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UNIVERSITY of FLORIDA

FNGLA Endowment 2020-2021 Funding Reports

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ABOUT THE FNGLA ENDOWMENT

The Florida Nursery, Growers and Landscape Association (FNGLA) created an endowment in 2005 to address problems and questions that are important to the Florida nursery industry.

The FNGLA Endowed Research Fund (#F003129/30) provides awards up to $5,000 each to supplement and extend existing research projects. The principal balance of the endowment is more than $1.45 million, and **10 projects** were funded for a total of **$49,950** and involved **19 faculty members**, including a collaboration with Tennessee State University.

The following priorities were determined for the selection of the 2019-20 projects:

1. Enhance Floridians' Quality of Life
2. Improve Environmental and Resource Management
3. Improve Pest Management Practices and Strategies
4. Improve Production Systems Practices and Strategies
5. Genetics and Breeding to Enhance Quantities and Diversity of Plant Material

The selection process included a review by the following FNGLA committee members:

- Ed Bravo
- Stefan Liopiros
- Mike Marshall
- Joe Cialone
- Van Donnan
- Nancy McDonald
- David McDonald
- Sylvia Gordon
- David Liu
- Nate Jameson
- Linda Reindl

A MESSAGE OF THANKS

To the Florida Nursery, Growers and Landscape Association:

Now, more than ever, support from associations like yours allows UF/IFAS researchers to continue their great work towards research and discovery both on campus and at our off-campus research centers (see map on the back of this document). The additional funding your organization raised is truly appreciated and will be used well.

We also want to thank the selection committee for the time they dedicated to this program. Your thorough review ensures the projects that receive funding are the best of the best.

We look forward to this continued collaboration and hope you find this document helpful.

Sincerely,

Robert Gilbert
UF/IFAS Dean for Research
Director of the Florida Agricultural Experiment Station (FAES)

Damian Adams
UF/IFAS Associate Dean for Research
Associate Director of the FAES

Jerry Fankhauser
Assistant Director of the FAES

ENHANCE FLORIDIANS' QUALITY OF LIFE

This priority area is defined as:

FNGLA supports research that will improve or enhance the quality of life for Floridians.

FNGLA supported two projects under this priority area, and their summaries are on pages 5-14.

The Role of Gardening Activities on Resilience Quality of Life (Especially During the COVID-19 Pandemic)

PI: MYSHA CLARKE, School of Forest, Fisheries and Geomatics Sciences

ABSTRACT

Gardening activities provide important benefits for people and ecosystems and are an important way for communities to get physical exercise, reduce stress, and connect with nature. The purpose of this research is to assess 1) the role of private yard and community gardens as a way for people to cope with the COVID-19 pandemic including their choice of plants, perceptions, and overall outlook on the role of gardening activity on their quality of life during the pandemic and 2) to assess any changes in consumers' purchasing habits. Intercept surveys were used to collect data at 3 garden centers/nurseries in Florida – Garden Gate Nursery (Gainesville, FL), Rockledge Gardens (Rockledge, FL) and Flamingo Road Nursery (Davie, FL). A total of 257 surveys were completed. We found that most people use their gardens as a place of beauty (90%), a place to observe nature (77%) and a place to promote natural biodiversity (42%). Although there are social distancing requirements because of COVID-19 pandemic, 65% of respondents still purchased their plants in-person. Respondents also indicated that gardening provides social connectivity as 61% strongly agreed or agreed that they liked the social activities connected to gardening, felt connected to other people they garden with (57%) and 55% agreed or strongly agreed they felt a strong sense of community with others who garden. On the other hand, the most common challenges of gardening during the pandemic includes lack of knowledge (51%), insufficient time (42%) and insufficient money to purchase resources (37%). This project can be used to inform policy and educational programming geared towards incorporating gardening to enhance the wellbeing of Floridians.

OBJECTIVES

This proposal assessed:

- The role of gardening activities on wellbeing and as a coping mechanism during the COVID-19 pandemic
- The impacts of the COVID-19 pandemic on the purchasing habits and preferences of consumers including plant preferences and associated connections to nature related to quarantine and stay at home orders.
- The survey will elucidate responses from Floridians about ways gardening may help address their quality-of-life concerns and how FNGLA can help including ways to by creating learning opportunities for example reduce stress via gardening at home, increasing food security via growing fruits and vegetable in home gardens or containers in apartments etc.
- This survey will assess the needs of consumers including plant material preferences, product delivery options, topics or skills related to gardening that they could help them strengthen their resilience and their gardening plans for the future.

METHODS

The research collected data using in-person intercept surveys at 3 garden center sites in the state of Florida. The researchers were stationed at the exit/entrance of selected nurseries and garden centers associated with the FNGLA chapters. Twelve nursery owners/managers were initially contacted to participate in the study. Three nurseries/garden centers responded with their willingness to serve as study sites for the surveys. These in-person intercept surveys were conducted at 3 locations from each North Florida Chapter, Central Florida Chapter and South Florida Chapter. We collected 104 surveys from Rockledge Gardens (Rockledge, FL), Flamingo Road Nursery (Davie, FL) and Garden Gate Nursery (Gainesville, FL). Prior to collecting data, the research protocol was reviewed and approved by the University of Florida's Institutional Review Board to ensure that the project met the ethical guidelines for research involving human subjects.

The data was collected by two research assistants on a Saturday at each garden site. The research assistants had a table booth, stand for advertising the survey, various seed packets (primarily "Bee Happy" pollinator seed packets) as tokens of appreciation for participants and a letter explaining the purpose of the research for participants to keep. The researchers had printed copies of the survey for consumers to complete. In total, we collected 257 surveys responses including 104 surveys from Rockledge Gardens, 77 from Garden Gate Nursery and 76 from Flamingo Road Nursery. The survey asked questions about 1) gardening experience, 2) motivations for gardening (why)/sense of place, 3) plant purchases and sources of information, 4) knowledge of invasive species and gardening, 5) the impacts of COVID-19 on gardening activities and 6) future intentions related to gardening activities. The completed paper versions of the survey were then individually uploaded into Qualtrics for analysis.

RESULTS

Gardening experience

Of the survey respondents, 92% of them garden in private yard and/or community garden. In terms of gardening experience, 41% have been gardening for more than 10 years, 47% in the last 1-5 years while only 10% started gardening in the past year. Majority of respondents garden in their private home or yard garden (60%) while 15% gardened on a patio or balcony, 17% gardened with indoor plants and 8% gardened elsewhere including at a friend/neighbor/relatives' house, community garden or shared co-op space and volunteer school gardens. The vast majority of respondents participated in container gardening (85%) while others also indicated butterfly garden (40%), organic gardening (27%), vertical garden (11%), water garden (8%) and other types of gardens (24%) for example indoor fruit trees **(Figure 1)**.

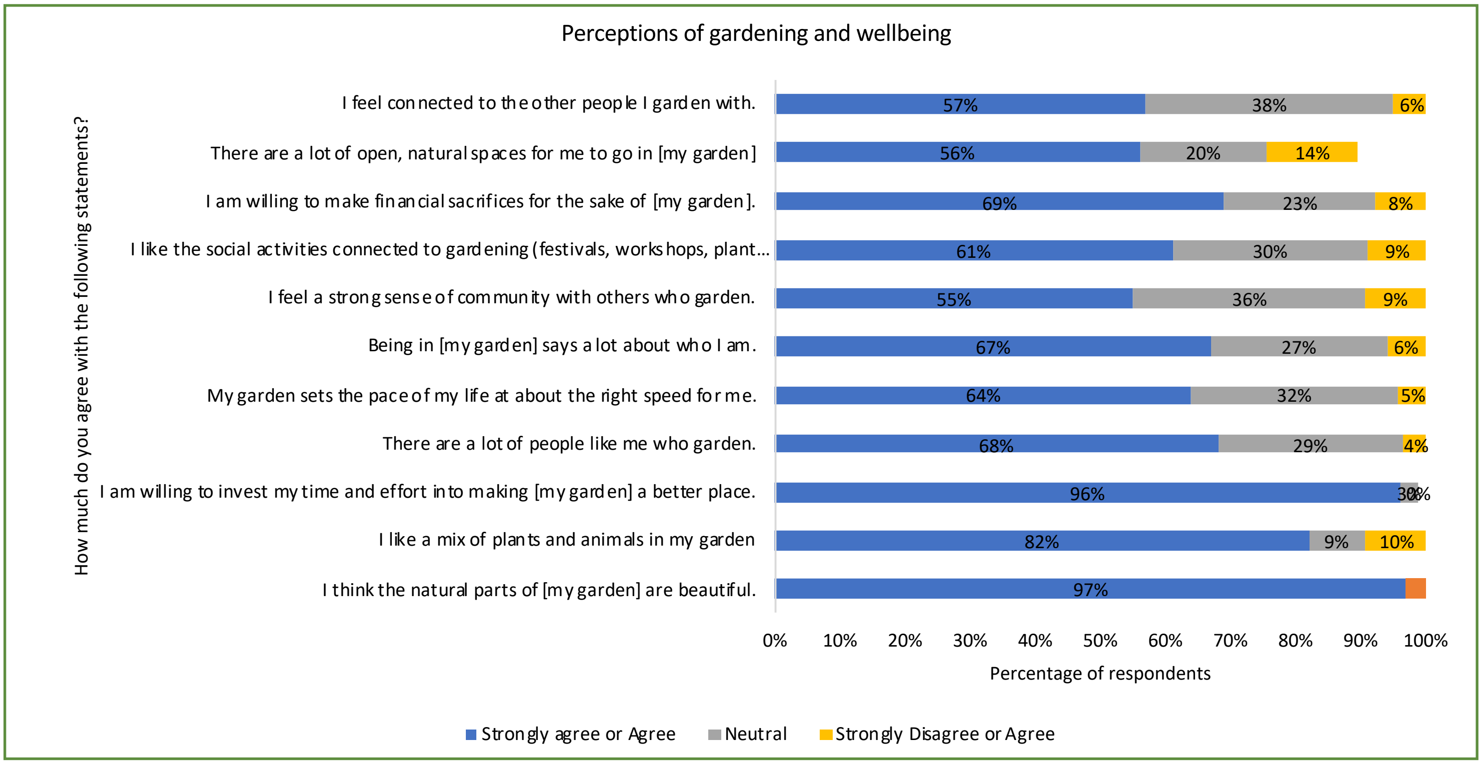


Figure 1. Perceptions of gardening and wellbeing

Motivations for gardening

When asked about their reasons for gardening, the most common responses were for relaxation (77%), to spend time outdoors (65%) and to observe nature and wildlife (64%) **(Figure 2)**.

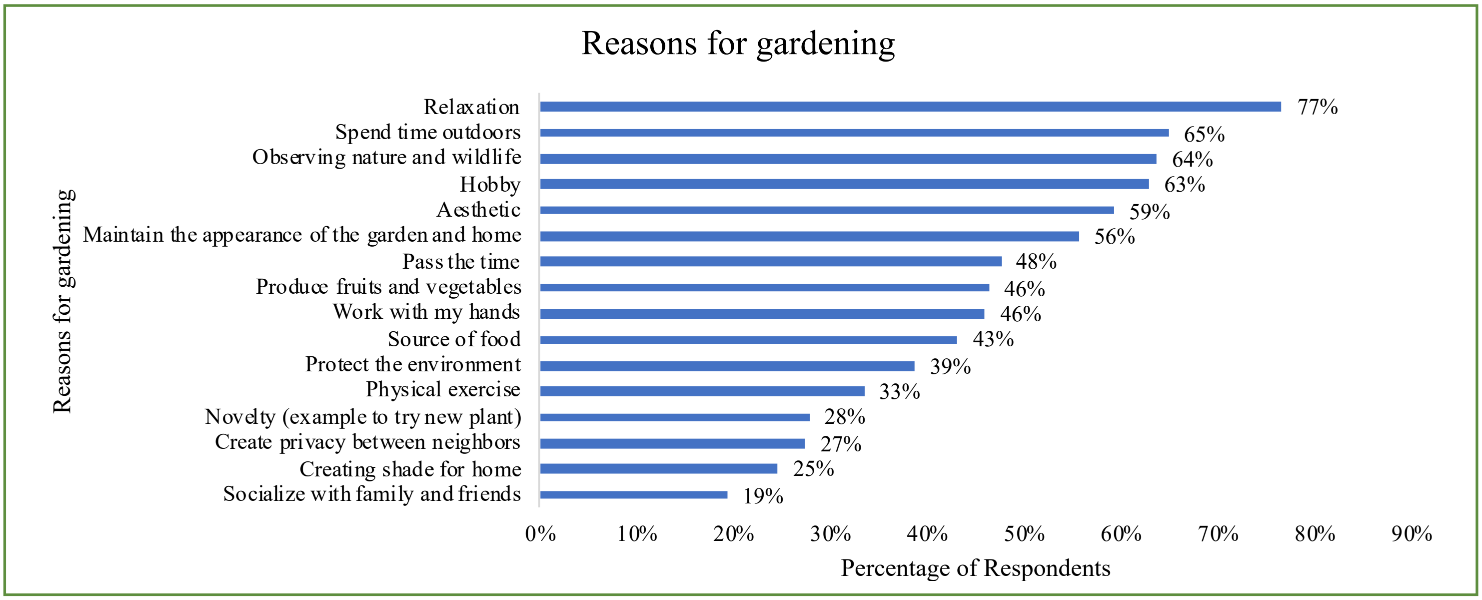


Figure 2. Reasons for gardening overall

Knowledge of invasive species and gardening

When asked about their knowledge of invasive species and gardening, 33% of respondents were moderately familiar with invasive plants (knew about invasive plants but cannot identify specific invasive plant species), 23% had low familiarity (heard of invasive plants but do not know much about them), 23% were familiar (can identify some invasive species), 13% were not familiar and 7% were very familiar.

The impacts of COVID-19 on gardening activities

The COVID-19 pandemic has influenced respondents' gardening activities in various ways. Some of the challenges of gardening during the pandemic includes lack of knowledge (32%), insufficient money to purchase resources (23%), insufficient time (26%) and inadequate space to garden (20%). Despite the regulations regarding social distancing during the pandemic, 87% indicated that they purchased their plants in-person while 21% used online sales, 12% did curbside pick-up, 6% used delivery and 8% called ahead or did other purchasing methods. Overall, most people indicated that during the COVID-19 pandemic, they gardened because it made them happy (79%), provided the opportunity to be out in nature (67%), stress-relief and relaxation (64%) (see **Figure 3**).When asked which resource option would be most beneficial during the pandemic, the top 3 responses were 1) information on the specific types of plants they like to grow (61%), availability of materials for gardening (53%) and information for beginning gardeners (52%) **(Figure 3)**.

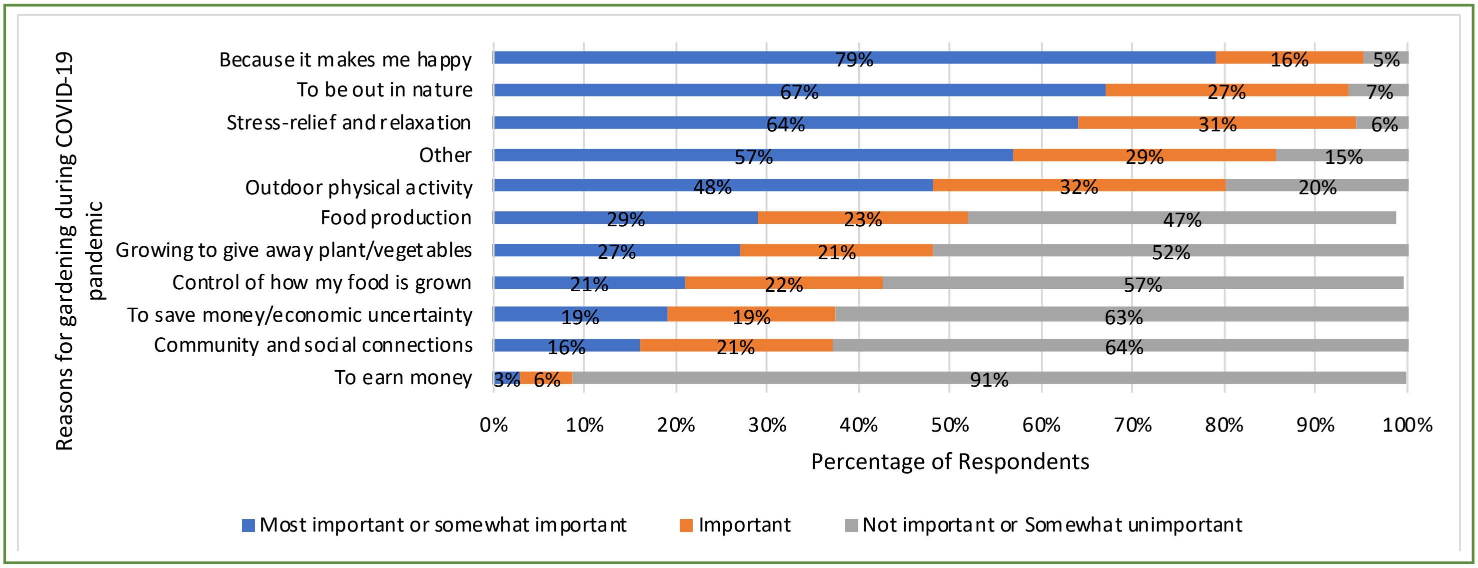


Figure 3. Reasons for gardening during the COVID-19 pandemic

The COVID-19 pandemic has also impacted the wellbeing of respondents in various ways. Seventy-two percent of respondents indicated that it increased their time spent gardening while others expressed that it increased their appreciation for nature (71%), increased their desire to in nature (70%), sense of connectedness to nature (66%), time spent outdoors (61%), and time spent seeking information about gardening (60%). On the other hand, 38% of respondents also indicated that they experience reduced sense of connectedness to others **(Figure 4)**.

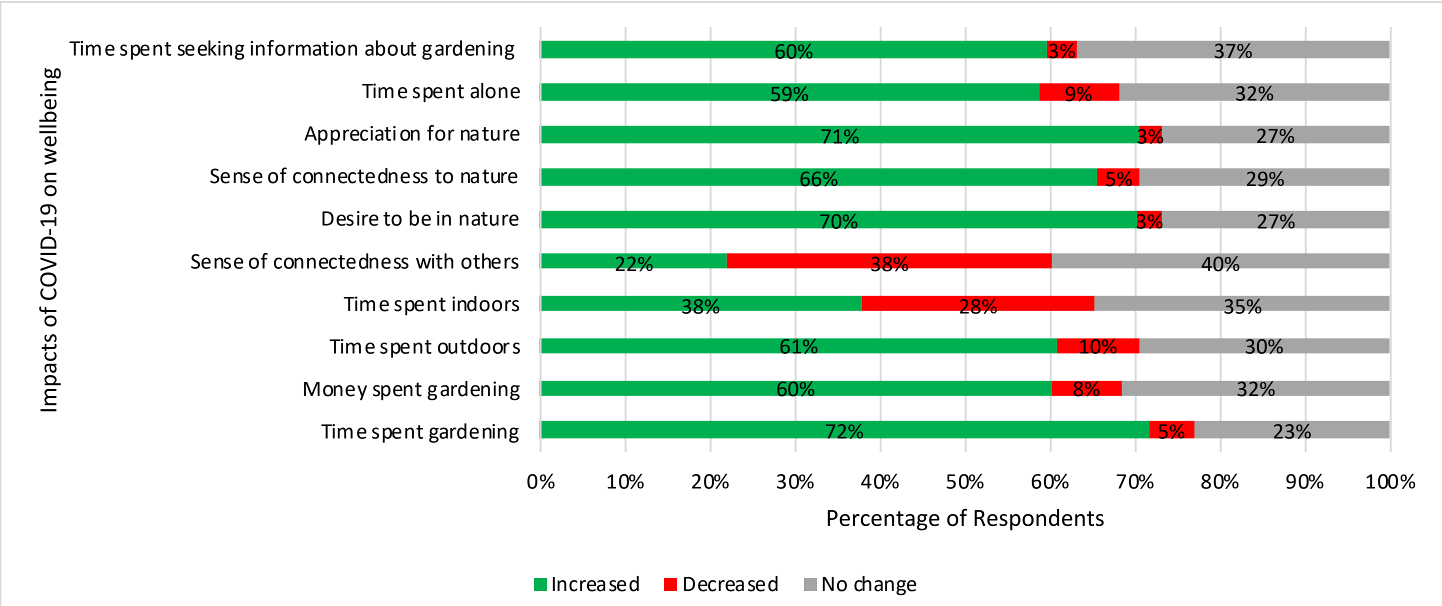


Figure 4. Impacts of COVID-19 on wellbeing

Future intentions related to gardening activities

When asked about their future plans related to gardening activities, respondents expressed interest in a variety of information sources. The top three topics of interest were related to 1) best gardening practices, 2) treatment of plant pests and diseases and 3) gardening in containers 4) invasive species management and 5) gardening in small spaces **(Table 1)**. Respondents' preferences for how the topic related content was delivered varied. Workshops were the preferred delivery method for information about best gardening practices and cooking of garden produce and gardening in containers. On the other hand, videos were preferred for information related to gardening in containers (35%), gardening in small spaces (30%) and treatment of plant pests and diseases (32%).

Table 1. Topics of interest and preferred source of information

Gardening related topic	*Workshop*	*Webinar*	*Newsletter*	*Blogs*	*Video*	*Not interested*
Best gardening practices	39%	33%	26%	21%	33%	16%
Treatment plant pests and diseases	26%	35%	30%	19%	32%	15%
Invasive species management	24%	29%	32%	21%	31%	19%
Gardening in containers	32%	30%	28%	21%	35%	19%
Gardening and mental health	20%	21%	25%	16%	24%	39%
Gardening and stress reduction	22%	23%	25%	18%	24%	35%
Gardening in small spaces	29%	27%	26%	18%	30%	25%
*Gardening and physical mental**	17%	23%	26%	17%	25%	36%
Cooking workshops for gardening produce	30%	22%	18%	16%	29%	33%

CONCLUSIONS

Our survey results highlight that gardening plays an important role in people's wellbeing and creates a coping mechanism for Floridians during the COVID-19 pandemic. Although most respondents gardened to relax, spend time outdoors and to make themselves happy, they are also interested in learning more about best gardening practices, treatment of pests and diseases and how to garden in containers. The information produced from this study can be used to better tailor educational programming for gardening enthusiasts, inform policy that can be used to support home and yard gardening not only as a way to promote biodiversity and stormwater management but also to enhance the wellbeing of Floridians.

Determining Minimum Planting Widths for the Small-Stature Trees in Compact Developments

PI: ANDREW KOESER, Gulf Coast REC (GCREC)
Co-PIs: DEB HILBERT (GCREC)
DREW MCLEAN (GCREC)

ABSTRACT

Trees, as part of the larger developed landscape, do a lot of good for the state of Florida. In a recent canopy assessment of Florida's 29 metro- and micropolitan areas, it was determined that the state's urban forests reduce stormwater flow by 50 billion gallons annually. In addition, Florida's urban trees filter 600,000 tons of air pollutants each year, reducing respiratory health care costs in the state by $605 million. Finally, the yearly growth of the state's urban trees captures the same amount of CO2e as is emitted by 15 power plants. While the ecosystem services noted above are most commonly attributed to large-stature tree species such as live oak (Quercus virginiana), many new developments lack the space required to sustain growth while avoiding root conflicts with the built infrastructure. In these situations, small stature trees may be a better option when one considers the balances of ecosystem services and disservices (e.g., concrete lifting or cracking). In this study we measured the diameters of 260 small stature trees to predict trunk flare diameter at the ground level. We found a strong relationship between stem diameter, species, measurement height and our response, trunk flare diameter (R2 = 0.84). Interestingly, we found that the small stature trees tested in this study tended to have larger trunk flare diameters relative to stem diameter compared to our earlier results with shade tree species. Despite this, small stature trees could be planted twice as close to paved surfaces as large stature trees and have the same likelihood of causing damage.

OBJECTIVES

1. Develop an equation that can be used to estimate root space requirements for small stature urban tree species.
2. Determine the minimum allowable planting space for trees typically selected for space-limiting planting conditions.

METHODS

Working with local urban foresters, we located and measured trees in Lakeland, Sarasota, Tampa, Venice, Pinellas County, and Hillsborough County, Florida. We collected data on 42 crapemyrtles (*Lagerstroemia indica*), 28 East Palatka hollies (*Ilex x attenuata*) 29 Geiger trees (*Cordia sebestana*), 26 Japanese privets (*Ligustrum japonicum*), 22 Pink Trumpet trees (*Handroanthus impetiginosus*), 33 Silver-Leafed Golden Trumpet trees (*Tabebuia aurea*), 18 Simpson's stoppers (*Myrcianthes fragrans*), 25 yaupon hollies (*Ilex vomitoria*), and 37 yew plum pines (*Podocarpus macrophyllus*). The trees represented a range of diameters spanning from the newly established to the largest specimens found in the respective locations.

To measure trunk flare diameter, we used flags to delineate the points at which trunk tissue transitioned to root tissue and to guide a measuring tape around the base of the tree in an approximately circular shape (**Figure 1**). We converted the circumference to diameter afterwards. In addition to measuring diameters, we recorded planting space dimensions, tree defects, and infrastructure damage. We also noted characteristics that might influence circumference such as girdling roots or deep plantings. As it is not always possible to measure diameter at breast height (DBH, nominally 4.5 feet), diameter measurements were collected at one of three locations on the tree. If the tree was of sufficient height and pruned to elevate the crown, then diameter was measured at DBH. If the tree's stem split at or below DBH, but the stems merged above ground, then the diameter was measured at caliper height (6 inches). If the tree was multi-stemmed or the pith merged below ground, then the diameter was recorded at the base of the tree, at ground level.

Figure 1. Image of the field method for measuring the circumference of the trunk flare.

RESULTS

Our linear regression model had relatively high predictive power with an adjusted R^2 of 0.84. Species was a significant factor (min P-value = 0.04). Similarly, diameter and measurement height were significant predictors of TFD (both P-value < 0.001). For practical purposes, a simplified model factoring in just diameter and height of measurement is shown in **Figure 2.**

Diameter Measurement Height	TFD Conversion
DBH (4.5 ft)	Dx*3.7+8.6
Caliper (6 in)	Dx*3.7+1
Ground Level	Dx*3.7

Figure 2. Formulas to predict trunk flare diameter at DBH, Caliper, and Ground Level depending on the form of the tree being measured.

In modelling damage to infrastructure, both stem diameter and distance to hardscape were significant predictors of pavement cracking or lifting. However, including both in the initial model would lead one to drop out given non-significance. As such we adopted a final model with distance to hardscape as the sole predictor as this was the more easily controlled aspect of tree planting and management.

Figure 3 shows how the odds of avoiding hardscape damage increase as spacing increases. In this figure we overlay a similar analysis conducted on large oaks (Quercus spp.) for a previous FNGLA project. As one can see, a small stature tree planted with 100 cm (~3 feet) of spacing is as likely to avoid causing damage to nearby pavement as 200 cm (`6.5 feet) of spacing for a large tree.

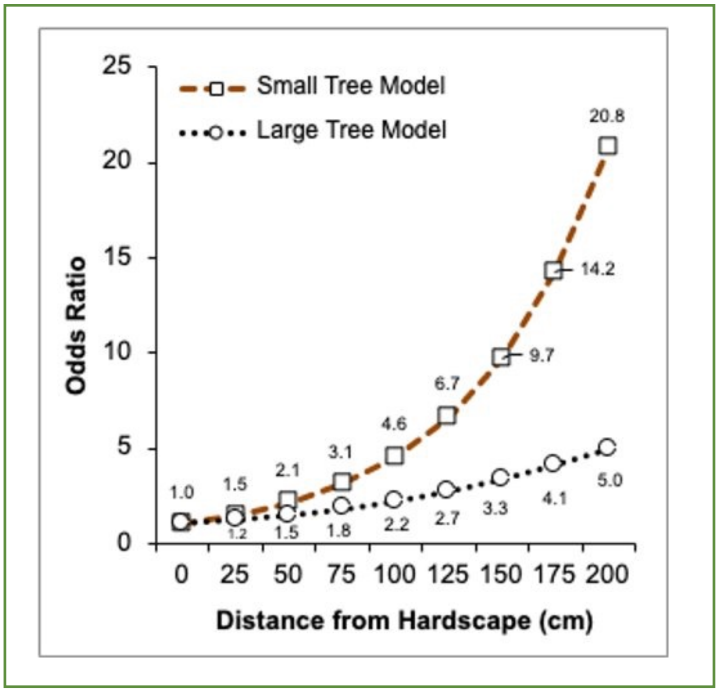


Figure 3. Odds of avoiding hardscape conflicts as the distance between the tree and paved surface increase. For example, a small tree is ~20 times less like to cause damage when 200 cm away from pavement as compared to when the roots are right up against the neighboring hardscape (0 cm).

CONCLUSIONS

Findings from this work are currently being drafted for peer-review. The equations generated will be used to predict TFD for species featured in municipal and county planting lists. As summary table will be published as an EDIS Factsheet and will provide actionable planting space guidelines for practitioners and those mandating tree planting as part of urban development. Future research regarding tree roots and development will investigate the costs and benefits associated with non-traditional construction practices that are less likely to lead to belowground conflict. Additionally, we will be looking into the impacts of root loss, which often results when trees are planted too close to hardscape and repairs are needed to maintain accessibility.

IMPROVE ENVIRONMENTAL AND RESOURCE MANAGEMENT

This priority area is defined as:

FNGLA encourages and supports research to maximize efficient water use and research designed to react to and identify exotic insects, diseases, and plants that can harm our industry and our environment. FNGLA supports research for control and prevention of such pest introductions.

FNGLA supported three projects under this priority area, and their summaries are on pages 16-24.

Construction of Plots for Long-Term Evaluation of Effects of Effluent Water on Turfgrass

PI: MARCO SCHIAVON, Ft. Lauderdale REC

ABSTRACT

The lawncare industry contributes $1.3 billion to the national economic impact. However, global weather conditions and growing populations decrease available resources for turfgrass growth like clean water for turfgrass irrigation, particularly because a large portion is used for landscape irrigation, which is considered nonessential. Reclamation of municipal wastewater shows promise as a means to meet the continued demand and growing pressure on irrigation water resources. Unlike potable water reserves, quantities of reclaimed wastewater continue to increase due to population growth and provide a readily available source of irrigation for urban areas. Diminishing freshwater resources are jeopardizing the future of turf and its benefits to recreation, urban culture, the environment, and the economy. Replacing potable water with effluent/reclaimed water, meets a state objective for conserving freshwater supplies. However, the long-term effects of wastewater irrigation on turf, soil, and environment are not completely understood. Wastewater contains levels of nutrients and micronutrients that are higher than those found in potable water, but also has higher electrical conductivity (EC) which may be detrimental to turfgrass growth. Leaching and modification of soil physicochemical properties can help alleviate salinity stress. However, leaching consists in applying water to levels that are above those required for turfgrass growth and may result in groundwater pollution. Developing and implementing proper water conservation and irrigation management strategies as well as finding alternative sources of irrigation water for turfgrass has become a critical issue for both municipalities and the turfgrass industry. Research is needed to identify and implement best management irrigation practices when wastewater is used as an alternative to potable water.

OBJECTIVES AND METHODS

1. The objective of this proposal was to construct a research area consisting of 12 irrigation main plots (6 irrigated with potable water and 6 irrigated with reclaimed water; 20 ft x 20 ft); half of which sodded with St. Augustinegrass and the other half with bermudagrass.
2. Long term objectives include to investigate if N leaching is increased when reclaimed water is used for turfgrass irrigation and to investigate if turfgrass can adsorb nutrients present in reclaimed water, and consequently reducing the need for exogenous N fertilization

In August 2020 purple line was brought to FLREC from Town of Davie Water Treatment and Water Reclamation Facility, which is adjacent to the research station (Picture 1). Chemical constituents of regular irrigation water vs. reclaimed water obtained from the treatment plant are listed in **Table 1**. Reclaimed water is considered high in salinity, medium for Na permeability hazard, and very severe for bicarbonates hazard (U.S. Regional salinity laboratory, 1954). In January 2021 from 360 cubic yards of mason sand were brought to FLREC to construct new irrigation system in order to avoid confounding effects of organic matter content in native soil.

Table 1. Chemical analysis of reclaimed and fresh water to be used in the study

	Reclaimed	Fresh
Electrical Conductivity dS m^{-1}	1.08	0.53
pH	7.6	7.6
Sodium (Na^{+}) ppm	1550	28
Bicarbonates (HCO_3) ppm	1200	275
SAR	13	1
Nitrate (NO_3^{-}) ppm	13.6	0.093
Phosphate (PO_4^{3-}) ppm	1.98	0.001

Picture 1. Four inches main line purple pipe brought to FLREC from Town of Davie Water Treatment and Water Reclamation Facility that is going to feed the research plots

Picture 2. Freshly sprigged Celebration bermudagrass on newly constructed irrigation system. Picture taken February 5, 2020.

RESULTS

FNGLA grant partially covered the cost for the irrigation system materials and supply. In particular, the budget was spent for: 500 ft of 3/4 in. PVC pipes, 72 PVC Tees, 12 main valves, 48 sprinklers body, 48 sprinklers heads, 48 sprinklers swing joints, 24 release/butterfly valves, 2 irrigation controllers, primer, and cleaner, and 500 ft of electrical sprinkler wire. Starting January 2022, a 2-year field study will be conducted to evaluate the effects of reclaimed water and different N rates and sources on bermudagrass and St. Augustinegrass performance and nitrate (NO_3-N) ammonium (NH_4-N) and ortho P leaching from Celebration and CitraBlue. Plots watered daily based on previous week evapotranspiration (ET) with environmental data obtained from a Florida Automated Weather Network (FAWN https://fawn.ifas.ufl.edu/) station which is located within 500 ft of the test site to prevent drought stress. Fertilization treatments will be applied monthly. Nitrogen rates will mimic current recommendation for fairway and lawn fertilization when fresh water is used for irrigation, and will include lower and higher rates.

CONCLUSIONS

Over the last 40 years, the number of golf courses and municipalities that use treated effluent for irrigation has steadily increased. Because raw effluent typically contains significant quantities of many essential plant nutrients, particularly nitrogen and phosphorus, its use to irrigate turfgrass could reduce the need and reliance on commercial fertilizers. Thus, irrigating with effluent may provide plants with similar quantities of essential plant nutrients to those delivered via fertigation with a dilute concentration of fertilizer. However, there is still a lack of knowledge weather reclaimed water can be used as a 'fertigation' source and could potentially decrease the need for exogenous N application, and if different sources of N in combination with reclaimed water irrigation could pose a significant threat for nutrient leaching. The results of the proposed research will provide golf course superintendents and turfgrass managers an understanding of potential benefits of using reclaimed water on sandy soil. The results will be made accessible to the public in general through an Extension Publication in the Electronic Data Information Source (EDIS) system of the University of Florida, trade magazine articles, and the *Florida Green*. It is expected that the research will be published in two articles in peer-reviewed scientific journals. Furthermore, the results will be presented in regional meetings of the golf course, turfgrass and landscape industries.

LITERATURE CITED

U.S. Salinity Laboratory Staff. (1954). *Diagnosis and improvement of saline and alkali soils, USDA Handb. 60*. U.S. Gov. Print. Office, Washington, DC.

Establishment and Evaluation of Mixed Species Landscapes Comprising Perennial Grasses and Legumes: Nutrient Leaching, Ecosystem Services and Public Perception

PI: BRYAN UNRUH, West Florida REC
Co-PI: ANN BLOUNT, North Florida REC
ADAM DALE, Entomology and Nematology Department

ABSTRACT

Mixed species groundcovers have the potential to enhance ecosystem services (ES) in urban and suburban lawns, assuming they are aesthetically pleasing and accepted by the end-user. Since the mid-1980s, perennial peanut (*Arachis sp.*) has been touted as a viable landscape alternative; however, wide-scale adoption has been limited. Two studies are being conducted at the West Florida Research and Education Center, Jay FL. These studies are aimed at evaluating factors such as ecosystem services tradeoffs, drought tolerance and consumer acceptance of different alternative lawn mixtures. Information gleaned from these projects will be used to develop recommendations for managing mixed-species groundcovers in Florida's landscapes.

OBJECTIVES AND METHODS

<u>Nutrient leaching study:</u> An increasing trend of promoting turfgrass removal and conversion to alternative landscapes with the intent to reduce water use is occurring across the US. In turf removal programs, turfgrass is generally killed or completely removed and replaced either by living vegetation or non-living ground covers. Transitioning from turfgrass systems to other lawn types can lead to an accumulation of soil nitrogen (N) and phosphorus (P) that may be lost following irrigation or rainfall.

In April 2021, plots containing drainage lysimeters (i.e., high-density polyethylene tanks, filled with soil, covered by turfgrass, and exposed to the environment) covered with either common centipedegrass (*Eremochloa ophiuroides* Munro) or 'Floratam' St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] were stripped using a sod harvester. After one week, the plots were planted/covered with three alternative landscapes which included 1.) mixed forbs, 2.) 'Pensacola' bahiagrass (*Paspalum notatum* Flugge) + 'Ecoturf' rhizoma perennial peanut, and 3.) woodchip mulch as a nonliving ground cover (**Figure 1**). The plants selected for the forb mixture included sunshine mimosa (*Mimosa strigillosa* Torrey & A. Gray), coreopsis (*Coreopsis lanceolata*), frogfruit (*Phyla nodiflora*), and centipedegrass. Undisturbed plots (i.e., existing turfgrass left intact) serve as the untreated controls.

Figure 1. Aerial image of the alternative lawns: Perennial Peanut + Bahiagrass; Forb Mixture; Mulch; Turfgrass monoculture.

The objectives of this study are to: 1) quantify the ecosystem services tradeoffs and 2) evaluate the feasibility and public perception of different lawn alternatives.

A survey was administered to the attendees of the Gulf Coast Turfgrass Field Day to quantify their understanding and perception of these alternative lawns. Additionally, we directly measured surface temperature (FLIR), weed pressure (weed counts), pollinator (visual assessment of insects pollinating flowers), crawling arthropods (pitfall traps), soil properties and nutrient leaching. Leachate samples were collected weekly by removing all leachate water by vacuum extraction for volume determination and acquiring a water sample for NO_2 + NO_3, NH_4, and ortho-P determination (**Figure 2**).

Figure 2. Pumping station utilized to collect water leachate samples.

Linear gradient irrigation system study: In June 2021, four legumes were interplanted in three common lawn grasses (i.e., St. Augustinegrass, centipedegrass and bahiagrass). Turfgrass species were selected based on their popularity as turfgrass lawns and management requirements The legumes selected included a round leaf stoloniferous perennial peanut (PP) ['Golden Glory' pinto peanut (*Arachis pintoi*)], a round leaf rhizomatous PP (Ecoturf), a narrow leaf rhizomatous PP ('Cowboy') and a native stoloniferous legume (sunshine mimosa). The plots were established under a linear gradient irrigation system (LGIS). The LGIS provides an irrigation gradient from 0 to 120% of reference evapotranspiration (ET_0). The grass and legume mixture are being mowed weekly at the recommended mowing height for each turfgrass species (2" for centipedegrass and 3" St. Augustinegrass and bahiagrass).

Percent cover, density, quality, and normalized difference vegetation index (NDVI) are being collected biweekly using digital image analysis and RapidSCAN CS-45© crop sensor (Holland Scientific Inc. NE, USA). Soil volumetric water content, soil temperature, and electric conductivity will be measured biweekly using a TDR 350 (Spectrum Technologies, IL, USA). Thermal images of the plots' surface will be recorded every day at noon and prior to sunrise with an infrared thermal camera.

The objective of this study is to evaluate the establishment, aesthetic quality, plant species association, and drought response of turfgrass-legume mixtures.

PRELIMINARY RESULTS

Reducing the amount of fertilizer and attracting pollinators were identified as the most important ES by the survey respondents. The survey respondents consisted of an even population of master gardeners and turfgrass professionals. The forbs had the greatest pollinator visits and crawling arthropod biodiversity followed by the peanut + bahiagrass mix. These groundcovers also had the lowest surface temperatures (**Figure 3**).

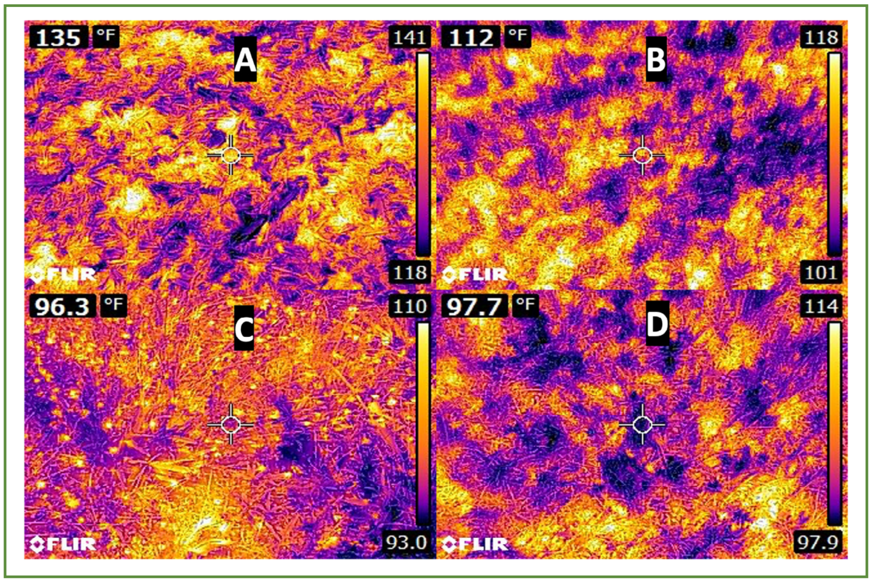


Figure 3. Thermal images collected in A. Mulch, B. Turfgrass, C. Peanut + Bahiagrass and D. Forbs.

However, while only 24% of the field day attendees would consider using the forb mix, 38% of the attendees indicated they would use the peanut + bahiagrass mix in their own lawn. Moreover, the forb mix had a greater weed pressure (**Figure 4**) than the peanut + bahiagrass mixture and turfgrass. Recreational benefits were also identified as an important ES that was provided by peanut + bahiagrass mixture and turfgrass.

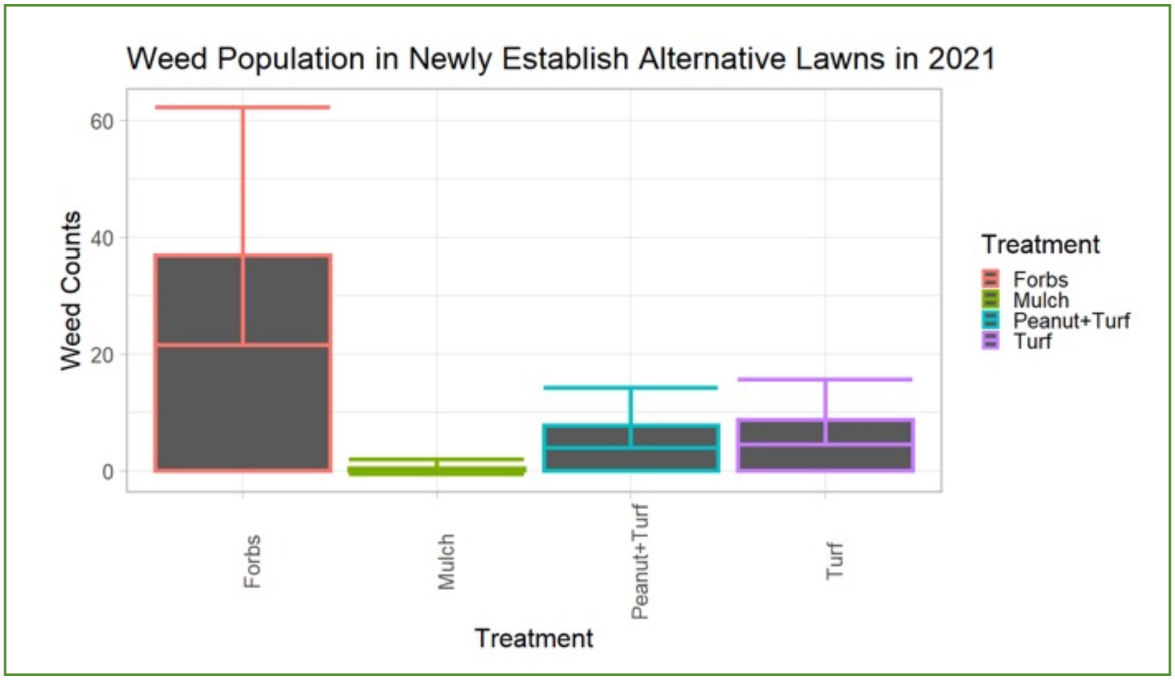


Figure 4. Weed pressure qualified as Weed counts in Forbs, Mulch, Peanut + Bahiagrass and Turfgrass.

Predisturbance soil nutrient concentrations were higher in St. Augustinegrass compared to centipedegrass. However, those differences were not reflected in nutrient leachate loads following disturbance and ortho-P leachate was not detected in any treatment. Preliminary data suggest that the conversion process does not have an immediate effect on N or P leaching. However, nutrient leaching levels in the undisturbed plots remained near zero whereas N leaching was detected in the disturbed plots. This suggests that leachate differences may be observed over time.

CONCLUSIONS

Preliminary results from the leaching study suggest that the peanut + bahiagrass mixture provides a middle ground between the traditional turfgrass lawn and the forb mix providing ecosystem services from both grasses and legumes. Moreover, the peanut + turfgrass mixture would retain the recreational benefits and cultural values from a traditional turfgrass lawn being more likely to be adopted by the end-user. Through biological N_2 fixation, legumes could provide the nitrogen needed for turfgrass growth, reducing nitrogen fertilizer needs. The Linear Gradient Irrigation System study would address this question by evaluating the lawn quality of the legume + turfgrass mixtures compared to a turfgrass monoculture. This study will also evaluate if these mixtures would increase the drought performance of the lawn, possible reducing irrigation needs. Finally, we would determine the best legume + turfgrass association for St. Augustinegrass, centipedegrass and bahiagrass.

Future studies should evaluate how different management practices affect the ecosystem services provided by the alternative lawns. Therefore, we propose planting half of the alternative lawns with winter ground covers and observe the effect of these practice on the overall ecosystem tradeoffs.

Reducing Nutrient Loss from Containers

PI: THOMAS YEAGER, Environmental Horticulture Department (ENH)
Co-PI: JEFF MILLION (ENH)

ABSTRACT

Dwarf Burford holly plants were planted with a pine bark-based substrate in black plastic or porous fabric containers. The substrate was amended with controlled-release fertilizer and micro-irrigation was applied daily to the substrate surface based on leaching fraction (LF=container drainage ÷ irrigation applied) measurements. After 24 weeks, 43% of nitrogen and 34% of phosphorus applied in the fertilizer was recovered in the leachate from plastic containers. For the fabric containers, 27% of nitrogen and 16% of phosphorus was recovered in the leachate even though 81% more irrigation was applied to the fabric containers to target a 25% LF. These results indicated that cooler afternoon substrate temperatures (23°F) in fabric containers resulted in reduced nutrient loss in leachate even though more irrigation was applied to fabric than plastic containers.

OBJECTIVE AND METHODS

Objective: Determine the amount of nitrogen and phosphorus loss in drainage or leachate when plants are grown in black plastic containers versus porous fabric containers.

Methods: Multiple-branched liners of an evergreen shrub (*Ilex cornuta* `Burfordii Naná) were planted in July 2020 with a 70% pine bark, 20% Florida peat, and 10% leaf compost (by volume) in 5-gallon trade black plastic containers at the University of Florida, IFAS, Gainesville. The equivalent volume of substrate was also placed in porous fabric containers with same top diameter (14 inches). The substrate for each container was amended with a controlled-release fertilizer with 270 days to release 80% of the nitrogen at 77 °F. A total of sixty-four plants were spaced (≈31 inches) in a triangular arrangement on black polypropylene ground cover with micro-irrigation scheduled three times daily. Leaching fraction (LF=leachate ÷ water applied) tests were conducted for nine plants per container type and based on the results irrigation was adjusted approximately every two weeks to a target LF of 25%. Total leachate volumes from an additional nine plants per container type were measured weekly and subsamples were analyzed for total nitrogen and phosphorus. Substrate temperatures were measured periodically for three containers of each type using soil thermometers positioned one half the depth of the substrate in the southwest quadrant approximately one inch from the container sidewall.

RESULTS

Approximately 81% more irrigation was applied to fabric containers than black plastic containers to achieve a similar LF (**Table 1**). The increase in water demand was likely due to the evaporation from the fabric container sidewall because leachate volumes (including rain) were only 48% more for fabric than plastic containers. The evaporation cooled the substrate that often reached 118 °F for plastic containers. Fabric container temperatures at 1700 HR EDT averaged 23 °F less than plastic containers. The cooler temperatures impacted the loss of nitrogen and phosphorus from the fertilizer. After 24 weeks, approximately 37% less nitrogen and 53% less phosphorus had leached from fabric containers based on the amount of nitrogen and phosphorus added by the fertilizer amendment (**Table 1**). Total nitrogen and phosphorus losses recovered in the leachate during the experiment averaged 123 lbs/acre and 14 lbs/acre, respectively, for plastic containers, and 75 lbs/acre and 6.8 lbs/acre, respectively, for fabric containers. Plant growth was similar regardless of container type.

CONCLUSIONS

Data from this experiment revealed that nitrogen and phosphorus leaching losses from container substrate amended with controlled-release fertilizer were reduced 37 and 53%, respectively, due to cooler substate temperatures of the porous fabric containers. Additionally, for the fabric container, less leaching and water applied may be possible by targeting a lower LF. Reduced leaching and hence less nutrient loss from nurseries has important implications in protecting natural waters such as springs. The practical implication is that container plant production strategies must be developed that minimize high substrate temperatures of black plastic containers.

This report has not been peer reviewed and is not a recommendation of UF/IFAS. Specific companies and product names will be given in the peer-reviewed paper.

Table 1. Dwarf Burford holly were grown for 24 weeks in black plastic (5-gallon trade) or porous fabric containers in equivalent volumes of a pine bark-based substate amended with controlled-release fertilizer. Micro-irrigation was applied three times daily to target a 25% leaching fraction. Percent of substrate-amended nitrogen and phosphorus loss in leachate was determined.

Container	Irrigation Applied	Substrate Nutrient Loss (% of fertilizer applied)	
Type	Liters	Total Nitrogen	Total Phosphorus
Black Plastic	148	43	34
Porous Fabric	268	27	16

IMPROVE PEST MANAGEMENT PRACTICES AND STRATEGIES

This priority area is defined as:

FNGLA supports research to develop new biological and chemical pest management tools that are effective and environmentally safe.

FNGLA supported four projects under this priority area, and their summaries are on pages 26-46.

Measuring Degradation of Insect and Phytoplasma DNA on Sticky Traps

PI: BRIAN BAHDER, Ft. Lauderdale REC

METHODOLOGY

A total of 55 *Haplaxius crudus* were collected from Montgomery Botanical Center in Coral Gables, Florida and stored at -80°C. Trunk phloem from a palm infected with confirmed 16SrIV-D phytoplasmas was extracted and mixed with ethanol. The head of each insect was gently removed with a probe. Using a pipette, 10 microliters of the phloem solution were injected into the hemocoel of each *H. crudus* specimen. On January 25th, 2021, fifty of the *H. crudus* were placed on a yellow sticky trap which was then tied to the leaf of a palm tree at the Fort Lauderdale Research and Education Center (FLREC) in Davie, Florida. Five insects were collected from the trap every 24 hours, for seven days. Then five insects were collected from the trap every week for three more weeks. Five insects were not placed on the sticky trap and instead had their DNA extracted immediately after being injected with the phloem solution. DNA extraction was performed on the insects using the DNeasy Blood and Tissue kit (Qiagen, Hilden, Germany). The manufacturer's instructions were used, but without grinding the specimens and using a lysis time of approximately 18.5 hours. Each DNA sample was quantified using the NanoDrop Lite Spectrophotometer (ThermoFisher Scientific, Inc). Using primer sets for the COI gene, the 18S gene, and the H3 gene, PCR was performed to assess whether the *H. crudus* DNA had degraded over time, and if there was a difference in degradation between genes of different organelles. The PCR products were visualized on 2% agarose gels. qPCR was also performed to determine whether the samples had a detectable titer of the 16SrIV-D phytoplasma.

RESULTS

DNA degradation of the insect vector was measured most noticeably after 24 hours of being placed on sticky traps both in regard to DNA concentration (**Figure 1**) and based on PCR amplification of target genes. However, the concentrations remained comparable for one week, after which yield significantly dropped. PCR success loosely reflected this trend where amplification was strongest in fresh individuals but dropped rapidly. Over two weeks COI (**Figure 2**), 18S (**Figure 3**), and H3 (**Figure 4**) template was easily amplified but then PCR readily failed after being on the traps for more than 2 weeks. The exception was 18S that appeared to have stronger PCR success for a slightly longer period of time.

Phytoplasma showed no sign of degradation based on the Ct value measured in the qPCR assay. While the method used is not a natural state and the amount of phytoplasma DNA we loaded is likely much higher than would naturally be in an insect in the wild, within the confines of the experiment, no decrease was observed, suggesting the pathogen DNA is protected and stable in the insect. It is consistent with observations that phytoplasma is still present in dead palm trunks up to one year after the palm dies.

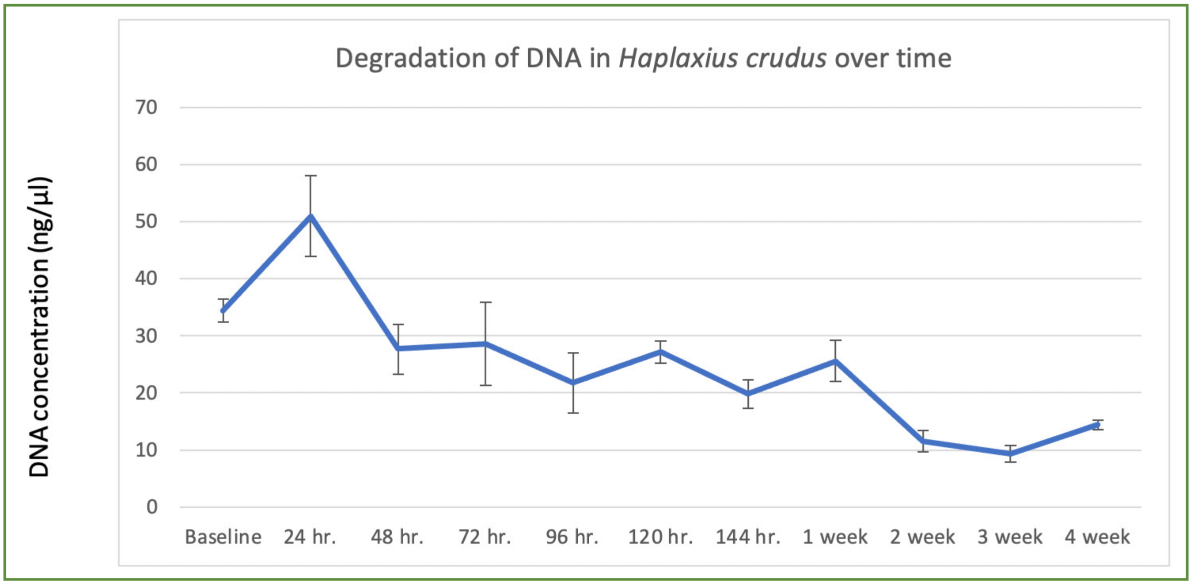


Figure 1. Concentration change of total DNA over one month period from *Haplaxius crudus* collected from yellow sticky traps

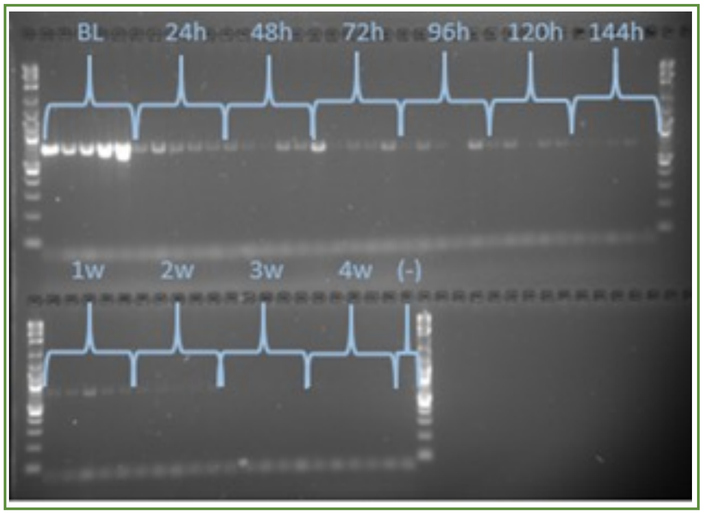


Figure 2. PCR amplification success based on COI for specimens of *Haplaxius crudus* collected from yellow sticky trap.

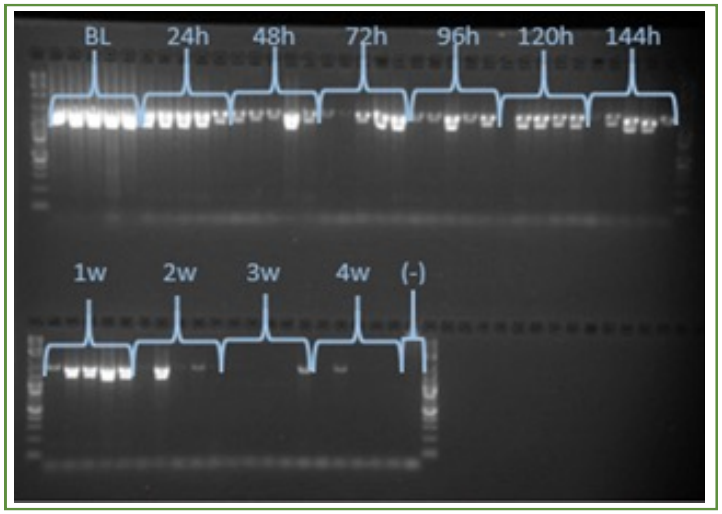


Figure 3. PCR amplification success based on 18S for specimens of *Haplaxius crudus* collected from yellow sticky trap.

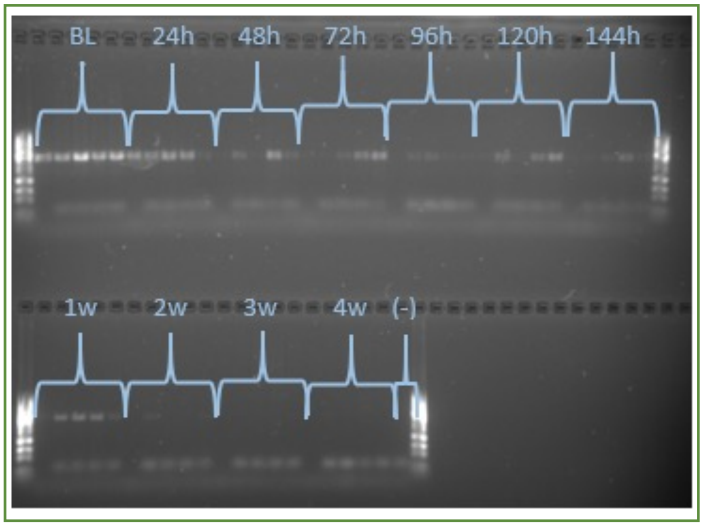
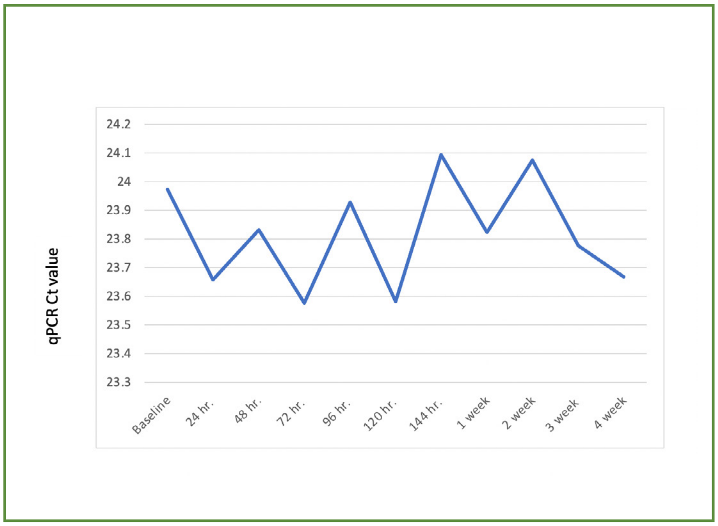


Figure 4. PCR amplification success based on H3 for specimens of *Haplaxius crudus* collected from yellow sticky trap.



Developing Methods for Biodiversity-certified Ornamental Plant Production

PI: ADAM DALE, Entomology and Nematology Department
Co-PI: JARET DANIELS, Florida Museum of Natural History

ABSTRACT

Demand for wildlife-friendly plants, especially plants that support pollinators, has never been higher. This is great because producing and planting wildlife-friendly plants helps mitigate biodiversity loss, which is an increasing global concern. This demand also presents a business opportunity for Florida's green industry. Unfortunately, many plants that support pollinators are also attacked by damaging insect pests. Insect pests reduce plant health and marketability, which often requires chemical intervention to produce a saleable product. Pollinators play a critical role in U.S. agriculture and ecosystem functioning, but insecticides used during crop production can harm them. Most pollinator toxicological data focus on bees. Lepidopteran pollinators (i.e., butterflies and moths) differ in susceptibility to insecticides compared to bees and have different routes of exposure (e.g., larval leaf-feeding versus nectar consumption). Consequently, products compatible with bee conservation pose an unknown risk to lepidopteran pollinators, yet both taxa are pervasive in agroecosystems and urbanized landscapes. We used the milkweed-monarch-oleander aphid system as a model to begin developing integrated pest and pollinator management (IPPM) strategies for ornamental plant production. Our results will be used to begin developing a certified wildlife-friendly plant production protocol that will increase the positive environmental and ecological impact of ornamental plant production.

OBJECTIVES AND METHODS

Objectives

1. Determine the effects of insect pest infestation on wildlife-friendly plant conservation value.
2. Determine the acute toxicity of commonly used and proposed alternative insecticides to monarch butterfly larvae.
3. Develop pest management recommendations that reduce cost, increase pest control efficacy, and minimize negative effects on pollinators.

Methods

The Study System

Tropical milkweed (*Asclepias curassavica*, L.) is a nonnative, herbaceous perennial ornamental plant that is widely available for purchase across the eastern and southern United States and is the most popular milkweed variety for landscape and garden purposes. We purchased insecticide-free *A. curassavica* in 1-gallon containers from Green Isle Gardens (Groveland, FL) for use in all experiments. Plants were maintained in a nursery setting at the University of Florida under natural light and temperature conditions for the duration of the experiments.

The monarch butterfly (*Danaus plexippus*, L.) is a widely recognized charismatic North American butterfly that engages in a yearly migration from the eastern United States and Canada to overwintering grounds in Mexico. Monarch larvae are dietary specialists that feed exclusively on milkweed (family Apocynaceae, subfamily Asclepiadoideae). Monarch populations have declined by over 80% in recent decades (Brower et al. 2011, Thogmartin et al. 2017, USFWS 2020a, b), which has spurred conservation efforts, primarily in the form of providing larval host plants through mass plantings along agricultural field margins, urban greenspaces, and residential gardens. We obtained monarch eggs from Shady Oak Butterfly Farm in Brooker, FL. Eggs were stored at 28 °C and 75% relative humidity with a 12:12 light cycle until eclosion. Neonate larvae were fed untreated *A. curassavica* leaves until they reach third instar.

The oleander aphid (*Aphis nerii*, Fonscolombe, 1841) is an important sap-feeding insect pest of milkweed and other ornamental plants in tropical to warm temperate regions around the world. This pest can cause serious plant damage or even plant death. Sap-feeding insects are among the most damaging and difficult to control insect pests of ornamental plants in the Southeast (Frank 2019). Milkweed and other plants infested with oleander aphids become chlorotic, drops leaves, and are often covered with black sooty mold, ultimately resulting in an unsaleable plant. Thus, insecticides are commonly used during production to prevent plant damage and loss. Since many insecticides are toxic to lepidoptera, milkweed treated for aphid infestations may inadvertently control monarch larvae or other beneficial caterpillar species during plant production and after sale. Consequently, plants produced and planted for wildlife conservation purposes may have the opposite effect. Additionally, frequent insecticide applications to control this pest are expensive, highlighting the need for growers to understand the cost-benefit ratio of managing this pest. This combination of factors makes the monarch butterfly-milkweed-oleander aphid system ideal for developing IPPM strategies compatible with lepidopteran larvae conservation.

Objective 1 approach

Insect pests like the oleander aphid reduce plant health and marketability, which conflicts with grower goals and can have substantial negative economic impact. Although insect pests are a major issue for growers, they also introduce potential challenges for pollinator conservation in the form of insecticide exposure and competition for plant resources. Here, we investigate if pest pressure interferes with conservation efforts by reducing pollinator colonization and fitness. If it does, then this further justifies the need to control insect pests on pollinator conservation plants. Specifically, we tested the hypothesis that oleander aphid infestations will reduce monarch butterfly oviposition.

We infested potted milkweed plants with aphids and kept others aphid-free. Once aphid infestations reached approximately 50 individuals per terminal end (the aphid treatment threshold), we placed one infested milkweed plant and one aphid-free plant in a mesh butterfly cage. We added an adult male and an adult female monarch butterfly into each cage and left them for approximately one week. We evaluated each milkweed plant daily and counted the number of monarch eggs per plant. We then compared the total number of eggs laid on each aphid-infested and aphid-free plant over a one-week period.

Objective 2 approach

Insecticides were selected based on a 2018 grower survey of industry standards and newer or less commonly used products that may provide viable options (**Table 1**). Flonicamid (Aria), pymetrozine (Endeavor), and spirotetramat (Kontos), which are all labeled for aphid control, not labeled for caterpillar control, and are considered "practically nontoxic" to bees. Acetamiprid (TriStar) and flupyradifurone (Altus) are labeled for aphid control and are considered "moderately" toxic to bees (US EPA). Acetamiprid is labeled for caterpillar control, whereas flupyradifurone is not. Insecticidal soap (SaferSoap) is labeled for aphids and caterpillars but is generally considered a low risk to bees due to short residual time. Imidacloprid is labeled for aphid control and caterpillar control and was used as a positive control.

Table 1. Industry standard and alternative insecticides for control of aphids on milkweed.

Insecticide active ingredient	IRAC mode of action	Reduced risk[1]	Organo-phosphate alternative[1]	Labeled for caterpillars	Honey bee contact toxicity rating	Honey bee oral toxicity rating
Flonicamid[2]	29	No	Yes	No	Practically nontoxic	Practically nontoxic
Pymetrozine	9-B	Yes	Yes	No	Practically nontoxic	Practically nontoxic
Spirotetramat[2]	23	Yes	No	No	Practically nontoxic	Practically nontoxic
Acetamiprid	4-A	Yes	Yes	Yes	Practically nontoxic	Moderate
Flupyradifurone	4-D	Yes	No	No	Practically nontoxic	Moderate
Imidacloprid[2]	4-A	No	No	Yes	High	High
Pyrethrins	3-A	No	No	Yes	High	High
Insecticidal soap[2]	-	No	No	Yes	n/a	n/a

[1]US EPA

[2]Industry standard based on unpublished survey data collected by Co-PI Daniels.

Plants were randomly assigned to each treatment and treated with insecticides at labeled rates for aphid control. Insecticides were applied via foliar spray and only treated once at the beginning of the experiment. Leaves were harvested 24 h after insecticide treatment for the first assay and 1, 2, 3, and 4 weeks after treatment for the second, third, fourth, and fifth assays, respectively. Each leaf was placed in a petri dish with a single third-instar monarch larva and a piece of damp filter paper to maintain humidity. Larval mortality and leaf area consumed was assessed after 24 and 48 h. Data from this objective will provide critical information on the direct acute effects of commonly used insecticides on monarch larvae.

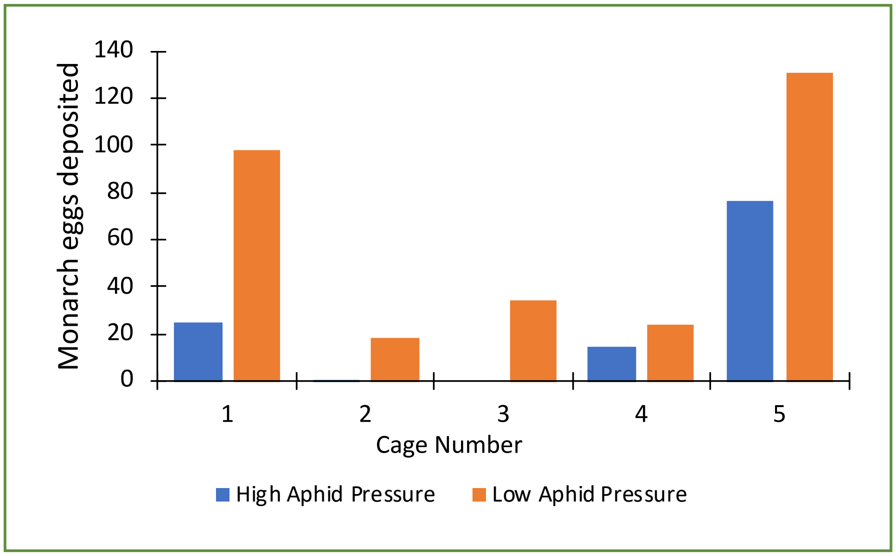
Objective 3 approach

In addition to the acute effects of each insecticide on monarch larvae, we wanted to determine how well each insecticide controlled oleander aphids so that we could work towards developing management protocols that maximize pest control efficacy and minimize negative effects on pollinators. Simultaneous to the previously described experiment from Objective 2, we surveyed all milkweed plants from each insecticide treatment group for oleander aphid infestations. During each week after insecticide application (weeks 1-4), we counted the number of aphids on each milkweed plant in our nursery plot and categorized them as zero, low, moderate, and severe infestations.

RESULTS

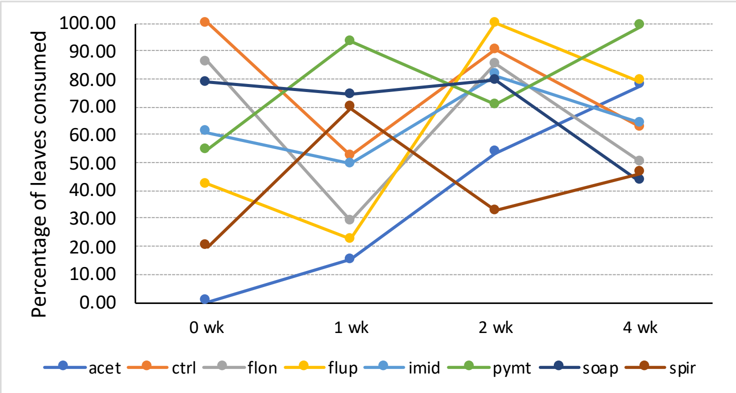
Objective 1

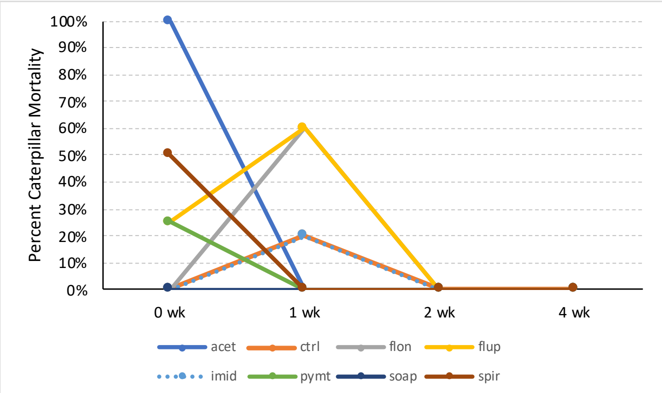
We found that on average, over a one-week period, monarch butterflies deposited nearly three times as many eggs on aphid-free milkweed plants than on aphid-infested milkweed plants. This convincingly demonstrates that insect pests like aphids interfere with caterpillar pollinator conservation efforts. These results help justify the need to control aphids when they reach threshold levels. This is among the first demonstrated evidence that oleander aphids reduce monarch colonization rates.



Objective 2

We found clear evidence that several insecticides have acute negative effects on monarch caterpillars. Surprisingly, we found that fewer products had negative acute effects and that these acute effects lasted for shorter durations after treatment than anticipated. That being said, products like acetamiprid were highly acutely toxic to monarch caterpillars and this took four weeks to dissipate. Other products like pymetrozine and spirotetramat were toxic 24 hrs after treatment, but were no longer acutely toxic after one week. This is encouraging because it suggests that there is ample opportunity to control insect pests with a relatively short high risk window. Ongoing and future work will dig deeper into these results and expand to investigate sublethal effects and effects of product rotations.





Objective 3

Our insecticide efficacy results indicate clear differences between the products tested and how effectively and how long they reduce oleander aphid infestations. For example, flupyradifurone (Altus) suppressed aphid populations to nearly zero for at least four weeks after treatment, while plants treated with insecticidal soap had moderate-to-severe aphid infestations by week 3. This is important because a common recommendation is to use insecticidal soap to control aphids without introducing risks to monarchs. Our results suggest that several synthetic insecticides may effectively control aphids while posing low risk to monarchs. Ongoing work is refining these results and digging deeper to generate specific recommendations.

Another important component of our results is the cost per treatment application, which illustrates a dramatic difference in aphid management cost between products like insecticidal soap and something like imidacloprid (dirt cheap) or even flupyradifurone (moderately expensive). For example, a grower would need to apply insecticidal soap every one to two weeks at $180 per 100 gallons whereas they could apply flupyradifurone every six weeks for 1/3 the cost per application. Over a six week period, this translates to $540-1,080 for soap and $60 for flupyradifurone. Ongoing and future work aims to refine this into a product rotation and management program that minimizes risk to pollinators, minimizes costs for growers, and maximizes aphid control.

Table 2. Cost per 100 gallons of insecticide mixed according to label rates for controlling aphids and average aphid pressure on A curassavica after treatment. Plants were rated as having either low (<25 aphids), medium (25-50 aphids), or high (>50 aphids) aphid densities.

Product	Active Ingredient	Price Per 100 Gallons Mix[1]	Anticipated risk to monarchs[2]	Aphid Pressure[2] 2 Weeks Post Treatment	3 Weeks Post Treatment	4 Weeks Post Treatment
Aria	Flonicamid	$ 60.00	Moderate	Low	Low	High
Endeavor	Pymetrozine	$ 67.00	Low	Low	Low	High
Kontos	Spirotetramat	$ 80.00	Moderate	Low	Low	Moderate
TriStar 8.5 SL	Acetamiprid	$ 40.00	High	Low	Low	Moderate
Altus	Flupyradifurone	$ 60.00	Moderate	Low	Low	Low
Lada 2F	Imidacloprid	$ 3.00	Moderate	Low	Low	Moderate
SaferSoap	Potassium salts of fatty acids	$ 180.00	Low	Low	Moderate	High
Control	N/A	$ -	Low	Low	Moderate	High

[1]Based on local prices in Gainesville, FL. Costs are rounded to the nearest dollar.
[2]Mach and Dale 2021, unpublished data.

CONCLUSIONS

Thus far, this project has generated a large amount of valuable data investigating insect pest management on wildlife friendly plants that will be used to fuel additional research and develop IPPM recommendations for green industry professionals. Our results indicate that insect pests like the oleander aphid warrant control because they reduce plant marketability but also interfere with the intended wildlife conservation value of plants. Therefore, insecticide use is likely required to produce and maintain wildlife friendly plants like milkweed. Our data also suggest that some insecticides are more effective than others at controlling sap-feeding pests like the oleander aphid by rapidly controlling them and providing extended residual control. More recently collected data also provides encouraging evidence that some of the insecticides that effectively control aphids introduce minimal toxicity to monarchs. Combined, our pest efficacy and pollinator toxicity results can and will be used to generate pest management recommendations that protect plants and pollinators while reducing costs to growers and plant managers.

Finding, Evaluating, and Fine-tuning Herbicide Alternatives to Glyphosate for the Florida Landscape Industry

PI: CHRIS MARBLE, Mid-Florida REC
CO-PI: ANTHONY WITCHER, Tennessee State University

ABSTRACT

Despite its benefits and efficacy, many municipalities in Florida have banned the use of glyphosate on public property due to negative publicity with the herbicide. Regardless of any bans, it is important to evaluate alternatives to glyphosate for spot spraying weeds in planting beds as rotation is an important aspect of integrated pest management. The objective of this research was to evaluate the efficacy of eight different non-selective postemergence herbicides in comparison with glyphosate for control of common landscape weeds including garden spurge, large crabgrass, and common woodsorrel. Results differed by weed and growth stage, but overall, glufosinate provided control that was most consistent with the control achieved with glyphosate. Data show that many herbicides can be used successfully in addition to or as an alternative to glyphosate, but more frequent monitoring and reapplication may be necessary to achieve the same level of weed control.

OBJECTIVES AND METHODS

Due to negative publicity, many cities and counties in Florida have passed legislation to reduce or outright ban glyphosate on all public properties. In addition to bans on public properties, many private businesses and homeowners no longer wish or will allow glyphosate to be applied on their properties. Recently in July of 2021, Bayer announced that glyphosate would no longer be sold in the home and garden segment beginning in 2023.

Bans on glyphosate create challenges in ornamental/manicured landscapes for several reasons. First, glyphosate is one of the few options labeled for use in and around ornamental plants. Secondly, in Florida specifically, glyphosate is one of the few "Caution" label products available for use in landscape beds. This means that applicators with a Limited Commercial Maintenance license, the certification held by most maintenance companies, can apply glyphosate legally. Lastly, the most significant challenge is that there is very limited efficacy data available for most of the alternative herbicides. Contractors that have never used these products have no way of selecting the best alternative(s) for their particular situation. The objective of these experiments was to evaluate glyphosate in comparison with 8 other non-selective postemergence herbicides for control of common landscape weeds including garden spurge (*Euphorbia hirta*), large crabgrass (*Digitaria sanguinalis*), and woodsorrel (*Oxalis stricta*).

Experiments were conducted at the Mid-Florida Research and Education Center in Apopka, FL in 2020. Nursery pots (1.9 liter) were filled with a pinebark:sand:peat potting soil that had been amended with a controlled release fertilizer [Osmocote Blend (8 to 9 month) 17-5-11] at a rate of 16 lbs. per cubic yard based on the manufacturer rate for incorporation. After filling, pots were moved to a full sun container pad and received 0.5 inches of overhead irrigation daily. Pots were seeded with approximately 30 seeds of either garden spurge, large crabgrass, or woodsorrel on two separate dates including August 13 and September 8, resulting in two weed growth stages at the time of herbicide application (a 6 week and 10 week growth stage). Weeds were allowed to grow until October 20 when herbicide treatments (**Table 1**) were applied. Herbicides were applied using a CO2 backpack sprayer calibrated to deliver a 25 to 100 gallon per acre application volume based on herbicide label instructions (**Table 1**).

Non-ionic surfactants were added to each product if recommended on the manufacturer's label. Following treatment, pots were grouped by weed species and growth stage in a completely randomized design with 6 single pot replications per treatment in each species and growth stage. Data collected including visual control ratings at 1, 2 and 4 weeks after treatment (WAT) on a 0 to 100 basis where 0 = no control or no difference with the non-treated pots and 100 = 100% or no visible living plant tissues. At 4 weeks after treatment, shoot weight was assessed by clipping plants at the soil line and weighing on a portable field balance.

All data were subjected to analysis of variance using JMP statistical software (SAS). Each weed species and growth stage was analyzed separately. For comparison purposes, all species and weed stages were also combined in order to compare the efficacy of each herbicide treatment over a range of species and growth stages. In all cases, treatment means were compared using Tukey's Honest Significant Difference Test and differences were considered significant at $P = 0.05$.

RESULTS

Crabgrass. At 1 WAT, diquat provided the highest control rating (90%) with d-limonene, ammonium nonanoate, glufosinate, and pelargonic acid providing a similar level of control (**Table 1**). By 2 and 4 WAT, glyphosate and glufosinate provided a higher level of control than any other herbicide (>95%). At this time, crabgrass treated with glyphosate or glufosinate had minimal green tissues while recovery was noted in many of the other treatments. Biomass analysis revealed few differences in herbicides, but in general, the lowest fresh weights were observed in crabgrass treated with glyphosate or glufosinate with diquat and pelargonic acid providing similar results. At the 10 WAT growth stage, a much lower level of control was observed overall. Few differences were observed among herbicides at any evaluation period and shoot weights were also relatively similar among all treatments.

A lower level of relative control with crabgrass at this larger (10 week) stage was likely due to multiple factors. First, herbicides generally provide less control of large, mature weeds in the reproductive stages of growth. Secondly, crabgrass was starting to naturally desiccate by the conclusion of the trial. This was a result of delaying treatments for 10 weeks after seeding and then harvesting shoots another 4 weeks after treatment. Future research should focus on younger grass plants that are not likely to desiccate during the evaluation period. Data is also needed on perennial grass species which are generally more difficult to control.

Garden spurge. By 2 and 4 WAT, glyphosate provided higher control ratings than any other herbicide treatment (**Table 2**). In general, the next most effective herbicide was glufosinate, but several other herbicides performed similarly to glufosinate including pelargonic and acetic acid at 2 WAT and pelargonic acid at 4 WAT. Shoot fresh weight data confirmed findings from the visual control ratings with the greatest percent reduction in shoot fresh weight (or % control) being observed with glyphosate.

At the 10 week growth stage, a lower level of control was observed with most herbicides. Other than at the 1 WAT evaluation, glyphosate performed as well or better than all other herbicides evaluated. In contrast to results observed at the 6 week stage, caprylic + capric acid provided control similar to glyphosate at 4 WAT and based on spurge shoot weights. Spurge was the only annual broadleaf weed species evaluated (woodsorrel is a perennial), and caprylic + capric acid has provided a high level of annual broadleaf weed control in previous evaluations (Marble, unpublished data). However, it is unclear why this herbicide was not more effective on the smaller 6 week spurge.

Woodsorrel. At the 6 week growth stage, glyphosate and glufosinate tended to provide higher control ratings than any other herbicide on all evaluation dates (**Table 3**). Biomass data showed however that all herbicides with the exception of eugenol provided a similar level of biomass reduction.

At the 10 week growth stage, several herbicides provided control similar to or greater than glyphosate. By 4 WAT, pelargonic acid provided the highest level of control (83%) while all other herbicides provided 68% control or less. Similar to results with other species at the 10 week growth stage, few differences were observed in shoot weights, possibly due to natural desiccation.

CONCLUSIONS

While results differed by species and growth stage, the two most consistently effective herbicides were generally glyphosate and glufosinate. When all biomass data were averaged over all three species and both growth stages, glyphosate provided the highest level of control followed by glufosinate which was similar (**Figure 1**). For other herbicides to provide a similar level of control, especially when considering weeds in the reproductive stage of growth as evaluated here, it is likely that two or more applications may be required. When averaged across all three species, most of the herbicides evaluated provided higher levels of observed control at 1 WAT in comparison with glyphosate (**Figures 2 and 3**). As glyphosate was the only systemic (translocated) herbicide evaluated, phytotoxicity symptoms were not evident for 7+ days after treatment, whereas with the other herbicides which are all contact (not translocated), symptoms appeared in as little as a few hours after application. For applicators, it is important to note that initial die-back and high control ratings at early weeks did not always correspond with a high level of control at the conclusion of the experiments (**Figures 2 and 3**). Sites treated with these contact herbicides may need to be visited or scouted more frequently to observe any re-growth or weed control failures. More research is needed to determine if control can be enhanced with these alternative herbicides by increasing rates or application volumes, and also to determine if and when reapplication is necessary.

For managers looking for options to replace glyphosate, in addition to efficacy, another important consideration is chemical cost and more importantly, application cost (**Table 4**). For those who have previously used glyphosate, many of the alternatives evaluated here must be applied at higher rates (on a v:v basis) and/or require higher application volumes (amount of water used to apply the herbicide, a function of coverage) compared with glyphosate. When factoring in costs, higher rates and higher application volumes can quickly increase total costs. For example, the acetic acid product evaluated only cost $45 per gallon, but this product is to be applied as is with no dilution. At the recommended application volume, this product would result in a cost of $25.83 to treat 1,000 ft^2 (compared with $0.27 for glyphosate). For informational purposes, the costs of each of each herbicide was calculated based on the rate and application volume evaluated in these experiments (**Table 4**). It should be noted that costs can vary widely depending on quantity purchased, distributor or manufacturer individual pricing, rebates, and also the trade names chosen as each herbicide evaluated is available and sold under multiple different trade or brand names.

Overall, the results of these experiments indicate that many different alternative herbicides could be used as a replacement or in addition to glyphosate. Of all the alternatives evaluated, glufosinate provided the most consistent control across all three weeds and both growth stages. For the other herbicides, at least some control was observed with each herbicide on all the weeds tested, and better results are likely possible by applying either a higher rate or higher application volume than we evaluated in these experiments. Additional research is needed to determine the most effective rate and application volume for each herbicide evaluated here.

Table 1. Efficacy of glyphosate and alternative herbicides for control of large cragrass (*Digitaria sanguinalis*) in Florida.

6 Week Growth Stage[z]									
Treatment[y]					Visual Control Ratings (0 to 10)[x]			Biomass[w]	
Trade name	Herbicide (active)	Rate/acre	App. Vol.	Cost	1WAT	2WAT	4WAT	F.W. (g)	% Control
Avenger Ag	d-limonene	20%	100	$34.50	62 abc[v]	38 bcd	18 c	1.7 abc	7 bcd
Axxe	Ammonium nonanoate	13%	100	$24.65	60 abc	37 bcd	22 c	1.5 abc	16 bcd
Finale	Glufosinate	4 qt.	40	$1.52	68 abc	100 a	93 a	0.2 d	88 a
FireWorxx	Caprylic + Capric acids	6% (v:v)	100	$16.46	48 bc	33 cd	25 c	1.8 abc	-2 bcd
Ranger Pro	Glyphosate	2.66 qt.	25	$0.27	47 bc	95 a	97 a	0.1 d	92 a
Reward	Diquat	2 pts.	40	$0.65	90 a	60 b	47 b	1.1 cd	41 ab
Scythe	Pelargonic acid	7% (v:v)	100	$9.60	72 ab	48 bc	42 b	1.2 bcd	36 abc
WeedPharm	Acetic Acid	RTU	25	$25.83	55 bc	35 bcd	12 c	2.4 a	-31 d
Weed Slayer	Eugenol	3 qt.	25	$4.53	37 c	17 d	17 c	2.2 ab	-23 cd
Control	N.A.	N.A.	N.A.	$0.00	---	---	---	1.8 abc	---
10 Week Growth Stage									
Avenger Ag	d-limonene	20%	100	$34.50	62 a	47 a	53 a	7.1 b	46 a
Axxe	Ammonium nonanoate	13%	100	$24.65	58 a	52 a	37 ab	8.2 b	37 a
Finale	Glufosinate	4 qt.	40	$1.52	48 ab	42 ab	27 ab	10.5 ab	20 ab
FireWorxx	Caprylic + Capric acids	6% (v:v)	100	$16.46	42 ab	32 ab	32 ab	9.1 ab	31 ab
Ranger Pro	Glyphosate	2.66 qt.	25	$0.27	52 ab	48 a	40 ab	10.6 ab	19 ab
Reward	Diquat	2 pts.	40	$0.65	62 a	48 a	51 ab	8.1 b	38 a
Scythe	Pelargonic acid	7% (v:v)	100	$9.60	45 ab	35 ab	22 ab	10.6 ab	19 ab
WeedPharm	Acetic Acid	RTU	25	$25.83	28 bc	24 bc	27 ab	10.0 ab	23 ab
Weed Slayer	Eugenol	3 qt.	25	$4.53	12 c	8 c	12 b	14.5 a	-10 b
Control	N.A.	N.A.	N.A.	$0.00	---	---	---	13.1 ab	---

[z]Growth stage shows the timing when herbicide applications were made relative to seed germination. All plants treated at the 10 week growth stage had reached the flowering/seeding growth stage.

[y]Rates are shown on a per acre basis. Application volume is shown in gallons per acre and was based on manufacturer label instructions. Cost shows the chemical cost of each herbicide on a 1,000 square foot basis.

[x]Visual control ratings were based on a 0 to 100 scale where 0 = 0% control or no difference from the non-treated control and 100 = 100% control or no visible green plant tissues present.

[w]Biomass shows shoot fresh weights collected at 6 weeks after treatment. % Control based on shoot weight reduction vs. control. Negative values indicate a percent increase relative to the non-treated control.

[v]Means followed by the same letter within each row and growth stage are not significantly different (Tukey's test, $P = 0.05$).

Table 2. Efficacy of glyphosate and alternative herbicides for control of garden spurge (*Euphorbia hirta*) in Florida.

6 Week Growth Stage[z]									
Treatment[y]					Visual Control Ratings (0 to 10)[x]			Biomass[w]	
Trade name	Herbicide	Rate/acre	App. Vol.	Cost	1WAT	2WAT	4WAT	F.W. (g)	% Control
Avenger Ag	d-limonene	20%	100	$34.50	58 bc	32 de	30 de	1.7 a	-9 b
Axxe	Ammonium nonanoate	13%	100	$24.65	65 abc	45 cd	35 d	1.6 a	0 b
Finale	Glufosinate	4 qt.	40	$1.52	70 abc	77 b	75 b	1.2 ab	26 b
FireWorxx	Caprylic + Capric acids	6% (v:v)	100	$16.46	67 abc	52 cd	47 cd	1.9 a	-17 b
Ranger Pro	Glyphosate	2.66 qt.	25	$0.27	53 cd	100 a	100 a	0.1 b	100 a
Reward	Diquat	2 pts.	40	$0.65	80 ab	57 bc	45 cd	2.0 a	-28 b
Scythe	Pelargonic acid	7% (v:v)	100	$9.60	82 a	65 bc	62 bc	1.8 a	-11 b
WeedPharm	Acetic Acid	RTU	25	$25.83	53 cd	30 de	10 f	1.6 a	2 b
Weed Slayer	Eugenol	3 qt.	25	$4.53	35 d	18 e	17 ef	1.8 a	-16 b
Control	N.A.	N.A.	N.A.	$0.00	---	---	---	1.6 a	---
10 Week Growth Stage									
Avenger Ag	d-limonene	20%	100	$34.50	78 ab	58 abc	53 ab	4.0 bc	55 ab
Axxe	Ammonium nonanoate	13%	100	$24.65	72 ab	45 bc	35 bc	6.4 ab	29 bc
Finale	Glufosinate	4 qt.	40	$1.52	65 bc	35 c	37 bc	5.8 ab	35 bc
FireWorxx	Caprylic + Capric acids	6% (v:v)	100	$16.46	85 a	68 ab	62 ab	4.2 bc	54 ab
Ranger Pro	Glyphosate	2.66 qt.	25	$0.27	68 b	88 a	82 a	2.4 c	74 a
Reward	Diquat	2 pts.	40	$0.65	78 ab	55 bc	34 bc	5.7 ab	36 bc
Scythe	Pelargonic acid	7% (v:v)	100	$9.60	75 ab	30 c	42 bc	5.8 ab	35 bc
WeedPharm	Acetic Acid	RTU	25	$25.83	52 c	30 c	15 cd	5.2 a	9 c
Weed Slayer	Eugenol	3 qt.	25	$4.53	8 d	32 c	3 d	5.6 a	4 c
Control	N.A.	N.A.	N.A.	$0.00	---	---	---	8.7 a	---

[z]Growth stage shows the timing when herbicide applications were made relative to seed germination. All plants treated at the 10 week growth stage had reached the flowering/seeding growth stage.

[y]Rates are shown on a per acre basis. Application volume is shown in gallons per acre and was based on manufacturer label instructions. Cost shows the chemical cost of each herbicide on a 1,000 square foot basis.

[x]Visual control ratings were based on a 0 to 100 scale where 0 = 0% control or no difference from the non-treated control and 100 = 100% control or no visible green plant tissues present.

[w]Biomass shows shoot fresh weights collected at 6 weeks after treatment. % Control based on shoot weight reduction vs. control. Negative values indicate a percent increase relative to the non-treated control.

[v]Means followed by the same letter within each row and growth stage are not significantly different (Tukey's test, $P = 0.05$).

Table 3. Efficacy of glyphosate and alternative herbicides for control of common woodsorrel (*Oxalis stricta*) in Florida.

Trade name	Herbicide	Rate/acre	App. Vol.	Cost	1WAT	2WAT	4WAT	F.W. (g)	% Control
6 Week Growth Stage[z]									
Treatment[y]					Visual Control Ratings (0 to 10)[x]			Biomass[w]	
Avenger Ag	d-limonene	20%	100	$34.50	75 abc	50 bcd	32 bc	0.6 bc	17 ab
Axxe	Ammonium nonanoate	13%	100	$24.65	68 bc	47 bcd	30 bc	0.6 ab	14 abc
Finale	Glufosinate	4 qt.	40	$1.52	90 a	93 a	77 a	0.2 bc	75 ab
FireWorxx	Caprylic + Capric acids	6% (v:v)	100	$16.46	63 bc	54 bc	34 bc	0.4 bc	38 ab
Ranger Pro	Glyphosate	2.66 qt.	25	$0.27	83 ab	100 a	97 a	0.1 c	90 a
Reward	Diquat	2 pts.	40	$0.65	62 bc	55 b	51 b	0.6 bc	15 abc
Scythe	Pelargonic acid	7% (v:v)	100	$9.60	63 bc	58 b	43 bc	0.4 bc	38 ab
WeedPharm	Acetic Acid	RTU	25	$25.83	61 c	37 cd	24 c	0.6 ab	8 bc
Weed Slayer	Eugenol	3 qt.	25	$4.53	55 c	35 d	20 c	1.1 a	-61 c
Control	N.A.	N.A.	N.A.	$0.00	---	---	---	0.7 ab	---
10 Week Growth Stage									
Avenger Ag	d-limonene	20%	100	$34.50	82 b	58 ab	45 abc	2.8 bc	44 bc
Axxe	Ammonium nonanoate	13%	100	$24.65	92 ab	80 ab	63 ab	1.9 cd	63 ab
Finale	Glufosinate	4 qt.	40	$1.52	43 c	52 bc	45 abc	2.8 bc	43 bc
FireWorxx	Caprylic + Capric acids	6% (v:v)	100	$16.46	82 b	48 bc	68 ab	1.6 cd	69 ab
Ranger Pro	Glyphosate	2.66 qt.	25	$0.27	18 e	62 ab	40 bc	2.4 cd	51 ab
Reward	Diquat	2 pts.	40	$0.65	77 b	62 ab	48 abc	2.1 cd	57 ab
Scythe	Pelargonic acid	7% (v:v)	100	$9.60	100 a	95 a	83 a	0.7 d	86 a
WeedPharm	Acetic Acid	RTU	25	$25.83	37 cd	50 bc	32 bc	3.5 abc	31 bc
Weed Slayer	Eugenol	3 qt.	25	$4.53	20 de	17 c	18 c	4.6 ab	7 c
Control	N.A.	N.A.	N.A.	$0.00	---	---	---	5.1 a	---

[z]Growth stage shows the timing when herbicide applications were made relative to seed germination. All plants treated at the 10 week growth stage had reached the flowering/seeding growth stage.

[y]Rates are shown on a per acre basis. Application volume is shown in gallons per acre and was based on manufacturer label instructions. Cost shows the chemical cost of each herbicide on a 1,000 square foot basis.

[x]Visual control ratings were based on a 0 to 100 scale where 0 = 0% control or no difference from the non-treated control and 100 = 100% control or no visible green plant tissues present.

[w]Biomass shows shoot fresh weights collected at 6 weeks after treatment. % Control based on shoot weight reduction vs. control. Negative values indicate a percent increase relative to the non-treated control.

[v]Means followed by the same letter within each row and growth stage are not significantly different (Tukey's test, $P = 0.05$).

Table 4. Comparison of postemergence herbicide costs including chemical cost and application cost based on manufacturer instructions.

		Product Cost[z]			
Trade name[y]	Active ingredient	Cost per gallon (formulated product)	Cost per fl. oz. (formulated product)	Application volume evaluated (GPA)	Mix Rate: Product needed (fl. oz.) per gal. of water
Avenger Ag	d-limonene	$75.15	$0.59	100	25.6
Axxe	Ammonium nonanoate	$82.80	$0.65	100	16.6
Finale XL	Glufosinate	$66.40	$0.52	40	3.2
Fireworxx	Caprylic + Capric acids	$119.22	$0.93	100	7.7
Ranger Pro	Glyphosate	$18.00	$0.14	25	3.4
Reward	Diquat	$114.00	$0.89	40	0.8
Scythe	Pelargonic acid	$59.46	$0.46	100	9.0
WeedPharm	Acetic Acid	$45.00	$0.35	25	---
Weed Slayer	Eugenol	$266.00	$2.08	25	3.8
		Cost Per Application[x]			
		Cost per acre	Cost per 1000 ft^2	Cost per backpack	Area Covered
Avenger Ag	d-limonene	$1,503.00	$34.50	$60.12	1,742
Axxe	Ammonium nonanoate	$1,073.81	$24.65	$42.95	1,742
Finale XL	Glufosinate	$66.40	$1.52	$6.64	4,356
Fireworxx	Caprylic + Capric acids	$717.18	$16.46	$28.69	1,742
Ranger Pro	Glyphosate	$11.95	$0.27	$1.91	6,970
Reward	Diquat	$28.50	$0.65	$2.85	4,356
Scythe	Pelargonic acid	$418.08	$9.60	$16.72	1,742
WeedPharm	Acetic Acid	$1,125.00	$25.83	$180.00	6,970
Weed Slayer	Eugenol	$197.42	$4.53	$31.59	6,970

[z]Product cost is based on average retail price paid for the trade names listed in 1 or 2.5 gal. quantities. Herbicides with the same active ingredients but different trade names may be available at either higher or lower price points at different quantities or from different suppliers. Cost per gallon and per fl. oz. is the chemical cost of the formulated product prior to mixing with water. Application volume shows the application volume evaluated (in gallons per acre or GPA) and is based on label instructions. Mix rate shows the amount of formulated product to be added to each gallon of water prior to application based on manufacturer directions. Mix rate was based on rates evaluated in UF/IFAS experiments.

[y]Trade names are listed for informational purposes and based on products evaluated in experiments. The same active ingredients are typically available and sold under other trade names.

[x]Cost per application are based on rates evaluated in UF/IFAS experiments and shown on a per acre and per 1,000 ft^2 basis. Cost per backpack is given to show the estimated cost of filling one 4 gallon pump up backpack sprayer for spot spraying. Area covered shows the square footage covered with one 4-gallon backpack sprayer using the application volume listed for each herbicide.

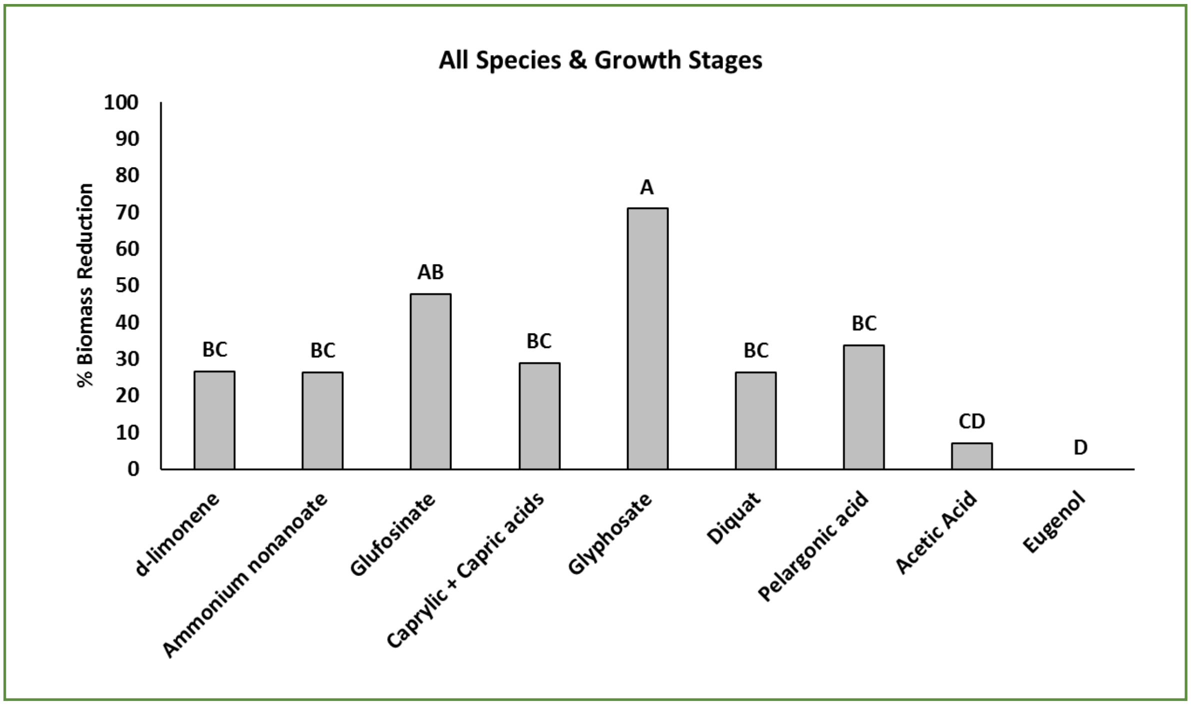


Figure 1. Shoot fresh weight (biomass) reduction resulting from application of nine different herbicides in relation to a non-treated control. Shoot weight reductions were averaged over three different weed species (garden spurge, large crabgrass, and common woodsorrel) and two growth stages (6 and 10 weeks after emergence) and taken at 4 weeks after herbicide treatment. Mean shoot weight reduction is shown for each herbicide. Columns followed by the same letter are not significantly different (Tukey's, P = 0.05).

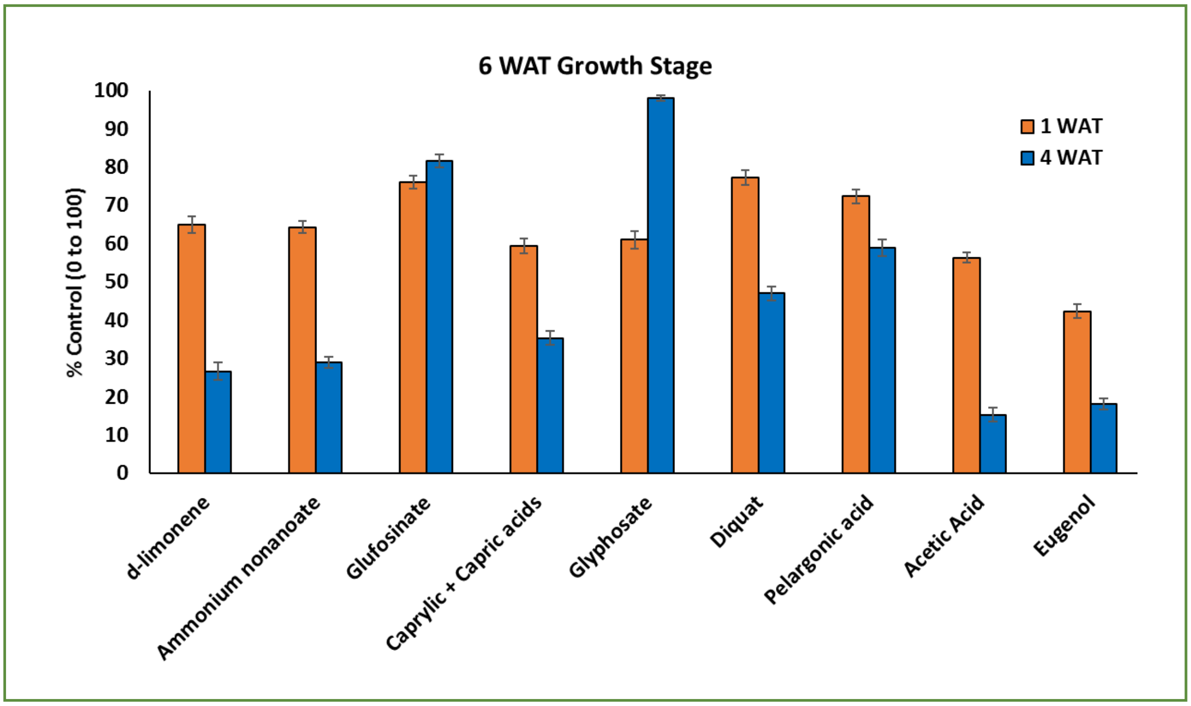


Figure 2. Average percent control ratings of nine different post-emergence herbicides applied to garden spurge, woodsorrel, and crabgrass at the 6 week growth stage (6 weeks after emergence). Means and standard errors are shown for each herbicide at 1 and 4 weeks after treatment and averaged across all three weed species.

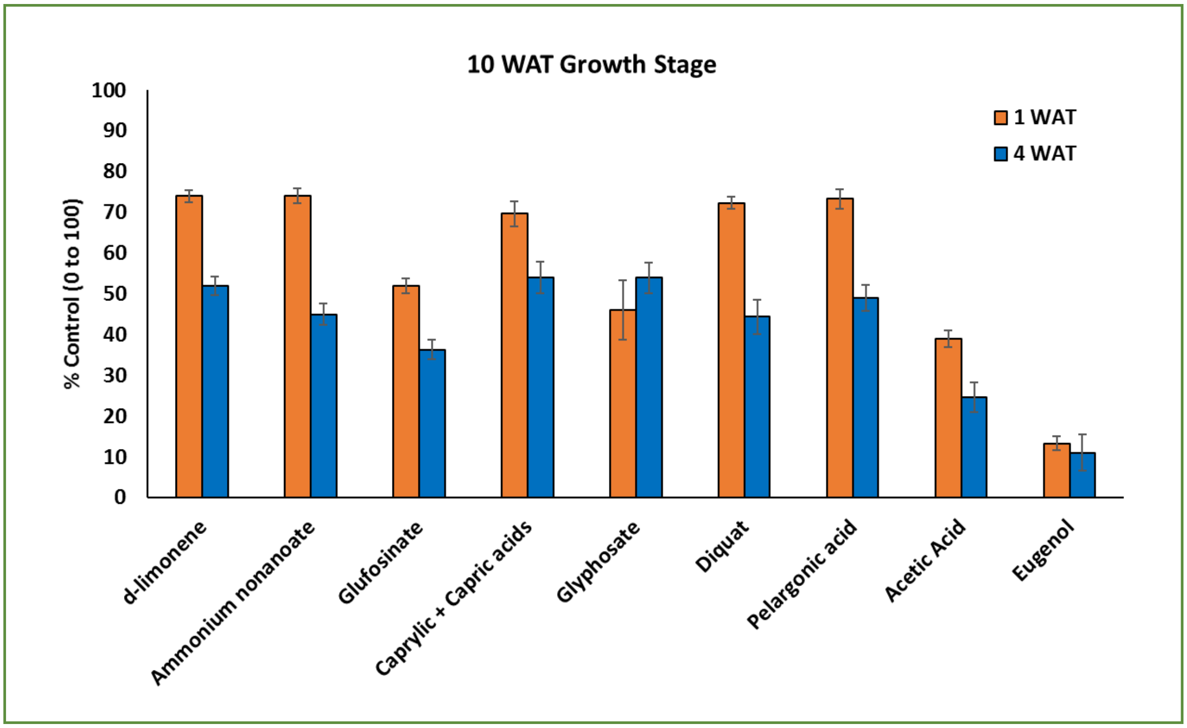


Figure 3. Average percent control ratings of nine different post-emergence herbicides applied to garden spurge, woodsorrel, and crabgrass at the 10 week growth stage (10 weeks after emergence). Means and standard errors are shown for each herbicide at 1 and 4 weeks after treatment and averaged across all three weed species.

Viburnum Foliar Disease Management; Downy Mildew & Cercospora Leaf Spot

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ABSTRACT

Central Florida nursery growers have reported disease management challenges since 2004 impacting the production of ornamental *Viburnum* spp. Reported symptoms included blighting and rapid defoliation that were indicative of downy mildew (DM). Growers indicated that common labeled fungicides failed to provide acceptable levels of disease management. Beginning in the spring of 2020, symptomatic plant samples were collected from local nurseries. Identification of isolated fungi, revealed the presence of multiple pathogens throughout the growing seasons (spring, summer, and fall), including *Plasmopara* sp., *Cercospora* sp., *Corynespora* sp., *Colletotrichum* sp., *Phoma* sp., *Phyllosticta* sp., and *Pestalotiopsis* sp. Several isolates were collected and preserved for subsequent pathogenicity testing. Subsequently, two trials were conducted at a commercial nursery, to evaluate the performance of a range of fungicides. Both trials utilized natural pathogen populations present on diseased plant materials, with overhead watering and fertilization per grower standards. The first trial, conducted in July thru August, evaluated thirteen fungicides available to nursery growers. The second trial, conducted in September thru October, focused on seven fungicides. Both trials included a non-treated control, with all treatments replicated (n=6) and arranged in randomized complete blocks. Disease severity, based on percent symptomatic foliage, was rated weekly and used to calculate Area Under Disease Progression Curve (AUDPC). Initial plant samples collected in May, identified DM (*Plasmopara* sp.), *Cercospora* sp. and *Colletotrichum* sp. as the primary pathogens. However, later samplings found *Colletotrichum* sp., *Corynespora* sp., and *Phylosticta* sp., that caused leaf symptoms similar to those commonly associated with downy mildew. Not surprisingly, fungicides that target oomycetes (i.e., *Plasmopara* sp.), containing ametoctradin, cyazofamid, dimethomorph, fluopicolide, mandipropamid, mefenoxam, and oxathiapiprolin, failed to statistically reduce disease severity relative to the non-treated control based on AUDPC. Fungicides containing benzovindiflupyr, difenoconazole, fluxapyroxad, and pyraclostrobin that typically target true fungi, statistically reduced disease. Copper sulfate and mancozeb, or the systemic fungicide, flutriafol, failed to reduce disease severity, while a generic phosphite gave an intermediate level of control. Results stress the importance of getting an appropriate disease diagnosis to avoid making an ineffective fungicide application.

OBJECTIVE

Determine efficacies of commercially available fungicide chemistries for the management of DM on *Viburnum* sp. to increase profitability and economic sustainability.

METHODS

Symptomatic foliage of Sandankwa viburnum (*Viburnum suspensum*) and Awabuki viburnum (*V. odoratissimum* var. awabuki) was collected from local nurseries for pathogen identification throughout the growing seasons of viburnum (spring, summer, and fall) in Hillsborough and Manatee Counties.

Two fungicide trials were conducted at a commercial nursery in Hillsborough County. The first trial was conducted in July through August using naturally infected *Viburnum suspensum* plants grown in 3-gallon containers at a commercial production plant nursery. The trial was designed in completely randomized blocks with 6 replicates including 13 fungicide treatments representing 12 Modes of Action (MOA) and water control (**Table 1**). A second trial was conducted in September through October using the same setup as the first trial but focused on 7 fungicides with a water control (**Table 2**).

All fungicide spray treatments were applied twice at a 14-day interval, except for copper sulfate, mancozeb and a phosphite that were applied weekly, using a handheld pump sprayer, calibrated to deliver fungicide treatments in 0.5L volume. In the second trial, Ryora was applied as a soil drench per manufacturer's recommendation. Plants were fertilized and overhead irrigated according to grower production standards. The percentage of symptomatic foliage was rated weekly for six weeks to calculate the Area Under the Disease Progression Curve (AUDPC).

Data analysis was conducted using a generalized mixed model analysis (PROC GLIMMIX) within SAS (version 9.4) with blocking as a random variable and fungicide treatment as a fixed effect. Means separations were performed using Fisher's protected LSD at a 95% level of confidence.

RESULTS

Identification of isolated fungi, revealed the presence of multiple pathogens throughout the growing seasons (spring, summer, and fall), including *Plasmopara* sp. (Fig. 1), *Cercospora* sp., *Corynespora* sp., *Colletotrichum* sp., and *Phyllosticta* sp. (Figs. 2 &3). Many that caused symptoms of leaf spotting, blighting and defoliation like downy mildew. Unfortunately, repeated sampling during trials failed to detect *Plasmopara sp.,* the cause of downy mildew. Additional surveys of diseased Viburnum from other nursery sites also failed to identify *Plasmopara sp.* in winter and spring of 2021. Controlled inoculations confirmed pathogenicity for *Colletotrichum* sp. and *Corynespora* sp., while *Pestalotiopsis* sp. appears to be an opportunistic saprophyte. Pathogenicity tests for *Phyllosticta* sp. and *Phoma* sp. are in progress. Each fungal genus designation was confirmed based on internal transcribed spacer region sequence. Additional sequencing is in progress for proper phylogenetic placement at the species level. These results stress the importance for growers to get an appropriate disease diagnosis to avoid making ineffective fungicide applications.

At the initiation of the first trial (**Table 1**), the initial survey of viburnum found *Plasmopara sp.* (downy mildew) (**Figure 1**), *Cercospora* sp. and *Colletotrichum* sp. as the primary pathogens present. However, subsequent sampling failed to find any sign of downy mildew. Rather, *Colletotrichum* sp., *Corynespora cassiicola*., *Phyllosticta* sp., *Phoma* sp., and a *Pestalotiopsis* sp. were recovered from symptomatic foliar tissues (**Figures. 2 and 3**). Not surprisingly, the fungicides containing ametoctradin, cyazofamid, dimethomorph, fluopicolide, mandipropamid, mefenoxam, and oxathiapiprolin that specifically target oomycetes (i.e., *Plasmopara* sp.), failed to statistically reduce disease severity relative to the non-treated control based on AUDPC. While benzovindiflupyr, difenoconazole, fluxapyroxad, and pyraclostrobin fungicides that are typically applied for the management of true fungi, statistically reduced disease severity.

In the second trial, a subset of 7 fungicides (**Table 2**) were re-evaluated on a new set of younger plants. In this trial, lower disease pressure from *Cercospora* sp., *Colletotrichum* sp., *Corynespora cassiicola*., *Phyllosticta* sp. produced more variable results. Numerically, the fungicides flutriafol and oxathiapiprolin appeared to increase disease severity relative to the non-treated control. Based on AUDPC, only benzovindiflupyr + difenoconazole (Postiva) statistically reduced disease severity relative to the non-treated control; while pyraclostrobin + fluxapyroxad (Orkestra) numerically also gave some control based on the final disease severity rating. This trial is currently being repeated.

CONCLUSIONS

Our findings align with the growers' reports of challenges with foliar disease management in viburnum while shedding a light on the components of this management puzzle. Growing season and environmental conditions play a key role in management decisions as a result of the multiple foliar diseases of *Viburnum* sp. occurring throughout the year. These results stress the importance of correct disease and pathogen diagnosis to select the appropriate fungicide treatments. Recommendations for foliar disease management of viburnum can be adjusted based on this research which includes correct disease identification, the timing of preventative broad-spectrum and pathogen-specific fungicide treatments based on environment and season, and fungicide rotations. Future research will include pathogenicity testing of isolated fungi (*Phyllosticta* and *Phoma*) and additional sequencing for phylogenetic placement to the species level; repeated testing for some of the previously tested chemistries (currently in progress), continued sampling to better understand the different diseases during propagation (**Figure 4**), and evaluating fungicide applications during plant propagation (proposal submitted).

OUTREACH EFFORTS

Elwakil, W., Steed, S.T., Vallad, L.A., and Vallad, G.E. 2021. Viburnum downy mildew – an action plan for growers. American Phytopathological Society, Plant Health 2021, Aug. 2 – 6, 2021 (Research on demand; presentation & e-poster).

Elwakil, W., Steed, S.T., Vallad, L.A., and Vallad, G.E. 2021. Viburnum downy mildew – an action plan for growers. https://www.youtube.com/watch?v=8omLE9yu6q4 (Extension video).

Steed, S.T., Elwakil, W., Vallad, L.A., and Vallad, G.E. 2021. Viburnum downy mildew – an action plan for growers. National Association County Agricultural Agents, Virtual Meeting, Aug. 2 – 6, 2021 (E-Poster).

Vallad, G.E., Vallad, L.A., Elwakil, W., and Steed, S.T. 2020. Viburnum disease management – summary of nursery trials. Hillsborough and Manatee Counties Extension, Ornamental Production & Landscape Field Day, Nov. 5, 2020 (Live virtual presentation).

UPCOMING OUTREACH: EDIS publication, 2021 FSHS Meeting, Ornamental Field Day, and Extension Blog Post.

Table 1. List of fungicide treatments applied in the first trial conducted in July thru August 2020 and area under disease progression curve (AUDPC) representing disease severity

Product	Active Ingredient	FRAC	Rate/100 gal	DS_{final} [Z]	AUDPC [Y]
Cuprofix Ultra 40D	copper sulfate	M1	1.9 lbs	74.5 ab [X]	1742 a
Ryora	flutriafol	3	14 floz	54.4 abc	1621 ab
Micora	mandipropamid	40	8 floz	63.2 abc	1611 ab
Protect	mancozeb	M3	2 lbs	74.6 ab	1467 ab
Orvego	dimethomorph + ametoctradin	40 + 45	14 floz	57.9 abc	1229 abc
Subdue Maxx	mefenoxam	4	2 floz	63.2 abc	1198 abc
Stature	dimethomorph	40	12.25 floz	50.3 abc	1105 abc
Segovis	oxathiapiprolin	49	3 floz	43.7 bc	1099 abc
Adorn	fluopicolide	43	4 floz	53.2 abc	1080 abc
Segway	cyazofamid	21	6 floz	38.7 c	935 abc
Phostrol	phosphite	33	2 qt	38.7 c	772 bcd
Orkestra	pyraclostrobin + fluxapyroxad	11+7	10 floz	17.6 d	588 cd
Postiva	benzovindiflupyr + difenoconazole	7+3	28 floz	11.9 d	437 d
Water control	-	-	- -	80.4 a	1642 a
			P-value =	*0.0001*	*0.0112*

[Z] Based on final disease rating, based on percent symptomatic foliage, collected on Aug. 6, 2021.
[X] Area Under the Disease Progression Curve (AUDPC), calculated using final four disease severity ratings.
[Y] AUDPC means followed by the same letter are not significantly different at the 95% level of confidence

Table 2. List of fungicide treatments applied in the second trial conducted in September thru October 2020 and area under disease progression curve (AUDPC) representing disease severity.

Product	Active Ingredient	FRAC	Rate/100 gal	DS_{final} [Z]	AUDPC [Y]
Protect	mancozeb	M3	2 lbs	17.0 bc [X]	139 ab
Phostrol	phosphite	33	2 qt	20.3 abc	193 ab
Cuprofix Ultra 40D	copper sulfate	M1	1.9 lbs	17.7 bc	160 ab
Orkestra	pyraclostrobin + fluxapyroxad	11 + 7	10 floz	13.5 cd	144 ab
Postiva	benzovindiflupyr + difenoconazole	7 + 3	28 floz	7.5 d	90 b
Ryora	flutriafol (drench)	3	14 floz	41.2 a	290 a
Segovis	oxathiapiprolin	49	3 floz	29.9 ab	261 a
Water control	-	-	- -	21.7 abc	172 ab
			P-value =	*0.0079*	*0.0309*

[Z] Based on final disease rating, based on percent symptomatic foliage, collected on Oct. 22, 2021.
[Y] Area under the disease progression curve (AUDPC), calculated using final four disease severity ratings.
[X] means followed by the same letter are not significantly different.

Figure 1. Viburnum leaf exhibiting symptoms of downy mildew (top) caused by (Plasmopara sp.), with sporulation showing on leaf underside (bottom left), through a hand lens (center) and through a microscope (bottom right).

Figure 2. Common foliar symptoms observed on Viburnum spp. caused by Cercospora sp., Corynespora cassiicola, Colletotrichum sp., and Phyllosticta sp. Symptom similarities highlight difficulties to accurately diagnose.

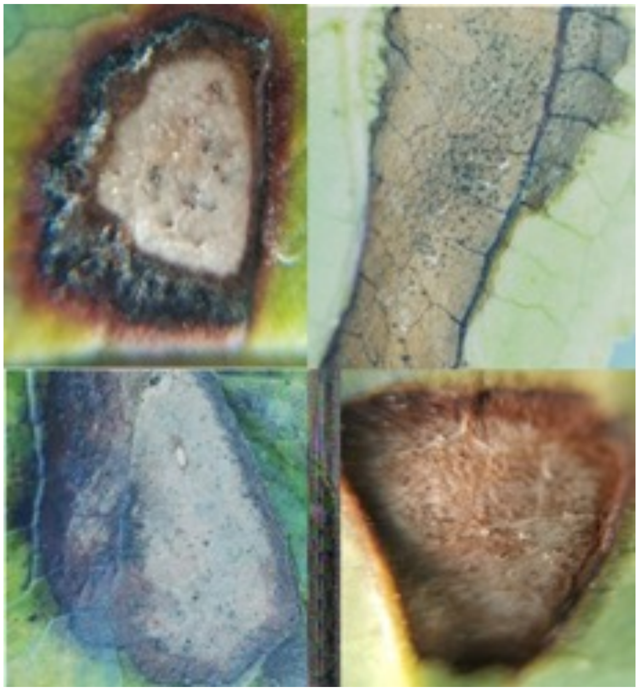


Figure 3. Hand lens view of Viburnum leaf lesions associated with Colletotrichum (top left), Cercospora (top right), Phyllosticta (bottom left) and Corynespora (bottom right).

Figure 4. Foliar disease symptoms observed during Viburnum propagation in liners (top) and recently potted plants (bottom) showing the issues of propagating from diseased plants.

IMPROVE PRODUCTION SYSTEMS PRACTICES AND STRATEGIES

This priority area is defined as:

FNGLA supports research to develop advanced systems of product handling and transportation that will improve safety and efficiency.

FNGLA supported one project under this priority area, and the summary is on pages 48-52.

Improving Seed Production and Availability of Major Citrus Rootstocks by Determining Seed Viability During Maturation and Storage

PI: FERNANDO ALFEREZ, Southwest Florida REC
Co-PI: MANJUL DUTT, Citrus REC

ABSTRACT

This proposal addressed the Improve Production Systems Practices and Strategies priority area. We have focused on product (citrus rootstock seed) longevity during seed postharvest storage.

Vigorous seeds with good viability are necessary to produce strong citrus rootstocks. The ability of the seed to germinate and establish seedlings rapidly is dependent on the seed vigor. This in turn depends on seed maturation and can be influenced by the extent of cold storage. In general, more mature seeds can be stored longer. We determined that seeds from some citrus rootstocks can germinate as early as July. However, we also observed that harvesting so early in the season might affect germination rate and may affect the storage ability. Harvesting in August greatly improved germination rate, but we did not know for how long these seeds could be cold stored without losing vigor. Hence, it was necessary to determine how maturation and storability interact so we could harvest the fruit and extract the seeds at the right time.

We have found that harvesting seeds in August and storing them in cold for at least 4 months does not significantly impact viability and germination rate, confirming that early harvesting (August instead of November) is a viable strategy for producing rootstock seeds.

OBJECTIVE

To determine seed vigor and the maximum time that the seeds harvested at each time point can be stored and germinate later.

Justification

Under the current situation of pressure for replanting and resetting HLB-infected groves, there is a clear concern among citrus nursery operators and growers on seed availability of the most popular rootstocks in Florida. Thus far, over 80% of the licensed citrus nurseries prefer uniform liners from seeds rather than from tissue culture sources. Vigorous seeds are necessary to produce strong rootstocks. This depends on seed maturation and can be influenced by the extent of cold storage. In general, the more mature a seed, the longer it can be stored. In the past years, current practices were to harvest seeds from all rootstocks between October and December, when the varieties that took longer to mature were ready to be harvested. At the same time, natural calamities such as Hurricane Irma on September 10th, 2017, severely affected the ability of our industry to produce adequate seeds necessary to satisfy nurseries needs. In the hardest hit areas, there was massive fruit drop, especially from the US802, US812, US897 and US942 varieties, at a time when fruit was almost ready to be harvested and processed for supplying the seeds to the nurseries. Seed availability from the SWFREC Immokalee, USDA Fort Pierce, and Whitmore Foundation in Leesburg decreased by 66% as compared to previous season, resulting in a shortage in seed availability. This subsequently affected the whole supply chain leading to replanting. In this scenario, we hypothesized that it would be advantageous to know in advance when the fruit contains viable seeds.

After two years of work, we determined that for US942 and US897 harvesting can be advanced to August without losing germination potential. This would allow us to make informed decisions on when to harvest the fruit of each variety, facilitating to work around the peak of the hurricane season.

However, early harvesting can affect germination rate and affect the storage ability. It was therefore necessary to know the maximum time a seed can be cold-stored and still be viable as it relates to its maturity. Hence, we wanted to determine how these parameters may interact to harvest the fruit and extract the seeds at the right time.

METHODS

Seed extraction and characterization

For each fruit harvest, four replicates of 50 fruits were collected. Seeds were hand-extracted from each fruit, washed under distilled water, and air-dried at room-temperature for 24 h. The number of seeds per fruit was counted using four replicates of 10 fruit per rootstocks. Seeds were also assessed for seed weight, in which eight replicates of 100 seeds were weighed for each rootstock using an analytical scale (Radwag, AS 60/220.R2, Radom, Poland). The seed length and width were measured using a digital caliper (Fowler High Precision, Inc., 54-101-150-2, Newton, USA) with four replicates of 10 seeds. The evaluations of seed germination and emergence were assessed for seeds extracted in July, August, September, and December 2020.

Germination test

Seeds from all three rootstocks were individually peeled, surface-sterilized for 20 min in a solution with 5.0% (v/v) sodium hypochlorite (Clorox Co., Oakland, CA) and 0.01% (v/v) Tween 20 (Sigma-Aldrich, St. Louis, MO), rinsed three times in distillated sterile water, and then planted. The germination test was performed in vitro using four replicates of 15 seeds per rootstock in a complete randomized design immediately after harvest and at 2, 4 6 and 8 months after harvest. These seeds were cold stored at 4 ˚C until the time of planting. One peeled seed was individually placed per culture tubes (25 × 150 mm) containing 18 mL of basal Murashige and Skoog medium supplemented with sucrose and agar (Sigma-Aldrich, St. Louis, MO), previously adjusted to pH of 5.8 and autoclaved at 121 ºC for 15 min. After planting, the culture tubes were sealed and maintained in growth chamber (Conviron Ltd., CMP6010, Winnipeg, Canada) at constant temperature of 25 ± 1 ºC and dark for 30 d. Measurements were taken daily after root protrusion in order to calculate the total percentage of germination, germination speed index (Maguire, 1962), root and shoot growth rate. The percentage of multiple seedlings per seed (polyembryony) were calculated at the end of the germination test. To calculate the root and shoot growth rate we proposed the following formula:

$$Growth\ rate = \frac{|a_2 - a_1| + |a_3 - a_2| + \cdots + |a_n - a_{n-1}|}{\mathrm{n} - 1}$$

where a_1, a_2, ..., $a_{(n)}$, $a_{(n-1)}$ = root or shoot length at corresponding day; and n = number of days. Growth rate was expressed in mm day^{-1}.

Emergence test

Nursery performance assessment of citrus rootstock seedlings were also evaluated using seeds and standard nursery methods at the same times as the germination test. The emergence study was set in a complete randomized design using four replicates of 48 seeds per rootstocks. One seed per cell was planted 0.5 cm depth into seedling trays of 16.8 × 35.6 × 61.0 cm with 96 cells (Stuewe and Sons, Inc., FT96-7, Tangent, USA) containing sterilized growing medium composed by sphagnum peat moss (Premier Horticulture, Inc., Pro-Mix HP Mycorrhizae, Quakertown, USA). The trays were set on benches inside a controlled-environment greenhouse at the Southwest Florida Research and Education Center (Immokalee, FL) and irrigated in a daily basis. The number of seedlings was monitored every day to determine the number of days required to emerge 50% of the population. After 60 d of planting, when seeds ceased emerging, the total percentage of emerged seedlings was determined.

Statistical analysis

The experimental design was completely randomized with a factorial arrangement [three treatments (rootstocks) × four seed extraction periods] replicated four times. All data were processed using the ExpDes package (Husson et al., 2017) in R v. 3.4.1 (The R Foundation for Statistical Computing, Vienna, Austria) and tested for significant differences by analysis of variance. The means were separated by Tukey's multiple range

RESULTS

The stage of fruit maturation significantly affected the germination performance of citrus rootstock seeds (**Figure 1**). There were observed a significant interaction ($P \leq 0.001$) between rootstock and time of harvest for almost all physiological potential evaluations. Seeds extracted in July had the lowest percentage of germination for the evaluated rootstocks, particularly US-802 that less than 50% of seeds were able to germinate at that time (Fig. 1A). However, an enhancement on seed germination was observed when fruit harvest was progressed. These differences were maintained irrespective of the storage period.

Rootstock fruits harvested in August and September had seeds with higher germination potential, where over than 90% of the seeds generated new seedlings being similar or even higher than seeds produced by fully mature fruits in December. This trend was also observed for seedling emergence when seeds were cultured under nursery conditions (**Figure 1B**). We did not find significant differences with cold storage (up to 4 months) in these seeds. In July, the evaluated rootstock seedlings did not emerge in any of the conditions assayed (planted immediately or after increasing periods of cold storage), suggesting that the seeds were not physiologically ready to be extracted from the fruits. Later, the seeds performed better showing good seedling emergence specially for US-942. In general, seeds from fruits harvested in September showed the highest vigor according to the germination speed index, root and shoot growth rate (**Figure 1**; **Table 1**). All these measurements are of paramount importance during production of rootstock liners as the time-consuming required by this process in the nurseries, which can take about 6–8 months, is dependent of the seed vigor. Based on that, US-942 seeds were more vigorous than US-802 and US-897 resulting in rapid germination and seedling growth. This rootstock took about 24 days to reach 50% of the total seedling emergence which it is significantly lower than the 37 and 43 days reported for US-897 and US-802 respectively (**Table 1**).

PRESENTATIONS/PUBLICATIONS

Alferez, F., Carvalho, D., Boakye, D., Gast, T., and Dutt, M. Maximizing rootstock seed production. Citrus Industry, July, 2021.

Carvalho, D., Alferez, F. 2020. Evaluation of germination potential of citrus seed rootstocks. FSHS Annual Meeting. Virtual, October 2020.

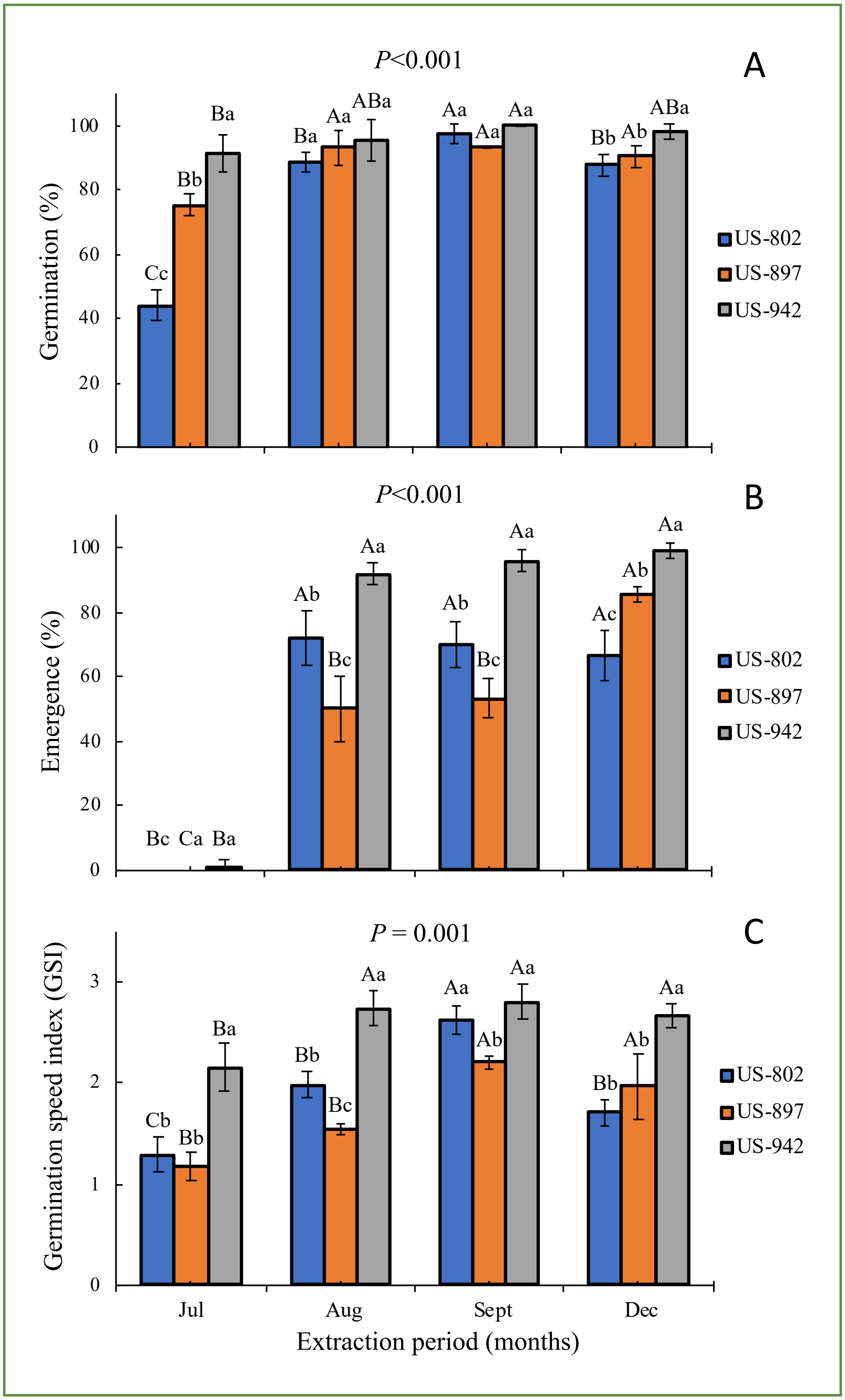


Figure 1. Percentage of germination (A), emergence (B), and germination speed index (C) of three citrus rootstocks during different period of seed extraction at the Southwest Florida Research and Education Center, Immokalee, FL. Bars followed by the same letter, lowercase between rootstocks and capital case between each extraction period, do not significantly differ according to Tukey's test (P≤0.05). Upon cold storage for up to 4 months, results were not significantly different in August, September and December as compared to freshly planted seeds.

Table 1. Seedling root growth rate and days to reach 50% of the total emergence of three citrus rootstocks during different period of seed extraction at the Southwest Florida Research and Education Center, Immokalee, FL (mean value ± standard deviation).

Source of variance	Root growth rate (mm day^{-1})	T50 (days)[1]
Rootstock		
US-802	3.87 ± 0.51 B[2]	43 ± 4.96 A
US-897	3.04 ± 0.54 C	37 ± 5.37 B
US-942	4.61 ± 0.47 A	24 ± 6.43 C
Extraction period		
Jul	3.87 ± 0.60 b	38 ± 0.01 a
Aug	3.74 ± 0.77 b	31 ± 10.57 a
Sept	4.42 ± 0.67 a	31 ± 8.77 a
Dec	3.32 ± 0.79 c	39 ± 7.68 a
CV (%)	8.32	24.15
Rootstocks	<0.001***	<0.001***
Extraction period	<0.001***	<0.001***
Rootstock × Extraction	0.056ns	0.365

[1]Days to reach 50% of the total emergence. [2]Means followed by the same letter in the column do not significantly differ according to Tukey's test ($P \leq 0.05$). *, $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

GENETICS AND BREEDING TO ENHANCE QUANTITIES AND DIVERSITY OF PLANT MATERIAL

This priority area is defined as:

FNGLA supports research to improve the quality of plant material to improve ecological and social benefits.

No projects were supported under this priority area.

List of FNGLA Funded Projects Since 2005-06

2005-2006

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Statewide Expansion of South Florida BMP Effort
William Crow	Entomology & Nematology	Gainesville Campus	Biological Control of Root-Knot Nematodes on Woody Ornamentals
Forrest Howard	Environmental Horticulture	Ft. Lauderdale REC	Biology and Management of West Indies Mahogany Scale, Conchaspis cordiae (Hemiptera: Conchaspididae)
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	Genetic Sterilization of Lantana
David Clark	Environmental Horticulture	Gainesville Campus	Development of New Coleus Cultivars for Better Foliage Color Stability and Use as Groundcovers
James Gibson	Environmental Horticulture	West Florida REC	Consumer Purchase Patterns in Florida (3-year study) Study 1 (completed): The Impact of In-House Displays on Impulse Buying Behavior; Study 2 (ongoing project): The Impact of Display Gardens on Identifying Consumer Needs, Trends, and Preferences; Study 3: (Proposed): Developing Employee Plant Knowledge to Effectively Educate Consumers and Increase Sales

2006-2007

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
James Barrett	Environmental Horticulture	Gainesville Campus	Evaluating Flowering Annuals and Herbaceous Perennials for the Florida Climate
Monica Elliott	Plant Pathology	Ft. Lauderdale REC	Determine the etiological agent for a new disease affecting Syagrus romanzoffiana (queen palm) in landscapes and nurseries
Kati Migliaccio	Agricultural & Biological Engineering	Tropical REC	Designing Irrigation BMPs Considering Capillary Rise for Production Cost Savings
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Fertilization Effects on Water Requirements of Container Grown Ornamentals during Establishment in the Landscape
Wagner Vendrame	Environmental Horticulture	Tropical REC	Potential Horticultural and Disease Management Benefits of Silicon Fertilization of Potted Orchids
Tom Yeager	Environmental Horticulture	Gainesville Campus	Expanded BMP Education

2007-2008

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Organic Matter and Irrigation Frequency Effects During Shrub Establishment
Tom Yeager	Environmental Horticulture	Gainesville Campus	BMP Workshops for Field-Grown Plant Producers
Michael Dukes	Agricultural & Biological Engineering	Gainesville Campus	Development of Programming Recommendations for Smart Irrigation Controllers
Gurpal Toor	Soil & Water Sciences	Gulf Coast REC	Characterization of Organic Compounds in Nursery Reclaimed Water
Monica Elliot	Plant Pathology	Ft. Lauderdale REC	Fusarium Decline of Palms: Pathogen, Hosts, Diagnosis and Control
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	Toward Sterilizing Nandina: Inducing Tetraploids for Development of Sterile, Non-Invasive Triploid Nandina
Francisco Escobedo	School of Forest Resources & Conservation	Gainesville Campus	The Benefits of Florida's Urban Forests on Environmental Quality

2008-2009

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Richard Beeson	Environmental Horticulture	Mid-Florida REC	Commercial Evaluation of Automated Irrigation Control for Overhead Irrigation Based on Daily Weather
Geoffrey Denny	Environmental Horticulture	Gulf Coast REC	Validation of Nitrogen Fertilizer Recommendations for Florida Landscape Plants
Michael Dukes	Agricultural & Biological Engineering	Gainesville Campus	Irrigation Controller Programming Guidelines by Multimedia Methods
Paul Fisher	Environmental Horticulture	Gainesville Campus	Onsite Monitoring of Water Treatment Technologies in Recycled Irrigation Water for Florida Nurseries
Paul Monaghan	Agricultural & Biological Engineering	Gainesville Campus	Using Community Based Social Marketing to Evaluate Homeowner Attitudes Towards Florida Friendly Waterfront Landscapes
Brian Pearson	Environmental Horticulture	Mid-Florida REC	Quantification of Stormwater Nutrient Runoff in the Environment
Amy Shober	Soil & Water Sciences	Gulf Coast REC	Effects of Organic Matter and Tillage on Plant Establishment and Nutrient Losses in an Residential Landscape
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Production Strategies for Water Savings in the Landscape

2009-2010

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Jianjun Chen	Environmental Horticulture	Mid-Florida REC	Improving the Quality of Recycled-Irrigation Water by Minimizing Algal Density Using Plant-Friendly Chemicals
Geoffrey Denny	Environmental Horticulture	Gulf Coast REC	Validation of Nitrogen Fertilizer Recommendations for Florida Landscape Plants
Rosanna Freyre	Environmental Horticulture	Gainesville Campus	Breeding of Sterile and Non-Invasive Ruellia Cultivars
Jason Keith Kruse	Environmental Horticulture	Gainesville Campus	Determining Required Width of Unfertilized Buffer Strips to Limit Fertilizer Movement Into SurfaceWater Bodies
Amy Shober	Soil & Water Sciences	Gulf Coast REC	Evaluation of Soil Physical and Chemical Properties at Newly Constructed Residential Home Sites to Improve Plant Growth and Environmental Quality
Tom Yeager	Environmental Horticulture	Gainesville Campus	Developing a BMP Manual for Field-Grown Plant Producers
Tom Yeager	Environmental Horticulture	Gainesville Campus	Automatic Irrigation Control Based Upon Plant Need

2010-2011

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
David Clark	Environmental Horticulture	Gainesville Campus	The University of Florida Sensory Gardens
Catharine Mannion	Entomology & Nematology	Tropical REC	Impact of Insecticides and Method of Application on Natural Enemies in the Landscape
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Use of Reclaimed Waste Water to Grow Greenhouse Ornamental Plants
Kati Migliaccio	Agricultural & Biological Engineering	Tropical REC	Interactive Tool for Improving Water Management in Landscapes
Robert Stamps	Environmental Horticulture	Mid-Florida REC	Evaluation and Identification of Effective and Safe Herbicides, Herbicide Formulations and Application Rates for Landscape and Nursery Use
Tom Yeager	Environmental Horticulture	Gainesville Campus	Development of an Economic Decision Support Tool for Container Nursery Management
Tom Yeager	Environmental Horticulture	Gainesville Campus	Enhanced Decision Capabilities for Irrigation of Container Plants

2011-2012

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Gul Shad Ali	Plant Pathology	Mid-Florida REC	Development of a Rapid and Sensitive Diagnostic Kit for Ornamental Plant Pathogens Using Loop-Mediated Isothermal Amplification and Recombinase Polymerase Amplification
Erin Alvarez	Environmental Horticulture	Gainesville Campus	The University of Florida Sensory Gardens
Eileen Buss	Entomology & Nematology	Gainesville Campus	Gall-Maker Management in Live Oak Nurseries
Aaron Palmateer	Plant Pathology	Tropical REC	Management of High Consequence Bacterial
Amy Shober	Soil & Water Sciences	Gulf Coast REC	Evaluation of Nutrient Leaching From Mixed Landscapes
Tom Yeager	Environmental Horticulture	Gainesville Campus	Continued Development of an Economic Decision Support Tool for Container Nursery Management

2012-2013

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Tom Yeager	Environmental Horticulture	Gainesville Campus	Evaluating the Effect of Plant Species on Water Usage to Improve Container Nursery Irrigation BMPs
James P. Cuda	Entomology & Nematology	Gainesville Campus	Mass Rearing of the South American Psyllid Calophya terebinthifolii (Hemiptera: Calophyidae), a Candidate Biological Control Agent for Brazilian Peppertree
Gary Knox	Environmental Horticulture	North Florida REC	New Crapemrytle Cultivars for the Southeastern U.S. An Extensive Evaluation of Field Resistances to Fungal, Bacterial and Abiotic Disorders and Plant and Flower Characteristics
Tesfamariam Mengistu	Entomology & Nematology	Gainesville Campus	Development of a New Molecular Method to Detect Major Root-Knot Nematodes (Meloidogyne spp.) Occurring in Florida Nurseries
Gul Shad Ali	Plant Pathology	Mid-Florida REC	Implementation and Field Testing of a Rapid and Sensitive Diaignostic Kit for Ornamental Plant Pathogens Using Loop-Mediated Isothermal Amplification Integrated with Lateral Flow Devices
Monica Elliott	Plant Pathology	Ft. Lauderdale REC	Fungicide Movement, Distribution and Persistence in Palms
Robert Stamps	Environmental Horticulture	Mid-Florida REC	Development of Control and Eradication Methods for a Weed Posing a Nursery Quarantine Risk and a Weed Posing Human Health and Environmental Risks
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	Developing Superior Native Plant Varieties for the Florida Nursery and Landscape Industry

2013-2014

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Steven Arthurs	Entomology & Nematology	Mid-Florida REC	Processed Coffee Grounds to Manage Cycad Aulacaspis Scale in Landscapes
Jianjun Chen	Environmental Horticulture	Mid-Florida REC	Developing Color-Leaved Ficus Plants Through Biotechnology Approaches
Huangjun Lu	Horticultural Sciences	Everglades REC	Enhancing St. Augustinegrass for Drought Tolerance
Paul Monaghan	Agricultural & Biological Engineering	Gainesville Campus	Increasing Tree Sales and Survivability in Urban Areas Community Tree Stewardship Programs
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Determination of Salt Tolerance of Container Grown Ornamental Shrubs
Quisto Settle	Agricultural & Biological Engineering	IFAS Center for Public Issues Education	Understanding Public Opinion of Issues Facing the Nursery and Landscape Industry in Florida
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Enhancing Irrigation in Container Nurseries Using Mobile Device App
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Develop Video to Promote BMPs

2014-2015

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Bala Rathinasabapathi	Horticultural Sciences	Gainesville Campus	Toward a Novel Biopesticide to Control Fall Armyworms: Beebalm Phytochemicals
Tom Yeager	Environmental Horticulture	Gainesville Campus	A Mobile Device App for Enhancing Irrigation in Container Nurseries
Aaron Palmateer	Plant Pathology	Tropical REC	Using Plant Diagnoistic Reports as a Tool for Preventative Disease Management in Florida Nurseries and Landscapes
Ronald Cave	Entomology & Nematology	Indian River REC	Biological Control of Green Croton Scale on Ornamental Plants
Stephen Marble	Environmental Horticulture	Mid-Florida REC	Increasing the Accuracy and Effectiveness of Herbicide Applications in Florida Nurseries
Mathews Paret	Plant Pathology	North Florida REC	Rose Mosaic: Management of Destructive Rose Virus Complex Using Early Detection and Novel IPM Strategies
Nathan Boyd	Horticultural Sciences	Gulf Coast REC	Weed Management Options for Tropical Ornamentals
Erica Goss	Plant Pathology	Gainesville Campus	New Method to Detect Hybrid Phytophthora in Nursery Production
Catharine Mannion	Entomology & Nematology	Tropical REC	Contributing Factors in Ficus benjamina Decline

2015-2016

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Mace Bauer	Horticultural Sciences	Gainesville Campus	Improve Environment and Resource Management
Nathan Boyd	Horticultural Sciences	Gulf Coast REC	Weed Management Options for Tropical Ornamentals
Paul Fisher	Environmental Horticulture	Gainesville Campus	Delivering Adequate Oxygen for Rooting of Plant Cuttings
Paul Fisher	Environmental Horticulture	Gainesville Campus	Lowcost and Automated Sensorbased Technology for Improving Irrigation Strategies
Stephen Marble	Environmental Horticulture	Mid-Florida REC	Determining the Impact of Metsulfuron a Turf Herbicide on Growth and Establishment of Ornamental Trees and Shrubs in Florida's Landscapes
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Varying Leaching Fractions and Waste Water Blends to Grow Containerized Foliage Plants
Bart Schutzman	Environmental Horticulture	Gainesville Campus	Expansion and Enhancement of the Gardens at Fifield for Research, Teaching and Extension
Tripti Vashisth	Horticultural Sciences	Citrus REC	Evaluate the Use of Plant Growth Regulators and Different Growing Media to Accelerate the Rate of Germination and Growth in Citrus Rootstock Seedlings and Budded Trees
Tom Yeager	Environmental Horticulture	Gainesville Campus	Using Leaching Fraction to Achieve Appropriate Irrigation Application Amounts

2016-2017

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Brian Bahder	Entomology & Nematology	Ft. Lauderdale REC	Evaluation of Insects in Areas Impacted by Texas Phoenix Palm Decline for Their Potential as Vectors
Nathan Boyd	Horticultural Sciences	Gulf Coast REC	Preemergence Herbicides for Weed Control in Allamanda,Bird of Paradise, Firebush and Hibiscus
Adam Dale	Entomology and Nematology	Gainesville Campus	Novel Cultural Strategies for Managing Insect Pests of St. Agustinegrass
Paul Fisher	Environmental Horticulture	Gainesville Campus	Remediating Agrichemicals from Irrigation Water Using an Activated Carbon Filter
Rosanna Freyre	Environmental Horticulture	Gainesville Campus	Breeding Sterile Dwarf Mexican Petunia (Ruellia Simplex) at the University of Florida
Catharine Mannion	Entomology and Nematology	Tropical REC	Managing Ficus Whitefly Without Pesticides
S. Chris Marble	Environmental Horticulture	Gainesville Campus	Impact of Herbicide Application Carrier Volume on Weed Control in the Absence of Rainfall or Irrigation for Activiation
Xavier Martini	Entomology and Nematology	North Florida REC	Investigating Potential Alternative Vectors and Reservoirs of Rose Rosette Virus in the Florida Panhandle
Bryan Unruh	Environmental Horticulture	West Florida REC	A Mobile Web Application for Geolocating Fertilizer Ordinance Jurisdictions

2017-2018

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Charles Guy	Environmental Horticulture	Gainesville Campus	Assessing Human Health Benefits of Gardening
Raymond Odeh	Environmental Horticulture	Gainesville Campus	
Allan Bacon	Soil and Water Science	Gainesville Campus	Long-term Recovery of Compacted Residential Soils
Eben Broadbent	Forest Resources and Conservation	Gainesville Campus	
Adam Dale	Entomology and Nematology	Gainesville Campus	Investigating the Causal Agent of Bud Galls on Florida Ornamental Plants
Gul Shad Ali	Plant Pathology	Mid-Florida REC	
Erin Harlow	Duval County Extension	IFAS Extension	
Rhuanito Ferrarezi	Horticultural Sciences	Indian River REC	Accelerated Production of Citrus Nursery Trees Using Automated Ebbandflow Subirrigation
Basil Iannone	Forest Resources and Conservation	Gainesville Campus	Planting Stormwater Ponds: Determining the Benefits and Best Management Practices for Ornamental Plants in an Underutilized Portion of Residential Landscapes
Michelle Atkinson	Manatee County Extension	IFAS Extension	
Mary Lusk	Soil and Water Science	Gulf Coast REC	
Tom Yeager	Environmental Horticulture	Gainesville Campus	Redefining Irrigation Permit Allocations for Nurseries
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Developing dPCR for Detecting Phytoplasmas in Palms
Heqiang "Alfred" Huo	Environmental Horticulture	Mid-Florida REC	Development of Genetically Engineered Banker Plants for Biological Control of Whiteflies in Greenhouses
Lance Osborne	Entomology and Nematology	Mid-Florida REC	
H. Dail Laughinghouse	Agronomy	Ft. Lauderdale REC	Developing Effective Management Options for *Nostoc* spp. in Florida Nurseries
Chris Marble	Environmental Horticulture	Mid-Florida REC	
David Berthold	(No Unit Affiliation)	Ft. Lauderdale REC	
Mathews Paret	Plant Pathology	North Florida REC	Recent Widespread Damage of Commercial and Landscape Roses In Florida To Crown Gall Disease: Characterizing the Bacterial Strains and Establishing Management Strategies
Gary Knox	Environmental Horticulture	North Florida REC	

2018-2019

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Andrew Koeser	Environmental Horticulture	Gulf Coast REC	Determining Root Space Requirements for Florida Street Trees
Deb Hilbert	Environmental Horticulture	Gulf Coast REC	
Heidi Radunovich	Family, Youth and Community Sciences	Gainesville Campus	Identifying the Impacts of Opioids on Florida Nursery, Growers and Landscapers
Christa Court	Food and Resource Economics	Gainesville Campus	
Heqiang "Alfred" Huo	Environmental Horticulture	Mid-Florida REC	Development of Salinity Tolerant Petunia Through CRISPR/Cas9 GeneEditing
Linhchi Nguyen	Environmental Horticulture	Mid-Florida REC	
Tom Yeager	Environmental Horticulture	Gainesville Campus	Use of Reclaimed Water in Production Nurseries
Shawn Steed	Hillsborough County Extension	IFAS Extension	
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Evaluating vector potential of Haplaxius crudus and Idioderma virescens
Thomas Chouvenc	Entomology and Nematology	Ft. Lauderdale REC	Measuring the Impact of a New Invasive Ant Species (Plagiolepis alluaudi) on Plant Feeding Insects in South Florida Nurseries
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	
Andrea Lucky	Entomology and Nematology	Gainesville Campus	
Chris Marble	Environmental Horticulture	Mid-Florida REC	Improving Nursery Weed Control by Choosing Herbicides Based on Application Timing Flexibility and Formulation
Chris Marble	Environmental Horticulture	Mid-Florida REC	Developing Postemergence Weed Control Strategies for Nonturf Groundcovers in Florida
Sandra Wilson	Environmental Horticulture	Gainesville Campus	Introduction of New Native Plants to Florida's Green Industry
Carlee Steppe	Environmental Horticulture	Gainesville Campus	

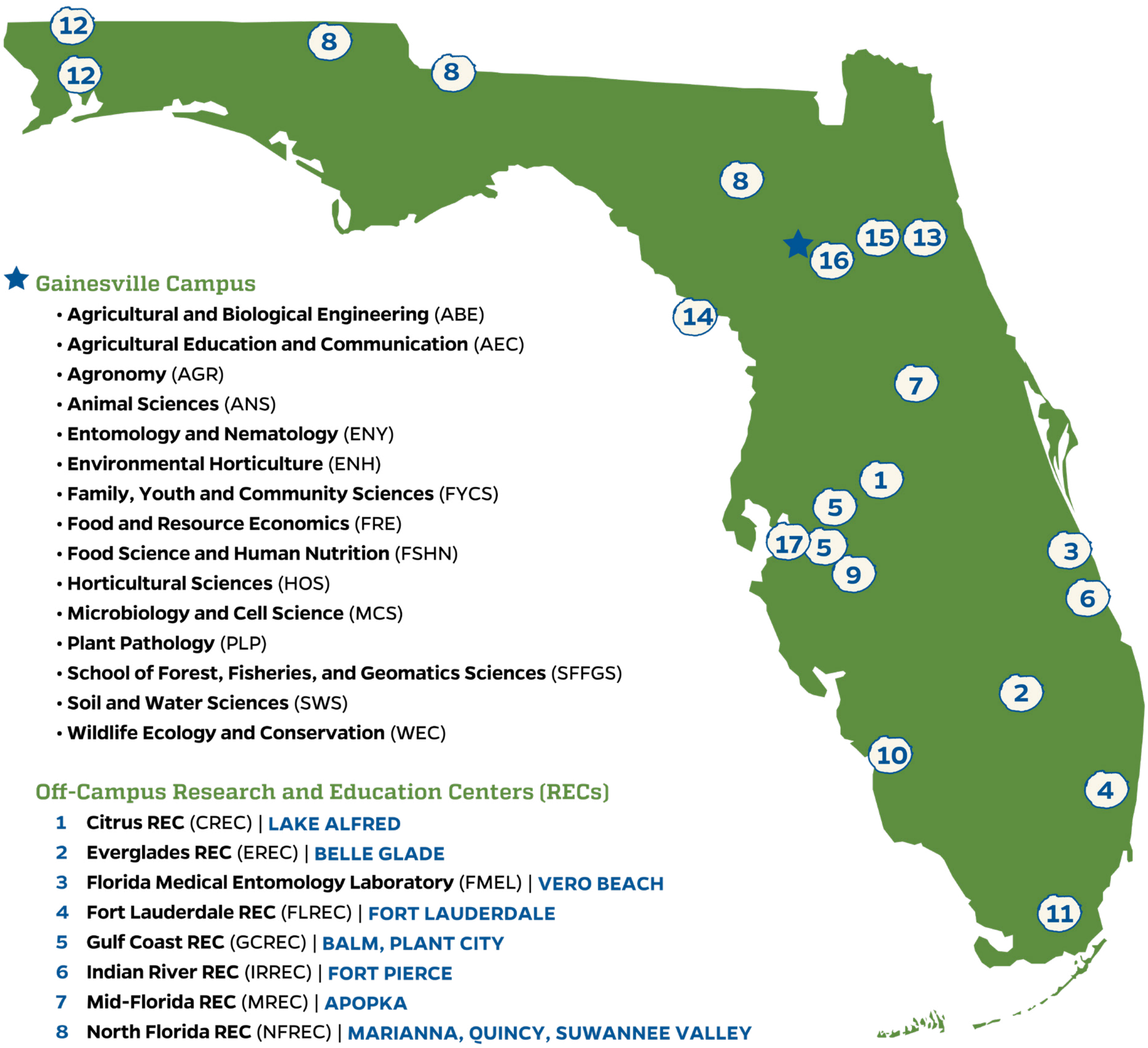
2019-2020

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Andrew K. Koeser	Environmental Horticulture	Gulf Coast REC	Tree Preservation Ordinances in the State of Florida – How does Policy Impact Canopy Coverage?
Deborah R. Hilbert	Environmental Horticulture	Gulf Coast REC	
Drew C. McLean	Environmental Horticulture	Gulf Coast REC	
Alexander J. Reisinger	Soil and Water Sciences	Gainesville Campus	Quantifying Nitrogen Leaching from Residential Soils in Florida
Eban Bean	Agricultural and Biological Engineering	Gainesville Campus	
Mark Clark	Soil and Water Sciences	Gainesville Campus	
Tom Yeager	Environmental Horticulture	Gainesville Campus	Automated Rain Gauge Device to Monitor Container Drainage for Irrigation Management
Jeff Million	Environmental Horticulture	Gainesville Campus	
Laura Warner	Agricultural Education and Communication	Gainesville Campus	Environmentally Friendly Landscaping: Addressing a Need for the Communications Research
Michael Dukes	Agricultural and Biological Engineering	Gainesville Campus	
Esen Momol	Center for Landscape Conservation & Ecology	Gainesville Campus	
Eban Bean	Agricultural and Biological Engineering	Gainesville Campus	Optimizing Soil Amendment Characteristics for Improving Environmental and Resource Sustainability
Michael Dukes	Agricultural and Biological Engineering	Gainesville Campus	
Wagner Vendrame	Environmental Horticulture	Tropical REC	Pilot Study on Management Strategies of Hibiscus Bud Weevil
Catharine Mannion	Entomology and Nematology	Tropical REC	
Romina Gazis	Plant Pathology	Tropical REC	
Adam G. Dale	Entomology and Nematology	Gainesville Campus	Determining the Effects of St. Augustinegrass Cultivar Diversity on Belowground Ecosystem Processes
Dorota Porazinska	Entomology and Nematology	Gainesville Campus	
Xavier Martini	Entomology and Nematology	North Florida REC	Survey of the Invasive Mite *Phyllocoptes Fructiphilus* Rose Rosette Virus (RRV) and of its Predatory Mites in Northern Florida
Austin N. Fife	Entomology and Nematology	North Florida REC	
Catharine Mannion	Entomology and Nematology	Tropical REC	Hibiscus Bud Weevil – A New Threat to Hibiscus Production
William Schall	IFAS Extension	Tropical REC	
Alfred Huo	Environmental Horticulture	Mid-Florida REC	Effect of Carbon and SiO2 Nanoparticles on Rooting and Growth of Different Ornamental Plants
Roger Kjelgren	Environmental Horticulture	Mid-Florida REC	

2020-2021

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Mysha Clarke	School of Forest, Fisheries, and Geomatics Sciences	Gainesville Campus	The role of gardening activities on resilience quality of life (especially during the COVID-19 pandemic)
Andrew Koeser	Environmental Horticulture	Gulf Coast REC	Determining Minimum Planting Widths for the Small-Stature Trees in Compact Developments
Deb Hilbert	Environmental Horticulture	Gulf Coast REC	
Drew McLean	Environmental Horticulture	Gulf Coast REC	
Marco Schiavon	Environmental Horticulture	Ft. Lauderdale REC	Construction of plots for long term evaluation of effects of effluent water on turfgrass
Bryan Unruh	Environmental Horticulture	West Florida REC	Establishment and Evaluation of Mixed Species Landscapes Comprising Perennial Grasses and Legumes
Ann Blount	Agronomy	North Florida REC	
Adam Dale	Entomology and Nematology	Gainesville Campus	
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Reducing Nutrient Loss from Containers
Jeff Million	Environmental Horticulture	Gainesville Campus	
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Measuring degradation of insect and phytoplasma DNA on sticky traps
Adam Dale	Entomology and Nematology	Gainesville Campus	Developing methods for biodiversity-certified ornamental plant production
Jaret Daniels	Floridam Museum of Natural History	Gainesville Campus	
Chris Marble	Environmental Horticulture	Mid-Florida REC	Finding, Evaluating, and Fine-tuning Herbicide Alternatives to Glyphosate for the Florida Landscape Industry
Anthony Witcher	Tennessee State University		
Gary Vallad	Plant Pathology	Gulf Coast REC	Viburnum Foliar Disease Management; Downy Mildew & Cercospora Leaf Spot
Shawn Steed	Extension Agent III	Hillsborough City	
Fernando Alferez	Horticultural Sciences	Southwest Florida REC	Improving seed production and availability of major citrus rootstocks by determining seed viability during maturation and storage
Manjul Dutt	Horticultural Sciences	Citrus REC	

UF/IFAS Research Units



★ Gainesville Campus

- **Agricultural and Biological Engineering** (ABE)
- **Agricultural Education and Communication** (AEC)
- **Agronomy** (AGR)
- **Animal Sciences** (ANS)
- **Entomology and Nematology** (ENY)
- **Environmental Horticulture** (ENH)
- **Family, Youth and Community Sciences** (FYCS)
- **Food and Resource Economics** (FRE)
- **Food Science and Human Nutrition** (FSHN)
- **Horticultural Sciences** (HOS)
- **Microbiology and Cell Science** (MCS)
- **Plant Pathology** (PLP)
- **School of Forest, Fisheries, and Geomatics Sciences** (SFFGS)
- **Soil and Water Sciences** (SWS)
- **Wildlife Ecology and Conservation** (WEC)

Off-Campus Research and Education Centers (RECs)

1 **Citrus REC** (CREC) | **LAKE ALFRED**
2 **Everglades REC** (EREC) | **BELLE GLADE**
3 **Florida Medical Entomology Laboratory** (FMEL) | **VERO BEACH**
4 **Fort Lauderdale REC** (FLREC) | **FORT LAUDERDALE**
5 **Gulf Coast REC** (GCREC) | **BALM, PLANT CITY**
6 **Indian River REC** (IRREC) | **FORT PIERCE**
7 **Mid-Florida REC** (MREC) | **APOPKA**
8 **North Florida REC** (NFREC) | **MARIANNA, QUINCY, SUWANNEE VALLEY**
9 **Range Cattle REC** (RCREC) | **ONA**
10 **Southwest Florida REC** (SWFREC) | **IMMOKALEE**
11 **Tropical REC** (TREC) | **HOMESTEAD**
12 **West Florida REC** (WFREC) | **JAY, MILTON**

Research and Demonstration Sites

13 **Hastings Agricultural Extension Center** (HAEC) | **HASTINGS**
14 **Nature Coast Biological Station** (NCBS) | **CEDAR KEY**
15 **Ordway-Swisher Biological Station** (OSBS) | **MELROSE**
16 **Plant Science Research and Education Unit** (PSREU) | **CITRA**
17 **Tropical Aquaculture Laboratory** (TAL) | **RUSKIN, APOLLO BEACH**

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