though this cultivar had the highest chinch bug density. Color and quality ratings for 'Amerishade' were significantly lower than all other cultivars. The data suggested that the St. Augustinegrass cultivars exhibited different levels of tolerance to infestation by southern chinch bug. The results called into question the established treatment threshold of 20-25 chinch bugs 0.1 m-2, which does not consider the tolerance levels among St. Augustinegrass cultivars. Numbers of the predator *Lasiochilus palidulus* also varied

by genotype and were least abundant in the resistant cultivars and most abundant in 'Winchester'.

Grubs on Paspalum

Ten cultivars of seashore paspalum, Paspalum vaginatum Swartz, were compared for their response to Japanese beetle, Popillia japonica Newman, larval root feeding. Cultivars of bermudagrass, Cynodon sp. and zoysiagrass, Zoysia sp. were also included for comparison. Turf grown in pots in the greenhouse was infested with second and third instar larvae in this two year study. Grub survival and weight gain, foliar growth and root loss were compared among turfgrass species and cultivars. Few species related differences were identified. Differences in grub tolerance were however, observed to be a function of turfgrass cultivar. Some turf types demonstrating tolerance to grub feeding had rapid root growth and high root mass in control pots, but this was not consistent for all cultivars showing enhanced ability to maintain foliar growth despite grub feeding. The paspalum cultivars that appeared most tolerant of grub feeding were 561-79, Sea Isle 2000, Durban, HI-10, Kim-1, Sea Dwarf and Sea Spray.



Fall armyworms on Paspalum

Eight of 10 turfgrass species and cultivars evaluated supported growth and development of the fall armyworm in this study. Larval and pupal weights and days to develop to pupal stage were significantly influenced by turfgrass selection. *Paspalum* selections with the lowest larval weights, suggesting some degree of antibiosis, included PI-422024 (*P. notatum var. saurae*) and PI-462298 (*P. quadrifarium*). The lowest pupal weights were observed among *Paspalum* spp. accessions, including PI-286486 (*P. thunbergii*), PI-310146 (*P. notatum*). Extended days to develop to pupal stage were observed for PI-422024 (*P. notatum var. saurae*) and PI-310146 (*P. notatum*). All initial 30 neonate larvae failed to survive to 8d on 'Cavalier' zoysiagrass.
Larvae failed to survive to 8d on 1 of the 10 *Paspalum* spp. accessions, this was. PI-404449 (*P. ionanthum*). The grass with highest survival was *P. vaginatum* 03-539-31 (83.34%). Larvae failed to survive to the pupal stage on 1 *Paspalum* spp. accession; this was PI-404449 (*P. ionanthum*). Survival of initial 30 neonate larvae to 8d ranged from 30% on PI-422024 (*P. notatum var. saurae*) *to 83.34% on P. vaginatum* 03-539-31.

Among *Paspalum* spp. accessions evaluated, *P. vaginatum* 03-539-31.and *P. vaginatum* 03-525-22 were the most suitable (susceptible) hosts, as measured by larval and pupal weights and days to develop to pupal stage. The least suitable (resistant) hosts among *Paspalum* spp. accessions were PI-404449 (*P. ionanthum*), PI-422024 (*P. notatum var. saurae*), PI-310146 (*P. notatum*) and PI-286486 (*P. thunbergii*).

Two lined spittlebugs on centipedegrass

Warm season turf selections of centipedegrass, bermudagrass, St. Augustinegrass, and zoysiagrass were evaluated for tolerance to adult two lined spittlebug (*Prosapia bicincta* Say) feeding in choice and no- choice experiments, and for their ability to support nymphal development (antibiosis potential). Among 133 selections evaluated for response to the two lined spittlebug, several showed evidence of potential antibiosis and/or improved tolerance over commercially available cultivars. Most of the centipedegrass germplasm evaluated was susceptible to the spittlebug. Some potential antibiosis among Chinese centipedegrass introductions was identified, and there was a gradient in the ability of the different grasses to tolerate spittlebug feeding. Among the centipedegrasses evaluated, fewest nymphs developed on TC 341, TC 379, TC 399, TC 422 and E. c*illiaris.* The bermudagrasses 00-23 and 00-28 and the St. Augustinegrasses T638 and Mercedes failed to support development in either of the two developmental trials conducted. In a laboratory trial, the fewest nymphs developed on St. Augustinegrass. Among centipedegrasses, the least damage was visible on TC 441, TC 341, TC 358, TC 342, TC 344, TC 390, TC 438, TC 362, TC 347 and TC 346 in no- choice trials. In choice trials, however, the least damaged centipedgrasses were TC 324, 325, 326 and 338 and TC 358 and 359. The most tolerant bermudagrasses were 00-23, 03-14, and 03-15.

Survey results

Although lawn care and landscape maintenance professionals appear increasingly willing to use Integrated Pest Management (IPM) strategies and adopt nonchemical pest management alternatives into management practices, the opinions of landscape management professionals have not been assessed regarding anticipated influences of increased use of insect- and disease-resistant ornamental plants on grounds management activities, client satisfaction, or business profitability. Lawn care and landscape professionals are well positioned to implement many IPM practices into landscape use and to educate their consumer clients about ecologically sustainable landscape designs and beneficial management techniques. Conversely, if some of these professionals are unwilling to advocate installation of ornamental host plants that are resistant to certain pests or diseases, market success of such plants can be limited. To better understand perceptions of green industry professionals related to these issues, we

surveyed lawn care and landscape business owners and employees to categorize their perceptions about insect- or disease-resistant ornamental plants and qualified their beliefs in relation to both personal and firm demographics. A total of 391 completed surveys were received from Tennessee, Florida, and Georgia participants. Data analyses revealed that lawn care and landscape maintenance professionals largely believe that insect- and disease- resistant plants will benefit their businesses and should result in increased client satisfaction. Only ’4% of respondents stated concern that business would incur at least some negative effect if pest-resistant plants were made more available or used in greater numbers in client landscapes. Among all respondents, there was an average expectation that 60% or more of plants within a given client’s landscape would have to be resistant to insect pests or plant diseases to result in a decrease in company profits. If insect- and disease-resistant ornamental plants were used more widely in client landscapes, respondents expected that the required number of site visits to client landscapes would remain unchanged and that moderate reductions in insecticide and fungicide use would result.

GardenSource

GardenSource is designed as a web application to reach the largest possible audience of agents, homeowners and growers. Easily expandable and adaptable to allow for any changes necessary to the content or how it's organized. Everything about the plants in the database is searchable and can be used to organize your results. Putting it on the web allows for unlimited growth and cooperation with interest groups at any point. Setting up a multiuser website let's us have multiple contributors and future collaboration with growers and industry professionals.

A broad selection of plants is needed to provide adequate diversity of data. Once the list is prepared a fieldset representative of the whole can be selected. Once a sample set of plants are entered into the database a series of "views" can be constructed to assess the most desirable ways to search for and view the information. Additional sections of the site can be built as new needs are determined.

Impact of the Results/Outcomes

Literally hundreds of ornamental and turfgrass taxa were evaluated for their resistance characteristics to traditional or newly invasive pests in Georgia, Florida, Alabama and Tennessee. These experiments allowed better-adapted species and cultivars of ornamental plants and turfgrasses to be identified and recommended for more sustainable performance in the nursery and landscape.

Surveys conducted in Tennessee, Florida, and Georgia revealed that lawn care and landscape maintenance professionals largely believe that insect- and disease-resistant plants will benefit their businesses and should result in increased client satisfaction indicating a demand for plants with an improved sustainability profile.

Electronic and web-based plant selection tools have been developed that can assist in decision making for those involved in recommending plants to the general public.

Publications/Outreach

Publications Refereed Journal:

Braman S.K., Raymer P. 2006. Impact of Japanese beetle (Coleoptera: Scarabidae) feeding on seashore paspalum. J. Econ. Entomol. 99(5): 1699-1704.

Braman, S. K., E. R. Carr and J. C. Quick. 2011. Cannas pp. cultivar response to the lesser canna leafroller, *Geshna cannalis* (Quaintance), and the Japanese beetle, *Popillia japonica* (Newman). J. Environ. Hort. 29: 87-90.

Braman, S. K., J. C. Quick, M. Mead and S. Nair. Range in Japanese beetle response to field-grown crape myrtles. J. Entomol. Sci. in Review.

Braman, S.K., W.W. Hanna and B. Schwartz. Evaluation of Chinese Centipedegrasses and other Turfgrass Species and Cultivars for Potential Resistance to Twolined Spittlebug, *Prosapia bicincta* (Say). J. Entomol. Sci. In Review

Braman, S.K., L. D. Nissen , P .L. Raymer , M. Harrison-Dunn and E. Ferrufino. Antibiosis among selected paspalum taxa to the fall armyworm (Lepidoptera: Noctuidae). Fla. Entomol. In Review

Carr, E. R., S. K. Braman and W. W. Hanna. 2011. Host plant relationships of *Leptodictya plana* (Hemiptera: Tingidae). J. Environ. Hort. 29: 55-59.

Chong, J., Braman, S. K., Waltz, F. C. (2009). St. Augustinegrass Cultivar Influences on Southern Chinch Bug and Predator Populations. Applied Turfgrass Science, http://www.plantmanagementnetwork.org/sub/ats/research/2009/chinch/chinch.pdf. Online. Applied Turfgrass Science doi:10.1094/ATS-2009-1123-01-RS

Joseph, S. V., S. K. Braman and J. L. Hanula. 2011. Effects of fertilization of four hemlock species on *Adelges tsugae* (Hemiptera: Adelgidae) growth and feeding preference of predators. J. Econ. Entomol. 104: 288-298.

Klingeman, W.E., G.V. Pettis and S.K. Braman. 2009. Lawn care and landscape maintenance professional acceptance of insect- and disease-resistant ornamental plants. HortScience 44(6): 1608-1615.

Nair, Shakunthala, S. K. Braman and D. A. Knauft. Host plant utilization within family Ericaceae by the andromeda lace bug, Stephanitis takeyai Drake and Maa (Hemiptera: Tingidae). J. Environ. Hort. In Review.

Nair, Shakunthala, S. K. Braman and D. A. Knauft. Gradients in susceptibility of Pieris taxa to Stephanitis spp. lace bugs (Hemiptera: Tingidae). Environ. Entomol. In Review.

Nair, Shakunthala, S. K. Braman and D. A. Knauft. Resistance mechanisms in Pieris taxa to Stephanitis takeyai Drake and Maa (Hemiptera: Tingidae). Environ. Entomol. In Review.

Pettis G.V., Braman S.K. 2007. Effect of temperature and host plant on survival and development of *Altica litigata* Fall. J. Entomol. Sci. 42(1): 66-73.

Theses and Dissertations:
This grant provided partial support for projects in the following thesis and dissertation work:

Carr, E. R. 2010. Biology and ecology of *Leptodictya plana* Heidemann (Hemiptera: Tingidae). MS. Thesis. The University of Georgia, Athens, GA.

Nair, S. 2011. *Stephanitis* lace bugs affecting ericaceous plants: host range, resistance mechanisms and management, Ph.D. Thesis. The University of Georgia, Athens, GA.

Joseph, S. V. 2010. "Management Strategies to Reduce Hemlock Woolly Adelgid (Hemiptera: Adelgidae) Damage". Ph.D. Thesis. The University of Georgia, Athens, GA.

Publications/ Extension, Trade Journal or Conference Proceedings:

Braman, S.K. 2007. Tolerance of Seashore Paspalum to feeding by Japanese Beetle, Golf Course Magazine.

Braman, S.K. and C. Waltz. 2007. Evaluation of St. Augustine cultivars for chinch bug resistance, a research update. Georgia Sod Producers Association News. 17(2) 26-28, July

Raymer, P.L., S.K. Braman, L.L. Burpee, R.N. Carrow, Z. Chen, and T.R. Murphy. 2008. Seashore paspalum: breeding a turfgrass for the future. USGA Green Section Record. Jan-Feb- 2008.

Braman, K. 2008. White grub management update. Georgia Sod Producers Association News. Vol 18: Number 1, March.

Wayne Hanna and Kris Braman. 2008. Breeding Turf for Insect Resistance. GTA Today. Vol 23 No. 2 Mar/Apr.

Wayne Hanna and Kris Braman. 2008. Breeding Turf for Insect Resistance. Tee to Green: Spring 2008: 12-13

Wayne Hanna and Kris Braman. 2008. Breeding Turf for Insect Resistance. Through the Green. May/June. P. 30.

Wayne Hanna and Kris Braman. 2008. Breeding Turf for Insect Resistance. Georgia Sod Producers Association News. P. 31, July 2008

Klingeman, W.E., G.V. Pettis and S.K Braman. 2008. Landscape professional perspectives on ornamental host plant resistance. Proc. Ann. Res. Conf. Southern Nursery Assoc. 252-256.
http://www.sna.org/content/Economics%20and%20Marketing%20Section%202008%20SNA %20Proceedings_1.pdf

Knox, Gary W., Sydney Park Brown, Sandra B. Wilson, Keona Muller, Jozer Mangandi and James H. Aldrich. 2009. Initial Performance of 12 Roses Grown in North, Central and South Florida under Low Maintenance Conditions. Proc. Southern Nursery Assn. Res. Conf. 54: 245-249.

Presentations at Professional Society Meetings

Braman, S.K. and C. Waltz. 2007. St. Augustinegrass influence on southern chinch bug and associated natural enemies. ESA National Meeting, San Diego, CA. December.

Braman, SK. And C. Waltz. 2007. Influence of turfgrass cultivar on southern chinch bug and natural enemies. SEB, ESA. Knoxville, TN. March.

Braman, S.K. 2007. Crapemyrtle cultivar response to Japanese beetle. Georgia Entomological Society. Athens GA. May.

Braman, S. K., L. Nissen, P. Raymer. M. Harrison-Dunn. 2008. Antibiosis among selected Paspalum taxa to the fall armyworm. South Eastern Branch, Entomological Society of America. Jacksonville, FL. Mar.

Braman, Susan K., Carr, Evelyn. March 2010.
SEB-ESA. Entomological Society of America, Atlanta Resistance among canna spp. cultivars to the lesser canna leafroller.

Carr, Evelyn, Braman, Susan K. March 2010. SEB-ESA. Entomological Society of America, Atlanta Biology and Ecology of Leptodictya plana.

Carr, Evelyn, Braman, Susan K.. March 2009. Southeastern Branch of the Entomological Society of America. Southeastern Branch of the Entomological Society of America, Montgomery, AL Field phenology of Leptodictya plana: first record in Georgia.

Joseph, S.V., S.K. Braman and J. Hanula. 2008. Distribution and abundance of hemlock wooly adelgid within a hemlock stand. South Eastern Branch, Entomological Society of America. Jacksonville, FL. Mar.

Joseph, Shimat, Braman, Susan K., Hanula, James L.. March 2010.

SEB-ESA. Entomological Society of America, Atlanta Effects of fertilizer on hemlock wooly adelgid growth on various hemlock species.

Joseph, Shimat, Braman, Susan K., Hanula, James L.. March 2010.
SEB-ESA. Entomological Society of America, Atlanta Influence of hemlock species and fertilization on feeding preference of specialist predators of hemlock wooly adelgid.

Joseph, Shimat, Braman, Susan K., Hanula, James L.. March 2009.
Southeastern Branch of the Entomological Society of America. Southeastern Branch of the Entomological Society of America, Montgomery, AL Influence of olfactory response of predators to hemlock species.

Nair, Shaku, Braman, Susan K., Knauft, David A.. October 2010.
GES. Georgia Entomological Society, McCormick, SC Gradients in susceptibility of Pieris taxa to Stephanitis lace bugs.

Nair, Shaku, Braman, Susan K., Knauft, David A.. March 2010.
SEB-ESA. Entomological Society of America, Atlanta Gradients in susceptibility of Pieris taxa to Stephanitis lace bugs.

Nair, Shakununthala, Braman, Susan K., Knauft, David A.. March 2009.
Southeastern Branch of the Entomological Society of America. Southeastern Branch of the Entomological Society of America, Montgomery, AL Susceptibility of Pieris varieties to lace bugs.

Presentations to Industry Groups

Braman, SK. 2007. First Line of Defense: Host Plant Resistance, Southern Nurserymen's Association, TechShop, Atlanta, Aug.

Braman, S.K. 2007. Beneficial Insects. Turfgrass Institute, Atlanta, December.

Braman, S.K. 2007. Integrated Pest Management. GA Master Gardeners, Griffin, September.

Braman, S.K. 2007. Insect Pests of Ornamentals. Green Industry Update, Paulding Co. November

Braman, S. K. 2008. First Line of Defense: Host Plant Resistance, Kentucky Nursery and Landscape Association Winter Conference Invited Presentation, Louisville. KY, USA
January 2, 2008
Participants: 130; Total CEUs: 4; Total Contact Hours: 130

Braman, S.K. 2008. Insects of ornamentals and turf., University of Georgia, Griffin. GA, USA
March 2008
Participants: 30; Total CEUs: 2; Total Contact Hours: 30

Braman, S.K. 2008. Insect Pests of Turf, University of Georgia, Griffin. GA, USA
August 28, 2008
Participants: 800; Total Contact Hours: 800

Braman, S.K. 2008. Managing and controlling pests in the landscape, University of GA, Tifton. GA, USA
May 5, 2008
Participants: 100; Total Contact Hours: 100

Braman, S.K. 2008. The Power to Resist, GGIA Wintergreen Conference, Athens. GA, USA
January 23, 2008
Participants: 100; Total CEUs: 2; Total Contact Hours: 100

Braman, S.K. 2009. Crape myrtle management, UGA/ GA Mountain Station.
July 31, 2009
Participants: 60;
Mode of Delivery: Face to Face

Braman, S.K. 2009. IPM for Turf, Georgia Turf Association, Atlanta.
December 9, 2009
Participants: 100;
Mode of Delivery: Face to Face

Braman, S.K. 2009. Safe, effective and environmentally friendly pest control, Georgia Turf Association.
December 9, 2009
Participants: 40;
Mode of Delivery: Face to Face

Braman, S.K. 2009. Insect Pests of Turf, Master Gardner wimba.
March 23, 2009
Mode of Delivery: Fully at a Distance (96% or more)

Braman, S.K. 2009. Insect Pest Management for ornamentals, UGA Master Gardener wimba, Griffin. GA, USA
February 23, 2009
Participants: 185; Total Contact Hours: 185
New Course Prep: Yes
Mode of Delivery: Fully at a Distance (96% or more)

Braman, S.K. 2009. Getting Greener in the Green Industry: Alternative Pest Management, GGIA Wintergreen Conference, Athens. GA, USA
January 21, 2009
Participants: 70; Total CEUs: 2; Total Contact Hours: 70

Braman, S.K. 2010. GA/FL Green Industry Update: Insect ID & Insect Control, UGA and University of Florida, Webinar-based with participants in 69 counties across GA and FL., Various. GA, US
November 8, 2010
Participants: 97; Total CEUs: 2; Total Contact Hours: 2.5
Instructor % Responsibility: 10%
New Course Prep: Yes
Mode of Delivery: Fully at a Distance (96% or more)

Braman, S.K. 2010. Landscape IPM Workshop, Georgia Turfgrass Assoc, Duluth, Gwinett. GA, USA
December 8, 2010
Participants: 75

Held, D.W. 2007. Insect pest management for wholesale and retail nurseries. MSU-ES Nursery Workshop, Hattiesburg, MS. Aug. 15.

Held, D.W. 2007. Practical ways to incorporate IPM into landscape management. Mid-south greenhouse growers conference, Raymond, MS. June 6.

Klingeman, W. E. 2007. Disease and insect resistant plants for TN landscapes. Spring Express Landscape Seminar, Chattanooga, TN. 2/21/2007.

Klingeman, W. E. 2007. Using disease and insect resistant plants. Tri-Cities Landscape Seminar, Jonesboro, TN. 2/9/2007.

Klingeman, W. E. 2007. Host plant resistance and disease and insect resistant plants. TN Nursery & Landscape Assoc. Educational Conference, Pigeon Forge, TN. 2/5/2007.

Klingeman, W. E. 2006. Are you using the resistant plants that are available? Middle TN Nursery Assoc. Trade Show, McMinnville, TN. 10/6/2006.

Pettis G. V. 2007. Pest- resistant Plants. Florida/Georgia Green Industry Update For Landscape and Turfgrass Professionals, North Florida Research and Education Center, Quincy, FL. Wednesday, October 17, 2007

Pettis G. V. 2007. Pest- resistant Plants. Florida/Georgia Green Industry Update For Landscape and Turfgrass Professionals, Duval County Extension, Jacksonville, FL. Tuesday, October 16, 2007

Pettis G. V. 2007. Pest- resistant Plants. Florida/Georgia Green Industry Update For Nursery and Greenhouse Personnel, North Florida Research and Education Center Quincy, FL. Thursday, October 18, 2007

Other Outreach-Graduate/Undergraduate Curriculum Development
Spring 2010 Landscape Entomology, Auburn- section in host plant resistance, discussed the database as a resource for landscape professionals or extension agents to design and implement more sustainable landscapes. This is my graduate\undergraduate course.

ENTO 4500/6500, Biological Control, University of Georgia, Lectures on Host Plant Resistance and integration with Biological Control incorporated the results of research described above.

Farmer Adoption
Growers and allied urban ag industries have experienced significant economic challenges during the time frame of this project. High energy costs, work force challenges, water restrictions and economic decline with a weakening consumer demand have contributed to unprecedented challenges to the industry. Growers have adopted varying strategies, growing large numbers of fewer items for mass markets or diversifying in a wider selection with limited production of plant offerings. With limited resources to devote to pest management, low-input plants such as those identified by this research are being increasingly grown across the southeast. In particular, certain Pieris, knockout roses, St. Augustinegrass selections, cannas and crapemyrtles have gained popularity.

Areas Needing Additional Study
Further research is needed to identify adapted plants with multiple resistance that are compatible with biological control to ensure sustainability in landscape design. Growers and consumers are less defining forces in market selection compared with mass retailers providing many production challenges. Opportunities exist to direct market research with mass retailers in supplying sustainable plant material for consumer choice.